THE NORTH AND SOUTH AMERICAN ASCIDIANS

WILLARD G. VAN NAME

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INTRODUCTION

In this work I have attempted to give within the limits of a single volume a general survey of the ascidians of the North and South American regions and to provide a manual that will be of help to those who have specimens of ascidians that they wish to identify.

But the latter purpose, especially, is a most difficult one to fulfill, owing to the character of these soft-bodied animals, which lack the definitely shaped, hard skeletal structures that assist in distinguishing species in many other groups. There is no quick and easy road to a knowledge of the ascidians, and except in the case of a few species that have unusually conspicuous distinguishing characters, some perseverance in the study of the subject and practice in handling the material may be needed before successful results in identifying even quite well-preserved specimens will be found easy to attain. Those doing such work may find help by keeping in mind the statements and suggestions on identification of specimens made on pages 16 to 19.

GEOGRAPHICAL AREA COVERED

This requires more definite statement. The work deals with the ascidians (class Ascidiacea of the subphylum Tunicata) of the coastal waters, continental shelf areas, and neighboring islands of North and South America. It thus includes Greenland, Bermuda, the West Indies, the Falkland Islands, South Georgia, the Juan Fernandez Islands (about the Galápagos Island ascidians virtually nothing is known), the Aleutian Chain, and Bering Sea. For convenience the Antarctic regions lying directly south of South America are also included, as well as such deep-sea species as have been dredged at stations not too far removed from the American coasts.

It includes all the Tunicata of these regions except the free-swimming forms (classes Thaliacea and Larvacea), the best known of which are the families Salpidae and Pyrosomatidae. These are widely distributed in the oceans of the world and do not belong exclusively to the region this work covers.[1]

It has been necessary to keep this work within the limits of a handbook or manual that I could hope to complete, rather than to undertake an extensive monograph which I would surely never finish; and the large number of species to be dealt with has made it imperative to limit greatly the introductory part and omit, or touch only briefly on, some subjects that would otherwise be deserving of more consideration.

THE AMERICAN ASCIDIAN FAUNA

Taking the word "American" in the broad sense above stated, the present work recognizes the list of American ascidians as including 309 species and 10 additional forms which are ranked only as subspecies but which are well-marked ones and in many works have been or would probably be treated as full species.

Poorly marked and dubious subspecies, "varieties," and "forms" are not taken account of in this total, and a few very insufficiently described forms whose genus and, in many cases, family cannot be made out are also entirely disregarded. Of course these 319 forms that are given recognition are not all equally well known, and among them are a few whose validity is not as yet too well established; on the other hand, there are some which are probably being taken in too comprehensive a sense and which future investigation may prove to be divisible into more than one distinct species. The great range of individual, age, and seasonal variation as affecting not only the external shape and appearance but many of the internal characters of ascidians, to which must be added the varied effects of preservation under different conditions, was far from being realized until within a very few years and is not always appreciated even today.

In this work I have been more critical, and species described on the basis of a few, often poorly preserved, museum specimens (sometimes on a single one, or a single colony of a compound form) and which differ only in

[1] For identifying the American members of these families, which include all the larger and most commonly observed pelagic tunicates, see Metcalf, 1918, and Metcalf and Hopkins, 1919 (in bibliography).

minor characters within the probable range of individual variation of better known species found in the same geographical area have usually been relegated to the status of synonyms or probable synonyms, in many cases without discussion.

No doubt I have sometimes been too arbitrary in this respect; if so, future collecting and study will prove me wrong, but I suspect that often I have not been ruthless enough. I have endeavored to make the list of species recognized in this work a fair but rather conservative one, as far as the present available information permits. What the future will bring forth I cannot venture to predict. At present we are not able to divide the genera of groups such as the ascidians, in which there are no hard, permanently and definitely shaped shells or other skeletal structures, but in which every organ is subject to change of shape by muscular contractions and where colors are not permanent in preservation, into a multitude of evidently distinct species, as we do in such groups as crustaceans, insects, mollusks, etc. Unless we can discover an additional entirely new and revolutionizing method of distinguishing species of ascidians, I incline to the belief that future additions to the American list will be gradual and not very extensive in comparison to the number already known.

The most promising outlook for the better distinction of closely allied species is in the study of the development of the eggs (which appear in many cases to be rather distinctive in size and characters) and the larvae. Such investigations must usually be carried on at marine laboratories where a supply of running sea water is available, and is often difficult and very time consuming. Work of this kind by Berrill, Grave, Plough and Jones, and Lucas in recent years is worthy of special mention.

A critical study of the species of regions where the ascidian fauna has been well investigated, such as the Arctic and the West Indies, shows that the number of species has often been over-estimated by the earlier writers, and we are justified in believing that the same is true of a number of other regions less well known, such as the Magellanic and East Indian, from which many ascidians have been described, the majority of which are based on very limited material. A number of supposed species differ chiefly in having been collected by different scientific expeditions or found on coasts under the control of different nationalities.

On the other hand, I have taken a conservative course and usually maintained as distinct species those that are separated by distant habitats and important geographical barriers, especially if these involve strongly marked differences in the water temperatures.

While a few subspecies and varieties have seemed worthy of recognition, most genera and species of ascidians have not as yet been so thoroughly studied that attempts to divide them into subspecies are worth while at the present time. The practice of naming new "subspecies," "varieties," and "forms" simply because the specimen or specimens that come to hand differ in small details from the published descriptions of the species they are referred to is not to be commended.

NEW SPECIES DESCRIBED

Sixteen species and two subspecies are described as new to science and are listed below with their type localities. The types are in the American Museum of Natural History. No new genera or families are proposed.

Species

Amaroucium propinquum, Pacific Grove, California

Amaroucium arenatum, Pacific Grove, California

Polyclinum laxum, Espiritu Santo Island, Gulf of California

Didemnum santa-elenae, Salinas, Ecuador

Trididemnum thetidis, Tarpon Springs, Florida

Eudistoma tarponense, Tarpon Springs, Florida

Eudistoma carolinense, off Charleston, South Carolina

Eudistoma pachecae, Panama Bay

Eudistoma platense, "Albatross" Station 2766, near La Plata River

Eudistoma mexicanum, "Albatross" Station 3033, Gulf of California

Eudistoma ritteri, Pacific Grove, California

Clavelina fasciculata, La Paz, Gulf of California

Styela schmitti, "Albatross" Station 2764, near La Plata River

Molgula provisionalis, Bar Harbor, Maine

Molgula habanensis, off Havana, Cuba, 189 fathoms

Molgula platana, "Albatross" Station 2764, near La Plata River

SUBSPECIES

Ascidia sydneiensis protecta, Concepcion Bay, Gulf of California

Eugyra arenosa californica, Corona Del Mar, California

CLASSIFICATION AND NOMENCLATURE

Innovations in the classification of the ascidians have not been introduced as the classification has been fairly well stabilized for a long period, and the introduction of any except minor changes would, I think, be vastly more productive of inconvenience and harm than of any possible good that I can foresee.

More than 90 per cent of the known ascidians fit perfectly into a comparatively small number of genera and families that are self-evidently natural groups which all classifications must accept. There are a few genera which fail to do so; a genus may leave us the choice of making a separate family for it or stretching the definition of one of the other families (sometimes at the cost of sacrificing some particularly convenient diagnostic character), but such genera are not numerous enough to make it a matter of great importance which of these two evils we adopt in dealing with them. Personally, I still believe, as I always have done, that simplicity and convenience are promoted by keeping genera and families reasonably few and comprehensive. The ideal, which has been approached in some groups of animals, of a genus for almost every species and a separate family for a large proportion of the genera is not, in my opinion, one to strive for but rather one to be opposed. The recognition of subgenera where needed seems to me far better than breaking up genera with the resulting changes in names.

As in virtually all recent works on ascidians, the classification used in the present one follows in most respects that of Hartmeyer in the volume on the ascidians in Bronn's "Klassen und Ordnungen des Tierreichs" (Hartmeyer, 1909–1911), though with the modification almost always adopted in recent works, including the later ones of Hartmeyer himself, of restoring as *nomina conservanda* a number of familiar generic and family names, which Hartmeyer had rejected and replaced by others in his work mentioned above on grounds of priority. (See Hartmeyer, 1908b, 1915a.)

This classification is based primarily on the characters of the branchial sac and secondarily on those of the gonads, but other available characters are taken into account. The groups of ascidians living today are more or less separated and isolated survivors of a much larger assemblage of forms developed in past geological periods. No fossil ascidians are known, nor considering their soft-bodied character are many ever likely to be found, and in many cases we have no means of knowing just how and in what succession the present groups branched off from their common ancestors. Attempts to classify ascidians on the basis of any single character or organ, as, for instance, that on the basis of the epicardium, are less satisfactory, as they either group together very unlike forms or break up evidently natural assemblages recognized in the generally adopted classifications.

The acceptance of many *nomina conservanda* in the nomenclature of the ascidians is unavoidable, for any satisfactory application of the law of priority is in many cases impossible. Often we cannot be sure to what species the brief and vague descriptions (usually dealing with external characters only) given by the early writers were intended to apply. The validity and priority of many names now in general use may be questioned. As we become better acquainted with the species inhabiting certain regions and localities, we are sometimes able to make a better guess or even to feel pretty sure what species some old name, long misused or rejected as undeterminable, must have been intended to designate. Must we then substitute it for a familiar name in wide usage, upsetting the names of many species, if the genus is a large one, and sometimes the family name also? I believe not. Established names should be retained in such instances, if not on the merits of the case, then as *nomina conservanda.*

BRIEF HISTORICAL REVIEW OF THE LITERATURE

Lack of space prevents dealing with this subject except very briefly and compels me to pass over much good work without the mention it deserves. Most of the literature can be best considered in groups dealing with particular regions of the American coasts.

During the last century and the first decade of the present one, the published work on the ascidians by American zoologists dealt, with a few exceptions noted below, with the species of northeastern America, especially the New England and eastern Canadian coasts. The earlier accounts are generally comprised in articles on the Mollusca of the region, in which branch of the animal kingdom the ascidians were included in old classifications.

As my previously published articles on the New England ascidians (Van Name, 1910, 1912; see bibliography at end of this work) give a detailed review of the early American work, I will refer here only to Lesueur (1823), Couthouy (1838), and Gould (1841) as initiating it, and L. Agassiz (1850), Stimpson (1851, 1852, 1854), Packard (1863, 1867), and Binney (1870) as chief among those who continued it during the early period. In 1871 Verrill began and continued for a number of years the publication of an important series of papers in which most of the species of the New England region were described in detail and in many cases figured. Verrill's work was followed by an inactive period lasting into the early years of the present century, but the study of the ascidians of northern Europe and the Arctic regions, including Greenland, was being constantly carried on by Old World investigators.

Preëminent among the European writers was Hartmeyer, who in 1903 published the volume on the ascidians of the "Fauna Arctica," which, as many of the species are common to both hemispheres, was most important as a contribution to our knowledge of the northern American forms also. It was followed by the 1910 and 1912 articles of the present writer, by one of Huntsman (1912), and various later publications by Hartmeyer, especially his article on the ascidians of western Greenland (1921a) and the magnificent work completed just before his untimely death in 1923 (the last volume was posthumous) on the ascidians of the Ingolf Arctic expedition, which he expanded into an admirably thorough treatise on all the Arctic and northern ascidians. More recent works by Ärnbäck (1922 and later) and Huus have also contributed much to bringing the knowledge of the ascidians of the northern regions of both the Old and New Worlds to its present well-advanced state.

Passing to the ascidians of the warm regions of the eastern American coasts, we find that except for brief descriptions by Lesueur (1823) and Stimpson (1852) the important work was, until the end of the last century, carried on by foreign authors exclusively, especially Heller (1878), Traustedt's excellent articles of 1882 and 1883 on the West Indian species, Herdman's "Challenger" reports (1880–1886), and Sluiter's (1898) report on the collections of the steamer "Chazalie."

The Bermuda ascidians have been dealt with by Herdman (1886) and Verrill (1900) and the present writer (1902); more recently also by Berrill (1932). Other articles by myself dealing with the West Indian areas appeared in 1921, 1924, and 1930 (see bibliography), as well as briefer contributions by various other authors, so that the ascidian fauna of eastern tropical America is now fairly well known.

Information on the ascidians of the east coast of South America is very scanty until we reach the Magellanic region, which includes also a long extent on both the east and west coasts of southern South America. The literature on it is extensive, but none of it by American authors. Most of it is contained in the reports of various scientific expeditions, the chief authors being Lesson (1830), Cunningham (1871), Herdman (1880–1886), Michaelsen (1900, 1907) and Ärnbäck (1938). The reports by Sluiter (1905, 1906, 1906a, and 1912, 1914) on the two Charcot expeditions (French Antarctic expeditions) and Ärnbäck's (1938) article just mentioned describe many species from the Antarctic region lying south of South America, some of them common to the Magellanic region also.

In such a review of the literature on ascidians as we are now making we may pass over entirely the whole west coast of South and Central America. It is not that we do not have considerable disconnected information and descriptions of a number of the species available, but what we do have is mostly scattered in articles and publications dealing with other groups and other subjects, and very little in the way of any systematic study of the ascidian fauna of those coasts has been carried out or published.

From the Mexico-United States boundary northward, including Alaska, however, the west coast ascidians have been the subject of much study and much literature. Though a few species were described by earlier writers, as Stimpson, 1864, and Dall, 1872, it is chiefly through the numerous articles by Ritter, beginning in 1893 and continuing until 1917 (the last one with Forsyth as joint author), covering all parts of the western United States coast and northward to, and including, Bering Sea, and those of Herdman, 1898, and Huntsman, 1912, 1912a, dealing especially with those of the Puget Sound and British Columbia regions, that our knowledge of the ascidian fauna of this region has reached its present state.

EXTRA-AMERICAN DISTRIBUTION OF THE AMERICAN ASCIDIANS

A large percentage of the known ascidians appear to be animals of wide geographical range. Reference to the list given below of the American species and subspecies, which gives also a brief indication of the distribution of each, shows that very nearly one-third of them have been reported, probably correctly in a majority of cases, from Old World regions or localities also. (See list beginning on p. 21.) A large proportion of these are Arctic and northern species having a more or less continuous range by way of Norway, Iceland, and Greenland. In some cases they are completely circumpolar. But even in the tropical regions, there are a number of species that are inseparable or closely similar in the two hemispheres.

A conclusion that similar species from widely separated regions are actually identical should not be hastily made; they may be merely near allies, as it is difficult to identify ascidians positively from descriptions and illustrations (even good ones). Specimens for comparison are often necessary, perhaps also some familiarity with the species in a living condition. In the present work I have avoided taking much space for discussion of the possible identity of allied Old and New World species, as in many cases any conclusion made with the present insufficient information would be little more than guesswork.

The following 58 ascidians of northern and Arctic regions are known from both American and Old World regions or localities: *Amaroucium spitzbergense*, *A. mutabile*, *A. glabrum*, *A. pallidum*, *Synoicum pulmonaria*, *S. cymosum*, *Didemnum albidum*, *D. albidum polare*, *Leptoclinides faeröensis*, *Trididemnum tenerum*, *Lissoclinum aureum*, *Polycitor vitreus*, *Distaplia clavata*, *Ciona intestinalis*, *Ciona i. longissima*, *Ciona i. gelatinosa*, *Ascidia prunum*, *A. dijmphniana*, *A. callosa*, *A. obliqua*, *Chelyosoma macleayanum*, *Ch. inaequale*, *Corella borealis*, *Corellopsis pedunculata*, *Botrylloides aureum*, *Kükenthalia borealis*, *Polycarpa fibrosa*, *Cnemidocarpa mollis*, *C. rhizopus*, *C. finmarkiensis*, *C. mortenseni*, *Dendrodoa aggregata*, *D. pulchella*, *D. lineata*, *D. grossularia*, *Styela gelatinosa*, *S. coriacea*, *S. rustica*, *S. rustica macrenteron*, *S. atlantica*, *S. clavata*, *Pelonia corrugata*, *Pyura mirabilis*, *Microcosmos glacialis*, *Halocynthia pyriformis*, *H. aurantium*, *H. igaboja*, *Boltenia echinata*, *Molgula griffithsii*, *M. siphonalis*, *M. citrina*, *M. complanata*, *M. retortiformis*, *M. immunda*, *Rhizomulgula globularis*, *Eugyra glutinans*, *E. pedunculata*, *Hexacrobylus arcticus*.

Some other ascidians described from northeastern Asiatic waters, Japan, etc., especially by Redikorzev (1927, 1937) and in various articles by Oka, seem to be allied to those of the northwestern American coasts but cannot be identified with them with the information now available. In case their identity should be proved, I believe that priority would in most cases protect the validity of the names used in this work.

In the case of the Antarctic and Subantarctic (Magellanic) species it is probable that a very large proportion of the species will eventually be found to be completely circumpolar, but owing to an apparently smaller ascidian fauna and to our incomplete knowledge of it, we can at present list only 22 as common to both the Western and Eastern Hemispheres: *Amaroucium fuegiense*, *A. caeruleum*, *Synoicum adareanum*, *Didemnum studeri*, *D. biglans*, *Polycitor magalhaensis*, *Holozoa cylindrica*, *Sycozoa sigillinoides*, *Ascidia challengeri*, *A. translucida*, *Corella eumyota*, *Polyzoa reticulata*, *Cnemidocarpa drygalskii*, *C. verrucosa*, *Pyura setosa*, *P. squamata*, *P. discoveryi*, *Bathypera splendens*, *Molgula pulchra*, *M. pedunculata*, *M. bacca*, *Ascopera gigantea*.

In spite of the fact that in the case of species (except a few abyssal ones) of warm temperate and tropical latitudes, continuous geographical ranges comprising American and Old World localities are not possible on account of the great extent of deep oceanic waters that intervene, no fewer than 22 cases of identity of such species in the two hemispheres are either well established or quite reliably reported. The following list is a conservative one, some rather doubtful cases being omitted: *Aplidium lobatum*, *Polyclinum constellatum*, *Didemnum candidum*, *Trididemnum savignii*, *Diplosoma macdonaldi*, *Cystodytes dellechiajei*, *Distaplia stylifera*, *Ciona intestinalis*, *Ascidia nigra*, *A. sydneiensis*, *Rhodosoma turcicum*, *Botryllus schlosseri*, *B. primigenus*, *Botrylloides nigrum*, *Polyandrocarpa maxima*, *Polycarpa circumarata*, *Styela partita*, *S. plicata*, *Pyura vittata*, *Herdmania momus*, *Microcosmus exasperatus*, *M. helleri*.

These species are mostly common to the West Indian region and parts of the Indo-Malayan region but not really circumtropical. (See Michaelsen, 1919b, p. 4; 1934, p. 137.) Almost all of them are unknown from the American Pacific coast, conspicuous exceptions being *Cystodytes dellechiajei* and *Ciona intestinalis* which are common on the California coast, and but few (seven or eight) are found in the Mediterranean and on the warmer parts of the West African coast, though there are a few other allied forms in those regions that may eventually prove to be identical. (See Huus, 1927, for a discussion of this subject.)

In some cases it is very difficult to see by what means such an extended distribution can have been acquired. There are species known only from restricted areas in one hemisphere that have turned up unexpectedly in some place in the other hemisphere, the authors reporting that no distinguishing characters could be found. Examples of this are *Styela atlantica*, *Polyandrocarpa maxima*, *Distaplia stylifera*, *Botryllus primigenus*, and *Heterostigma singulare*.

Transportation of species on drifting logs doubtless accounts for some cases; in a few, human agency may have had a part by carriage of specimens on the bottoms of ships, which was probably more frequent in the days of wooden sailing vessels than now. Species whose wide distribution is probably in part due to the last-mentioned cause include *Styela plicata*, *S. partita*, *Ciona intestinalis*, *Microcosmus exasperatus*, *Herdmania momus*, and *Botryllus schlosseri*.

FAUNAL REGIONS IN THE DISTRIBUTION OF THE AMERICAN ASCIDIANS

This is a subject on which the available information is still insufficient. Hartmeyer's (1909–1911) outstanding work on the distribution of the ascidians of the world, in the volume on ascidians in Bronn's "Tier-reich" (vol. 3, suppl.), was handicapped by the fact that at that time the study of the American species had been much neglected for many years; his information regarding their distribution was deficient, and his list of species on which he based conclusions contained many synonyms.

Even today there are extensive regions, particularly on the South American and Central American west coasts, where very little collecting of ascidians has been done. We know some species from those regions, but not enough about their geographical range to determine the limits of zoogeographical regions or the character of the transitions between them. On the other hand, we have information on which to deal fairly well with many of the other regions, especially those of the United States coasts.

The Arctic and Eastern Canadian Regions

The Arctic faunal region is circumpolar, the majority of the species being the same in both the Eastern and Western Hemispheres. This region extends very much farther south along the American Atlantic coast than anywhere else. In the shallow waters along the shores, the ascidian fauna is composed almost exclusively of Arctic region species as far south as the mouth of the Bay of Fundy and the eastern part of the Maine coast; a number of its species range farther southward to, or sometimes slightly beyond, the latitude of Cape Cod, Massachusetts, on the fishing banks and in moderately deep water off shore. As it seems rather far-fetched to call the fauna of this part of the coast "Arctic," the term "Eastern Canadian" may be a better one for this southern extension of the Arctic fauna.

Common shallow-water ascidians that the ordinary collector is likely to obtain in it are *Amaroucium glabrum*, *A. pallidum*, *Didemnum albidum*, *Molgula complanata*, *M. citrina*, *M. provisionalis*, *M. retortiformis*, *Boltenia ovifera*, *B. echinata*, *Halocynthia pyriformis*, *Dendrodoa carnea*, and *Ascidia callosa*.

From Cape Cod northward the water is cold, and rocky coasts and beaches strewn with large boulders prevail, but from the southern side of that Cape down to southern Florida, sandy ocean beaches with extensive regions of shallow water and sandy bottoms, and shallow bays, sounds, and estuaries are found in most places. Moreover, the proximity of the Gulf Stream makes the water much warmer. We may term this region

The Eastern United States Region

The ascidian fauna of this region is not strictly limited by Cape Cod. A few of its species occur in the warmer and shallower bays and harbors north of the Cape, especially Cape Cod Bay and Boston Harbor, or even in the vicinity of Portland, Maine, and a few of the Eastern Canadian forms occur in deeper water around and south of Cape Cod, but generally speaking the Cape forms a pretty definite limit between the two faunas.

The Eastern States fauna extends southward along the coast to northern Florida, and some traces of it reappear in the northern part of the Gulf of Mexico, but in the region of Beaufort, North Carolina (about 34° N.), an admixture of southern (West Indian) species begins, so that from there southward the fauna becomes transitional; as we proceed southward the tropical species become more and more predominant, especially where there are coral reefs.

The ascidians of the Eastern States region are not numerous in species but often abundant in individuals.

Among those common in shallow situations and on piles of wharves, etc., we may mention *Perophora viridis*, *Didemnum candidum lutarium*, *Amaroucium constellatum*, *A. pellucidum*, *A. stellatum*, *Botryllus schlosseri*, *Styela partita*, *Dendrodoa carnea*, *Molgula manhattensis*, *M. arenata*, and *Bostrichobranchus pilularis*; from North Carolina southward the large *Styela plicata* becomes locally abundant and conspicuous.

The West Indian or Eastern American Tropical Region

This is a region of great extent and is numerous in species. As already stated, it begins on the North Carolina coast by an admixture of some of its species with the Eastern States fauna; on the coasts of southern Florida that fauna is virtually replaced by purely West Indian forms. The West Indian fauna has another northern outpost in the Bermuda Islands, whose ascidians are almost exclusively tropical species, doubtless colonized there by specimens drifted north by the Gulf Stream (see Berrill, 1932).

The West Indian region comprises also the Gulf of Mexico, the Caribbean, all the West Indies, and extends down the east coast of South America as far as tropical conditions prevail—at least as far as Santos, State of São Paulo, Brazil.

Common shallow-water West Indian ascidians include: *Polyclinum constellatum*, *Amaroucium bermudae*, *Trididemnum savignii*, *Didemnum candidum*, *Diplosoma macdonaldi*, *Lissoclinum fragile*, *Eudistoma olivaceum*, *E. capsulatum*, *Clavelina oblonga*, *C. picta*, *Distaplia bermudensis*, *Perophora viridis*, *Ecteinascidia turbinata*, *Ascidia nigra*, *A. interrupta*, *A. curvata*, *Botryllus planus*, *Botrylloides nigrum*, *Symplegma viride*, *Polyandrocarpa tincta*, *Polycarpa obtecta*, *Styela partita*, *S. plicata*, *Pyura vittata*, *Microcosmus exasperatus*, *Molgula occidentalis*.

Unfortunately so little collecting of ascidians has been done along the extreme southern Brazilian and Uruguayan coasts that we are not yet in a position to attempt a discussion of their fauna or of the character of the transition by which the tropical fauna is replaced by the cold-water species of the next following region.

The Subantarctic or Magellanic Region

The American part of this region, which is actually a circumpolar one, is commonly known as the "Magellanic." Its central area is the Strait of Magellan; in the broad sense in which it is taken in this work it comprises Tierra del Fuego and adjacent islands, also the Falkland Islands and South Georgia. The cold currents that flow northward along both coasts of South America take this fauna with them for very long distances; on the east throughout most of the Argentine coast to about 35° or 36° south latitude, and on the Chilean coast very much farther, to about 20° S., according to Hartmeyer (1909–1911), though no doubt with increasing admixture of northern species on the northern part of the coast.

A great many species of ascidians have been described from the Magellanic region, which was generally believed to have the most remarkable ascidian fauna in the world.

Unquestionably ascidians grow there in great abundance and luxuriance; they form large groups or clusters which are often broken loose in storms and washed up on the beaches. There are also certain species there that attain relatively gigantic size (for ascidians), but after a study of the literature and examination of considerable material I do not believe that the total number of valid Magellanic species is very great, or that those whose individuals attain very large size or which, if compound species, produce very bulky colonies, are actually numerous; many of the supposed species described differ in little else than that they were collected by expeditions sent out by different nationalities.

Characteristic and conspicuous species of the Magellanic region include *Amaroucium fuegiense*, *Holozoa cylindrica*, *Sycozoa gaimardi*, *S. sigillinoides*, *Didemnum studeri*, *Ascidia meridionalis*, *Corella eumyota*, *Polyzoa opuntia*, *Alloeocarpa incrustans*, *Cnemidocarpa verrucosa*, *Styela magalhaensis*, *Pyura legumen*, *Paramolgula gregaria*.

The Antarctic Region

Though a considerable number of species have been described from this region which, like the Subantarctic, is a circumpolar one, and some of the Subantarctic or Magellanic species have also been reported from it, its ascidian fauna is still rather unsatisfactorily known. Our information is based entirely on the collections made by a very few expeditions, and most of the species were described from material very limited in amount and often unsatisfactory in preservation.

The species that have been reported from that part of the Antarctic with which this work is concerned are briefly dealt with in its systematic part. Of the works dealing with the Antarctic ascidians, those of Sluiter (1906, 1914), Hartmeyer (1911b), and Ärnbäck (1938) may be especially mentioned.

The West Coast of South and Central America

This very extensive stretch of coastline is known to comprise two very distinct ascidian faunas: the part of the cold Magellanic region which extends north along most of the Chilean coast, though with some admixture of warmer-water forms in its northern[1] portion, and a subtropical and in part completely tropical region which extends from southern Ecuador to northern Mexico inclusive. How abrupt the change is at the northern limit of the Magellanic region (which Hartmeyer places at 20° south latitude) and to what extent there can be recognized a distinct temperate region with a fauna more or less its own between the Magellanic and the tropical one north of it, will require future investigation to determine. Up to the present too little collecting has been done to justify speculating upon it. The Juan Fernandez Islands in the latitude of Valparaiso (about 34° S.) apparently have a transitional ascidian fauna (see Hartmeyer, 1920a); the ascidians of the Galápagos Islands are as yet unknown. The ascidian fauna of the Gulf of California is decidedly tropical (see Ricketts and Calvin, 1939).

The Pacific Coast of the United States and Canada

Through the work of many authors, especially Ritter and Huntsman, we are pretty well informed regarding the species of the western United States and Canadian coasts. We also have some information about the species of the deeper waters off shore from dredgings made by the "Albatross," but it is, nevertheless, much more difficult to divide this coast into satisfactorily differentiated faunal regions than in the case of the American Atlantic coast. This is due to the fact that cold water prevails along the entire Pacific coast from the southern boundary of California northward, and ascidians characteristic of the latitude of British Columbia can find temperature conditions favorable to them at very moderate depths and close along the shore even as far south as the most southern part of California. Many of the species show in their geographical range great disregard of parallels of latitude and of the boundaries of faunal regions that we may attempt to define, ranging along vast stretches of the coast from north to south.

However, Point Conception on the southern California coast, in latitude about 34° 22′ N., divides off a southern California ascidian fauna from a northern California one, much as Cape Cod divides those of the New England coast, though not so effectively. The southern California ascidian fauna is very fully described by Ritter and Forsyth, 1917. The northern California fauna extends along the rest of the California coast and probably (though with some modification) to Cape Flattery, Washington. (See Ritter, 1907, p. 2; 1913, pp. 429–433.)

Amaroucium californicum, *Polyclinum planum*, *Eudistoma psammion*, *Distaplia occidentalis*, *Clavelina huntsmani*, *Euherdmania claviformis*, *Perophora annectens*, *Ciona intestinalis*, *Ascidia ceratodes*, *Metandrocarpa dura*, *Styela gibbsii*, *Styela montereyensis*, *Pyura haustor*, and *Boltenia villosa* are some of the widely distributed and conspicuous species on our west coast.

Botrylloides diegense and *Styela barnharti* are locally abundant on the southern part of the California coast.

The region of Vancouver Island, Puget Sound, and the rest of the British Columbia coast appears to constitute another faunal region though the distinctness of the separation is weakened by a number of overlapping species from the California coast. It seems doubtful whether any definite demarcation between the British Columbian fauna and the one which extends to, and includes, the southern coast of the Alaskan Peninsula can be demonstrated, though some species probably fail to extend the entire distance.

The Bering Sea Fauna

In Bering Sea, including the Pribilof and Aleutian Islands (we know very little about the ascidians of the Asiatic shores) the fauna must be regarded as an extension of the Arctic, though some species not known elsewhere (unless they range into Asiatic waters) have been described from it. The extreme northern part of Bering Sea, Bering Strait, and the coasts north of it both on the American and Siberian sides are purely Arctic in their fauna.

GENERAL INFORMATION ON ASCIDIANS AND ON CHARACTERS USED IN THEIR CLASSIFICATION

The ascidians are a group of exclusively marine animals which constitute a class (Ascidiacea) of the subphylum Tunicata, or Urochordata, of the phylum Chordata to which the vertebrates also belong. The reason for classifying them with the highest group of animals is not exhibited in their adult characters but in their development, as they pass through a larval stage bearing striking points of resemblance to the tadpoles of the frogs and salamanders in too many fundamental characters to be mere coincidence or to be explained in any other way than by true genetic relationship (see pp. 12, 13). The ascidians are a group which has evidently undergone retrograde instead of progressive evolution.

Many ascidians differ from their allies, the vertebrates, in possessing an additional method of reproduction besides the usual sexual one by means of eggs fertilized by spermatozoa; they reproduce also asexually by budding or gemmation; the new individuals thus produced usually remain united or attached together in a common mass known as a *colony*. Ascidians that bud are called *compound* or *colonial* ascidians; the individuals constituting a colony are called *zooids;* these individuals are commonly small, usually only a few millimeters to two or three centimeters in length, though the colonies may become large and massive.[1]

The Simple Ascidians

Ascidians that do not bud are called *simple* or *solitary* ascidians; the individuals become much larger and are the more generally familiar members of the class. They live buried in the mud or sand of the sea bottom or attached permanently to rocks, corals, shells, the piles of wharves, and other objects under water, and depend for food upon the minute organisms that the tides and currents carry to them. The typical simple ascidians are sac-like objects of oval or irregular form, usually from half an inch to two or three inches in diameter, rarely much more, and are covered with a more or less tough, though somewhat flexible, outer tunic called the *test*, which protects the delicate internal parts after the manner of a mollusk's shell. By the older naturalists the ascidians were, in fact, classed as soft-shelled mollusks. The test not only serves to protect the body from injuries, but also to fix it in place, for it becomes firmly attached to solid objects or, if the animal lies buried in the sand or mud of the sea bottom, it often develops hair-like or root-like extensions to anchor the body. The test of ascidians is peculiar in that it contains a substance closely resembling the cellulose which forms the fibrous and woody structures of plants. It entirely encloses the body except for two small openings, which are commonly situated at the tips of conical protuberances or short projecting tubes.

One of these is the mouth, also called the *branchial* (or *incurrent*) *siphon* or *aperture.* Through it enters a current of sea water bearing the minute organisms on which the creature feeds, as well as the oxygen utilized in respiration. The other, called the *atrial* (or *excurrent*) *siphon* or *aperture,* allows this water, as well as the waste products of the body, to pass out, and usually also serves for the exit of the eggs or young. The ascidians have very poorly developed organs of sense but, when the animal is touched or otherwise alarmed by any sudden movement of the water, its muscles contract, and the water contained in the body is forced out through these apertures in small jets, hence the name "sea squirts."

If an ascidian is cut open, we find inside the tough, thick test a much thinner sac-like membrane (in this article termed the *mantle*), composed of an external epithelium and connective tissue, muscles, and blood vessels, which encloses all the internal parts so that the body can be removed entire from the test. The mantle represents the real external body wall of the animal; the test is primarily a secretion of it, though cellular structures and blood vessels may grow out into it and multiply there so that it assumes the appearance of a true cellular tissue.

The body (enclosed by the mantle) is largely hollow and during life is usually distended with sea water, the internal organs occupying but a small part of the space enclosed. In most species the two tubes or siphons already mentioned above arise from the body rather near together. The end at or near which the mouth or branchial siphon is situated is, of course, the anterior end of the body; the excurrent or atrial siphon is on the dorsal aspect or back. If we carefully open the mantle, preferably by a longitudinal slit, it will be found that the interior is largely occupied by a third very delicate sac adher-

[1] For characters of compound ascidians, see page 13.

ent to the interior of the mantle at certain points only (especially along the mid-ventral line and about the base of the incurrent siphon in such a way that the mouth opens into the interior of the sac), but otherwise hanging loosely in the general cavity of the body. Examined with a lens, this innermost sac, the *branchial sac* or *gill sac*, will be seen in the gill sac which opens at its rear end into the oesophagus and thus into the stomach and intestine. These latter organs form a loop lying either beside the branchial sac or somewhat behind it.

In reality the branchial sac constitutes a greatly expanded and modified part of the alimentary canal, corresponding to the

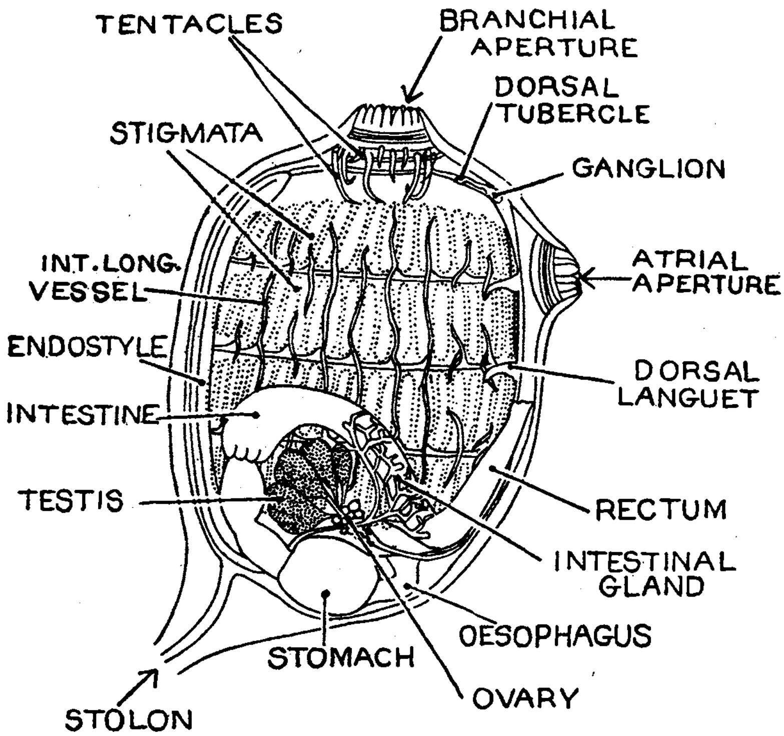

FIG. 1. An ascidian (*Perophora*) showing many of the principal internal structures used in the classification and descriptions.

to be perforated with a great number of rows of minute clefts or slits called *stigmata* whose margins bear cilia. These place its interior in communication with the *peribranchial cavity*, which surrounds it within the mantle and which is in communication with the excurrent siphon and through that with the exterior of the body.

The walls of the branchial or gill sac are pierced with such vast numbers of stigmata that it is, in fact, a net or sieve. It serves not only for respiration (its walls being full of blood vessels) but also for straining out the minute organisms which form the food supply of the ascidian. As the water taken in at the mouth passes through the stigmata, into the excurrent siphon, it leaves the food with- pharyngeal region of the vertebrates, that is, the part between the mouth and the oesophagus, and we may point out here the resemblance in the method of respiration to that which occurs in aquatic vertebrates, as fishes.

The fish also takes in the water through its mouth; the water passes into the cavity of the throat, or pharynx (corresponding to the gill sac of the ascidian), and from there it passes through the gill clefts in the sides of the pharynx (corresponding to the stigmata in the ascidian). In fishes the walls of these clefts bear the true gills or structures containing the blood vessels by which the oxygen in the water is absorbed, just as it is by the blood vessels in the walls of the gill sac of the ascidian. Even in their feeding, many fishes, for example the herrings, which live on minute swimming organisms, use a method similar to that of the ascidian, the gill apparatus straining the food from the water as it passes out through the gill clefts.

The possession of these characters by the ascidians might not be significant if we found them in other invertebrates, but among all the invertebrate animals of the land and sea, the above correspondence to the vertebrate type occurs only in the ascidians and a very few forms evidently closely related to them, so that its importance becomes obvious.

If we study only the adult ascidian, we shall note little else to suggest relationship to the vertebrates, and many things that seem to argue against it. One of these may be mentioned because of its strangeness. This is that the heart of the ascidians, which is tubular in form and situated in the posterior part of the body, after beating for a number of seconds in one direction, stops and reverses its action, so that the vessels which at one moment function as veins leading blood to the heart the next moment function as arteries carrying blood from the heart. Yet this remarkable process, which can be watched easily through the microscope in the case of some small and transparent species of ascidians, perhaps most easily in the genus *Perophora*, does not argue for relationship to the other invertebrates either, for it is almost unique.

As soon, however, as we study the life history of the ascidians, we come upon very strong evidence, first, that the ascidians are degenerate animals which have had ancestors more highly organized than themselves, and second, that these ancestors had the general type of structure that is possessed by the vertebrates, and by the vertebrates and other members of the phylum Chordata only. Each additional point of similarity makes it less probable that we are dealing with mere coincidences and confirms more strongly the conclusion that a real relationship exists, due to descent from common ancestors.

The Larvae of Ascidians

As in nearly all the other attached marine animals, the early larval stages of both simple and compound ascidians are almost always free swimming, for in order to make possible the continued existence of a species, not only its reproduction but its dispersal must be provided for.

In the ascidians the larvae have a form and appearance very similar to the larval stage or tadpole of the frog, though they are of comparatively minute size, the largest being only a few millimeters long. The larva of the ascidians possesses, just as does the tadpole of the frog, a cylindrical rod-like stiffening or supporting structure extending nearly the length of the body. This structure, called the notochord, represents in position and in function the backbone of the vertebrates. It is found in the early stages of development of all vertebrates, including man, and in the higher vertebrates the bony segments or vertebrae forming the backbone or spinal column develop around it. In many of the lower vertebrates it persists throughout life, running through the center or body of each vertebra. Here again we have a character not found among invertebrates, but common to the vertebrates and ascidians. Moreover, if we study the process of its development in the early stages of the embryo, we are forced to the conclusion that it is the same in these two groups.

Another important character common to the vertebrates and the ascidian larva is the possession of a central nervous system of elongate tubular form lying dorsal to the notochord. In the vertebrates this is called the spinal cord, and both in the ascidians and in the vertebrates it develops in the embryo in the same way, by a pair of folds growing up on each side of the middle line of the back to form a trough-like area. The edges of this trough soon arch inward and join together, thus forming a tubular passage which becomes the central canal of the spinal cord. Here again we find this character is not possessed by other invertebrates. In them the usual type of central nervous system is a pair of parallel nerve cords which are solid, not tubular, and which usually lie in the ventral part of the body, and not along the back or dorsal region as in the vertebrates.

The mode of respiration by means of gill clefts in the wall of the pharynx, the notochord that represents the first step toward the development of a backbone, the dorsally situated and tubular central nervous system or spinal cord—all separate the ascidian larva from invertebrates and indicate unmistakable relationship to the chordates.

These resemblances and a few other less striking and conclusive ones are for the most part recognizable only in the larva of the ascidian, being lost or obscured in the adult by degenerative changes that begin to take place after the larva permanently attaches itself. This it does after swimming about for a very short time, at most a few hours or a day or two. It fixes itself to some solid object by means of adhesive organs developed for that purpose on the front end of the body, and the tail is soon drawn in and absorbed. The notochord and most of the nervous system degenerate (the latter forming a small, dorsally situated ganglion), as do also the single eye and an organ supposed to serve either for hearing or for balancing the body. The animal grows in size and relapses into the almost mechanical and vegetative existence of the adult ascidian.

Some brief suggestions regarding obtaining ascidian larvae for examination or study will be found on pages 19, 20.

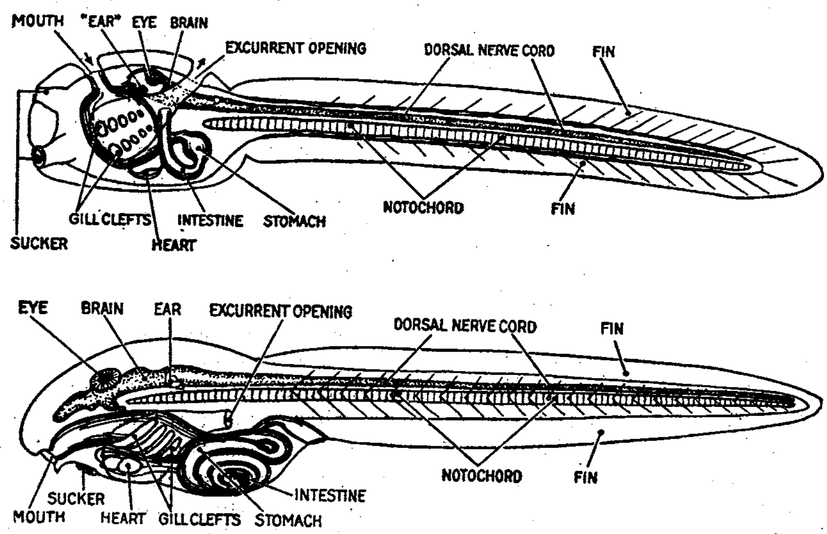

FIG. 2. Comparative diagrams of the tadpoles or larval stages of an ascidian (upper figure), and of a frog (lower figure), to show their correspondence in many points of structure, especially in having gill clefts in the walls of the pharnyx or throat, and a rod-like notochord corresponding to the backbone in the higher animals, above which is the main part of the nervous system, corresponding to the brain and spinal cord.

THE COMPOUND ASCIDIANS[1]

The division of ascidians into simple and compound forms does not, for the reasons stated below (p. 14), provide a basis for a phylogenetic classification but is often a matter of convenience, for most compound ascidians possess many characters in common that distinguish them from simple ascidians. There are exceptions to this; some compound forms resemble groups of small, simple ascidians, the individuals (zooids) being separate and connected only by vascular stolons, but the majority of compound forms have the zooids, which, as stated above, are usually very small, completely embedded in a common mass of test substance instead of each having its separate covering of test. The colony thus formed varies greatly in shape; it may be massive or divided into a few or into many lobes, or of flat incrusting form; it may comprise only a few or a great many hundreds of zooids.

The branchial apertures of the zooids all open separately on the surface of the colony; the atrial apertures may do so likewise, but

[1] For characters of simple ascidians, see page 10.

in the majority of species the latter apertures discharge into *common cloacal cavities* or *canals* in the test, and finally open on its surface by one or more larger apertures, the *common cloacal apertures*. The zooids discharging into the same cavity or the canals connected with it constitute a *system*.

In the compound ascidians the individuals are usually of more or less elongate form, and the body is (except in those of the order Stolidobranchia) marked off by constrictions into two or three segments. The anterior segment, called the *thorax*, bears the apertures and contains the branchial sac; the second, called the *abdomen*, contains the digestive and reproductive organs and the heart, or, in one large family (the Synoicidae), the digestive organs only, the reproductive organs and heart being in a third segment of the body known as the *post-abdomen*.

As would be expected from their much smaller size, the zooids, though conforming in type of structure to the larger solitary forms, show less complication in the details of their organs; the branchial sac has comparatively few stigmata and usually a very simple system of vessels; the gonads are of simpler form; the tentacles are fewer and never branched, etc. For illustrations of zooids, see for examples figures 10, 42, 64.

There is much diversity in the methods of budding in the different groups of compound ascidians, but this is a subject which cannot be discussed in the present work, though it is briefly alluded to in the systematic part. For a recent extensive work on the subject see Berrill, 1929–1936, part 4 (1935). Older authors held that the compound ascidians have been derived from simple ascidians by a decrease in the size and complexity of structure of the individuals and by the acquirement of the power of budding. All recent authors have, however, recognized the fact that some compound ascidians were more closely related to certain simple ones than to each other, and, to explain this, the assumption usually has been made that the power of budding has been independently acquired in two or more different groups of ascidians.

I freely admit that the diversity shown in the methods of budding in different families mentioned above lends support to such a view, but that theory involves what appear to be more insuperable difficulties. It is hard to imagine how an animal of apparently unquestionable relationship to the highest forms of animal life should suddenly acquire this extraordinary power, otherwise found only in the lower phyla. The advocates of such a theory must assume that the function has developed very rapidly if not suddenly. We have examples of closely allied ascidians distinguished by characters of no more than generic or even specific importance; one member of these pairs of allied forms, however, produces buds and forms colonies, the other does not. Such instances are afforded by the genera *Polycarpa* and *Polyandrocarpa* in the Styelidae, by *Rhopalaea* and *Rhopalopsis* in the Diazonidae, and by the close relationships between the Ascidiidae and Periphoridae. Such pairs of closely related simple and compound genera would indicate, according to the usually accepted theory, that the budding power has been very recently acquired, since no other important morphological differentiation has since taken place. Moreover, were the process gradual, one would expect it to begin with the development of incomplete non-functional buds, and it is difficult to see how any utility could insure the continued production of such buds (with progress toward perfection) until a complete functional individual could be produced. As a matter of fact, we know of no ascidians habitually producing such rudimentary or imperfect buds.

For these reasons I prefer the opposite view—that all ascidians originally had the power of budding inherited from very remote and primitive ancestors, and that the larger, simple ascidians have lost it. In conformity with this view I begin the treatment of the ascidians in the systematic part of this book not with the simple but with the compound forms.

Additional Notes on Anatomical Details

Certain anatomical parts of ascidians should be more particularly mentioned, as they are of importance in the classification of the animals or in distinguishing the species or higher groups, and are, therefore, very frequently referred to in the descriptions or shown in the illustrations:

Tentacles or Oral Tentacles: Flexible

processes extending into the interior of the branchial tube or siphon close to its base. They are usually of several sizes and may be (and in compound ascidians always are) simple slender processes, or the larger ones may be branched, sometimes in a very complex manner. (Some ascidians also have small, simple *atrial tentacles* in the excurrent siphon but, if not otherwise specified, the word tentacle refers to one of the oral tentacles.)

DORSAL TUBERCLE: A small, usually rounded prominence on the mid-dorsal line at the anterior end of the branchial sac on its inner surface, close to, but inside (posterior to), the circle of oral tentacles. It bears the aperture of a gland situated close to the nerve ganglion. This aperture may be a small rounded opening or an elongated but variously curved slit. One of the commonest forms of this slit is C-shaped, with one or both of the horns of the C strongly incurved or even spirally inrolled. The form of the slit is often regarded as a character of importance in distinguishing species, but its reliability has been much overrated, as in many species great individual variation in the form of the aperture is common. In compound ascidians it is almost always a simple pit-like opening.

BRANCHIAL SAC: This organ (which is in reality the enormously enlarged pharyngeal part of the alimentary canal) and its functions in respiration and collecting food have already been briefly described. The details of its structure furnish some of the best characters for the classification and identification of ascidians. In most of them the sac is built up of transverse and longitudinal bars bearing (we might almost say composed of) blood vessels of different sizes, crossing one another at right angles; the smallest longitudinal vessels separate the stigmata, which usually have the form of short longitudinal (anteroposterior) clefts. In a few groups a well-developed spiral arrangement of the stigmata occurs.

In one order (Stolidobranchia) the surface of the branchial sac is generally increased by a small number of pleat-like longitudinal folds of its wall. Such folds are usually definite and nearly constant in number in a given species. Whether such folds are present or not, many simple and a few compound ascidians have, in addition to the longitudinal blood vessels that take part in forming the wall of the branchial sac, a second system of longitudinal vessels, the *internal longitudinal vessels* lying upon, but usually slightly raised up from, the inner surface of the sac, with the transverse vessels of which they communicate by short connecting ducts. These vessels are much more numerous on the folds (if the latter are present) than on the flat parts of the sac between the folds. The midventral line of the branchial sac is occupied by a conspicuous structure termed the *endostyle*, consisting of two inwardly projecting parallel longitudinal ridges forming between them a broad and well-marked channel or furrow, the ciliated and mucus-secreting cells of which have an important function in collecting and dealing with the food material which has been strained out of the water by the branchial sac.

Opposite the endostyle on the mid-dorsal vessel of the branchial sac there is in many cases an inwardly projecting membrane, the dorsal lamina, which may have a serrate or toothed edge, or it may be replaced by a series of entirely separated, tongue-like processes (the *dorsal languets*), one arising at the origin of each pair of transverse vessels of the sac. (In many compound ascidians these languets, though present, are more or less displaced to the left of the median line.)

The ALIMENTARY TRACT proper begins at or near the posterior end of the branchial sac (though more strictly speaking the branchial sac should be included as the anterior segment of it) with a narrow oesophagus which opens into a stomach. The stomach may be short and rounded or elongate, and its walls may be smooth or plicated or pitted; in a few groups the external wall bears a glandular mass of tubules, the *hepatic gland* or *liver*, which discharges its secretion into the stomach. In many forms that have no liver a blindly ending curved pouch or *caecum* communicates with the cavity of the stomach. The intestine usually loops around so as to pass near or beside the stomach and then continues as a comparatively straight and more or less elongate *rectum*, which ends inside the body, but near the base of the atrial or excurrent siphon; through the latter undigested material is passed out of the body. There is also a peculiar "intestinal gland" consisting of some delicate tubules that embrace a section of the intestine some distance beyond the stomach. They join to form a common duct that runs to, and opens into, the alimentary canal at or near the pylorus or point where the intestine leaves the stomach. Its function is so little understood that no agreement has been reached even as to a satisfactory name for the organ. The heart is situated in the posterior part of the body (in many compound ascidians at the extreme posterior end). It is tubular, and is surrounded by a pericardium; the main blood vessels, which run to the branchial sac and other organs, and which, due to the peculiar alternating pulsations of the heart already mentioned (p. 12), function alternately as arteries and veins, extend from each end of the heart.

NERVOUS SYSTEM: The nervous system is poorly developed in adult ascidians, though in the larva an elongated dorsal nerve cord corresponding to the spinal cord in vertebrates is present. In the adult this degenerates into a small oval mass, the *cerebral ganglion*, which lies in the dorsal body wall between the bases of the siphons. The gland opening on the dorsal tubercle (see p. 15) lies in close contact with it, usually ventral to it, but dorsal to it in the order Stolidobranchia.

KIDNEY: In one large family (Molgulidae) there is on the right side of the body a large, closed, kidney-shaped sac in which waste matter is gradually deposited in the form of a hard concretion. This so-called kidney has no outlet, and the solid matter deposited in it must remain during the lifetime of the animal. In some members of the family Ascidiidae, there is, instead of one such "kidney," a multitude of minute vesicles containing concretions, but in most ascidians this waste material must in some way be eliminated, for no such concretions are to be found.

REPRODUCTIVE ORGANS: All ascidians reproduce sexually whether or not they do so by budding also. In many there is a seasonal alternation in the two methods. The reproductive organs, often called *gonads*, are varied in their structure and position and furnish some of the principal characters used in the classification of the ascidians. Their arrangement in the different species and higher groups is shown in the illustrations given and need not be described in detail here. Generally ascidians are hermaphroditic and, though sometimes the testes and ovaries are not both functional at the same time, in other cases fertilization of the eggs by spermatozoa from the same individual would seem to be the normal, if not the only possible, course of events.

In many ascidians the male and female glands, comprising several or many small testes and an ovary, are grouped together to form one or more hermaphroditic gonads or reproductive bodies, which are in such cases usually attached to the inner surface of the mantle on one or both sides of the body. The eggs are usually discharged into the peribranchial cavity (the space surrounding the branchial sac), and in some species, including most compound ones, they develop there into tadpole larvae before they make their way out by the atrial siphon. In the genus *Distaplia* and a few others, a large *incubatory pouch* or *sac*, in which the larvae undergo development, may be produced by an outgrowth or dilation of the body wall of the parent.

IDENTIFICATION OF SPECIMENS

In a work of this kind the first thing that is looked for is usually a system of keys by which a person with no knowledge of the group of animals under consideration may, by a mere process of elimination and without much expenditure of mental exertion, successfully determine the species of the specimen he has in hand.

There are some groups of animals for which keys can be made that really work in a considerable number of instances, but the ascidians are not among them. It would have been quite possible to have padded this work out with an imposing looking set of keys which would favorably impress and perhaps evoke commendation from reviewers who might casually inspect the work, provided they did not try to use any of the keys.

Owing to the soft contractile character of the parts and organs of ascidians and the consequent variation in their shape and appearance, it is hardly possible to make any statement about them that does not need qualifications and allowances for exceptions, which either introduce vagueness or make impossible the brevity and conciseness of language which is necessary in a key if we are to avoid uncertainty and confusion in the minds of those who try to use it. If exceptions are ignored in the key, it may throw the user entirely off the track.

I have, therefore, omitted formal keys from this work, but as a compromise have given brief synoptic tables of the chief characters of the genera in the larger families in hopes that, short and incomplete as these statements are, they may aid in directing the users of the book to the most probable genus of the specimens under consideration, suggesting the best place to look first, but not the only one to consider. To determine species within the genera, it is usually necessary in such animals as ascidians to consider the detailed descriptions and the illustrations, not forgetting that generic and family characters, even if not repeated under the species, nevertheless apply unless exceptions are indicated. For these reasons I do not attempt to give synoptic tables of the species within the genera, but the reader should not be appalled at the considerable number of species in some of the genera, for the majority of them can at once be eliminated as inhabiting other regions. In the general list of American species given below their distribution is indicated. Within each genus, Atlantic coast species are listed first, beginning at the north, then Magellanic and Antarctic, and lastly Pacific species.

The determination of specimens of ascidians is often a matter of considerable difficulty, and it may be well to call the attention of those who use this and other works on the subject to the great allowance which must frequently be made for individual peculiarities, different degrees of contraction incident to preservation, and the variations in the degree of transparency, color, and consistency of the tissues which depend on the physiological condition of the animal at the time of preservation, the strength and nature of the preserving fluids employed, and the presence of other material which may give off substances that discolor, shrink, or otherwise alter the tissues. In the simple ascidians, the number of certain internal parts as internal longitudinal vessels of the branchial sac, the component glands of the male reproductive organs, the number and complexity of branching of the tentacles, etc., vary, usually increasing with the age and size (or both) of the individual. But in this connection it must be remembered that size is influenced not only by age but also by environment and food supply, and that of two specimens the smaller one will often be the older and show more fully adult characteristics.

The shape of the body or colony and the character of its external surface are very liable to be affected by the environment, especially in those species which attach themselves in exposed situations, as on piles, rocks, etc. Other species, particularly those that bury themselves in the sand or mud, are more uniform in these respects, though the material in which they conceal themselves often affects the character and color of the test by adhering to it and becoming embedded in it.

With a series of specimens at hand it is usually possible to recognize the characters of the species and to distinguish them from the variations due to the above-mentioned extrinsic factors; with but a single specimen this may be very difficult. Among the compound ascidians especially, many examples, because of unsatisfactory preservation, immaturity, poor development, or the seasonal periods of degeneration and regression of the organs that many compound species undergo, or from being in a quiescent stage of growth, present scarcely any diagnostic characters, and their positive determination may be difficult or impossible unless they happen to be found with better specimens evidently of the same kind.

To word a description so as to cover all the numerous variations to which these soft-bodied animals are subject, both from internal and extrinsic factors, is manifestly impossible. Only the usual, well-developed, and normal can be described and illustrated, as otherwise the descriptions become too long and too indefinite, and the mention of accidental or occasional individual peculiarities obscures those of general occurrence and real importance.

In the simple ascidians the type of structure of the reproductive organs and branchial sac, with due allowance for possible immaturity or incomplete development and for individual variations in the number of vessels and component parts of those organs, will usually be found to give the safest indications in identifying specimens.

In the compound forms the general habit of growth and the characters of the colony as a whole must be considered as well as the zooids, and also the stage in the life history of the colony, for in some species the colonies pass through periods of degeneration in which many of the distinctive characters are lost or obscured. The practice of basing specific distinctions on the number of oral tentacles seems to be usually unwarranted; it is one of the characters most subject to variation with age and with the individual. Distinctions based on the form or stoutness of soft parts, such as the lobes of the branchial, atrial, and anal apertures, the dorsal and atrial languets, etc., which change shape with the degree of contraction of the tissues, appear to be practically worthless. In simple ascidians the dorsal tubercle is subject to much more individual variation than has commonly been assumed and is very unreliable as a specific character. No general rule can, however, be given; a certain character may be very constant and of diagnostic importance in one genus or family, yet in another it may be entirely unreliable. While it is hoped that the descriptions and figures here given will enable those with a little zoological knowledge to identify most of their specimens they must not expect to be able to do so without dissection and often also microscopical examination of some of their material, and (especially in the compound species) without some study of the subject.

Examination of Simple Ascidians

Unless the specimen is small and its test exceptionally transparent, it is necessary to remove the internal body (the mantle and its contained structures) from the test which encloses it. This is best done by opening the test by a longitudinal cut along the entire median ventral line with a pair of sharp pointed scissors. Continue the incision to near the base of each siphon but leave intact the dorsal part of the median line between and including the siphons. The two halves of the test may then be opened apart enough to take out the internal body which, especially in alcoholic specimens, is usually adherent to the inside of the test only on the two siphons, and can usually be detached without much trouble or injury to the structures in it.

Its examination is best carried out in alcohol in a shallow glass dish permitting study by either reflected or transmitted light. The mantle with the contained branchial sac should be cut open along the mid-ventral region, close alongside the endostyle (if the original cut through the test did not already do this) and the two sides of the body spread apart for study. Some specimens persistently refuse to stay spread open. Such perversity is best dealt with by cutting alongside the mid-dorsal line also, dividing the specimen into two entirely separate halves, but in doing this try to avoid damaging the tentacles, dorsal tubercle, and dorsal lamina by keeping the cut a little way to one side, leaving those structures in one of the halves of the body.

Examination of Compound Ascidians

For compound ascidians with numerous small, sometimes quite minute, individuals or zooids embedded in a mass of test, different methods are needed. Their identification is often a matter of some difficulty, and removal and microscopic examination of some of the zooids will usually be necessary. This is best carried out by clearing the zooids in concentrated glycerin and examining them in a few drops of that same fluid.

The best method of procedure is to tear up pieces of the colonies with a pair of sharp but stout needles in alcohol or diluted glycerin until many zooids have been released. In some species they easily come out entire; in others it takes time and trouble to get them out, and the thorax and abdomen are generally broken apart, if indeed they do not come out in a still more fragmentary condition. Then the only way is to dissect out and study plenty of them until one can get an idea of their structure and can piece together an entire zooid in one's mind or in a sketch or drawing. The difficulty of studying compound ascidians, unless the colony is in a condition of development and preservation to show the important structural details of the zooids, has already been alluded to.

Another method of study of these animals is by embedding pieces of the colonies and cutting serial sections, but this is laborious and time consuming, and cannot be done if the colonies contain siliceous sand grains. I have not found it so successful as the first-described method for determining the gross structure, but it is, of course, often necessary for histological, cytological, and embryological studies.

NOTES ON THE COLLECTION AND PRESERVATION OF ASCIDIANS

Tidal currents are favorable for ascidians, as these animals are dependent for food on what the waters bring them. Some species grow in abundance on the piles of wharves; others inhabit only deeper situations and must be dredged for. Turning over stones lying on the shore at or near low-water mark is one of the best ways to collect ascidians and other attached organisms, for, provided the stone is not too closely bedded on the bottom, examples of the smaller compound ascidians may be found adhering to its underside where fishes, crabs, and other enemies cannot get at them.

Many of the ascidians are very handsomely colored during life; though there is often so much variation in color in different individuals of the same species that in some genera little reliance can be placed on color as a diagnostic character. Specimens preserved in alcohol usually lose their color entirely. (For methods of preserving ascidians expanded, see Bull. 39, U. S. Natl. Mus., 1899, pt. M, pp. 39–40.)

A weak solution of formalin, not over 2 or 2½ per cent (one part of the commercial 40 per cent solution in 18 or 20 of water) will be found satisfactory for preserving ascidians and will in many cases preserve the colors for a time. Do not be misled by the common mistake of supposing that because weak formalin is good, strong formalin is better. Sea water may be used in making the solution.

Specimens that are to be kept for more than a couple of years should be transferred to alcohol. Seventy per cent is strong enough to preserve them permanently, and considerably less strength will suffice to keep specimens that have once been thoroughly saturated with alcohol or formalin of the above-mentioned strength. In the case of large massive specimens, several slits should be made in them to facilitate penetration of the preserving fluid; the latter should be used at first in some quantity and changed once or twice at intervals of a day or two to insure thorough saturation.

Fresh examples and formalin specimens will usually be more easily studied if hardened a little by previously transferring them to strong alcohol for a few days. Owing to their great variation in shape, color, and external appearance, it is generally necessary to examine the internal structure to make identification certain, although a few species are so characteristic in appearance that they are recognizable from their external features.

Larvae of Ascidians

Detailed consideration of the larval ascidian and its development does not come within the scope of this work, but some hints as to how ascidian larvae may be found by those who desire to see or study them may be useful.

In most simple or solitary ascidians larvae are rather difficult to obtain, because the species are usually strictly oviparous. The eggs are discharged into the water through the atrial tube or siphon while in a very early stage and undergo most of their development outside the parent's body.

There are, however, a number of viviparous simple ascidians that retain the developing eggs and larvae until they reach an advanced stage in the peribranchial cavity (that is, in the space between the mantle and gill sac, see above). In those species during the breeding season (usually during the warmer part of the year) eggs and larvae in various stages may often be found in large numbers and in a living condition in the body of adult specimens.

The following are some viviparous simple ascidians of the United States coasts in which larvae may often be found: *Corella willmeriana*, *Dendrodoa carnea*, *D. grossularia*, *Polycarpa fibrosa*, *Pyura haustor*, *Halocynthia pyriformis*, *Boltenia echinata*, *Molgula citrina*, *M. complanata*, *M. cooperi*, *M. verrucifera*.

The majority of, if not all, compound or colonial ascidians are viviparous; the larvae are retained in the peribranchial cavity, usually in the dorsal part of it near the atrial tube or opening, which part is called the *atrial cavity*, or in cavities in the common test; some have a special incubating pouch or sac for the larvae to develop in. It is, therefore, usually easy to obtain the larvae from colonies collected during the breeding season, which in many species is a prolonged one. If freshly collected colonies are torn up with needles in sea water, many larvae, some fully developed and able to swim around, will be released. In some species the larvae can, with proper methods and equipment, be kept alive and enabled to undergo further development. (See Grave, 1937; Berrill, 1937.)

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A work covering such a large field as this one must necessarily depend to a great extent on the published results of many different authors, and I wish to express my realization of my obligations to those who have taken part in accumulating the information presented in it, especially to those who have favored me with copies of their publications. In some cases credit is given, but there are also many whom I could not specifically mention.

This work has, however, been also largely based on the extensive collection of ascidians that has been gradually built up in the American Museum of Natural History, as well as on the examination of specimens in other museums, and in part by collecting that I have done myself on different parts of the American coasts aided by the hospitality and assistance received from various scientific institutions and from individual members of their staffs. This has enabled me to keep the work from being merely a compilation from, or condensation of, the published literature, and made it possible to supplement and evaluate the latter with new observations. Among the institutions and men to whom I am especially indebted I would mention the United States National Museum and especially the head of its Department of Biology, Dr. Waldo L. Schmitt, whose continued interest in this work during the long period of its preparation and his constant assistance in lending specimens, including new material as soon as it was secured by his museum, have contributed much to making it possible to clear up many doubtful and incorrectly understood points, particularly regarding the South American species. I also wish to express my thanks to Dr. Roy W. Miner, Curator Emeritus of the Department of Invertebrates of the American Museum of Natural History, for the opportunity to carry on the work, as well as for his interest and aid in its progress.

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LIST OF AMERICAN SPECIES

Abbreviations indicating their distribution: Ant., Antarctic; Arct., Arctic; B. C., British Columbia; Ber., Bermuda; Can., Canada; Carib., Caribbean; circ., circumpolar; d. w., deep water; e., eastern; E. H., Eastern Hemisphere; Fla., Florida; Magell., Magellanic region (including the Falkland Islands and South Georgia); Mass., Massachusetts; n., northern; N. A., North America; N. C., North Carolina; N. E., New England; O. W., Old World or Eastern Hemisphere; Pac., Pacific; s., south or southern; S. A., South America; S. C., South Carolina; trop., tropical; w. d., widely distributed; W. I., West Indian region.

A few species which appear to be based on too little material or for other reasons seem to be not too well established are designated with a dagger sign (†), though I have not felt justified in excluding them from the list.

Order **APLOUSOBRANCHIA** Lahille

Family **SYNOICIDAE** Hartmeyer, 1908

Genus *Aplidium* Savigny, 1816
- *A. lobatum* Savigny, 1816, Fla., W. I., O. W.
- †*A. effrenatum* (Herdman), 1886, off La Plata R., d. w.

Genus *Amaroucium* Milne Edwards, 1841
- *A. spitzbergense* (Hartmeyer), 1903, Arct. s. to n. N. E., O. W.
- *A. mutabile* Sars, 1851, Arct., Greenland, O. W.
- *A. glabrum* Verrill, 1871, Arct. s. to N. E., O. W.
- *A. pallidum* Verrill, 1871, Arct. s. to w. France and N. E.
- *A. stellatum* Verrill, 1871, Mass. to Fla.
- *A. pellucidum* (Leidy), 1855, Mass. to Fla.
- *A. constellatum* Verrill, 1871, New Hamp. to Fla.
- *A. bermudae* Van Name, 1902, N. C. to W. I.
- *A. exile* Van Name, 1902, Ber., Fla., W. I.
- †*A. funginum* (Sluiter), 1898, Tortuga Id., W. I.

Genus *Amaroucium* (cont.)
- *A. fuegiense* (Cunningham), 1871, Magell., Ant. circ.
- †*A. longicaudatum* Sluiter, 1912, W. Ant.
- *A. caeruleum* Sluiter, 1906, w. Ant., E. H.
- *A. radiatum* (Sluiter), 1906, w. Ant.
- *A. ordinatum* (Sluiter), 1906, w. Ant.
- *A. californicum* Ritter and Forsyth, 1917, Pac. coast of N. A.
- *A. solidum* Ritter and Forsyth, 1917, Calif.
- *A. propinquum*, new species, Calif.
- *A. arenatum*, new species, Calif.
- *A. spauldingi* (Ritter), 1907, Calif.
- *A. coei* Ritter, 1901, Alaska
- *A. translucidum* Ritter, 1901, Alaska
- †*A. dubium* Ritter, 1899, Bering Sea

Genus *Synoicum* Phipps, 1774
- *S. pulmonaria* (Ellis and Solander), 1786, Arct. s. to n. N. E., O. W.
- *S. molle* (Herdman), 1886, off La Plata R.
- *S. adareanum* (Herdman), 1902, w. Ant., South Georgia, E. H.
- †*S. triplex* (Sluiter), 1906, w. Ant.
- †*S. pererratum* (Sluiter), 1912, w. Ant.
- *S. par-fustis* (Ritter and Forsyth), 1917, Calif.
- *S. pellucidum* (Ritter and Forsyth), 1917, s. Calif.
- *S. irregulare* Ritter, 1899, Bering Sea
- *S. jordani* (Ritter), 1899, Bering Sea
- †*S. kincaidi* (Ritter), 1899, Bering Sea
- *S. cymosum* Redikorzev, 1927, Bering Sea, n. Asia

Genus *Aplidiopsis* Lahille, 1890
- †*A. pannosum* (Ritter), 1899, Alaska

Genus *Polyclinum* Savigny, 1816
- *P. constellatum* Savigny, 1816, Fla., trop., w. d.
- *P. laxum*, new species, trop. Pac. coast
- *P. planum* (Ritter and Forsyth), 1917, Calif.

Genus *Sigillinaria* Oka, 1933
- *S. pulchra* (Ritter), 1901, Calif. to Alaska
- *S. aequali-siphonis* (Ritter and Forsyth), 1917, Calif.

Genus *Pharyngodictyon* Herdman, 1886
- *Ph. reductum* Sluiter, 1906, w. Ant.

Genus *Euherdmania* Ritter, 1904
- *E. claviformis* (Ritter), 1903, Calif.

Family DIDEMNIDAE Verrill, 1871

Genus *Didemnum* Savigny, 1816
- *D. albidum* (Verrill), 1871, Arct. circ. s. to Mass.
- *D. albidum polare* (Hartmeyer), 1903, Arct.
- *D. candidum* Savigny, 1816, w. d. in warm regions
- *D. candidum lutarium* Van Name, 1910, e. U. S.
- †*D. candidum fusiferum* Van Name, 1921, w. Fla.
- *D. vanderhorsti* Van Name, 1924, trop. America
- *D. studeri* Hartmeyer, 1911, Magell., circ.
- *D. tenue* (Herdman), 1886, Magell. d. w.
- *D. biglans* (Sluiter), 1906, Ant. circ.
- †*D. chilense* Ärnbäck, 1929, Chile
- *D. santa-elenae*, new species, Ecuador
- *D. carnulentum* Ritter and Forsyth, 1917, Calif. to Panama
- *D.* (*Polysyncraton*) *amethysteum* (Van Name), 1902, Ber., Fla., W. I.

Genus *Leptoclinides* Bjerkan, 1905
- *L. faeröensis* Bjerkan, 1905, Arct. and n. Atlantic, O. W., abyssal
- †*L. brasiliensis* Michaelsen, 1923, off Brazil

Genus *Trididemnum* Della Valle, 1881
- *T. tenerum* (Verrill), 1871, Arct. circ. s. to Mass.
- *T. savignii* (Herdman), 1886, Ber., S. C. to W. I., O. W.
- †*T. solidum* (Van Name), 1902, Ber., W. I.
- *T. orbiculatum* (Van Name), 1902, Ber., W. I.
- *T. thetidis*, new species, Fla.
- *T. propinquum* (Herdman), 1886, Magell.
- *T. auriculatum* Michaelsen, 1919, Magell.
- *T. opacum* (Ritter), 1907, Pac. coast
- *T. strangulatum* (Ritter), 1901, S. Alaska

Genus *Coelocormus* Herdman, 1886
- *C. huxleyi* Herdman, 1886, off La Plata R., d. w.

Genus *Diplosoma* Macdonald, 1859
- *D. macdonaldi* Herdman, 1886, Ber., S. C. to Brazil, O. W.
- *D. longinquum* (Sluiter), 1912, w. Ant.
- *D. pizoni* Ritter and Forsyth, 1917, s. Calif.

Genus *Lissoclinum* Verrill, 1871
- *L. aureum* Verrill, 1871, Arct. s. to Mass., O. W.
- *L. wandeli* (Hartmeyer), 1924, Davis Strait, d. w.
- *L. fragile* (Van Name), 1902, Ber., Fla., W. I.
- *L. caulleryi* (Ritter and Forsyth), 1917, s. Calif., Juan Fernandez

Genus *Echinoclinum* Van Name, 1902
- *E. verrilli* Van Name, 1902, Ber., Fla.

Family POLYCITORIDAE Michaelsen, 1904

Genus *Eudistoma* Caullery, 1909
- *E. capsulatum* (Van Name), 1902, Ber., Virginia to W. I.
- *E. hepaticum* (Van Name), 1921, Fla., W. I.
- *E. olivaceum* (Van Name), 1902, Ber., Fla., W. I.
- *E. obscuratum* (Van Name), 1902, Ber., Fla., W. I.

Genus *Eudistoma* (cont.)
- *E. tarponense*, new species, w. Fla.
- *E. clarum* (Van Name), 1902, Ber. (Azores?)
- *E. carolinense*, new species, S. C. to Fla.
- *E. platense*, new species, near La Plata R.
- †*E. pachecae*, new species, Panama Bay
- *E. mexicanum*, new species, Gulf of Calif.
- *E. diaphanes* Ritter and Forsyth, 1917, Calif.
- *E. ritteri*, new species, Calif.
- *E. psammion* Ritter and Forsyth, 1917, Calif.
- *E. molle* (Ritter), 1900, Calif.

Genus *Archidistoma* Garstang, 1891
- *A. aggregatum* Garstang, 1891, N. C., O. W.

Genus *Polycitor* Renier, 1804
- *P. vitreus* (Sars), 1851, Arct. s. to Newfoundland, O. W.
- *P. magalhaensis* (Michaelsen), 1907, Magell.
- *P. glareosus* (Sluiter), 1906, Ant.

Genus *Cystodytes* von Drasche, 1884
- *C. dellechiajei* (Della Valle), 1877, Ber., Fla. to Brazil, Pac., O. W.
- *C. antarcticus* Sluiter, 1914, w. Ant.
- *C. lobatus* (Ritter), 1900, Calif. to B. C.

Genus *Clavelina* Savigny, 1816
- *C.* (*?*) *concrescens* Hartmeyer, 1924, Davis Strait, d. w.
- *C. oblonga* Herdman, 1880, Ber., Fla. to Brazil, (O. W.?)
- *C. picta* (Verrill), 1900, Ber., S. C. to Brazil
- *C. gigantea* Van Name, 1921, w. Fla.
- †*C. fasciculata*, new species, Gulf of Calif.
- *C. huntsmani* Van Name, 1931, Calif. to B. C.

Genus *Holozoa* Lesson, 1830
- *H. cylindrica* Lesson, 1830, Magell., Ant. circ.

Genus *Distaplia* Della Valle, 1881
- *D. clavata* (Sars), 1851, Arct. s. to Mass., O. W.
- *D. bermudensis* Van Name, 1902, Ber., N. C. to Fla., W. I.
- *D. stylifera* (Kowalevsky), 1874, S. C. to W. I., O. W.
- *D. colligans* Sluiter, 1932, South Georgia
- *D. occidentalis* Bancroft, 1899, w. d. on Pac. coast

Genus *Sycozoa* Lesson, 1830
- *S. gaimardi* (Herdman), 1886, Magell.
- *S. sigillinoides* Lesson, 1830, Magell., Ant. circ.
- *S. umbellata* (Michaelsen), 1898, Magell.
- †*S. georgiana* (Michaelsen), 1907, South Georgia

Order PHLEBOBRANCHIA Lahille

Family DIAZONIDAE Garstang, 1891

Genus *Diazona* Savigny, 1816
- †*D. geayi* Caullery, 1914, French Guiana
- *D. gigantea* (Sluiter), 1919, W. I.

Genus *Rhopalaea* Philippi, 1843
- *Rh. abdominalis* (Sluiter), 1898, Fla., W. I.

Genus *Tylobranchion* Herdman, 1886
- *T. antarcticum* Herdman, 1902, Ant.

FAMILY **CIONIDAE** LAHILLE, 1887

Genus *Ciona* Fleming, 1822
- *C. intestinalis* (Linnaeus), 1767, w. d. both American coasts, O. W.
- *C. intestinalis longissima* Hartmeyer, 1899, Arct., O. W.
- *C. intestinalis gelatinosa* Bonnevie, 1896, Arct., O. W.
- †*C. mollis* Ritter, 1907, Calif., abyssal

FAMILY **PEROPHORIDAE** GIARD, 1872

Genus *Perophora* Wiegmann, 1872
- *P. viridis* Verrill, 1871, Mass. to Fla., Ber., W. I. (O. W.?)
- *P. bermudensis* Berrill, 1932, Ber., Fla., W. I. (O. W.?)
- *P. annectens* Ritter, 1893, B. C. to s. Calif.

Genus *Ecteinascidia* Herdman, 1880
- *E. turbinata* Herdman, 1880, Ber., Fla., W. I. (O. W.?)
- *E. conklini* Berrill, 1932, Ber., Fla., W. I.
- *E. conklini minuta* Berrill, 1932, Fla., W. I.
- *E. tortugensis* Plough and Jones, 1939, Fla.

FAMILY **ASCIDIIDAE** HERDMAN, 1880

Genus *Ascidia* Linnaeus, 1767
- *A. prunum* O. F. Mueller, 1776, Arct. circ. s. to Mass. and B. C.
- *A. dijmphniana* (Traustedt), 1886, Arct., O. W., Baffin Bay
- *A. callosa* Stimpson, 1852, Arct. circ. s. to Mass. and Puget Sd.
- *A. obliqua* Alder, 1863, Arct. circ. s. to Mass.
- *A. interrupta* Heller, 1878, N. C. to Brazil
- *A. nigra* (Savigny), 1816, Ber., Fla. to Brazil, O. W., w. d.
- *A. curvata* (Traustedt), 1882, Ber., Fla., W. I.
- *A. corelloides* (Van Name), 1924, W. I.
- *A. sydneiensis* Stimpson, 1855, W. I., O. W., w. d.
- *A. sydneiensis protecta*, new subspecies, Gulf of Calif.
- *A. meridionalis* Herdman, 1880, Magell., ?E. H.
- *A. challengeri* Herdman, 1882, w. Ant., E. H.
- †*A. dispar* Ärnbäck, 1938, South Georgia
- *A. translucida* Herdman, 1880, South Georgia, E. H.
- *A. vermiformis* (Ritter), 1913, s. Calif.
- *A. ceratodes* (Huntsman), 1912, w. d. Pac. coast
- *A. clementea* Ritter, 1907, Calif., abyssal
- *A. paratropa* (Huntsman), 1912, Puget Sd. to Alaska
- †*A. unalaskensis* (Ritter), 1913, Bering Sea

FAMILY **AGNESIIDAE** HUNTSMAN, 1912

Genus *Agnesia* Michaelsen, 1898
- *A. glaciata* Michaelsen, 1898, Magell.
- *A. septentrionalis* Huntsman, 1912, Bering Sea to s. Calif.

Genus *Caenagnesia* Ärnbäck, 1938
- *C. bocki* Ärnbäck, 1938, w. Ant.

FAMILY **RHODOSOMATIDAE** HARTMEYER, 1908

Genus *Rhodosoma* Ehrenberg, 1855
- *Rh. turcicum* (Savigny), 1816, W. I., Calif., w. d. in E. H.

Genus *Chelyosoma* Broderip and Sowerby, 1830
- *Ch. macleayanum* Broderip and Sowerby, 1830, Arct. circ. s. to Mass.
- *Ch. productum* Stimpson, 1864, B. C. to s. Calif.
- *Ch. columbianum* Huntsman, 1912, B. C., n. Washington
- *Ch. inaequale* Redikorzev, 1913, Sea of Okhotsk, n. Alaska (d. w. off Pac. coast)

Genus *Corella* Alder and Hancock, 1870
- *C. borealis* Traustedt, 1886, Arct., off Mass. coast, O. W.
- *C. minuta* Traustedt, 1882, Fla., W. I.
- *C. eumyota* Traustedt, 1882, Magell., Ant. circ.
- *C. willmeriana* Herdman, 1898, B. C. to Puget Sd.

Genus *Corelloides* Oka, 1926
- *C. molle* Oka, 1926, Bering Sea

Genus *Corellopsis* Hartmeyer, 1903
- *C. pedunculata* Hartmeyer, 1903, Arct., O. W., Bering Sea

Genus *Corynascidia* Herdman, 1882
- *C. suhmi* Herdman, 1882, abyssal, w. d.
- *C. herdmani* Ritter, 1913, Bering Sea

Genus *Benthascidia* Ritter, 1907
- *B. michaelseni* Ritter, 1907, abyssal, off Calif.

FAMILY **HYPOBYTHIIDAE** SLUITER, 1895

Genus *Hypobythius* Moseley, 1879
- *H. moseleyi* Herdman, 1882, off La Plata R.

ORDER **STOLIDOBRANCHIA** LAHILLE

FAMILY **BOTRYLLIDAE** VERRILL, 1871

Genus *Botryllus* Gaertner, *in* Pallas, 1774
- *B. schlosseri* (Pallas), 1766, e. U. S., O. W.
- *B. planus* (Van Name), 1902, Ber., Fla., W. I.
- *B. primigenus* Oka, 1928, Florida, Japan
- *B. tuberatus* Ritter and Forsyth, 1917, s. Calif.

Genus *Botrylloides* Milne Edwards, 1841
- *B. aureum* Sars, 1851, Arct., s. to n. N. E., O. W.
- *B. nigrum* Herdman, 1886, Ber., Fla., W. I., w. d. O. W.
- *B. diegense* Ritter and Forsyth, 1917, s. Calif.
- †*B. magnum* (Ritter), 1901, Alaska

Family STYELIDAE Sluiter, 1895

Genus *Symplegma* Herdman, 1886
S. viride Herdman, 1886, Ber., N. C. to Fla., W. I., (O. W.?)
S. viride stolonica Berrill, 1932, Ber., Fla.
Genus *Kükenthalia* Hartmeyer, 1903
K. borealis (Gottschaldt), 1894, Arct., O. W.
Genus *Gynandrocarpa* Michaelsen, 1900
G. placenta (Herdman), 1886, O. W., Magell.
Genus *Polyzoa* Lesson, 1830
P. opuntia Lesson, 1830, Magell.
P. reticulata (Herdman), 1886, Magell., E. H.
P. translucida Ritter and Forsyth, 1917, s. Calif.
Genus *Alloeocarpa* Michaelsen, 1900
A. incrustans (Herdman), 1886, Magell.
A. bridgesi Michaelsen, 1900, Magell.
A. bacca Ärnbäck, 1929, s. Chile
Genus *Metandrocarpa* Michaelsen, 1904
M. dura (Ritter), 1896, Calif. to B. C.
M. taylori Huntsman, 1912, B. C.
M. michaelseni Ritter and Forsyth, 1917, Calif.
Genus *Polyandrocarpa* Michaelsen, 1904
P. maxima (Sluiter), 1904, Fla., Brazil, O. W.
P. zorritensis (Van Name), 1931, Peru
P. sabanillae Van Name, 1921, W. I.
†*P. pilella* Herdman, 1881, Brazil
P. (Eusynstyela) tincta (Van Name), 1902, Ber.. Fla., W. I. (O. W.?)
P. (E.) gravei Van Name, 1931, Fla.
P. (E.) floridana Van Name, 1921, Fla.
Genus *Polycarpa* Heller, 1877
P. fibrosa (Stimpson), 1852, Arct. s. to Mass., O. W.
P. albatrossi (Van Name), 1912, off e. U. S., abyssal
P. obtecta Traustedt, 1883, Ber., N. C. to Brazil
P. spongiabilis Traustedt, 1883, Fla., W. I., Brazil
P. circumarata (Sluiter), 1904, Fla., W. I. Philippines
P. aspera Herdman, 1886, d. w. off La Plata R.
Genus *Cnemidocarpa* Huntsman, 1913
C. mollis (Stimpson), 1852, Hudson Bay to N. Y., O. W.
C. rhizopus (Redikorzev), 1907, Arct. circ.
C. finmarkiensis (Kiaer), 1893, Arct. s. to Puget Sd., O. W.
C. mortenseni (Hartmeyer), 1912, Arct. d. w. s. to Mass., O. W.
†*C. annectens* (Hartmeyer), 1921, Greenland
C. ohlini (Michaelsen), 1898, Magell. Strait
C. drygalskii (Hartmeyer), 1911, Ant. circ., Pac.?
C. robinsoni Hartmeyer, 1916, Juan Fernandez
C. verrucosa (Lesson), 1830, Magell., Ant., E. H.
Genus *Dendrodoa* McLeay, 1824
D. aggregata (Rathke), 1806, Arct. circ., Bering Sea
D. pulchella (Verrill), 1871, Arct. circ. s. to e. Maine and n. Bering Sea
D. lineata (Traustedt), 1880, Greenland, Arct., O. W.
D. (Styelopsis) grossularia (Van Beneden), 1846, Arct. s. to n. Maine, O. W.
D. (S.) carnea (Agassiz), 1850, N. E.
Genus *Styela* Fleming, 1822
S. gelatinosa Traustedt, 1886, Arct., chiefly O. W.
S. coriacea (Alder and Hancock), 1848, Arct. circ. s. to Mass., and B. C.
S. coriacea hemicaespitosa Ritter, 1913, Pac. coast
S. rustica (Linnaeus), 1767, Arct. circ. s. to Newfoundland
S. rustica macrenteron Ritter, 1913, Bering Sea, Asiatic coast
S. partita (Stimpson), 1852, Mass. to Fla., Ber., W. I., O. W.
S. atlantica (Van Name), 1912, d. w. off e. U. S., off Norway
S. plicata (Lesueur), 1823, N. C. to Uruguay, O. W.
S. schmitti, new species, near La Plata R.
S. oblonga Herdman, 1881, d. w. off La Plata R.
S. glans Herdman, 1881, d. w. off La Plata R.
S. magalhaensis Michaelsen, 1898, Magell.
S. paessleri Michaelsen, 1898, Magell.
S. nordenskjöldi Michaelsen, 1898, Magell.
S. insinuosa (Sluiter), 1912, w. Ant.
S. grahami Sluiter, 1905, w. Ant.
S. serpentina (Sluiter), 1912, w. Ant.
S. tholiformis (Sluiter), 1912, d. w., w. Ant.
S. wandeli (Sluiter), 1911, w. Ant.
†*S. quidni* (Sluiter), 1912, w. Ant.
S. milleri Ritter, 1907, Pac., abyssal
S. barnharti Ritter and Forsyth, 1917, s. Calif.
S. montereyensis (Dall), 1872, B. C. to s. Calif.
S. gibbsii (Stimpson), 1864, B. C. to s. Calif.
S. truncata Ritter, 1901, s. Alaska to s. Calif.
S. clavata (Pallas), 1774, Bering Sea region
S. yakutatensis Ritter, 1901, s. Alaska, B. C.
Genus *Pelonaia* Goodsir and Forbes, 1841
P. corrugata Goodsir and Forbes, 1841, Arct. circ. s. to e. Can. (Mass.)

Family PYURIDAE Hartmeyer, 1908

Genus *Pyura* Molina, 1782
P. vittata (Stimpson), 1852, Ber., N. C. to W. I., O. W.
P. antillarum Van Name, 1921, d. w. W. I.
P. legumen (Lesson), 1830, Magell.
P. georgiana (Michaelsen), 1898, South Georgia (Argentine coast)

Genus *Pyura* (cont.)
P. paessleri (Michaelsen), 1900, Falkland Ids.
P. stubenrauchi (Michaelsen), 1900, Magell.
P. turqueti (Sluiter), 1905, w. Ant.
P. setosa (Sluiter), 1905, Ant. circ.
P. squamata Hartmeyer, 1911, Ant., E. H.
P. discoveryi (Herdman), 1910, Ant. circ.
P. obesa Sluiter, 1912, South Shetland Ids.
P. chilensis Molina, 1782, s. Peru, Chile
P. bradleyi Van Name, 1931, Ecuador, Peru
P. lignosa Michaelsen, 1908, w. Cent. Amer., Mexico
P. haustor (Stimpson), 1864, B. C. (s. Alaska) to s. Calif.
P. mirabilis (von Drasche), 1884, N. A. Pac. coast (Japan)

Genus *Herdmania* Lahille, 1887
H. momus (Savigny), 1816, W. I. to Brazil, O. W.

Genus *Microcosmus* Heller, 1878
M. glacialis (Sars), 1859, Arct. s. to Newfoundland, O. W.
M. exasperatus Heller, 1878, Ber., S. C. to Brazil, Hawaii, E. H.
M. helleri Herdman, 1881, W. I., O. W.

Genus *Boltenia* Savigny, 1816
B. ovifera (Linnaeus), 1767, w. Arct. s. to Mass. and Bering Sea
B. echinata (Linnaeus), 1767, Arct. circ. s. to N. E. and B. C.
B. villosa (Stimpson), 1864, s. Calif. to B. C.

Genus *Hartmeyeria* Ritter, 1913
H. triangularis Ritter, 1913, Aleutian Ids.

Genus *Halocynthia* Verrill, 1879
H. pyriformis (Rathke), 1806, Arct. s. to Mass., O. W.
H. aurantium (Pallas), 1787, Bering Sea to Puget Sd., and Japan
H. igaboja Oka, 1906, Calif. to B. C. (Japan)

Genus *Culeolus* Herdman, 1881
C. suhmi Herdman, 1881, N. Atlant., abyssal
C. pyramidalis Ritter, 1907, off Calif., abyssal
C. sluiteri Ritter, 1913, off Aleutian Ids., d. w.

Genus *Fungulus* Herdman, 1882
F. antarcticus Herdman, 1912, Ant., abyssal

Genus *Bathypera* Michaelsen, 1904
B. splendens Michaelsen, 1904, Ant., E. H.
B. ovoida (Ritter), 1907, off s. Calif., abyssal

Genus *Heterostigma* Ärnbäck, 1924
H. singulare (Van Name), 1912, s. N. E. littoral; (off Azores, abyssal?)

Family MOLGULIDAE Lacaze-Duthiers, 1877

Genus *Molgula* Forbes and Hanley, 1848
M. griffithsii (MacLeay), 1825, Arct. circ. s. to e. Can. (Mass.)

Genus *Molgula* (cont.)
M. siphonalis Sars, 1859, Arct. s. to n. N. E., O. W.
M. citrina Alder and Hancock, 1848, e. Can. s. to s. N. E., O. W.
M. complanata Alder and Hancock, 1870, Arct. s. to Mass., O. W.
M. manhattensis (DeKay), 1843, w. Maine to Louisiana, (O. W.?)
M. provisionalis, new species, New Brunswick, e. Maine, (O. W.?)
M. robusta (Van Name), 1912, s. Mass.
M. arenata Stimpson, 1852, s. Mass. to N. J.
M. verrilli (Van Name), 1912, off Mass., abyssal
M. lutulenta (Van Name), 1912, d. w. off e. U. S. and Cuba
M. occidentalis Traustedt, 1883, N. C. to W. I., Lower Calif.
M. habanensis, new species, off Havana, Cuba
M. contorta Sluiter, 1898, Goajira, Colombia
M. eugyroides Traustedt, 1883, Bahia, Brazil
M. platana, new species, near La Plata R.
M. pyriformis Herdman, 1881, d. w. off Buenos Aires
M. malvinensis Ärnbäck, 1938, Falkland Ids.
M. kophameli Michaelsen, 1900, Magell.
†*M. setigera* Ärnbäck, 1938, Falkland Ids.
M. pulchra Michaelsen, 1900, Magell., Ant., E. H.
M. pedunculata Herdman, 1881, Ant. circ.
M. bacca Herdman, 1910, w. Ant., E. H.
M. confluxa (Sluiter), 1912, w. Ant.
M. platei Hartmeyer, 1914, Chile
M. verrucifera Ritter and Forsyth, 1917, s. Calif.
M. regularis Ritter, 1907, s. Calif.
M. cooperi (Huntsman), 1912, B. C., Oregon
M. pugetiensis Herdman, 1898, B. C. and Puget Sd. (s. Calif.?, E. H.?)
M. pacifica (Huntsman), 1912, B. C.
M. oregonia Ritter, 1913, Oregon to Pribilof Ids.
M. (*Meristocarpus*) *retortiformis* Verrill, 1871, Arct. circ., s. to Mass. and s. Alaska
M. (*Molguloides*) *immunda* (Hartmeyer), 1909, off Chile, abyssal, E. H.

Genus *Ascopera* Herdman, 1881
A. gigantea Herdman, 1881, Magell., Ant. circ.

Genus *Rhizomolgula* Ritter, 1901
Rh. globularis (Pallas), 1776, Arct. circ. s. to Labrador, Bering Sea

Genus *Anomopera* Hartmeyer, 1923
A. ingolfiana Hartmeyer, 1923, Arct., abyssal

Genus *Paramolgula* Traustedt, 1885
P. gregaria (Lesson), 1830, Magell.

Genus *Pareugyrioides* Hartmeyer, 1914
P. dalli (Ritter), 1913, Alaska

Genus *Eugyra* Alder and Hancock, 1870
- *E. glutinans* (Moeller), 1842, Arct. circ. s. to Lower Calif.
- *E. pedunculata* Traustedt, 1886, Arct., O. W.
- *E. kerguelenensis* Herdman, 1881, Argentine coast, Kerguelen
- *E. arenosa californica*, new subspecies, s. Calif.

Genus *Bostrichobranchus* Traustedt, 1883
- *B. pilularis* (Verrill), 1871, E. Can. to Fla.

Genus *Hexacrobylus* Sluiter, 1905
- *H. arcticus* Hartmeyer, 1923, Arct., O. W.

Summary

Total number of species	309
Additional well-marked subspecies	10
Genera represented	73
Families represented	14

A few additional supposed species too imperfectly described to be placed are not included in the above figures (see pp. 443–446.

DESCRIPTIONS OF SPECIES

THE STATEMENTS made under the genera as well as under the species should both be taken into consideration, as limitations of space have often prevented mentioning under each species characters of general occurrence in most or all the members of the group.

"Regularity" in the distribution of tentacles or transverse branchial vessels of different sizes implies that they are arranged according to size as follows: 1-3-2-3-1-3-etc. (when of three sizes or orders) or 1-4-3-4-2-4-3-4-1-4-3-4-etc. (when of four sizes or orders). The degree of regularity is subject to much individual variation and is not so important as a taxonomic character, as some have supposed.

In giving numerical schemes of the distribution of the internal longitudinal vessels of the branchial sac the numbers indicating vessels borne on the folds are enclosed in parentheses, beginning with the most dorsal fold; those borne on the flat parts of the sac are not so enclosed.

EXPLANATION OF LETTERING ON ILLUSTRATIONS

at, atrial orifice
br, branchial orifice
ccl, common cloacal aperture
dl, dorsal lamina
ecp, endocarp
em, embryo
en, endostyle
g, gonad
gc, gastric caecum
ilv, internal longitudinal vessel
in, intestine
ing, intestinal gland
k, kidney
l, liver
lg, languet
lv, larva
mdv, median dorsal vessel
mp, muscular process
ng, nerve ganglion
od, oviduct
oe, oesophagus
ov, ovum
r, rectum
sd, sperm duct
st, stomach
trv, transverse vessel
vp, vascular process

ORDER **APLOUSOBRANCHIA** LAHILLE

(=Krikobranchia Seeliger)

Compound ascidians having the body divided into two or three parts or segments (thorax, abdomen, and sometimes post-abdomen), the digestive tract, reproductive organs, and heart being situated in the posterior part or parts. Tentacles simple, branchial sac without folds or internal longitudinal vessels. Dorsal lamina represented by languets arising usually a little to the left of the median dorsal vessel on the transverse vessels.

Though judging entirely by the adult zooids, this seems to be a homogeneous group; important differences in the budding in the families composing it indicate that the resemblances are in part due to convergence.

FAMILIES OF APLOUSOBRANCHIA

A. Body of zooid elongate, in three divisions, gonads and heart in posterior division (post-abdomen). Budding by segmentation of post-abdomen . . . . Synoicidae
  B. Body of zooids in two divisions, alimentary loop, gonads, and heart, all in posterior division.
    C_1. Colony incrusting, minute stellate spicules usually present in test, zooids very small; never more than three or four rows of stigmata; budding of pyloric type (see p. 79). Didemnidae
    C_2. Colony lobed or massive, zooids when large often more or less independent. No stellate spicules (disk-like spicules in one genus). Budding by segmentation of body or from stolons . . . . Polycitoridae

FAMILY **SYNOICIDAE** HARTMEYER, 1908

(=Polyclinidae auct. mult.)

Body of adult zooids consisting of three divisions or segments, the last (post-abdomen) containing the reproductive organs and heart. A post-abdomen occurs in a few other compound ascidians, but only in this family does it contain the heart. Budding by transverse segmentation of the post-abdomen, the segments developing into new zooids.

In most members of this family the branchial orifice has six lobes, and the atrial orifice commonly has a small languet. The branchial sac is usually long and often has rather numerous rows of stigmata.

GENERA OF SYNOICIDAE

A_1. Adult zooids elongate, post-abdomen in more or less direct continuation of thorax and abdomen. Zooids probably always arranged in systems.

- B_1. Stomach wall usually with well-marked longitudinal plications sometimes irregular or obsolete in part of the stomach.
  - C_1. Post-abdomen rather short, the testes in irregular group . . . *Aplidium*
  - C_2. Post-abdomen (in adults) elongate, ually with serially arranged testes.
    - D_1. Atrial aperture not produced, usually well forward with a small, sometimes three-cleft languet . . . . *Amaroucium*
    - D_2. Both apertures six-lobed on forwardly directed tubes . . . . *Sigillinaria*
- B_2. Stomach wall with rounded areolations (not in longitudinal rows) which are often obsolete so that the wall is smooth. Atrial aperture usually slightly produced, its anterior lip often three-parted . . . . *Synoicum*

A_2. Post-abdomen sac-like, connected with abdomen by a slender neck.

- B_1. Post-abdomen elongate; transverse vessels of sac smooth . . . . *Aplidiopsis*
- B_2. Post-abdomen ovate, sac-like; branchial sac large with minute papillae on its transverse vessels (unique in this order). Atrial languet large. . . . *Polyclinium*

A_3. Zooids cylindrical, independent, connected by basal stolons . . . . *Euherdmania*

A_4. Imperfectly known abyssal genus (see p. 75) . . . . *Pharyngodictyon*

GENUS **APLIDIUM** SAVIGNY, 1816

As established by Savigny, 1816, this was a comprehensive group, including, besides *Aplidium* as ordinarily employed, also the large number of species now included in *Amaroucium* Milne Edwards, 1841. These two genera are not well distinguished.

As commonly used now, *Aplidium* is restricted to species having the colony generally sessile by a broad base; rather stout zooids with few rows of stigmata and a comparatively short post-abdomen; the stomach wall with a few deep folds extending throughout its length; and the atrial aperture placed well back on the dorsal side of the body. This aperture may or may not be provided with a languet. In reality there are intermediate forms that may be assigned to either genus, as far as such characters are concerned.

Michaelsen (1919a, p. 90) has pointed out another distinguishing character: that, as in the species *A. lobatum* (see below), the testes are grouped in a compact mass about the end of the common sperm duct instead of being distributed in one or two series along its sides as in *Amaroucium*. This seems to be a well-marked character, at least in that species.

Aplidium lobatum Savigny, 1816

Text figure 3

Aplidium africanum SLUITER, 1905a, p. 17, pl. 2, fig. 9.

Aplidium lobatum SAVIGNY, 1816, p. 182, pl. 3, fig. 4, pl. 16, fig. 1; MICHAELSEN, 1920, p. 22, pl. 1, figs. 11, 12; VAN NAME, 1921, p. 303, fig. 3; 1930, p. 425, fig. 4; HUUS, 1937, p. 666, fig. 571; PLOUGH AND JONES, 1937, p. 100.

Aplidium tremulum SAVIGNY, 1816, p. 184, pl. 16, fig. 2; SLUITER, 1909, p. 99.

The following description was prepared from West Indian specimens which I regard as belonging to this species.

The colony is apparently normally of a rather thick incrusting type with rounded edges. The borders and surfaces show a tendency to be raised into low rounded elevations at many points or produced into more or less distinct rounded lobes. Greatest diameter of largest West Indian colony, about 75 mm.; average thickness, where covering an even surface, probably not much over 3 mm. Zooids arranged in elongate groups and rows; the limits of the systems are hard to determine, but in large colonies, at least, they appear to be quite extensive and more or less branched. The branchial orifices may or may not be slightly prominent on the surface; the common cloacal apertures are ordinarily inconspicuous in the preserved material. The test itself is rather transparent and nearly colorless or somewhat yellowish, but the colonies are rather opaque from the considerable quantities of sand which are present all through the test, and assume more or less the color of the sand.

Zooids small and short; in the contracted condition found in preserved material not usually over 2 to 3 mm. in total length, or even less when the body is bent or distorted. Thorax short, separated by a constriction from the rest of the body, post-abdomen short and wide even when the reproductive organs are well developed; it is often curved or bent ventrally.

Branchial aperture with six bifid lobes. Atrial aperture on the dorsal side of the thorax; less prominently lobed than the branchial aperture. Close in front of it is a small languet cleft into three pointed lobes.

Mantle musculature consisting mainly of the sphincters of the apertures and a few narrow longitudinal bands on the thorax. Tentacles well developed, apparently 16 in number of three sizes regularly arranged. Dorsal languets on the transverse vessels of the left side a little way from the median dorsal vessel. About seven rows of stigmata (fairly long and narrow when the sac is expanded) with about 13 to 15 in a row on each side. The number of rows of stigmata is variable. Michaelsen, 1920, found usually nine (Savigny in his figure of the doubtless identical *A. tremulum* indicates 11). The atrial languet may have from one to three or (perhaps abnormally) even four lobes.

Stomach wall with five very deep furrows and the same number of very thick prominent longitudinal ridges.

Ovaries were not found in the zooids that I have examined. The male glands are rounded or pyriform, rather few (15 to 30) in number and form a compact, more or less rounded cluster which largely fills the wide, short post-abdomen. The main sperm duct has its origin in the midst of the cluster, curves dorsally, and runs along the dorsal aspect of the post-abdomen and abdomen. The small ducts from the testes mostly join it at or near its end; a few of them, however, do so at points farther along its length as in *Amaroucium*, at least in some zooids. These branch ducts are in some cases formed by the union of those from two or more testes.

My observations are limited to a few colonies, but as far as they go they bear out the opinion expressed by Michaelsen (1920, pp. 26, 27) that the zooids are either male or female. All those in one colony are often of one sex, but this is not always the case.

DISTRIBUTION: *Aplidium lobatum* was described by Savigny from the Gulf of Suez (first mentioned and, therefore, the type lo-

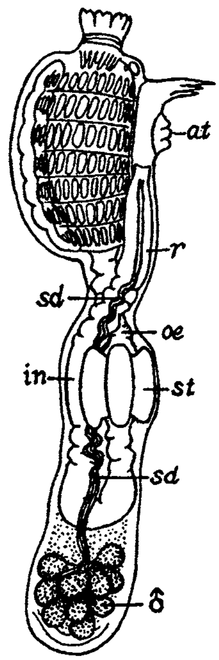


FIG. 3. *Aplidium lobatum* Savigny. Zooid, ×32.

cality) and the Mediterranean coast of Egypt. It ranges through the Red Sea (Gulf of Tadjourah, Sluiter, 1905) and, though with some doubt, to the Malay Archipelago (Sluiter, 1909).

In American waters it has been found at St. Thomas, West Indies, and in the vicinity of Guanica Harbor, Puerto Rico; also at Tortugas, Florida (Plough and Jones). Colonies collected at St. Thomas by the United States steamer "Albatross" in January and at Puerto Rico in June by an American Museum expedition have the male reproductive organs well developed in most of their zooids. The specimens were all obtained by dredging, the depths when given are 5 fathoms and 160 feet (about 27 fathoms).

Aplidium effrenatum (Herdman), 1886

Aplidium effrenatum HARTMEYER, 1909–1911, p. 1471.

Psammaplidium effrenatum HERDMAN, 1886, p. 241, pl. 32, figs. 6, 7.

Colony an uneven incrusting mass of large size, 7.5 by 4 cm. and 8 mm. thick, attached by an extended base. Color dark brown. Test with much embedded sand; no bladder cells present.

Zooids of small size, about 2.5 mm. in length, visibly arranged in systems in some places. Post-abdomen distinctly marked off from anterior part of body.

Mantle fairly muscular, with longitudinal bands, branchial aperture six-lobed, atrial without lobes or languet, some distance removed on the dorsal aspect of the thorax. Stomach globular with wall slightly folded longitudinally.

LOCALITY: "Challenger" Station 320, off mouth of La Plata River, 37° 17′ S., 53° 52′ W., 600 fathoms. Two colonies collected.

GENUS **AMAROUCIUM** MILNE EDWARDS, 1841

This genus is universally adopted in all works on ascidians, though it hardly merits recognition as anything more than a rather indefinitely distinguished subgenus or section of *Aplidium* Savigny. It includes species which have the colony usually of massive or capitate form (or often composed of heads or lobes joined at the base); rather large zooids with an elongate branchial sac and many (usually 10 to 18 at least) rows of stigmata; the atrial orifice on, or close to, the anterior end of the thorax, and the post-abdomen (which is not borne on a stalk) very long when fully developed, with the testes serially arranged along the common sperm duct. The wall of the stomach is commonly distinctly longitudinally plicated; an atrial languet is usually present. Some species are intermediate in character and might be placed either in *Aplidium* or *Amaroucium*.

The species of *Amaroucium* are numerous and occur in all regions but are so variable with age, season, environment, physiological condition, etc., both in respect to the characters of the colonies and of their zooids, that they are in many cases difficult to define and distinguish. Those of the northeastern United States coasts and eastern Canadian provinces, and the Arctic regions are now pretty well known, but more facts are needed regarding those of other parts of the coasts of the Americas, as, for instance, those of the southeastern United States. It seems unlikely that we can attain a satisfactory knowledge of the species of this group until their larvae and life histories have been studied, as was done by Grave, 1922, in the case of two well-known and closely allied species of the New England region, *A. pellucidum* and *A. constellatum* (see below). Meanwhile, the treatment of many of the species must remain a provisional one subject to future revision.

Amaroucium spitzbergense (Hartmeyer), 1903

Amaroucium sarsi BJERKAN, 1908a, pp. 91, 115, figs. 6, 7.

Amaroucium spitzbergense HARTMEYER, 1924, p. 208.

Aplidium spitzbergense HARTMEYER, 1903, p. 341, pl. 6, fig. 14, pl. 13, fig. 17; HUNTSMAN, 1912, pp. 112, 137; HARTMEYER, 1912c, p. 283; 1922a, p. 28.

The colony is apparently always of rather small size and is of rounded form, either sessile or raised on a short thick stalk. Occasional examples may be termed club shaped. The largest colony on record, according to Hartmeyer, 1924, measures 28 by 22 by 11 mm.

The test substance is more or less transparent, though it may contain some sand both on the surface and in the interior. The color, said to be that of living specimens also, is greenish, gray, or a grayish white, permitting the yellowish zooids to be seen.

The zooids are small, according to Hartmeyer not usually over 2.5 mm. to 5 mm. long, though Bjerkan gives 8 mm. as the maximum. They exhibit the usual characters of the genus, having a short, conical, atrial siphon with an atrial languet of simple form, which is usually fairly long.

The easiest way to recognize this species is by the presence of only four rows of stigmata (Bjerkan says five rows also occur). Such a small number is, as far as I know, unique in the family. The stomach has four or five well-marked longitudinal ridges in the wall.

The post-abdomen is comparatively short; the testes, though not numerous, form a longitudinal series along the sperm duct.

DISTRIBUTION: This is a rare species of the arctic and boreal waters of both hemispheres. Hartmeyer (1924) reported it from off southwest Greenland, 65° 34′ N., 54° 31′ W., 122 meters, and from Angmagsalik, southeast Greenland, 18 to 45 meters; Huntsman (1912) obtained it in the vicinity of Grand Manan Island, Bay of Fundy, in 8 and 35 fathoms; most southern record, off Gloucester, Massachusetts, 42° 33′ N., 70° 25′ W., 84 fathoms (A.M.N.H). The few existing Old World records include Iceland, Spitzbergen and Jan Mayen, west Finmark, and the west coast of Norway, and range down to about 100 meters in depth. It is found attached to stones, shells, etc.

Amaroucium mutabile Sars, 1851

Amaroucium mutabile SARS, 1851, p. 155; 1859, p. 66; HUITFELD-KAAS, 1896, p. 17, pl. 2, figs. 17–19; HARTMEYER, 1903, p. 330, figs. 43–45, pl. 6, fig. 7, pl. 13, figs. 13–15; BJERKAN, 1908a, pp. 89, 115, fig. 5; HARTMEYER, 1921a, p. 95; 1922a, p. 27; 1924, p. 203.

For other references, see Hartmeyer, 1924.

This colony in this species may be rounded, hemispherical, or more or less depressed and attached by a wide base; in other cases it is of somewhat capitate form. Under favorable conditions the colonies attain quite a large size, diameters of 40 to 55 mm. or even more being reported from some localities.

The surface of the colony is smooth or more or less incrusted with sand; the systems are hard to distinguish in most preserved specimens; both small round or oval systems and elongate ones of irregular form may sometimes be demonstrated. The color is said to be yellowish gray or ocher yellow in life; it often becomes reddish or reddish violet in preserved material.

The zooids are slender and may be over 20 mm. long in large colonies, but a large part of their length is due to the long narrow postabdomen. A three-lobed atrial languet is present. The rows of stigmata are few, varying from seven to 11 or rarely 12.

The stomach affords the easiest means for recognizing the species. There are only four (less often five) deep longitudinal furrows and the same number of broad longitudinal ridges, giving that organ, when four plications are present, a cross-shaped transverse section.

DISTRIBUTION: The Arctic and adjacent regions from Franz Josef Land and Barents Sea to Iceland are the chief range of this species. It is reported by Hartmeyer from various stations about Greenland and Davis Strait, in depths from 79 to 315 meters (30 to nearly 500 meters in other regions). Two small specimens were collected by R. A. Bartlett in the Fox Basin, in 66° 43′ N., 80° 07′ W., 32 to 37 fathoms and in 66° 30′ N., 80° W., respectively (A.M.N.H).

Amaroucium glabrum Verrill, 1871

Plate 1, figure 5; text figure 4

Amaroecium glabrum VERRILL, 1873–1874, vol. 7, pp. 39, 40, etc.; 1874, pp. 352, 355, etc.; 1874a, pp. 59, 60; STAFFORD, 1912, p. 64.

Amaroucium glabrum HERDMAN, 1891, p. 628; KINGSLEY, 1901, p. 183; WHITEAVES, 1901, p. 266; VAN NAME, 1910, p. 410, fig. 24, pl. 35, fig. 2, HUNTSMAN, 1912, pp. 112, 138; SUMNER, OSBURN, AND COLE, 1913, pp. 159, 733; HARTMEYER, 1921a, p. 96; 1924, p. 195; PRATT, 1935, p. 743.

Amaroucium translucidum (in part, not specimens from Alaska) HARTMEYER, 1903, p. 326, figs. 40–42, pl. 6, figs. 8–9, pl. 13, fig. 10; REDIKORZEV, 1906, pp. 308–310; 1907, p. 149; 1908a, p. 47; 1910, p. 165, fig. 48. Not Ritter, 1901; not Van Name, 1910, p. 411.

Amoroecium glabrum VERRILL, 1879, p. 27.

Amouroecium glabrum WHITEAVES, 1873, p. 17; 1874, p. 12.

Amouroucium glabrum VERRILL, 1871, p. 288 (orig. descr.), figs. 20–22; 1872a, p. 212; WHITEAVES, 1872, p. 348.

Aplidium flavum HUITFELD-KAAS, 1896, p. 16; BJERKAN, 1908a, p. 96, fig. 8; HARTMEYER, 1903, p. 344, pl. 14, figs. 7, 8; REDIKORZEV, 1906, pp. 308–310.

Circinalium pachydermatinum JACOBSOHN, 1892, pp. 158, etc.

For complete references to 1923, see Hartmeyer, 1924.

"Ordinarily, colonies of *Amaroucium glabrum* form rounded or more or less flat-topped heads, 10 to 20 mm. in height, usually with rather abrupt sides which contract to a narrow base or short peduncle. A colony may consist of but one or several such heads, which when small generally consist of a single system containing rather few irregularly placed zooids surrounding a single cloacal aperture. Larger and broader heads may contain several systems, though in preserved specimens their number and limits are rarely discernible. The amount of common test substance as compared with the bulk and number of the zooids is generally large, so that the zooids are commonly well separated from each other and from the margin of the colony.

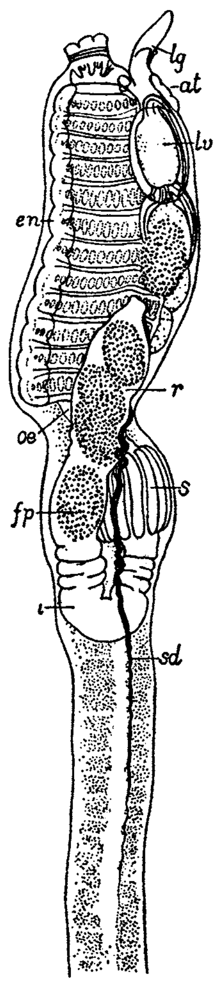


FIG. 4. *Amaroucium glabrum* Verrill. Zooid with larvae in atrial cavity, ×27.

The tendency to irregularity and individual variation in the shape of the colony is considerable, but nearly all the shapes are readily recognized as modifications of the capitate form above described" (Van Name, 1910, pp. 411–412).

Among many colonies dredged by Verrill and the United States Fish Commission, there are some of unusual size, consisting of one or more turbinate lobes similar to those of *A. constellatum*, and several of these may be aggregated or even completely fused into a hemispherical or flattened mass, sometimes 80 mm. in diameter, attached by a more or less narrowed base. Such colonies are formed only under conditions unusually favorable for their growth. In most localities only small capitate or cushion-shaped colonies are to be found.

The test is moderately firm in consistency, and in specimens growing in clear water in the New England region is usually of a pale translucent bluish or grayish color, allowing the zooids to be distinctly seen. In preservation it becomes less transparent, milky white, or more or less yellowish or brownish; rarely it is tinged with reddish. The upper part of the surface of the colonies is usually smooth and glossy; the basal part is generally incrusted with sand.

The zooids in the great majority of preserved specimens are found greatly contracted and distorted due to the strong longitudinal muscle bands of the mantle (especially on the thorax), making the study of them difficult. In zooids thus contracted, the usual length ranged from 4 or 5 mm. to 6 mm. according to the development of the post-abdomen. In life the zooids are in part yellowish with the stomach deep orange in color.

In their structural details the zooids resemble those of *A. constellatum* (see below) so closely that it will be better to point out the few points of difference to avoid repetition.

In this species, however, the atrial languet has a pair of lateral lobes arising at its base on each side. These may, in rare cases, be nearly as long as the main or central lobe, making a trident-like languet, or they may be reduced to short blunt projections, or be in some cases rudimentary or wanting entirely. The atrial opening itself may be plain or obscurely lobed.

The rows of stigmata appear to be 10 to 12 in number, but most specimens are too much contracted to make accurate counts possible. The number in a row appears to be about 16 to 18.

The folds in the stomach wall are generally well defined and regular, extending the whole length of the stomach, and average fewer than in *A. constellatum*. In most colonies they form from 12 to 15 ridges, in other colonies the average may be higher, and in the latter case occasional irregularities in the folds may occur but usually involve only a small part of the wall of the stomach.

DISTRIBUTION: Partially circumpolar in the Arctic and northern regions, though I do not include Ritter's *A. translucidum* from Alaska in this species. (See the remarks on that species.) *A. glabrum* is known from Greenland, Iceland, Spitzbergen, the White Sea, and the Siberian Arctic Ocean. On the east coast of North America it extends farther south than elsewhere and is the most common representative of the family in the Bay of Fundy, and on the banks off the northern New England coast. South of Cape Cod it is much less common and more local and is found exclusively in the colder and deeper waters. On and near Crab Ledge, off Chatham, Massachusetts, at the southeastern angle of Cape Cod, it may be found in considerable abundance in 15 to 50 fathoms, but south or west of that point it virtually disappears, and the few colonies found are small and poor, though it has been taken on the Southwest Ledge, 11 miles southwest of Martha's Vineyard, and what appears to be this species occurs at stations in the deeper parts (12 to 26 fathoms) of Narragansett Bay, Rhode Island.

This species grows on rocky bottoms or where there are shells, stones, etc., for its attachment. It is often found in company with other ascidians, especially *Didemnum albidum* Verrill and *Ascidia callosa* Stimpson. It ranges from low-water mark to about 200 fathoms, but most records are not deeper than 50 fathoms.

Amaroucium pallidum Verrill, 1871

Text figure 5

Amaroecium pallidum VERRILL AND SMITH, 1873, pp. 496, 705; STAFFORD, 1912, p. 64.

Amaroucium pallidum KINGSLEY, 1901, p. 183.

Amoroecium pallidum VERRILL, 1879, p. 27.

Amouroecium pallidum WHITEAVES, 1873, p. 17.

Amouroucium pallidum VERRILL, 1871, p. 289 (orig. descr.); 1871a, p. 362; 1872a, p. 212.

Aplidium despectum HERDMAN, 1886, p. 210, pl. 28, figs. 11–13; WHITEAVES, 1901, p. 265.

Aplidium lacteum HUITFELD-KAAS, 1896, p. 15, pl. 2, figs. 14–16; HARTMEYER, 1903, p. 338, figs. 46, 47, pl. 6, fig. 13, pl. 13, fig. 16.

Aplidium melleum ALDER AND HANCOCK, 1912, vol. 3, p. 26, pl. 55, figs. 1, 2, pl. 56, fig. 6.

Aplidium pallidum VAN NAME, 1910, p. 400, fig. 22; HARTMEYER, 1912c, p. 281; HUNTSMAN, 1912, p. 113; SUMNER, OSBURN, AND COLE, 1913, pp. 159, 732; HARTMEYER, 1922c, p. 28; 1924, p. 188; HARANT, 1931, p. 267; HARANT AND VERNIÈRES, 1933, p. 84.

Aplidium zostericola GIARD, 1872, p. 636, pl. 26, fig. 5.

For full list of references to 1923, see Hartmeyer, 1924.

Verrill and Smith, 1873, describe the appearance of fresh specimens as follows:

"Masses sessile, hemispherical or subglobular, usually attached by a large base. Surface generally evenly rounded, sometimes irregular in large specimens, smoothish, but thinly covered with minute, firmly adherent particles of fine sand which are embedded in the common tissue and scattered throughout its substance. The cloacal openings are few in number and irregularly placed, except in small specimens, which usually have but one large central opening. The animals often form somewhat circular groups of six or eight individuals around the cloacal openings. . . . Color of the masses pale yellowish or grayish; stomach dull orange color; ovaries yellowish white. The larger specimens are 15 mm. to 25 mm. in diameter."

Alcoholic specimens vary much in the shade of color of the common test, which ranges from a milky yellowish white to rather dark brownish gray, but the small, closely crowded, and usually much contorted zooids are generally visible through the test, though any arrangement of them in systems cannot generally be recognized. The amount of sand in and on the surface of the test is very variable; in some specimens it is insignificant. In form and size, the specimens mostly agree well with Verrill's description, and though there are irregularly shaped colonies among them, as would be expected in large series, it is evident that anything approaching the capitate form characteristic of *A. glabrum* is less frequently met with in this species, which tends to form a low sessile colony with a rounded or more or less flattened upper surface. Few of the colonies exceed 30 mm. in greatest diameter.

The zooids in preserved specimens generally do not exceed 3.5 mm. long and usually have a rather short post-abdomen. The branchial aperture is six-lobed; the atrial

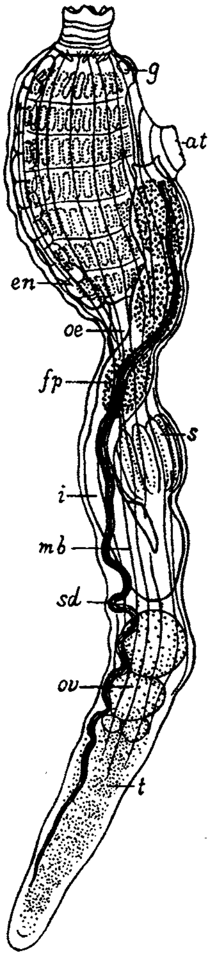


FIG. 5. *Amaroucium pallidum* Verrill. Zooid, ×42.

orifice, which is placed at a varying but often considerable distance back from the anterior end, is plain, or nearly so, usually without a languet and raised on a low conical projection. The oral tentacles, in one case where they could be fairly well seen, appeared to number about a dozen and to be of two sizes alternating. The number of rows of stigmata varies from five to seven, possibly in some cases one or two more. The stomach has 10 to 12 longitudinal ridges extending its full length.

The testes are arranged serially along the sperm duct, as usual in *Amaroucium*, not grouped as in the type of *Aplidium*, and I am, therefore, restoring this species to *Amaroucium* in which Verrill originally placed it.

DISTRIBUTION: A species of the northern waters of Europe and eastern North America and the neighboring parts of the Arctic region. Not known from the Pacific. In American waters it ranges from Davis Strait, Newfoundland, the Gulf of St. Lawrence, and southward along the coasts of Nova Scotia and New England to southern Massachusetts (vicinity of Martha's Vineyard) and Rhode Island, though in the more southern localities only in water at least a few fathoms (8 to 20 or more) in depth. In the Old World it is known from Iceland to Nova Zembla, and southward to the English Channel and west coast of France.

The recorded depths are from near low-water mark to 126 fathoms off Nova Scotia, and even 471 fathoms off Newfoundland, though most of the specimens are from depths much less than 100 fathoms. It will grow in a variety of bottom conditions, provided objects for its attachment are present. It seems to be a rather uncommon and local species throughout its range, though its small size and inconspicuous appearance doubtless cause it to be often overlooked. (See Hartmeyer, 1924; Van Name, 1910, for details.)

Brément, 1913, has described as a variety, *mortolaense*, of this species, a form certainly closely allied to it, from the Mediterranean near Monaco, but the warmer locality indicates a distinct species.

Amaroucium stellatum Verrill, 1871

Plate 7, plate 13, figure 1; text figure 6

Amaroecium stellatum VERRILL AND SMITH, 1873, pp. 704, 402, 411, etc.; COUES AND YARROW, 1878, p. 304; HOWARD, 1883, p. 304.

Amaroucium stellatum METCALF, 1900, p. 526; HARTMEYER, 1909–1911, p. 1467; VAN NAME, 1910, p. 416, fig. 25, pl. 34, fig. 1; SUMNER, OSBURN, AND COLE, 1913, pp. 159, 415, 753, chart 197; PRATT, 1916, p. 670; HARTMEYER, 1924, p. 203; PRATT, 1935, p. 742.

Amoroecium stellatum VERRILL AND RATHBUN, 1879, p. 231; MCDONALD, 1889, p. 858.

Amouroucium stellatum VERRILL, 1871, p. 291; 1871a, p. 359; 1872a, p. 212.

Aplidium (subg. *Amaroucium*) *stellatum* VAN NAME, 1921, p. 308.

This species is usually distinguished by the plate-like form of the colonies, the comparative hardness, toughness, and smoothness of the test and the small, more or less widely separated circular groups or systems in which the zooids are arranged. In alcoholic specimens the areas occupied by these systems usually become somewhat depressed below the general surface of the colony, giving it a pitted appearance, but in life the surface is quite smooth. The test often becomes very hard in alcoholic specimens.

"It forms large, smooth, irregular plates, or crest-like lobes and masses, which are attached by one edge to the stones and gravel. These plates are sometimes one to two feet long, six inches high, and about an inch thick, and, owing to their smooth surface and whitish color, look something like great slices of salt-pork, and in fact it is often called 'sea pork' by the fishermen. Other specimens will be four or five inches high, and only one or two inches broad at the base, and perhaps half an inch in thickness, and the summit often divides into broad flat, blunt lobes; various other shapes also occur, some of them very irregular. The larger specimens of this species are generally of a pale bluish or sea-green color by reflected light when first taken from the water, but pale salmon or flesh-color by transmitted light. The zooids are much elongated and arranged in more or less regular circular groups over the whole surface, with a small cloacal orifice in the center of each circle. If kept in water, when they grow sickly the zooids will be forced partially or wholly out of their cavities by the contraction of the tissues around them—a peculiarity seen also in other species of this genus. These zooids have the branchial tube prominently six-lobed, and of a bright orange color, this color also extending over the upper or outer end of the body, between the tubes, and more or less over the branchial sac, which is pale yellow or whitish below. The stomach is longitudinally sulcated, with bright orange-red ribs or glands; intestine bright orange or yellow.

"This species is devoured by sharks, skates, and the tautog, although it would seem difficult for them to digest it, or get much nutriment from it. The supply is certainly sufficiently abundant" (Verrill and Smith, 1873, p. 402).

Except in being somewhat smaller, the

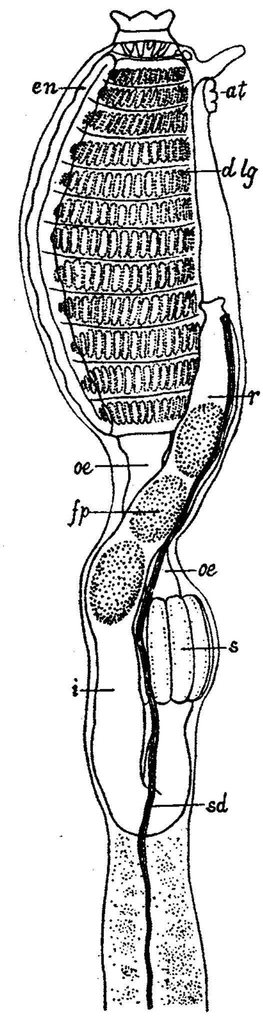


FIG. 6. *Amaroucium stellatum* Verrill. Zooid, ×27.

zooids much resemble those of *A. glabrum*, but the atrial languet is always simple, without lateral lobes, as far as I have observed, and the atrial orifice is quite noticeably lobed. They have about a dozen rows of stigmata with a maximum of about 17 or 18 in a row. In well-expanded examples it can be seen that the stigmata near the endostyle progresthat several stigmata near endostyle progressively decrease in length; near the median dorsal line they do not do this. The stomach usually has about a dozen well-developed longitudinal ridges, quite regular in the majority of colonies.

DISTRIBUTION: Massachusetts to the Gulf coast of Florida but apparently quite local. Type locality, Woods Hole, Massachusetts.

Crab Ledge, off Chatham, Massachusetts, is the most northern and eastern locality from which it has been reported. It is abundant in the eastern part of Vineyard Sound and in the channel at Woods Hole in from 4½ to 17 fathoms on stony, gravelly, or sometimes also sandy bottoms, where there are strong tidal currents.

From North Carolina it was reported by Coues and Yarrow, 1878, some of whose specimens are in the Yale University Museum at New Haven, Connecticut, and appear to be correctly identified as this species. Their statement is as follows:

"Very abundant on rocks and stones near Beaufort, and on the piles of the wharf at Fort Macon. This species attains a large size and the rapidity of its growth is surprising; new clean piles used to repair a wharf were in less than four months well covered with large clusters of this ascidian." But I have never found it growing near low-water mark or in very shallow water. At least on the Massachusetts coast it does not appear ever to grow on piles.

The American Museum of Natural History has colonies that I would refer to this species from Jekyl Island, Georgia, from the east coast of Florida, and Indian Harbor, Port St. Joe, Gulf coast of Florida.

Amaroucium pellucidum (Leidy), 1855

Plate 9, figures 1–3; text figure 7

Alcyonidium? pellucidum LEIDY, 1855, p. 142, pl. 10, fig. 24.

Amaroecium pellucidum VERRILL AND SMITH, 1873, pp. 703, 401, 419, etc.; METCALF, 1900, p. 526.

Amaroucium pellucidum (form *pellucidum*) VAN NAME, 1910, p. 404, pl. 35, fig. 3, pl. 37, fig. 6; SUMNER, OSBURN, AND COLE, 1913, pp. 159, 732, chart 195; PRATT, 1916, p. 670; GRAVE, 1922, p. 27, fig. 1, pl. 1; HARTMEYER, 1924, p. 202; PRATT, 1935, p. 742, fig. 960; PLOUGH AND JONES, 1937, p. 100; RICHARDS, 1938, p. 254, pl. 28, fig. 1.

Amoroecium pellucidum VERRILL AND RATHBUN, 1879, p. 231; McDONALD, 1889, p. 858.

Amouroucium pellucidum VERRILL, 1871, p. 290; 1871a, p. 359; 1872a, p. 212.

Aplidium (subg. *Amaroucium*) *pellucidum* VAN NAME, 1921, p. 309, fig. 5; BERRILL, 1937, p. 566.

When growing under favorable conditions, the appearance of this species is very characteristic. Though the test substance is clear and pellucid, the surface of the lobules composing the colony is so densely incrusted with sand that its character is entirely obscured; the sand grains also permeate the interior of the test, especially in the lower part of the colony, making it more or less brittle.

"The large rounded masses in which this form is often found exceed in bulk the colonies of the other New England species of the genus. They often reach 160 to 200 mm. in diameter and 70 to 90 mm. in height, being sometimes almost perfectly hemispherical. These large masses are subdivided into or built up of elongated lobules, which arise from the common base of the colony as narrow stalks and increase gradually in diameter as the upper part of the colony is approached, their truncated upper extremities forming the free convex surface of the colony. So closely do these lobules fit together that the clefts between them, although they extend nearly to the base of the colony and are lined with the coating of sand mentioned above, show but slightly unless they are opened out and the lobules separated by rough handling. Each lobule generally contains a single circular or oval system of zooids with a cloacal orifice in the center, and at the upper and larger end is 5 mm. to 10 mm. or more in diameter, the length depending on the height of the colony. In regularly hemispherical specimens the lobules are often very regular in size and form. In general, those near the edges of the colony are more completely divided off, and tend to diverge from the central mass and from each other, while the central lobules, especially where the coating of sand is more or less imperfect, tend to fuse. The color of the colony depends chiefly on that of the sand with which it is incrusted. The zooids have the stomach of a bright orange or red color, but the remainder of the body is not conspicuously colored" (Van Name, 1910, pp. 405–406).

In conformity with the long narrow lobules into which they are crowded, the zooids are long and slender, often 25 mm. long when the post-abdomen is well developed, but they exhibit no characters unusual in this genus. Except in their very slender form the zooids are very similar to those of *A. constellatum* (see below).

The branchial aperture is six-lobed, the atrial usually obscurely lobed with a languet of simple tapering form. There are usually 12 to 18 rows of stigmata, and the stomach, as in *A. constellatum*, has closely placed longitudinal folds, but these are usually less numerous than in that species.

This describes the species as it grows in Vineyard Sound, Massachusetts. Under less favorable conditions the colony as a whole is irregular, and the lobules are unequal in size and height and less closely fitted together. In some cases the coating of sand is incomplete, and the division of the colony into lobules is less complete and regular.

Among the lobules of colonies of this species growing in Vineyard Sound there may often be found here and there single lobules devoid of sandy covering or one or more much larger smooth lobes also nearly free from sand. These, whether large or small, show the characters and colors of *A. constellatum* described below, but their surface conforms so completely to that of the adjacent sand-covered lobules, preserving the uniform curve of the surface of the colony, that it looks as if they were parts of the same colony as the latter. The additional fact that the adult zooids of the two species are lacking in constant distinguishing characters led me to conclude that the two were merely different growth forms of the same species, and that *A. constellatum* should be called *A. pellucidum* form *constellatum*, as the name *pellicudum* has priority.

That this view was incorrect, and that such specimens are mixed groups of two species which are really quite distinct was shown by Grave, 1921, 1922, by a study of the larvae and development of both forms, which show well-marked differences.[1] If larvae are present in a colony they may serve to determine doubtful specimens.

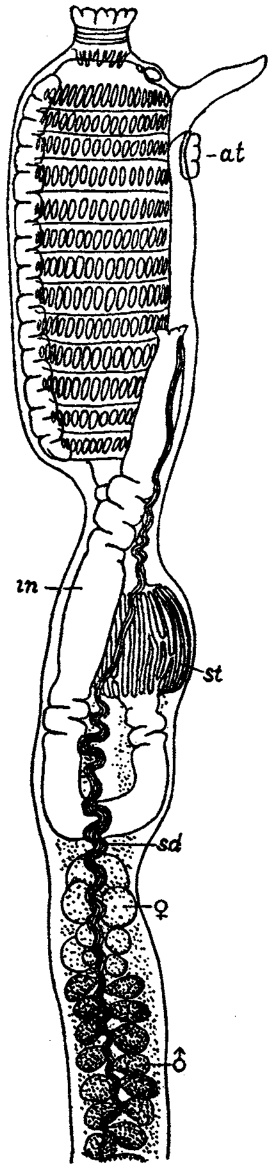


FIG. 7. *Amaroucium pellucidum* (Leidy). Zooid, ×27.

This demonstration that two distinct species exist instead of one variable one raises questions regarding the range and distribu-

[1] According to Grave, the body length of the fully developed larva of the present species is from 0.48 to 0.54 mm., total length including tail, 1.50 to 1.74 mm., while in *constellatum* the body length is from 0.74 to 0.78 mm. and the total length, 2.25 mm. The larvae of *pellucidum* have eight large, conspicuously developed epidermal tubes which are persistent in the primary zooid; in *constellatum* none is present, and only about 42 muscle cells are present in the tail in *pellucidum*, while there are about 160 in *constellatum*.

tion of each, and unfortunately also a troublesome uncertainty regarding the nomenclature.

Verrill (1871, p. 290) was certainly correct in deciding that Leidy's *Alcyonidium pellucidum* was an ascidian, but as Leidy does not say anything about a coating of sand, why did Verrill identify the present sand-covered species with Leidy's *pellucidum* when the sand-free species found in the same region seemingly would have fitted it better?

At that time Verrill had not begun the extensive collecting he did later in the Woods Hole region, and in his description of *pellucidum* in his paper of March, 1871, he refers to only two specimens dredged at Woods Hole by H. E. Webster. The description shows that these were composed both of narrow sand-covered lobes in the outer parts (these Verrill called "young colonies") and larger lobes with "but little adhering sand" on their upper parts, in the central portion. These specimens may have been more or less poorly characteristic specimens of the sandy species, some of whose lobes were deficient in the sandy covering and coalescent to an unusual degree, perhaps as a result of that deficiency, or they may have been mixed groups (see above) composed of both species.

These considerations certainly introduce an element of uncertainty in regard to the correctness of the application and use of the names *pellucidum* and *constellatum*, but as an examination of Leidy's types, which have apparently long since disappeared, would be necessary for an absolutely positive settlement of the question, and as we have the authority of so experienced and careful an observer as Verrill for the present usage, I believe that this usage should be continued. Indeed the introduction of more confusion into the nomenclature of this troublesome genus would be such a nuisance that the above names, as they have long been employed, should be retained as *nomina conservanda*, even if it cannot be done on the merits of the case.

DISTRIBUTION: This species is extremely local and seems to require for favorable development a sandy bottom (yet mixed with stones, shells, or gravel to afford objects for attachment) and swift tidal currents. The eastern half of Vineyard Sound, Massachusetts, where the water ranges from about 5 to 12 fathoms in depth, affords these conditions and there it is very abundant and forms the large colonies above described. Sometimes the dredge will come up filled almost exclusively with them.

I know of no records from farther north or east. I have seen examples from Buzzards Bay, Massachusetts, where, however, it is not common, and some poorly developed ones which I would refer here from the United States Fish Commission Station 775, Narragansett Bay (near Dutch Island, 12 fathoms, sand and shells) and from Stonington, Connecticut. Leidy's type of *pellucidum* was from Point Judith, Rhode Island, where he reported it abundant.

Verrill and Smith, 1873, reported it as ranging south to North Carolina; the record of Plough and Jones, 1937, and a specimen in the United States National Museum, pieces of which are in the American Museum of Natural History, extend its range to the Tortugas and Cedar Keys on the Gulf coast of Florida, but the scarcity of records indicates that it is not common in the southern part of its range.

Amaroucium constellatum Verrill, 1871

Plate 8, figure 1; text figure 8

Amaroecium constellatum VERRILL AND SMITH, 1873, pp. 704, 388, 393, etc.; DAVENPORT, 1898, p. 687; PEARSE, HUMM, AND WHARTON, 1942, p. 188.

Amaroucium constellatum HARTMEYER, 1909–1911, p. 1466; PRATT, 1916, p. 670; GRAVE, 1922, pp. 27–33, fig. 1, pl. 1; PRATT, 1935, p. 742; GRAVE, 1937 (*Ammaroucium*), p. 560; RICHARDS, 1938, p. 256, pl. 28, fig. 2.

Amaroucium pellucidum form *constellatum* VAN NAME, 1910, p. 406, fig. 23, pl. 36, figs. 4, 5, pl. 38, fig. 9; SUMNER, OSBURN, AND COLE, 1913, pp. 159, 733, chart 196; PRATT, 1916, p. 670; HARTMEYER, 1924, p. 202.

Amoroecium constellatum VERRILL AND RATHBUN, 1879, p. 231; VERRILL, 1879, p. 27; McDONALD, 1889, p. 858.

Amouroucium constellatum VERRILL, 1871, p. 359 (orig. descr.); 1872a, p. 212.

Aplidium (Amaroucium) pellucidum form *constellatum* VAN NAME, 1921, p. 310.

Ordinarily colonies of this species are ovate or more or less turbinate in form, attached by a narrow base. The upper surface may be convex and the edges rounded; in other cases, especially when several such masses are crowded together, the edges may be abrupt and the surface more flattened. Such colonies usually measure 10 to 25 mm. in height and in width at the upper end. Occasionally colonies are more depressed and of very thick incrusting form, attached by the whole or most of the lower surface. Under very favorable conditions large hemispherical or dome-shaped masses up to 80 mm. in diameter and 30 to 50 mm. in height may be formed, but more often such masses are more or less divided by clefts into several parts.

"The surface of the colony is smooth and its texture gelatinous and only moderately firm. Preserved in formaldehyde it becomes quite soft. The test is rather opaque, but the deep color of the zooids renders them conspicuous in spite of this. In life, the color of the test varies from a cream color through various shades of yellow (or more frequently flesh color) to a pale orange or reddish. The branchial orifices often have six radiating white lines.

"Anal orifices often surrounded by a pale or whitish border; zooids generally orange-yellow; the orifices and tubes with upper part of the mantle bright orange, or lemon-yellow; branchial sac usually flesh-color or pale yellow, sometimes bright orange; stomach with bright orange-red longitudinal glandular ribs; intestine light orange; mantle with minute opaque white specks. In some specimens the cloacal chamber or 'atrium' contained three or four bright purple tadpole-shaped larvae" (Verrill and Smith, 1873, p. 704).

The zooids are generally arranged in rather irregular and extensive systems, though small circular or oval groups also occur. The limits of the systems are often difficult to make out. The zooids average larger and stouter than in some of the related species, often measuring 4 to 5 mm. exclusive of the post-abdomen which, when well developed, may add at least 10 to 12 mm. to this length.

The branchial orifice has normally six lobes, each of which may be slightly cleft into two. The atrial orifice has five slight lobes and a rather long simple languet.

Tentacles about 12 in number and of two sizes. Rows of stigmata rather few, commonly 10 to 12 or 13, with 16 to 18 stigmata in a row on each side. As the endostyle is approached the three or four last stigmata become successively smaller.

The dorsal languets arise from the transverse vessels of the left side a little removed

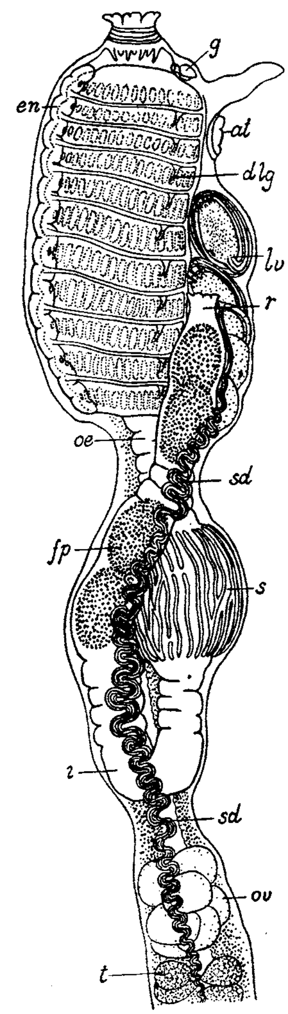


FIG. 8. *Amaroucium constellatum* Verrill. Zooid with larvae in atrial cavity, ×27.

from the median dorsal vessel. This is true in many compound ascidians of this family and the Didemnidae, but it is more easily demonstrated in species like this one that have rather large zooids and comparatively weak mantle muscles.

The longitudinal plications of the stomach wall afford one of the easiest ways to recognize this species among the other forms of our northeastern coasts, the ridges being more numerous, often 22 to 25 or more, and being narrower and closer together. They show occasional irregularities, such as forking, joining with an adjacent ridge, or by being interrupted at one or several points. These interruptions may sometimes so break up the ridges as to produce on limited parts of the stomach wall an areolated, rather than a longitudinally plicated, condition.

DISTRIBUTION: The range of this species is wider than that of some of the related ones. It extends from north of Cape Cod (Isles of Shoals, New Hampshire, and Ten Pound Island near Gloucester, Massachusetts), to the Gulf coast of Florida and is a very common species in many places. It is very abundant on the southern coast of Massachusetts where it grows in large quantities on the piles of the wharves at Woods Hole, Vineyard Haven, Edgartown, and other ports, as well as on the bottom in depths of 1 to 15 fathoms. In the latter situations it often forms curious mixed colonies with the related species *A. pellucidum*, which have been described under the latter species.

Other localities represented by specimens in the American Museum of Natural History, the United States National Museum, or in both are Buzzards Bay, Noank, and off Stonington, Connecticut; Peconic Bay, Jones Beach, Far Rockaway, and Cold Spring Harbor on the shores of Long Island, New York; off Indian River, Delaware, depth 130 feet; near Beaufort, North Carolina; "Albatross" Station 2618, 33° 37′ 15″ N., 77° 35′ 30″ W. off the South Carolina coast, 17 fathoms; and Cedar Keys, and near the banks in that vicinity off the Gulf coast of Florida. The records range in depth from tide levels to a little over 20 fathoms.

The proof by Grave, 1921, 1922, of the distinctness of this species from *A. pellucidum* has been mentioned under that species.

Amaroucium bermudae Van Name, 1902

Plate 11, figure 1, plate 19, figure 4; text figure 9

Amaroucium bermudae VAN NAME, 1902, p. 352, pl. 50, fig. 20, pl. 58, figs. 96, 97; HARTMEYER, 1909–1911, pp. 1466, 1633.

Aplidium (*Amaroucium*) *bermudae* VAN NAME, 1921, p. 305, fig. 4; 1924, p. 25; 1930, p. 426, figs. 5, 6; BERRILL, 1932, p. 77.

This is a species much resembling *A. glabrum*, commonly forming colonies of more or less capitate form, somewhat flattened above and with rather abrupt sides contracting to a narrow base, as in that species. The test is of somewhat cartilaginous consistency with the upper surface usually smooth and glossy and usually free from sand and sufficiently translucent to allow the zooids, which have the stomach and parts of the thorax orange or red in life but which fade to yellowish in preservation, to be seen through it.

The test in life is grayish, with a bluish or sometimes a pinkish cast. In preservation it often becomes more transparent and more yellowish in color.

The zooids are usually quite irregularly distributed and separated by considerable test substance. Their arrangement in systems is not always easy to make out.

At Bermuda, the type locality, the colonies I found were all rather small, 20 mm. or less in height and 20 to 30 mm. across the wide part or in most cases smaller, but on the coasts of the southeastern United States, from North Carolina southward, very much larger and more massive colonies of rounded or oval form, attached usually by a small base, are found, which seem to be of this species. The largest of these that I have seen is from the North Carolina coast and is a dome-shaped mass 110 by 60 mm. across and about 70 mm. high. Another from southern Florida is of depressed ovoid form about 90 by 50 mm. in diameter and over 40 mm. thick, attached by a small area on one of the broad sides.

The zooids average somewhat larger and stouter than those of *A. glabrum*, partially contracted individuals in preserved material, commonly measuring 2.5 to 4 mm. long, exclusive of the post-abdomen which may often add 5 to 10 mm. to the length. They much resemble those of *A. glabrum* in structure, though they usually have more rows of stigmata, often 16 to 17. The stomach normally has, as in *glabrum*, a comparatively small number (ranging generally from 10 to 15) of longitudinal ridges or plications in its wall, but these are generally narrow and sometimes rather poorly defined, and the stomach wall is quite thin, so that the contraction of the body often crushes it in and throws it into irregular transverse or oblique folds which may more or less obscure the natural longitudinally plicated condition. The atrial languet may be simple or three-parted; it is usually fairly long.

The larger number of rows of stigmata and the thin-walled stomach seem to afford the best means for recognizing the species. Its entirely different geographical range prevents its being confused with *A. glabrum* in spite of its close relationship.

From *A. stellatum*, which is likewise found on the coasts of the southeastern United States, it is not always easily distinguishable in the case of poorly preserved or small and poorly developed colonies. Well-developed specimens of *stellatum* can, however, usually be recognized by the plate-like form of the colony, the very hard test, the distinctly demarcated circular or oval systems and by the zooids, which appear to have usually a smaller number of rows of stigmata.

DISTRIBUTION: Type locality, Bermuda; type in the American Museum of Natural History, A.M.N.H. No. 1300. Berrill, 1932, also reports it from Bermuda. It was found there by Verrill and myself on corals, gorgonians, etc., brought up from well below low-water mark. Most of the specimens collected in early spring were of small size.

In the West Indies it appears to be very rare; small specimens from Water Island, Virgin Islands, and Curaçao being all that I have seen that I would refer to it even doubtfully. Some specimens from Cubagua Island, Venezuela, may belong to this species.

The localities of the large massive specimens from the southeastern United States range from near Beaufort, North Carolina, to Key West and the Gulf coast of Florida (Charlotte Harbor and St. Joseph, specimens in the American Museum of Natural History). In these regions examples are sometimes washed up on the beaches after storms. It is a shallow-water species; deepest record, 14 fathoms.

This is still one of the most unsatisfactorily known species of our eastern coast; and, owing to the poor condition of preservation of the material I have had an opportunity to examine, I cannot as yet feel sure that I am correct in regarding the large colonies from the southeastern states as identical with the Bermuda types. Unfortunately, I was unable to find any specimens at Beaufort, North Carolina, in the collecting I did there in the summer of 1940, though previously recorded from that place.

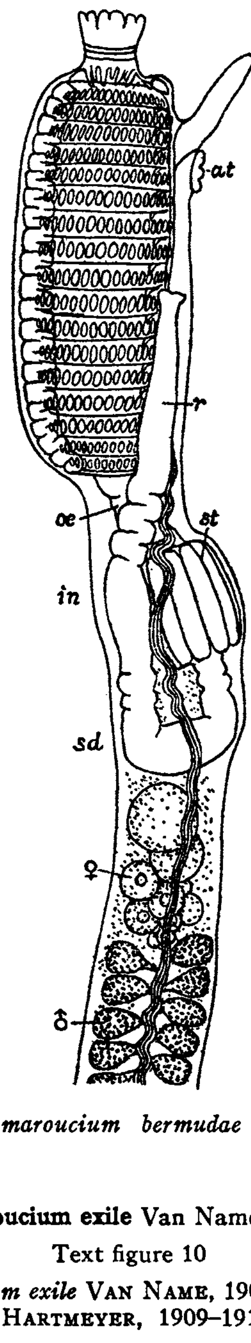


FIG. 9. *Amaroucium bermudae* Van Name. Zooid, ×25.

Amaroucium exile Van Name, 1902

Text figure 10

Amaroucium exile VAN NAME, 1902, p. 354, pl. 50, fig. 21; HARTMEYER, 1909–1911, pp. 1467, 1639.

Aplidium (*Amaroucium*) *exile* VAN NAME, 1921, p. 311, fig. 6; 1930, p. 427; BERRILL, 1932, p. 77.

Besides *A. bermudae* described above, a smaller, apparently distinct species was obtained at Bermuda. In it the colony is rounded or button shaped, adhering by the greater part of its lower surface, and is usually not over 10 to 15 mm. wide and 5 to 6 mm. in its thickest part. Its edges are rounded,

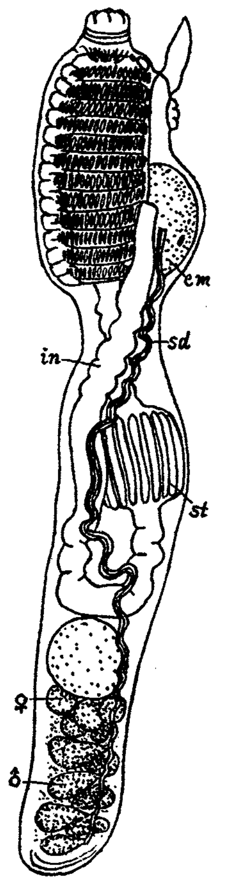


FIG. 10. *Amaroucium exile* Van Name. Zooid, ×30.

and the test is of rather soft consistency unless, as is often the case, it is quite thickly filled with coarse sand grains and minute shell fragments. In other cases it is entirely free from such inclusions and is very transparent, either colorless, or, during life, having a bluish opalescence that disappears after death, and the zooids, which are orange or red (often bright scarlet), are plainly visible through the test, making the colony a very beautiful object. The zooids appear quite irregularly distributed in the colony, often lying very obliquely to the surface; but they doubtless form one or more small systems whose limits are commonly not distinguishable. (See below in statement on distribution, regarding larger colonies perhaps assignable to this species.)

Zooids rather small and slender; the postabdomen often shorter than the remainder of the body which is often much contracted and contorted in the preserved specimens, and even when extended does not usually exceed about 6 mm. in length.

Branchial aperture with six or seven lobes, atrial aperture plain or slightly lobed, and provided with a long languet of simple form at its anterior edge. Tentacles of two sizes. Dorsal languets borne on transverse vessels of left side a little way from the median dorsal vessel. There are about 12 to 14 rows of stigmata, with apparently from 16 to 18 in a row on each side. The number of rows is subject to a little variation in different individuals.

Intestinal loop of moderate length, usually twisted, in the contracted specimens at least. Stomach wall of firmer consistency than in *A. bermudae*, considerably resembling that of *A. constellatum* in its numerous, narrow, closely placed plications; the externally prominent ridges may number 20 or even more and are, as in the latter species, subject to occasional division or other irregularities, so that the number, if counted at or near the opposite ends of the stomach, may not agree (the number of stomach plications given in the original description was too small).

Ovary in the anterior part of the postabdomen; testes in the posterior part. Many of the zooids contain larvae in the atrial cavity, these beginning the secretion of test substance while still within the atrial cavity of the parent.

DISTRIBUTION: Type locality, Bermuda, where it is common on the under side of large stones along the shore at or near low-water mark and occurring also on corals, etc., in deeper water. Cotype in American Museum of Natural History, A.M.N.H. No. 1310. Berrill, 1932, also reports it from Bermuda under stones.

It apparently occurs in the West Indies and on the Florida coasts also; I have examined specimens from Curaçao; "Albatross" Station 2362, off northern Yucatan, in 25 fathoms (the last mentioned was referred to *A. bermudae* in Van Name, 1921, p. 308), but owing to their state of development or poor preservation their identification with this species is not certain.

Several *Amaroucium* colonies, obtained by the American Museum near Tarpon Springs, Florida, growing upon large colonies of *Clavelina gigantea* in shallow water, are evidently related to *A. exile* and perhaps referable to it. They are, however, of flat incrusting form—not a common shape in the genus *Amaroucium*. They are about 3 mm. thick in most parts and of straggling, irregular outline; their diameter may reach about 5 or 6 cm. in certain directions. The test is transparent, the zooids irregularly distributed and lying at various angles; in some places they evidently form systems which are rather small and irregular in outline. The zooids are pale yellow in preservation, the thorax whiter; they conform to the description of *A. exile* in size and structure. The stomach wall has numerous, often at least 20, closely placed plications which sometimes fork or show irregularities. At present I do not feel justified in assuming that they represent a new species.

Plough and Jones (1937, p. 100) list an "*Amaroucium* sp. nov." from Tortugas, Florida, but give no information about it.

Amaroucium funginum (Sluiter), 1898

Macroclinum funginum HARTMEYER, 1909–1911, p. 1471.
Psammaplidium funginum SLUITER, 1898, p. 31.

This appears to have been described by Sluiter from a single lot of specimens. It is apparently an *Amaroucium*, but I cannot identify with it either of those known from the West Indies.

The colonies form small cylindrical masses, the largest only 12 mm. long and 8 mm. wide. The test is gelatinous and glassy in the upper part and impregnated with sand grains below.

The zooids are 7 to 8 mm. long and have but six rows of stigmata with six in a row on each side. The stomach is described as without salient folds and not distinctly separated from the oesophagus and intestine.

LOCALITY: Tortuga Island, West Indies, in a depth of 45 meters.

See under *Psammaplidium flavum* (p. 445) for statement regarding the genus *Psammaplidium*.

Amaroucium fuegiense (Cunningham), 1871

Amaroucium fuegiense MICHAELSEN, 1907, p. 28, pl. 3, figs. 25, 26; HARTMEYER, 1911b, p. 547, pl. 56, figs. 9, 10; 1912b, p. 338; 1921, p. 275.
Amaroucium irregulare HERDMAN, 1886, p. 223, pl. 30, figs. 1–7; MICHAELSEN, 1907, p. 28.
Amaroucium irregulare var. *concinnum* HERDMAN, 1886, p. 225, pl. 30, fig. 8; MICHAELSEN, 1907, p. 28.
Amaroucium laevigatum HERDMAN, 1886, p. 231, pl. 30, figs. 12–15; MICHAELSEN, 1907, p. 28.
Amaroucium meridianum SLUITER, 1906, p. 15, pl. 1, fig. 12.
Amaroucium pallidulum HERDMAN, 1886, p. 226, pl. 30, pp. 9–11; MICHAELSEN, 1907, p. 28; HERDMAN, 1912, p. 100.
? *Amaroucium recumbens* HERDMAN, 1886, p. 227, pl. 29, figs. 13–15; MICHAELSEN, 1907, p. 28.
? *Amaroucium variabile* HERDMAN, 1886 (see remarks at end of description); ? COIFMANN, 1933, p. 2, figs. 1, 2.
Amaroucium vastum SLUITER, 1912, p. 458; 1914, p. 32, pl. 3, fig. 37, pl. 4, fig. 46.
Aplidium fuegiense CUNNINGHAM, 1871, p. 66; 1871a, p. 490, pl. 58, figs. 1a–1c.
Atopogaster elongata HERDMAN, 1886, p. 173, pl. 24, figs. 1–8 (not Herdman, 1902, p. 194); not *Atopogaster elongata* var. *pallida* Herdman, 1886, p. 175. (See Hartmeyer, 1921, pp. 275–278.)
Atopogaster gigantea HERDMAN, 1886, p. 164, pl. 23, figs. 1–6. (See Hartmeyer, 1921, p. 274.)
? *Polyclinum incertum* HERDMAN, 1886, p. 196, pl. 26, fig. 10.
Psammaplidium annulatum SLUITER, 1906, p. 27, pl. 2, figs. 25, 26.
? *Psammaplidium paessleri* MICHAELSEN, 1907, p. 25, pl. 1, fig. 3, pl. 3, figs. 19, 20.

The test in well-preserved specimens is usually of some shade of grayish, yellowish, or brownish, translucent or semitransparent, allowing the lighter-colored yellowish zooids (probably orange or more or less red in life) to show through to some extent. It may be quite free from included sand, though considerable sand may be present in other examples. The test has a rather tough outside layer; internally it is softer.

An attempt to describe the colonies in respect to form and size is impossible to fulfill. Every imaginable variation in size and shape seems to occur, from small, simple, rounded, or irregular colonies a few millimeters in diameter, long narrow ones attached by one end, or groups of lobes or heads, to large masses of ovate or irregular shape which may attain a bulk at least as great as those of any other compound ascidians. Herdman, in describing the type of the form which he named *Atopogaster gigantea* but which Hartmeyer (1921) found on reëxamination to be not distinct from the present species, gave its dimensions as 26 cm. by 7.5 cm. in greatest width, with an average thickness of 4 cm., and called it the largest compound ascidian in the "Challenger" collection.

Many of the small colonies are of capitate form, and larger ones are often divided by deep clefts into lobes, also often of capitate form. If one of these lobes is sliced in a plane extending through both the upper, wider part and the narrower, basal part, the manner in which the long, narrow post-abdomens of the zooids extend in a crowded mass down into the basal part, while the thoracic ends diverge and occupy the wider upper portion, is often very conspicuous.

In the larger colonies the zooids can often be clearly seen to be arranged in systems. Though these may be small in some parts of the colony, they are more often extensive and much branched, common cloacal apertures being rather few. In a large proportion of the preserved specimens, systems are difficult to demonstrate, though we are not justified in assuming their absence in such cases.

The colonies seem to be subject to seasonal periods of retrogression, during which the anterior parts of the zooids undergo degeneration, and the upper part of the colony shrinks, the test becoming firmer and less transparent.

The zooids are of rather small size and when young are very slender; older zooids with actively functional gonads, and often with larvae in the atrial cavity, become much stouter. A total length of 6 to 8 mm. is quite usual, but zooids may reach or exceed double this length if the post-abdomen is elongated.

Their structure presents no unusual characters. The branchial aperture is six-lobed, the atrial has a languet which in many cases is quite deeply three-parted, in others only small lateral lobes may be present, or none at all, the languet being simple. Usually about 12 tentacles alternating in size are present. About 15 rows of stigmata appear to be the prevailing number but is subject to variation in both directions. The stomach is short and wide. It has few, apparently usually six, rather deep longitudinal plications, in young zooids apparently only five or even four. But in other cases the plications may number at least eight or ten. They are mostly equally spaced, but on the side of the stomach that lies against the ascending branch of the intestine there is a wide, flattened interval between the folds.

The ovary is in the anterior part of the post-abdomen; the testes, which when actively functional are of relatively large size, extend through a considerable distance of the post-abdomen behind the ovary. Posterior to the gonads there may be a slender extension of the post-abdomen of varying, sometimes of very considerable, length. A bulbous enlargement of the extreme end of the post-abdomen is frequently present.

Distribution: This species is apparently of very wide range in the Antarctic and other colder regions of both the Western and Eastern Hemispheres, but the references to it in literature appear under many different names. In the Magellanic region and in the waters around the southern end of South America, including the Falkland Islands and the waters of West Antarctica, this appears to be the commonest and most generally distributed compound ascidian. It follows the cold current up the east coast of South America to the mouth of the La Plata; definite data on the Chilean coast and from South Georgia seem to be still lacking. While the majority of specimens have been obtained in water that was rather shallow or only quite moderately deep, it is probable that it also occurs in fairly deep water. *A. recumbens* Herdman from the west end of Magellan Strait, which seems very doubtfully distinct, was obtained in 285 fathoms.

Its occurrence in the Old World regions of the Subantarctic and Antarctic is likely, but discussion of the probably or possibly synonymous species from that part of the world is outside the field that this work attempts to cover.

One of these very likely synonymous forms should, however, be mentioned here:

Amaroucium variabile HERDMAN, 1886, p. 216, fig. 9, pl. 29, figs. 7–12; HARTMEYER, 1911b, p. 541, figs. 12, 13, pl. 47, figs. 1–5, pl. 56, figs. 4–8; 1912b, p. 335, pl. 44, figs. 8, 9, originally described from Kerguelen Island.

It seems to differ from *A. fuegiense* chiefly in usually having several more plications in the stomach wall. Coifmann's (1933) figure 2 represents the plications much too numerous for either *fuegiense* or *variabile.* Her specimen was from the Strait of Magellan. It may possibly represent a different, as yet unnamed species.

Amaroucium longicaudatum Sluiter, 1912

Amaroucium longicaudatum SLUITER, 1912, p. 459; 1914, p. 33, pl. 3, fig. 38.

Based on two massive ovoid colonies, the largest 9 cm. long and 6 cm. thick; test grayish in the alcoholic specimens, semi-transparent, nearly free from sand, the zooids irregularly distributed. Distinct systems not discernible.

Zooids very elongate, reaching about 26 mm., four for the thorax, two for the abdomen, and the rest for the slender post-abdomen. Branchial aperture six-lobed, the atrial with a long languet, spatulate but not cleft at the end. Mantle musculature strong. Twelve tentacles alternating in length. Twenty rows of stigmata with up to 18 in a row on each side. Stomach with four deep longitudinal folds. Gonads in the anterior part of the post-abdomen; the ovary is short and in the anterior part, the testes farther back. The rear part of the post-abdomen is a very slender extension.

LOCALITY: Western Antarctic. Two specimens obtained by the second Charcot expedition at the South Shetland Islands in 75 meters.

Though apparently closely related to *A. fuegiense* and based on too little material, it does not seem justifiable at present to include it among the synonyms of that species.

Amaroucium caeruleum Sluiter, 1906

Amaroucium caeruleum SLUITER, 1906, p. 16, pl. 1, figs. 13–16, pl. 4, fig. 49 (name misprinted *coeruleum*, p. 49); HARTMEYER, 1911b, p. 504, fig. 3, pl. 54, figs. 1–9, text fig. 3.

Though there is considerable variation in shape, the typical form of the colony in this species is club shaped, or inverted conical, tapering to a narrower lower end by which it is attached, and more or less flat topped, often with a slightly raised margin. The usual dimensions do not exceed 30 mm. in height and 10 to 12 mm. in diameter at the upper end.

The test is somewhat transparent with a thin, firm, but not strong, outer layer, often with adherent sand, but softer and gelatinous in the interior of the colony. Some colonies are colorless, or pale yellow throughout, but more often the interior portion is pervaded with an ultramarine blue color, sometimes pale, but often very deep. This coloration when present seems to be characteristic of the species; it is not dissolved out by alcohol.

The zooids are quite large and very few in number, not more than nine, even in the largest colonies, according to Hartmeyer. They are arranged in a single system around a central, common cloacal aperture in the middle of the upper end of the colony, and reach a length of 18 mm. in the preserved specimens; of this length 10 mm. is post-abdomen. They have a six-lobed branchial aperture and a plain atrial aperture with a well-developed languet which is often three-parted at the end. According to Sluiter, there are 20 tentacles of two sizes placed alternately, and 10 rows of stigmata of about 20 on each side.

The stomach, according to the same author, has eight longitudinal plications in addition to several others that extend only a short distance from the pyloric end. Hartmeyer, however, found no actual folds in the stomach wall, though plication was simulated by an interior longitudinal striping.

The long, tapering post-abdomen contains the ovary in the anterior part and the numerous testes arranged in several series in the posterior part. Sluiter figured a specimen having a rounded brood pouch full of developing embryos attached by a contracted neck to the posterior part of the atrial cavity. According to Hartmeyer, who had much material at his disposal, this must have been abnormal, though there is often much distension of the atrial cavity by embryos and larvae.

DISTRIBUTION: This well-characterized species has been found only in two regions in the high latitudes of the Antarctic. It was collected by the first Charcot expedition in the Schollaert Canal (type locality), and at many

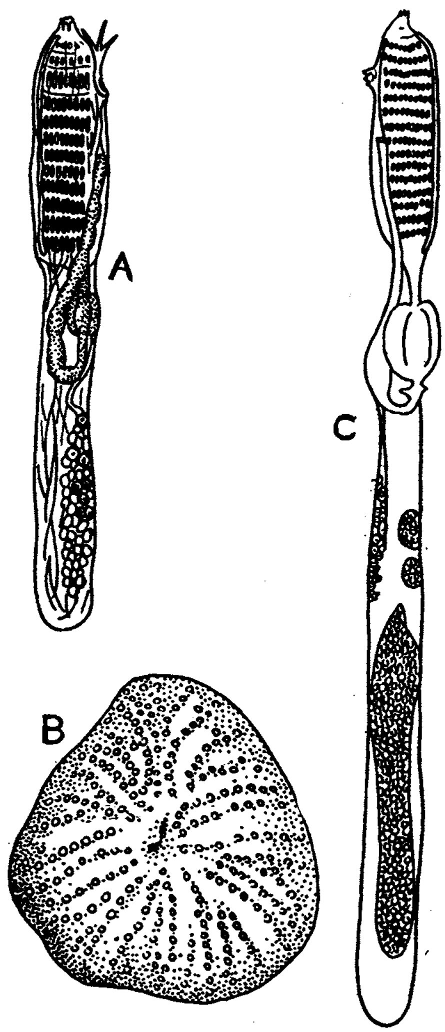


FIG. 11. *Amaroucium radiatum* (Sluiter). A. Zooid. B. Colony as seen from above, slightly reduced. C. *Amaroucium ordinatum* (Sluiter). Zooid. Adapted from figures of Sluiter.

stations in the Kaiser Wilhelm II Land region, in depths of 350 to 385 meters, by the Gauss expedition.

Amaroucium radiatum (Sluiter), 1906

Text figure 11A, 11B

Amaroucium radiatum HARTMEYER, 1909–1911, p. 1471.

Psammaplidium radiatum SLUITER, 1906, p. 25, pl. 2, figs. 23–24, pl. 4, fig. 52.

The colony forms a more or less hemispherical or ovoid mass, attached by a flattened base. Two of the specimens are more cylindrical and provided with a pedicel. Test fairly firm, containing considerable included sand in the superficial parts, giving the colony a grayish color.

A single common cloacal aperture is situated at the summit of the colony; the zooids are arranged in rather straight rows which converge toward the central cloacal orifice. Small elevations indicate the position of the branchial orifices. Largest colony, 70 by 35 mm. across and 10 mm. thick.

The zooids are of the usual *Amaroucium* type and reach 15 mm. in length. Branchial orifice six-lobed; atrial orifice back a little on the dorsal side of the thorax and provided with a large, deeply three-cleft languet. Branchial sac with 12 to 14 rows of stigmata, 14 to 16 in a row on each side.

Stomach wall with four deep longitudinal folds.

The gonads appear to be peculiar in the ovary and testes being located virtually side by side in the post-abdomen, the ovary occupying most of the length of the latter in the dorsal part, the numerous testes occupying the ventral part.

DISTRIBUTION: Western Antarctic. This species is based on a number of specimens collected by the first Charcot expedition. Type locality, Schollaert Canal at Antwerp Island, 64 meters; others from Booth Wandel Island in 40 meters (some specimens also picked up on the beach) and Port Charcot, 40 meters.

Amaroucium ordinatum (Sluiter), 1906

Text figure 11C

Aplidium ordinatum SLUITER, 1914, p. 35; HARTMEYER, 1909–1911, p. 1471.

Psammaplidium ordinatum SLUITER, 1906, p. 22, pl. 2, figs. 19–20.

An insufficiently known species originally based on two specimens, the larger of which is said to have a cylindrical base, the upper part "forming two dome-shaped protuberances containing the zooids, arranged quite regularly in lines." Common cloacal orifices not found. Color gray, the surface covered with sand. Dimensions of the colony not given.

The zooids that reach 10 mm. in length are of the *Amaroucium* type in most respects; the atrial orifice is a short distance back on the dorsal side of the thorax. No atrial languet present, 12 branchial tentacles alternating in size. Fifteen rows of stigmata with seven to nine in a row on each side. Stomach with four wide, but not deep, longitudinal folds.

LOCALITIES: Western Antarctic. Type locality, Schollaert Canal, two specimens collected by the first Charcot expedition. A third example was collected by the second Charcot expedition in the South Shetland Islands in 75 meters.

Amaroucium californicum Ritter and Forsyth, 1917

Plate 28, figures 2, 3; text figure 12

Amaroucium californicum RITTER, 1900, p. 608 (*nomen nudum*); 1901, p. 254 (*nomen nudum*); HARTMEYER, 1909–1911, p. 1466; RITTER AND FORSYTH, 1917, p. 483, pl. 46, fig. 72; HARTMEYER, 1924, p. 215.

Colonies of this species vary greatly in shape, but the prevailing type is flat and cake-like, attached by a large area of the lower surface, though often having the edges free and rounded off. They attain a large size; according to Ritter and Forsyth they often reach an expanse of 10 to 20 cm. and a thickness from 0.5 to 2 or 3 cm., in some parts of a large colony. Some colonies are so irregular as to defy description; small ones are often rounded or capitate. The surface is usually fairly smooth, often glossy, and almost free from sand, though sand grains may be more or less thickly scattered in the interior of the test, especially in the deeper portions. The test is gelatinous, usually rather soft and often transparent, allowing the zooids to be very clearly seen, but it is more opaque where the water is muddy.

Their color is quite variable, "opalescent white to reddish brown" according to Ritter and Forsyth. Most of those I collected in the Monterey Bay region were dull yellowish or somewhat brownish yellow when fresh, the zooids with the thorax whitish, the other parts of the body yellow or orange, or in some cases quite bright red. An arrangement of the zooids in small oval or more or less elongate systems is often discernible, at least in some parts of a colony; in others it is not, but systems probably exist nevertheless.

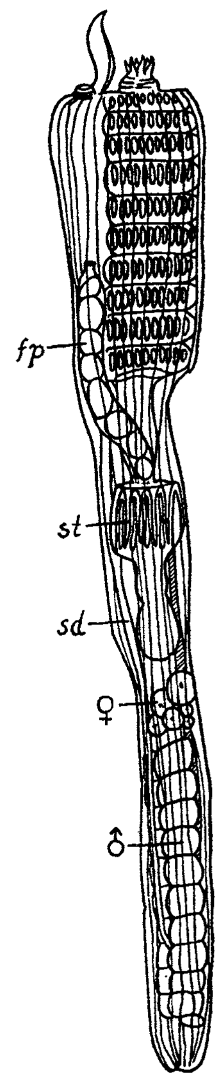


FIG. 12. *Amaroucium californicum* Ritter and Forsyth. Zooid. Adapted from Ritter and Forsyth.

The small size of the zooids of this species in comparison with those of most members of this family found on the California coast is often quite striking, also the great number and close placing of the zooids in many of the colonies. According to Ritter and Forsyth the zooids do not often exceed 6 mm. in length, approaching 1 cm. only when the post-abdomen is greatly developed, but in many preserved colonies contraction of the longitudinal mantle muscles, which are rather well developed, reduces the usual lengths of the zooids to about half these measurements.

The branchial aperture usually has six well-developed simple lobes, the atrial aperture an entirely smooth or nearly smooth margin, and a fairly long languet, usually entirely simple in form. The branchial tentacles number about 10, the rows of stigmata usually also about 10 (varying, however, from eight to 12) with about a dozen stigmata in a row on each side. These figures, given by Ritter and Forsyth, are in good agreement with my own observations on a number of specimens. The stomach is short, oblong, or more or less rounded with a quite variable number of longitudinal folds which are usually pretty regular and deeply impressed, and usually only moderately numerous, though the number averages greater on some colonies than in others. The folds of the stomach wall were carefully counted and tabulated by Ritter and Forsyth in a large number of zooids from each of five different colonies coming from several separated stations from San Diego to Santa Monica. The extremes of variation that they found were from 12 to 23 ridges, the maximum variation in one colony (in which those in 29 zooids were counted) was from 16 to 23, the average in that colony being nearer the higher than the lower number. In a number of colonies in which I made counts the average was not over about 15 or 16.

The ovary, located in the anterior part of the post-abdomen, and the double row of testes occupying a considerable length of the abdomen in the posterior part are shown in the figure.

Distribution: This, according to Ritter and Forsyth, is probably the commonest ascidian on the California coast. They say it occurs on rocks, usually on the under sides at all points where collecting has been done and is found everywhere on piles, floats, breakwaters, etc., except in the upper portions of bays where the density and temperature of the water are distinctly different from normal sea water. Dredgings do not indicate that it flourishes in depths beyond a very few fathoms; a record of 46 fathoms appears to be unusual. It occurs also in Puget Sound (Ritter, 1900). Type locality, San Diego, where it is abundant in the Bay.

I can testify to its abundance on the intertidal rocks of the region about Pacific Grove, California, but I failed to find it at all in or near Newport Bay in 1939. It occasionally grows on the shells of large crabs or abalones.

It ranges beyond the boundaries of the United States both northward, where it occurs about Vancouver Island, and southward, and may be the "*Amaroucium* sp. A" reported by Huntsman, 1912 (pp. 114 and 115), but Ritter's (1901) record from shore rocks on Popof Island, Shumagin Islands, was based on very poor specimens and is uncertain. (Huntsman, 1912, also reports dredging an "*Amaroucium* sp. B" off the west coast of Vancouver Island, but gives no information about it.)

The American Museum of Natural History has specimens received from E. F. Ricketts from various points in the Gulf of California which I assign to this species: Espiritu Santo Island, Bahia de la Paz, Concepcion Bay, Tiburon and Angel de la Guardia Islands, the last localities well in the northern part of the Gulf.

A couple of small colonies of irregular shape obtained by the "Albatross" at Station 2809, Galápagos Islands, 45 fathoms, also agree with this species in all the characters I could make out. The zooids have 14 to 16 or more rows of stigmata; the stomach wall has 12 to 14 plications.

So wide is this apparent range that we may question whether more than one species is not being confused, but, if so, I would be at a loss to name characters by which they might be distinguished.

I quite agree with Ritter and Forsyth and differ from Hartmeyer, 1924, in considering this species distinct from *A. glabrum* Verrill, 1871. The latter is especially an Arctic or Subarctic species, though extending south off the northern New England coast; it ranges down to depths of 200 fathoms, and the prevailing form of the colonies is capitate.

Amaroucium solidum Ritter and Forsyth, 1917

Plate 28, figure 4; text figure 13

Amaroucium solidum Ritter and Forsyth, 1917, p. 486, pl. 46, figs. 69, 70.

The following description is quoted from the above authors:

"Superficial Characteristics of the Colony: Large, fleshy, potato-shaped lobes; young colonies more globular; largest colony studied, length 16 cm., width 7 cm., thickness 3.5 cm. Some living colonies opalescent white, the zooids showing as opaque white objects; others opalescent with a yellowish blue tinge, the zooids distinctly yellow. Zooids very numerous, standing at various angles in colony. Systems seemingly never present. Test gelatinous with many variously shaped pigment grains; surface layer tougher than underlying portion.

"Zooids: A little pressure on a living colony forces zooids out upon surface; easily removed from test in preserved specimens; varying greatly in length, some very long, extending well back into central gelatinous core; average length in large colony, thorax 3 mm., abdomen 2 mm., postabdomen 8 mm. Mantle delicate and transparent, containing about twenty-four longitudinal muscle bands on a side, these separated by considerable spaces in the thorax but closer together in the abdomen and postabdomen; a few transverse fibers in the siphonal region.

"Branchial System: Branchial siphon with six blunt lobes grooved so as to appear twelve when viewed from above; atrial siphon with short, overhanging, triangular languet and five small, pointed lobes. Branchial sac with from 13 to 15 series of stigmata with about 15 stigmata on a side in middle of sac. Endostyle wide and straight, with a narrow space on each side free from stigmata. Branchial tentacles about twenty, of varying sizes.

"Digestive System: Plane of intestinal loop, transverse; esophagus almost as long as stomach; stomach cylindrical, one and one half times longer than wide, having about eight folds, these sometimes discontinuous; intestine divided into several parts; first, a piece a little shorter than stomach with a bulge about midway of its length; second, a larger section which makes the loop; third, a short, very narrow isthmus connecting the large piece just described with rectal limb, the beginning of which is provided with prominent caeca; and finally, the rectal piece running up left side of body to end as a constricted anus about one-third the distance up branchial sac.

"Postabdomen and Reproductive System: The postabdomen variable in length, often three or four times as long as thorax; about

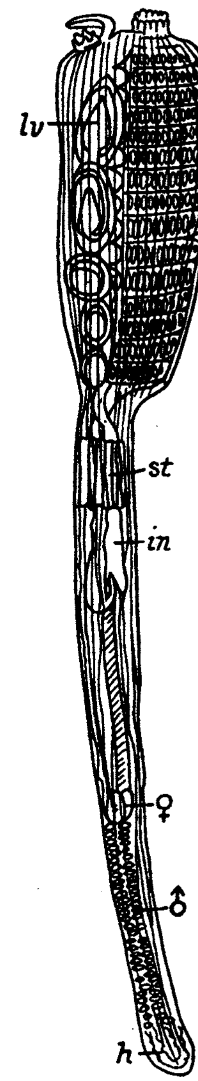


FIG. 13. *Amaroucium solidum* Ritter and Forsyth. Zooid. Adapted from Ritter and Forsyth.

half the diameter of thorax, tapering toward posterior end. The conspicuous cloison, or partition, halves the cavity of post-abdomen from right to left; many round pigment granules occurring in walls of this partition. Numerous regular testis lobes occupy posterior half of postabdomen. The ovary just anterior to the latter, quite remote from intestinal loop.

"Breeding Season: Summer months at least, the atrial chambers of zooids examined at this time being filled with tadpoles.

"The great variability in the colonies of *A. californicum* makes the species seem to include *solidum* so far as external appearance is concerned, and since the two overlap a good deal in distribution, if indeed they are not coincident, the collector is likely to confuse them at times. In general, however, the much greater massiveness of *solidum* will distinguish them even to cursory observation. But examination of the zooids leaves no question about the specific distinctness of the two. Perhaps the most accessible point of distinction between the zooids of the two is in the secondary lobing of the lobes of the branchial siphon of *A. solidum* and the teeth around the atrial orifice in the same species" (Ritter and Forsyth, 1917, pp. 486, 487).

Unfortunately, in strongly contracted preserved specimens these characters of the apertures may be hard to demonstrate. The thinner-walled, less deeply plicated stomach and the larger zooids of the present species help in distinguishing it from *californicum.* Small irregular systems are undoubtedly present in many cases, and I am inclined to doubt their absence even when not distinguishable.

DISTRIBUTION: Southern California coast and northward; littoral. According to Ritter and Forsyth the only localities from which specimens have been certainly identified are San Diego Bay (the type locality) and Santa Monica, growing on piles in both places. However, they expressed the opinion that it "almost certainly" occurs at Monterey Bay and other northerly points. This appears to be correct, as some quite large colonies, pinkish or yellowish white with red or yellow zooids, which I collected on the intertidal rocks near the Hopkins Marine Station and at Pescadero Point in the Monterey Bay region, agree with the above description in most characters both of the colonies and of the zooids, though the number of stomach plications is much larger, the number of ridges often exceeding 20, and there may be at least 18 rows of stigmata. In view of the variability of those characters in many species of *Amaroucium*, these discrepancies do not seem to justify assuming the existence of another species or prevent referring these specimens to the present one.

Amaroucium propinquum, new species

Text figure 14

Colonies of this species consist of rather loose clusters of irregularly club-shaped heads which closely resemble those of *A. arenatum* (see below), though they become larger. They narrow toward their bases where they are united by a mass of branching stolons. The two largest heads in the available specimens measure about 45 mm. in height; these are considerably flattened laterally, very narrow at the base and about 10 by 14 mm. across the slightly rounded top, but most of the others are much smaller. The upper surface of the heads is uneven, showing a slight tendency to split up into small elevations or projections, each enclosing the anterior end of a zooid. The whole colony is everywhere incrusted with sand, though not very heavily. No conspicuous coloration was noted in the specimens when fresh.

In the preserved specimens the adult zooids average 4.5 to 6 mm. long (or more when well expanded) exclusive of the slender post-abdomen, which may itself occasionally reach 25 mm. in length. The branchial aperture is six-lobed, the atrial is plain and has its anterior margin produced into a languet, which may be three-cleft, forming tips which may be all small and more or less equal, or the middle one may be much the longest. The atrial aperture is sometimes a little produced but not approaching to the tubular condition characteristic of the genus *Synoicum.*

The mantle muscles are mainly longitudinal, weak and rather diffuse; the tentacles about 16 in number and of at least two sizes. The dorsal languets are removed a little way to the left of the median vessel.

Conspicuous characters of the present species are the large number of rows of stigmata, which often reaches 20 or 21 (but is considerably less in young zooids) with at least 16 to 18 stigmata in a row on each side, and the rather numerous longitudinal plications of the stomach wall, forming narrow rounded ridges (often 18 to 20 or more) separated by sharply defined furrows, as is typical in the genus *Amaroucium*, though on a part of the stomach they are sometimes very sinuous and irregular and often anastomose with adjacent plications.

The intestinal loop has a constricted segment just beyond the stomach and another in the transverse posterior part of the loop. Where this enters the larger ascending part the latter has a pair of sac-like caeca.

I failed to find developing eggs or larvae in the atrial cavities of the zooids studied, and the gonads were likewise in an insufficiently developed condition for study. Apparently the very numerous testes extend a long distance in the post-abdomen, and the ovary, likewise elongated, lies anterior to or beside them in the anterior part.

The few specimens upon which this species is based were found among other ascidians collected on intertidal rocks near the Hopkins Marine Station at Pacific Grove, California, in the summer of 1939. Type in the American Museum of Natural History (A.M.N.H. No. 1631).

Amaroucium arenatum, new species

Text figure 15

The individual lobes of which the colonies are built up are capitate or very irregularly clavate or club shaped, narrow, and enlarged only at the upper end, sometimes considerably, but in other cases only to a small extent. They may be quite closely crowded so that their adjacent upper ends form, though not actually united, a fairly even surface, sometimes 2 or 3 cm. across, but oftener the lobes are so crooked and irregular that they are in close contact only at the lower ends where they arise from a network of stolons.

The heads and basal stolons are everywhere thickly incrusted and impregnated with sand grains; they sometimes range up to about 25 mm. or a little more in height and are generally less than 5 mm. in transverse diameter at the upper end, though some exceed that width by a few millimeters. Owing to the narrowness of some of the lobes, there can hardly be room in them for more than one or two zooids in a functional state of development. In the wider lobes the zooids apparently form a small system.

The zooids often reach 12 to 15 mm. in length or occasionally more, and are very slender, most of their length being in the abdomen and (especially) the post-abdomen.

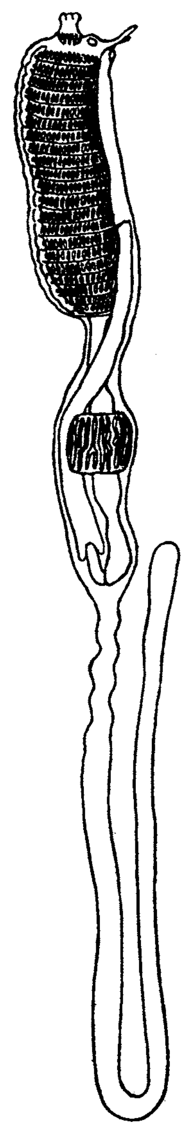


FIG. 14. *Amaroucium propinquum*, new species. Zooid, ×24.

The branchial aperture has six lobes which may be slightly bifid. It is raised on a short, wide tube. The atrial siphon also has the form of a projecting tube, though the aperture is not terminal but situated obliquely on the dorsal or dorsoposterior aspect, the tube extending beyond it to form a languet which is usually truncated, with the end irregularly cleft into two or three small blunt lobes.

The mantle muscles are mainly longitudinal but diffuse and not gathered into con-

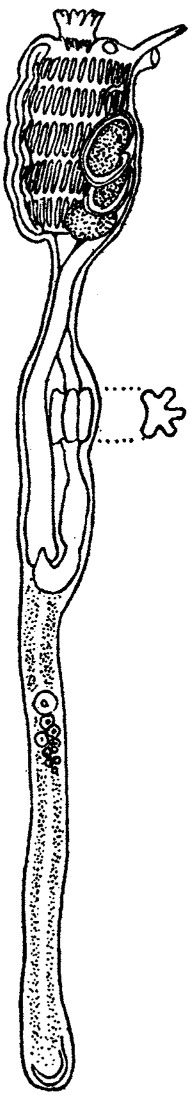


FIG. 15. *Amaroucium arenatum*, new species. Zooid, ×12. Also cross section of stomach.

spicuous bands. Sixteen branchial tentacles representing three orders quite regularly arranged were all that I could count in several unusually well-expanded zooids.

There are only five rows of rather long, narrow stigmata with about 14 or 15 in a row on each side. The dorsal languets are short and arise the width of several stigmata to the left of the median vessel.

Owing to the length of the oesophagus, the stomach is well removed from the thorax. When seen from one side, it is quite elongate and has five prominent longitudinal ridges rounded at their ends (the anterior end especially), separated by deep furrows. The side of the stomach which lies against the ascending limb of the intestine is smooth and slightly concave, two of the ridges being far apart on that side. Behind the stomach the intestinal loop is quite long. A narrow segment of the intestine comes next to the stomach, followed by a wide one, then an abruptly narrow one at the rear end of the loop. Where this enters the wider ascending limb of the intestine the latter forms a pair of well-marked, posteriorly extending, sac-like caeca.

The reproductive organs are poorly developed in the specimens at hand which were collected in July, though some of the older zooids contain two or three eggs in an advanced stage or tadpole larvae in the atrial cavity, indicating that the breeding period was drawing to a close. These larvae are proportionately quite large (about 0.52 mm. in body length). In most of the specimens, little structure was recognizable in the contents of the post-abdomen, but in a few the ovary appeared to be represented by a small group of eggs some distance posterior to the intestinal loop. What appeared to be the testes in a formative state of development extended beside the ovary and both anteriorly and posteriorly to it for a long distance in the post-abdomen. The heart is in the slightly enlarged posterior end of the latter.

LOCALITIES: The specimens on which this species is based were collected on the intertidal rocks near the Hopkins Marine Station at Pacific Grove, California, growing in situations somewhat sheltered from the full force of the surf. The type specimen is No. 1634 in the American Museum of Natural History collection. I have also received specimens from S. F. Light from Dillon Beach, California.

This is a species related to *Amaroucium spitzbergense* in the structure of the zooids, though their atrial siphon of tubular form, with its anterior margin produced into a three-cleft languet, is quite different from that of *spitzbergense*, as is also the character of the colony. Their ranges are also widely separated geographically.

Amaroucium spauldingi (Ritter), 1907

Amaroucium spauldingi HARTMEYER, 1909–1911, p. 1471.
Psammaplidium spauldingi RITTER, 1907, p. 41, pl. 3, fig. 39.

Ritter's description, which was based on a single specimen, is quoted in full:

"General Characters of the Colony: Expanded, loosely adherent by whole under surface, top smooth but undulating, hard from great quantity of sand, which is uniformly disseminated through the whole test. Edge of the colony rolled up a little. The small zooids numerous, evenly distributed, no systems (?), each branchial orifice marked on surface of colony by a small papilla. Color uniform grey, due to the imbedded sand.

"The single colony taken, 6 cm. by 5 cm. in its greatest dimensions and 1.8 cm. thick in thickest part, though considerably thinner in most places.

"Zooids: Abundant, long, slender and nearly straight, the thorax but little thicker than the abdomen and long post-abdomen. Thorax about 3 mm. long; abdomen, before contraction, probably about 2 mm.; post-abdomen variable, but several times as long as thorax and abdomen combined. Mantle containing a few slender longitudinal muscle bands which extend far down into the post-abdomen.

"Thorax: Branchial orifice on prominent siphon, six-lobed, atrial situated well back—a distance from the end of the branchial siphon about equal to the thickness of the thorax. Atrial orifice beset with a moderately long languet, this usually undivided, but occasionally bifid at tip. The long cylindrical sac with about eighteen series of short stigmata, muscle bands in inter-stigmatic series well developed. Endostyle large and tortuous. Branchial tentacles about ten, unequal in length, some of them quite long.

"Digestive Apparatus: Loop narrow, e-sophagus about equaling stomach in length, and also about equal both in thickness and length to the pyloric portion of the intestine. Stomach with three or four large longitudinal folds or lobes. A distinctly set-off enlarged section of the intestine following the pyloric portion. Ascending rectal limb of the intestine straight, uniform in diameter and parallel with the descending limb.

"Gonads: Far behind the intestinal loop in the post-abdomen, the testes further back and disposed in a number of spherical lobes."

LOCALITY: "Albatross" Station 4420, 3.8 miles off the east point of San Nicolas Island, California, in 33 fathoms, fine gray sand.

The genus *Psammaplidium* Herdman, 1886, in which this species was originally placed, is a mixed group in which various Synoicidae that have the test densely permeated with sand grains have been placed. But the larger part of compound ascidians have more or less sand embedded in the test, and that character provides no adequate basis for generic distinction. The group in question has been rejected by recent authors. (See also p. 445.)

Amaroucium coei Ritter, 1901

Text figures 16, 17

Amaroucium coei RITTER, 1901, p. 251, pl. 29, figs. 31, 32; HARTMEYER, 1924, p. 215.

Forms large pear-shaped masses, many of them loosely joined together by their narrow bases. They are, as a rule, very regular in form, the expanded upper part domed and oversetting the regularly narrowing peduncular part. Color in life light salmon, zooids more highly colored than the test. In preservation, color "ashen with a tinge of green,"

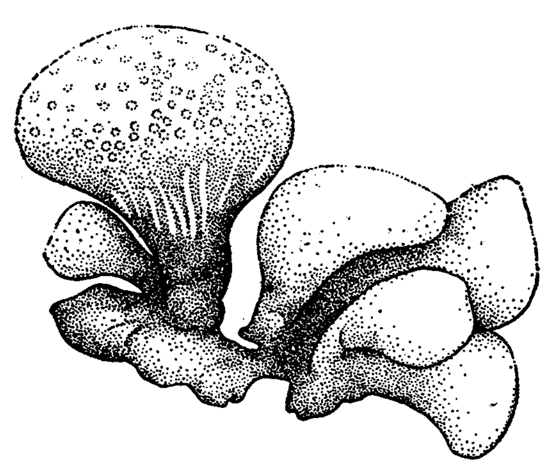


FIG. 16. *Amaroucium coei* Ritter. Colony, somewhat reduced. Adapted from Ritter's figure.

the zooids showing through rather indistinctly. Size of largest mass: height, 58 mm., diameter at widest part, 43 mm.; of a medium-sized mass: height, 33 mm., width, 20 by 24 mm.

Numerous small systems, usually of six or seven zooids, distinct in life, obscured in preserved specimens.

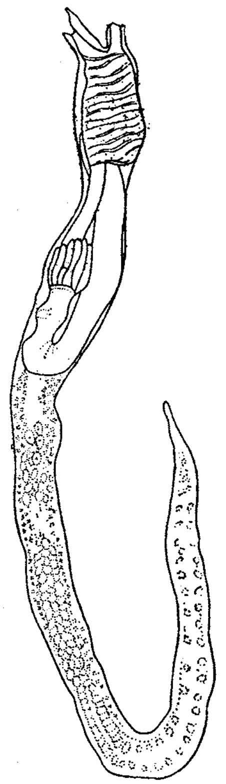


FIG. 17. *Amaroucium coei* Ritter. Zooid. Outline from Ritter's figure.

Zooids extremely long and slender; total length, including the very elongate post-abdomen, may reach about 25 mm.

Mantle musculature feeble. Both branchial and atrial siphons much alike; branchial six-lobed; atrial obscurely and irregularly lobed, usually with its anterior side extended with an "imperfect atrial languet, though frequently showing no indication of that structure." Branchial tentacles about 17, of several sizes; 11 to 16 series of stigmata; stomach usually somewhat longer than broad; folds of the wall well defined, extending throughout its length, usually regular but sometimes broken and anastomosing.

Post-abdomen very long and slender and of uniform diameter for most of its length. Ovary a short distance behind intestinal loop, rather small; testis beginning immediately behind the ovary and extending through almost the entire remaining portion of the post-abdomen, masses regular in size and form, nearly spherical, not crowded.

LOCALITY: Kodiak Island, Alaska. "Taken with the dredge near the wharf in St. Paul harbor in a few fathoms, rocky bottom with coarse pebbles and shells. Apparently very abundant here as every haul brought up a number of specimens."

Ritter also states that "in the form and size of the colony it is strikingly like *A. figarium* Ritter (MS.) from the coast of California, but the surface of the test of the latter species is firmly incrusted with sand." As far as I am aware no description of "*A. figarium*" has been published.

I have not seen any specimens that I could refer to *A. coei*, and the above description is condensed from that of Ritter.

Judging from Ritter's figure of the zooids, *A. coei* approaches the genus *Synoicum* in the form of the atrial siphon, in the broad compact mass of small rounded testes, and the feeble musculature of the mantle, not to mention the massive colony with numerous small systems composed of few zooids. It resembles more especially *S. kinkaidi* which also has the stomach wall plicated.

Amaroucium translucidum Ritter, 1901

Text figure 18

Amaroucium glabrum in part (Alaska specimens only) HARTMEYER, 1921a, p. 96; 1924, p. 195.

? *Amaroucium strandi* REDIKORZEV, 1937, p. 122, pl. 13, fig. 1, pl. 14, fig. 2.

Amaroucium translucidum RITTER, 1901, p. 249, pl. 30, figs. 29, 30; VAN NAME, 1910, pp. 411, 415. Not Hartmeyer, 1903; Redikorzev, 1906, 1907, 1908a, 1910; Derjugin, 1912, 1915, except in so far as Ritter's Alaska specimens are referred to.

This is a near ally of *A. glabrum*, but a careful study of Ritter's description and figures and of a colony from Pavlof Bay indicates that it should be recognized as distinct, although beginning with Hartmeyer's work of 1903, it has commonly been confused with that species.

A. translucidum forms capitate or pear-shaped colonies attached by a narrowed base and reaching a height of 15 mm. or more and a transverse diameter of 15 to 20 mm.

These colonies differ from those of *A. glabrum* in the greater transparency of the test; there is a light red tint suffusing the test as well as the zooids. The latter are both stouter and longer (10 to 12 mm. in the contracted state) than in *glabrum*, extending much of the height of the colony. They are closely crowded in the heads in an upright position. They have the mantle very thin and transparent with very weak, mainly longitudinal musculature. The post-abdomen is often long, much exceeding in length the thorax and abdomen together. The branchial aperture has six lobes which may be quite long and acute; the atrial is plain with a long languet which is often deeply three-cleft. The rows of stigmata usually number from nine to 11 with 18 or more stigmata in a row on each side.

The stomach presents one of the most conspicuous differences from *A. glabrum.* It is large and globular and, though its wall is longitudinally plicated, the folds are so narrow and numerous (usually 20 to 30) and, though distinct, so little impressed that they do not greatly affect the smooth rounded appearance of the stomach. Some of the folds are often somewhat irregular, interrupted or joined with adjacent ones. Ritter's figure of one of the zooids shows the intestinal loop in a very contracted condition. No valve-like constrictions are shown. In the Pavlof Bay colony mentioned below the intestine is much relaxed in some of the zooids, and the existence of an abruptly narrowed section of the intestine in the lower part of the loop is easily seen. The ascending part is of much larger diameter. Where the narrowed section enters it has a pair of more or less distinct, lobe-like caeca, the condition being like that shown in the figure of *A. solidum*, which seems to be quite closely allied to the present species.

LOCALITIES: Ritter's type specimens were collected at Orca, Prince William Sound, Alaska, on reefs at low tide. As mentioned above, the American Museum of Natural History has one from Pavlof Bay, dredged on a gravelly bottom in 13 fathoms by W. Williams. It does not appear to be a very northern species. The "*A. translucidum*" from Spitzbergen, the White Sea, Siberian Arctic Ocean, etc., reported by Hartmeyer, Redikorzev, and others is *A. glabrum.* On the

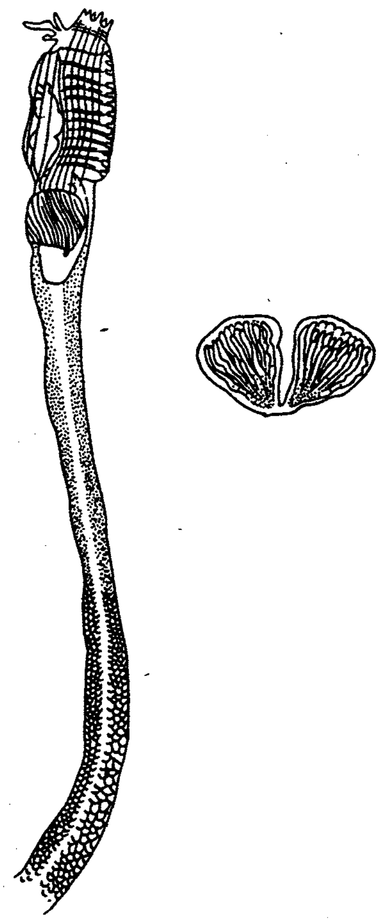


FIG. 18. *Amaroucium translucidum* Ritter. Zooid. Also two lobes of a colony somewhat reduced. Outlines from Ritter's figures.

other hand, *A. strandi* Redikorzev, 1937, from the Sea of Okhotsk, may be the present species.

Amaroucium dubium Ritter, 1899

Amaroucium dubium RITTER, 1899, p. 528; HARTMEYER, 1924, p. 215.

From its locality this species hardly comes within the scope of the present work, which is just as well, as almost nothing distinctive can be made out of Ritter's description.

The largest available fragment had evidently been attached to *Laminaria* roots, and measured about 3 cm. across and 1 cm. in average thickness. Color grayish, test dense, with some embedded sand in parts; zooids apparently arranged in small systems.

Zooids short, not over 4 to 5 mm. in total length in their greatly contracted condition: regions of the body indistinctly indicated, post-abdomen wide anteriorly, tapering toward the end. Branchial siphon with five lobes (unusual in *Amaroucium*), atrial with a short wide simple languet. Rows of stigmata apparently 10 to 12. Stomach wall "longitudinally ridged on inner surface though the ridges are not always regular and parallel. Apparently about 10 to 12 in number." Ovary compact, situated some distance back in the post-abdomen. Embryos present in the atrial chamber of a few zooids.

LOCALITY: Several fragments washed up on the shore of Copper Island, Commander group (Russian), in the Asiatic part of Bering Sea.

GENUS **SYNOICUM** PHIPPS, 1774

In the typical members of this group the colonies are massive or divided up into capitate lobes; the systems are small rounded groups each with a central common cloacal aperture; the zooids are elongated, averaging of rather large size and have many rows of stigmata; the branchial aperture is usually six-lobed, the atrial slightly extended in tubular form, with the anterior part of its margin produced into a three-parted languet.

The stomach has a longitudinal typhlosole; the rest of the wall is either smooth or areolated in a manner often described as "mulberry-like."

This genus appears to be bipolar in distribution, although centering in the region of the northern North Pacific, Bering Sea, Sea of Okhotsk, etc., but the validity of a majority of the described forms requires investigation.

Synoicum pulmonaria (Ellis and Solander), 1786

Plate 6, figure 1; text figure 19

Alcyonium pulmonaria ELLIS AND SOLANDER, 1786, Natural history of zoophytes, London, p. 175.

Amaroucium incrustatum SARS, 1851, p. 155.

Amaroucium pomum SARS, 1851, p. 155; 1859, p. 66; ALDER, 1863, p. 170 (*Amaroecium p.*).

Aplidium ficus SAVIGNY, 1816, p. 183.

Macroclinum crater VERRILL, 1871, p. 293, figs. 23–25; 1872a, p. 212; 1879, p. 27; HARTMEYER, 1903, p. 319, figs. 37–39, pl. 6, fig. 5, pl. 13, figs. 6, 7.

Macroclinum pomum HARTMEYER, 1903, p. 322; BJERKAN, 1905, p. 17; 1908a, p. 88; VAN NAME, 1910, p. 396, fig. 21, pl. 38, fig. 8; REDIKORZEV, 1910, p. 156, fig. 42; HARTMEYER, 1912c, p. 280.

Macroclinum pulmonaria HARTMEYER, 1914a, pp. 262–282, fig. 1.

Polyclinopsis haeckli GOTTSCHALDT, 1894, p. 353, pl. 24, fig. 3, pl. 25, figs. 1–4.

Synoicum haeckli HARTMEYER, 1903, p. 353, pl. 6, fig. 12, pl. 14, figs. 2–4.

Synoicum incrustatum HUITFELDT-KAAS, 1896, p. 18, pl. 2, figs. 23–25; BONNEVIE, 1896, p. 12; HARTMEYER, 1903, p. 352, pl. 6, fig. 11, pl. 14, fig. 5; BJERKAN, 1908a, p. 97; HARTMEYER, 1912c, p. 285; 1921, p. 140.

Synoicum pulmonaria HARTMEYER, 1921a, p. 101; 1922a, p. 29; 1924, p. 223; ÄRNBÄCK, 1923, p. 3, fig. 1; PROCTER, 1933, p. 285.

See especially Hartmeyer, 1914a, regarding the numerous synonyms of this species.

A large and conspicuous compound ascidian of the northern seas, forming massive spherical or more or less pear-shaped colonies attached by a rather small base or sometimes raised on a short thick peduncle. The test in alcoholic specimens is rather opaque and of firm consistency with a tough outer layer. The rounded colonies often have large flattened or even depressed areas on the surface and attain diameters of 75 to 100 mm. or even 130 to 140 mm. in some cases. Irregularly shaped colonies, sometimes divided into several lobes by deep clefts, also occur.

The surface is usually quite smooth; it may or may not be lightly incrusted with sand. In many cases the arrangement of the zooids in small circular systems of five to 12 individuals having a common cloacal aperture in the center can be easily seen. The color of the preserved specimens varies from yellowish white to gray.

The zooids were described and figured from an exceptionally well-expanded and well-preserved specimen by Van Name (1910, pp. 397, 398) from whom the following quotation is taken:

"The thorax and abdomen together measure about 10 mm. in length, but in the usual contracted state are of but half that length or less. The post-abdomen (the length of which is less affected by the contraction of the muscles) may itself measure fully 10 mm. in length. The muscles in the mantle form a network in which most of the fibers are longitudinal, but on the thorax a considerable number of oblique fibers and a few transverse fibers occur. The branchial orifice has six obtuse lobes. The atrial orifice is at the end of a short funnel-shaped tube situated well forward on the thorax, and is smooth-margined, with the anterior part of its border produced into a short languet, ending in three small finger-like processes.

"The tentacles, which appear to number about 12, are of two sizes placed alternately. The branchial sac has about 20 rows of moderately long stigmata. The number in a row on each side reaches 30 or even more. The stigmata begin close to the median dorsal vessel and extend close to the endostyle, which is narrow and inconspicuous. The stigmata at both ends of the rows are small, but reach their full length at a very short distance from the endostyle, while at the dorsal ends of the rows only the first two stigmata are generally perceptibly shortened. In the first or anterior series, however, the stigmata increase gradually in length to the middle point of the series and this is also true to some extent of the last series. The transverse vessels are not strongly muscular. The dorsal languets are short and hooked, and directed posteriorly, the recurved point bending toward the ventral side. They appear to have absolutely no connection with the median dorsal vessel, for they are placed about opposite the sixth or seventh stigma on the left side of the body, arising from the transverse vessels of the branchial sac. There are no languets on the right side.

"The intestinal loop is little or not at all twisted in most of the well expanded zooids, but in other cases it is (as usual in the genus *Amaroucium*) twisted through a full half turn, bringing the stomach, which is oval and longer than broad, to the dorsal side.

"In some specimens the stomach wall, which is very thin and easily thrown into irregular folds by the contraction of the animal, is, as noted by Alder (1863) and Bjerkan (1908), raised into numerous but very small shallow areolations which show no tendency whatever to be arranged in rows, but are quite irregularly though evenly distributed. In other specimens, it is difficult to detect the areolation. To what extent this is due to individual variation rather than to imperfect preservation, the writer will not attempt to decide from the limited material at hand."

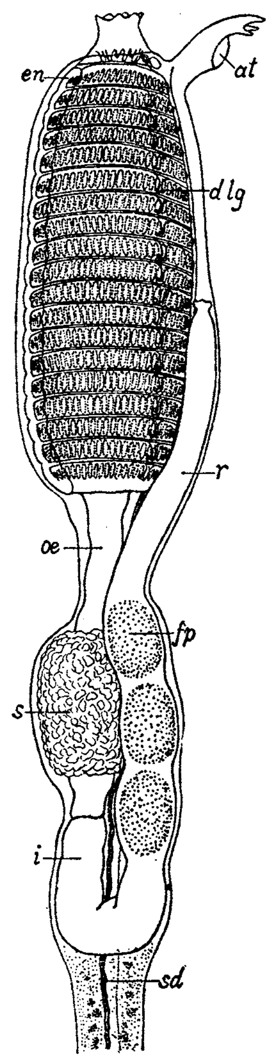


FIG. 19. *Synoicum pulmonaria* (Ellis and Solander). Zooid, ×12.

The colonies that I have been able to examine did not have well-developed reproductive organs. According to Ärnbäck, 1925, the ovary and the numerous small rounded male glands form a more or less compact mass in the anterior part of the post-abdomen, sometimes encroaching also on the abdomen beside the rear part of the intestinal loop. When the post-abdomen is much elongated the gonads do not extend into the posterior part. The oviduct and main sperm duct accompany the ascending part of the intestine and rectum. The oviduct is a thin-walled tube of rather large diameter; the ducts from the individual testes unite into several larger ducts which in turn join (but often not until reaching the abdomen) to form the main duct or vas deferens.

DISTRIBUTION: This species ranges from Spitzbergen (with one record from off the northern Siberian coast) to Iceland and the west coast of Greenland, extending southward in Europe to the North Sea, where it grows in abundance and reaches a large size on some of the fishing banks, especially the Dogger Bank and Great Fisher Bank, and to both sides of the English Channel. I cannot accept reports from much farther south (Sluiter, 1928, from off the coast of Morocco) without more confirmation. In American waters it is not common, but a few large colonies have been obtained on the Newfoundland Banks and one specimen from off Mount Desert Island on the Maine coast.

Nearly allied, if distinct, forms have been described from eastern Asiatic waters and Bering Sea, so this species may eventually prove to be circumpolar. (See *Synoicum jordani* below.) *S. jacobsoni* Redikorzev, 1927, from the Sea of Okhotsk and *S. derjugini* Redikorzev, 1927, from the Sea of Japan appear only doubtfully distinguishable from *S. pulmonaria*.

It is chiefly a species of quite moderate depths, the records ranging from a very few fathoms to over 300 fathoms in one instance, though most of them are not over 40 fathoms.

Synoicum molle (Herdman), 1886

Text figure 20

? *Aplidium incrustans* HERDMAN, 1886, p. 201, pl. 27, figs. 3–8. [Nothing to do with *Amaroucium incrustatum* (Sars) = *Synoicum pulmonaria*.]

Polyclinum molle HERDMAN, 1886, p. 194, pl. 25, figs. 7–9; HARTMEYER, 1912b, p. 335.

Although I do not believe that this species was correctly placed in *Polyclinum*, I do not know just where to put it. But *Synoicum* seems nearer than *Polyclinum*. Herdman says that the transverse vessels of the branchial sac are wide and have well-marked horizontal membranes but gives no indication of their bearing papillae. The post-abdomen is large and elongated with a tapering rear end, and does not resemble the post-abdomen of a typical *Polyclinum*.

The colony of the only specimen is an irregularly rounded mass 2.4 cm. by 3.3 cm. in diameter and 1.5 cm. thick; it is soft and readily torn and has some embedded sand.

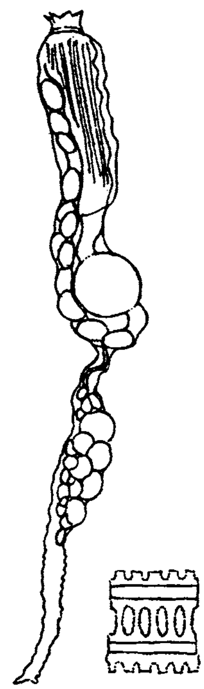


FIG. 20. *Synoicum molle* (Herdman). Zooid and small piece of branchial sac. Outlines from Herdman's figures.

The zooids which, when of average size, apparently have a total length of 7.5 mm. have a short pointed atrial languet. "The stomach is of large size and almost spherical, it is thick-walled, but smooth. . . . The post-abdomen is swollen in its upper part, where the reproductive organs are placed, and very narrow in its lower part, the edges are much corrugated.

"Fully developed tailed larvae were found in the peribranchial cavities of several of the zooids. The body of the larva is narrow and elongated. There is a single pigmented sense organ placed rather far back" (Herdman, 1886, p. 196).

Locality of only specimen of *Polyclinum molle*, "Challenger" Station 320, near mouth of La Plata River, 37° 17′ S., 53° 52′ W., depth 600 fathoms.

Aplidium incrustans, which I include here as a possible synonym, was obtained by the "Challenger" at the same station and very probably in the same haul of the dredge as *Polyclinum molle*. Herdman (1886, p. 203) says of it, "This species closely resembles *Polyclinum molle* in the external appearance and also in the structure of the test, but they differ notably in the form of the ascidiozoids and in the structure of the branchial sacs."

In the description, Herdman mentions several characters in the zooids of *incrustans* which at first sight would certainly exclude identity of the two species. "The branchial sac is stated to be very long, with 15 rows of stigmata with nearly twenty in each row in some cases; the stigmata are long and narrow." But as the figure of the zooid shows, the thorax in Herdman's specimen of *molle*, though much contracted, is still quite long; if more relaxed it might agree with the sac as described for *incrustans*. The relation between the length of the stigmata and width of the vessels is entirely changed by strong contraction.

The form of the body, including the abdomen and post-abdomen, is greatly dependent on the state of development of the gonads and on the contraction of the mantle muscles which are well developed in both species according to the descriptions. Of the stomach of *incrustans*, Herdman says only "the wall of the stomach is very much folded, the longitudinal ridges projecting into the interior." There is nothing in this statement to indicate that the "folded" condition may not be one caused by collapse of, and muscular pressure on, the stomach walls, or to indicate that a regular and permanent plication exists, as usual in *Amaroucium*, for instance.

The descriptions of the two supposed species are so inadequate (perhaps through the poor condition of the material) that the only thing that can avail to clear up the uncertainty will be a reëxamination of the types, if they still exist.

Synoicum adareanum (Herdman), 1902

Text figure 21

? *Amaroucium steineni* MICHAELSEN, 1920, p. 34.

Atopogaster elongata HERDMAN, 1902, p. 194, pl. 21, figs. 1–10 (not Herdman, 1886, see Hartmeyer, 1921, p. 278).

Atopogaster incerta HARTMEYER, 1911b, p. 512, pl. 55, figs. 1–4.

Lissamaroucium magnum SLUITER, 1906, p. 19, pl. 1, figs. 17, 18, pl. 4, fig. 53; HARTMEYER, 1911b, p. 514, pl. 54, fig. 13; HERDMAN, 1912, p. 102.

Macroclinum incertum HARTMEYER, 1909–1911, p. 1660.

Macroclinum magnum SLUITER, 1914, p. 30.

Polyclinum adareanum HERDMAN, 1902, p. 195, pl. 22, figs. 1–9; SLUITER, 1906, p. 13, pl. 1, fig. 11.

Synoicum adareanum HARTMEYER, 1921, p. 280. (See this article for information on the above synonyms.)

? *Synoicum georgianum* SLUITER, 1932, p. 11, figs. 9, 10.

? *Synoicum kohli* SLUITER, 1932, p. 14, figs. 11, 12.

? *Synoicum steineni* MICHAELSEN, 1907, p. 33, pl. 1, figs. 4, 5, pl. 3, figs. 21–24; 1920, p. 34; HARTMEYER, 1921, p. 279.

These various names appear to apply to an Antarctic species related to *Synoicum pulmonaria* of the northern seas and greatly resembling it in many respects, though more variable in the shape of the colony and in the lobation of the atrial aperture, and having a rather elongate, smooth-walled stomach provided with a typhlosole.

Some colonies are massive, irregularly rounded or more often ovate or somewhat elongate, usually somewhat loosely attached by a narrowed base at one end, which may form a very short, stout peduncle. They reach considerable size. Sluiter, 1906, figures an ovate colony 10 cm. high and 65 cm. in diameter in its middle part; Herdman, 1902, mentions one 14 by 12 by 10 cm. Young and small colonies are clavate in form, sometimes quite narrowly so, and often grow in groups or clusters. Herdman describes some of those obtained by the "Southern Cross" expedition as looking like nothing so much as a group of new potatoes.

The basal part of the colony is often rough, transversely wrinkled and incrusted with sand; the rest of the surface is usually fairly smooth and clean and bears the zooids arranged in small circular systems, usually of six to 10 individuals, with a small common cloacal aperture in the middle of each system. Small heads may contain only one system.

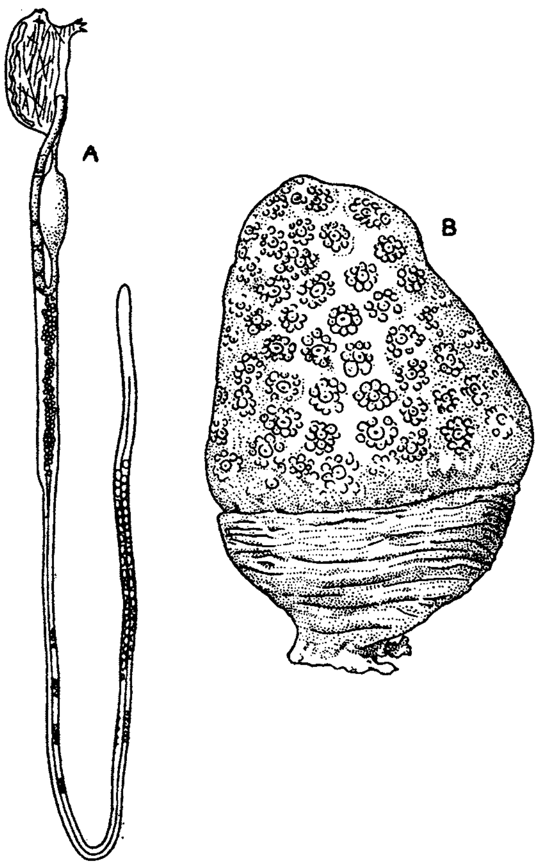


FIG. 21. *Synoicum adareanum* (Herdman). A. Zooid. B. Large colony two-thirds natural size. Outlines from Sluiter's (1906) illustrations.

The zooids are long and slender, sometimes reaching 20 to 30 mm. in length or even more when the post-abdomen is greatly developed. The branchial aperture is six-lobed; the atrial aperture is placed well forward and is more or less produced. It is subject to variation in the number and form of its lobes. The anterior part of the margin is apparently normally extended into a three-cleft languet. The posterior part of the margin may, however, also be lobed. About 12 tentacles of two sizes alternating; the number of rows of stigmata is very variable, often not over 14, but sometimes reaches 18 to 20, with a dozen or more in a row on each side. Areolation of the stomach wall, which is common in *S. pulmonaria*, does not appear to have been observed in this species. The intestinal loop is commonly not twisted. The gonads have the usual positions in the post-abdomen, the ovary in the anterior part, the testes extending a considerable part of the length of the post-abdomen.

DISTRIBUTION: Apparently a common and widely distributed Antarctic species. Type locality, Cape Adare (specimens washed up on the beach, Herdman, 1902). It was collected in some quantity at various points in the western Antarctic region by both Charcot expeditions and at Kaiser Wilhelm II Land by the Gauss expeditions. Depths range from 20 to 385 meters.

It seems very probable that its range extends to South Georgia also. Hartmeyer, 1921, calls attention to the close relationship of *S. steineni* Michaelsen, 1907, based on a single lot of specimens from Moltke Harbor on that island, and I am including it in the list as a probable synonym.

Two other supposed species of this genus from South Georgia were described by Sluiter, 1932, under the names *S. georgianum* and *S. kohli*. The statements and figures given show very close relationship to *S. adareanum;* and, considering that they are both based on only single specimens (each a group of small clavate heads), it seems very doubtful whether the differences described represent specific characters, or that sufficient justification for regarding them as distinct from each other or from *S. adareanum* is made clear.

Synoicum triplex (Sluiter), 1906

Text figure 22

Macroclinum triplex HARTMEYER, 1909–1911, p. 1471.

Psammaplidium triplex SLUITER, 1906, p. 23, pl. 2, figs. 21–22, pl. 4, figs. 51.

Based on two colonies of irregular massive form, the largest 7 cm. by 5 cm. in measurements.

The surface is smooth, the color gray, the test tough, transparent, and containing considerable sand. Common cloacal orifices were not found; the zoids lie with their axes in various directions, apparently without the least regularity.

The zooids reach 13 mm. in length. The branchial aperture is six-lobed; the atrial, situated a little way back on the thorax, is less distinctly lobed and without a languet. There are 13 rows of stigmata; the branchial sac is described as peculiar in that there is a broad strip on each side along the endostyle and another along the dorsal lamina which are not pierced with stigmata; the latter occupy only a strip about one-third the width of the sac on each side (see figure reproduced from Sluiter). There are only eight tentacles; the stomach is rather elongate, somewhat spindle shaped, and smooth walled.

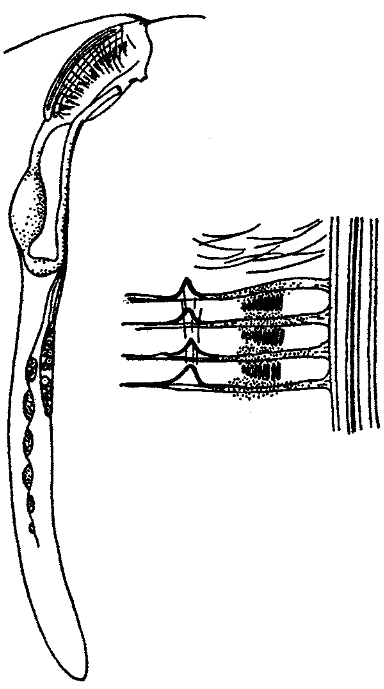


FIG. 22. *Synoicum triplex* (Sluiter). Zooid and part of branchial sac. After Sluiter.

The gonads were not greatly developed in Sluiter's specimens, the ovary was in the anterior dorsal part of the post-abdomen, the testes beside it and also extending farther back, but only occupying a part of the length of the post-abdomen.

LOCALITY: Western Antarctic. Schollaert Canal (two specimens).

Synoicum pererratum (Sluiter), 1912

Text figure 23

Macroclinum pererratum SLUITER, 1912, p. 458; 1914, p. 30, pl. 3, fig. 36, pl. 4, fig. 45.

Described by Sluiter from three large specimens, largest 10 cm. long and wide and 5 to 10 mm. thick. Apparently they were pieces of large colonies. They were attached by the lower surface; the zooids cause little dome-shaped elevations arranged in long curved or serpentine lines, often parallel and in some cases evidently double, on the surface of the colony, which is also roughened by embedded sand grains.

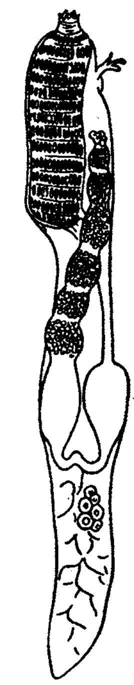


FIG. 23. *Synoicum pererratum* (Sluiter). Zooid. Outline from Sluiter's figure.

The zooids, which measure about 8 mm. in total length, of which 2.5 mm. is occupied by the post-abdomen, have a six-lobed branchial and plain-edged atrial orifice, the latter with a deeply three-parted languet. Sixteen tentacles, 13 or 14 rows of stigmata with 12 or 13 in a row on each side.

The stomach is described and figured as pear shaped and smooth walled. The ovary, situated a little way back in the post-abdomen, contains six or eight fairly large eggs; the greater part of the post-abdomen is stated to be filled with the "testicular vesicles."

LOCALITIES: Western Antarctic. Dredged by the second Charcot expedition near King George Island, South Shetlands, at two stations in 420 and 75 fathoms, respectively.

Synoicum par-fustis (Ritter and Forsyth), 1917

Plate 29, figure 1; text figure 24

Macroclinum par-fustis RITTER AND FORSYTH, 1917, p. 480, pl. 38, fig. 3, pl. 45, fig. 63.

See also *Synoicum pellucidum*.

Ritter and Forsyth describe the external appearance as follows: "Sand-encrusted, consisting of a few or numerous club-shaped

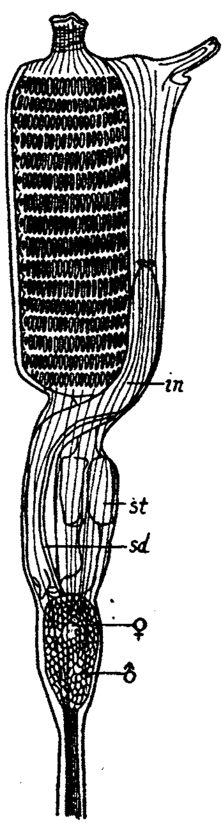


FIG. 24. *Synoicum par-fustis* (Ritter and Forsyth). Zooid. After Ritter and Forsyth.

masses each having a peduncle usually about twice as long as the more or less rounded head; masses connected together in colony by a stolonic basal network. . . . On smaller heads one common cloacal orifice present in center of anterior portion; on larger heads several such orifices occur, each surrounded by about twelve zooids. Branchial orifices indicated by slight, sand-covered elevations in preserved specimens. Test gelatinous and transparent, containing many small test cells scattered throughout its substance. Surface layer tougher and usually thickly embedded with sand grains" (Ritter and Forsyth, 1917, p. 480).

The individual heads are, according to my own observation, generally rather small, not over 10 to 15 mm. in diameter and 15 to 25 mm. in height including the pedicel, but occasionally much larger. Some groups of very fine specimens which I collected at Pacific Grove, California, contained pear-shaped heads up to 20 to 25 mm. in diameter and 50 mm. in height, of which the pedicel, into which the head tapered, formed about half the height. These colonies were only lightly incrusted with sand. The test was bright red and the zooids deeper red in life, so that they were of very handsome and striking appearance, but the colors fade out entirely in preservation.

"Zooids: Consisting of thorax, abdomen, and postabdomen; thorax a little longer than abdomen; total length about 1 cm.; long postabdomen terminating in an elongated granular mass, probably stored up nutrient material. Mantle very thin with numerous delicate longitudinal muscle bands extending entire length of animal; circular fibers in branchial siphon and a few irregular ones in mantle over upper part of branchial sac.

"Branchial System: Branchial orifice with six blunt lobes; atrial with flat truncated languet ending in three lobes. Branchial tentacles about thirty, of three sizes. Branchial sac with sixteen series of stigmata, from twenty-five to thirty stigmata in a half-series; a small space near the endostyle free from stigmata; stigmata next to endostyle smaller than others of a series. Endostyle straight and narrow. Dorsal languets with flattened bases which run into transverse vessels upon which they are situated, about as long as stigmata in anterior part of the sac, becoming a little longer and heavier toward posterior end of series.

"Digestive Apparatus: Esophagus emerging from middle of posterior end of branchial sac, about equal to stomach in length. Stomach roughly cylindrical, a little longer than wide, with a seam on left surface; wall granular on its inner surface, but not folded. Intestine extends posteriorly from stomach for a distance about equal to length of stomach, then makes a loop and after running parallel to stomach crosses esophagus on left side and ends in a bilobed anus less than half way up atrial chamber. In base of loop intestine narrows abruptly to enter rectal arm between two blunt caeca.

"Reproductive System: Gonad a pyriform elongated mass just behind intestinal loop, the numerous testicular lobes composing the great bulk of it; usually one well-developed egg and several much smaller ones, yellow in preserved specimens, situated in anterior of gonad, surrounded by testis lobes" (Ritter and Forsyth, 1917, pp. 480, 481).

The zooids of colonies in the collection of the American Museum of Natural History from the Monterey Bay region correspond so closely with the above description that there is little occasion for any comment, although it would perhaps be better to describe the stomach as rounded-oblong rather than cylindrical, the ends being much rounded; the "seam" mentioned is a typhlosole, a longitudinal furrow forming a ridge on the inner surface. Some of these specimens have the reproductive organs especially well developed and well preserved. The testes, which are of cuneate or pyriform shape, are numerous (often 50 or 60) and fill the post-abdomen, which is long and narrow, for a considerable length in its upper or anterior part. They do not, however, connect directly with a single sperm duct. There are several long parallel ducts which do not usually join together until the region of the intestinal loop is reached. After combining into two larger ducts they finally form one common duct in the region of the stomach. This common duct accompanies the rectum in the usual way. The ovary, usually consisting of only a few eggs of various sizes, is not situated anterior to the male glands but is more or less buried in the elongated mass that the testes form, some of the latter being anterior or to one side but more of them posterior to the ovary. The longitudinal muscle bands of the mantle are narrow and numerous and are loosely built up of slender fibers.

DISTRIBUTION: Southern California coast. Rocky shores at La Jolla (type locality), Santa Monica, and Pacific Grove, and dredged off San Pedro in 28 meters, according to Ritter and Forsyth (1917). At Pacific Grove it could be obtained in some quantity in the summer of 1939 and was one of the conspicuous species on account of its bright color.

NOTE: Huntsman (1912, p. 115) reports two species from Ucluelet, west coast of Vancouver Island, which he assigns doubtfully to the genus *Synoicum*: "*Synoicum* (?) sp. A" on rocks at low tide, and "*Synoicum* (?) sp. B" dredged in 5 to 10 fathoms, but gives no information about them.

Synoicum pellucidum (Ritter and Forsyth), 1917

Text figure 25

Macroclinum pellucidum RITTER AND FORSYTH, 1917, p. 482, pl. 39, fig. 9, pl. 45, fig. 62.

This species was based on a single lot of specimens and appears to be very closely allied to *S. par-fustis*.

The colony is made up of heads not unlike those of that species in size and form, each

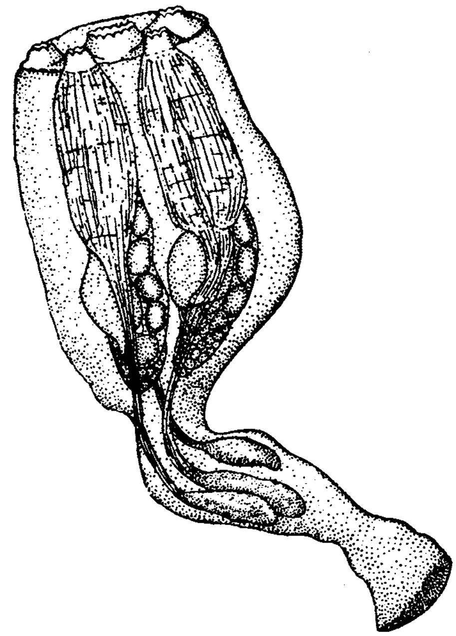


FIG. 25. *Synoicum pellucidum* (Ritter and Forsyth). One of the heads composing a colony, ×6. After Ritter and Forsyth.

containing a single system with a central common cloacal orifice. The common test is described as free from sand, and of almost glass-like transparency.

The zooids are also similar to those of *S. par-fustis* in size and many details of structure but have only 11 rows of stigmata or in young individuals still fewer, with about 20

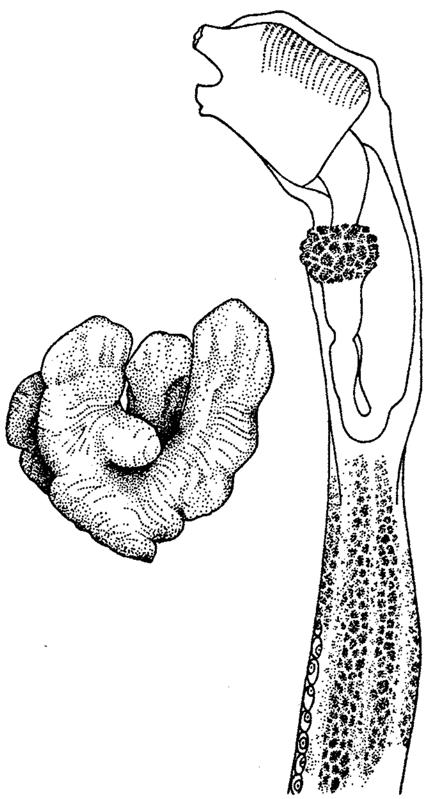


FIG. 26. *Synoicum irregulare* Ritter. Colony, somewhat enlarged, and zooid. After Ritter, 1899.

in a row on each side, and have about 20 branchial tentacles. The stomach is described as large, globular, and smooth walled, "the ovary and testis closely associated, mostly on the dorsal side of the intestinal loop when immature but extending behind it in maturity. Testicular lobes numerous and surrounding the comparatively few eggs located in anterior part of gonad." Tadpoles were found in the atrial cavity in July.

LOCALITY: La Jolla, California, on rocky shore between tides.

Synoicum irregulare Ritter, 1899

Text figure 26

Synoicum irregulare RITTER, 1899, p. 530, figs. 26–28; HARTMEYER, 1903, p. 350, pl. 6, fig. 10, pl. 14, fig. 1; 1924, p. 222.

? *Synoicum turgens* PHIPPS, 1774, Voy. North Pole, p. 199, pl. 13, fig. 3a–d; SAVIGNY, 1816, pp. 43, 180, pl. 3, fig. 3, pl. 15; SWEDERUS, 1887, p. 411; HARTMEYER, 1903, p. 349; 1914b, p. 1114; 1915a, p. 258; 1924, p. 219. Not Rink, 1857, p. 104 (erroneous report from Greenland; see Lütken, 1875, p. 139).

Ritter described this species from a number of colonies from one locality in Bering Sea; all were apparently in a rather degenerate condition. He mentions its evident close relationship to *S. turgens* Phipps of the European arctic regions, and, considering the condition of his material, his description does not appear to exclude the possibility of identity with that species.

The colonies are divided up into small lobes, each containing from three to 10 zooids. The longest lobes in his largest colony were 17 mm., 8 mm. thick at the base and 13 mm. thick at the summit. Test white or gray, semi-cartilaginous; very little sand or foreign matter on the surface. Apertures of the zooids not distinguishable on the surface of the colonies.

Zooids elongate, though the thorax was much contracted and was atrophied in most of the specimens. Branchial aperture six-lobed, atrial with a short languet whose lobulation was not determined; at least 17 rows of stigmata, stomach rounded (figured as areolated in Ritter's illustration). Reproductive organs evidently in poor preservation; testes distinguished with difficulty from the great mass of mesenchymatous matter filling the long post-abdomen. Ovary elongate and narrow, placed at one side of the post-abdomen.

LOCALITY: St. Paul Island, Pribilof group (Ritter's types). Hartmeyer (1903) assigns specimens collected by the "Vega" expedition in Bering Sea and reported as *S. turgens* by Swederus, 1885, and one in the Berlin Museum from Unalaska Island to Ritter's *S. irregulare*.

Synoicum jordani (Ritter), 1899

Aplidiopsis jordani RITTER, 1899, p. 521, figs. 19, 20.

Aplidiopsis sp. RITTER, 1898, p. 77.
Macroclinum jordani HARTMEYER, 1903, p. 322; REDIKORZEV, 1910, p. 157.
Synoicum jordani HARTMEYER, 1924, p. 236.
See also *Synoicum kinkaidi*, below.

Ritter placed this species in *Aplidiopsis* rather than in *Synoicum* in the belief that common cloacal apertures and systems were wanting. He based the species on a single damaged colony of massive rounded form with a small area of attachment found on the beach at St. Paul Island, Pribilof group. Hartmeyer, 1924, questioned (with much justification, I believe) the absence of systems and pointed out that the species was unquestionably a true *Synoicum* closely allied to *S. pulmonaria*, of which it can be considered the representative in the Bering Sea region.

The American Museum of Natural History has a number of colonies dredged in shallow water in Bering Strait by R. A. Bartlett which seem almost without question to represent Ritter's *jordani*. They are massive and of more or less rounded form, attached either directly by a small part of the lower surface or in the case of some of the smaller colonies, somewhat pedunculated or even capitate in shape. The longest reach a diameter of over 90 mm. Small rounded systems of six to 10 or more zooids with a common cloacal aperture can be seen at least on part of the surface.

I have been unable with the available material to find any reliable characters by which this form can be differentiated from *S. pulmonaria*, but feel it safer to continue to treat the two as distinct until more material can be studied.

Both the general character and appearance of the colony and the structure of the zooids of *pulmonaria* and *jordani* correspond closely. In the present species I have found the stomach smooth walled except for an internal projecting typhlosole, and nearly always without indications of areolation, but the preservation of the material was such that a small degree of areolation, if present, would have been very difficult to demonstrate. The reproductive organs are much as in *S. pulmonaria*. Though ordinarily situated in the anterior part of the post-abdomen, they may extend forward more or less into the abdomen as in that species. The position of the ovary is somewhat variable even in individuals of the same colony; in many cases it is close behind the intestinal loop and anterior to the testes, or sometimes farther back in the post-abdomen beside the testes or more or less buried in the rather broad closely packed mass that the male organs commonly form. The system of sperm ducts conforms to that of *S. pulmonaria*.

Ordinarily the group of testes, which are of small size, occupies only a part, sometimes only a small part, of the length of the post-abdomen, which tapers often quite abruptly into a long narrow extension which may be several times the length of all the rest of the body. In this extension no definitely formed reproductive organs are visible. When this part is well developed, the zooid may reach a total length of 20 to 25 mm.

DISTRIBUTION: The possibility that this form is inseparable from *Synoicum pulmonaria* has been discussed above. If a distinct species, its distribution, as far as now known, is limited to Bering Sea and Bering Strait in rather shallow water. Redikorzev, 1927, has described closely allied forms from the Sea of Okhotsk.

Synoicum kinkaidi (Ritter), 1899

Amaroucium kinkaidi RITTER, 1899, p. 524, fig. 21; HARTMEYER, 1903, pp. 334, 337; REDIKORZEV, 1910, p. 162; HARTMEYER, 1924, p. 214.
Amaroucium pribilovense RITTER, 1899, p. 525, figs. 24, 25; HARTMEYER, 1903, pp. 334, 335, pl. 6, fig. 6, pl. 13, figs. 8, 9; REDIKORZEV, 1910, p. 161, fig. 45; HARTMEYER, 1924, p. 214.
Amaroucium snodgrassi RITTER, 1899, p. 527, figs. 22, 23; HARTMEYER, 1903, pp. 334, 335; REDIKORZEV, 1910, p. 160; HARTMEYER, 1924, p. 214.
Amaroucium sp. RITTER, 1898, p. 77.
See also *Amaroucium coei* and *Synoicum jordani*.

The opinion expressed by Hartmeyer (1903, 1924) that these three supposed species, which all have nearly the same type locality, are probably identical is adopted in this work. But it seems evident from the form of the atrial tube and character of the stomach wall that they belong rather in *Synoicum* than in *Amaroucium* and are very closely related to, if really distinct from, *S. jordani*, whose type was also from the same islands.

The colonies are described as depressed and cake-like in shape instead of having the rounded or sometimes pedunculated form that prevails in *S. jordāni*, but as in that species they are thick and massive with small circular systems.

A study of Ritter's description and a supposed specimen in the American Museum collection show that the zooids also agree with those of *S. jordani* in most of their characters and are evidently subject to similar variations in form, size, number of rows of stigmata, and form of the post-abdomen due to the state of development of the reproductive organs. The most tangible difference from those of *S. jordani* appears to be in the wall of the stomach which is not described as smooth in any of Ritter's three forms. It has "irregular thickenings" in *kinkaidi;* irregular longitudinal folds "neither conspicuous nor numerous" in *pribilovense* while in *snodgrassi* the folds are more distinct, "about six extending the entire length of the organ and in addition two or three shorter and narrower ones on one side, in some cases these strongly suggesting the areolated condition." A tendency of the stomach wall "to become areolated between the furrows" in the case of *pribilovense* and of distinct indications of areolation in that of *kinkaidi* are likewise mentioned in the descriptions.

As in *S. jordani* the post-abdomen may become of considerable length; 10 mm. is mentioned by Ritter for *pribilovense* and 12 to 15 mm. for *snodgrassi.*

DISTRIBUTION: The type and only localities of Ritter's *A. kinkaidi* and *A. pribilovense* are St. Paul Island, and of *A. snodgrassi*, St. George Island, of the Pribilof group, all evidently from quite shallow water.

The American Museum of Natural History collection has an irregularly rounded colony about 20 mm. in diameter that may be of this dubious species. It is attached by a narrowed base and was from Pavlof Bay on the Alaskan Peninsula, dredged in 13 fathoms (volcanic mud) by the yacht "Stranger," Capt. W. Williams. The zooids have the post-abdomen very elongate; their stomach wall (which is quite thin) is distinctly plicated longitudinally though the folds are few and of slight elevation. Very small papilla-like elevations (especially noticeable on the ridges of the folds) gave a slightly areolated appearance to some parts of the stomach.

Synoicum cymosum Redikorzev, 1927

Synoicum cymosum REDIKORZEV, 1927, p. 399, figs. 19, 20.

Usual shape of the colony that of a short inverted cone attached by the smaller end and more or less flat topped. Surface with small papillae which on the sides of the upper part of the colony are more or less acute and arranged in vertical rows. Stomach of zooids with coarse areolations. In other respects the characters conform to those of *S. pulmonaria* and *S. jordani.*

DISTRIBUTION: Recorded by Redikorzev, 1927, from several localities in the Sea of Okhotsk in 20 to 63 meters. The American Museum has a rather small colony labeled *cymosum* by, and received from, Redikorzev in 1937, obtained in Bering Sea in latitude 62° N., longitude 179° 15′ W., August 28, 1933.

The papillation of the surface in this specimen is not very strikingly developed. The condition of preservation of the stomach makes it hard to determine how much areolation of the wall is present. In this specimen at least, the differences from *S. pulmonaria* and *jordani* do not appear at all impressive.

GENUS **APLIDIOPSIS** LAHILLE, 1890

An imperfectly understood, if valid, genus evidently quite closely related to *Synoicum* but differing in having a superficial resemblance to *Polyclinum* in the smooth-walled stomach and in the post-abdomen of sac-like (though elongate) form which is connected with the abdomen by a constricted neck, though the transverse vessels of the branchial sac lack the papillated condition characteristic of *Polyclinum.*

Hartmeyer, 1924, placed the Alaskan species *pannosum* and *globosum*, included in *Polyclinum* by Ritter (1899), in the present genus, as the absence of papillae on the vessels of the branchial sac proved that they did not belong in *Polyclinum.* I follow Hartmeyer in this, but unite Ritter's two species under the specific name which has page priority, as the probability of their identity seems very strong.

Aplidiopsis pannosum (Ritter), 1899

Text figure 27

Aplidiopsis pannosum HARTMEYER, 1924, p. 187.

Aplidiopsis sphaeroides HARTMEYER, 1924, p. 187.

Polyclinum sp. RITTER, 1898, p. 77.

Polyclinum globosum RITTER, 1899, p. 518, figs. 14–16; HARTMEYER, 1903, p. 317. Not Herdman, 1899; Sluiter, 1906.

Polyclinum pannosum RITTER, 1899, p. 519, figs. 17, 18; HARTMEYER, 1903, p. 316; 1909–1911, p. 1461.

Polyclinum sphaeroides (new name for *globosum*, antedated) HARTMEYER, 1909–1911, p. 1461.

The colonies vary from globose to somewhat irregularly ovate form, and in the latter case were apparently attached by a small area near one end or along one side. The largest was, when entire, 95 by 45 mm. in diameter; the others are much smaller. The test is moderately firm externally, though softer in the interior part, and of brownish color, sufficiently dark and opaque to render the yellowish zooids only indistinctly visible. The surface of the colonies is smooth in parts, but in most places roughened and often has some adhering sand. Neither the branchial nor the common cloacal apertures are clearly distinguishable. The zooids, however, appear to be arranged in rather small systems; their bodies are variously curved and lie at different angles to the surface. I could not observe the fibrous structure of the test in the central part of the colony which is mentioned by Ritter, 1899.

A zooid may attain 5 mm. in length, exclusive of the post-abdomen, which is narrow and elongate and may, if well developed and straightened out, add another 5 or 6 mm. to the length, though usually it lies curved or bent at an angle to the body axis. The post-abdomen is joined to the left side of the abdomen by a narrow neck. The branchial tube is very short or is represented by a mere raised border; its opening has about six very short lobes. The atrial orifice is close to the anterior end and is directed obliquely forward. Its margin is smooth, or nearly so, and a cowl-shaped atrial languet usually extends over it like a hood. The languet varies much in length and width in different zooids; it is commonly long and large and sometimes slightly three-cleft at the tip.

The mantle is thin and transparent. The apertures have weak sphincter muscles of slender fibers; on the body the muscles are principally confined to the anterior parts of the thorax and consist of slender irregularly longitudinal and oblique fibers. These muscles cause more contraction of the anterior than of the posterior part of the sac, making it difficult to count accurately the oral tentacles which are of at least three sizes. The number given by Ritter is about 24.

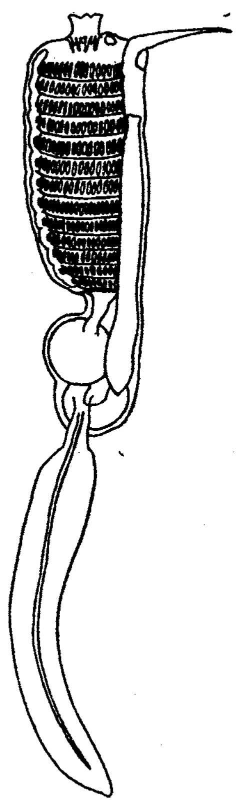


FIG. 27. *Aplidiopsis pannosum* (Ritter). Zooid, ×9.

There are about 13 (11 to 14) rows of stigmata with apparently at least 18 on each side in some of the rows. The dorsal languets are large and well developed. The transverse vessels of the sac are muscular; they do not bear inwardly projecting papillae as in the genus *Polyclinum.*

The stomach is rounded and except for an internally projecting typhlosole has a thin, smooth wall which may become creased or folded in preservation. The oesophagus enters the stomach more or less on the dorsal side, not on the anterior aspect. The loop of the alimentary canal is slightly, or not at all, twisted; and there may be two conspicuous constrictions beyond the stomach. The rectum is straight and ends at a point anterior to the middle of the thorax in an expanded aperture.

The ovary in Ritter's figure was represented by a group of eggs quite far back in the posterior part of the post-abdomen, the rest of which was filled by the small testes and cellular tissue of uncertain character. The eggs undergoing development are mostly crowded in the right posterior part of the atrial cavity.

DISTRIBUTION: Alaska. The type locality of both Ritter's species, here considered identical, was St. Paul Island of the Pribilof group.

The only specimens that I have seen that may belong to it are several small rounded sessile colonies about 12 mm. in maximum diameter received by the American Museum of Natural History from W. Williams of the yacht "Stranger," dredged in 15 fathoms near Montague Island, Prince William Sound.

Redikorzev, 1927, has described a related species, *A. helenae,* from the Sea of Okhotsk.

GENUS **POLYCLINUM** SAVIGNY, 1816
(Syn. *Glossoforum* Lahille, 1886)

Though it was well described and figured by Savigny, the characters and limits of this genus have been imperfectly understood by many authors. It happens to have a smooth-walled stomach, and many Synoicidae that are by no means closely related to it have been wrongly placed in it for that reason. Its chief peculiarities are three in number: the transverse vessels of the branchial sac have on their inner or free margin a series of minute papillae; second, the part of the .intestine behind the stomach (that part only) is twisted into a closed loop; third, the post-abdomen is an ovate or moderately elongated sac connected with the abdomen by a quite long and narrow neck, usually extending laterally instead of directly posteriorly from the abdomen. The genus *Glossoforum* Lahille was supposed to be distinguished from *Polyclinum* by having the above-mentioned branchial papillae, but Hartmeyer, 1916, discovered that all true *Polyclinums* have them and that the two genera are synonymous.

Other characters of *Polyclinum* are the massive, more or less gelatinous colonies with small systems in which the zooids are arranged along radially extending cloacal canals often quite symmetrically developed about the rounded common cloacal apertures whose margin is provided with minute papillae; the weak, chiefly longitudinal mantle musculature and the long branchial sac with many rows of stigmata; the six-lobed branchial aperture; the large and long atrial languet, which takes part in forming the roof of the cloacal canal into which the zooid discharges.

Zooids in the central part of a system have the tip of the atrial languet truncated and taking part in forming the border of the common cloacal aperture and bearing some of the marginal papillae of that aperture mentioned above. In zooids farther from the center of the system the languet tapers off to a narrow tip.

The true *Polyclinum* are all very closely related to each other, their zooids apparently having nearly the same structure, so that we must depend chiefly on the gross charaters of the colonies for distinguishing them. A supposed difference in the number of branchial tentacles (whether in multiples of four or six) appears to be of questionable value as a specific character, multiples of six being probably normal, though subject to irregularities.

Polyclinum constellatum Savigny, 1816

Plate 13, figures 2, 3; text figure 28

Polyclinum brasiliense MICHAELSEN, 1923, p. 3, fig. 1.

Polyclinum constellatums SAVIGNY, 1816, p. 189, pl. 4, fig. 2, pl. 18, fig. 1 (translation, with illustrations, in Isis, 1820); HARTMEYER, 1912b, p. 334; 1916, p. 429; MICHAELSEN, 1919a, p. 87; 1920, p. 10; VAN NAME, 1921, p. 299, figs. 1, 2; MICHAELSEN, 1923, p. 8; VAN NAME, 1930, p. 422, fig. 3; PLOUGH AND JONES, 1937, p. 100.

Polyclinum festum HARTMEYER, 1905, p. 401, pl. 13, figs. 6, 7; 1916, p. 429; VAN NAME, 1918, p. 162, fig. 111.

Polyclinum sp. HARTMEYER, 1908, p. 111; 1916, p. 430.

For other possible synonyms, see the above articles by Michaelsen.

This species usually forms colonies of a grayish or purplish brown color which, when of small or medium size, tend to assume a capitate oval or pyriform shape. The attachment is by the smaller end; the top may be rounded or more or less flattened. Larger colonies often become broader and sometimes even assume expanded and flattened or umbrella-like forms, but the area of attachment is usually small, so that much of the base of the colony, as well as the sides and top, is free, though the zooids are chiefly confined to the upper portions. In some cases the basal part of the colony tapers gradually to the size of the attached area, but a distinct pedicel is rarely developed, not even a very short one, the colony being sessile on the object on which it grows. Some colonies are cleft into two or more distinct lobes; these are perhaps often separate colonies that have grown together more or less at the base. Naturally, among the numerous examples collected, there are many which vary greatly in shape from the above-described usual types.

In all but the smallest colonies the zooids are arranged in several or many distinct systems. The small, round, or oval, common cloacal orifices are scattered over the surface of the colony at distances of a centimeter apart, or less. Each orifice opens from a small common cloacal cavity, into which several branching cloacal ducts or groups of individual ducts open. These lead from the atrial orifices of the individual zooids; the latter are arranged in short, curved rows and clusters. The arrangement of the zooids and manner of branching of the cloacal ducts are shown in the figure. In many specimens the anterior ends of the zooids, the small six-lobed branchial orifices, and the cloacal orifices may be

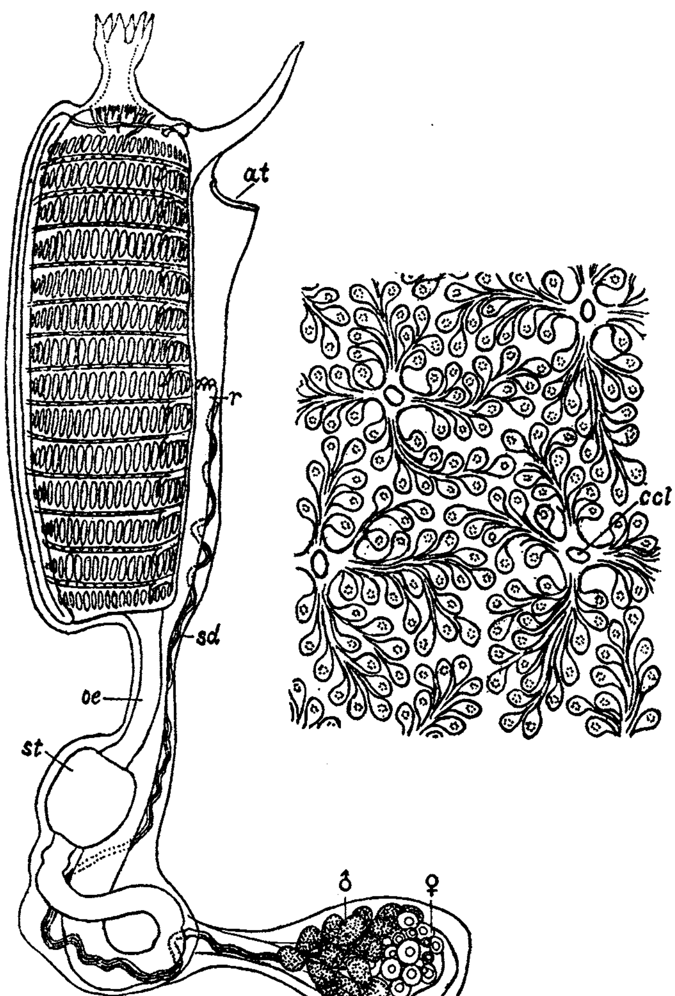


FIG. 28. *Polyclinum constellatum* Savigny. Zooid, ×30, and part of surface of colony showing branchial and common cloacal apertures, ×4.6.

very distinctly seen on the surface, and the course of the cloacal ducts and the limits of the systems very easily followed. In other cases, at least in alcoholic material, some or all of these features may be greatly obscured by the dark pigmentation of the test and the contracted condition of the colony.

The pear-shaped or ellipsoidal colonies become 30 to 40 mm. high and 30 to 60 mm. in diameter near the top, or occasionally larger. One very low but wide colony is 160 mm. across the upper surface, though no more than 18 to 20 mm. high at any point, its attachment being by a small central area on the lower side. Surface of colony generally smooth but not shiny, and generally free from incrusting sand; if a coating of sand is present, it does not pervade the interior of the colony to any considerable extent. Test usually dark-colored, of gelatinous consistency. In the alcoholic specimens, at least, it is much firmer toward the outside of the colonies than in the center, where it becomes very soft, and there may be a large cavity. This, however, does not have any connection with the cloacal cavities. The dark color is due chiefly to pigment grains in the test cells and in some of the cells in the tissues of the zooids. A few colonies show, in the preserved state at least, very little pigmentation, and are yellowish or light grayish. Zooids, when expanded and straightened out, often 5 to 6 mm. long.

Four orders of tentacles, totaling about 32, often quite regularly arranged.

Dorsal languets narrow and pointed, arising from the median dorsal vessel but fused with the transverse vessels of the left side of the branchial sac for a distance equal to the width of four or five stigmata so that they appear to arise from the transverse vessels.

Branchial sac with 14 to 18 rows of stigmata with from 18 to 22 stigmata in a row on each side of the body, except in the most posterior rows, where the sac becomes narrower and the number a little fewer. The transverse vessels bear very minute papillae projecting inward into the cavity of the branchial sac; they do not correspond in number to the stigmata but are somewhat fewer, though arranged along the vessels with considerable regularity.

The digestive tract has the peculiar course characteristic of this genus, the intestine being twisted to form a small, closed loop posterior to the stomach; the latter is smooth walled. The rectum is rather long, extending to about the middle of the thorax, where it ends in a six-lobed aperture.

The anterior part of the post-abdomen is occupied by the male reproductive organs, which consist of a group of 20 or more small pyriform or oval testes. Their common sperm duct extends through the pedicel of the post-abdomen into the abdomen and then accompanies the intestine almost to the end of the rectum. The more posterior part of the post-abdomen contains the ovary, visible as a group of eggs in various stages of growth; the heart is in the extreme end.

DISTRIBUTION: Savigny described *P. constellatum* from Mauritius, but I cannot find sufficient reason for distinguishing the West Indian form from his species which appears to be of very wide distribution. *P. festum* Hartmeyer, type locality Mauritius but apparently occurring eastward to the Malay region and Hongkong, including the Philippines, and at St. Helena Island, and possibly other forms from the warmer parts of the Old World, is also inseparable from it.

The American specimens that I have examined are from the west coast of Florida (depths down to 26 fathoms), including Tortugas; off the north coast of Yucatan (24 fathoms); Bahamas; Cuba (Cienfuegos); Jamaica; Puerto Rico (Guanica, on piles); Santo Domingo; and Sabanilla, Colombia. One specimen appears to have grown on a crab.

I believe that it ranges south on the eastern South American coast to the vicinity of Rio de Janeiro, as I have examined specimens which, though small and rather poor and not altogether conclusive, I would assign here. Michaelsen, 1923, described a species, *P. brasiliense*, from that same region (in 30 fathoms off Praiado Furado) based on a colony which he describes with great minuteness, but without disclosing any characters to hinder assigning it to the present species, although he found somewhat fewer stigmata (about 12 to 15) in a row on each side of the sac.

Polyclinum laxum, new species

? *Polyclinum saturnium* SAVIGNY, 1816, p. 190, pl. 19, fig. 1 (translation, with illustrations, in Isis, 1820); HARTMEYER, 1916, p. 424; MICHAELSEN, 1920, p. 9; 1930, pp. 543, 546.

Specimens of *Polyclinum* from the Gulf of California are apparently different from those (*P. planum*) from the west coast of the United States.

The colonies are of somewhat depressed ovate form, or "potato-shaped" to use a term that has been employed by some writers on ascidians, and which well enough describes the form and size of the larger examples. They were evidently attached by a considerable area on one side; the largest is about 55 mm. in longest diameter.

The test has a fairly tough outer layer, but internally it is soft and gelatinous, allowing the shape of the colony to be easily distorted and the surface to become wrinkled.

The surface when bare is smooth and glossy, but in part is covered by a thin layer of coarse grains of calcareous sand which by not covering the apertures often discloses the form and extent of the systems. These are rather few and quite extensive; long canals with zooids in a row along each side branch out from the positions of the common cloacal apertures.

The test in formaldehyde specimens is rather light brown with usually an olive or occasionally a slight purplish shade. It is sufficiently translucent to allow the yellowish zooids to be more or less visible through it. The collector's notes describe it as "mahogany colored" in life.

I know of no characters in the zooids by which the zooids can be distinguished from those of *P. planum*, or for that matter from various other described species of the genus. In the individuals examined 12 or 13 rows of stigmata were found, with at least 18 or 19 in a row in some cases. Many of the zooids (specimens collected in April) contained a number of developing eggs and larvae in the atrial cavity. While the condition of the material did not allow me to be very certain, I am inclined to believe that these are not loose in that cavity but are contained in, and undergo development inside, a very thin-walled expansion of the oviduct. If this is correct it may very likely prove true throughout the genus.

DISTRIBUTION: Gulf of California in shallow water. This species is based on colonies collected by E. F. Ricketts at Gabriel Bay on Espiritu Santo Island (the type locality), where it was abundant. Some of the colonies were attached to living shells of the mollusk *Chione*. It was also obtained at Mogote near La Paz. Type in the American Museum of Natural History (A.M.N.H. No. 1742), which also has small specimens found on pearl oysters from the "Gulf of California" without more definite locality. Three small button-shaped *Polyclinum* colonies in the United States National Museum collection, the largest 14 mm. in maximum diameter and apparently originally attached by a part of the under side, which were collected at Salinas, Ecuador (also one from shore rocks at Clipperton Island, Galápagos) by Waldo L. Schmitt, may be referable to this species, but fail to exhibit sufficiently definite specific characters for any positive decision for or against that view.

The resemblance of the Gulf of California form to *P. saturnium* Savigny, 1816, from the Gulf of Suez is, in the present incomplete state of our knowledge, so close that the main objection to including it in Savigny's species is the extremely wide geographical separation of their habitats. I have been strongly inclined to do so, yet much as I regret to add another to the list of unsatisfactorily distinguished species of this genus, the possibility of error and increased confusion through a premature adoption of that course makes it seem advisable to treat the Gulf of California form as a new species for the present.

Polyclinum planum (Ritter and Forsyth), 1917

Text figure 29

Glossophorum planum RITTER AND FORSYTH, 1917, p. 479, pl. 39, fig. 13, pl. 46, fig. 71; JOHNSON AND SNOOK, 1927, p. 597, fig. 697.

Polyclinum planum RICKETTS AND CALVIN, 1939, p. 77, fig. 34.

"Larger colonies pumpkin-seed shaped, smaller ones spherical, all having short, thick, cylindrical peduncles; outline regular, surface smooth, free from sand or other foreign substances; systems distinct and regular, zooids plainly seen through test; common cloacal orifices open and very distinct even in preserved specimens. Color grayish brown, much the same in living and preserved specimens. Length of about maximum-sized colony 10 cm., width 5 cm., thickness 1.5 cm. The test consisting chiefly of a well-defined central core into which zooids do not extend;

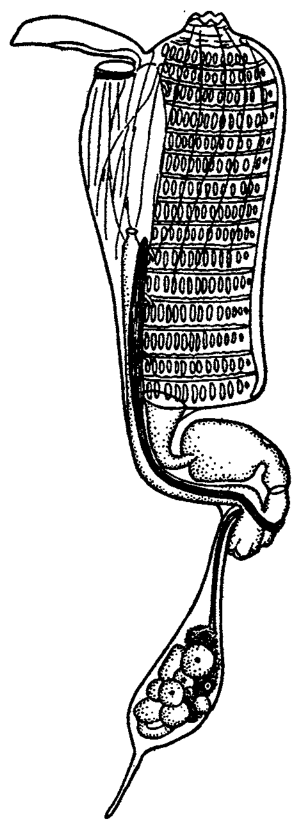


FIG. 29. *Polyclinum planum* (Ritter and Forsyth). Zooid. From figure of Ritter and Forsyth.

small in quantity among zooids; matrix semicartilaginous and transparent, but containing a great number of very small pigmented cells which impart to it a somewhat dirty tinge; portions among zooids containing scattered, rather small bladder cells; central core thickly penetrated by thin-walled transparent stolons to which zooids are always attached.

"Zooids numerous, distinctly seen through test, arranged in very regular systems, on an average about a dozen individuals in a system, occasionally as many as twenty in a system. The three regions of body, thorax, abdomen, and postabdomen, distinctly set off from one another, making it difficult to extract zooids entire; never much contracted; little pigment matter in tissue; musculature very feeble; mantle thin and transparent; entire structure easily made out by examining animals *in situ* in slices of colony. Length of zooids about 4.5 mm.; length of branchial sac about 3 mm.; postabdomen slightly longer than abdomen; musculature very weak. . . .

"Branchial orifices easily seen on surface of colony; each with six broad scallops when fully expanded, but becoming pointed lobes upon contraction. Atrial orifice overarched by a long broad languet often truncated but sometimes with three delicate terminal lobes; size and shape of languet depending upon age of zooid and its position in system. Tentacles eighteen to twenty-six, of three lengths, the six longest nearly as long as the half-diameter of circle in which they are situated. Number of series of stigmata from thirteen to seventeen; about thirteen or fourteen very regular stigmata in each half-series; number of series as well as number of stigmata increasing with age of zooid; a small muscle band in each inter-stigmatic vessel; papillae on interstigmatic vessels regular in size and arrangement, there being one for the interval between every two stigmata" (Ritter and Forsyth, 1917, pp. 478, 479).

The zooids correspond too closely to those of *P. constellatum* described above to require a full description. The peculiar laterally flattened pedunculated form of the colony, which, moreover, is of firmer consistency than that of the sessile species of the genus, is the best specific character. It is, moreover, the only member of the genus recorded from the Pacific coast north of Mexico.

"DISTRIBUTION: Species widely distributed on California coast, it having been found at almost every point where ascidian collecting has been done, from Mendocino to San Diego. It is confined to rocky localities, but not to the littoral zone, judging from the frequency with which it is washed ashore. To what depths it extends is not known as it has never been taken by dredge or trawl.

"At San Diego it occurs on the United States Government breakwater at the entrance of the bay; also on the breakwater at Coronado. In these localities it is not confined to the under surfaces of rocks, but grows on their tops and sides.

"Type Locality: San Diego, California" (Ritter and Forsyth, 1917, p. 480).

Apparently San Diego is near its southern limit of distribution, though there is a large specimen labeled "Lower California" in the United States National Museum collection.

GENUS SIGILLINARIA OKA, 1933

This genus was established by Oka for a species collected at Sakhalin Island and Kamtchatka. Oka briefly characterizes the genus as follows:

"Colony branched in a tree-like manner with short club-shaped thick branches. Zooids with body in three divisions, thorax, abdomen and post-abdomen. Apertures both six-lobed, opening directly on the surface of the colony. Gonads hermaphrodite, both testes and ovary in the post-abdomen" (Oka, 1933, p. 78).

In his description of the only species, *S. clavata*, Oka brings out other characters of the genus, which he considers intermediate between the Polycitoridae and Synoicidae, although I do not think that its place in the latter family can be doubted.

The two following species from the American Pacific coast, which are evidently closely allied to each other and out of place in the genera (*Distoma*, syn. *Polycitor*, and *Amaroucium*, respectively) in which they were placed by their describer, appear to fit pretty well into Oka's genus, where I am accordingly placing them.

They appear to be distinct from Oka's species which has more numerous rows of stigmata and a smooth-walled stomach.

Sigillinaria pulchra (Ritter), 1901

Plate 29, figure 3; text figure 30

Distoma pulchra RITTER, 1901, p. 243, pl. 30, figs. 24, 25.

Polycitor pulcher MICHAELSEN, 1920, p. 7.

The colonies of this species are quite well described by Ritter as "composed of sheaf-like bunches united by their basal ends, each bunch usually containing from 10 to 20 large zooids." These "bunches" are themselves more or less cleft at the anterior end where the zooids project beyond the surface, commonly only to the extent of forming rounded elevations, but sometimes a large part (or, according to Ritter, the whole) of the thorax of the zooids extends out and is provided with its own individual covering of test, approaching the condition in *Clavelina picta* described elsewhere in this work.

The colonies thus formed are of inversely conical or capitate form and may reach 20 to 25 mm. in height and half that in diameter at the top (the widest part), or remain smaller. Several of them may join at the base, but so far as I have seen they do not unite

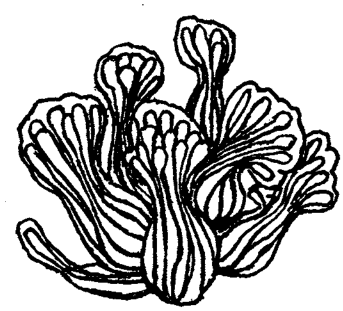


FIG. 30. *Sigillinaria pulchra* (Ritter). Group of heads, natural size.

into extensive colonies nor form any extended basal mass of test.

The test is colorless and remarkably transparent, especially in the upper parts of the heads; it contains no bladder cells; the zooids of those that I collected were bright red in life and clearly visible through the test, making the colonies very beautiful and conspicuous objects among the various other ascidians and animals of other classes which cover the intertidal zones of the rocks on the Pacific coast.

The zooids may extend nearly to the base of the heads, their length thus nearly equaling the height of the latter. The apertures are on fairly long tubular siphons; both are bordered by six rounded lobes separated by fairly deep clefts. The thorax is the widest part of the zooid; a contracted neck, often quite long, intervenes between the thorax and the abdomen.

The mantle is delicate and transparent, with its musculature (aside from the sphincters of the siphons) composed mainly of some slender, obliquely longitudinal bands running from the anteroventral region of the thorax dorsally and posteriorly. They extend onto, and become very diffuse and inconspicuous on, the abdomen.

Ritter gives the number of branchial tentacles as about 12; there may, however, be some additional smaller ones. There are eight to 10 rows of stigmata; the number in a row on each side may considerably exceed 20 in large zooids, though in those I examined I did not find as many as 35, the number which Ritter gives. The dorsal languets arise from the left margin of the median dorsal vessel, which is wide, and the adjacent part of the transverse vessels. The latter bear rather wide internally projecting membranes.

Owing to the form of the body, the oesophagus and ascending part of the intestine are long. The stomach is large and of oblong shape; its wall is thin and longitudinally plicated, sometimes in parts a little irregularly; the plications form about six to eight wide projecting ridges. The intestinal loop behind the stomach is rather short; a pair of sac-like caeca can be demonstrated in some individuals at the beginning of the enlarged ascending part of the loop. Ritter gives no satisfactory description of the reproductive organs. All he says of them is as follows: "Situated in the intestinal loop; ovary composed of numerous cylindrical often anastomosing branches. No specimens in reproductive activity at hand." No member either of the Polycitoridae or the Synoicidae has gonads of any such type, and it is pretty clear that Ritter's specimens were not in condition to afford him a correct understanding of the gonads.

Some of the specimens I had available had the gonads very well developed. They are of the usual *Amaroucium* type; the ovary, consisting of a group of eggs of different sizes, is in the anterior part of the post-abdomen just behind (in some individuals partly beside) the intestinal loop. The larvae develop in the atrial cavity. The testes are numerous, small, and irregularly rounded or ovate, and though often irregularly arranged in the part of the post-abdomen just behind the ovary, become arranged in a more regular double series farther back. The abdomen usually extends much farther back than the last of the testes; this extension may be very slender or be somewhat widened and filled with opaque granular or cellular tissue.

There is apparently no question that this species is a member of the Synoicidae related to "*Amaroucium aequali-siphonis*" Ritter and Forsyth, 1917, and not a *Distoma* (syn. of *Polycitor*) where Ritter placed it.

DISTRIBUTION: Unless I am incorrect in my identification, which the striking characters of the species seem to render improbable, this species ranges from Yakutat Bay, Alaska (Ritter's type locality) to Pescadero Point near Pacific Grove, California. In both cases it was found on rocks at extreme low tide. I know of no definite record between these two widely separated points. However, Ritter and Forsyth (1917, p. 489), in mentioning species similar to *Amaroucium aequali-siphonis* from points north of Point Conception, may have had this form in mind.

Sigillinaria aequali-siphonis (Ritter and Forsyth), 1917

Plate 28, figure 1; text figure 31

Amaroucium aequali-siphonis RITTER AND FORSYTH, 1917, p. 487, pl. 38, fig. 4, pl. 45, fig. 61.

The following quotation repeats the original description:

"Superficial Characteristics of the Colony: Consisting of long, pedunculated, club-shaped lobes, completely encrusted with sand, each growing from a basal network. Both head and peduncle of each lobe usually flattened throughout its entire length; heads not sharply set off, but tapering gradually into peduncle which becomes gradually smaller until attached end is reached. New lobes spring at times from substratum and result in a dense growth of more or less parallel, slender lobes. Sometimes many lobes arise from a common center, resulting in a more or less spherical body whose surface is made by the heads of the lobes. In this form of growth the heads of the lobes have a broader anterior expanse than in the form first described; the lobes themselves sometimes branched. Test gelatinous and transparent, but having a dirty tinge due to innumerable small test cells. No common cloacal orifices present.

Length of longest lobes about 2 cm., width of heads about 7 mm., thickness 3 mm.

"Zooids: Not arranged in systems; both siphons opening on surface of distal ends of lobes of colony; long and slender, the postabdomen extending through almost entire length of peduncle to end in a slight swelling which contains heart; abdomen somewhat longer than thorax. Mantle contains longitudinal muscle bands which run length of zooid and are separated by considerable spaces over thorax and abdomen, but are closer together in postabdomen.

"Branchial System: Both orifices distinctly 6-lobed. Branchial tentacles about twenty, alternating long and short. Branchial sac with eight series of stigmata, about fifteen stigmata in a half-series. Dorsal languets about as long as stigmata.

"Digestive System: Intestinal loop somewhat longer than branchial sac, its plane oblique to sagittal plane of zooid; esophagus about equal in length to stomach, tapering to a small diameter at its entrance into stomach; stomach somewhat longer than broad, wall longitudinally folded, the folds, never more than six or seven, sometimes broken, often one whole side practically foldless; portion of intestine between stomach and loop about twice as long as stomach, constricted about midway in its course; a small, short tube intercalated into intestine at beginning of rectal limb; lobed anus located a little anterior to middle of branchial sac.

"Reproductive System: Ovary posterior to intestinal loop, not in contact with it; testis lobes numerous, beginning just posterior to ovary and extending through entire postabdomen."

LOCALITY: Ritter and Forsyth give Rincon Point, Santa Barbara, California, as the only known locality. I obtained a few heads agreeing closely with the description given by these authors except that some of the zooids have nine or 10 rows of stigmata, from the intertidal rocks near the Hopkins Marine Station at Pacific Grove, California. I have also received specimens from W. G. Hewatt from Christy Beach, Santa Cruz Island, California, and S. F. Light from a locality considerably farther north, Dillon Beach, California, where it appears to be common.

GENUS **PHARYNGODICTYON** HERDMAN, 1886

Herdman established this genus for a peculiar deep-sea compound ascidian, conforming to the Synoicidae in its general characters but whose branchial sac was divided into large square meshes, which were not subdivided into stigmata, the sac thus approach-

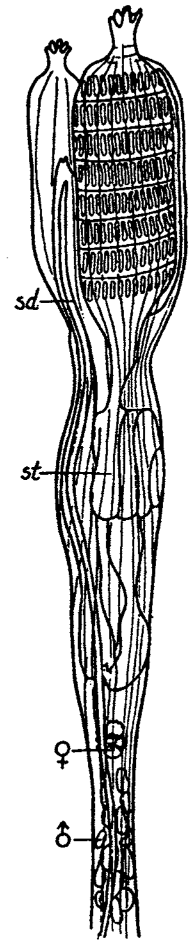


FIG. 31. *Sigillinaria aequali-siphonis* (Ritter and Forsyth). Zooid. Outline from figure of Ritter and Forsyth.

ing in structure that of *Culeolus* and certain other deep-sea simple ascidians. The single specimen, which Herdman named *Ph. mirabile*, was dredged by the "Challenger" in 1600 fathoms, between the Cape of Good Hope and Kerguelen Island, and does not come within the scope of the present work.

Sluiter, 1906, referred the following species to this genus.

Pharyngodictyon reductum Sluiter, 1906

Pharyngodictyon reductum SLUITER, 1906, p. 11, pl. 1, figs. 9, 10, pl. 4, fig. 48.

Based on a single colony of somewhat cylindrical form, 40 mm. and 25 mm. in diameter, attached by one end with the aid of root-like processes, and the other end rounded and bearing a common cloacal aperture which served for the whole colony; the zooids all forming a single system.

Test transparent, whitish, the large zooids being visible through it. The zooids attain a length of 9 mm. without the post-abdomen which may itself measure 25 mm. in addition.

The apertures are both on short, anteriorly directed, six-lobed siphons; the mantle musculature consists mainly of oblique bands crossing at right angles and a few weak longitudinal and transverse bands.

Fifteen tentacles of different sizes. Branchial sac with six or seven transverse vessels, but only a few rudiments of interstigmatic vessels in the form of bifurcated appendages ("appendices bifurqués") on the transverse vessels are present. There are consequently no stigmata.

The intestinal loop is not twisted; the stomach is small with four well-marked plications. Gonads as usual in the Synoicidae, the ovary in the anterior part of the long post-abdomen, the testes farther back arranged in two series, but overlapping the rear part of the ovary.

LOCALITY: Found washed up on the beach of Booth Wandel Island, western Antarctic.

I doubt whether this form has anything to do with Herdman's *Pharyngodictyon.* It is more probable that action of the waves on the beach or other rough handling had destroyed the delicate intestigmatic vessels but left the larger vessels of the sac intact. In other respects, Sluiter's figure of the zooid would well represent a species of *Sigillinaria.*

GENUS **EUHERDMANIA** RITTER, 1904
(=*Herdmania* Ritter, 1903; not Lahille, 1887, not Metcalf, 1900)

Colonies consisting of groups or masses of very elongate club-shaped zooids each with its separate covering of test for its entire length, arising from a basal mass of branching stolons.

Structure in most respects similar to *Clavelina,* but the gonads lie largely or entirely posterior to the intestinal loop in a long post-abdomen. This also contains the heart at its posterior end. Other peculiarities are the presence of two epicardial tubes and the development of the embryos in the long oviduct posterior to the thorax, not (so far as known) in the atrial cavity.

This genus was considered by Ritter, 1903, as intermediate between the Polycitoridae and Synoicidae, and made a separate family Herdmaniidae or Euherdmaniidae. Seeliger, 1909, followed by Hartmeyer (1909–1911) and Berrill, have included it in the Synoicidae. In his last work (1924) Hartmeyer changed his views and expressed very positively his conviction that it should be placed in the Polycitoridae near *Clavelina,* which would be my own view were it not for the position of the heart in the post-abdomen.

(See Ritter, 1903, Berrill, 1935, 1936, for studies of this genus.)

Euherdmania claviformis (Ritter), 1903

Text figure 32

Euherdmania claviformis RITTER, 1904, p. 650; SEELIGER, 1909, p. 1278, fig. 241; HARTMEYER, 1909–1911, p. 1470; RITTER AND FORSYTH, 1917, p. 490; JOHNSON AND SNOOK, 1927, p. 597, fig. 698; BERRILL, 1931, p. 334; PRATT, 1935, p. 744; BERRILL, 1935, p. 339, fig. 6; 1936, p. 56, fig. 9b; HUUS, 1937, p. 667; RICKETTS AND CALVIN, 1939, p. 77, fig. 33.

Herdmania claviformis RITTER, 1903, pp. 239–261, pls. 18, 19. See also Ritter, 1896a, p. 434, which deals with this species though not giving it any name; also Hartmeyer, 1924, pp. 112, 113.

The colonies are of the same general type as those of *Clavelina huntsmani,* consisting of groups or masses of very slender club-shaped zooids, each with its own covering of test for its entire length, and arising from an interwoven mass of branching stolons. The colonies may be of considerable extent, sometimes 120 mm. or more across, with the zooids extremely numerous and densely crowded, or in other cases they may consist of only a few zooids.

They are easily distinguished from *Clavelina huntsmani* by the much smaller, much more slender, and often more or less bent and crooked zooids, which, moreover, commonly are thickly incrusted with rather firmly adhering sand except at or near the anterior end.

When adult they usually range from 20 to 35 mm. in length and from 2.5 to 3.5 mm. in greatest diameter, which is at or near the anterior end, tapering to the basal or attached end. Young ones are much smaller and very narrow throughout. The test where bare is translucent or more or less transparent, and of a slightly greenish hue in life due, I believe, to simbiotic algal cells. It is tough in consistency, but pliable.

The zooids, when removed from the test, are extremely long and slender. The thorax, which is the widest part, occupies only a small proportion of the length of the body. Behind this there is a slender neck through which the oesophagus, ascending part of the intestine, sperm duct, and oviduct pass. This neck is very long, the stomach and gonads being far back. The latter are mostly or wholly posterior to the intestinal loop in a posterior extension of the body (the "postabdomen" according to Ritter).

The two siphons are each six-lobed; the branchial is the larger and more prominent one and has the dorsally situated lobe noticeably longer than the others, the branchial opening being turned in a somewhat ventral direction, perhaps partly as an effect of this.

The mantle musculature is mainly longitudinal and forms many slender bands on the thorax; elsewhere it is diffuse.

There are numerous simple branchial tentacles (Ritter gives the number as 30 or 40 well-developed ones with additional small ones) and about a dozen rows of stigmata which may have, according to Ritter, as many as 40 in a row on each side. The transverse vessels carry membranes that project prominently into the cavity of the sac, and there is a well-developed dorsal languet where each one crosses the median dorsal vessel.

The stomach is quite small and is about one and one-half times as long as wide. Its wall has about six longitudinal ridges or plications which are unequally distributed, the side next to the intestine being smooth. There is a longitudinally furrowed typhlosole between two of these folds similar to that in *Clavelina huntsmani* (see description of that species).

The male gonad consists of numerous small oval testes each connected by its own branch with the long common sperm duct which extends most of the length of the body. Only the more anterior testes are beside, the others posterior to, the intestinal loop. The

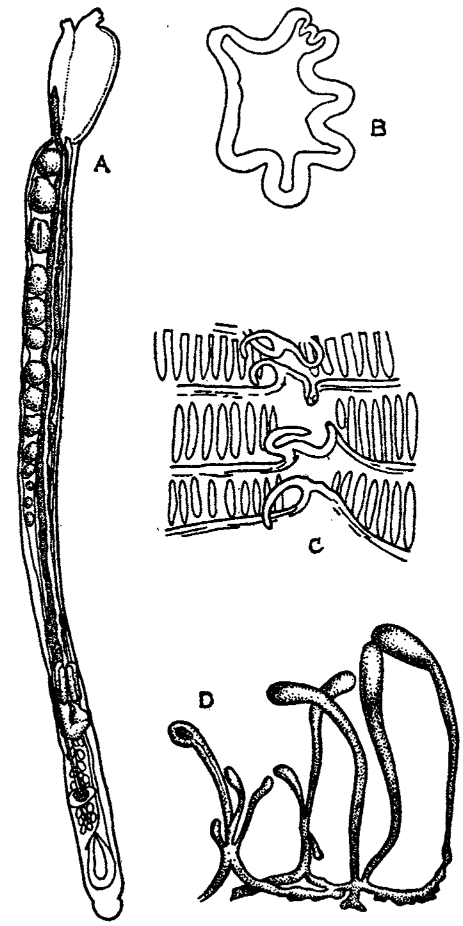


FIG. 32. *Euherdmania claviformis* (Ritter). A. Zooid with embryos and larvae in the oviduct. B. Cross section of stomach. C. Part of median dorsal vessel with languets and adjacent stigmata. D. A few zooids from a colony, somewhat enlarged. After Ritter, 1903.

ovary when small is oval in shape; the eggs leave it and pass into the oviduct when still quite small and undergo development in the part of the oviduct posterior to the thorax. The developing embryos form a longitudinal series in the oviduct, those toward the anterior end being the most advanced, developing into larvae with a long tail and a sense vesicle with a large and a small black pigment spot. Adhesive papillae were not demonstrated on the larvae, though in the distal part of the oviduct the larvae are sometimes quite large, 1.02 to 1.2 mm. in body length. Such larvae are still enclosed in a delicate membrane. Ritter, 1903, expresses the opinion that there is no actual free-swimming stage. (For other particulars, see Ritter's 1903 description.)

DISTRIBUTION: This is apparently a littoral species only, and ranges on the California coast from north of San Francisco (Bodega Bay) to La Jolla or beyond, and is abundant in some places (Monterey Bay, Santa Cruz, La Jolla). It grows on rocks, especially among the roots of sea weeds in the vicinity of low-water mark, often where uncovered at low tides, and where subject to moderate but not extreme wave action.

In spite of considerable study of this species by Ritter, and some by Berrill, there remains much to be learned about the development of the colonies.

At various points on the California coast (as Pacific Grove and Bodega Bay) there may be found among the roots of sea weeds near low-water mark, where sand as well as rocks are present, dense sandy masses of small tubular zooids closely packed, the masses often 6 to 10 cm. across, which appear to be colonies of young zooids of this species. The zooids in such masses are extremely numerous and are from 12 to 15 mm. or more long in most of those that I have examined. The zooids are separate for their whole length, the test covered with adhering sand except at the anterior end (the part enclosing the thorax) which is smooth and free from sand. The thoracic ends of the zooids project beyond the general upper surface of the sandy mass of tubes and are conspicuous in fresh specimens, as the thorax is bright orange, but it soon fades in preservation. Such colonies may be collected in abundance in June and July. In some specimens, presumably older colonies, the zooids average larger than in others.

A conjecture that they may represent an allied form with smaller zooids than *E. claviformis* does not seem justified with the information available. The zooids are in nearly all cases evidently immature; in a very few cases where the zooids were rather large, I have found a few eggs in an early stage in the oviduct in the long narrow neck between the thorax and the region of the stomach. The careful study and observation of such colonies at different seasons of the year would be very desirable.

FAMILY **DIDEMNIDAE** VERRILL, 1871

Colony usually flat and incrusting, sometimes thicker and more massive, but even in such cases adhering by a broad base, not capitate or clavate.

The zooids are of small size (averaging much smaller than in any other group) and are arranged in complex systems. The test commonly contains minute calcareous spicules of stellate form which are in many cases so abundant as to make the test hard and opaque and give it a white chalky appearance.

The body of the zooids is in two divisions joined by a constricted but usually short neck. A muscular retractor process commonly extends out obliquely posteriorly into the test from the posterior end of the thorax but may be either well developed or wanting in zooids of the same species, so that it is unreliable as a taxonomic character.

The zooids usually have a six-lobed branchial aperture; the form of the atrial aperture varies in the different genera. There are (apparently always) either three or four rows of stigmata. Branchial tentacles simple, rather few in number; dorsal lamina represented by two or three languets. The stomach has a rather thick smooth wall. The gonads are in or beside the intestinal loop. The ovary consists of a group of eggs of various sizes; only one egg at a time reaches its full size, which is very large relative to the zooid; the testis is either a large single rounded or conical gland or is cleft into two or more separate glands; if into several, the glands are placed radially in a circular group. The tadpole larvae, which are relatively very large, develop in the cavities in the common test of the colony.

In many species the zooids may have a rather large, definitely defined but usually shallow concavity on the exterior surface of the thorax, one on each side of the middle part of the thorax or a little posterior to the middle. The test filling this cavity commonly contains a dense group of minute spicules of different sizes which look as if these concavities were active spicule-forming glands, and that the spicules drifted out from them to the other parts of the test. They were so considered by Michaelsen who had especially studied them. He called them "side organs" or "lateral organs" ("Seitenorgane") and considered them important as taxonomic characters.

This does not appear to be the case, at least in most species, since colonies or zooids of the same species may have them well developed, poorly developed, or apparently entirely wanting, and although spicules may form in them, they certainly form in other parts of the test also. In the case of most of the described species of this family no observations on these organs appear in the literature. They are a subject on which thorough investigation is much needed.

Adult zooids of this family have much resemblance in structure to some of the family Polycitoridae (especially to those of the genus *Eudistoma*) but are separated from all other compound ascidians by their peculiar method of budding.

This method, known as "pyloric budding," takes place by the formation of two buds in the middle or constricted region of the body of the parent zooid. The anterior of these buds, arising from the region of the oesophagus, forms a new abdomen; the posterior of them, arising from the anterior part of the abdomen, forms a new thorax, the result being the production of a double zooid of a Siamese twin type. The continuation of the process has been commonly believed to be that the double zooid separates into two, one formed of the old thorax and new abdomen, the other of the old abdomen and new thorax. But Salfi (1933) found that an entire zooid may be formed from each of the two buds by a subsequent development of a new abdomen from the new thorax and of a new thorax from the new abdomen. The process is not always carried to completion; zooids may often be found with only one bud, so that a zooid with two thoraces, each with its branchial sac attached to a single abdomen, is formed, at least temporarily. In such cases the old thorax is believed to degenerate, producing a zooid part parent and part bud.

The genera of this family, perhaps with the exception of *Coelocormus* which we know next to nothing about, fall naturally into two distinct groups considered separate families in some old classifications, though now commonly not recognized even as subfamilies. These are typified by the genera *Didemnum* and *Diplosoma*, respectively. The most important difference is in the male gonad. In the *Didemnum* group the sperm duct arises from the middle of the external aspect or apex of the more or less conical testis or the middle of the group of testes, if the organ is divided, and makes a number of spiral turns (usually from three or four to a dozen) upon the surface of the gland or group of glands before leaving to accompany the distal branch of the intestinal loop (see figs. 34, 38, 42, etc.).

In the *Didemnum* group, bladder cells (see genus *Cystodytes*) are often abundant in the test, and the dorsal languets are conspicuously developed, curved, and directed posteriorly. They are borne upon the transverse vessels of the branchial sac, well removed to the left of the medial dorsal vessel.

In the *Diplosoma* group, the sperm duct pursues a direct course from the gonad without coiling. The great development of the common cloacal cavities in some species of this group should also be mentioned.

Genera of Didemnidae

- A_1. Proximal part of sperm duct spirally coiled. Thoracic muscles usually strong.
  - B_1. Four rows of stigmata. Stellate spicules usually abundant, rarely absent.
    - C_1. Atrial aperture not produced, sometimes with a small languet; testis single or in two (rarely three) divisions . . . . *Didemnum*
    - C_2. Atrial aperture with languet. Testis usually in five or more divisions . . . Subgenus *Polysyncraton*
    - C_3. Atrial aperture produced into a short funnel-like tube often directed somewhat posteriorly. Testis divided . . . . *Leptoclinides*
    - C_4. Imperfectly known abyssal genus . . . . *Coelocormus*
  - B_2. Three rows of stigmata. No atrial languet. Testis single. Stellate spicules present or absent . . . . . . *Trididemnum*
- A_2. Proximal part of sperm duct not coiled. Thoracic muscles usually weak. Always four rows of stigmata.

B_1. No spicules. Common cloacal cavities usually very extensive. Testis of two rounded divisions. No atrial languet . . . . *Diplosoma*

B_2. Spicules present. Testis more or less cleft or divided.

C_1. Spicules tetrahedral (four-pointed). Testis partially cleft. *Echinoclinum*

C_2. Spicules stellate. Testis of two or more glands. Small atrial languet present . . . . *Lissoclinum*

Genus **DIDEMNUM** Savigny, 1816

(= *Leptoclinum* Herdman, 1886, and many authors; not Milne Edwards, 1841)

Proximal part of the sperm duct wound spirally upon the testis, which may be a single rounded gland or cleft into two or more pyriform lobes or separate glands. Four rows of stigmata. Calcareous spicules, usually of stellate form or spherical with small projections, normally present in the common test.

The white or yellowish (sometimes red or reddish) colonies of animals of this group, which incrust stones, sponges, algae, and other objects and are often so densely crowded with minute spherical or stellate spicules as to become somewhat hard and brittle, are common in many parts of the world. Under the wrongly applied name *Leptoclinum* Milne Edwards, they are familiar to nearly everyone who has collected marine invertebrates. Their systematic treatment involves many difficulties. The colonies are too opaque to study in a living state, and the zooids are minute and exceptionally hard to preserve except in a violently contracted condition that makes a study of the organs difficult. Such features as the character of the surface of the colony, whether smooth or wrinkled, whether the apertures and the systems in which the zooids are arranged are conspicuous or obscurely visible, or differences in the size of the zooids or in the proportions and shape of their soft parts are not reliable as specific or even varietal characters. Many such apparent differences are due to varying states of muscular contraction or varying degrees of shrinkage incident to preservation, or to modifications due to the immediate effect of the conditions under which the colony grew. Differences in the spicules of different colonies are often conspicuous, though quite uniform within a colony, but with a large series of specimens at hand such a complete gradation between the extremes may be shown that these differences lose most of their weight as specific characters; neither is the number of parts into which the testis is cleft always constant within the same species.

More study, probably including investigations regarding the development, will be needed before we can decide how many species exist and just what are their distinguishing characters. The treatment of the species that is possible with present information is necessarily somewhat provisional and will doubtless require future revision, but the evidence seems to be that instead of *Didemnum* being one of the largest genera of ascidians, the species are in reality rather few, though in some cases widely distributed geographically.

Didemnum albidum (Verrill), 1871

Plate 1, figure 5; text figures 33, 34

Didemnium roseum Packard, 1867, p. 276; Binney, 1870, p. 4; Dall, 1870, p. 255; Packard, 1891, p. 397.

Didemnum albidum Hartmeyer, 1912c, p. 279; 1914b, p. 1113; 1921a, p. 81, 1922a, pp. 24, 44; 1924, p. 144, pl. 1, figs. 21–23; Michaelsen, 1924, p. 354 (in part); Huus, 1933, p. 66, fig. 21; Procter, 1933, p. 285; Pratt, 1935, p. 743.

Didemnum roseum Sars, 1851, p. 153; 1859, p. 66 (not Delle Chiaje, 1828); Huitfeldt-Kaas, 1896, p. 6; Vanhoeffen, 1897, p. 184, fig. 29.

Leptoclinum albidum Van Name, 1902, p. 363, pl. 52, fig. 41; not Verrill and Rathbun, 1879; not McDonald, 1889; probably not Metcalf, 1900.

Leptoclinum albidum (in part)+*L. albidum* var. *luteolum* (in part) Verrill, 1879, p. 27; Kingsley, 1901, p. 183; Whiteaves, 1901, p. 265. Not Herdman, 1886, pp. 287, 290, pl. 40, figs. 10–15. Not *L. albidum* var. *grande* Herdman, 1886; not *L. albidum* var. *luteolum* Sluiter, 1905, p. 103; 1905a, p. 20.

Leptoclinum albidum (in part, not specimens from southern New England)+*L. luteolum* (in part) Verrill, 1871, p. 446; 1872a, pp. 212, 213; 1873–1874, vol. 7, pp. 39, 42, 413, 504; 1874, pp. 352, 355, etc.; Verrill and Smith, 1873, pp. 403, 411, 424, 705, 706; Stafford, 1912, p. 64.

Leptoclinum roseum Hartmeyer, 1903, p. 361, pl. 6, figs. 17, 18, pl. 14, fig. 17; Redikorzev, 1907, pp. 150–153.

Leptoclinum structum Gottschaldt, 1894, p. 357, pl. 24, fig. 4a, 4b, pl. 25, fig. 9.

Lissoclinum albidum+*Lissoclinum luteolum* GIARD, 1873, p. 511.

Tetradidemnum albidum VAN NAME, 1910, p. 378, figs. 13–15, pl. 35, fig. 2, pl. 39, fig. 13; HUNTSMAN, 1912, pp. 111, 112, 138.

See also *Didemnum albidum polare* below.

This is the common *Didemnum* of the Arctic regions and of the northern parts of the eastern North American coast. It forms colonies of the incrusting type which are in most cases not over 2 to 3 mm. thick and of irregular outline, occasionally measuring more than 100 mm. across but usually very much less. They incrust stones, shells, sponges, etc., and not infrequently the larger simple ascidians. Preserved specimens are white, but many of them are yellowish, salmon, or rosy during life. In consistency they are generally rather hard and brittle owing to the great abundance of large spicules which in most colonies are rather thickly distributed throughout the test, and quite densely crowded in the upper layers, often rendering the surface slightly

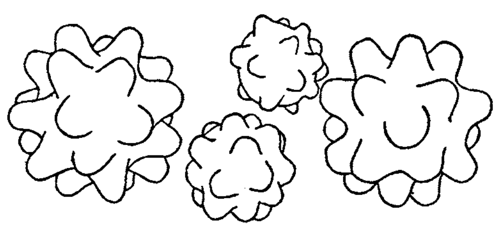


FIG. 33. *Didemnum albidum* (Verrill). Typical spicules, ×400.

rough and gritty to the touch. Neither common cloacal apertures nor arrangement of the zooids in systems can generally be distinguished; often the branchial apertures are also inconspicuous, but in many colonies small, low, rounded elevations mark the positions of the zooids.

The spicules afford the easiest means of recognizing this species; they are quite large, averaging in some colonies as much as 0.08 mm. in diameter, though in others not over 0.05 mm., if as much as that. In many specimens the spicules are beautifully uniform in size, form, and distribution, and their shape is characteristic. They consist of a spherical central mass studded with regularly placed, somewhat conical projections whose summits are smoothly rounded off. This is the type of spicules that I have always found in the hundreds of colonies of this species that I have examined.

The zooids are rather small, in the preserved material usually only about 1.5 to 1.7 mm. long. The branchial aperture is six-lobed; the atrial is a plain opening with a languet, usually narrow and short, arising

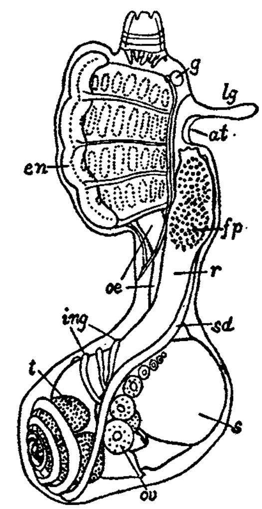


FIG. 34. *Didemnum albidum* (Verrill). Zooid, ×45.

from its anterior margin. The tentacles usually number 16, alternating in size. There are four rows of stigmata; the number in a row is variable, in one colony there were (beginning with the anterior row) 7, 8, 8, 6, or 7 in a row on each side, but in some colonies the maximum may reach 10 or 11 in the second and third rows. The stomach is rounded or slightly elliptical.

The male reproductive organs consist of two pyriform testes forming together a conical mass about which the sperm duct makes four to eight loose spiral turns. In some colonies the cleavage of the testis into two glands is incomplete. The ovary is elongated, lying, when still small, beside the ascending part of the sperm duct. The eggs in its posterior part are the furthest advanced in development.

The spicule-forming organs ("Seitenorgane" of Michaelsen) are present in the zooids of many colonies in the form of a rather large oval depression containing small spicules on each side of the thorax; in other colonies they are not noticeable. A muscular retractor process may or may not be developed; if present it is usually short.

DISTRIBUTION: This is a circumpolar species and is one of the commonest ascidians in those parts of the Arctic region lying to the north of Europe and the Atlantic Ocean. It is common about Spitzbergen, northern Norway, Iceland, and on both the east and west coasts of Greenland, ranging south on the European side to Gullmar Fjord on the Swedish coast (Ärnbäck, 1934) and to the Faeroe Islands, but on the American side very much farther south, as stated in more detail below. On the Pacific side records are few, one from Bering Strait and from a nearby part of the Siberian coast of the Arctic Ocean are given by Hartmeyer, 1924; and specimens from St. Lawrence Island in the northern part of Bering Sea are in the American Museum of Natural History. In most of Bering Sea it appears to be absent.

Returning to its distribution on the eastern American coast, we find it ranging south to, and even a little beyond, Cape Cod, though south of eastern Maine where Verrill reported it at low-water mark in the vicinity of Eastport (the type locality), it is found chiefly on the ledges and banks off shore in water at least a few fathoms in depth. It grows attached to stones, shells, sponges, etc., and often on the larger simple ascidians. The latitude of Boston is about the limit of its range as a common species; south of that latitude its distribution is local and irregular. It was dredged by the United States Fish Commission in quantity a few miles off Chatham, Massachusetts, at Stations 964 to 979, near the southeastern angle of Cape Cod, in 10 to 16 fathoms, and at a few stations off Nantucket and Martha's Vineyard Islands, United States Fish Commission Stations 762 to 767, about 11 miles southwest of Gay Head on the latter island in 16.5 to 18 fathoms, being the most southerly records. All other specimens of supposed *D. albidum* from south of Cape Cod, including localities on the south side of that Cape, that I have examined are of another species (see *D. candidum lutarium*).

Unless we include the deep-water form which is treated in this work as *D. albidum polare*, *D. albidum* is a species of shallow water and moderate depths only, usually less than 50 fathoms, though there is a record of 110 fathoms near Cash's Ledge in the Gulf of Maine, and Hartmeyer reports one of 200 to 410 meters in a Greenland fiord. In this connection, see the statements under *D. albidum polare*.

Didemnum albidum polare (Hartmeyer), 1903

Didemnum polare HARTMEYER, 1909–1911, p. 1450.

Didemnum tenue HARTMEYER, 1909–1911 (in part), p. 1451.

Leptoclinum polare HARTMEYER, 1903, p. 363, pl. 14, figs. 18–21.

Leptoclinum tenue HERDMAN, 1886 (in part; specimens from the North Atlantic only), p. 281, pl. 40, figs. 3–5; HARTMEYER, 1912c, p. 279. (The type of *L. tenue* was from the Strait of Magellan and has nothing to do with this species.) Not *L. tenue* Sluiter, 1898.

This is a deep-water form included by Hartmeyer in his latest works (1921a, 1924) in *D. albidum* without even subspecific distinction. Hartmeyer states that he found no differences between the two, other than in the form of the spicules, *polare* having stellate spicules with acute conical points, as the majority of species of *Didemnum* have, instead of the rounded-off projections characteristic of the spicules of *D. albidum*.

Though this view may be correct, I am not in haste to adopt it, first, because there is a conspicuous difference in the distribution of the two forms in depth, and to some extent geographically, and second, because usually the spicules in any one colony are very definitely of one type or the other, colonies with spicules of intermediate form being few, and according to Hartmeyer's (1924) statement, in no case did he find typical spicules of both types together in the same colony; at most there would be some intermediate forms ("Uebergangsformen") present along with the prevailing ("vorherrschend") type in the colony.

DISTRIBUTION: According to Hartmeyer (1924), who studied specimens from many regions, only the typical *albidum* with spicules with rounded projections occurs in shallow waters. In a zone extending from a minimum of 85 meters to 200 or 300 meters or a little more, both types may occur. In greater depths, down to 1047 (off the entrance to Davis Strait) or possibly still deeper (1430 meters), the *polare* type is found exclusively. The few colonies with spicules of intermediate form found by Hartmeyer were from intermediate depths, a minimum of 75 to 250 and 330 meters.

The colonies of *D. a. polare* are from Old World or Arctic localities. They have not been reported on the American side of the Atlantic south of Davis Strait, or in the Bering Sea region.

Didemnum candidum Savigny, 1816

Plate 13, figure 4; text figure 35

Didemnum annectens VAN NAME, 1921, p. 484.

Didemnum candidum SAVIGNY, 1816, pp. 14, 194, pl. 4, fig. 3, pl. 20, fig. 1; HARTMEYER, 1916, p. 419, figs. 13, 14; MICHAELSEN, 1919, p. 18; 1920a (in part), p. 19; VAN NAME, 1921, p. 323, figs. 16–25; 1924, p. 25; MICHAELSEN, 1924 (in part), p. 358; VAN NAME, 1930, p. 435, figs. 13, 14; BERRILL, 1932, p. 77; PRATT, 1935, p. 743, fig. 961; PLOUGH AND JONES, 1937, p. 100.

? *Didemnum cineraceum* VAN NAME, 1921, p. 484.

? *Didemnum conchyliatum* VAN NAME, 1921, p. 484.

Leptoclinum annectens HERDMAN, 1886, p. 280, pl. 34, fig. 14, pl. 38, figs. 5–9.

? *Leptoclinum cineraceum* SLUITER, 1898, p. 30, pl. 2, fig. 41, 41a, pl. 3, fig. 38.

? *Leptoclinum conchyliatum* SLUITER, 1898, p. 29, pl. 3, fig. 47.

Leptoclinum speciosum+*L. speciosum* var. *asperum* HERDMAN, 1886, pp. 274, 277, pl. 34, figs. 8–13, pl. 36, figs. 1–9.

Leptoclinum speciosum+vars. *bermudense, pageti, hamiltoni, harringtonense, acutilobatum,* and *somersi* VAN NAME, 1902, p. 363, pl. 52, figs. 37, 42–52, pl. 61, fig. 127, pl. 62, figs. 130c, 132, 134–136.

Leptoclinum tenue SLUITER, 1898, p. 31 (not *L. tenue* Herdman, 1886).

First described as an inhabitant of American waters by Herdman, 1886, under the name *Leptoclinum speciosum,* but it is now generally regarded as inseparable from Savigny's type of the genus, *D. candidum* from the Red Sea.

Colonies of the incrusting type, usually thin (not over 2 or 3 mm. thick), though sometimes measuring 60 to 70 mm. across or more. When growing upon uneven objects its thickness in some places may be greater. This is its usual form of development when growing on a continuous surface, but when it grows on an irregular branching object, as a gorgonian, hydroid, or branching sponge, it surrounds the branches and often binds together or encloses two or more of them. As it grows larger it may finally entirely envelop the object, covering all its branches and assuming more or less its form. In extreme cases a colony may have the form of a large rounded or dome-shaped mass with a deeply convoluted and plicated surface penetrated in different directions by numerous clefts, canals, and passages of various diameters, giving the colony as a whole a sponge-like character, as far as its shape is concerned. There are zooids and common cloacae opening on the walls of the clefts and canals as well as on the outer surface. The United States National Museum contains such colonies dredged at stations in the Gulf of Mexico in water down to 28 fathoms deep, that measure 100 to 130 mm. in diameter. I regard them as resulting merely from the original attachment of the colony to an object of complex branching form as a hydroid, alga, or perhaps a sponge, which in course of time the ascidian may entirely enclose and kill, the different lobes of the ascidian colony finally uniting where they approach close together but leaving many clefts and canals between them, thus forming the sponge-like colony. Similar forms occur in the Malayan representatives of this genus (see Van Name, 1918, p. 148), and Sluiter (1909, p. 67) has described a species, *D. spongioides,* on the basis of such a colony form, a course which does not seem justified.

Color usually white, sometimes very pure white, in other cases yellowish or less frequently reddish or red; in turbid waters more or less discolored with mud. Borders of the colony varying from thin to thick and rounded, surface very variable, sometimes quite even, in other cases much wrinkled. The surface, if comparatively free from spicules in the extreme superficial part, may be somewhat glossy and smooth to the touch, but any abundance of spicules there renders it a dead white and makes it feel slightly gritty. When the spicules are abundant, the zooids, which are yellow or in parts orange during life, may be entirely concealed unless their branchial apertures are expanded, but their positions are often indicated by a small, low, rounded elevation over the anterior end of each zooid.

When less abundant the spicules are often gathered chiefly in the upper layers of the colony, leaving the deeper portions of the test yellowish and translucent and the colony comparatively soft. In some colonies the branchial apertures are conspicuous in the preserved condition, and each is surrounded by a minute circle of more densely crowded spicules within which the six-lobed character of the aperture is indicated by six minute groups of very small spicules. (This is, however, not always demonstrable and is not peculiar to this species.) Bladder cells are present in the test in varying quantity; their number or distribution does not appear to afford a diagnostic character. The systems in which the zooids are arranged are of varying size and form; except in small colonies a number of common cloacal apertures are present, though in preserved material these are usually by no means easy to demonstrate. Different colonies vary very greatly in respect to the clearness with which these systems and the courses of the common cloacal ducts show on the surface. These features may be very conspicuous, so that the zooids are seen to be arranged in groups or in branching and curving lines, or they may be impossible to follow

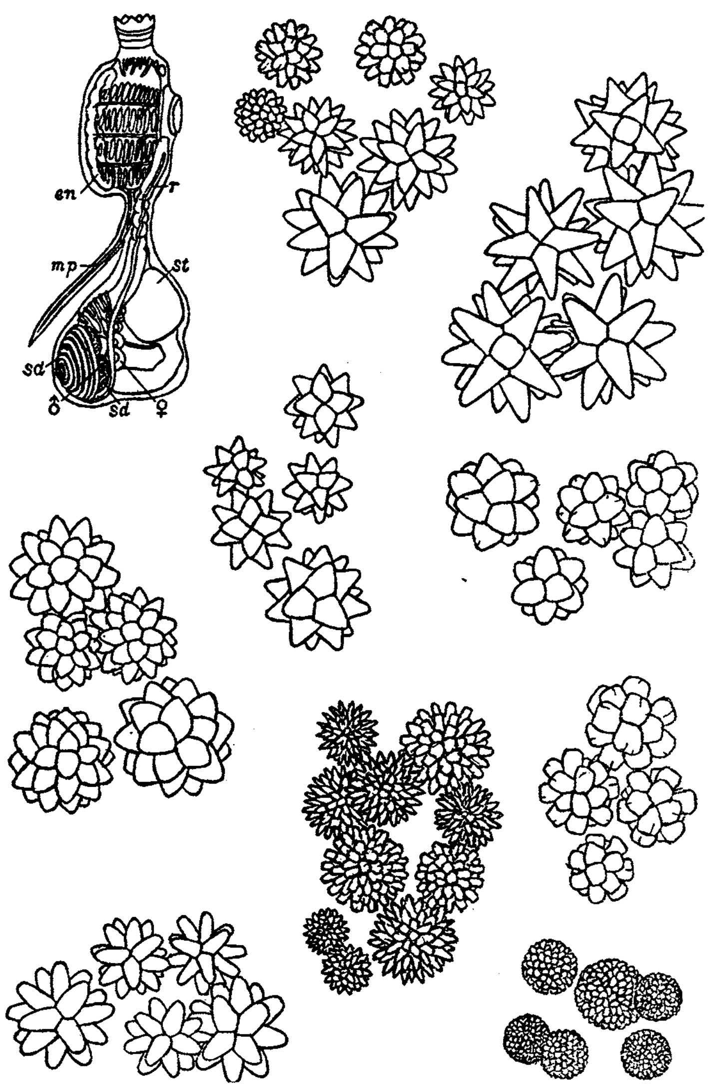


FIG. 35. *Didemnum candidum* Savigny. Zooid, ×40, and groups of spicules from different colonies, all ×460.

out, the zooids appearing to be merely scattered irregularly in the superficial part of the colony.

In some colonies the spicules exhibit very striking uniformity in size, in others they are of various sizes, which may be present in varying proportions; occasional abnormally large spicules ("giant spicules") may be found in a few specimens. The usual diameter of the spicules varies in different colonies from 0.025 mm. (sometimes even less) to about 0.04 or 0.05 mm., rarely more. Commonly there is within a single colony great uniformity in the shape of the spicules, as well as in their size; different colonies, even those growing side by side on the same stone, may differ conspicuously in the type and average size of their spicules. The illustrations here given show typical groups of spicules from different colonies and illustrate the principal modifications that occur. Spicules showing varying degrees of irregularity, imperfection, or incomplete development are of course often present, but in the majority of specimens only in small proportion to the more perfect ones.

Water of high calcareous content, as in most places with many coral reefs and much coral rock, is especially favorable for the development of the colonies having large spicules with long and well-formed conical rays. The attachment of the colony to some rigid object as a stone or shell is also favorable, while attachment to a flexible object that allows of even slight bending or movement of the test is more likely to result in forming smaller types of spicules with shorter and less perfect rays or points.

In completing this description of the general character of the colony, it should be mentioned that there are occasional colonies, apparently of this species, which for some unexplained reason develop very few spicules in the test, so that the colony remains soft, flexible, semi-transparent, and (in the preserved material) of a yellowish or grayish color. The few spicules present are generally in the upper parts of the colonies (sometimes chiefly about the branchial apertures of the zooids) and are of small size and usually burr-like in form. Such colonies may attain a large size and appear normal in all other respects except in the scarcity and poor development of the spicules, though this deficiency gives them a very different superficial appearance. I have seen such colonies from widely separated localities (Florida, Puerto Rico, and South Carolina).

There are also colonies containing large accumulations of dark-colored faecal pellets in the cloacal canals and cavities and embedded in the solid test substance. I quite agree with Michaelsen's view (1919, p. 11) that this is merely the result of some abnormal or pathological condition, the water currents being insufficiently strong to carry off this waste material. Its presence in large quantities may greatly alter the appearance of the colonies and make it difficult to realize that they belong to the same species as normal examples, and Sollas, 1903, even went so far as to found a genus (*Hypurgon*) on a colony of one of the common species of *Didemnum* exhibiting the above conditions.

When considerably expanded, the zooids may measure 1.6 mm. in total length, even in preserved material, but in most alcoholic specimens they will be found strongly contracted and often not more than 1 or 1.1 mm. long. They have six lobes to the branchial tube; these lobes vary greatly in length and form in different colonies. A tapering muscular process, often of considerable length, extends out into the test from the constricted middle part of the zooid; its development is very variable in different colonies, though often quite constant within the same colony. Atrial orifice round, with a languet. Its border is usually almost flush with the dorsal surface of the thorax; even if slightly raised it is not produced sufficiently to form a tube.

In adult zooids there are generally 16 tentacles representing three orders (4+4+8), but one or two of the large ones may exceed the others in size, and the small tentacles do not appear to be always developed.

Dorsal languets borne on the transverse vessels of the left side of the branchial sac a little removed from the median dorsal vessel. Stigmata in four rows; 12 on each side was the maximum number demonstrated in a single row; in most cases the number in a row does not appear to be so large, about 10 in the anterior rows and as few as eight in the posterior row; in young zooids still fewer.

Stomach rounded; ascending part of the intestine surrounded by a branching glandular organ composed of from five to 10 thin-walled tubules which unite to form a duct opening into the proximal part of the intestine just beyond the pylorus. One or more valvular constrictions may be present in the intestinal loop; their presence does not seem to be a constant character.

Testis sometimes cleft into two completely, or almost completely, separated lobes or distinct glands, but oftener it is undivided. I have never observed it cleft into three lobes or glands. The sperm duct usually makes six or eight spiral turns about the testis. Ovary consisting of a few eggs situated in the region between the stomach and testis.

DISTRIBUTION: If we are correct in understanding this species in the above comprehensive sense, it is of very wide range in tropical and moderately warm waters in both the Old and New Worlds. Its synonymy is unfortunately in great confusion, which the efforts of Hartmeyer, Michaelsen, and others are far from having successfully cleared up. I believe, however, that it may be safely asserted that it has nothing to do with either *D. tenue* (Herdman), 1886, or *D. studeri* Hartmeyer, 1911b, which are inhabitants of the colder parts of the Southern Hemisphere. It also has nothing to do with *D. albidum* (Verrill), 1871, though its subspecies *lutarium* has, in the past, been confused with *albidum*. (See under *D. candidum lutarium*, below.)

In American waters it appears to be confined to the Atlantic side, ranging (if we include the subspecies *lutarium*) from the coast of New Hampshire, or possibly southwestern Maine, southward through the West Indian region (also Bermuda) to include the warmer parts of the Brazilian coast (Bahia was Herdman's type locality of "*Leptoclinum speciosum*") and São Sebastião Island on the coast of the State of São Paulo. Along the shore at Bermuda, on the Florida reefs, and at some West Indian points it is very abundant, in some places probably the most abundant ascidian. It occurs from tide level down to 30 or 35 fathoms but apparently not usually at much greater depth. However, at one place off Havana, Cuba, in the vicinity of 23° 10′ N., and 82° 20′ W., it was obtained at "Albatross" Stations 2159, 2167, 2168, and 2323 (2264 was incorrectly also mentioned in my 1921 article) in considerably deeper water, 98 to 201 fathoms.

The typical form occurs at Bermuda and in Florida waters, in the West Indies and southward. Northward along the coast of the eastern United States the typical form is replaced by the slightly distinguished subspecies *lutarium* described below. In my article on the Bermuda ascidians (1902) I described six varieties based chiefly on differences in the spicules (these are listed in the synonymy above), but at the present time I do not regard them as representing true races or subspecies, or as worthy of detailed consideration.

In its distribution in the Old World it has been dealt with under various synonyms. From the Red Sea it ranges eastward in the warmer parts of the Indian Ocean to the Malay region; according to many authors (Sluiter, 1927, Harant, 1927, 1933, etc.), it occurs in the Mediterranean and on the Atlantic coasts of Europe and northern Africa also.

This is the most difficult of all the American ascidians to deal with from a taxonomic point of view. I am far from being able to overcome the fear that I am confusing more than one species, but after the examination of a large amount of material from various American localities I am at a loss to find a reliable basis for dividing it by studying museum specimens. If studies on the characters and development of the eggs and larvae and of the early stages of colony formation are made, they may furnish a clue for making such a division.

Didemnum candidum lutarium Van Name, 1910

Plate 8, figure 2; text figure 36

Didemnium sp. PERKINS, 1869, p. 160.

Didemnum candidum lutarium VAN NAME, 1921, pp. 323, 330; PRATT, 1935, p. 743.

Didemnum lutarium VAN NAME, 1910, p. 371, figs. 8, 9, pl. 37, fig. 7; SUMNER, OSBURN, AND COLE, 1913, p. 731, chart 194.

Leptoclinum albidum METCALF, 1900, pp. 527, 562, 563, pl. 37, fig. 50, pl. 38, figs. 63, 64.

Leptoclinum albidum+*L. a.* var. *luteolum* VERRILL AND RATHBUN, 1879, p. 231; MCDONALD, 1889, p. 858; VAN NAME, 1902, p. 363, pl. 52, fig. 40.

Leptoclinum albidum (in part)+*L. a.* var. *luteolum* (in part) VERRILL, 1871, p. 446; 1872, p. 212; VERRILL AND SMITH, 1873, pp. 706, 403, etc.; VERRILL, 1879, p. 27; HERDMAN, 1886, pp. 287, 288.

This form is abundant and quite constant in its characters on the southern part of the New England coast, and in my article of 1910 I gave it the rank of a species. In the southern part of its range, however, it does not appear to be so definitely distinguishable from *candidum* and is, therefore, probably better considered a subspecies.

It forms incrusting colonies sometimes 100 mm. or more in diameter and 2 to 4 mm. thick or even thicker in large specimens. The test is chalky white, or somewhat tinged with yellow or reddish (the basis of Verrill's var. *luteolum*); the surface, owing to the minute size of the spicules, is rather smooth to the touch but often wrinkled, the furrows sometimes indicating the common cloacal canals. Branchial orifices of the zooids often conspicuous. In even slightly muddy water the colonies are apt to be discolored with mud.

The spicules are small, mostly under 0.02 mm. in diameter, and have rather short but regularly tapering points or rays which are not very numerous. Spicules are usually abundant and close together in most parts of the test.

Zooids average smaller and shorter than in typical *candidum*, often in the preserved, contracted state considerably under 1 mm. in length; the branchial orifice has six very short lobes; the atrial orifice is a rather small plain opening without a languet. There is a fairly long muscular retractor process. Tentacles apparently 16 in number, 10 or 11 stigmata in a row on each side, in adult zooids; perhaps a smaller number in the posterior row. The stomach is globular; the intestine has a valve or constriction some distance from the stomach, and the tubules embracing the intestine are clearly visible in some specimens and are few in number with tapering ends.

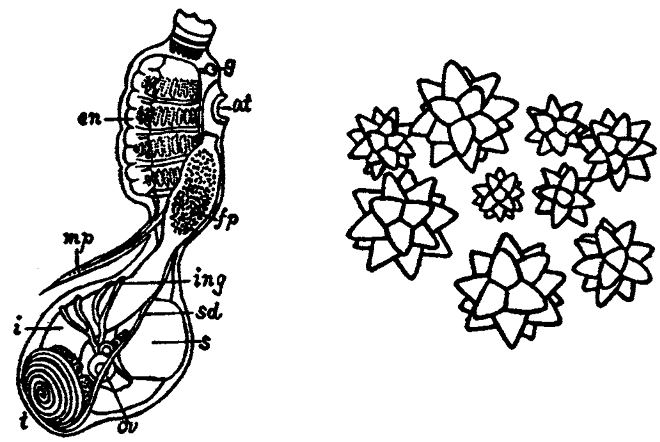


FIG. 36. *Didemnum candidum lutarium* Van Name. Zooid, ×56. Spicules, ×600.

The testis is very frequently, but apparently not invariably, divided into two distinct glands which form a conical mass about which the sperm duct is coiled, usually making about eight or nine turns.

DISTRIBUTION: This is a northern geographical race of *D. candidum*. On the southern coast of New England, including the south shore of Cape Cod, this is the common and, in most places, the only representative of the genus in shallow water, and probably all the published records of *Leptoclinum albidum* and *L. luteolum* from that part of the coast refer to it. It is abundant at Woods Hole, Edgartown, and Vineyard Haven, Massachusetts, on piles of wharves, shells, stones, sponges, and large ascidians of other kinds. It ranges, however, some distance north of Cape Cod (tide pool at Ten Pound Island, Gloucester, Massachusetts, Isles of Shoals, New Hampshire, possibly to Casco Bay, Maine), but on most of the Maine coast and farther north it is replaced by *D. albidum*.

Its southward ranges require more investigation. It is found along the Atlantic coast south to Florida (both the east and west coasts) in shallow water, but on the Florida coast the typical *candidum* also occurs and there may be intergradation. In Vineyard Sound, Massachusetts, it occurs down to 15 fathoms or more in depth.

(See Van Name, 1910, p. 374, for statements concerning confusion of this form with *D. albidum* by Herdman, 1886, and others.)

Didemnum candidum fusiferum Van Name, 1921

Text figure 37

Didemnum fusiferum VAN NAME, 1921, p. 331, fig. 26.

Colony of the incrusting type, in some parts quite thin (3 mm. or less) but sometimes becoming thick and massive, especially when growing upon irregularly shaped objects. Several large colonies from off Cedar Keys, Florida, growing on branching gorgonians, surround their branches, and where the latter are near together envelop and bind together two or more of them in the test, which becomes very thick and massive (sometimes over 30 mm. thick where there are zooids on all aspects). One of these irregularly lobed and extended colonies measures not less than 220 mm. by 125 mm. across, and has thick rounded edges.

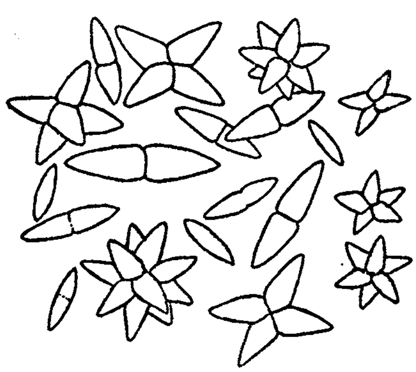


FIG. 37. *Didemnum candidum fusiferum* Van Name. Spicules, ×460.

The zooids are visible through the test and are arranged along complex branching and anastomosing common cloacal canals, which in preserved specimens, but perhaps not so clearly in fresh ones, are rendered conspicuous by furrows on the surface and by the distribution of the spicules described below. The apertures are not conspicuous in most preserved material.

The special peculiarity of this form is in the spicules, a considerable proportion of them being fusiform, that is, composed of two cones placed base to base. Such may be regarded as two-rayed spicules. In the same colonies are some spicules composed of four, six, eight, or more such conical points; when these points are sufficiently numerous the spicule takes on the usual stellate form. The spicules are generally too few to render the colony opaque; they are distributed chiefly in the upper parts of the colony and usually entirely wanting in most parts of it. In many colonies the spicules are present chiefly in the small, variously shaped areas left unoccupied by the zooids and cloacal canals, giving the colony a mottled appearance, the spicules forming whitish patches. In size they are not unusual, the larger ones averaging 0.02 to 0.03 mm. from point to point. The occasional occurrence of similar spicules in *Didemnum japonicum* (Herdman), 1886 (p. 302, pl. 34, figs. 1–7), is recorded, though most of the spicules in that form are of the usual stellate type. Among the perfectly formed spicules are also imperfectly or incompletely formed ones, and also crystalline and irregular deposits of calcareous material, which may much exceed the true spicules in number and bulk.

Zooids large, 1.25 to 1.5 mm. or more long when only moderately extended. They agree too closely with those of *D. candidum* in their characters to require separate description or illustration. The muscular process extending into the test is long and well developed; the testis, as in *D. candidum*, may be either single or distinctly cleft into two divisions.

DISTRIBUTION: The specimens are all from off the west coast of Florida. The type and also several other colonies (or perhaps fragments of the same colony) are from Station 7147, steamer "Fish Hawk" (29° 52′ 10″ N., 83° 51′ 47″ W., 3 fathoms, sand and coral); some large colonies (see above) were collected in the vicinity of Cedar Keys by the steamer "Bache" in February, 1887, and some by the American Museum of Natural History boat "Thetis" near Tarpon Springs, in shallow water, in 1942.

This may be better regarded as only a subspecies or form of *D. candidum*, though originally described as a species.

Didemnum vanderhorsti Van Name, 1924

Text figure 38

Didemnum vanderhorsti VAN NAME, 1924, p. 25, fig. 1; 1930, p. 438.

Colony of the flat incrusting type, in some parts often rather thick (3 to 5 mm. or even more), and sometimes several centimeters across. (See statements below on the measurements of certain specimens.)

The colonies all have a more or less deep chocolate brown color, due largely to pigment in the test cells, but apparently also to a suffused brownish color in the test and tissues of the zooids. In spite of its coloration, the test remains quite transparent; the zooids are distinctly visible through it, and even some of their internal characters can often be seen without removing them from it. The zooids are numerous and closely placed and can be seen to be arranged in systems of more or less complexity, but usually neither the limits of these systems nor the common cloacal apertures can be definitely distinguished.

Spicules are usually almost entirely (in some colonies perhaps entirely) wanting. In the type colony they are present in a few places; they are irregularly distributed and very minute, oftener under than over 0.01 mm. in diameter, and of burr-like or nearly spherical form, points being often scarcely at all developed. A specimen from Florida has larger spicules, often 0.015 or more.

The zooids are small, usually considerably under 1 mm. in length in the somewhat contracted preserved condition. They present no characters unusual in the genus.

The branchial tube is well developed, with six small triangular lobes to the aperture; atrial aperture is rather small, its opening not produced into a tube and not provided with a languet. The mantle has a few slender longitudinal bands on the thorax; the abdomen is not muscular. The mantle cells do not contain pigment, and the thorax, therefore, appears lighter colored than the surrounding test, thus causing the zooids to be more conspicuous from the exterior of the colony than would otherwise be the case.

The zooids of the type colony have a well-developed muscular process extending out into the test from the contracted region of the body, but this is not always present. Tentacles apparently 16 in number, representing three orders (4+4+8). Dorsal languets situated on the left transverse vessels of the sac removed a little way from the median dorsal vessel. Stigmata in four rows with at least 10 in a row on each side in the first two or three rows; possibly not quite so many in the posterior row.

Stomach rounded, intestinal loop large with a more or less distinct valve-like constriction a little way beyond the stomach. Many of the zooids have both male and fe-

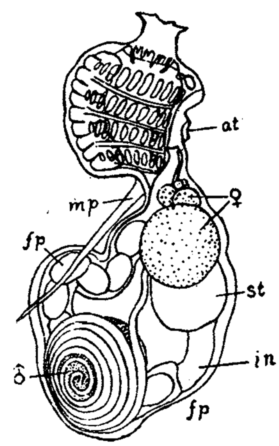


FIG. 38. *Didemnum vanderhorsti* Van Name. Zooid, ×56.

male organs well developed. Testis single, of large size when fully developed, situated in the rear ventral region of the abdomen; the sperm duct is coiled in six or seven turns upon its conical outer surface. The ovary, situated beside the ascending part of the intestine, consists of a small group of eggs in different stages of growth.

DISTRIBUTION: Though but few specimens referable to this species have come to my notice, it appears to be widely distributed in the West Indian region, occurring, as far as I know, only in the shallowest water. The type locality is Curaçao, four specimens obtained in a shallow bay, the Spanish Water, the type and largest of them 20 mm. in diameter. Other localities: Montego Bay, Jamaica, specimens covering the back of dromiid crabs, one of them over 50 mm. in greatest width, and Tortugas, Florida, on dead coral on a shallow flat.

Apparently it is not confined to the Atlantic side of the continent, as the American Museum of Natural History has an elongated colony of extremely irregular shape and thickness which measures in extreme length no less than 210 mm. and at one place over 60 mm. wide, received from E. F. Ricketts who collected it at Concepcion Bay, Gulf of California, also a small specimen which I collected at Pacheca Island, Bay of Panama. At present I do not know of any reason other than the obvious geographical one for treating these specimens as distinct from the West Indian ones.

Didemnum studeri Hartmeyer, 1911

Didemnum studeri HARTMEYER, 1911b, p. 538; 1912b, p. 322; MICHAELSEN, 1919, p. 23 (+var. *magalhaense*, p. 28); 1924, p. 342; SLUITER, 1932, p. 18.

Leptoclinum "undescribed specimens" HERDMAN, 1886, p. 283.

Not *D. studeri* var. *africanum* Michaelsen, 1919, p. 29; 1924, p. 344.

This is an incrusting *Didemnum* found chiefly if not exclusively in shallow waters, described by Hartmeyer from Kerguelen Island (Observation Bay) from specimens growing on the roots and stems of kelp (*Macrocystis*). That seems to be its commonest object for attachment; the colonies may surround the stems for several centimeters; but it grows also on stones, mussel shells, etc.

The colonies do not appear to have conspicuous distinguishing features externally; the spicules, however, are fairly large, 0.02 to 0.03 mm., or, in exceptional cases, 0.036 mm. in diameter, and are of spherical form with rather short projections comparable to those found in *D. albidum*, though not rounded as in that species, but less regular and separated by angular clefts, not by saddle-like depressions.

The zooids are described by Michaelsen, 1919, on the basis of Magellanic material as 1.2 mm. long when fully grown. Their branchial aperture has six short lobes; the atrial aperture is a simple oval hole near the middle of thorax or farther forward, without an atrial languet. The thoracic lateral organs vary from rather small to moderately large; they are on the posterior part of the thorax. A fairly long muscular retractor process is present, also often two or three vascular processes. Tentacles of three orders, 32 in number when all are developed.

The individuals mostly have the organs of both sexes; the ovary often with one very large egg. The testis is sometimes single and entire but oftener cleft into two or three glands forming a conical group about which the sperm duct usually makes seven or eight spiral turns.

DISTRIBUTION: This appears to be a circumpolar species in the Subantarctic regions and to be fairly common in shallow water (especially on kelp) in the Magellanic region and about Tierra del Fuego. Reported from South Georgia by Sluiter, 1932.

Michaelsen's conjecture (1919, p. 23) that there is a close relationship between this species and the *Didemnum* found at Bermuda (referred to *D. candidum* in the present work) overlooks, among other things, the entirely different temperature conditions under which the two species live. A three-parted testis is also very rare (if it occurs at all) in the Bermuda forms, but very frequent, if not the usual condition, in *studeri*.

Didemnum tenue (Herdman), 1886

Didemnum studeri var. *africanum* (in part) MICHAELSEN, 1919, p. 29; 1924, p. 344; HARTMEYER, 1912b, pp. 374, 375.

Leptoclinum asperum (in part) SLUITER, 1900, p. 19.

Leptoclinum tenue (in part, not specimens from North Atlantic) HERDMAN, 1886, p. 281, pl. 39, figs. 8–11 (not pl. 40, figs. 3–5). Not Sluiter, 1898, p. 31.

This is an incrusting species very similar to *D. candidum* in the general character of the colony; in fact, it is its cold-water and deep-water habitat in the Subantarctic region of South America that leads us to regard it as distinct from the other American *Didemnums* rather than the existence of distinctive characters of which we are aware in the present state of our knowledge.

In fact we know but little about it, as nearly all the details (including the arrangement of the spicules about the orifices) stated or figured by Herdman would apply equally well to many other species of the genus. The specimens are of the incrusting type, usually thin and of small size; the spicules of moderate size, not very closely packed in the test, of stellate form with fairly long acute rays or points. The zooids are described as large and conspicuous, with few (8 to 10) and short tentacles, the testis (evidently single) is "large and has the vas deferens coiled spirally around it." They thus appear to differ from *D. studeri* also of the Magellanic region in the stellate spicules and the single testis (*studeri* usually has it two- or three-parted).

DISTRIBUTION: Type locality, "Challenger" Station 308, 50° 08′ 30″ S., 71° 41′ W., 175 fathoms; other localities, "Challenger" Station 311, at west end of Strait of Magellan, 245 fathoms; "Challenger" Station 320, off the mouth of the La Plata River, 37° 17′ S., 53° 52′ W., 600 fathoms. Herdman's other localities evidently apply to different species. It is thus, as far as the type material shows, a species of quite deep water, but it is quite probable that it also occurs in shallower water in the Magellanic region and that it may also have a much wider distribution in the Subantarctic, but this requires further investigation. A specimen obtained in Teal Inlet, South Georgia, by W. L. Schmitt, may apparently be referred to this species.

D. tenue is attributed to the West Indies by a mistake by Hartmeyer (1912b, p. 375).

Didemnum biglans (Sluiter), 1906

Didemnum biglans HARTMEYER, 1911b, p. 499, pl. 46, figs. 7, 9, pl. 55, figs. 5–9; MICHAELSEN, 1924, p. 357; ? COIFMANN, 1933, p. 1.

Didemnum gaussi+ ? *Didemnum* sp. MICHAELSEN, 1919, p. 30.

Leptoclinum biglans SLUITER, 1906, p. 29, pl. 2, figs. 27, 28; ? MICHAELSEN, 1907, p. 39.

Colony usually small, normally of the incrusting type, not over 2.5 to 3 mm. thick and 20 to 25 mm. in extent, but when growing upon ramifying algae or bryozoans it commonly surrounds and encloses the branches, becoming thicker and more massive and developing zooids on all sides.

The test is semi-transparent and commonly of some shade of pale gray, sometimes slightly tinged with a violet or with reddish or brownish, and of rather firm, slightly cartilaginous consistency. It allows the zooids to be more or less distinctly visible. Minute, calcareous spicules of burr-like form, the longer ones usually not over 0.018 to 0.025 mm. in diameter, and in some colonies by no means reaching even such small dimensions, are present in the test. Though very few in some colonies, they are usually quite abundant in the surface layer, to which they give a whitish tinge; and by being more crowded about the branchial apertures of the zooids, they render these apertures and the position and arrangement of the zooids more conspicuous. In the interior of the colony, spicules are comparatively scarce or wanting. In small colonies, at least, the zooids apparently form but one extensive system.

This is a species in which there is an active spicule-forming focus in the test on each side of the thorax of the zooid, and a compact, rounded, or oval mass of the spicules very conspicuous from its white color results from their activity. The spicules of these masses appear to remain together and not disperse into the surrounding test, at least not for a long time. All the authors who have described this species have noted the presence of these white masses of spicules close beside, or often indenting, the lateral surface of the thorax, one on each side of the latter. They are also conspicuous in the colonies from Neny Fjord that I have examined, and while not invariably well developed, are very often of assistance in recognizing the species.

The zooids are rather small, usually from 1.5 to 2 mm., less often 2.5 mm. long in the preserved condition. They have the usual characters of this genus; a six-lobed branchial aperture, a rounded atrial aperture with a small languet, four rows of stigmata with eight or nine, possibly sometimes 10, in a row on each side. The proximal part of the intestine is narrow for some distance from the stomach, then it enters the abruptly enlarged ascending part of the tract. Unfortunately, no gonads were found in the specimens I have examined, though in some cases numerous larvae were present in cavities in the test.

Hartmeyer, who made a careful study of

this species (1911b), describes and figures the testis as formed of two distinct or nearly completely separated glands, while Sluiter apparently considered it as single. Both authors are agreed that the sperm duct makes but few (three or four) spiral turns about the male gonad. In this genus, unless very well-preserved specimens are available, the division of the testis, even if present, is not always easily observable, and I cannot attribute much importance to this discrepancy.

DISTRIBUTION: It seems to me that with such information as is now available, we are justified in believing that only specimens from the Antarctic regions belong to this species; from Port Charcot, 40 meters (type locality), and Schollaert Canal, 30 meters (Sluiter, 1906); Neny Fjord, Palmer Land, 15 fathoms, and Horseshoe Island, 67° 05′ 40″ S., 67° 17′ W., 19 fathoms (specimens in the United States National Museum). Also, in the Eastern Hemisphere, from numerous stations at Kaiser Wilhelm II Land in 350 to 385 meters (Hartmeyer, 1911b).

It seems likely that Michaelsen's record from Punta Arenas (see Michaelsen, 1919) and Coifmann's (1933) from the Chonos Islands on the Chilean coast refer to other species.

Didemnum chilense Ärnbäck, 1929

Text figure 39

Didemnum chilense ÄRNBÄCK, 1929, p. 19, fig. 5, pl. 2, figs. 17, 18.

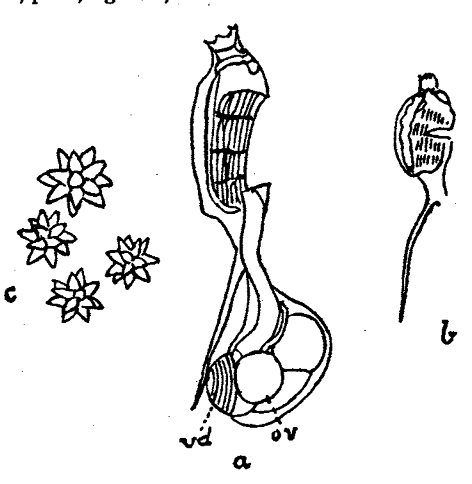


FIG. 39. *Didemnum chilense* Ärnbäck. Zooids, ×35. Spicules, ×350. After Ärnbäck.

Colonies thin, with uneven surface grayish white in color growing over the surface of galanoid shell fragments. Spicules very small, of regular stellate shape with pointed rays. Zooids numerous, densely arranged, measuring scarcely 1.5 mm. in length. Muscular process well developed. Branchial siphon with six small triangular lobes. No atrial languet. Atrial aperture when expanded of very large size. As far as could be observed, the male gland was undivided.

LOCALITY: Off the Guaitecas Islands, Chile (latitude 44° S.), depth about 23 meters.

Didemnum santa-elenae, new species

This species is based on a large number of small, incrusting colonies growing on simple ascidians (*Pyura bradleyi*), barnacles, stems of algae, etc. They are usually about 2 mm. thick or in many cases even less, and (perhaps because of the objects on which they grew) of very irregular outline and of small extent, a transverse measurement of over 2 or 3 cm. being infrequent.

The colonies are rather soft in consistency, semi-transparent, allowing the yellowish zooids to be seen, and of a light brown color with a tinge of reddish, in the preserved material. This color is diffused in the test.

The surface of the colony is glossy when wet but more or less uneven, often slightly raised over the anterior end of each zooid.

The spicules are very small, mostly between 0.01 and 0.017 mm. in diameter and of burr-like form; spherical, with numerous small, short, usually more or less acute projections. In most parts of the colony they are thinly scattered; in the superficial layer they are more numerous, and by being more numerous about the branchial apertures of the zooids make the latter more noticeable under low magnification. The zooids are numerous and quite closely placed, and in many cases their arrangement in extensive systems can be noticed. Common cloacal apertures are often visible; they are large and few in number, in small colonies commonly but one.

The zooids are typical of the genus *Didemnum* but are much contracted and not over 1 mm. long in the specimens available, the thorax being shortened into an oval form often little longer than wide, and the stout endostyle bent into a semicircular curve by the contraction of the strong longitudinal muscles of the mantle.

The branchial siphon is six-lobed; the atrial orifice is without a languet and appears to be a plain opening of moderate size. The tentacles could not be counted; there are four rows of stigmata with apparently about 10 in the first three rows, and perhaps fewer in the last row, but accurate counting was not possible in the contracted condition of the thorax.

A short but fairly narrow constriction separates off the abdomen from the thorax. A rather short retractor process extends obliquely from the constricted part of the body. The alimentary tract forms a rather small loop. The gonads are, as usual, situated beside it; many of the zooids have the organs of both sexes, a large undivided testis about which the sperm duct may make as many as 10 or 11 spiral turns, besides an ovary containing one every large egg. Many large tailed larvae are present in the cavities of the colony, but no budding was observed.

LOCALITY: Salinas, near Punta Santa Elena, Ecuador, littoral. Many colonies collected September 13, 1926, by Waldo L. Schmitt. Type colony in the American Museum of Natural History (A.M.N.H. No. 1843); a piece of it also is in the United States National Museum.

The specimens are all from one locality, but it is in a region from which no members of this genus have been recorded. While the zooids exhibit no unusual characters, the very minute size and small number of the spicules, and the rather transparent test and characteristic coloration of the colonies (which, however, may have been somewhat different during life) have made it impossible for me to assign these specimens to any described species, while the large number of colonies collected agreeing perfectly in their details indicates that their characters are not individual peculiarities.

Didemnum carnulentum Ritter and Forsyth, 1917

Text figure 40

Didemnum carnulentum RITTER AND FORSYTH, 1917, p. 470, pl. 39, fig. 11, pl. 44, figs. 57–59; JOHNSON AND SNOOK, 1927, p. 596, fig. 696.

See also remarks on *D. carnulentum* var. *lacteolum* below.

Described as follows by Ritter and Forsyth:

"Thin and encrusting and of considerable expanse, often half a foot or more; thickness 4 mm. or less. Color typically the pink of the human skin but varying to opaque white. Position of the zooids indicated by small spots caused by accumulation of spicules; these spots often appearing in double rows which surround islands of gelatinous-appearing semitransparent test and giving surface a reticulated appearance. Spicules varying in diameter from .19 to .075 mm. [see remarks below], their blunt rays springing from a spherical nucleus; confined mainly to uppermost stratum of colony. Bladder cells, usually polygonal from mutual pressure but free from

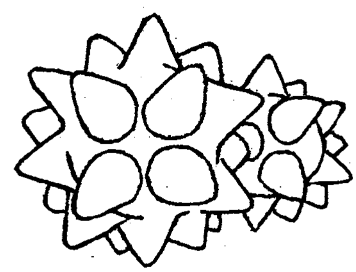


FIG. 40. *Didemnum carnulentum* Ritter and Forsyth. Spicules, ×950.

spicules, make up lower layer of test. Branchial sacs of zooids embedded in upper spicule-bearing stratum, their abdomens extending about halfway down into bladder-cell stratum. Upper stratum of test having spaces in it which seem to serve for communication with the common cloacal orifices, zooids not being arranged with any reference to these openings. Cloacal orifices comparatively few in number and large; branchial orifices small openings in center of spots caused by closely set spicules.

"Zooids: From 1 to 2 mm. long, depending upon thickness of colony; made up of thorax and abdomen. Mantle with no muscle fibers visible. Color orange.

"Branchial System: Branchial siphon with six distinct, usually pointed lobes, located in middle and anterior part of branchial sac. Atrial siphon a plain round opening on dorsal side opposite middle of sac. Branchial sac with four series of stigmata, each having about six in a half-series; stigmata elliptical. Endostyle proportionately very broad. Dorsal languets three. Branchial tentacles eight, very small. Two strong muscle bands from dorsal part of branchial sac continue to near the recto-esophageal collar where they terminate in a free process.

"Digestive System: An elongated loop with arms closely applied but open at bend. Esophagus proportionately large, emerging from middle posterior part of branchial sac; often as much as three times the length of sac. About two-thirds of its length from sac, esophagus bound to rectum by a band. Stomach almost globular with smooth surface; its long axis slightly inclined to that of zooid. First part of intestine, about equal in length to stomach, connected by a portion equally long but of smaller diameter with rectal arm of loop; anus very near atrial opening.

"Reproductive System: Large undivided testis situated on left side of intestinal loop; on its rounded mound-like surface is the coiled vas deferens, coil having six turns. Ovary, usually containing one large egg and several very small ones, located between stomach and testis; ripe eggs almost as large as branchial sac. No oviduct appears to be present and how eggs are discharged is not definitely known. Large tadpoles found in the test of some colonies."

"Breeding Season: Colonies containing many tadpoles in June, but few or none in January or February."

DISTRIBUTION: According to Ritter and Forsyth: "In littoral zone but never at limit of high tide; usually on under sides of rocks. Abundant at La Jolla and on all rocky beaches of the San Diego region. Although this species has not been found at any other point, in all probability this is due to insufficient collecting."

In, and in the vicinity of, Newport Bay it appears to be rare or absent.

The American Museum of Natural History has numerous specimens from littoral stations in the Monterey Bay region and from many parts of the Gulf of California in which, as material received from E. F. Ricketts shows, it is common from the south end at least as far north as Tiburon Island and Angel de la Guardia Island; also one from the harbor of Panama City. Greatest depth recorded, 10 to 15 fathoms. One specimen grew on the back of a crab.

In most characters these specimens agree well with the above description of *D. carnulentum*, and I believe they should all be referred to this species. In preservation they are all white; those that I collected myself at Pescadero Point near Pacific Grove on intertidal rocks were pale flesh-colored when fresh. But I find few colonies having any spicules over 0.035 to 0.045 mm., measuring to the tips of the points; in most cases they would average a good deal smaller; and as the spicule diameters given by Ritter and Forsyth are astonishingly large (I know of no Didemnidae in which such spicules prevail), I must assume a displacement of the decimal point in the measurements given by those authors. While some colonies have spicules with blunt rays as the prevailing form, in more cases I find the spicules with very symmetrically formed conical points, as shown in Ritter and Forsyth's figure 59 and in the figure given here, although quite frequently the points are longer and slenderer than shown in those figures. As a rule, most of the spicules are remarkably uniform in shape and often also in size throughout any single colony. I found more stigmata in a row (at least seven or eight on each side) than the number given by Ritter and Forsyth in the few cases in which they could be counted.

In the above article Ritter and Forsyth also describe the following variety:

Didemnum carnulentum var. *lacteolum* Ritter and Forsyth, 1917 (p. 471, pl. 40, fig. 23, pl. 44, fig. 60), which differs in the following particulars:

"Encrusting and very thin, never of the great extent of *Didemnum carnulentum;* 1 mm. and less in thickness. Color pure white, due to numerous calcareous spicules varying in size fron .15 to .065 mm.; spicules very numerous in lowermost stratum of colony, zooids extending into both upper and lower limy strata. Bladder cells not conspicuous but present around closely packed zooids. Zooids very similar to those of *Didemnum carnulentum* but smaller. The atrial orifice proportionately much larger, often over half the length of branchial sac. Testis almost spherical when fully ripe and half as large as sac. Coil of vas deferens contains seven turns. Ripe ova gigantic, even larger proportionately than in *carnulentum*. Budding similar to that of *Trididemnum della vallei*. Breeding season in June" (Ritter and Forsyth.)

DISTRIBUTION OF *D. carnulentum* VAR. *lacteolum:* "On under sides of rocks in the littoral zone and in the holdfasts of kelp, hence from depths of a few fathoms. Common at La Jolla and in the San Diego region" (Ritter and Forsyth).

With the material available I am not able to express any definite opinion in regard to the constancy or importance of the differences separating this from the typical *carnulentum*.

SUBGENUS **POLYSYNCRATON** (NOTT), 1891

Differs from the typical subgenus of *Didemnum* in having the testis divided into several entirely separate glands, disposed in a circular group, about which the sperm duct coils. The typical species (including the West Indian form) have an atrial languet. (See Hartmeyer, 1912b, p. 325, for a discussion of this group.)

Didemnum (Polysyncraton) amethysteum
(Van Name), 1902

Plate 18, figure 3; text figure 41

Didemnum (Polysyncraton) amethysteum VAN NAME, 1921, p. 333, figs. 27–29; 1930, p. 439, figs. 15, 16; BERRILL, 1932, p. 77.

Polysyncraton amethysteum VAN NAME, 1902, p. 366, pl. 54, figs. 62, 64–67, pl. 58, fig. 102; HARTMEYER, 1912b, p. 325.

The colonies in this species are of the flat, incrusting type; the upper surface is nearly smooth and even; the thickness of the colony is about 3 mm., and the greatest diameter rarely over 25 or 30 mm. In spite of their small size, they are during life of striking appearance. The test is transparent and of a handsome purple or rose purple tint which fades to yellow on preservation. The color is due to pigment in the test cells. The zooids during life are bright red. The upper surface layer of the colony contains a layer of small white burr-like or almost spherical spicules, but small oval areas about the branchial apertures of the zooids and a larger central area on the upper surface of the colony, surrounding the common cloacal aperture (there appears usually to be but one), are without spicules except for small V-shaped groups of them corresponding to the six lobes of the branchial orifices. The white spicule-covered areas show in strong contrast to the deep purple exposed areas of the test. The layer containing the spicules may readily be stripped off.

Spicules always small, 0.015 or 0.02 mm. in diameter or even less, with short and often

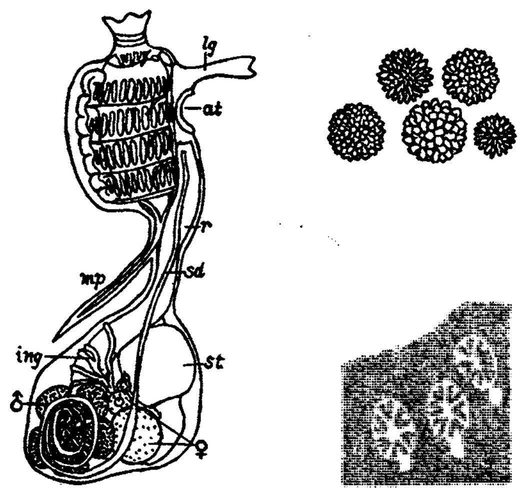


FIG. 41. *Didemnum (Polysyncraton) amethysteum* (Van Name). Zooid, ×40. Spicules, ×460, and part of surface of colony showing distribution of spicules in the superficial layer of test, ×11.

more or less blunted rays, so numerous that the spicule appears nearly spherical except except under high magnification.

Zooids about 1.5 mm. long when well expanded. Body strongly constricted between thorax and abdomen; a tapering muscular process extends ventrally and posteriorly out into the test from the constricted part of the body. Branchial aperture six lobed, atrial plain, with a languet at its anterior border. This languet is, in well-expanded zooids, fairly long and wider toward the end, where it is slightly forked. In strongly contracted individuals it is merely a small tongue-like projection.

Well-developed longitudinal muscle bands present on the thorax. Tentacles at least eight in number; additional smaller ones are probably present. The dorsal languets apparently arise from the transverse vessels of the left side, but the sac was too much contracted in the specimens studied to determine this satisfactorily.

Stigmata in four rows: apparently about a dozen in a row on each side. Male reproductive organs consisting of a group of usually

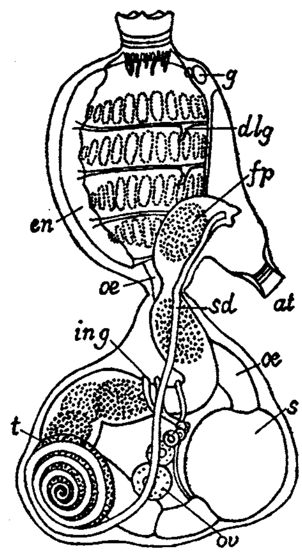


FIG. 42. *Leptoclinides faeröensis* Bjerkan. Zooid, ×40.

about five or six radially disposed, pear-shaped testes, whose narrow ends are connected with the origin of the common sperm duct by very short individual ducts. The common sperm duct makes about five loose spiral turns about or upon the whole group before accompanying the distal branch of the intestine. Ovary between the testis and stomach. Eggs very large when fully grown.

DISTRIBUTION: This is a moderately common species at Bermuda on stones along the shore and in other shallow situations. I have also found it growing on calcareous algae on the banks near Soldier's Key, Biscayne Bay, Florida. It occurs at Puerto Rico, where specimens were taken on a *Microcosmus* growing on a pile in Guanica Harbor, and others dredged off Point Brea and off Guanica Harbor in 35 to 100 feet, and I have seen specimens from the Colombian Caribbean coast near Cape Vela. The type (from Bermuda) is in the Yale University collection.

GENUS **LEPTOCLINIDES** BJERKAN, 1905

Differs from *Didemnum* only in having the atrial opening at or posterior to the middle of the thorax and produced into a short tube with a circular, often slightly funnel-shaped orifice which is often directed obliquely backward. There are four rows of stigmata; the sperm duct is coiled; the testis may be single or divided.

This is hardly worthy of more than subgeneric rank, but is commonly recognized as a genus.

Leptoclinides faeröensis Bjerkan, 1905
Text figures 42, 43

Leptoclinides faeröensis BJERKAN, 1905, p. 20, pl. 3, figs. 4–6; 1908a, p. 99; VAN NAME, 1910, p. 374, figs. 10–12, pl. 39, fig. 14; HARTMEYER, 1912b, pp. 374, 379; 1922a, pp. 25, 44, fig. 7; 1924, p. 164, pl. 1, fig. 24.

For other references, see Hartmeyer, 1924. The specific name has been misprinted *faroënsis* and *faeröerensis*.

This deep-water species forms irregular, thick, incrusting colonies often massive and of considerable size (in one case 85 mm. in

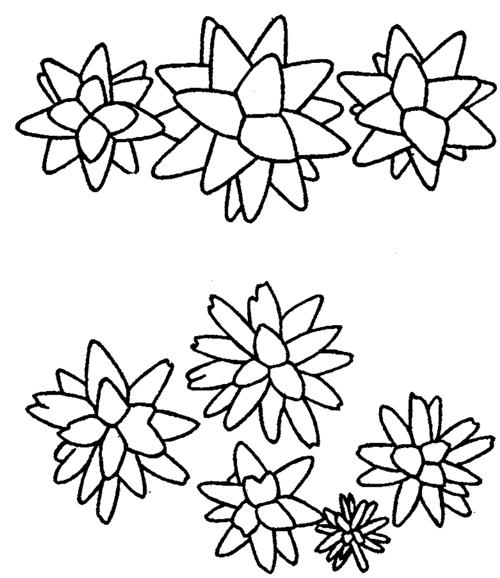


FIG. 43. *Leptoclinides faeröensis* Bjerkan. Upper group, typical spicules, ×600. Lower group, imperfect spicules, from a specimen from very deep water (1582 fathoms), ×600.

greatest diameter and no less than 25 mm. thick at one point). The zooids occupy only the superficial part of the colony; the spicules are also most abundant near the surface of the colony. In its interior it is composed of test substance of firm consistency and yellow color containing scattered spicules.

The character of the surface is variable; the alcoholic specimens are yellowish or grayish white owing to the abundance of spicules in the superficial parts. The surface is often slightly raised in small rounded elevations over the position of each zooid; the branchial apertures are commonly quite conspicuous; the common cloacal apertures are large and very few, apparently but one in small colonies.

The spicules are rather large and usually have rather long and not very numerous conical points, and in many colonies are beautifully regular in form and rather uniform in size in the superficial parts of the common test. They do not usually much exceed 0.05 mm. in diameter.

The zooids are rather large, the specimen figured, which was fairly well expanded, measuring 1.7 mm. long. Their body is usually strongly constricted or strangulated between the thorax and abdomen; their most conspicuous feature is the large, inversely funnel-shaped atrial siphon, which arises far back on the dorsal side of the thorax and is directed more or less obliquely backwards. The margin of its aperture is plain or slightly sinuate.

The zooids had 16 or more oral tentacles of at least three sizes, and there were four rows of stigmata with 11 on each side in the anterior rows and about nine in the last row in the specimens studied. The testis is undivided; the sperm duct is coiled in only a few turns.

DISTRIBUTION: This species has a wide range in the deeper waters of the northern seas, but most of the records are south of the Arctic Circle. In Old World waters it occurs in the vicinity of Iceland (Bjerkan's type was from northwest of that island in 590 meters), near the Faeroes, the Norwegian west coast, and south of Spitzbergen; on the American side in Davis Strait, off Newfoundland and Nova Scotia, and southward (farther than in any other region) in the deep water off our northeast coast. Colonies were dredged by the "Albatross" at Station 2429, 42° 55′ N., 50° 51′ W., 471 fathoms, gray mud; and in 42° 53′ N., 59° 04′ W., 100 to 150 fathoms; Station 2523, 41° 48′ N., 65° 44′ W., 111 fathoms; also (based on poor specimens) Station 2264, 37° 07′ 50″ N., 74° 34′ 20″ W., 167 fathoms, gray sand. There appear to be no American records (and few Old World ones) of less than 100 fathoms, but it ranges down to great depths. Hartmeyer records it from 1251 and 1505 meters, and two specimens were obtained by the "Albatross" at the great depth of 1582 fathoms, at Station 2228, 37° 25′ N., 73° 06′ W. Though the zooids are not well preserved and the spicules, as would be expected at such a depth, are less well formed than usual, the spicules from one colony show in many cases the characteristic form of their rays or points, so that I do not feel doubt in referring the colonies to this species.

Leptoclinides brasiliensis Michaelsen, 1923

Leptoclinides brasiliensis MICHAELSEN, 1923, p. 34, fig. 6; 1930, pp. 512, 513, fig. 3d.

A species known only from Michaelsen's description. It forms thin ($\frac{2}{3}$ to 1 mm. thick), brittle, rough, incrusting colonies on branching sea weeds. Color light gray to yellowish or brownish gray.

The test contains many bladder cells and calcareous spicules very unevenly distributed. The spicules are quite regularly stellate, some of them up to 0.075, a few as much as 0.095 mm. in diameter, but usually smaller, and have fairly long, numerous, and well-formed conical points.

Zooids arranged in complex systems; their location is indicated on the surface by small rounded areas with fewer spicules. The common cloacal openings were not distinguishable. Zooids small, up to $1\frac{1}{3}$ mm. long, the branchial tube large and funnel shaped, smooth margined, without any trace of lobes; the atrial tube very large, conical, ending in a small smooth aperture. Its expanded base occupies much of the dorsal side of the thorax; it is usually directed obliquely posteriorly. Both tubes with well-developed circular muscles. There are six narrow longitudinal muscle bands on each side of the thorax, also a large oval spicule-forming organ on each side.

Branchial tentacles apparently normally 24, of three orders. Branchial sac apparently ("anscheinend") with four rows of stigmata. Thirteen were demonstrated in a row on each side.

Stomach nearly spherical; the middle part of the intestine separated from the proximal and distal parts by deep constrictions.

No zooids with both male and female reproductive organs were found. The male organs consist of two or three, rarely four, pear-shaped testes arranged radially with the small ends joined together ("verwachsen"). The sperm duct makes about six loose turns about the group of testes. In the female zooids no ovary was found, but a single large egg, 0.18 mm. in diameter, was present in the abdomen of some individuals, and some large eggs and larvae in cavity in the common test.

LOCALITY: Atlantic Ocean off Brazil, latitude 09° S., 18 fathoms.

The uncertainty regarding the number of rows of stigmata makes the generic position of the species likewise somewhat doubtful. Michaelsen in his original description calls attention to the fact that the common cloacal canals are largely very deeply situated in the colony; later (1930) he describes and figures them as lying chiefly below the layer containing the zooids, which explains the obliquely posterior direction of the atrial tube.

GENUS **TRIDIDEMNUM** DELLA VALLE, 1881

Differs from *Didemnum* in having but three rows of stigmata. The testis is a single undivided gland about which the sperm duct coils as in *Didemnum.* No atrial languet is present; the atrial aperture is a plain opening, often situated with back toward the posterior end of the thorax, which in some of the species is produced into a short tube. Stellate calcareous spicules, usually large and with well-formed conical points, are present in the test of most species.

The slight differences in structure and other characters of the species of this genus make it a most difficult one to deal with, and considerable revision of the treatment of them given below will no doubt be required in the future when the group has been more thoroughly studied.

The name *Didemnum* was incorrectly used for this genus in Herdman, 1886, and many older works. *Didemnopsis* Hartmeyer, 1903 (syn. *Lioclinum* Verrill, 1871, and *Didemnoides* Lahille, 1890, not von Drasche, 1883), has been used for species such as *T. tenerum* in which the spicules are few or wanting, but that character is not of generic importance.

Trididemnum tenerum (Verrill), 1871

Text figure 44

Didemnoides variable HUITFELD-KAAS, 1896, p. 5, pl. 1, figs. 1, 2.

Didemnopsis tenerum VAN NAME, 1910, p. 385, figs. 16, 17, pl. 39, fig. 15; HUNTSMAN, 1912, pp. 112, 138.

Didemnopsis variabile HARTMEYER, 1903, p. 366, pl. 6, fig. 19, pl. 14, fig. 22; BJERKAN, 1905, p. 22, pl. 3, fig. 9; 1908a, p. 101.

Didemnum gelatinosum SARS, 1851, p. 153; 1859, p. 66 (not Milne Edwards, 1841).

Lissoclinum tenerum VERRILL, 1871, p. 445; 1872a, p. 212; 1879, p. 27; HARTMEYER, 1909–1911, p. 1456.

Trididemnum tenerum HARTMEYER, 1921a, p. 88, figs. 21–23; 1924, p. 130, pl. 1, figs. 19, 20; ÄRNBÄCK, 1934, p. 42.

For other references and synonyms, see Hartmeyer, 1924, pp. 130–131.

"Colonies incrusting shells, ascidians, etc., forming thin, soft, gelatinous crusts, which are translucent and filled with numerous very small zooids which are nearly uniformly distributed. Cloacal openings small round apertures numerously scattered over the surface" (Verrill, 1871, p. 445).

The colonies are usually small, from 2 to (rarely) 8 or 10 mm. thick and occasionally 60 mm. or more across.

Though most colonies are nearly or apparently entirely free from spicules in the test, in many cases small elongate or needle-like calcareous crystals are scattered in the test, and these are often aggregated into small, sometimes very irregular, sometimes quite regular spherical groups (0.02 to 0.04 mm. in diameter or occasionally larger) which in some cases must be regarded as true spicules (see Hartmeyer, 1921a, 1924).

The color ranges from grayish to yellowish white. The zooids are thickly distributed, sometimes without any discernible regularity; in other colonies their arrangement in double rows clearly indicates the existence of extensive and complex systems. The zooids vary much in size. As they are found in the preserved specimens, few of them exceed 1.5 mm. to 1.75 mm. in length, and a large majority are much smaller (1.15 mm. to 1.4

mm.), though in many cases such small size appears to be due to immaturity as well as to strong contraction. In many cases the body is violently constricted or strangulated between the thorax and abdomen. A short retractor process may or may not be developed, and at certain stages of growth clavate vascular processes extending into the test from the middle region of the body are found. where the stigmata could be accurately counted, there were 12 in the first and 11 in the second and third rows on each side; in another, 11 in the first two rows and 10 or nine in the last. In others, 10 was the maximum in the anterior rows, though in those cases the zooids were perhaps not mature. The stigmata begin quite close to the endostyle and extend to the median dorsal vessel.

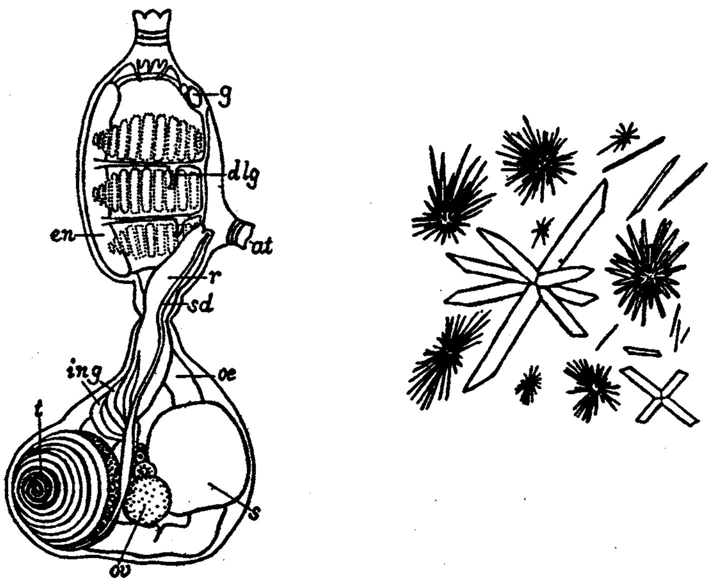


FIG. 44. *Trididemnum tenerum* (Verrill). Zooid, ×45, and crystalline deposits and spicules in the test, ×515.

The branchial aperture is obtusely six-lobed; the atrial aperture, which is placed at the end of a somewhat funnel-shaped tubular projection, is situated posterior to the middle of the thorax in adult zooids, though farther forward in young ones. It is plain margined in young zooids, but often conspicuously lobed in older ones. This tube often gets broken off in dissecting out the zooid from the common test.

In many individuals it can be clearly seen that there are but eight tentacles, larger and smaller ones alternating, those opposite the endostyle and median dorsal vessel being larger than any of the others. In other individuals there are additional still smaller ones, or 16 in all. The dorsal tubercle is situated close against the ganglion.

There are three rows of stigmata, with a rather broad space free from stigmata intervening between the anterior end of the thorax and the first row. In one individual At the ventral end of the rows the stigmata usually become successively shorter as the endostyle is approached, but at the dorsal end only the first, if any, is much shortened. The dorsal languets (two in number) arise from the transverse vessels of the left side of the sac about opposite the second or third stigma from the median dorsal vessel. They are short, curved, and directed posteriorly.

An oblique constriction in the intestine some distance beyond the stomach (which is globular and smooth walled) is generally noticeable. The few tubules constituting the glandular organ surrounding the intestine have tapering ends.

The single large testis has the usual position in the left posterior part of the abdomen, and the proximal part of the sperm duct makes usually from eight to 10 turns about it. Many of the colonies contain large tailed larvae of the type usual in this group in cavities in the common test.

DISTRIBUTION: A species of the northern seas which appears to be circumpolar (Hartmeyer, 1924), though most of the records are from the European and east American regions where it ranges south on the American side to Cape Cod (United States Fish Commission Station 372, north latitude 40° 40′, west longitude 69° 28′ 30″, 70 fathoms, sand and pebbles, the most southerly record) and to the western part of the English Channel in Europe. Other localities are Spitzbergen, the Murman coast, the Siberian Arctic Ocean, the Sea of Okhotsk, and Bering Strait (specimen in the American Museum of Natural History). It occurs on various kinds of bottom, provided, of course, there are objects for attachment; the usual depths range from about 18 to 75 fathoms. Verrill's type locality was Eastport, Maine. This type specimen was examined by the writer in the Peabody Museum of Yale University. I do not agree with Hartmeyer, 1924, in including *T. strangulatum* (Ritter) from southern Alaska in this species.

Trididemnum savignii (Herdman), 1886

Plate 18, figure 4; text figure 45

Didemnum atrocanum+*D. lucidum*+*D. porites* VAN NAME, 1902, pp. 359, 360, pl. 51, figs. 26, 28–30, 33, 34, 37, pl. 59, figs. 114, 115.

Didemnum savignii HERDMAN, 1886, p. 261, pl. 34, figs. 1–5; VAN NAME, 1902, p. 358, pl. 51, figs. 27, 35, pl. 59, fig. 112.

Trididemnum savignii VAN NAME, 1921, p. 314, figs. 7–9 (+*T. s.* form *porites*, p. 317); 1924, p. 23; 1930, p. 428, figs. 7–8; BERRILL, 1932, p. 77; PLOUGH AND JONES, 1937, p. 100.

This ascidian forms incrusting colonies, occasionally of considerable size (one specimen measures 90 mm. across) and of very variable thickness, usually only about 2 to 3 mm., but often considerably more when growing on an irregular surface. The external appearance of the colony is greatly dependent on two characters, both subject to very great variability in different specimens, first, the number and distribution of the large stellate spicules, and second, the abundance and distribution of the pigment cells in the test. The spicules are of comparatively large size, generally 0.04 to 0.06 mm.; in some colonies some of them are 0.08 or 0.1 mm. in diameter, or even more. They are generally beautifully regular in form, being stellate, with moderately numerous conical points which taper to a rather sharp extremity, though in many colonies among such regularly formed spicules there will be found many in which the points are irregular and broken or blunted at the tip. Occasional colonies occur in which the majority or all the spicules exhibit such imperfections, the points being reduced to mere irregular protuberances on the spherical central portion of the spicule. In some specimens the spicules exhibit striking uniformity in size; in others large and small ones occur in varying proportions. Their distribution and relative abundance in the test are also subject to much variation. Generally the spicules are chiefly or entirely confined to a layer in the test a little beneath the upper surface, leaving the latter smooth and glossy. The spicules are often distributed in this layer in groups and patches, which may show white, in strong contrast to the dark areas where spicules are few or wanting, giving the surface of the colony a very conspicuously mottled or spotted coloration, but this occurs only in a small proportion of the specimens. The branchial apertures of the zooids are usually distinguishable on the surface, and the zooids themselves are often more or less distinctly visible through the test.

As a rule, dark smoky brown or blackish pigment is present both in the test and on some parts of the zooids, especially about the anterior end and on the thorax and sometimes on much of the mantle. The pigment is chiefly contained in special cells which are most abundant in the superficial parts of the test and vary in form from the most irregular and elongate shapes to regularly oval. Generally the pigment cells just described give the upper surface of the colony, or sometimes the whole test, a brownish or blackish color, according to their abundance; after preservation in alcohol for some time, this pigment becomes of a warmer brown tint. Bladder cells are usually very abundant, especially in the superficial parts of the colony.

The zooids show this to be a typical member of the genus. In the preserved material they vary from 1.5 to 1.6 mm. to less than 1 mm. in length, this being largely dependent on the state of contraction they are in. They have a tapering muscular process extending out into the common test from the constricted middle part of the body; its length and thickness are very variable in different colonies.

Branchial aperture with six short lobes. Atrial aperture round, situated on the dorsal side of the thorax about the middle or somewhat farther toward the posterior end, the position varying in different colonies and often also in different individuals of the same colony. It is slightly produced, but usually not sufficiently to be called a tube. Mantle with well-developed longitudinal muscle bands on the thorax. Tentacles not less than eight, of at least two sizes arranged alternately; additional smaller third-order tentacles are probably present in the intervals. Dorsal languets (two in number) borne on the transverse vessels of the left side, a little way from the median dorsal vessel. Branchial sac with three rows of stigmata. The number in a row on each side in adult zooids appears to be variable. It reaches and possibly sometimes exceeds a dozen. The sperm duct may make as many as 10 or 12 turns about the large conical testis.

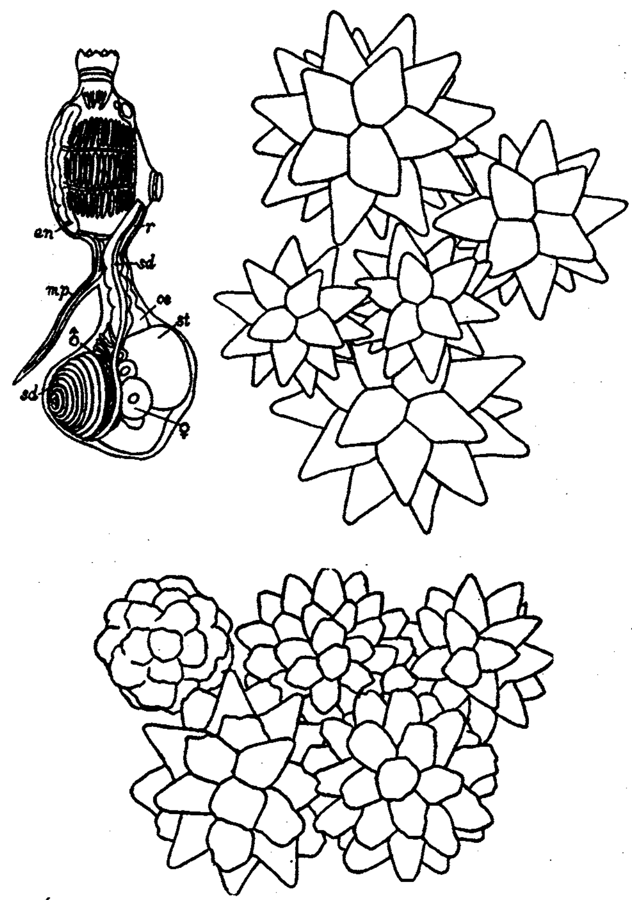


FIG. 45. *Trididemnum savignii* (Herdman). Zooid, ×40. Typical spicules, ×460. Below, less well-formed spicules from another colony, ×460.

DISTRIBUTION: *T. savignii* was described by Herdman from a specimen obtained by the "Challenger," whose locality was marked as doubtful but probably from a station in 150 fathoms off the Cape of Good Hope. The close correspondence of Herdman's very detailed description with Bermuda and Florida specimens from shallow water suggests that the type may really have come from shallower water, and perhaps from Bermuda, where the "Challenger" expedition also made collections. The American Museum contains specimens from Biscayne Bay, Florida, collected by myself, and one from off Salinas Cove, south coast of Puerto Rico; the United States National Museum contains one from the Blackfish Banks off Charleston, South

Carolina, and many from various points off the west coast of Florida from Cedar Keys to off Key West, also one from off the southeastern part of Jamaica. The greatest recorded depth (other than that of Herdman's type) that has come to my notice is 27 fathoms.

The form *porites* of this species (originally described as a distinct species) was based on specimens having the spicules abundant and numerous in the superficial layer of the test as well as in the deeper parts, which gives the surface of the colony a finely granular character and renders the apertures of the zooids more conspicuous. I have seen such specimens from many different localities within the range of the species. Every gradation may be found between such specimens and the usual ones with fewer spicules.

Two other supposed species, *T. atrocanum* and *T. lucidum*, both from Bermuda, were, I now believe, based merely on immature or small, poorly developed colonies of the present species, and should be rejected as not valid. *T. lucidum* was based on small and probably young colonies with scarcely any pigmentation.

T. natalense Michaelsen, 1920, from Natal, Africa, and *T. cyclops* Michaelsen, 1921, from Madagascar are Old World forms evidently closely related to the present species.

Trididemnum solidum (Van Name), 1902

Plate 19, figure 1; text figure 46

Didemnum solidum Van Name, 1902, p. 358, pl. 51, figs. 31, 36, pl. 59, fig. 119.

Trididemnum solidum Van Name, 1921, p. 318, figs. 10–12; 1930, p. 431, figs. 9, 10.

This species was described from a single specimen now in the Yale University collection obtained at Coney Island, Bermuda, in shallow water. It is of irregular form, 45 mm. in greatest length, and 4 to 5 mm. in thickness in some parts, and incrusts a piece of seaweed. The test is rather hard and opaque, owing to the abundance of the spicules, which are quite uniformly distributed throughout the colony. During life it was of a pale reddish gray color, almost a flesh color, darker above; this faded in preservation to a yellowish white. Surface slightly raised over the position of each zooid; branchial apertures moderately conspicuous, not very close together. Spicules seldom exceeding 0.05 to 0.06 mm. in diameter; they have quite numerous well-formed and regular conical points; the points are short and arise from a large central spherical mass. The individual points have the form of concave-sided cones and are thus rather narrow toward the apex in spite of having a broad base. Bladder cells few in most parts of the colony.

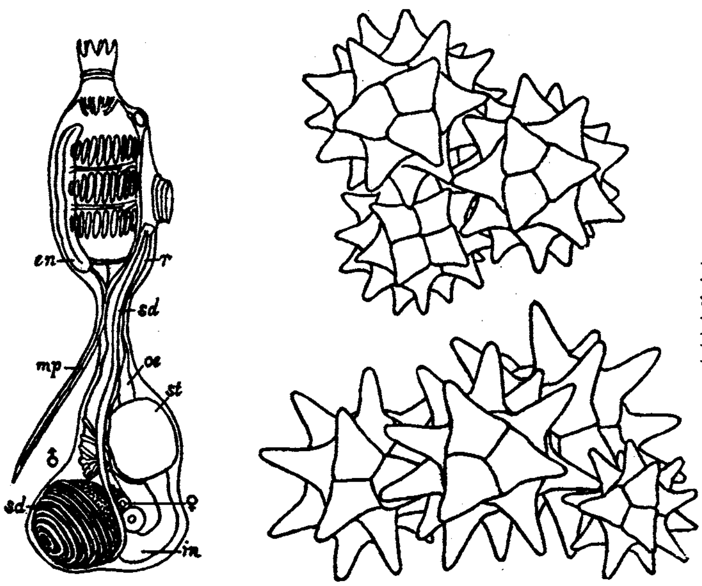


Fig. 46. *Trididemnum solidum* (Van Name). Zooid, ×60. Upper, spicules of type colony from Bermuda, ×460. Lower, spicules of a colony from Puerto Rico, ×460.

The zooids do not appear to differ materially from those of *T. savignii*, except in being rather small and slender and perhaps also in having somewhat fewer stigmata in the rows.

DISTRIBUTION: Type locality, Bermuda, in shallow water. Several other colonies apparently referable to this species were obtained by the American Museum expedition to Puerto Rico, some of them in depths down to 35 fathoms. One colony incrusts a convex head of dead coral and would measure, if flattened out, about 130 mm. across and 4 to 5 mm. thick, or in some places even thicker. In its yellowish white color (in alcohol) and in the character of the surface and of the test it closely resembles the Bermuda specimen. The zooids likewise are elongate and slender and usually have about 11 or 12 stigmata in a row on each side. Some of them have well-developed reproductive organs similar to those of *T. savignii*, described above. The spicules in all the colonies are numerous and closely crowded; they average greater in diameter than those in the Bermuda type of *T. solidum*, sometimes reaching 0.07 mm. or even 0.08 mm. across the points. The points are much fewer and longer and slenderer than in the type colony, but quite regular, and the spicules have in consequence a very symmetrical stellate form. These Puerto Rican specimens were dredged south of Guanica on sandy bottom with coral rocks and algae, in depths of about 23 and 35 fathoms, and between Cayo Caribe and Cayo Parguera in 5½ to 8 fathoms. The United States National Museum contains similar specimens (also with rather long-pointed spicules) from the Bahamas, collected by B. A. Bean, 1903, and from Mosquito Bay, St. Thomas, collected by C. R. Shoemaker, also several very large ones from St. John (former Danish West Indies), growing on millepore corals, collected by Shoemaker. One of these is 250 mm. in maximum length, covering a flattened branch of the coral on both sides and having a maximum width of over 80 mm., but it is not very thick at any point.

I am far from being satisfied in regard to the validity of this species; perhaps the specimens on which it is based may be old colonies of *T. savignii* which were no longer in an actively growing condition.

Trididemnum orbiculatum (Van Name), 1902

Text figure 47

Didemnum orbiculatum VAN NAME, 1902, p. 361, pl. 51, figs. 32, 38, pl. 61, figs. 127a, 128; PRATT, 1916, p. 671.

Trididemnum orbiculatum VAN NAME, 1921, p. 320, figs. 13–15; 1924, p. 25; 1930, p. 431, figs. 11, 12; BERRILL, 1932, p. 77.

Colony (in contrast to that of *T. savignii*) always very thin, flat and incrusting, translucent; during life, of a characteristic light slate-gray color fading to almost white on preservation. Size of the largest specimens, 25 to 30 mm. across and 2 mm. or less in thickness. Surface smooth in fresh specimens; in preserved material often uneven and raised over the positions of the zooids, which are usually quite thickly and evenly distributed, and are more or less concealed by a rather dense layer of spicules in the upper stratum of the colony. The spicules are so distributed that the surface of the colony usually shows over the position of each zooid a circular or oval area of about the diameter of the thorax, more transparent than the intervening spaces, which latter are whiter and more opaque, owing to the greater abundance of spicules in them. Spicules mostly between 0.035 and 0.04 mm. in diameter, quite regularly stellate, with a moderate number of rather long points of fairly regular tapering conical form.

Zooids very small, often only 1 mm. long when much contracted. Usually there is much blackish pigment in the cells of the mantle in the thoracic region. Branchial orifice six-lobed; atrial orifice almost plain edged, without a languet. It is situated either opposite the middle of the thorax, or farther toward the posterior end, and is produced into a very short tube. A strong muscular process extends back into the common test from the constricted middle region of the body.

Strong sphincters are present about the apertures and many strong longitudinal muscle bands on the thorax, which so contract that part of the body that a satisfactory study of the internal parts becomes very difficult. There are eight tentacles of two sizes; eight additional smaller ones may be present in the intervals. Three rows of stigmata with probably not over eight or 10 in a row on each side. No peculiarities in the alimentary or-

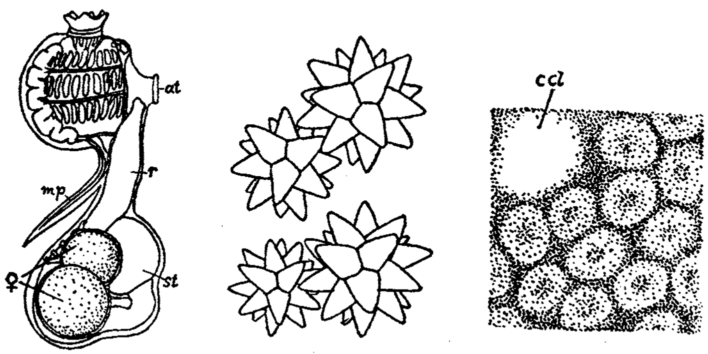


FIG. 47. *Trididemnum orbiculatum* (Van Name). Zooid, ×40. Spicules, ×460. Part of surface of colony showing distribution of spicules in the superficial layer of the test, ×11.

gans were noted; stomach rounded; intestinal loop small.

Although zooids from many colonies collected in April and May were examined, no male reproductive organs were found. (Specimens of *T. savignii* collected at that season usually have them well developed.) Many of the zooids, however, contain one or two large eggs in the abdomen.

DISTRIBUTION: This species was described from Bermuda, where it was found common on the under side of large stones at many points along the shore, especially at Long Bird Island, Waterloo, and Castle Harbor, growing in company with other ascidians such as *Didemnum*, *Lissoclinum*, and *Botryllus*. As a considerable number of specimens were obtained, all very constant in their characters and quite different in appearance from *T. savignii* during life and in preservation, it seems likely that this is a valid species in spite of the variability shown to exist in *T. savignii* by the material now available. The type is in the Yale University collection.

A specimen was also found in the collection from Curaçao which I studied (Van Name, 1924); in this example also only eggs but no male organs were found.

Trididemnum thetidis, new species

A number of examples of a form closely allied to *T. orbiculatum*, just described, were obtained by the American Museum party on the west coast of Florida in November, 1941.

These specimens are mostly entirely without spicules; they are flattened incrusting colonies usually only 1.5 to 2 mm. thick when growing on an even surface and of very irregular outline; one much elongated colony is about 80 mm. in maximum measurement and 2.3 mm. wide at the point of greatest width.

The test is of quite firm and solid consistency, fairly transparent, though slightly yellowish in some of the alcoholic specimens; the lighter-colored zooids show plainly through it. There is no pigmentation except a minute blackish spot over the anterior end of the endostyle and sometimes also six slight deposits of the same pigment on the six small lobes surrounding the branchial aperture.

The very close and even distribution of the minute zooids in almost all parts of all the specimens is quite conspicuous; neither the common cloacal apertures nor the limits of the systems are distinguishable in the preserved material, though the systems appear to be extensive and of complex outline.

The type and most of the other colonies are apparently entirely without spicules; in several cases, however, there are in a few parts of the colony some scattered spicules present in the upper but not the most superficial layer of it. These spicules are of the usual *Trididemnum* type, as illustrated under *T. savignii*—stellate with well-formed conical points; they are mostly of quite small or very small size; the largest measured were from 0.03 to 0.04 mm. in diameter from tip to tip of opposite rays, but spicules as large as that are comparatively very few.

The zooids are also very small, in the much contracted condition they are in, measuring seldom over 0.6 to 0.75 mm. in length and half that in transverse diameter of the thorax.

The branchial orifice is on a more or less prominent siphon; the atrial orifice forms a short funnel-shaped tube of rather small diameter, whose somewhat enlarged terminal opening is smooth margined. It usually arises from near the middle of the dorsal aspect of the thorax and is in many cases directed obliquely posteriorly, but its position and direction vary, being dependent on the position of the zooid in relation to the common cloacal canal.

The thorax has narrow but quite strong longitudinal muscle bands; as well as I could determine in the contracted state of the thorax, there are eight or more tentacles and three rows of stigmata with about nine or 10 in the two anterior rows and one or two less in the last row. The side walls of the thorax are somewhat concave, but I did not find definite lateral organs. A muscular retractor extending into the test was either absent or quite rudimentary in the zooids studied. No gonads were found in any of them, but some were reproducing by budding.

LOCALITY: These specimens were from two stations near Tarpon Springs, Florida, growing mostly on larger ascidians, especially *Clavelina gigantea*, on reefs of limestone rock in 30 to 45 feet of water. The type (A.M.N.H. No. 1986) and cotypes are in the American Museum of Natural History, which also has a specimen from a pile of the railroad pier at St. Joseph, Florida.

Trididemnum propinquum (Herdman), 1886

Leptoclinum propinquum HERDMAN, 1886, p. 284, pl. 39, figs. 16–20.

Trididemnum propinquum HARTMEYER, 1909–1911, p. 1446.

An insufficiently known species based on several small, thin incrusting colonies attached to a worn fragment of coral, largest colony 2 cm. by 1 cm. and 1 mm. thick. Color grayish white, systems not recognizable, spicules "mostly stellate with many narrow pointed rays, some with the rays shorter and broader so as to produce a more nearly spherical form of spicule." They are uniformly distributed except immediately around the branchial apertures, where they are more numerous and closely placed about the edges of the six lobes.

The zooids have the neck connecting the thorax and abdomen short; three rows of stigmata, no retractor process, and the testis a single large rounded mass about which the sperm duct makes spiral turns.

LOCALITY: "Challenger" Station 311, at the western end of the Strait of Magellan, in 245 fathoms.

Trididemnum auriculatum Michaelsen, 1919

Text figure 48

Leptoclinum tenue MICHAELSEN, 1907 (in part), p. 39.

Trididemnum auriculatum MICHAELSEN, 1919, p. 38, fig. 3.

Trididemnum auriculatum f. *separ* ÄRNBÄCK, 1929, p. 16, fig. 4, pl. 2, figs. 19, 20.

This is another insufficiently known species perhaps not distinct from *T. propinquum*, based by Michaelsen on an incrusting colony

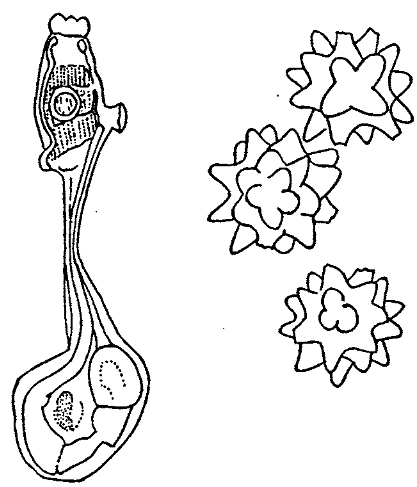


FIG. 48. *Trididemnum auriculatum* Michaelsen. Zooid, ×30, and spicules, ×350, from illustration of *T. a.* "form *separ*" Ärnbäck, 1929.

about 1 mm. to 1.5 mm. thick, having spicules of very regular stellate form sometimes 0.065 mm. in diameter but usually smaller, with rather slender conical points. The zooids are slender with a long narrow neck connecting the thorax and abdomen; the atrial aperture well back on the posterior part of the thorax and produced into a short tube; lateral (spicule-forming) organs of large diameter; three rows of stigmata with eight to 10 in a row on each side. Testis single, the sperm duct making five spiral turns about it.

LOCALITY: Michaelsen's type, which he had previously (1907) referred to *Didemnum tenue* (Herdman), came from Punta Arenas in the Strait of Magellan, in 11 fathoms; Ärnbäck's specimen ("forma *separ*"), from Guaitecas Islands, Chile, in 23 meters depth. This specimen was of larger size (50 by 50 mm. in extent and 2 mm. thick) and had spicules with very regular but rather short points (see fig. 48).

Trididemnum opacum (Ritter), 1907

Text figure 49

Didemnum opacum RITTER, 1907, p. 42, pl. 3, figs. 40, 41; HARTMEYER, 1909–1911, p. 1446.

Trididemnum della vallei RITTER AND FORSYTH, 1917, p. 472, pl. 44, figs. 54–56.

? *Trididemnum opacum* STEINBECK AND RICKETTS, 1941, p. 566.

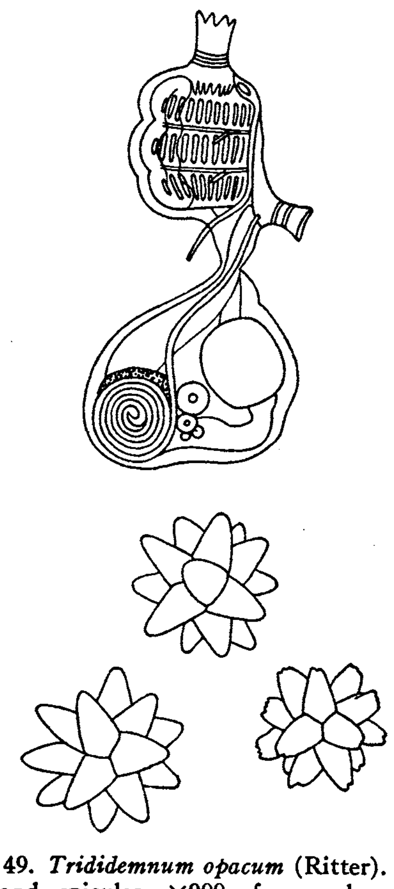


FIG. 49. *Trididemnum opacum* (Ritter). Zooid, ×30, and spicules, ×900, from colony from Pacific Grove, California.

This description is based on colonies which I collected near Pacific Grove, California, but which seem referable to the above species of Ritter.

The colonies are of the incrusting type and frequently of considerable extent, sometimes measuring 150 mm. or more across. Small colonies growing on an even surface are usually not over 1.5 to 3 mm. thick, but large ones, especially when they grow on an uneven object, may have the surface raised into rounded elevations 10 to 15 mm. in height or even more. The specimens which I collected were, when alive, pale flesh color tinged with grayish and dotted with whitish specks where the spicules were most densely aggregated. In preservation they became a dull brownish or grayish white.

The test is firm and tough so that the colonies may often be stripped off entire from the rocks on which they grow. It is rendered entirely opaque by the calcareous spicules which are everywhere abundant, but especially so in the superficial portion.

The surface of the colony may be smooth and even, or minutely verrucose, the positions of the zooids being often shown by small but very prominent rounded elevations, which give the surface a rough character. In more expanded specimens the branchial apertures may be indicated by small round clear spots containing three radially placed triangular groups of spicules. The zooids are arranged in extensive branching systems whose limits are not usually determinable; the common cloacal apertures are apparently rather few. The spicules are rather regularly stellate, the points long and not very many and often somewhat truncated at the tips, but very frequently with beautifully regular conical points. Their size varies much within the same colony, the larger ones being commonly about 0.03 mm. to 0.035 mm. in diameter.[1]

The zooids are often less than 2 mm. long in the contracted preserved state, but when fully grown they are of rather stout build, having the constricted part between the thorax and abdomen well marked but generally rather short.

Both branchial and atrial tubes are well developed, the former, which has six usually acute lobes, is generally the longer and larger; the atrial tube is far back on the thorax, slightly funnel shaped and commonly di-

[1] The extraordinarily large spicules (0.2 to 0.8 mm. in diameter) credited to *T. della vallei* by Ritter and Forsyth are doubtless to be explained by a misplaced decimal point.

rected obliquely backwards at a varying angle. It has a distinct sphincter muscle; its margin, which is smooth in most cases, may be somewhat uneven or obscurely lobed in adult zooids. The mantle muscles are strong, and the longitudinal muscles each side of the median dorsal vessel are also well developed. The latter muscles unite at the postero-ventral end of the thorax into a retractor process, though this is always quite short and often so rudimentary that it must be carefully looked for, or in some colonies it is apparently entirely wanting.

The endostyle certainly appears relatively stouter than in a majority of the members of the family, but to what extent this may be due to the contraction of the unusually well-developed muscles of the sac and mantle I do not know. The contraction of the two pairs of transverse muscles between the rows of stigmata commonly draws the endostyle dorsally at the points of their insertion so that it forms three deep curves convex ventrally.

The contracted condition of the specimens at hand prevents an accurate count of the tentacles. Sixteen are probably normally present in adults, representing three orders, of which the smallest may be rudimentary or wanting. Two dorsal languets are present.

There are three rows of stigmata with about 12 in the first two and apparently one or two less in the last row. One or two stigmata next to the endostyle in the anterior row are noticeably shortened; those in the other rows, less so. Usually the rows of stigmata occupy only the middle part of the sac, leaving an unperforated area of the wall anterior and also posterior to the stigmata. Differences in individual zooids in the extent of these unperforated areas may be in part due to unequal muscular contraction.

The stomach is large and globular, the intestine large, usually with an abruptly narrower section located a little distance beyond the stomach; farther on it is again larger.

Few of the numerous zooids studied had well-developed reproductive organs. One very large egg and a few smaller ones were found in the abdomen of some zooids; the testis, when developed, was rounded and undivided, the vas deferens usually making about half a dozen spiral turns on its surface; in young examples, not so many.

I found this species abundant on rocks in the lower part of the intertidal zone on the ocean shore at Pescadero Point near Pacific Grove, California, in July, 1939, growing in crevices or on overhanging rock surfaces where it was somewhat sheltered from the full force of the surf, and I feel little hesitation in identifying it with *Didemnum opacum* Ritter, 1907, collected by the "Albatross" off San Nicolas Island, California, in 33 fathoms. Ritter's description was from a single colony 35 mm. in diameter.

It seems strange that in describing *T. della valle* from the San Diego region (type locality, La Jolla) and off San Pedro, as a new species, Ritter and Forsyth, 1917, should pass over without the slightest mention the fact that the senior author of that article had described so closely similar a species as *T. opacum* from the same region. In the present work I am treating *della vallei* as a synonym of *opacum*.

No specimens of *Trididemnum* from the State of California coast north of Pacific Grove have come to my notice (but see remarks under *T. strangulatum* below). Its southward range has not been determined. A small, poorly preserved specimen from Cape San Lucas, Lower California, reported by Ricketts and Calvin, 1941, may be of this species. The genus *Trididemnum* also occurs along the tropical part of the Pacific coast (Pearl Islands, Bay of Panama, Salinas, Ecuador), but the material I have seen from those regions has not been sufficient in quantity or quality to come to a conclusion regarding the species.

Trididemnum strangulatum (Ritter), 1901

Text figure 50

Didemnum strangulatum RITTER, 1901, p. 247, pl. 29, fig. 28; VAN NAME, 1910, p. 388.

Trididemnum strangulatum HARTMEYER, 1909–1911, p. 1446; 1924, p. 139.

Closely allied to *T. opacum* but of more northern distribution on the Pacific coast of North America.

The zooids are like those of *T. opacum*, though Ritter considered the existence of a very strong constriction in the narrow neck connecting the thorax and the abdomen, in his type species, as a specific character. It is, however, apparently of no taxonomic importance; it occurs in other species of this and allied genera and may be a preliminary to a division of the zooid incidental to budding, or perhaps merely the result of strong contraction of the transverse muscles at the time of preservation of the specimen.

There appears to be a difference in the spicules, if we may judge by the limited material available. Ritter described those of *strangulatum* as not abundant and not present at all in some colonies, and as having the "rays short and blunt." In a large colony from Chignik Bay (see below), south side of the Alaskan Peninsula, and, therefore, quite near Ritter's type locality of *T. strangulatum*, the spicules are in most parts rather thinly distributed but abundant in the superficial part of the colony. Their rays are numerous, irregularly rounded or blunted, and quite short, giving the spicules an unevenly spherical rather than a truly stellate form. Few of them reach 0.03 mm. in diameter; many are less than 0.02 mm.

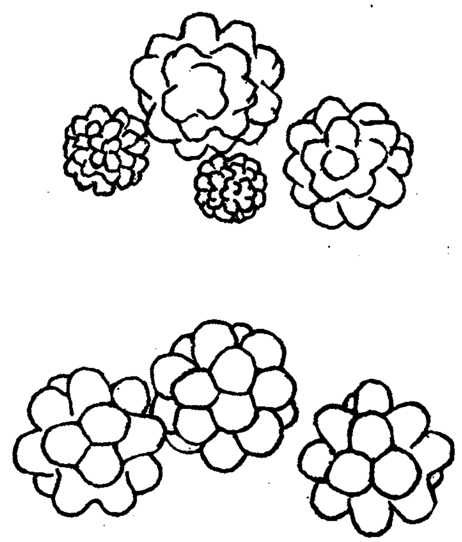


FIG. 50. *Trididemnum strangulatum* (Ritter). Spicules, ×550. Upper group from specimen from Chignik Bay, Alaska. Lower group from off the mouth of the Columbia River.

LOCALITIES: Ritter's type was from St. Paul Harbor, Kodiak Island, in about 20 fathoms; the Chignik Bay specimen, which probably belongs to Ritter's species, is in the United States National Museum and was obtained by the "Albatross" at Station 4284 in 30 to 41 fathoms. No doubt future investigation will show that the species is more widely distributed, but at present we cannot be sure of its validity or its relationship to the other Pacific coast forms.

A few small, flat, incrusting colonies, perhaps of this species, pure white in perservation, growing on a *Molgula oregonia* were dredged by the "Albatross" near the mouth of the Columbia River (Station 3088 in 46 fathoms). They have fairly large spicules (0.035 to 0.045 in diameter to the tips of the rays), having regular but rather few and short rays usually bluntly rounded off at the end. In fact, many of their spicules much resemble those of the typical form of *Didemnum albidum* (see fig. 33), but at present we know nothing definite about the species of *Trididemnum* of the northwest coast of the United States and British Columbia. Huntsman, 1912, reported two species of this genus, which he did not describe or name, from the coasts of Vancouver Island. One of them, which he designated "*Trididemnum* sp. B," was common on the rocks of the exposed west coast, and also dredged in 5 to 10 fathoms.

The other species, "*Trididemnum* sp. A," reported by Huntsman, 1912, was from the east coast of Vancouver Island. He says (p. 113), "a very dark *Trididemnum* with few or occasionally no (?) spicules was taken several times in the dredge."

GENUS **COELOCORMUS** HERDMAN, 1886

Herdman characterizes this genus as follows:

"Colony massive but not attached, deeply concave on the upper surface so as to contain a large central cavity.

"Ascidiozooids large, not distinctly divided into regions; the branchial aperture five-lobed.

"Test soft and gelatinous. Test cells numerous and large, no bladder cells. Calcareous spicules present in the superficial layer.

"Branchial sac large, stigmata very long and narrow. Dorsal lamina represented by a series of long triangular languets. Tentacles well developed.

"Alimentary canal extending beyond the branchial sac posteriorly but not forming a distinct abdomen. Stomach smooth walled.

Reproductive organs not large, ovary only present in adult ascidiozooids. Testes formed of a number of spermatic vesicles, vas deferens spirally coiled."

Coelocormus huxleyi Herdman, 1886

Coelocormus huxleyi HERDMAN, 1886, p. 318, pl. 37, figs. 1–8, pl. 38, figs. 1–4.

Based on a single colony of about 36 mm. in longest diameter, which from its peculiar shape with a large interior cavity led Herdman to suppose that it had characters transitional between the ordinary compound ascidians and the pelagic tunicate *Pyrosoma*, but any such relationship is purely visionary.

The central cavity of *Pyrosoma* represents a greatly enlarged common cloacal cavity; only atrial apertures open into it, while the central cavity of *Coelocormus* bears the branchial apertures of numerous zooids and hence must be regarded as merely a deep concavity of the external surface of the colony.

Herdman, 1886, established a family Coelocormidae for this specimen, but the structure of the reproductive organs indicates a near relationship to the subgenus *Polysyncraton* of the family Didemnidae. The stellate calcareous spicules likewise resemble those of that family. For further details the reader is referred to Herdman's work.

Locality of only specimen, "Challenger" Station 320, off the mouth of the La Plata River, 37° 17′ S., 53° 05′ W., 600 fathoms, green sand.

GENUS **DIPLOSOMA** MACDONALD, 1859

(*Nomen conservandum.* Antedated by *Leptoclinum* Milne Edwards, 1841, which name has, however, been more often applied to the genus called *Didemnum* in the present work.)

Colony incrusting, of delicate consistency; test gelatinous and transparent, no spicules. Zooids with four rows of stigmata; atrial aperture very large, without a distinct languet. Testes of two glands of round or elliptical outline, sperm duct not spirally coiled. Common cloacal cavities usually greatly developed, hollowing out much of the interior of the colony.

Diplosoma macdonaldi Herdman, 1886

Plate 12, figure 5; text figure 51

Diplosoma atropunctatum VAN NAME, 1902, p. 370, pl. 53, fig. 56, pl. 58, fig. 103, pl. 62, fig. 137.

Diplosoma lacteum VAN NAME, 1902, p. 369, pl. 53, fig. 59.

Diplosoma macdonaldi HERDMAN, 1886, p. 315, pl. 42, figs. 1–4; GOTTSCHALDT, 1898, p. 657, pl. 36, fig. 5; VAN NAME, 1902, p. 368, pl. 53, fig. 60, pl. 60, fig. 124; 1930, p. 440, figs. 17, 18; PLOUGH AND JONES, 1937, p. 100.

Leptoclinum macdonaldi VAN NAME, 1918, p. 159, fig. 109; 1921, p. 335, fig. 30; 1924, p. 26; GRAVE, 1927, p. 218; 1928–1930 (1928), p. 274; BERRILL, 1932, p. 77.

Leptoclinum macdonaldi+*L. lacteum*+*L. atropunctatum* HARTMEYER, 1909–1911, pp. 1454, 1455.

Colony incrusting, conspicuous from the thinness and delicacy of its structure, rarely

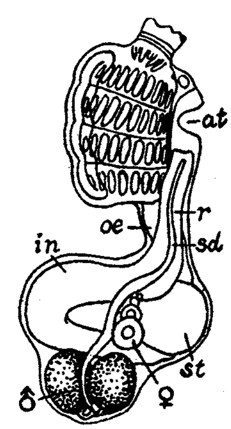


FIG. 51. *Diplosoma macdonaldi* Herdman. Zooid, ×48.

much over 2 mm. thick, but sometimes 50 mm. or more across. (One specimen surrounds a blade of turtle grass for a length of 138 mm.) Test transparent and colorless in life, or sometimes suffused with milky white which commonly disappears on preservation. The zooids are clearly visible through the test and often quite conspicuous as small, irregularly distributed, blackish objects, since they usually have more or less black pigment in the mantle cells about the branchial tube and especially on the surface of the abdomen. Their tissues are otherwise light colored, except that the stomach and part of the intestinal loop are yellow or orange during life, fading out in preservation.

Common cloacal cavities very extensive, though developed to a varying degree in different colonies; in extreme cases the entire interior of the colony may be hollow, except for columns or trabeculae of test substance in which the zooids are embedded. Large and conspicuous pale yellowish oval cells are often present in the test substance; they are perhaps symbiotic vegetable cells.

Zooids very small; their apparent length is further diminished by the fact that the axis of the abdomen is usually bent at right angles to that of the thorax, so that they often average only 0.8 or 0.9 mm. long in the preserved colonies, but when moderately expanded and straightened out they may measure 1.5 or 1.6 mm. in total length. As seen from the surface of the colony, the branchial apertures appear round or oval, without lobes, but the usual six lobes are slightly developed on the branchial tube and are often visible within the circular exterior orifice. No atrial tube or atrial languet; the atrial opening is transversly oval, plain edged, and very large when expanded; in that condition it exposes an area of the posterior and posterior-lateral part of the branchial sac; no muscular process from the constricted middle part of the body, but one or two vascular processes may extend from this part of the body. Mantle musculature insignificant. A dozen or more tentacles of three sizes, quite regularly arranged. Dorsal languets long and narrow; very difficult to demonstrate.

Four rows of stigmata with maximum of nine or perhaps 10 in a row on each side.

Stomach rounded, smooth walled, intestine of rather large diameter. Testis consisting of two large oval glands lying beside the intestinal loop (the lateral bending of this loop brings them, however, to the extreme posterior end of the body). They are connected with the proximal end of the common sperm duct by short individual ducts. The common sperm duct does not coil about the testis. Female reproductive organs represented by one or more eggs beside or somewhat behind the intestinal loop.

DISTRIBUTION: A common and widely distributed shallow-water species, ranging from Bermuda and South Carolina (vicinity of Charleston, if not farther north) to Brazil (Bahia, Herdman's type locality; São Sebastião). It occurs on both coasts of Florida, especially the west coast where it has been collected from Cedar Keys to Key West and the Dry Tortugas, and dredged in depths down to 27 fathoms. The *Leptoclinum* reported by Hartmeyer (1909–1911, p. 1929) from the Tortugas and West Indian localities was doubtless this species. It grows on piles, corals, gorgonians, sponges, and especially on other ascidians, often close to low-water mark, but its delicate structure is not adapted to withstand much exposure to air or to strong waves.

It is believed to occur in the Malay region also; specimens from Ternate have been referred to this species by Gottschaldt, 1898, and from the Philippines by Van Name, 1918. It has not, so far as I am aware, been considered identical with the species of western Europe. I have not had the opportunity of comparing it with material from that region and am not in a position to deal with that question.

Diplosoma longinquum (Sluiter), 1912

Leptoclinum (*Diplosoma*) *longinquum* SLUITER, 1912, p. 460; 1914, p. 36, pl. 3, fig. 39.

Described from a small incrusting colony of gelatinous consistency, 20 mm. in greatest width, growing upon an annelid tube. Three common cloacal orifices were discernible about which the zooids were grouped in irregular circles.

The zooids were 4 mm. long, rather large for this group; the branchial orifice six-lobed, the atrial oval, not produced and without lobes or languet. Ten large tentacles besides some smaller ones. Four rows of 12 to 14 stigmata on each side of the branchial sac. Stomach smooth-walled, testes two in number, sperm duct not coiled.

LOCALITY: Western Antarctic. The only specimen was dredged in Marguerite Bay by the second Charcot expedition, in 200 meters. Though there is nothing distinctive in the description given by Sluiter, the Antarctic locality makes it seem very probable that it will prove to be a valid species.

Diplosoma pizoni Ritter and Forsyth, 1917

Diplosoma pizoni RITTER AND FORSYTH, 1917, p. 474, pl. 43, figs. 50, 51, pl. 45, figs. 66–68; MACGINITIE, 1939, p. 443.

This is the Pacific coast representative of *D. macdonaldi*. It was described by Ritter and Forsyth from a single colony from San Diego Bay, but a considerable number of specimens that I collected at other points on the California coast shows that it is even more closely similar to *D. macdonaldi* than Ritter and Forsyth's description indicates.

In most respects the description and figures of that species given above would apply to both forms. The colonies are similar in size, character, and color, though often of somewhat less delicate consistency, but the zooids of the present species appear to average a trifle larger, and their atrial aperture, though of course subject in both species to great variation in size due to the extent of muscular contraction, is larger, sometimes leaving uncovered nearly half the rear and lateral parts of the branchial sac, so that the zooids have very little of an atrial cavity as distinguished from the common cloacal cavity or canal of the system to which the zooid belongs. Ritter and Forsyth give the number of tentacles as 16, which I have confirmed, and the stigmata in a row on each side of the branchial sac as only seven or eight. Though an accurate count is very difficult to make, I believe that some specimens have one or two more stigmata in a row. I do not feel sure how much confidence we can have in the constancy and reliability of these differences as specific characters. However, one important fact supporting the belief in the distinctness of *macdonaldi* and *pizoni* is that, while the former is tropical and subtropical, the latter is an inhabitant of much colder waters.

DISTRIBUTION: Known with certainty only from the southern half of the California coast. Type locality and most southern record up to the present time, San Diego Bay. I obtained a considerable number of specimens in Newport Bay and at Pacific Grove, mostly from piles of wharves or floats, usually among or on larger ascidians, hydroids, bryozoans, etc.[1] This species appears spontaneously in the tanks of the Kerckhoff Marine Laboratory at the entrance to Newport Bay.

Ritter and Forsyth give some observations on the reproduction of this species. Their figure 68 on plate 45 is, however, very misleading as it indicates that the stomach wall is longitudinally plicated as in *Amaroucium*. The stomach is actually smooth walled as in other Didemnidae.

[1] Huntsman (1912, p. 115) reports a "*Leptoclinum* (*Diplosoma*) (?) sp." from Ucluelet, west coast of Vancouver Island, in 5 to 10 fathoms.

GENUS **LISSOCLINUM** VERRILL, 1871
(Syn. *Diplosomoides* Herdman, 1886)

Differs from *Diplosoma* in having stellate calcareous spicules (usually not numerous) in the test, and an atrial languet. Testis divided into two or more glands. Sperm duct not spirally coiled.

Lissoclinum aureum Verrill, 1871
Text figure 52

Diplosomoides bathyphilum HARTMEYER, 1903, p. 370, pl. 14, figs. 14–16.

Diplosomoides dubium HARTMEYER, 1903, p. 368, pl. 14, figs. 11–13; REDIKORZEV, 1907, pp. 150, 152.

Diplosomoides flavescens REDIKORZEV, 1907a, p. 525; 1908a, p. 51, pl. 1, fig. 7, pl. 2, figs. 37, 38.

Lissoclinum aureum VERRILL, 1871, p. 444, fig. 26; 1872a, p. 212; 1879, p. 27; VAN NAME, 1910, p. 390, figs. 18–20, pl. 39, figs. 11, 12, 16, 17; HUNTSMAN, 1912, p. 113; HARTMEYER, 1924, p. 177, pl. 1, fig. 25.

The colonies of this species are of the incrusting type; most of them do not exceed 30 mm. in greatest diameter or 3 to 6 mm. in greatest thickness. The test is brownish or grayish and often somewhat transparent in preservation; in life, according to Verrill, the

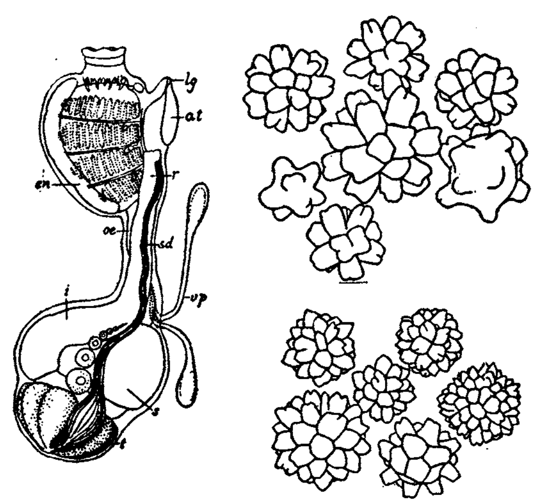


FIG. 52. *Lissoclinum aureum* Verrill. Zooid, ×28, and spicules from two colonies, × about 500.

colonies are light yellow with bright orange zooids, which are arranged in systems of considerable extent and complexity in the larger colonies. In some cases the colonies contain quite extensive cloacal cavities; in others the test substance appears quite solid.

In some colonies fairly well-formed stellate calcareous spicules are numerous enough to give the test an opaque white appearance; in other cases they can be found only by a careful microscopical examination, and in such specimens are often so irregular and imperfect in form as to be better described as irregular crystalline deposits of calcareous matter. The diameter of the spicules when well formed is usually 0.03 to 0.05 mm.; their points are short and blunted or broken. Redikorzev's statement of spicules up to 0.4 mm. in his *D. flavescens* is doubtless an error, due to displacement of the decimal point.

A study of the zooids of well-preserved specimens from off the eastern American coast showed them to be about 2 mm. long (though this length is often exceeded); the branchial aperture has six blunt lobes or undulations; the atrial aperture is large and oval with a very short languet which extends but little beyond its margin. There are 12 large tentacles, often also 12 smaller ones between them; four rows of stigmata with from 12 to 14 (in the last row only about 10) in a row on each side. The dorsal languets arise from the median dorsal vessel but perhaps more from its left than its right side.

The stomach is round and smooth walled; the intestinal loop is twisted and bent to the right so that the reproductive organs, when well developed, lie more or less posterior to the intestinal loop.

The testis is completely cleft (or sometimes only nearly so) into from five to nine or even 10 pyriform glands arranged in a close group with their narrow ends approximated.

The common sperm duct formed by the convergence and union of the individual ducts is not spirally coiled but has a nearly straight course accompanying the intestine. Often it is expanded into a spindle-shaped seminal receptacle in its proximal part. The ovary was poorly developed in the specimens studied. It appeared as a series of eggs arranged according to size, the largest posterior, near the common sperm duct.

DISTRIBUTION: In Old World waters this species is quite rare and is Arctic in distribution, ranging from the Siberian Arctic Ocean to northwest of Iceland; in American waters it is more common and ranges very much farther south. It has been collected from off Newfoundland, in the Bay of Fundy at Eastport and Casco Bay, Maine, and on the ledges and banks off shore southward to the latitude of Martha's Vineyard, Massachusetts (two most southerly records, United States Fish Commission Station 264 off Cape Cod, 42° 10′ N., 69° 56′ 30″ W., 80 fathoms, and Station 873, off Martha's Vineyard, 40° 02′ N., 70° 57′ W., 100 fathoms). In the Eastport, Maine, region it occurs in very shallow water; in most cases the records are between 50 and 100 fathoms. A muddy bottom with stones or shells seems to be preferred.

Lissoclinum wandeli (Hartmeyer), 1924

Didemnum wandeli HARTMEYER, 1923, p. 4 (*nomen nudum*).

Lissoclinum wandeli HARTMEYER, 1924, p. 180, pl. 1, fig. 26.

Colonies varying from rounded to pear shaped, attached sometimes by a narrowed, in other cases by a wide, base. The largest colony, which was egg shaped, measured 15 by 12 by 9 mm.; most of the specimens are much smaller. Surface of the test smooth, greenish gray to pale brick red. One common cloacal aperture for the colony which consists of a single system.

Spicules scattered and rather few, most numerous in the superficial part. They are of regularly stellate form and of rather large size, 0.06 to 0.07 mm., occasionally 0.09 mm.

Zooids 3 mm. or more long; they have a moderately long and wide atrial languet cleft at the end into two points; the atrial opening is an elongate oval aperture about the middle of the back. Stomach ovate, smooth walled.

The zooids studied had both male and female gonads. The testes consist of two pear-shaped glands in the intestinal loop; their ducts unite to a common duct which is not spirally coiled. The ovary was represented by a single large egg (reaching 0.17 mm. in diameter in some cases) situated anterior to the male glands.

LOCALITIES: Numerous specimens were collected by the Ingolf expedition in deep water

(572 to 786 meters) at several stations in Davis Strait.

Lissoclinum fragile (Van Name), 1902

Text figure 53

Diplosomoides fragile VAN NAME, 1902, p. 370, pl. 53, figs. 57, 58, pl. 61, fig. 126; HARTMEYER, 1909–1911, p. 1633.

Diplosomoides molle (in part) SLUITER, 1909, p. 85.

Lissoclinum fragile VAN NAME, 1921, p. 338, figs. 31, 32; 1924, p. 26; 1930, p. 442, fig. 19; BERRILL, 1932, p. 77; PLOUGH AND JONES, 1937, p. 100.

This animal forms very thin, flat, incrusting colonies, often of considerable extent (60 mm. to 80 mm. across), but only 2 to 3 mm. thick. Living specimens collected at Bermuda were easily recognizable by two characters: first, their snowy whiteness without the least tinge of yellowish (though preserved specimens become somewhat yellowish) and, second, by their very fragile character. The test breaks or tears at the slightest touch, and the colony cannot readily be removed entire from the surface on which it grows. The white color is due to the spicules that densely crowd the test and conceal the zooids, which are yellow or orange during life. The spicules are minute (usually not more than 0.02 to 0.023 mm. in diameter) and stellate or burr-like in form, built up of very numerous rays which may end in sharp points, but are more often truncated or broken at the tips. The rays or points are so short and numerous that under low magnification the spicules appear nearly spherical. The fragile character of the colony is in part due to the brittleness of the test, caused by the great abundance of spicules, but still more to the very extensive development of the common cloacal cavities. The apertures of the zooids are usually quite conspicuous on the surface of the colony, which is fairly smooth though not glossy during life, but becomes much wrinkled through the collapse of the very extensive common cloacal cavities in preserved specimens.

Zooids about 1.5 mm. long when fairly well expanded. They have the branchial aperture six-lobed; the atrial is provided with a languet. No muscular process extending out into the test is developed. Lateral (spicule-forming) organs may be present on each side of the thorax.

Mantle musculature and muscles of the branchial sac very weak. Tentacles slender, of at least two sizes. Dorsal languets difficult to demonstrate. Branchial sac large, with four rows of large stigmata; probably about 10 or 11 in a row on each side.

Intestinal loop small; stomach very thin walled, so that it becomes folded in preservation, but it is probably round and smooth walled during life.

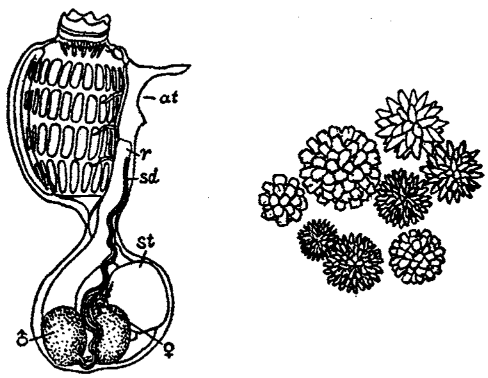


FIG. 53. *Lissoclinum fragile* (Van Name). Zooid (branchial sac well expanded), ×36. Spicules all from the same colony, ×460.

Male reproductive organs consisting of two large oval testes beside the extreme posterior part of the intestinal loop. Their short individual ducts unite to form a stout common duct which accompanies the ascending or distal branch of the intestinal loop without making any spiral turns about the testes. The ovary, a small group of eggs, lies beside the common sperm duct a little way from the origin of the latter.

This species was found common at Bermuda at a number of stations along the shore, growing on the under side of stones near low water. Other localities are St. Thomas, West Indies, where some good-sized colonies were collected by C. R. Shoemaker in 1915 (United States National Museum collection) growing on ascidians, on piles, and elsewhere in shallow water (½ to 2¾ fathoms), Barahona Harbor, Santo Domingo, on ascidians in shallow water, Caracas Bay, Curaçao, and Tortugas, Florida.

The atrial languet does not appear to be present in immature zooids, and even in fully adult ones it is very easily torn off in dissecting out the zooid for examination. The original description and figure gave it as wanting. The demonstration of its presence appears to remove the reason for considering *Diplosomoides* Herdman, 1886, as a genus distinct from *Lissoclinum* Verrill, 1871.

Lissoclinum caulleryi (Ritter and Forsyth), 1917

Text figure 54

Diplosoma caulleryi RITTER AND FORSYTH, 1917, p. 498 (error for *Diplosomoides*).

Diplosomoides caulleryi RITTER AND FORSYTH, 1917, p. 476, pl. 40, fig. 21; HARTMEYER, 1920a, p. 133, fig. 1.

Forms thin incrusting colonies which reach, according to Ritter and Forsyth, several centimeters across; thickness about 2 mm. (3

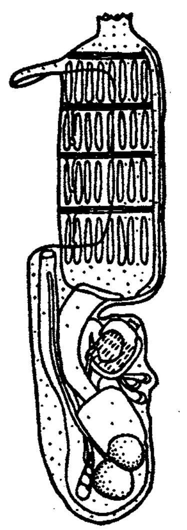


FIG. 54. *Lissoclinum caulleryi* (Ritter and Forsyth). Zooid. Outline from illustration of those authors.

mm. or more, according to Hartmeyer). Color dark gray sprinkled with white calcareous spicules. Zooids numerous, each branchial orifice six-lobed; common cloacal orifices few, large, rounded or elongate, flush with surface. Little test immediately around branchial sacs, this stratum of colony being cavernous, lower stratum containing abdomen of zooids and large eggs, more continuous and solid. Spicules fairly numerous and evenly scattered in surface and basal layers of test; more sparingly scattered through test in the interior parts.

The spicules consist of radially disposed, more or less irregularly shaped crystals; some of them approach the regular stellate form characteristic of *Didemnum*. They average about 0.03 mm. in diameter. Bladder cells are present in the superficial and some parts of the deeper layers of the test. Zooids 1.5 to 2 mm. long. Branchial aperture with six-pointed lobes. Atrial aperture very large and oval, according to Hartmeyer; according to Ritter and Forsyth it is relatively enormous, extending the length of the thorax and well around on the sides. There is a rather large atrial languet (described as "scoop-shaped" by the latter authors) anterior to the aperture.

A group of small spicules in the common test beside the fourth row of stigmata on each side and near the endostyle represent the "spicule-producing" or lateral organs.

Branchial tentacles long and narrow, not all of the same size, about 16 in number according to Ritter and Forsyth. Four rows of stigmata with eight in a row on each side. Stomach smooth walled, globular-elliptical. Intestinal loop not twisted.

Male reproductive organs not found in Hartmeyer's specimens; according to Ritter and Forsyth, the testis consists of a pair of globular glands; the sperm duct arises between them and accompanies the intestine as usual in this group. The ovary is an elongated sac situated between the stomach and ascending part of the intestine and contains a longitudinal series of small eggs, according to Ritter and Forsyth. In Hartmeyer's specimens, evidently in a later stage of reproduction, he found two large eggs in a posterior extension of the body behind the intestinal loop, one of these eggs much larger than the other and often already in the cleavage stage. Evidently these eggs become constricted off from the body of the parent and undergo development into larvae in the common test.

DISTRIBUTION: The type and only locality given by Ritter and Forsyth was the upper part of San Diego Bay near National City, California. Hartmeyer's specimens were from the Juan Fernandez Islands, where it was collected both by Plate and by Skottsberg's Swedish expedition. Those obtained by the latter were attached to simple ascidians (*Corella eumyota*) dredged in 40 to 60 meters.

GENUS OR SUBGENUS **ECHINOCLINUM** VAN NAME, 1902

The zooids agree in most characters with those of *Lissoclinum;* as in that genus, the sperm duct is not coiled but pursues a direct course along and near to the intestine. The testis, however, consists of a single gland. The justification for the separation of this group consists in the peculiar four-pointed shape of the calcareous spicules which, as far as I am aware, is entirely unique. Perhaps the rank of a subgenus is all that it merits. Michaelsen's (1915) conjecture that it is related to *Cystodytes* is entirely untenable. The following is the only known species.

Echinoclinum verrilli Van Name, 1902

Text figure 55

Echinoclinum verrilli VAN NAME, 1902, p. 372, pl. 50, figs. 23–25; SEELIGER, 1907, p. 1236; HARTMEYER, 1908, p. 44; 1909–1911, pp. 1452, 1630, 1633; VAN NAME, 1921, p. 340, figs. 33–35; 1930, p. 443, fig. 20; PLOUGH AND JONES, 1937, p. 100.

Colony of the flat incrusting type but usually rather thick, the upper surface generally smooth but uneven. It attains a considerable size, one specimen from near Key West, Florida, measuring 125 mm. by 95 mm. across and averaging at least 5 or 6 mm. in thickness (at some points considerably more). Zooids arranged in systems often of considerable extent and complexity. In large specimens the zooids can often be seen to be in double rows, between which run the common cloacal canals; these branch and anastomose in a net-like manner, leaving in the meshes islands of completely enclosed areas of test, bordered by the rows of zooids.

Test colorless or somewhat yellowish and transparent in preserved specimens. No notes on its colors during life. Common cloacal cavities not extensive. Test tough externally, softer within, but it forms a tougher investing membrane around each zooid, adhering strongly to the body about the atrial aperture and at a point on each side of the posterior part of the thorax where there is a deep depression that unquestionably represents the "Seitenorgan" of Michaelsen (see under the family Didemnidae).

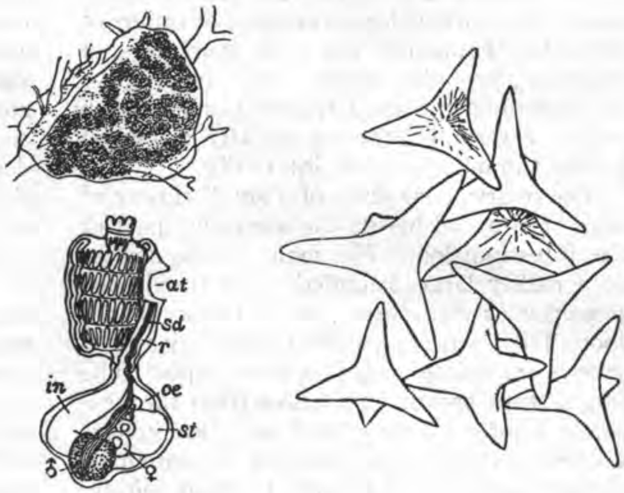


FIG. 55. *Echinoclinum verrilli* Van Name. Colony (type) growing on a branching seaweed, ×2. Zooid, ×30. Spicules, ×230.

The spicules are peculiar, having the form of tetrahedrons whose four apices are produced into somewhat elongated points. These spicules are mostly so placed around the bodies of the zooids that they form a spiny capsule about them, one of their four points projecting radially outward. Similar spicules are also scattered in other parts of the test, sometimes in considerable abundance, especially in the superficial layer of the colony. The larger spicules measure up to about 0.1 to 0.14 mm. from point to point, but there are many smaller ones. Some of the specimens contain additional calcareous matter deposited in the test in irregular granular or semicrystalline form; in one specimen the spicules have acted as centers for the disposition of such material to an extent that conceals their original form.

Zooids small, often less than 1 mm. long in the strongly contracted preserved condition. Branchial aperture six-lobed, atrial a large plain-edged opening whose anterior margin may be a little produced, but hardly enough to be termed a languet. No muscular process extending out into the test was observed.

The tentacles and dorsal languets were visible with difficulty in the contracted specimens; there are at least two sizes or orders of tentacles. Branchial sac with four rows of stigmata, probably nearly a dozen in a row on each side. Stomach rounded and smooth walled externally, though slightly ridged in a longitudinal direction internally.

The ovary, consisting of a small cluster of eggs, is situated beside the ascending part of the intestinal loop. The male organs consist of a rather large, rounded testis beside the posterior or transverse part of the intestinal loop. The testis is partially divided by a deep groove extending across its outer aspect. The large, stout sperm duct arises from the posterior border of the gland and lies in this groove; it then extends to, and accompanies, the intestine to near its end. It is not spirally coiled.

DISTRIBUTION: This species was originally described from three small specimens collected at Bermuda in 1898 by A. E. Verrill. Hartmeyer (1909–1911) and Plough and Jones, 1937, reported it from Tortugas, Florida. The United States National Museum collection contains a number of colonies, some of them of considerable size, all dredged in the vicinity of the Florida Keys in 3 to 11 fathoms except one (also from southern Florida) which is attached to a blade of turtle grass and hence evidently came from very shallow water. One of the specimens covers the back of a small maioid crab, which it much exceeds in size.

FAMILY POLYCITORIDAE MICHAELSEN, 1904

(= Polycitoridae (syn. Distomidae) +Clavelinidae auct. mult.)

Compound ascidians having the body divided by a narrow, often elongated neck into two parts, thorax and abdomen.

Branchial tentacles simple, of two or more sizes, the smaller ones inserted in a circle a little more anterior (nearer the branchial aperture) than the larger ones. Branchial sac with well-developed transverse vessels but no vestiges of a sytem of internal longitudinal vessels. Dorsal lamina represented by languets.

Gonads usually beside the intestinal loop in the abdomen; sometimes farther back in an extension of the abdomen which, however, is not a true post-abdomen homologous with that of the Synoicidae, as it does not contain the heart. The testes consist of small, separate, pyriform glands. The oviduct and sperm duct accompany the intestine. The zooids may be completely embedded in the common test or have varying degrees of independence; in extreme cases they each have their own covering of test and are connected only at the posterior ends.

This is not a very homogeneous family, as is indicated by differences in the budding, which may be by buds from, or transverse segmentation of, the zooid itself or by formation of buds on a stolon extending from the posterior end of the body. The latter method is the case in *Clavelina* and allied genera in which the zooids are usually partially or entirely separated and which in many classifications constitute a separate family, Clavelinidae. Berrill (1936) would separate off the genera *Eudistoma* and *Archidistoma* and transfer them to the family Diazonidae, considering them as degenerate or simplified members of that family on account of resemblances in the budding process, but the invariable complete absence of even a trace of a system of internal longitudinal vessels in the genera in question is strongly against such a step. There are also genera, as *Euherdmania,* that link this family and the Synoicidae.

In several genera of this family, notably in *Distaplia* and *Sycozoa,* a remarkably large sac-like diverticulum of the atrial or peribranchial cavity is formed in which the larvae develop, but in most genera they undergo their development in the dorsal or dorsolateral part of the atrial cavity which often becomes greatly distended, but not separated by any constriction from the rest of the thorax.

GENERA OF POLYCITORIDAE

A_1. Colony massive or lobed, zooids usually completely embedded or nearly so. No incubatory pouch (larva develop in the atrial cavity).

B_1. Disk-shaped spicules in test (sometimes poorly developed or replaced by calcareous deposits). Four rows of stigmata . . . . *Cystodytes*

B_2. No spicules.

C_1. Three rows of stigmata.

D_1. Zooids embedded . . *Eudistoma*

D_2. Posterior part only embedded . . . . *Archidistoma*

C_2. Four or more rows of stigmata . . . . *Polycitor*

A_2. Zooids large, numerous rows of stigmata, thorax and abdomen connected by a long neck. Zooids embedded or partially or wholly independent and connected only by stolons from which the buds form. No incubatory pouch . . . . . *Clavelina*

A_3. Colony variously shaped; four rows of stigmata. Embryos develop into larvae in an incubatory pouch joined to the parent by a slender neck.

B_1. A slender parastigmatic vessel crosses each row of stigmata at their middle. Several larvae in brood pouch . . . . *Distaplia*

B_2. Colony very long, band shaped, later breaks away and becomes pelagic. Said to have but one embryo in brood pouch . . . . *Holozoa*

B_3. No parastigmatic vessels, brood pouch with numerous larvae. Colony capitate, sometimes branched. Sexes in separate colonies . . . . *Sycozoa*

GENUS **EUDISTOMA** CAULLERY, 1909

Originally established as a subgenus of "*Distoma*" (=*Polycitor*) to contain those species having very few rows of stigmata and a smooth-walled stomach. It appears to be worthy of generic rank, though very close to *Archidistoma* Garstang (see below).

Its species are quite numerous, especially in warm regions, and there is such great uniformity in the structure of the zooids that the characters of the colony, including size, form, habit of growth, and average size of the zooids and (contrary to what is the case in many other ascidians) the coloration, must be largely depended on in determining the species. The satisfactory determination of small, stunted, or poorly developed examples may be impossible unless they are found growing with better specimens.

Shape of the colony variable, but in many species the upper surface is covered with small, slightly raised elevations, due to a slight projection of the anterior ends of the zooids; this is still more marked in living, expanded colonies. Bladder cells in the test few or wanting, at least in the case of most species. (See under *Cystodytes*.)

Zooids consisting of thorax and abdomen connected by a neck or peduncular part which is long and slender in an expanded state, but short or almost entirely effaced and represented only by a constriction in a contracted state. Violent contraction, and often distortion, is the common condition in preserved specimens owing to the very strong longitudinal mantle muscles, especially well developed and grouped into distinct bands on the thorax, but extending also to some extent on the neck and sometimes on the abdomen. An external, weaker layer of transverse or circular muscles is also present on the thorax, and on the two prominent tubes on which the apertures (both conspicuously six-lobed) are raised. When the zooid has both apertures opening on the surface of the colony, both tubes are directed forward and neither one is much elongated. When the zooid forms part of a system, the atrial tube is directed or bent toward the common cloaca and is more or less extended in order to reach it.

About 16 tentacles, comprising the two orders alternating with some regularity, are usually demonstrable, sometimes third-order tentacles also. Endostyle very stout, almost always thrown into curves by muscular contraction of the thorax; dorsal languets removed a little way to the left of the median dorsal vessel.

The number of rows of stigmata is probably always three. Positive determination of the number is often difficult owing to contraction and to the thick, opaque walls of the thorax. My own statement (1902) of the presence of four rows in the Bermuda species was erroneous. The thorax and branchial sac commonly extend back posterior to the last row far enough to permit of the existence of a fourth row, but that part is unperforated. In species with large zooids there may be 18 or more stigmata in a row on each side.

Stomach globular or somewhat oval, smooth walled. Unless too much distended, the intestine is narrow as it leaves the stomach but gradually becomes wider; in the posterior transverse part of the loop it is once more contracted; the ascending limb of the loop is abruptly much wider. On the surface of the intestine, in the region where it passes the stomach, the delicate tubes of the "intestinal gland" may be demonstrated in well-preserved material. They converge, leave the surface of the intestine and unite to form a duct which enters the intestine just below the pylorus. The course of these tubes (usually about six to 10 in number) on the ascending limb of the intestine varies very much; the tubes may be parallel and straight or very serpentine, or may curve around so as to embrace the intestine; they may be close together or somewhat apart. I believe these differences depend largely on the state of contraction of the intestinal walls as well as on individual variations in the course of the tubes, and I do not now attribute taxonomic significance to them as I formerly did. Whether these tubes taper off at the end, or terminate in a more or less distinct bulb, depends, I now believe, more on their functional condition and on the accumulation of secretion in them, than on structural difference.

The ovary, consisting of a group of eggs of various sizes, and the testes, consisting of a more or less rosette-like cluster of pyriform glands, more numerous in species with large zooids than in those with small ones, are both situated beside the intestinal loop on what is actually the left side of the latter, though the twist of about one-half turn in the intestinal loop brings them around to, or toward, the right side of the abdomen. The oviduct is a very thin-walled tube capable of great distension; the sperm duct, with whose posterior end the individual glands communicate by radially converging ducts, is a conspicuous, thick-walled tube whose course is usually very serpentine. Both the genital ducts accompany the rectum, through the narrow peduncular part or neck into the atrial cavity. When that part of the body, and often the neck also, is occupied by developing eggs or larvae, which are of relatively enormous size in the species with small zooids, the body is sometimes distended out of all resemblance to its natural form and outline.

A small stolonic vessel usually extends out into the common test from the posterior end of the zooid. It is short and does not connect with that of other individuals, nor does it function in budding. See Berrill, 1935, for studies in the budding or asexual reproduction in this and related genera. According to his account, it takes place in *Eudistoma* (studied in the species *olivaceum* from Bermuda and *lobatum* [=*ritteri*] from Pacific Grove, California) by separation of the thorax from the abdomen. Each of these parts then regenerates the missing portion of the body.

The taxonomic difficulties in dealing with this genus must be evident from the foregoing statements, and if the account of the American species that follows proves to be a step toward differentiating them and an aid in recognizing them, it will be all that I can hope for. These species are all treated as exclusively American. In the present state of our knowledge that is the only safe course, though possible identity of some of them with Old World forms is not to be excluded.

Berrill (1936) considers *Eudistoma* and *Archidistoma* as dwarfed and simplified allies of *Diazona* and proposes their transfer to the Diazonidae.

Eudistoma capsulatum (Van Name), 1902

Distoma capsulatum VAN NAME, 1902, p. 341, pl. 46, fig. 2, pl. 58, fig. 107.

Distoma convexum VAN NAME, 1902, p. 342, pl. 49, fig. 16, pl. 58, fig. 104, pl. 59, fig. 118; CAULLERY, 1909, p. 43.

Polycitor convexus PLOUGH AND JONES, 1937, p. 100.

Polycitor (Eudistoma) capsulatus VAN NAME, 1921, p. 352; BERRILL, 1932, p. 78 (*capsulatum*).

Polycitor (Eudistoma) convexus MICHAELSEN, 1915, p. 466; VAN NAME, 1921, p. 346; 1930, p. 447; BERRILL, 1932, p. 78.

Polycitor (Eudistoma) mayeri HARTMEYER, 1911, p. 91, pl. 1.

Colony usually a rounded or oval mass, often attached by one end; in other cases it is broad and thick with rounded edges and attached by most of the lower surface. Sometimes it may be capitate or consist of several heads united at their bases, but these are few and large; the colony does not break up into a multitude of small heads, as *Eudistoma olivaceum* commonly does.

It is also differently colored, being gray, yellowish, or brownish, often with a reddish or more or less strongly violet tint during life or even in preservation, instead of the greenish, olive, or partly blackish color of that species. The test in well-preserved material is translucent, so that the zooids may be more or less distinctly seen, and of fairly firm, often slightly cartilaginous, consistency. The basal parts of the test may contain, or be incrusted with, sand and shell fragments. Sand may be present to some extent in the interior of it but in most specimens not in any great quantity, and the upper surface is smooth and glossy. In parts of some colonies an arrangement of the zooids in small circular or oval systems grouped about a small common cloacal cavity, with a rather large, rounded aperture, can be clearly demonstrated. In other specimens, or in other parts of the colonies, there is no apparent regularity in the distribution of the zooids. Most of the colonies from the West Indies are of rather small size, not over 20 to 30 mm. in diameter.

But on the United States coasts very much larger colonies occur that appear to be of this species; the largest ones are various shaped, generally of irregular outline and often divided by clefts into several lobes or heads. The United States National Museum contains large ones from the southern and western Florida coasts (55 mm. by 42 mm. across and 28 mm. high, also a crest-like colony 65 mm. high and 108 mm. by 40 mm. in its other maximum diameters, and another irregularly lobed one 115 mm. in greatest diameter and 60 mm. high). The largest I have measured is 170 by 110 mm. and 75 mm. in greatest height.

The zooids (see description under the genus) are rather large and stout, ordinarily 4 to 6 mm. long in the somewhat contracted condition usual in preserved material, but doubtless twice as long as that when extended. The thorax may be spotted with dark pigment. Tentacles apparently normally about 32 (8+8+16) of three orders somewhat regularly arranged. Three rows of stigmata (not four as originally described and figured). In a well-preserved specimen, 18 or 19 were counted on each side in the anterior rows, and 16 or 17 in the last row. Stomach round and smooth walled; the testes may number 30 or 40 or more.

DISTRIBUTION: West Indian region including Bermuda (the type locality), Bahamas, Santo Domingo, and Cuba. Also off Yucatan and the coasts of the southeastern United States (Chesapeake Bay, mouth of Potomac River; the vicinity of Beaufort, North Carolina; Winyah Bay, South Carolina; and on the west coast of Florida, including the Dry Tortugas). It is a shallow-water species. Deepest record, 25 fathoms. Sometimes found washed up on the beaches after storms.

I regret that it seems necessary to replace the specific name *convexum*, which has appeared for this species in various articles, with *capsulatum* on account of page priority. The latter name was applied to some small, depressed, unpigmented colonies from Bermuda, containing few zooids and densely impregnated with calcareous sand. Through the kindness of Dr. Stanley C. Ball of the Peabody Museum of New Haven, I have been enabled to reëxamine the type and cotypes of *capsulatum* and believe that they are merely poor and more or less regressive colonies of the species usually known as *convexum*.

Eudistoma hepaticum (Van Name), 1921

Plate 15, figure 3

Polycitor (Eudistoma) hepaticus VAN NAME, 1921, p. 348; 1930, p. 447, pl. 7, fig. 2.

Colonies of this species become large and massive; the type colony is a fair example of one of the larger specimens. It is of flattened, oblong form, about 80 mm. by 45 mm. by 25 mm. in its diameters, and was apparently attached by a rather small area near, but not on, one edge. The test is of a uniform deep purple color, due to the abundant purple pigment cells; the tissues of the zooids are not pigmented. Consistency of test rather soft, the solid interior parts a little firmer; surface slightly wrinkled and exhibiting small, rounded, depressed areas indicating the small circular or elliptical systems in which the zooids are arranged. The center of each of these systems, which appear usually to comprise eight to 10 or more zooids, is occupied by a small common cloacal cavity with a rounded or somewhat lobed aperture.

Except that the color is deep purple instead of red, colonies of this species, especially when cleft into several or more or less angular lobes as is often the case, suggest in appearance and consistency the liver of a vertebrate animal. The purple pigment is of remarkable permanence; colonies preserved in alcohol retain their color without impairment for an apparently indefinite period of time (see below).

Zooids apparently exactly like those of *E. capsulatum*, except that they average a little smaller and less stout. The testes numbered 15 to 20 in the individuals studied; some zooids had young larvae in the atrial cavity.

The type colony, above described, is one of several similar ones collected by the "Albatross" at Jamaica, British West Indies, January 1–11, 1884. Three exactly similar smaller ones of an equally deep purple color were collected by the "Albatross" at St. Thomas, January 16–22, 1884; these appear to have grown on crabs. In July, 1915, C. R. Shoemaker, of the United States National Museum, obtained a number of other specimens at St. Thomas on piles near the town. These exactly resemble the "Albatross" specimens found over 30 years previously, both in their color and other characters; one of them is one of the most massive and bulky colonies of a compound ascidian that I have seen. It is a somewhat flattened mass with thick rounded edges, about 270 mm. by 240 mm. across and about 100 mm. high, attached by a small area of the lower surface and partially divided by a wide, deep cleft into two nearly equal lobes connected at the base. This colony has on one side an irregular lateral extension which, if straightened and stretched out, would make the diameter of the colony passing through it reach 450 mm.

Distribution: Jamaica and St. Thomas, as stated above, and Merida, Yucatan (specimen in the United States National Museum, piece in the American Museum). I also assign to this species several rather deep purple specimens from Tarpon Springs, Florida. In previous articles (1921, 1930) I attributed to this species a range including the coasts of the southeastern United Staes as far as North Carolina, but do not now believe that this was correct. The pale violet specimens from that region should, I now believe, be referred to *Eudistoma capsulatum*, not to the present species.

Eudistoma olivaceum (Van Name), 1902

Plate 16, figure 1; text figure 56

Distoma olivaceum Van Name, 1902, p. 344, pl. 48, fig. 9, pl. 49, fig. 113; Caullery, 1909, p. 43.

Eudistoma olivacea Berrill, 1935, pt. 4, p. 342, fig. 8a–8h.

Polycitor (*Eudistoma*) *olivaceus* Van Name, 1921, p. 343, fig. 36; 1930, p. 445, figs. 21, 22; Berrill, 1932, p. 77; 1937, p. 566.

Polycitor olivaceus Plough and Jones, 1937, p. 100.

The usual form of the colony in this species is a group of numerous, small, somewhat flat-topped heads of circular outline, with fairly abrupt sides which contract toward the base into a rather thick peduncle. The several peduncles expand and unite into a basal mass by which the colony is attached. These heads are usually only 5 to 8 mm. across and 8 to 10 mm. high, or often much smaller, but many may be united into one colony. The color in life varies from olive green or yellowish olive to olive brown, often more or less blackish on the upper surface. The color holds fairly well in alcoholic material.

Upper portion of colony smooth and shiny, commonly free from incrusting or embedded sand; the basal parts and peduncles contain sand grains and are often covered with an outside layer or pellicle densely crowded with fine sand. This pellicle, however, usually ends abruptly at the top of the peduncle. Test gelatinous and semi-transparent, in spite of its dark coloration, which is in part due to pigment contained in the test cells.

Zooids rather slender, often 3.5 to 4 mm. long in the considerably contracted preserved condition. They are light colored, with the stomach and parts of the intestinal loop orange during life. The mantle, especially on the anterior part of the thorax, is dotted with blackish pigment, sometimes to a very conspicuous extent; in other cases there is very little such pigment. In many colonies the regions over the ganglion and anterior end of the endostyle are much more deeply pigmented than elsewhere and show through the test as black dots. Usual number of testes in adult zooids from six to 12.

DISTRIBUTION: This species is common and widely distributed in shallow water, growing especially on mangrove roots and on corals, etc., at or near low-water mark at Bermuda, the type locality (type in Yale University collection). It is represented in the collection of the American Museum by specimens from Andros Island, Bahamas; Puerto Rico (mangrove roots in Guanica Harbor); Florida (Biscayne Bay on banks near Soldier's Key, and from the west shore of Plantation Key); and Cuba (Cayo Christo near Isabella on the north coast, 3 to 4 feet). In the United States National Museum collection there are specimens from several points on or near the west coast of Florida (depth given in one case only, Marco, Florida, 1 to 2 fathoms), and from St. Thomas, West Indies (shore).

Eudistoma obscuratum (Van Name), 1902

Distoma obscuratum VAN NAME, 1902, p. 343, pl. 48, fig. 11, pl. 58, figs. 105, 106; CAULLERY, 1909, p. 43.

Polycitor (*Eudistoma*) *obscuratus* VAN NAME, 1930, p. 447.

Polycitor (*Eudistoma*) *olivaceus* form *obscuratus* VAN NAME, 1921, p. 345.

An insufficiently known form. Though very different in appearance from the other members of the genus found in the West Indian region, the available specimens have been so few that I have been doubtful in regard to its validity as a species, and have suspected that it may be based on unusually shaped and colored examples of some other species, perhaps *Eudistoma olivaceum*, but am not now prepared to reject it as a species.

The colonies (until cut open and the abscence of calcareous capsules is made evident) look very like those of *Cystodytes dellechiajei*, being of flattened, incrusting form with rounded edges, up to 20 to 30 mm. in diameter and 3 to 4 mm. thick. Color uniform dull black with a greenish tinge when alive. The color is due to numerous pigment cells in the test and also in the mantle of the zooids where they are so abundant that the entire thorax is black.

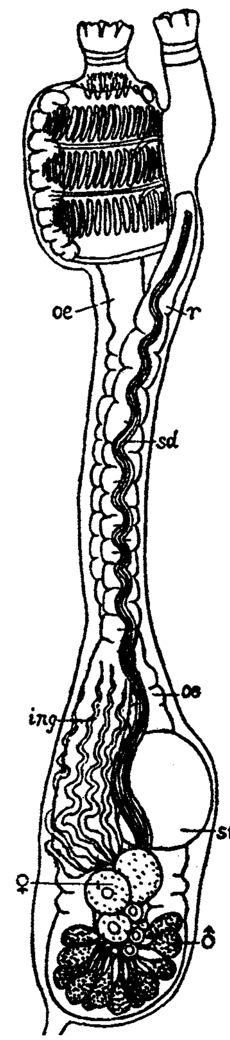


FIG. 56. *Eudistoma olivaceum* (Van Name). Zooid, ×32.

LOCALITIES: Type locality, Castle Harbor, Bermuda, on corals, two specimens. Small specimens in the United States National Museum from Drift Bay, Water Island, in the Virgin Islands, and Tortugas, Florida, also appear to represent this species.

Eudistoma tarponense, new species

Closely allied to *Eudistoma psammion* of the California coast. Like that species it forms thick, solid opaque colonies with rounded edges attached by their whole lower surface, which reach 10 to 12 mm. in diameter, and in some parts a thickness of 2 to 3 mm. The test contains a great deal of embedded sand, especially in its basal part, though the surface, which is uneven but not very rough, is not much incrusted.

The color of the test when not obscured by the abundance of sand grains is purple with a

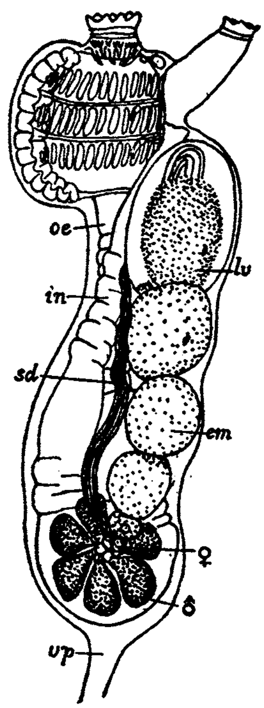


FIG. 57. *Eudistoma clarum* (Van Name). Zooid, ×35.

somewhat more reddish tinge than the pure purple of *E. hepaticum;* its color is much more vivid than the very dull color of *E. psammion.* Unlike that which is present in *E. hepaticum,* its purple pigment is soluble in alcohol, though quite slowly, and preserved colonies gradually change to a dull brown color, the alcohol acquiring a purplish and finally a yellowish tint.

The zooids are of the usual *Eudistoma* type, fairly stout and of moderate size, generally not over 4 or 5 mm. long in the contracted condition but no doubt 8 mm. or more long when well extended. They are of a dark yellowish color in preservation without conspicuous pigment cells; the opacity of the test usually makes them entirely invisible until the colony is cut open, but in some specimens their apertures are discernible on parts of the surface and show their arrangement in small oval or more or less irregular systems, apparently usually composed of comparatively few individuals.

DISTRIBUTION: The west coast of Florida in shallow water. It is especially common in the vicinity of Tarpon Springs (the type locality) and Anclote Keys, but is said to occur also at the Dry Tortugas. Type in the American Museum of Natural History (A.M.N.H. No. 1976).

Eudistoma clarum (Van Name), 1902

Text figure 57

Distoma clarum VAN NAME, 1902, p. 345, pl. 48, fig. 10, pl. 59, fig. 117; CAULLERY, 1909, p. 43; PRATT, 1916, p. 669.

Polycitor (*Eudistoma*) *clarus* VAN NAME, 1921, p. 350, fig. 37; HARANT, 1925, p. 2; 1929, p. 40; VAN NAME, 1930, p. 448, fig. 23; BERRILL, 1932, p. 78.

Colony a small, rounded, or oval mass without a peduncle, attached by most of the under surface. Test transparent and colorless in preserved specimens, but slightly opalescent in life, with a grayish, pinkish, or sometimes a blue or green cast. Size of the largest colonies about 12 mm. across and 6 mm. or less in height. Zooids irregularly distributed, lying in preserved colonies at all angles to the surface, no systems being discernible; they are visible with perfect clearness through the test.

Zooids small, provided with very strong longitudinal muscle bands on the thorax and anterior part of the abdomen; these usually produce such violent contractions in preserved specimens that the natural size and form of the zooid are entirely changed and distorted. Both apertures on tubes; the branchial tube very stout, six- or seven-lobed; the atrial longer, six-lobed. In immature zooids, both tubes may be mere conical projections. Posterior end of the body produced into a vascular process. Length of the zooids when moderately extended 3 to 4 mm. or more, but in the strongly contracted and distorted condition in which they are found in preserved specimens, usually much less (2 mm. or under). During life the thorax of the zooids is white, the stomach and more or less of the intestinal loop yellow or orange. In preservation the zooids fade to yellow or flesh color, and usually eventually turn dark colored (dark yellow or brown).

Testes and ovaries beside the intestinal loop, the stout common sperm duct accompanying the intestine to near its end. Testes few, usually six or eight in number, pear shaped. Eggs large; the embryos develop into tailed larvae in the atrial cavity of the parent. Sometimes four or five large embryos or larvae, together equaling in bulk their parent, are found in the dorsal region of the body of a single zooid, greatly distending that part of the body, though no distinct incubatory pouch is formed.

This is one of the most abundant ascidians at Bermuda, occurring attached to stones along the shore and on corals, etc., on the reefs, but I have not yet seen it from any other locality. The type is in the Yale University collection.

Harant (1929, p. 40) assigns a specimen taken at the Azores in 200 meters to this species, being unable to find any specific difference.

Eudistoma carolinense, new species

Text figure 58

The colony consists of groups or masses, sometimes a number of centimeters wide, of rather long, narrow, irregularly tapering clavate heads arising from an expanded, incrusting base which is irregular in outline and thickness. The heads are usually from 20 mm. up to 25 mm. or occasionally 30 mm. in height and from 3 to 4 to 10 mm. wide, or sometimes more, at the top, where they are commonly considerably widened; they taper irregularly below and are often somewhat flattened laterally, and partially cleft or subdivided above into lobes which lie more or less in one plane. The heads are generally curved and crooked, sometimes quite closely crowded, in other cases forming a somewhat open cluster. They do not all arise from the expanded base of the colony, but in many cases from the lower part of another head, or several may have a common pedicel.

The test composing them is in every part densely crowded with coarse sand grains, rendering it somewhat hard and brittle, entirely opaque and of the color of the sand. In fact, sand bound together by a little of the substance of the test forms the bulk of the colony. They are among the most densely sand-impregnated ascidian colonies that I have seen.

The zooids are very small. In the contracted state they are, in the preserved material, commonly only about 2 mm. long, sometimes less, and do not exhibit a long, constricted neck between the thorax and abdomen. In such specimens they are quite deeply buried in the heads, their anterior ends often withdrawn 4 or 5 mm. below the surface of the upper end of the head, to which they doubtless reach when expanded. The surface of the head is a little uneven, slight elevations indicating the positions of the anterior ends of the zooids, as in many other species of *Eudistoma.*

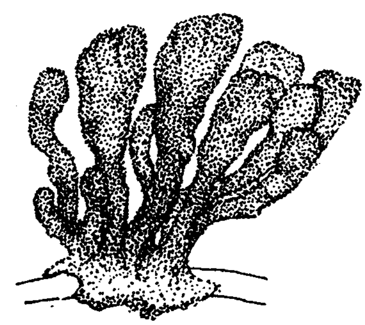


FIG. 58. *Eudistoma carolinense,* new species. Small colony, ×1.5.

The heads are so narrow that often they can accommodate only one or two fully developed zooids; in other cases they may contain a group of half a dozen or more. Whether or not these form a system is difficult to tell. The zooids have the atrial opening, which is six-lobed, either only a little prominent or on a tube, which, however, is seldom long. They have the musculature of the thorax comprising both longitudinal and transverse bands dense and strong; the longitudinal bands extend also far down on the sides of the abdomen. These thick muscles and the contracted condition and small size of the zooids render it difficult to make out the internal structure of the zooids, but they have three rows of stigmata with apparently at least 10 in a row on each side. The tentacles could not be counted but are not very numerous and appear to be of two sizes. Stomach rounded, smooth walled; the gland surrounding the intestine consists of very few tubules swollen at their ends. The testes are pyriform and few in number (about six or seven), appear to be well developed and lie beside the intestinal loop discharging by a thick sinuously curved sperm duct, as usual in this genus. The ovary, also beside the intestinal loop, was not well developed in the individuals dissected out for study.

DISTRIBUTION: Coasts of southeastern United States in shallow water. Large colonies labeled "Blackfish Banks off Charleston, S. C., Nov. 15, 1934, W.W.A." growing on gorgonian stems are in the United States National Museum and in the American Museum. One of these was selected as type (A.M.N.H. No. 2020; pieces in the United States National Mueum). Other localities are "Fish Hawk" Station 8283, 34° 20′ 15″ N., 76° 49′ W.; and Station 8264, 33° 13′ 22″ N., 79° 11′ 07″ W., Winyah Bay, South Carolina, 5 to 16 fathoms; off Florida Banks, 28° 55′ N., 82° 55′ W., and Cedar Keys, Florida, collected by J. F. Moses. The last-mentioned specimens were doubtfully assigned to *Eudistoma olivaceum* in Van Name, 1921 (p. 345).

Eudistoma platense, new species

The colonies consist of heads arising from a base composed of stout stolon-like branches incrusted with sand. The heads themselves are almost free from incrustations. Most of them are small (less than 10 mm. in diameter) and irregularly rounded, but in several cases one head in a group is much larger and of clavate or more or less pyriform outline compressed from side to side.

The largest of these heads is about 50 mm. in height, 22 mm. wide near the rounded upper end, and 11 mm. thick, and somewhat suggests a melon seed in shape. It tapers to a short, very narrow pedicel; the other heads of the group to which it belongs are very small. Several of the smaller specimens are of similar, though somewhat less regular, shape.

The test is yellowish gray, rather tough (especially the outside layer), and rather transparent, allowing the lighter yellowish zooids and also the dark-colored faecal pellets in their intestinal tract to be distinctly seen. Bladder cells were not demonstrated in the test.

The zooids are rather closely and evenly distributed, though systems are not evident. Whether systems are everywhere wanting I cannot say, but many of the zooids evidently have both apertures opening on the surface of the colony.

The zooids are slender and have the thorax and abdomen connected by a very long, narrow neck. Some of them reach 8 mm. or more in length in the preserved specimens but are usually much shorter owing to the contraction and contortion of the narrow neck. The apertures each have six regular lobes and are situated on short tubular siphons arising close together from the anterior end of the thorax. Both usually extend directly forward, but in some cases the atrial tube may be more dorsally directed. The thorax has rather closely placed longitudinal and transverse muscles (the former the best developed) which cross each other at right angles. Their contraction makes the determination of the internal structures of the thorax very difficult, but the longer branchial tentacles apparently number from 12 to 16. Some smaller ones may be present. Only three rows of stigmata were demonstrated, with a rather small number, not over a dozen, in a row on each side. The branchial sac appears long enough for a fourth row, but no stigmata were demonstrated in the posterior part.

The condition of the material made the characters of the stomach very hard to determine. It appears to be very thin walled, oval in shape, and without regular plication of the wall, though in some cases irregular folds due to contraction were present.

The gonads lie beside the intestinal loop. The testes were small and numerous (30 or more) in the zooids examined, often considerably distending the abdomen, while the ovary was but little developed. However, many of the zooids contained several tailed larvae in the atrial cavity.

LOCALITY: Dredged by the "Albatross" near the mouth of the La Plata River at two adjacent stations, 2766, 36° 47′ S., 56° 23′ W., 10.5 fathoms, and 2765, 36° 43′ S., 56° 23′ W., 10.5 fathoms. Type in the United

States National Museum; cotype in the American Museum of Natural History, A.M.N.H. No. 1863.

This species may possibly be more in place in *Polycitor* than in *Eudistoma.*

Eudistoma pachecae, new species

Although I have much hesitation in basing a new species of this genus on a single colony, the specimen is a good one, is from a region whose ascidian fauna is little known, and is apparently not satisfactorily assignable to any of the other *Eudistoma* described in this work, though most nearly allied to *Eudistoma clarum.*

The colony is of flattened incrusting form with rounded edges; of irregularly oval outline, about 14 by 11 mm. in diameter and 2 mm. thick.

The test is of firm gelatinous character slightly yellowish in tint, transparent, with a smooth upper surface and almost no included sand or debris.

The colony contains some 50 adult zooids and many additional immature ones; their arrangement, as well as the direction of their atrial tubes, indicates that they form several small systems of oval or elongated outline.

The zooids are small, about 2 mm. long in the preserved condition, and lie at various oblique angles to the surface. The abdomen is close to the thorax, often with very little constriction separating them.

The thorax is quite deeply brown pigmented in adult zooids, so that the zooids appear as small dark spots when the colony is viewed without magnification. The pigment is in corpuscles in the tissues of the mantle and branchial sac—in the vessels of the latter to an extent that often makes the three rows of stigmata visible even through the test with low magnification. The abdomen has little or no pigment; young zooids have much less than the adults, but there is a conspicuous dark spot over the anterior end of both the endostyle and dorsal lamina.

The structure of the zooids is as usual in the genus. The branchial aperture is six- or seven-lobed; it is not much produced; the six-lobed atrial aperture is on a tube that varies in length, direction, and curvature in order to enable it to reach the common cloacal canal or cavity, but it is usually rather short. There appear to be about 16 tentacles of two sizes alternating, and at least 10 stigmata in the rows on each side. The alimentary canal forms a fairly large loop; the gonads are not much developed, neither do the zooids contain embryos or larvae in the atrial cavity in this specimen.

LOCALITY: Pacheca Island, Bay of Panama, in shallow water.

Eudistoma mexicanum, new species

Two extremely large colonies in the United States National Museum collection are so unlike any other specimens of the genus that I have seen, that the establishment of a species for them seems necessary.

They are of flattened form; the largest is 65 cm. long by 6.2 cm. wide at its broadest point; its thickness in most parts varies between 1.5 and 2.2 cm. The area by which it was attached cannot have been very extensive, as the colony has zooids on a large part of the lower, as well as the upper, surface and on much of the edges, which are rounded.

The test in the alcoholic specimens is of watery transparency with a slightly yellow tint and of the consistency of rather firm jelly, and fairly uniform throughout the colony, though the superficial layer or skin is slightly tougher.

The zooids are confined to the superficial parts. Owing to curvature of their bodies or to often lying in very oblique positions, they do not generally extend deeply into it, nor do they have vascular appendages extending into the test. The interior part of the colony as can be seen in sections, or for that matter without cutting, consists of clear, solid jelly virtually free from any structures or included matter (other than cell nuclei) to interfere with its transparency. I failed to find any bladder cells.

The zooids are in such poor preservation that I was for some time in doubt regarding the genus of these species, but they appear to be of the usual *Eudistoma* type (see under the genus *Eudistoma*). They are very slender and when well extended may reach 11 mm. or more in length, the greater part of which is taken up by the narrow neck connecting the thorax and abdomen, but in their usual contracted condition generally not over 5 or 6 mm. long.

I could not demonstrate that any systems are present; the atrial siphon is usually directed straight forward and probably opens independently on the surface. Reproductive organs were not developed in the zooids examined.

LOCALITY: "Albatross" Station 3033 at the extreme northern end of the Gulf of California, 30° 50′ 45″ N., 114° 29′ 45″ W., 18 fathoms. Largest colony is the type, pieces also in the American Museum of Natural History (A.M.N.H. No. 1887).

Eudistoma diaphanes Ritter and Forsyth, 1917

Eudistoma diaphanes RITTER AND FORSYTH, 1917, p. 469.

In the characters of the colony this species is in strong contrast to *E. psammion* found in the same region. It is described as follows by Ritter and Forsyth:

"Flat and encrusting, soft, usually even surfaced and regular in outline. Rarely exceeding 10 cm. in greatest expanse; seldom if ever more than 1 cm., frequently only a few millimeters thick. Color varying from white to pale vermillion; test transparent, containing a great quantity of cellular material but no bladder cells or spicules; almost entirely free from sand.

"Zooids uniformly distributed, not disposed in systems; inconspicuous by reason of small size and meagreness of pigment; placed at various angles to surface of colony. Length about 3 mm., less in preserved condition. A distinct capsule of test enveloping each zooid. Mantle musculature similar to that of *Eudistoma psammion*. Branchial tentacles about twenty in number, of two sizes. Ectodermal processes present but not so long and numerous as in *E. psammion*.

"Siphons relatively shorter than those of *E. psammion*, the two of about equal length, both opening on surface. As far as could be made out, branchial sac very similar to that of *E. psammion*. Branchial tentacles about twenty in number, not all in same circle but scattered somewhat over surface of siphon."

I have never found any specimens of this species that were "pale vermillion" or anything approaching to that color. Those that I obtained on the ocean shore south of Newport Harbor were all rather small, some flattened and incrusting (though thick), others more or less capitate, and had the test yellowish olive in life and quite transparent, the zooids being pale yellow, with the stomach and part of the ascending limb of the intestinal loop brown. Those obtained in the vicinity of Pacific Grove, California, were commonly larger colonies, often of the incrusting type, and had the test grayish or yellowish and less transparent, yet sufficiently so for the light yellow or whitish thoraces of the zooids to show quite plainly.

As compared to *E. ritteri*, which replaces it on the coast of northern California (though their ranges overlap for some distance), this species has the test softer and more easily torn, the colonies are usually less massive (seldom assuming the high capitate or clavate form common in *ritteri*) and have considerably smaller zooids.

DISTRIBUTION: California coast from San Diego to San Francisco, according to Ritter and Forsyth. It is found on the under side of large stones and rocks on the ocean shore in the lower part of the intertidal zone. Type locality, La Jolla. Specimens collected in July often contain large eggs or larvae in the atrial cavities of the zooids.

Eudistoma ritteri, new species

Plate 27

"Distoma y" RITTER, 1900, p. 608.

Eudistoma lobata BERRILL, 1935, pt. 4, p. 340, fig. 81, 8m; 1937, p. 566 (*lobatum*).

Not *Distoma lobata* Ritter, 1900, p. 606, pl. 20, figs. 31–33 (= *Cystodytes lobatus*); not *Eudistoma lobatum* Hartmeyer, 1909–1911, p. 1432.

The colony usually consists of a number of heads of rather elongate capitate or clavate outline arising from a common base of irregular form by which it is attached. The basal part, which may be several centimeters wide, is of irregular outline and thickness and is usually incrusted and impregnated with sand. The heads are usually rather characteristic in appearance; they commonly reach 25 to 40 mm. or more in height and 10 to 15 mm. in diameter at the widest part, and, though often growing close enough together to be nearly or slightly in contact with each other, are not crowded so as to form a compact mass or make their cross section angular or polygonal from pressure of adjacent heads. Usually the upper part of the head is rounded or egg shaped and considerably wider than the neck or peduncle, but in some colonies the heads are widest not far from the base and taper gradually to a rather sharply rounded off end, so that they have a somewhat finger-like appearance which is increased by their frequently slightly curved axis. Many small colonies, and of course the young colonies also, consist of a single head. In other cases colonies consist mainly of the basal mass which gives off no actual heads but merely has its upper parts, in which the zooids are contained, raised into irregular lobes or low rounded elevations.

Neither in life nor in preservation is the species conspicuously colored; the whitish anterior ends of the zooids show somewhat distinctly through the yellowish or grayish olive semi-transparent test, which in the upper parts of the colony is free from sand, of moderately firm but not hard consistency, and with a smooth surface except for slight elevations (more prominent in living, expanded colonies) marking the anterior ends and branchial apertures of the zooids. The latter apparently sometimes form small systems but oftener have both their apertures on the surface of the colony.

Bladder cells are wanting in the test, which is of gelatinous character with great numbers of small oval nuclei. The zooids are rather long and slender, with an elongated neck between the thorax and abdomen when expanded. Some of them reach a length of 4 to 6 mm. or more in the preserved material. They are generally rather closely placed, more or less obliquely to the surface of the head.

The zooids conform to the usual *Eudistoma* structure described under the genus. The normal number of tentacles seems to be 16, representing three orders regularly arranged. Three rows of stigmata with about 14 in a row on each side. Stomach rounded, smooth walled. Ovaries and testes beside the intestinal loop; the testes usually consist of a group of about 12 to 15 pyriform glands. (For statements on budding, see Berrill, 1935, pp. 341–343.)

DISTRIBUTION: Found along a considerable part of the California coast from Pescadero Point near Pacific Grove (type locality), where I collected it in some quantity on intertidal rock exposed to surf of considerable force, and farther north. The American Museum also has specimens from Dillon Beach, received from C. R. Benton, and Bodega Bay, received from F. S. Light, north of San Francisco. How much farther it ranges I do not know. Huntsman (1912, p. 115) reports a "*Polycitor* (*Eudistoma*) sp. A," found in quantity on the exposed rocks on the west coast of Vancouver Island at Ucluelet, and a "*Polycitor* (*Eudistoma*) sp. B," occasionally dredged in 5 to 10 fathoms in the same vicinity, but gives no further information about them.

This is evidently the species which Ritter (1900, p. 608) says "is widely distributed on the coast of California and which I have designated in my MS. notes as *Distoma y.*" Ritter is sure of its specific distinctness from his *Distoma lobata* (= *Cystodytes lobatus* of this work) "as it is almost always without systems, while *D. lobata* almost always possesses them. The 'bladder' cells which are so characteristic of the test of *D. lobata* appear to be wholly wanting in '*D. y.*'" But he published no formal description and gave it no scientific name.

Berrill, 1935, who investigated the budding in material of the present species received from Pacific Grove from E. F. Ricketts, was evidently not correct in using the name *lobata* for it. As it appears to be still nameless, I am taking the liberty of naming it after Prof. W. E. Ritter. Type, A.M.N.H. No. 1667.

Eudistoma psammion Ritter and Forsyth, 1917

Eudistoma psammion RITTER AND FORSYTH, 1917, p. 467, pl. 44, figs. 52, 53.

Colonies rather thick and massive, attached by the entire lower surface. Test tough and unusually hard in consistency, rough and somewhat sandy on the surface; entirely opaque in consequence of the large amount of sand by which the test is permeated in nearly all parts. Its color in preservation is dull brown, the shade being more or less affected by the color of the included sand; in life the test usually has a strong tinge of reddish purple or claret. These characters render it one of the most easily recognized of the compound ascidians of the California coast.

The colonies usually have a thickness of 10 to 15 mm. and may become several centimeters in expanse. They are commonly bounded by somewhat abrupt edges.

Zooids arranged in small, rounded systems composed of about eight individuals, each system having a small, common cloacal aperture (often fairly conspicuous on the surface of the colony) in the center. Owing to the opacity of the test, the zooids are entirely invisible from the outside.

In their form and structure the zooids conform strictly to the characters given under the genus *Eudistoma*. In preserved material they are, in the usual somewhat contracted state, fairly stout and 4 to 5 mm. long; when the neck or peduncular part is well extended they may reach 8 mm. or more in length. Owing to their arrangement in systems, the atrial tube, which often arises well back on the dorsal aspect of the thorax, may be long and sometimes curved in order to reach the common cloaca. Ritter and Forsyth, 1917, give the number of branchial tentacles as about 30 and the stigmata as 10 on each side. A vascular process, often quite long, commonly extends from the rear end of the body. For a detailed description, see their article.

DISTRIBUTION: California coast from Bodega Bay on the north to San Diego on the south; also Santa Cruz Island off the coast. Type locality, La Jolla. It is commoner northward (Pacific Grove, Dillon Beach, Bodega Bay) and occurs both on rocky shores on the under side of rocks or in crevices where the force of the surf is somewhat broken, and in water a few feet or fathoms in depth. In the early part of the summer the zooids often have the atrial cavity much distended by large eggs and larvae.

Eudistoma molle (Ritter), 1900

Distoma molle RITTER, 1900, p. 605, pl. 20, figs. 29, 30.

Described by Ritter as follows:

"General Character of the Colony: Comparatively regularly disc-shaped, attached by nearly the whole of the under surface. Greatest diameter of the larger of the two colonies at hand 8.6 cm.; shorter diameter of same colony 5.5 cm.; thickness in thickest portion 2 cm. Very soft and flabby. Test more than usually transparent, the individual zooids showing through it very distinctly. Color, a light gray, this being imparted to the otherwise quite transparent testicular mass by the thin, somewhat more opaque superficial layer to which a small quantity of fine sand adheres. The soft testicular substance contains many cells which are small and rather uniform in form and size; no bladder cells present.

"General Character of Zooids: Distinctly seen through the test for nearly their entire length. No systems recognizable. Placed mostly at oblique but varying angles to surface of colony. Each zooid in the form of a dumbbell with a very long handle, the thorax forming one of the balls, the intestinal loop the other, and the much elongated oesophagus and rectal portion of the intestine the handle, the two ends or balls being nearly equal in size. Average length about 8 mm., of which about 5 mm. belong to the handle of the dumbbell. The ectodermal appendage at the posterior end of the abdomen large and always present.

"Branchial Apparatus: No orifices, either branchial or atrial, recognizable on the surface of the colony; this probably due to the extreme flabbiness of the test. Branchial and atrial siphons about equal in size and shape, both long and strong; the lobes of each well marked—almost tumid in some specimens. Thorax always much contracted, very dense, so that its internal structure is made out with great difficulty. Apparently three series of long stigmata in the branchial sac; but the extreme state of contraction makes certainty on this point impossible. Musculature of mantle well developed, particularly as to the circular fibers, these arranged in more or less regular bands, as are the longitudinal ones; the circular fibers almost as well developed at the posterior as at the anterior end of the thorax.

"Digestive Apparatus: Oesophagus very long and narrow; stomach nearly globular, its walls somewhat irregularly thickened, but not distinctly folded. Post gastric intestine short, the intestinal loop forming almost a circle, the stomach being situated at the point where the intestine returns upon itself to produce the circle. Rectal portion of the intestine very long, running closely parallel with the oesophagus.

"Sexual Organs: Situated on the left side of the intestinal loop, but extending slightly behind it; ovary not voluminous though the individual ova when fully grown are large; the ovary on the oesophageal side of the intestinal loop, and immediately behind the stomach. Testis forming a dozen or more large, distinct elliptical masses; vas deferens distinct throughout its length when filled with sperm.

"Embryos developed in the atrial chamber, this not produced into a special incubatory pouch; apparently about six embryos and tadpoles in the chamber at one time."

DISTRIBUTION: Puget Sound (Ritter), no particulars given. Two soft thick colonies, the largest 45 mm. in greatest measurement, obtained on the intertidal rocks near the Hopkins Marine Station at Pacific Grove, California, appear to belong to this species. When alive the test had a pinkish yellow shade and was sufficiently transparent to allow the zooids to be visible through it. I was able to confirm the correctness of Ritter's statement that there are three rows of stigmata.

This may be one of the two species of "*Polycitor* [*Eudistoma*]" reported from Vancouver Island by Huntsman, 1912 (see remarks under *E. ritteri*). *Polycitor mollis* Sluiter, 1909, from the Malay region has nothing to do with the present species.

GENUS **ARCHIDISTOMA** GARSTANG, 1891

Very closely allied to *Eudistoma*. Its zooids are disposed in small capitate groups, the individuals of which have their posterior ends embedded in the common test posteriorly, but more or less separate anteriorly or sometimes for almost their whole length. Structurally the zooids resemble those of *Eudistoma*, but Berrill (1935, pt. 5) believes that their budding is different, the abdomen undergoing transverse constriction or strobilization to form several new zooids, a process which he did not find occurring in *Eudistoma*. Unless this difference in budding can be confirmed as constant, the partial separation of the zooids in *Archidistoma* would hardly justify generic separation, as Hartmeyer, 1924, pointed out. In fact, in many species of *Eudistoma* the zooids project slightly above the surface of the common test when they are expanded. If the genera are united, Garstang's name will have priority over *Eudistoma*.

Archidistoma aggregatum Garstang, 1891

Text figure 59

Archidistoma aggregatum GARSTANG, 1891, p. 267, figs. 1, 2; HARTMEYER, 1903, p. 315; 1924, p. 112; HARANT AND VERNIÈRES, 1933, p. 56; BERRILL, 1935, pt. 4, p. 340 (*aggregata*), fig. 7.
Not Jacobsohn, 1892, pp. 159, 188.

"The colony possesses a thin spreading carpet-like base of test substance traversed by stolonid tube from which the zooids spring up at irregular intervals. Sometimes the zooids are entirely free but usually they are united into small clumps consisting of several individuals the tests of which are partially fused together. The zooids project from the basal carpet of test to a variable extent; as a rule their height is between six and ten millimeters. They possess a dilated and somewhat globular thoracic region and an elongated semicylindrical abdomen region" (Garstang, 1891).

The colony is of a greenish olive color and is more or less incrusted with sand. The zooids are very small, of the type described under the genus *Eudistoma*, and have the apertures both six-lobed on short tubes. There are about 30 tentacles, three rows of stigmata, and a rounded smooth-walled stomach. The eggs develop in the atrial cavity; there is no special incubatory pouch, and of course no common cloacal cavities or apertures.

DISTRIBUTION: This small and inconspicuous species was described by Garstang from the vicinty of Plymouth, England, in 5 to 15 fathoms. It incrusts stones, shells, etc., but is not common, or at least not easy to find and recognize. It has since been collected in the vicinity of Plymouth by Hartmeyer and Berrill, and according to Hartmeyer, 1924, has been reported from the French coast of the Channel by Caullery, though I have not been able to find where he published the record. A report of it from the White Sea by Jacobsohn, 1892, is rejected as incorrect by Hartmeyer, probably with good reason.

Until recently it has not been known from American waters, but a letter from N. J. Berrill states that he found it "very common" at Beaufort, North Carolina, "growing on small stones and clam shells and protruding above the general surface of one or two shoals that were never actually bare of water at low tide." I have examined only one colony or group of colonies, which were dredged near Beaufort by H. H. Plough, growing on and surrounding the basal part of a large hydroid stem for a length of about 5 cm., and

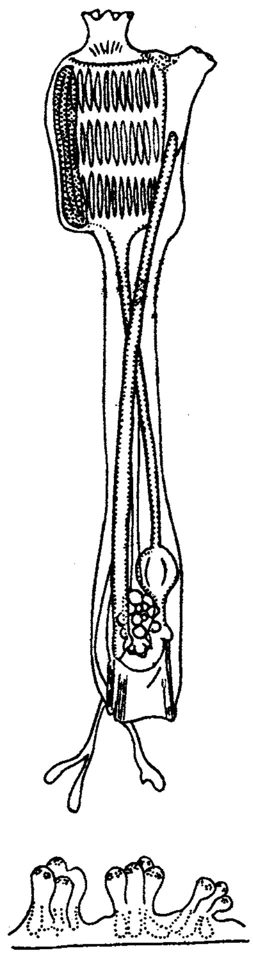


FIG. 59. *Archidistoma aggregatum* Garstang. Zooid and part of colony, as illustrated by Berrill, 1935.

comprising very numerous clusters of zooids, though the later were not in a favorable condition for detailed study (A.M.N.H. No. 1608). No other American locality is known as yet.

I follow Berrill's opinion indicated in his letter to me, in treating the American and European forms as identical, as he has had the opportunity of studying material from both regions.

GENUS **POLYCITOR** RENIER, 1804

This genus, the type of the family, was formerly a large group, including the numerous species with a smooth-walled stomach and but three rows of stigmata now placed in *Eudistoma*. The removal of that group left it with but few species, most of which are not too well known, so that with our present information, it is hard to give a satisfactory diagnosis of it. The species still retained in it differ from *Eudistoma* in having (or being supposed to have) four rows of stigmata or more, and in many cases more or less distinct longitudinal plications of the stomach wall. Nearly all of them stand in need of further investigation. Its type species is *P. crystallinus* Renier, 1804, a Mediterranean form said to have numerous (at least 10) rows of stigmata and a plicated stomach.

Polycitor vitreus (Sars), 1851

Text figures 60, 61

Collela kükenthali GOTTSCHALDT, 1894, p. 363, pl. 24, fig. 6.

Distoma crystallinum HUITFELD-KAAS, 1896, p. 9; BONNEVIE, 1896, p. 12.

Distomum vitreum SARS, 1851, p. 154; 1859, p. 66.

Distomus crystallinus HARTMEYER, 1903 (in part), p. 309, pl. 6, fig. 3, pl. 11, fig. 20.

Distomus kükenthali HARTMEYER, 1903, p. 311, pl. 14, fig. 6; REDIKORZEV, 1907, pp. 148, 153; 1908, p. 33.

Polycitor kükenthali VAN NAME, 1910, p. 362, figs. 4, 5; HARANT, 1929, p. 41, pl. 1, fig. 6.

Polycitor vitreus HARTMEYER, 1921a, p. 73 (on p. 75 the specific name *crystallinus* is used apparently by mistake), fig. 17; 1924, p. 113.

Tetrazona vitrea MICHAELSEN, 1930, p. 481.

NOTE: The synonymy of this species is involved, as it has been confused with a southern European species *P. crystallinus* (Renier), 1804. See Hartmeyer, 1921a, 1924.

Colony ovate or acorn shaped in the specimens I have examined, sometimes more elongate and finger shaped; attached by the larger end by a small area which may form a short, stout peduncle. The two largest colonies I have seen measured 46 mm. in height by 26 mm. in greatest width, and 40 mm. by 29 mm., respectively, but a more slender colony was 60 mm. in height.

Test somewhat opaque in the preserved specimens, translucent yellowish white or yellowish gray in color. Zooids apparently not arranged in definitely distinguishable systems, though in some specimens they form distinct rows from the base to the apex of the colony. Their anterior ends tend to project slightly above the surface of the colony, probably much more so during life when expanded.

The zooids conform to the type described under the genus *Eudistoma*, except that they apparently have four rows of stigmata instead of three. The mantle is, however, extremely thick and muscular, especially on the thorax, where the numerous strong, closely

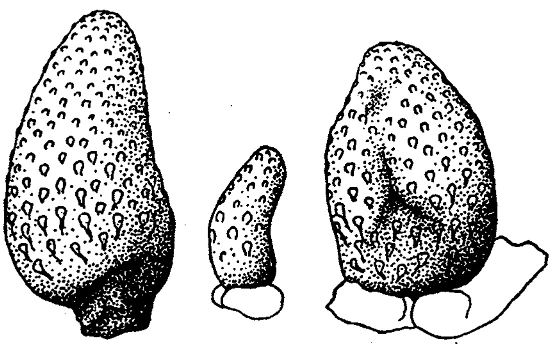


FIG. 60. *Polycitor vitreus* (Sars). Three colonies, natural size.

placed longitudinal and transverse muscle bands render the walls of that part of the body so opaque, and so distort and crush the internal structures, that it is very difficult to determine the number of rows.

There are at least about 12 larger and smaller tentacles placed alternately and additional smaller ones inserted nearer the branchial aperture. The neck or narrow part of the body between the thorax and abdomen is very long, and in living specimens the expanded zooids must measure 20 mm. or more in length, but in preserved colonies are often only 5 mm. or even less in their shrunken condition.

The stomach is smooth walled; it is said to be longitudinally striped with dark pigment in some cases, but I have not observed this. The gonads are beside the intestinal loop, though the group of testes may project a little behind it.

DISTRIBUTION: This is chiefly a species of the Arctic and northern waters of the Old World, occurring about Iceland, the northern and western coast of Norway, Spitzbergen, etc., and, in the region the present work covers, at various points on the west coast of Greenland (Davis Strait and near southern

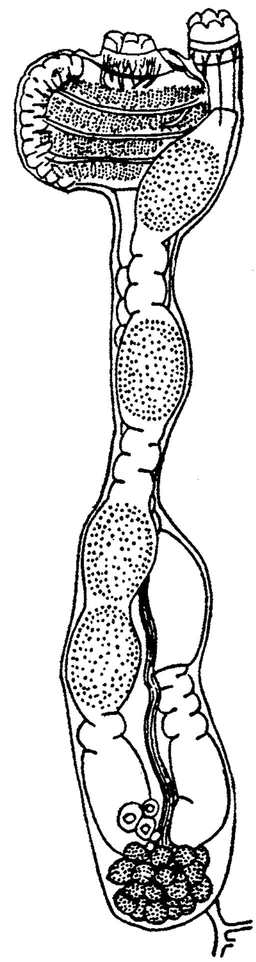


FIG. 61. *Polycitor vitreus* (Sars). Zooid, ×20.

end). Also obtained by the "Albatross" at three points off Newfoundland: Station 2699, 45° 04′ N., 55° 23′ W., 72 fathoms; Station 2693, 46° 53′ N., 44° 39′ 30″ W., 78 fathoms, and Station 2694, 46° 52′ 30″ N., 44° 54′ 30″ W., 86 fathoms, attached to small stones or *Boltenia* stems. Harant, 1929, illustrates specimens from near Newfoundland.

According to Hartmeyer, the extremes of depth recorded are 14 to 810 meters but usually not over 200 meters.

Polycitor magalhaensis (Michaelsen), 1907

Paessleria magalhaensis MICHAELSEN, 1907, p. 69, pl. 1, figs. 1, 2, pl. 3, figs. 11–13; 1930, p. 490.

Polycitor (Eudistoma) magalhaensis MICHAELSEN, 1915, p. 461.

Sigillina (Paessleria) magalhaensis MICHAELSEN, 1930, p. 492 (only so far as it refers to the type of *Paessleria magalhaensis*).

A very insufficiently known species based on a single colony of compact, massive form, 22 mm. in maximum diameter, with much embedded sand in the basal parts. Systems not definitely demonstrated.

Small "elastic" spherical bodies embedded in the upper parts of the test were first believed by Michaelsen to afford a character for a new genus (*Paessleria*), but in later articles (1915, 1930) he regards them as symbiotic cells.

The zooids were of very elongate form, the short thorax connected to the abdomen by a very long slender neck; their total length was about 11 mm. Branchial aperture six-lobed; atrial aperture on a curved tubular siphon also six-lobed, but the three anterior lobes much longer than the others. The thorax was greatly contracted, making the determination of the structure of the branchial sac very difficult. Michaelsen gives the number of rows of stigmata as three, but as he does not indicate them in his figure and expresses doubt as to there being only two dorsal languets, he apparently was not too certain that there were not four. Stomach oval, with a typhlosole and a few not very distinct or regular longitudinal folds. Gonads not distinguishable.

LOCALITY: Strait of Magellan. Eastern Hemisphere localities (Michaelsen, 1930) incorrect or unreliable.

Polycitor glareosus (Sluiter), 1906

Distoma glareosa SLUITER, 1906, p. 6, pl. 1, figs. 1–4; MICHAELSEN, 1915, p. 467 (*glareosa*).

Tetrazona glareosa MICHAELSEN, 1930, p. 482.

Based on two small, more or less spherical colonies with a diameter of 18 mm. They are pierced through by a cylindrical opening probably due to their having grown on and surrounded the stem of an anthozoan or other similar object. Surface of colony smooth, color pale gray, zooids visible as pale yellow spots; both their apertures six-lobed, the branchial larger and more distinct than the atrial.

Zooids short, only about 2 mm. long, divided into thorax and abdomen. Both siphons short, six-lobed; both opening on the surface of the colony.

Test gelatinous but resistant, composed largely of bladder cells closely pressed together ("grandes cellules vésiculaires serrées les unes contre les autres"). The test contains minute siliceous bars (crystals?) often arranged in the form of asterisks.

Mantle muscles of zooids quite powerful; 12 equal-sized tentacles; four rows of stigmata; intestinal tract short but wide; stomach smooth walled; gonads beside the intestine.

LOCALITY: Western Antarctic, Schollaert Canal, 30 meters.

In its general characters this species resembles a *Cystodytes*, though lacking the disk-shaped spicules, rather than a *Polycitor*, and the possibility of its being of that genus (the spicules, which are often very thin, having been dissolved out) seems worthy of consideration. A *Cystodytes*, *C. antarcticus* Sluiter, was later (1914) described from the same region, but on the basis of a colony evidently very immature, and grounds for the identification of the two forms are not sufficient.

GENUS **CYSTODYTES** VON DRASCHE, 1884

A group closely allied to *Polycitor* and *Eudistoma* but notable for the usual presence of disk-shaped calcareous spicules in the test, arranged in an overlapping manner so as to form capsules often completely enclosing the bodies of the zooids except the thoracic part, which may be extended or drawn back into the capsule. These capsules form a single layer a little way beneath the upper surface of the colony. But in some colonies the spicules may be few or poorly developed, and well-formed capsules may not be present at all. There are often scattered deposits of calcareous matter in granular or crystalline form in the test.

The genus also differs from *Eudistoma*, at least from most species of that genus, in having a great abundance of bladder cells in most parts of the test—cells consisting largely of one immense vacuole distended with fluid which crowds the nucleus and cytoplasm to one side. These cells are often so abundant as to make up a large portion of the test and so crowded as to be forced into polyhedral shapes by mutual pressure. In such cases they render the test rather firm and stiff.

The zooids are quite uniform in structure throughout the genus and are commonly arranged in systems which may be of considerable extent. In most details they resemble those of *Eudistoma* but are shorter (2.5 to 4 mm. long) and more compact in order to permit of being contained in the capsule. The thorax and abdomen are closely connected with very little of a neck between them; in fact, they often lie more or less side by side. The thorax is very muscular, the longitudinal bands are especially strong, and at the rear end of the thorax they converge and join into a single wide, strong band on each side of the body, which serves to retract the thorax back into the capsule from which it extends out when the zooid is expanded. On the sides of the abdomen the muscles spread out again in a thin layer.

The apertures are both six-lobed and on tubular siphons like those of *Eudistoma*. The tentacles are of several sizes; usually I have found about 16 large ones representing two or three orders with additional small ones (sometimes numerous) inserted a little more anteriorly in the siphon.

In one important respect this genus differs from *Eudistoma;* as far as I know, there are always four rows of stigmata, though it is often difficult to count them.

The stomach is rounded and smooth walled; the gonads, situated beside the intestinal loop, resemble those of *Eudistoma*. The testes, usually 10 or more in number, are pyriform and arranged in a somewhat circular group; the common sperm duct is conspicuous from its stoutness and tortuous course. The eggs and larvae are very large and few; the latter develop in the atrial cavity.

Differences in the average size of the spicules do not seem to be of any account in distinguishing species. In a fully developed state the spicules are of circular outline, with a wide thin margin, usually from 0.3 to 0.75 mm., but occasionally 1 mm. or more in diameter, the outer surface (that away from the body of the zooid) slightly convex or very greatly flattened conical with a distinct central boss; the opposite side is slightly concave. Young, developing spicules are small, thick, disk-shaped or more or less biconvex and lack the thin marginal part. They often show a conspicuously striated surface as if built up of slender elements radially arranged; indications of rings of growth may also be evident. Such marking may appear in fully formed spicules also, but are usually less conspicuous. Damaged or irregularly formed spicules are frequent in some colonies though few in others. In addition to those taking part in forming capsules, there are often others scattered in the test. These may have originally been parts of capsules that have disintegrated, the zooids having died.

With present information and material, the insufficiency of which I freely admit, I can distinguish only the following three species in the American area. It is difficult to find trustworthy characters for distinguishing the species of this genus. A considerable number have been described, a large proportion of which are apparently synonyms of Della Valle's (1877) type species *C. dellechiajei* from the Mediterranean, which seems to be very widely distributed in warm regions, including parts of the American coasts.

Cystodytes dellechiajei (Della Valle), 1877

Plate 19, figure 2; text figure 62

Cystodytes dellechiaiae Van Name, 1921, p. 360, figs. 41, 42; 1930, p. 452, figs. 27, 28; Berrill, 1932, p. 78.

Cystodytes dellechiajei Michaelsen, 1915, p. 483; Harant, 1929, p. 41; Michaelsen, 1930, p. 501.

Cystodytes draschii Herdman, 1886, p. 137, pl. 19, figs. 1–15; Van Name, 1902, p. 347, pl. 49, fig. 17, pl. 58, figs. 99–101; Michaelsen, 1915, p. 484 (*draschei*); 1924, p. 286 (*draschei*).

Cystodytes violaceus Van Name, 1902, p. 348, pl. 48, figs. 12–14; Harant, 1925, p. 3.

Distoma dellechiajiae Della Valle, 1877, p. 40 (*fide* Herdman). Original work not seen; the spelling of the specific name usually adopted and followed here is an emended one, perhaps justifiably emended, as it should be masculine.

See Michaelsen, 1930, for other references.

Forms flat incrusting colonies which occasionally reach a thickness of about 5 mm. and measure 60 to 80 mm. across. The surface is usually fairly smooth but in thin colonies slightly raised over the positions of the zooids.

Systems are evidently usually present. Consistency of the test usually rather firm, due to a great abundance of bladder cells in the test in most parts of the colony.

Considerable dark pigment, blackish gray to quite black, or purple, contained in oval corpuscles is present in most specimens, often rendering them so opaque that the white calcareous capsules are not visible until the colony is sliced open, but they are then very

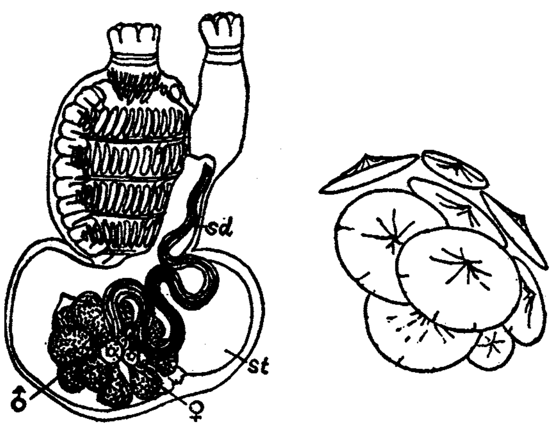


FIG. 62. *Cystodytes dellechiajei* (Della Valle). Zooid, ×32, and spicules, ×52.

conspicuous. In preserved material the pigment changes to brown and eventually fades out to some extent.

In this species the capsules are usually well formed and in a single layer rather close together a little way below the surface. The spicules composing them are shield shaped with a thin outer margin and usually range 0.3 to 0.8 mm. in diameter. The zooids conform to the description given under the genus.

DISTRIBUTION: This is apparently a species that ranges throughout a large part of the warm regions of the world. It has been described under a number of names which, however, do not appear to be based on any reliable distinctions (see Harant, 1929).

In American waters it occurs at Bermuda on the coral reefs and under stones along the shore, and in shallow water on the west coast of Florida. Although ascidians common to the Atlantic and Pacific coasts of America are few, this appears to be an exception. The American Museum of Natural History has specimens from several localities in the Gulf of California, in shallow water (Coronado Island, east end of La Paz, and Puerto Escondido) collected by E. F. Ricketts. They are well pigmented with blackish or dark brown pigment.

It seems to occur throughout a wide range of depths. The "Albatross" dredged it in the Gulf Stream off Key West in 98 fathoms, and at Station 2333, 23° 10′ 36″ N., 82° 19′ 12″ W., 169 fathoms, off Havana, and Herdman's type of *C. draschii*, which does not seem distinct, was obtained by the "Challenger" off Barra Grande, Brazil, in 400 fathoms.

Cystodytes antarcticus Sluiter, 1914

Cystodites antarcticus SLUITER, 1912, p. 459; 1914, p. 27.

? *Polycitor glareosus* SLUITER, 1906, p. 6, pl. 1, figs. 1–4.

Based on a single small, gelatinous, disklike colony 11 mm. in diameter and 4 mm. thick. Zooids arranged in one system with a central common cloacal aperture, enclosed in compartments composed of calcareous disks, 0.272 mm. in diameter, which can be seen through the transparent test. Test composed largely of bladder cells ("grandes cellules vésiculaires").

Mantle muscles of zooids weak; four rows of elongated stigmata; stomach spherical, smooth walled; gonads in and partly beside the intestinal loop.

LOCALITY: West Antarctic region. Collected by the second Charcot expedition near Peterman Island in 50 to 60 meters.

Sluiter states that this is the first *Cystodytes* described from the Antarctic; it is based on a specimen evidently very young and probably very far from showing the usual characters of an adult colony. See remarks under *Polycitor glareosus* (Sluiter), 1904, which may be a *Cystodytes*, and with which this species may be identical, the specific name *glareosus* having priority in that case.

Cystodytes lobatus (Ritter), 1900

Cystodites cretaceous RITTER, 1907, p. 39. (Apparently not *Cystodytes cretaceus* von Drasche, 1883.)

Distoma lobata RITTER, 1900, p. 606, pl. 20, figs. 31–33.

Eudistoma lobatum HARTMEYER, 1909–1911, p. 1432.

This species forms much thicker and more massive colonies than *C. dellechiajei*. Ritter, 1900, described the type colony of his *Distoma lobata* as "massive, the smaller ones rather regular, thick, cake-like, the larger ones very irregular and prominently lobulated." His figure shows several large rounded lobes projecting from the upper surface. In his article of 1907 he states, regarding which I believe to be the same species, that "there are a dozen colonies or perhaps pieces of the same colony, the largest of which is not less than 15 cm. across." I have also seen specimens of considerable size.

The texture of the colony is firm, due to the enormous abundance of bladder cells, but not tough or strong; the surface is usually smooth and clean, the test more or less clear and transparent, of a whitish or grayish shade without pigmentation.

Spicules are usually very few and in an imperfect state of development, often so completely wanting as to be overlooked entirely, as in Ritter's 1900 type which he consequently placed in "*Distoma*" (=*Polycitor*) instead of in this genus. If sufficient well-developed disks are present to form any capsules, they are present about only a few of the zooids, and usually incomplete even in those cases. There may be considerable calcareous deposits, amorphous or in the form of small but often well-formed crystals of elongate shape, or even these may be few and very minute. The zooids conform to the description under the genus *Cystodytes*.

This species may easily be mistaken for a *Eudistoma*, unless given microscopic examination.

DISTRIBUTION: Pacific coast from near Los Angeles northward to, and including, British Columbia.

Specimens I refer here were from near Long Beach, California (washed up on the shore), from the intertidal rocks at Pescadero Point, and other stations near Monterey Bay; Bolinas, Bodega Bay, and Dillon Beach, California; Puget Sound (Ritter's type specimen); and a colony of considerable size growing over and partly enclosing a cluster of living bivalve shells from Queen Charlotte Sound at the north end of Vancouver Island, British Columbia.

These specimens were probably all from shallow or rather shallow water, but Ritter, 1907, had examples which he identified with *C. cretaceus* von Drasche from "Albatross" Station 4463, off Pt. Pinos Light at the entrance to Monterey Bay, 41 to 111 fathoms; another received from the Hopkins Marine Station was obtained off Monterey Bay in 70 fathoms.

In spite of its resemblance to *C. cretaceus* von Drasche from the Adriatic (1883, "Die Synascidien der Bucht von Rovigna, Adria," Vienna), I am not inclined to accept Ritter's provisional identification of it with that form. In the first place, the present species is usually without or almost without spicules; second, it is widely separated geographically, with no connecting localities; third, it is a species of comparatively cold water only, as far as the records show.

GENUS **CLAVELINA** SAVIGNY, 1816

Zooids of large size for compound ascidians, adults usually 2 cm. or more long, with a stolon arising from the posterior part of the body from which the budding takes place.

The zooids may be separate for their whole length, of clavate form, each with its own covering of test and connected only by a basal stolon; or partly embedded, leaving the anterior part of the body free, or wholly embedded as in most compound ascidians, but no systems are formed.

Apertures on short tubes, both at the anterior end, plain or more or less lobed. Tentacles numerous, of several sizes, the smaller ones inserted nearer the aperture than the larger ones. Branchial sac very elongate with numerous rows of stigmata and stout transverse vessels which generally bear an internally projecting membrane on the aspect toward the interior of the sac.

Most of the attempts to subdivide the genus have been based on the degree of separation of the zooids, but this is a very superficial character and affords no satisfactory basis for division. The few species known from American waters are quite typical of the genus and much alike in internal characters, though they differ in the form of the stomach, which is smoothly ovate in the Atlantic forms but of angular cross section in the Pacific species.

Clavelina (?) concrescens Hartmeyer, 1924

Clavelina (?) concrescens HARTMEYER, 1924, p. 110.

Hartmeyer's description was based on a single narrowly club-shaped colony, 23 mm. in height, the upper part colorless and transparent, the basal part cartilaginous and opaque. It contained six zooids completely embedded in the test, into which they are deeply drawn back; they measured about 6 mm. in length in the contracted condition. Branchial opening obscurely lobed; atrial opening with two lips, each parted into three small lobes. The internal parts of the zooids were too poorly preserved for study.

LOCALITY: South entrance to Davis Strait, 63° 30′ N., 54° 25′ W., 1048 meters depth.

Clavelina oblonga Herdman, 1880

Plate 16, figure 6; text figures 63 (left), 64

? *Ascidia claviformis* LESUEUR, 1823, p. 5, pl. 1, fig. 3.

Chondrostachys oblonga HARTMEYER, 1909–1911, p. 1427; 1912b, p. 295.

Clavelina oblonga HERDMAN, 1880, p. 724; 1882, p. 246, pl. 35, figs. 6–10; VERRILL, 1900, p. 588; VAN NAME, 1902, p. 334, pl. 46, fig. 1, pl. 47, fig. 7, pl. 52, fig. 130a; PRATT, 1916, p. 668; VAN NAME, 1921, p. 354 (in part), fig. 38; 1930 (in part), p. 450, figs. 25 (left-hand part), 26; BERRILL, 1932, pp. 78, 85, fig. 4a–4c; 1935, pt. 3, p. 285; PRATT, 1935, p. 744.

Stereoclavella oblonga HERDMAN, 1891, p. 604; 1891a, p. 161; 1899, p. 8.

This species was confused with *C. picta* described below, in my articles of 1921 and 1930, but as shown by Berrill, 1932, it is undoubtedly distinct.

Individual animals club shaped, the anterior end rounded, the body tapering gradually into the very short stalk. The colony consists of a number of such individuals quite closely grouped together, united by the expanded bases of the stalks.

The total length of the largest individuals (including the short stalk) is about 30 mm. Removed from the test the zooid ordinarily measures less than half this length, but large ones fully expanded measure about 20 mm. in length.

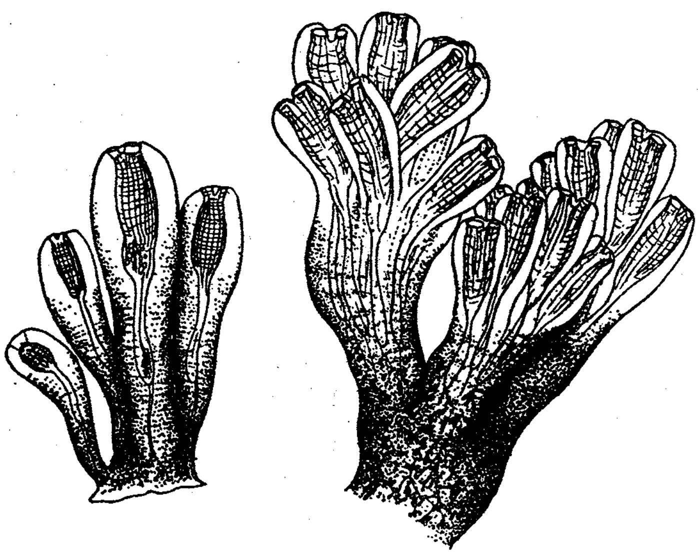


FIG. 63. Left figure, *Clavelina oblonga* Herdman. Small colony, ×1.8. Right figure, *Clavelina picta* (Verrill). Several lobes of a large colony, ×1.8. In both figures the zooids are represented with the branchial sac expanded.

The test is thick but perfectly transparent and colorless; the lower part may be slightly incrusted with fine sand. It is gelatinous in consistency, firmer near the base. The zooids themselves are nearly colorless. The stomach and intestine in life are brownish. There are often spots of very pure opaque white on the thorax and always about the edges of the orifices.

The musculature of the mantle consists of a rather small number of slender bands, most distinct on the thorax, which are crossed by delicate transverse muscles placed close together. These form an almost continuous but very thin layer about the thorax, but the longitudinal muscles are much the stronger and the animals contract greatly in length in preservation. The thorax contracts more than the abdomen. In life, when the animal is expanded, the branchial sac is fully half the length of the body.

There are 15 or more rows of stigmata, and sometimes 50 in a row. The stigmata begin close beside the dorsal lamina. About 20 tentacles comprising two sizes placed alternately with some regularity were counted in zooids examined; additional small tentacles inserted anterior to the main circle may sometimes be demonstrated. The dorsal tubercle is oval, with an oval (longitudinally elongate) aperture. The vessels of the branchial sac bear a conspicuous membrane attached along the inner aspect; these membranes are continuous at the dorsal lamina with the triangular dorsal languets. The stomach is quite elongate oval, smooth walled except for a single longitudinal typhlosole. The intestinal loop extends considerably beyond the stomach, and the gonads lie beside that part of the loop. The ovary, when small, is mostly posterior to the stomach; the large mass of small pear-shaped testes extends farther back, nearly to, or sometimes even beyond, the end of the loop. Both the oviduct and sperm duct accompany the rectum. Developing eggs and larvae are often present in numbers in the atrial cavity.

The following statements of Berrill, who studied the species at Bermuda, are of interest and should be compared with those he gives concerning *C. picta,* which I quote under that species.

"Number of zoöids rarely exceeds 40, usually much less. They are attached to a basal stolon, but otherwise are separated from one another. Budding occurs throughout breeding season so that zoöids of all sizes are to be found.

"*Clavelina oblonga* usually occurs in groups of two or three during May and increases in number throughout the breeding season until about forty zoöids of various size may be found in one colony. This was found to be the case in both 1930 and 1931, and the implication is that the oozoöid forms a few winter statoblasts which regenerate and give rise to the type of colony just described during the following spring, while such a colony dies off at the end of the summer, failing to form a second generation of statoblasts. That is, the life-cycle is completed within 18 months" (Berrill, 1932).

DISTRIBUTION: Bermuda is the type locality of this species, where it was dredged in shallow water by the "Challenger" expedition and where I have myself collected small colonies attached to the under side of stones near low-water mark. It occurs also on the Florida coasts, including the Dry Tortugas, in the West Indies (recorded from St. Thomas and other points by Herdman, 1912b), and

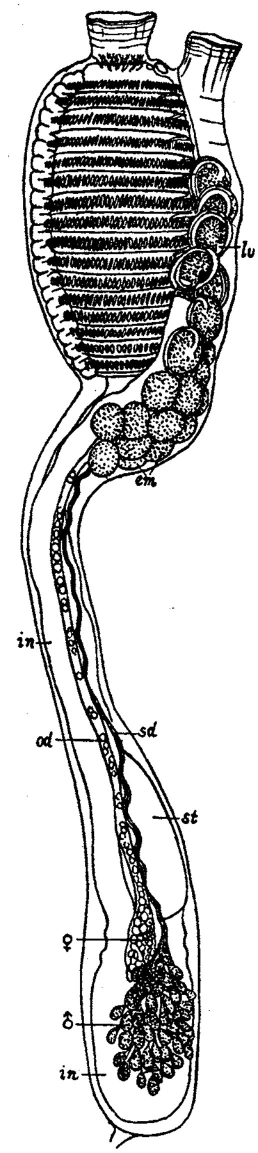


FIG. 64. *Clavelina oblonga* Herdman. Zooid, ×10.5. Branchial sac considerably contracted.

in southern Brazil (specimen in the American Museum of Natural History from São Sebastião Island, State of São Paulo, although Hartmeyer's Brazilian record seems to have been of *C. picta*, not this species). Hartmeyer, 1912b, considered that *Ascidia claviformis* Lesueur, 1823, from St. Vincent, West Indies, is this species. Of this I do not feel sure, as Lesueur's form may be an *Ecteinascidia*, a genus also found in the West Indies. Hartmeyer, 1912b, also refers to *C. oblonga* colonies from the Cape Verde Islands in the Berlin Museum. Several quite similar forms have been described from other warmer parts of the Old World.

Clavelina picta (Verrill), 1900

Plate 17; text figure 63 (part)

? *Aplidium crassum* HERDMAN, 1886, p. 207, pl. 25, figs. 15, 16.

Chondrostachys picta HARTMEYER, 1909–1911, p. 1427; 1912b, p. 295.

Clavelina oblonga VAN NAME, 1921, p. 354 (in part), fig. 39; 1930, p. 450 (in part), fig. 24 (left-hand part), fig. 25 (right-hand part), pl. 5.

Clavelina picta BERRILL, 1932, pp. 78, 83, fig. 4d–4f; 1935, pt. 3, pp. 257, 285, fig. 14h–14j, pt. 4, p. 352, figs. 13, 20; PLOUGH AND JONES, 1937, p. 100; BERRILL, 1937, p. 566.

Diazona picta VERRILL, 1900, p. 591, pl. 70, fig. 8.

Rhodozona picta VAN NAME, 1902, p. 335, pl. 46, fig. 3, pl. 47, fig. 5, pl. 60, fig. 122; SEELIGER, 1907, p. 1208.

Stereoclavella sp. HARTMEYER, 1908, p. 111.

See also remarks under *Clavelina gigantea.*

I know of no structural characters by which the zooids of this species can be differentiated from those of *C. oblonga*, just described, and no repetition of that description seems to be needed, but its colony formation and colors when alive are very different.

The zooids in the partially contracted condition found in preserved material are usually not longer than 15 to 18 mm. The colonies become large and may form masses a foot or more in diameter, which must sometimes contain upward of 1000 zooids. The basal fleshy mass extends out into lobes and short thick branches which also divide, ending in groups of zooids usually including from six to a dozen or more parallel-placed or slightly diverging individuals which are commonly of about equal size and age. The basal part of the zooid is contained in the common test of the lobe, which is also penetrated by the branching vascular processes (stolons) from the abdomens of the zooids, but more or less of the anterior (thoracic) part of the zooids projects out and is enclosed by its own covering of transparent test. In young colonies and those in their state of seasonal regression, the zooids are entirely and deeply embedded in rounded or capitate lobes of test, as in ordinary compound ascidians. That condition, with the zooids in a state of more or less atrophy, especially of the thoracic part, is usual in colonies collected in the fall and winter months.

Berrill, 1932, 1935 (pt. 4), has devoted some study to the colony formation of this species at Bermuda. He states that "winter statoblasts are formed after the breeding season and apparently at no other time. The oozoöid apparently forms about ten such bodies. These segments grow and become sexually mature during the winter and spring. They carry on these processes close together within the test of the oozoöid and so remain within a common test. During the late summer these processes are repeated, resulting in the formation of a colony the following year composed of about ten corms each containing ten or more zooids. This may be repeated a third year to form massive colonies. . . . During maturity the anterior parts of the zooids extend from the common test . . . they contract and degenerate after the breeding season, while the thoracic extensions of the test are sloughed off." Berrill gives the diameter of the egg as 0.49 mm. and the total length of the tadpole as 3.30 mm. He says that the "tadpole and young oozoöid have from the first, four rows of definite stigmata. All other species of *Clavelina* have but two" (Berrill, 1932. Cf. these statements with his corresponding observations on *C. oblonga*, under that species).

In contrast with *C. oblonga*, whose test and tissues are mostly clear and unpigmented, this species has the test slightly cloudy. In preservation the zooids usually appear dull pinkish, becoming more yellowish after long keeping in alcohol. Their color in life is thus described by Berrill, 1932:

"Test unpigmented but slightly opaque. Endostyle, dorsal lamina, and peripharyngeal bands densely colored with purple or carmine cells. They also extend throughout the abdomen and then accumulate in the ends of the test vessels. They appear in the late embryo in such places, and the oozoöid is as highly colored as the blastozoids."

I can confirm the correctness of this description, but feel that I should not omit to mention the wonderful beauty of well-developed colonies of this species, especially when expanded. The large size they attain, their delicate structure, transparency, and elegant coloration make it one of the most beautiful members of the varied marine life of the West Indian region.

DISTRIBUTION: The former confusion of this species and *C. oblonga* makes difficulties in the determination of the distribution, but specimens or records on which we can rely with certainty indicate for *C. picta* a range from Bermuda, the type locality, in whose clear waters very beautiful colonies are found, and South Carolina (Blackfish Banks off Charleston), to both Florida coasts, especially in the west coast including the Tortugas, and the West Indies (the American Museum has specimens from the south coast of Puerto Rico) and southern Brazil (Hartmeyer, 1912b; also specimens in the American Museum of Natural History from São Sebastião, State of São Paulo).

It grows attached to gorgonians, corals, etc., apparently always in water where it is constantly covered at least a few feet deep, perferably where there is some current. Twenty-eight fathoms off the west coast of Florida appears to be the maximum recorded depth.

I am strongly inclined to believe that the species described as *Aplidium crassum* by Herdman (1886, p. 207, pl. 35, figs. 15, 16) from a single specimen collected by the "Challenger" at Bahia, Brazil, in shallow water, maybe based on a colony of the present species in a state of partial regression. I can find little in his description (see p. 445 of this work) to indicate that it is an *Aplidium* or a member of that family. But even if the correctness of my suspicions should sometime be confirmed by a reëxamination of the type, I do not think that the name *picta* should be invalidated on the basis of a description so misleading.

C. australis Herdman, 1891 (see Herdman, 1899, p. 6, pl. 1), from Australia, probably also found in the East Indian region, is a form very closely allied to *C. picta*.

Clavelina gigantea Van Name, 1921

Plate 14, figure 1, plate 16, figure 4; text figure 65

Clavelina gigantea VAN NAME, 1921, p. 358, fig. 40 (in part, not *Polycitor gigantea* Sluiter, 1919); ÄRNBÄCK, 1925, p. 18.

Clavelina oblonga VAN NAME, 1930, p. 450 (in part), fig. 24 (right-hand part of figure).

The United States National Museum and the American Museum have a considerable number of specimens of a *Clavelina* forming

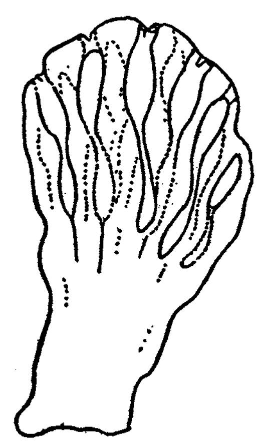


FIG. 65. *Clavelina gigantea* Van Name. Vertical section through a colony, natural size.

massive colonies, irregularly spherical, pear shaped or capitate, which may be attached directly by a narrow base or raised on a short thick peduncle. The zooids are, at least as far as I have seen, completely embedded in the test as in ordinary compound ascidians. The surface of the colony varies from smooth to quite deeply pitted over the positions of the zooids; this is probably due to the contraction of the latter in preservation and would not be observed in living material. In many cases the colony consists of two or three such lobes or heads connected at the base.

The test in the preserved specimens is rather hard and cartilaginous, opaque, and in fresh examples of a blackish color like that of *Ascidia nigra*. In a few of the colonies, preserved in alcohol for many years, the test is chocolate brown; in many of them it is unpigmented and of a yellowish color, but whether or not this is due to fading I do not know.

The larger colonies, or the heads if a colony is cleft into more than one lobe, may not infrequently reach 50 mm. in height and a diameter in the upper wider part of 30 to 35 mm., but they may very considerably exceed these dimensions.

The zooids are not arranged in systems and in many specimens have a length of about 25 mm. even in the preserved and somewhat contracted condition. Their anterior ends are usually separated by considerable test substance; their abdominal ends, extending down into the narrower lower part of the colony, are close together. The test substance immediately enclosing the abdominal part of the zooids is harder and forms a sort of sheath.

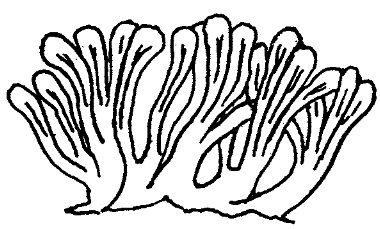


FIG. 66. *Clavelina fasciculata*, new species. Part of a large colony, natural size.

I know of no structural characters by which the zooids can be distinguished from those of *C. oblonga* and *picta*, but (no doubt on account of their large size) the stigmata may be very numerous, reaching 70 or more in a row on each side, and the number of the small testes may also be very great.

DISTRIBUTION: The specimens here referred to this species were all obtained in the Gulf of Mexico at stations off the west coast of Florida, from the vicinity of Cedar Keys to that of Key West, except one from off the southern coast of Yucatan. It is especially common in the vicinity of Tarpon Springs, Florida. The depths, where given, range from 2 to 28 fathoms; the bottom was sandy with some coral rock in a majority of cases where it was recorded. It is sometimes washed up on the beaches by storms.

As indicated in the synonyms given above, I united this species with *C. oblonga* and *C. picta* in my article of 1930. It is certainly not identical with either one, but is more closely related to *C. picta*, whose zooids in immature colonies, or during post-breeding resting stages, may also be entirely buried in the test.

However, this is a larger form with larger zooids and a firmer, more cartilaginous test, whose colonies are more massive and have much less tendency to divide up into small lobes. As stated above, I have not observed a tendency of the anterior part of the zooids to project out above the general surface, and I have found the branchial sacs in perfect condition and evidently fully functional in the fully embedded zooids.

With Sluiter's (1919) *Polycitor gigantea*, with which I at first believed this species to be identical, it has nothing to do, as Sluiter's form has been proved by the re-investigation of Ärnbäck, 1925, to be a *Diazona*.

As a type for this species is lacking, I designate a specimen received from the United States National Museum from off Cape Sable, Florida, collected by J. F. Moser in February, 1887 (A.M.N.H. No. 614).

Clavelina fasciculata, new species
Text figure 66

The few specimens of *Clavelina* from the Gulf of California which I have seen appear to belong to a species allied to *C. huntsmani*, having zooids of the same structure as in that species (including the four-ridged stomach), but differing in the character of the colony and in having smaller zooids. The zooids have their own covering of test for the whole or almost their whole length, each zooid forming a club-shaped lobe much like those of *C. huntsmani* but smaller, the lobes commonly measuring only 18 to 22 mm. long; and the zooids themselves contained in them, only 12 to 14 mm. long in the contracted preserved condition. The individuals are usually united in small groups of from three or four to a dozen zooids which are borne on a basal plexus of thick, branching, fleshy stolons. The zooids in a group, even though usually united only by the part of the test posterior to the end of the abdomen, may be compactly crowded, and the groups also compactly aggregated into an extensive colony often some centimeters across.

In the only large colony available, the

zooids appear to be fairly uniform in size and age, but a few of the lobes are composed of smaller, more intimately united and perhaps younger zooids.

The test is only moderately transparent; the tissues of the zooids are of a dull pinkish tint in the preserved condition. No color notes on living specimens appear to have been made by the collector.

DISTRIBUTION: The Gulf of California. I have examined colonies from only two localities, east of La Paz, where it was common (large colony, the type, A.M.N.H. No. 1725, and a small irregular colony from El Mogote. Both were collected by E. F. Ricketts in March, 1940, in shallow water (dead coral clusters on tidal flats). Ricketts' notes mention taking specimens apparently identical with those from La Paz at Concepcion Bay on submerged rocks and Pinna shells; and also collecting a "semi-compound" truncate possibly also this species, at Puerto Escondido. The localities are, according to Ricketts, more protected, and exposed to more feeble wave action and currents than those where *C. huntsmani* commonly occurs.

Clavelina huntsmani Van Name, 1931

Plate 30, figure 2; text figure 67

Clavelina sp. HUNTSMAN, 1912, p. 115; 1913a, pp. 440–450; 1913b, pp. 455–459.

Clavelina huntsmani VAN NAME, 1931, p. 208, fig. 1; RICKETTS AND CALVIN, 1939, p. 77, fig. 32.

The colonies consist of compact clusters of club-shaped zooids which, except while very young, are entirely distinct from each other. Each has its own separate covering of test for its whole length, often including also a short basal peduncular part into which the body of the zooid itself does not extend. At their base they join in an irregular mass of test which serves to attach the posterior ends of the zooids. Many of the branches of the stolons end in small, club-shaped enlargements.

The colonies are often of large extent, composed of hundreds of adult individuals, besides, at some seasons, a varying number of young ones, and are very beautiful objects, especially when the zooids are expanded. The test is colorless and quite transparent near the free ends of the zooids, becoming whitish and more opaque basally. Zooids in a healthy condition are usually quite free from attached material or other organisms, though I have found the small, transparent, compound ascidian *Diplosoma pizoni* growing on them.

Living colonies from Pacific Grove, California, had the bodies of the zooids, as seen through the test, yellowish with the branchial sac and gonads orange, the stomach and intestine appearing brown from ingested food. Two narrow sharply defined lines of carmine pink pigment mark the course of the median dorsal vessel and the endostyle, respectively, giving the colony a very handsome appearance. These pink lines retain their color in alcohol for some time. In one lot of preserved specimens there is much pink pigment scattered in small dots in the mantle over the stomach and along the course of the oesophagus.

The adult zooids measure up to 35 or sometimes 40 mm. in length, with a transverse diameter of 8 to 9 mm. near the anterior end where they are widest. These are the external dimensions of the test. In contracted preserved specimens, the body of the zooid is considerably shortened, and its anterior end is drawn back a little way. Undersized zooids in a colony are often merely individuals stunted or suppressed by crowding, not young ones. Young zooids bud off obliquely from the stolons near the bases of older ones and quickly begin to acquire their separate test on the anterior part of the body. Though a few zooids may remain for a time united in groups by the basal part, the usual completely separated condition is soon attained.

The thorax of the zooid after removal from the test is of oval outline when contracted but elongate and barrel shaped in expansion, and bears the very short tubular siphons at the anterior end. The orifices are smoothly rounded with no indication of lobes. Except the sphincters of the tubes, the muscles are mainly longitudinal. The abdomen is elongate oval, tapering anteriorly into the long constricted neck by which it is joined to the thorax. The normal number of tentacles is apparently 32 (4-4-16) comprising three or four orders distributed with considerable regularity according to the usual scheme (1-3-2-3-1-3-2, etc.). As usual in this family, the smaller tentacles are inserted a little nearer the distal end of the branchial tube than the larger ones. The dorsal tubercle is longitudinally elongate oval, with an orifice of similar form. There are from 16 to 20 rows of stigmata with a large number (often about 40) in a row on each side. The transverse vessels each bear an internally projecting membrane attached throughout the length of the vessel. This membrane is continuous at the median dorsal vessel with one of the series of acute triangular languets borne on the latter.

The stomach is rather elongate oblong and is four-sided in cross section, each angle being marked by a prominent ridge on the exterior. One of these ridges is double, consisting really of two ridges separated by a longitudinal furrow which forms an internally projecting ridge or typhlosole (that is itself furrowed along its free, inwardly projecting margin). The intestinal loop extends some distance beyond the stomach.

The reproductive organs consist of a saccular ovary containing many small eggs situated in the intestinal loop and a very large number (often several hundred) of small male glands, pear shaped or elongate, or sometimes cleft into two or more lobes, spread over the surface of the intestinal loop, especially on the left side of the body, but extending through and around the loop onto the right side to some extent. The common sperm duct, formed by the union of the numerous ducts

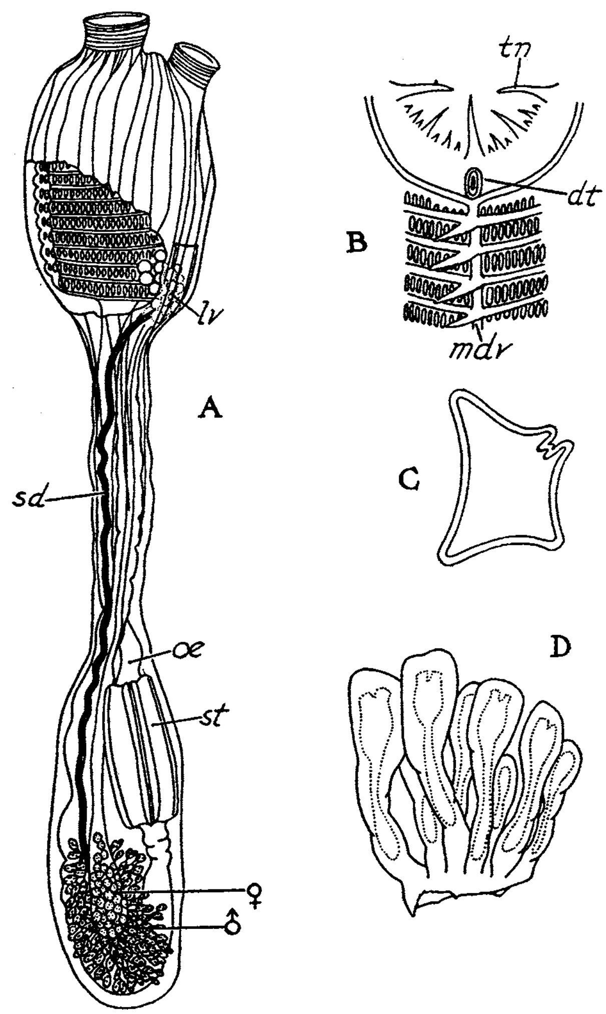


FIG. 67. *Clavelina huntsmani* Van Name. A. Zooid, ×6. B. Anterior pharyngeal region (seen from inside branchial sac). C. Cross section of stomach. D. Cluster of individuals, nearly natural size.

from the testes, and the oviduct, which is of rather large diameter, both accompany the ascending branch of the intestine. In some individuals the atrial cavity contains numerous developing eggs or young larvae, which evidently pass through their early stages in that location. Egg diameter 0.26 mm., according to Berrill, 1937. Body length of the larvae, about 0.42 mm. (Van Name, 1931).

DISTRIBUTION: It has been reported from Barkley Sound, British Columbia (in quantity on rocks at low tide and dredged in 5 to 10 fathoms, Huntsman) to the vicinity of Monterey Bay, California, where it occurs on the intertidal rocks in considerable abundance, often where exposed to fairly strong surf, and is one of the most conspicuous ascidians, and at Santa Cruz Island, where it was collected by W. G. Hewatt.

Huntsman, 1913a, 1913b, published observations on the development of this species, though using only its generic name.

GENUS **HOLOZOA** LESSON, 1830

As far as the structure of the zooids is concerned, this genus differes little from *Distaplia* (see below), although the brood pouches are said not to contain more than one egg or embryo instead of several or many. Parastigmatic transverse vessels are present in the branchial sac as in *Distaplia*. The extraordinary elongate form of the colony and its peculiar life history, which usually, at least, includes a free-swimming stage, may perhaps justify maintaining the two genera distinct. If the two genera are united, the name *Holozoa* has priority, but *Distaplia* has been accepted as a *nomen conservandum*.

Holozoa cylindrica Lesson, 1830

Distaplia cylindrica MICHAELSEN, 1924, p. 318, fig. 11.

Distaplia ignota HERDMAN, 1902, p. 197, pl. 20, figs. 7–9.

—(?) *ignotus* HERDMAN, 1886, p. 251, pl. 28, figs. 14, 15.

Holozoa cylindrica LESSON, 1830a, p. 439; HARTMEYER, 1911b, p. 474, pl. 46, figs. 6, 8, 10, pl. 53, figs. 6–17; HERDMAN, 1912, p. 97, pl. 4, fig. 2; SLUITER, 1914, p. 28.

Julinia australis CALMAN, 1894, p. 1, pls. 1–3.

Julinia ignota SLUITER, 1906, p. 8, pl. 1, figs. 5–7, pl. 5, fig. 55; MICHAELSEN, 1907, p. 40.

Young colonies of this species are of clavate form, comprising only a single system with a common cloacal aperture at the summit of the head. As the colony grows older, the stalk or basal part (which is devoid of zooids and expanded at its lower end for attachment) remains comparatively short, but the capitate part elongates sometimes to an enormous extent, acquiring a narrow, cylindrical form bearing small oval systems each of about six to a dozen zooids having a common cloacal aperture in the middle of the group. Colonies attain a length of 5 meters or more. Hartmeyer records one of 178 cm. long of which the peduncle constituted 10 cm., but he rejects as improbable a report of one 43 meters (!) long (see Sluiter, 1914, p. 29). Even the largest colonies remain slender and flexible, usually not exceeding 1 to 3 cm. in transverse diameter. The color in preservation is milky white to yellowish white; it is said to be so also in living ones.

Though this species grows attached to stones in water of moderate depths, the specimens commonly obtained are colonies or fragments of colonies that had broken loose and were floating near the surface, though they live for a time under such conditions. One was observed by Lesson to move with slow undulations of the colony. The zooids in unattached colonies are usually in poor condition for study.

The structure of the zooids was carefully studied by Hartmeyer (1911b) who had unusually good material available. They consist of thorax and abdomen connected by a short neck and measure from less than 1 to 3 mm. long, exclusive of vascular processes extending from their posterior ends. They have an atrial languet, sometimes of considerable length, usually 12 tentacles comprising two sizes placed alternately; four rows of stigmata with a maximum of about 30 in a row on each side, those of each row crossed by a parastigmatic vessel as usual in the genus *Distaplia*. The intestinal loop is simple; the ovate stomach has somewhat irregular longitudinal ridges or plications internally but is smooth externally. The zooids and the colonies as a whole are either male or female; the ovary or the group of pyriform testes is situated beside the intestinal loop. A brood pouch similar to that of *Distaplia* is developed but contains only one egg or developing larva.

DISTRIBUTION: Recorded from the Strait of Magellan and South Georgia; in the west Antarctic from Port Charcot (25 to 40 meters), Booth Wandel and Hoogaard Islands and the Bay of Flanders. The United States National Museum has fragments dredged in Neny Fjord, Palmer Land. In the east Antarctic the records are from Kaiser Wilhelm II Land (46 to 385 meters), Cape Adare, 38 to 43 meters, and north of Erebus and Terror Gulf.

GENUS DISTAPLIA DELLA VALLE, 1881
Nomen Conservandum

This is one of several genera (including *Holozoa* and *Sycozoa*) in which the embryos develop in a large incubatory pouch extending out from the dorsal side of the body of the parent instead of in the peribranchial cavity.

This structure is not present in all zooids, and in many colonies none will be found on any of them, as it apparently develops only when needed to receive the embryos. It is an elongate, curved, tapering evagination of the wall of the right posterior dorsal part of the peribranchial cavity connected with the body of the zooid by a neck which seems too narrow to allow the larvae to pass out through it when they have attained their growth, and they must escape by bursting its walls and the surrounding test. Often pouches with their contents of developing young are found in the common test unattached to any zooid, having broken away from the zooid generating them, which may have died and been absorbed.

The embryos, which may number up to about 12 or even more in some species, lie in the pouch in a single series according to age, the youngest, not the oldest, as might be expected, being at the distal end of the pouch. The oviduct, a thin-walled tube, extends forward from the ovary and enters the pouch, in which it may be clearly traced to the distal end of the latter in favorable material. But I believe that this is not the end of the oviduct, and that it really loops back again to the proximal end of the pouch, the series of embryos being actually contained in and developing in the returning branch of the oviduct, being thus enclosed a double wall, consisting of the distal part of the oviduct and the outer enclosing wall of the pouch (a part of the body wall), though these two structures may later coalesce, or perhaps in still later stages the oviduct wall may be absorbed, so that it is not possible to demonstrate it.

Distaplia forms colonies of very variable shape, ranging from capitate to flat and incrusting, in the latter case usually rather thick. The test is of soft consistency in the upper parts, tougher in the basal portion; the zooids, which have the thorax and abdomen connected by a rather short neck and have at least at certain stages a long vascular appendage, extending down from the rear end of the body, are arranged in systems, which are sometimes quite extensive.

The zooids are very uniform in the majority of their characters throughout the genus and may be described here to avoid repetition under the species.

Branchial aperture lobed (normally six-lobed) or merely irregularly sinuate, atrial aperture large, not lobed, its anterior margin extended into a large tapering languet. Sphincters and mantle musculature very weak, consisting of slender, widely spaced bands, those on the thorax mostly more or less oblique in direction. In consequence the zooids are often but little contracted in preserved specimens and afford beautiful objects for study. Usual number of tentacles apparently 16, alternating in size. Dorsal lamina represented by languets, three in number, arising very slightly to the left side of the median dorsal vessel.

Branchial sac with four rows of stigmata, each row crossed at its middle by a slender parastigmatic transverse vessel.

Stomach of characteristic ovate form, smaller toward the pyloric end, smooth walled or with ridges too slight to affect much its even contour. Intestinal loop not twisted; in consequence the gonads lie on the right side of the body, though in some species they are more or less removed posteriorly. In this genus the tubular glandular organ surrounding the ascending branch of the intestine is quite conspicuous, and the duct leading from it to the stomach may or may not be expanded into a small vesicle (see fig. 71). Whether this is the case or not is, in my opinion, dependent on the functional activity of the organ and is not reliable as a taxonomic character.

The zooids are hermaphroditic; the ovary has, as already described, a long oviduct leading into the incubatory pouch; the group of small pyriform testes has a common duct accompanying the intestine.

Even if incubatory pouches do not happen to be developed, the parastigmatic vessels in the branchial sac, the ovate stomach narrowing toward the pyloric end, and the weak mantle musculature are aids in recognizing colonies of this genus. Its members often have bright and varied coloration during life.

Distaplia clavata (Sars), 1851

Text figures 68, 69

Distaplia clavata HUITFELD-KAAS, 1896, p. 10, pl. 1, fig. 3; HARTMEYER, 1903, p. 313, pl. 6, fig. 4, pl. 11, fig. 21; 1904, p. 92; BJERKAN, 1905, p. 16, pl. 3, figs. 1–3; 1908a, p. 87; REDIKORZEV, 1908, p. 33; HARTMEYER, 1924, p. 121; BERRILL, 1935, pt. 3, p. 286; 1937, p. 566 (*D. clava*).

Holozoa clavata HARTMEYER, 1909–1911, p. 1437; VAN NAME, 1910, p. 366, figs. 6, 7; BRÉMENT, 1911, p. 34, figs. 1–2; HUNTSMAN, 1912, pp. 112, 138.

Leptoclinum clavatum SARS, 1851, p. 154; 1859, p. 66.

Typical form of the colony clavate or narrowly capitate; sometimes there may be more than one head arising from a common expanded base; including the rather short pe-

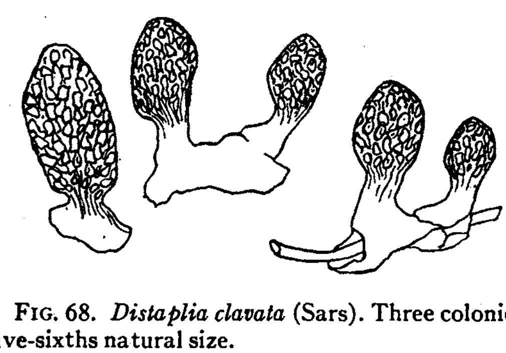


FIG. 68. *Distaplia clavata* (Sars). Three colonies, five-sixths natural size.

duncle, it is usually not over 2 to 3 cm. high. Young colonies are simple, small, rounded masses attached by a narrow base. Flattened incrusting forms also occur. Huntsman, 1912, reported that out of a number of colonies collected in the St. Andrews, New Brunswick, region none showed even an approximation to the capitate form. Preserved specimens are generally whitish or yellowish, the peduncle whiter; Huntsman, who, as far as I am aware, has given the only report on the color of living colonies, describes them as light yellow.

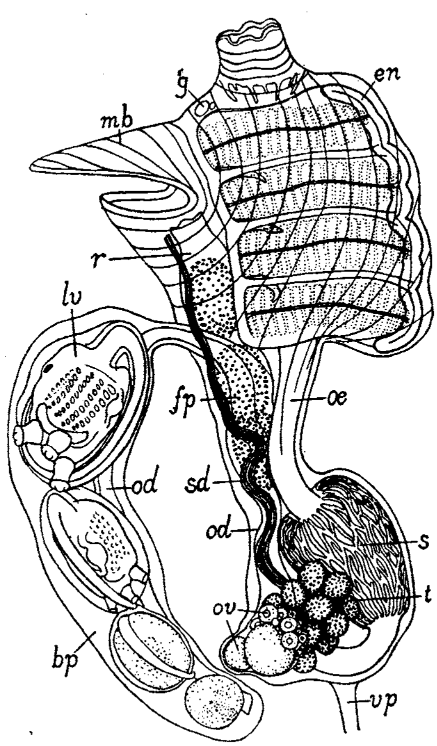


FIG. 69. *Distaplia clavata* (Sars). Zooid, ×25, with incubatory pouch.

The zooids conform to the description given under the genus. They are rather large, reaching 5 mm. or even more in length when well expanded, but in preserved material oftener only 4 mm. or less.

There are about 18 stigmata in the rows on each side of the branchial sac. The ovate stomach has a thin wall with not very conspicuous ridges, the prevailing course of which is longitudinal, but they always exhibit more or less irregularity and in some individuals curve and anastomose to such an extent as to form a network. In some individuals the ridges are so slight as easily to escape notice, or the stomach walls may be actually smooth.

The brood pouch may be very long, exceeding the body of the zooid in length and containing up to a dozen embryos, but oftener only from three to six, its length being dependent on the number of embryos.

DISTRIBUTION: In the Old World it is mainly an Arctic species occurring on or near the coasts of northern Norway, Spitzbergen, Iceland, and the east and west coasts of Greenland. On the American side it ranges very much farther south, occurring on the

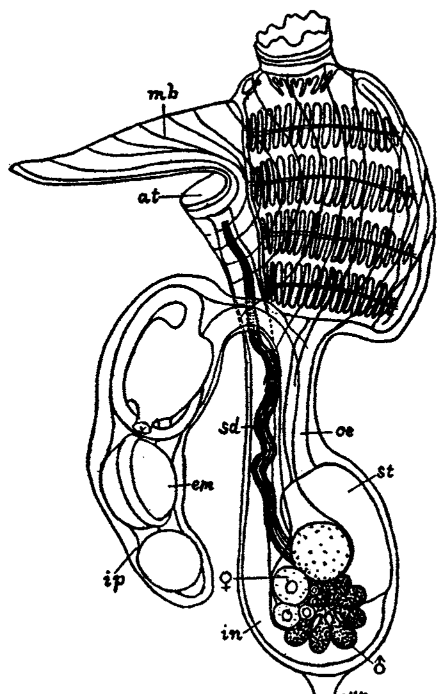


FIG. 70. *Distaplia bermudensis* Van Name. Zooid, ×30, with incubatory pouch.

Banks of Newfoundland about Eastport, Maine, and mouth of the Bay of Fundy, where it is common, south, though rarely, to Massachusetts (one poor and perhaps doubtful specimen off Salem, 22 fathoms, and one from off Chatham, at the southeast angle of Cape Cod, 41° 35′ 30″ N., 69° 35′ 30″ W., 34½ fathoms). I do not rely on a specimen reported to have come from Providence Harbor, Rhode Island; in that latitude it would occur, if at all, only in deeper water off shore.

Distaplia bermudensis Van Name, 1902

Plate 16, figure 2; text figure 70

? *Cellulophana collectrix* O. SCHMIDT, 1870, p. 25.

Distaplia bermudensis VAN NAME, 1902, p. 349, pl. 49, figs. 15, 18, 19, pl. 59, figs. 108, 111, pl. 62, fig. 130b; CAULLERY, 1909, p. 45; VAN NAME, 1930, p. 454, figs. 29, 30; BERRILL, 1932, p. 78; 1935, pt. 3, p. 286, pt. 4, p. 343; 1937, p. 566; PLOUGH AND JONES, 1937, p. 100.

Holozoa bermudensis HARTMEYER, 1909–1911, pp. 1437, 1633; 1911b, p. 486; VAN NAME, 1921, p. 363, fig. 43; 1924, p. 27; SALFI, 1927, pp. 286, 287, 290.

Form of colony very variable, sometimes capitate, consisting of one or more heads, usually somewhat flattened on top with rather abrupt sides tapering into a short peduncle; in other cases it forms a flat incrusting sheet, commonly 4 or 5 mm. thick and often several centimeters across. The colony may, however, have any of an infinite variety of intermediate forms. The heads in the capitate colonies may reach a diameter of 20 mm. or more. They are rarely of very symmetrical form. Colors of the colonies as variable as their shape, often very brilliant during life, but usually fading to green, blue green, yellowish, or olive tint in preserved material, though some alcoholic specimens are reddish or pink, or are mottled or marbled with areas of greenish or blue green and red or pink. As a rule, the basal parts of the colony are pale, the upper portions darker, sometimes shading into blackish. The colors of living specimens are much more varied and beautiful, often chocolate brown, shading into a marbled with olive, violet, purple, black, rose color, or even an intense orange red; any one of these colors may predominate. White pigment is often present about the orifices. These colors are chiefly due to oval pigment cells in the test.

Test translucent or semi-transparent; surface of the colony not shiny. Zooids arranged in systems, sometimes composed of but few zooids, in other cases extensive and complex. Vascular processes, straight and unbranched, extending down from the posterior ends of the zooids, are often conspicuous in the basal parts of the colonies.

Expanded zooids may measure over 3 mm.

long and 1.3 mm. across the thorax, even in preserved material. They conform in structure to the description given under the genus *Distaplia*.

There are about 18 or 19 stigmata in a row on each side of the branchial sac. The stomach is elongate-oval, tapering toward the pyloric end. In all of many zooids from different colonies and localities, its walls were found to be smooth within and without, except for a minutely granular roughness, visible on considerable magnification, and for a single, internal, longitudinal ridge or typhlosole. Stomach and proximal part of intestine orange or yellow during life.

The brood pouch is of curved tapering form, but usually not of great length, generally containing about three embryos or larvae in the colonies studied. Egg diameter about 0.40 mm., according to Berrill, 1937.

DISTRIBUTION: Common and widely distributed in the West Indian region, including Bermuda (type locality), Puerto Rico, St. Thomas, Curaçao, also Florida, both coasts. I have seen one small specimen from Beaufort, North Carolina. There is one record from the southern part of the South Carolina coast in 15 fathoms, and a poor and perhaps doubtful specimen from 27 fathoms off the west coast of Florida, but in general it lives in very shallow water on stones, piles, other ascidians, etc., where its bright and very varied colors make it a conspicuous form.

Distaplia stylifera (Kowalevsky), 1874

Text figure 71

Didemnium styliferum KOWALEVSKY, 1874, p. 443, pl. 30, figs. 1–16.

Distaplia bursata VAN NAME, 1930, p. 456, fig. 31.

Distaplia magnilarva SEELIGER, 1907 (not Della Valle, 1881), p. 1018.

Distaplia micropnoa HARTMEYER, 1919, p. 130.

Distaplia stylifera HARTMEYER, 1919, p. 135; MICHAELSEN, 1930, p. 502.

Holozoa bursata VAN NAME, 1921, p. 366, figs. 44–47; SALFI, 1927, p. 288.

Polyclinum micropnous SLUITER, 1909, p. 94, pl. 5, fig. 1.

Though I am adopting here the view of Michaelsen, 1930, that *D. bursata* (Van Name), 1921, of the West Indian region, should be united with the evidently very similar form *D. stylifera* (Kowalevsky), 1874, of the warm regions of the Eastern Hemisphere, the following description is based on specimens from Florida.

The best-developed colonies resemble ordinary mushrooms in shape, consisting of a broad head, convex above and slightly concave below, mounted on a thick pedicel approximately equaling or exceeding the diameter of the head in height. Size of one of the largest heads 17 mm. in greatest diameter and 15 mm. in height, inclusive of the pedicel, which is not complete at the base; the pedicel enlarges toward the top and has an average diameter of 6 to 7 mm. Several of the colonies have one or two smaller heads arising from the lower part of the pedicel where it is more or less expanded into a base for attachment. Some of the heads exhibit the mushroom form only imperfectly, having nearly the capitate shape seen in many other compound ascidians; sometimes this appears to be due to immaturity of the colony.

The zooids are arranged in the central part of the upper surface of the heads in several small, irregularly formed systems; branches from these systems extend radially toward the margin of the heads. In most of the specimens the test is of a light yellowish brown color and rather opaque, the parts occupied by the zooids and common cloacal cavities and canals showing darker brown in conspicuous contrast to the other parts of the colony, but in one lot of specimens (from "Albatross" Station 2136) the test is a dark grayish brown and the systems are inconspicuous. Another colony, from Florida, was, after preservation in formalin for some months, bright carmine above, the zooids and the peduncular part of the colony lighter colored, but fairly deep pink.

The zooids have a rather short but wide thorax, connected by a moderately long thick neck with the abdomen; arising from the latter is a pear-shaped or oval sac-like post-abdomen, containing the reproductive organs and much resembling the post-abdomen of *Polyclinum* except that it does not contain the heart. It is connected with the abdomen by a very narrow and often considerably elongated neck, which arises from the right posterior part of the abdomen and extends back either in prolongation of the body axis or making more or less of an angle with the latter.

The zooids average small in size; even including the above-described post-abdominal pouch, they often do not exceed 2 mm. in length. Fifteen stigmata in the anterior rows and 13 in the last rows were present on each side in one zooid in which an exact count could be made, some individuals apparently having a few more than this (at least 18 in the anterior rows). The loop formed by the alimentary tract is not twisted. The stomach is of the ovoid shape usual in this genus and has about 18 or 20 slightly irregular longitudinal plications which are not very deep but usually more or less evident. A little way posterior to its anterior end the stomach is joined by the duct from the tubular gland that surrounds the ascending branch of the intestine. This duct may be expanded into a fusiform vesicle between the intestine and the stomach; the tubules of the gland itself are crooked with more or less enlarged tips. The intestine often exhibits a more or less distinct constriction a short distance beyond the stomach.

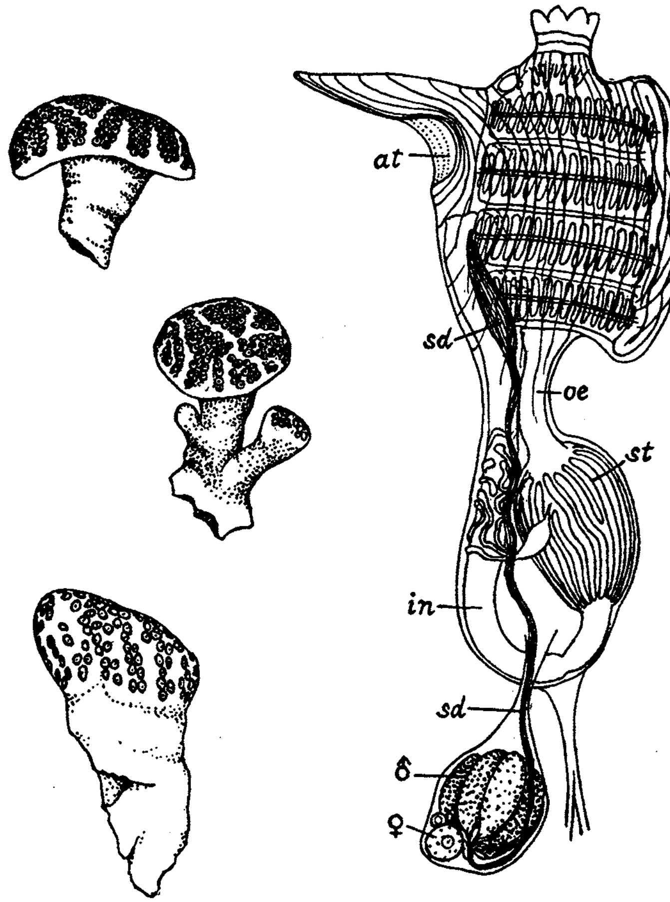


FIG. 71. *Distaplia stylifera* (Kowalevsky). Zooid, ×55, and three colonies, ×1.3.

The post-abdomen described above is completely filled by the reproductive organs. There are about six large pyriform testes situated in a circular group filling the proximal three-fourths of the post-abdomen; the sperm ducts arise from their distal (posterior) ends and immediately join to form the common duct which, passing forward beside the testes and through the neck into the abdomen, crosses on the right of the posterior part of the intestinal loop and follows the ascending branch of the intestine. In some individuals the terminal part of the sperm duct was much distended with spermatozoa.

I failed to find brood pouches in the American specimens, but Hartmeyer describes them in a West Australian colony as being oval and connected to the body with a very long neck, and containing but one larva.

DISTRIBUTION: In American waters this species has been found in shallow water at several points on the west coast of Florida (Key West, Marco, and Tarpon Springs) and on the Blackfish Banks off Charleston, South Carolina, and was dredged by the "Albatross" at Station 2136 (17° 43′ 40″ N., 75° 38′ 25″ W., 52 fathoms) southeast of Jamaica. Specimens are in the United States National Museum and the American Museum of Natural History. A small colony from the Colombian Caribbean coast near Cape Vela is probably also of this species.

D. stylifera (Kowalevsky), 1874, type locality the Red Sea, ranges eastward to Saleyer Island and west Australia (Cape Jaubert and Sharks Bay). I can hardly refuse to accept the identity of the two forms in view of Michaelsen's (1930) statement that his west Australian material, excepting in the unimportant matter of color, agrees with the West Indian form in even the smallest details, and even the color is similar in some specimens.

Distaplia colligans Sluiter, 1932

Text figure 72

Distaplia colligans SLUITER, 1932, p. 7, figs. 5–8.

Based on two cushion-shaped colonies 25 mm. by 20 mm. by 6 mm. thick and 15 mm. by 8 mm. and 8 mm. thick, respectively, apparently loosely attached by their lower surface. Surface smooth. Test glassy gray, allowing the zooids to show clearly. No common cloacal aperture or systems distinguished, but an arrangement of the zooids in double rows was noticeable in some places.

Zooids small (1.8 mm. long), of the usual *Distaplia* type, and resemble in form those of *D. bermudensis.* Anterior margin of atrial orifice extended into a long languet. Tentacles 12 or more; about 14 stigmata in a row on each side. Stomach apparently smooth walled without and within (no indications to the contrary).

All the zooids of the two available colonies were males.

LOCALITY: St. Andrews Bay, South Georgia. "*Colella concreta*" Herdman (1886, p. 123, pl. 16, figs. 8–16) from Kerguelen Island, 10 to 60 fathoms, is perhaps a *Distaplia*, though with present information this species is not identifiable with it.

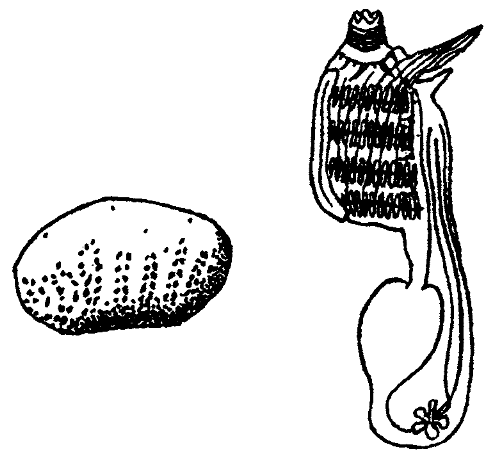


FIG. 72. *Distaplia colligans* Sluiter. Outline of colony, a little less than twice natural size, and zooid, ×28, as figured by Sluiter.

Distaplia occidentalis Bancroft, 1899

Distaplia californica MICHAELSEN, 1923, p. 23, fig. 5; 1924, p. 309.

? *Distaplia confusa* RITTER, 1901, p. 246, pl. 29, figs. 26, 27; HARTMEYER, 1911b, p. 486; MICHAELSEN, 1923a, p. 21; 1924, p. 311; HARTMEYER, 1924, p. 128.

Distaplia occidentalis BANCROFT, 1899, pp. 59–112, pls. 1–6; RITTER, 1900, p. 609; 1901, p. 245; HARTMEYER, 1911b, p. 486; RITTER AND FORSYTH, 1917, p. 464, pl. 45, figs. 64, 65; JOHNSON AND SNOOK, 1927, p. 596; PRATT, 1935, p. 744; RICKETTS AND CALVIN, 1939, p. 76.

Distaplia orientalis MICHAELSEN, 1923, p. 23 (misprint).

Distaplia sp. BERRILL, 1937, p. 566.

? *Distaplia* sp. HARTMEYER, 1920a, p. 135; ÄRNBÄCK, 1929, p. 14, fig. 3, pl. 2, figs. 15, 16.

Holozoa occidentalis HARTMEYER, 1909–1911, p. 1437.

? *Holozoa* sp. A. HUNTSMAN, 1912, p. 115.

"Colony varying from flat and incrusting to pedunculated or mushroom-shaped with all gradations between; flat form 3 or 4 mm. thick and several centimeters in expanse; pedunculated forms varying from 2 mm. to 1 cm. or more across flattened heads, peduncles being of the same length or longer; flat form often pedunculated at margins of colonies. Systems plain, several in a head, zooids closely arranged around a large cylindrical common atrial orifice, which extends considerably above the general surface as a delicate-walled short pipe. Color light green, variable, dark brown, cadmium yellow, brick red, dirty white. Test consisting of a thin tough outer layer covering the less resistant portions, both having many bladder cells; ectodermal vessels running parallel with long axis of peduncle and not branching.

"Zooids small, 2 to 3 mm. average of 12 individuals 2.5 mm." (Ritter and Forsyth, 1917).

When well expanded, the zooids may be considerably longer than the above dimensions. (See statements regarding their structure given under the genus.) Stigmata about 12 to 14 in a row on each side. Stomach wall smooth externally, but internally with somewhat irregular ridges giving it a reticulated appearance.

In early stages of their development the ovary and testis lie beside (on the right of) the intestinal loop, but in adults the ovary is posterior to the loop and the testis at least partly so, causing a protuberance of the posterior outline of the zooid. Incubatory pouch rather short, containing rarely as many as four embryos, but connected with the body by a long slender neck. Egg diameter about 0.4 mm.

Distribution: On littoral rocks from San Diego to Puget Sound, and probably still farther north. *D. confusa* Ritter, from Kodiak Island, southern Alaska, may not be distinct. In many places it is a very common species and is conspicuous for its bright and varied colors. This is probably the "*Holozoa* species A" of Huntsman, 1912, from Ucluelet, Vancouver Island. He also reported (1912, p. 115) "*Holozoa* species B" from dredgings near the same place, but gives no information about it.

Its range may perhaps be much wider. The *Distaplia* sp. of Ärnbäck, 1929, from the Guaitecas Islands, Chile, 18 to 27 meters, found with *Corella eumyota*, seems to agree very exactly with *D. occidentalis* in spite of the distant locality. What is probably the same species had been previously reported from Juan Fernandez by Hartmeyer, 1920a, but until more is known about this South American form, its identity with *occidentalis* must be treated as very uncertain.

Genus SYCOZOA Lesson, 1830

(Syn. *Colella* Herdman, 1886, in part)

Closely allied to *Distaplia*, having similar zooids divided into thorax and abdomen and provided with a vascular appendage from the posterior part of the body which breaks up into buds.

Colonies always stalked or pedunculated, usually ovate, clavate, or somewhat elongate, with a common cloacal aperture at the summit; an arrangement of the zooids in double rows along parallel cloacal canals on the sides of the colony is often noticeable. All the zooids of a given colony are of the same sex.

Zooids about 2 to 3 mm. long; virtually alike throughout the genus, their characters, therefore, of little help in distinguishing the species. They have normally a six-lobed branchial aperture and the atrial aperture with a large languet which takes part in roofing over the cloacal canal; four rows of stigmata usually with about 20 in a row on each side in adult specimens and rather few branchial tentacles (usually 12 to 16 or more), but differ from *Distaplia* in having no parastigmatic vessels. Stomach ovate, always smooth walled, intestinal loop short. The ovary or the group of pyriform testes, as the case may be, lies beside the intestinal loop which may or may not be twisted so that the intestine crosses the oesophagus. The females develop an elongated brood pouch similar to that of *Distaplia*, but often of even more striking length and dimensions.

The breaking away and subsequent pelagic existence of the colony in *S. sigillinoides* are dealt with under that species. We do not know how general that is in the genus.

The genus is characteristic of, and chiefly confined to, the colder parts of the Southern Hemisphere. A number of species and varieties have been described, but apparently only a few are valid. Huntsman (1912, p. 115) lists a "*Sycozoa* (*Colella*) sp." from Ucluelet, Vancouver Island, British Columbia, but I have never seen any species of this group from that region.

Sycozoa gaimardi (Herdman), 1886

Text figure 73

Colella gaimardi Herdman, 1886, p. 103, pl. 14, figs. 7–14; Michaelsen, 1907, p. 49, pl. 3, fig. 16; Caullery, 1909, pp. 35, 38.

Colella racovitzai Van Beneden and Selys-Longchamps, 1913, p. 50, pls. 11–14, text figs. D–J.

Sycozoa gaimardi Hartmeyer, 1909–1911, p. 1438; 1911b, pp. 488, 499.

The colonies of this very distinct and usually easily recognizable species resemble small, slender-stemmed mushrooms in shape; the dome-shaped head, quite convex above but more or less flattened below, is usually not over 12 mm. (rarely up to 20 mm.) in transverse diameter; and the stalk which arises from the middle of its lower surface is usually not much over 25 mm. long, often less, but may reach 40 mm. The stalk is thickest at the upper end where it joins the head, but even there not usually over 2 to 3 mm. in diameter. At the slender lower end it expands abruptly into a small base for attachment. The stalk does not branch.

The test is transparent, allowing the closely placed zooids to be clearly seen. They cover the upper part and sides of the head, encroaching also on the outer parts of the lower surface. In this species it is difficult to demonstrate an arrangement of the zooids in columns as described in *S. sigillinoides*, but there is a single common cloacal aperture at the summit of the colony.

In life the general color is said to be yellow. Adult zooids often have a small, dark pigment spot over the position of the ganglion.

The zooids average about 3 mm. long, equally divided between thorax and abdomen. The six-lobed branchial aperture is not prominent; the atrial aperture, situated on the dorsal aspect of the thorax, is large and often has its anterior margin extended into a languet of considerable size. The normal number of tentacles appears to be 16, larger and smaller ones alternating; the dorsal lamina is represented by three languets arising from the transverse vessels a little to the left of the median dorsal vessel. The transverse vessels bear internally projecting membranes. There are four rows of stigmata. In fully adult zooids there may be 20 or 21 in a row on each side. No parastigmatic vessels are present.

The stomach is pear shaped and smooth walled; the intestinal loop has a contracted section in its transverse part.

As is characteristic in this genus, the colonies are either male or female, the gonads being situated beside the intestinal loop (on its true right side regardless of any twisting of the loop). The testis is a radially disposed group of glands, from the central point of which the common sperm duct arises; the ovary comprises a group of eggs of various sizes from which a large, very thin-walled oviduct leads to the entrance of the incubatory pouch. This is long (often much longer than the zooid) and sausage shaped when fully developed, and may contain a great many eggs and developing larvae in different stages (between 30 and 40 in some cases). At the blind posterior end of the pouch where

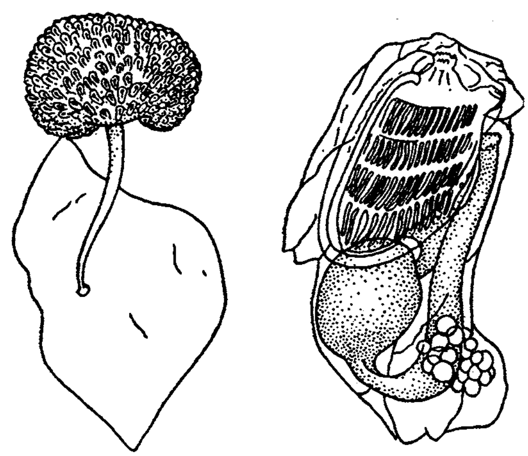


FIG. 73. *Sycozoa gaimardi* (Herdman). Colony attached to a piece of kelp, nearly twice natural size, and zooid, ×18.

the youngest ones are located, they are irregularly disposed, but toward the anterior part, their arrangement becomes more or less definitely serial, in a double or sometimes single series. The anatomy and budding of this species were carefully studied and beautifully illustrated by Van Beneden and Selys-Longchamps (1913).

DISTRIBUTION: Region of the Strait of Magellan and Tierra del Fuego; also the Falkland Islands (type locality). It is found in moderately shallow water, generally growing chiefly on the fronds of kelp and other large algae. The individual colonies are usually attached a little way apart, not forming actual clusters.

Sycozoa sigillinoides Lesson, 1830

Text figure 74

Aplidium pedunculatum QUOY AND GAIMARD, 1834, p. 636, pl. 92, figs. 18, 19; CUNNINGHAM, 1871a, p. 490.

Colella pedunculata HERDMAN, 1886, p. 74, pls. 5–9; PFEFFER, 1889, p. 4; 1890, p. 499; SLUITER, 1900, p. 5, pl. 1, fig. 1; 1906, p. 6, pl. 4, fig. 46; CAULLERY, 1909, pp. 30, 39, etc., pl. 1, figs. 3, 6, 7, 9–11.

Colella perrieri CAULLERY, 1909, p. 33, fig. 12.

? *Colella quoyi* var. *zschaui* MICHAELSEN, 1907, p. 47.

Colella ramulosa HERDMAN, 1886, p. 120, pl. 15, figs. 14–17.

Colella sigillinoides MICHAELSEN, 1907, p. 43, pl. 2, fig. 14.

Sycozoa patagonica SALFI, 1925, p. 3, figs. 1, 2, pl. 4, figs. 6–11; 1926, figs. 1–9.

Sycozoa sigillinoides LESSON, 1830, p. 436, pl. Moll. 13, fig. 15, 15b; HARTMEYER, 1911b, p. 534, figs. 4–11, p. 489 (*S.* aff. *sigillinoides*), figs. 1, 2, pl. 53, figs. 1–5; SALFI, 1925, p. 2.

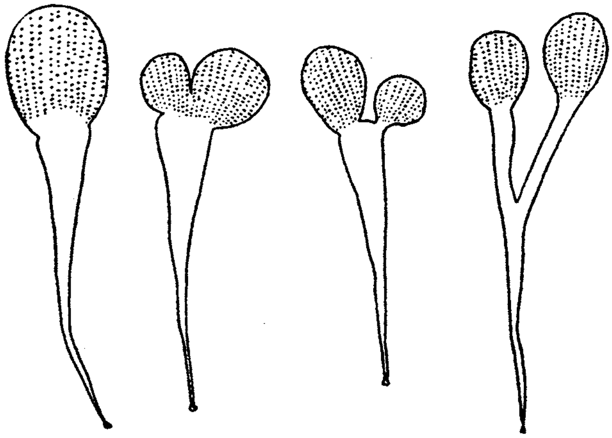


FIG. 74. *Sycozoa sigillinoides* Lesson. Outline of single and more or less divided colonies. After Caullery, 1909.

Sycozoa sigillinoides form *rigida* ÄRNBÄCK, 1929, p. 10, figs. 1, 2, pl. 1, figs. 7–9.

The colony usually consists of a single head supported on a long stalk, though as mentioned below some colonies having a branching stalk and consisting of more than one head appear to belong in the present species.

The head varies from ovate, or pyriform, to that of a short, thick cylinder more or less rounded at the ends. Young and small colonies are usually of more rounded form, the older ones more elongate. In the material I have examined, the head seldom exceeded 25 to 30 mm. in height and 12 to 15 mm. transversely at its widest point; the largest specimen measured about 60 by 14 mm. The soft consistency of the test in preserved material usually makes exact measurements impossible.

The stalk is very different in character from the head. It is usually slender (often not over 2 mm. in diameter in its lower part), horny in consistency, and somewhat stiff; dark brown to dull yellow in color; its surface smooth on the upper part but minutely wrinkled lower down. Its diameter increases very gradually as the head is approached, sometimes only slightly; in other cases the diameter at the upper end may be double or more than at the lower. It is, however, abruptly constricted into a narrow neck where it joins the head. At least that is the way it looks externally; actually the functional part of the colony extends a little way down into the hollowed, enlarged part of the stalk. The lower part of the stalk is not hollowed, though it has a softer central core; at its extreme basal end it forms a flattened expansion for attachment. In regard to the length of the stalk, see below.

In poorly preserved material it is often difficult to detect any arrangement of the zooids in systems, but well-preserved specimens show that a common cloacal aperture (in small colonies, at least, there appears to be but one) is situated at the summit of the head. From this the cloacal canals extend down the sides of the colonies, and the zooids are arranged along each side of them in rows.

In preserved material the test of the head varies from gray with a yellow or brownish tinge, to a decidedly brown shade; the lighter-colored zooids show through it more or less distinctly; during life it is grayish and more transparent. In many specimens, but not in all, the branchial aperture of each zooid may be surrounded by a deposit of opaque, pure white pigment; often the abdominal part of the zooids is largely covered with this same pigment, which retains its color in preserved material. According to Lesson, the anterior ends of the zooids are cinnabar red in life. A red coloration of the zooids in fresh specimens, possibly pervading the test also, is probably frequent; it is mentioned by both Michaelsen and Studer. During life the surface of the colony is slightly raised over the anterior ends of the zooids, especially, of course, when they are expanded; slight elevations are sometimes noticeable in preserved material.

The zooids conform to the characters given above under the genus *Sycozoa*, all those in one colony being either male or female. The branchial aperture is six-lobed; the atrial has a large languet of varying length. The usual number of tentacles appears to be from about 12 to 16 or a few more. There are four rows of stigmata without parastigmatic vessels, about 20 in a row on each side. The stomach is smooth walled; the ovary, or the testis (a small group of pyriform glands), as the case may be, is beside the intestinal loop.

The brood pouch of female zooids may, when well developed, greatly exceed the zooid's body in length; it is sausage shaped and often curved or curled in an incipient spiral manner at its distal end. It may contain as many as 17 embryos and larvae, if not more, arranged, usually at least, in a single series but sometimes in an alternating or more or less completely double series.

Certain matters concerning the stalk of this species still remain to be considered. Though it is occasionally, and in very young colonies no doubt always, very short, in the adult colonies I have examined it usually ranges from 4 to 8 or 9 cm. in length. Its length and stoutness do not bear any constant relation to the size of the head borne upon it. In many cases a long and stout stalk will bear at its top only a small and evidently young head which must be a secondary development, the original head having evidently been lost.

Moreover, a large proportion of the specimens of this species which have been found are heads that were found floating near the surface with no stalk attached, evidently having broken loose at the constricted neck mentioned in the description above. There is reason to believe that this separation of the head and its assumption of a pelagic existence is a normal or regular event in the life history of the colony in this species, the part of the colony which remains in the upper part of the stalk regenerating a new head. This it can do, as it contains many small buds derived from the vascular processes of the posterior ends of the zooids.

Most specimens of this species consist of a single head borne on a stalk as described above. But frequent specimens occur in which the stalk forks, or gives off one, or sometimes several, lateral branches, each bearing a head. We cannot exclude these branched colonies from the species *sigillinoides*, at least not in all cases. A number of specimens have been obtained which show that when regeneration of the head takes place, two heads instead of one may be produced, and each may develop its own stalk, thus forming a forked colony (see especially Caullery, 1909, Salfi, 1923).

DISTRIBUTION: Found in the Subantarctic regions all around the Pole.

Lesson's type was a detached, drifting head picked up near Cape Horn. It occurs in the Strait of Magellan, the Falkland Islands, South Georgia, Kerguelen, off south and southeast Australia, the Chatham Islands, etc. In the Antarctic it has been obtained at Port Charcot in 40 meters depth (Sluiter), and at Kaiser Wilhelm II Land in from 46 to 385 meters (Hartmeyer). The "Albatross" dredged a number of specimens, each attached to a small pebble, at Station 2771 (51° 34′ S., 68° 00′ W., 50 fathoms) off southern Patagonia. Other specimens were obtained in the Strait of Magellan at Stations 2776 in 21 fathoms and 2778 in 61 fathoms.

The detached heads remain alive long enough to drift to great distances, which has doubtless contributed to its wide distribution. The currents carry them northward along the Argentina coast. Strange as it may seem, one was found floating far within the tropical region off Rio Grande del Norte, Brazil, in latitude 05° S., longitude 34° W. (Michaelsen, 1907).

Sycozoa quoyi is a related if distinct form, with a short, stout stalk, described by Herdman from Kerguelen Island. Michaelsen assigned short-stalked specimens from South Georgia to it, making them a variety (*sschaui*). Several other species perhaps identical with *sigillinoides* have been described from localities in the Eastern Hemisphere, but these cannot be discussed in the present work.

Sycozoa umbellata (Michaelsen), 1898

Text figure 75

Colella umbellata MICHAELSEN, 1898, p. 371; 1907, p. 54, pl. 1, figs. 7–9, pl. 3, figs. 17, 18; CAULLERY, 1909, p. 35, fig. 13.

Colella, nov. sp. (from South Georgia) PFEFFER, 1889, p. 4.

Sycozoa umbellata SLUITER, 1919, p. 12.

Closely related to *S. sigillinoides*, from which it appears to be chiefly distinguished by the habitual reproduction of numerous heads from the top of the stalk or from broken or injured places along its length, also from fragments of stalks. Michaelsen described two forms, the *typica*, from southern Tierra del Fuego, and the form *kophameli* (B in the figure) from off east Patagonia, 43° S., 60° W., 56 fathoms. His figures of both forms are reproduced in outline here, though I do not believe that the latter can be regarded as a distinct race or subspecies. Sluiter, 1919, reports 10 specimens from Punta Arenas.

Caullery, 1909, assigns a specimen from Gretton Bay (wherever that may be) to this species. I reproduce his figure also.

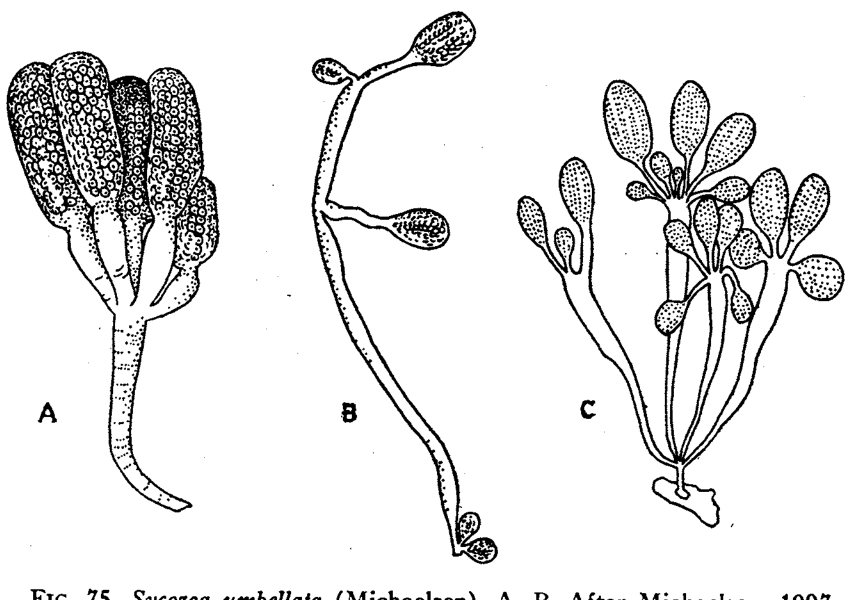


FIG. 75. *Sycozoa umbellata* (Michaelsen). A, B. After Michaelsen, 1907. C. After Caullery, 1909. Somewhat reduced.

Sycozoa georgiana (Michaelsen), 1907

Text figure 76

Colella concreta PFEFFER, 1889, p. 4 (not Herdman, 1886).

Colella georgiana MICHAELSEN, 1907, p. 62, pl. 1, fig. 6, pl. 3, fig. 15.

Sycozoa georgiana subsp. *profusa* SLUITER, 1932, p. 3, figs. 1–4.

This species is based on specimens from South Georgia. The heads are small (5–6 mm. high), pear shaped, each borne on a separate stalk which may reach 3 cm. in length but is usually much shorter. The stalks arise from a basal mass of anastomosing stolons by which the colony is attached. Michaelsen's specimens had four to eight heads, Sluiter's (subsp. *profusa*) up to 50 or 60. The zooids present nothing distinctive.

Pfeffer identified this form with "*Collela concreta*" Herdman, 1886, from Kerguelen Island on account of superficial resemblance in the group of heads. Michaelsen also con-

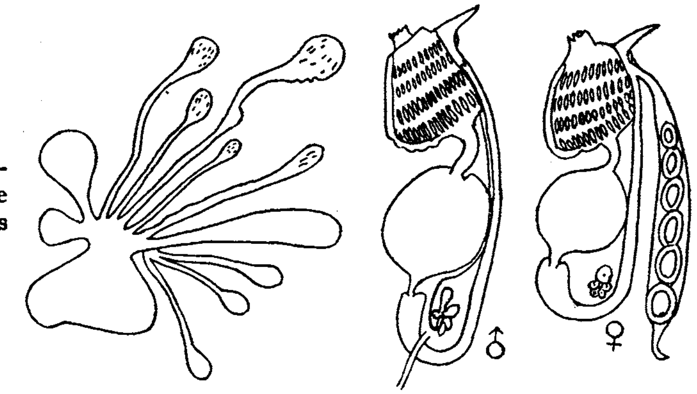


FIG. 76. *Sycozoa georgiana* (Michaelsen). Colony, slightly enlarged, and male and female zooids. Outlines from figures of Sluiter.

sidered them allied. But this appears to be incorrect. Herdman's *concreta* is probably a *Distaplia*, not a *Sycozoa* (*Colella*) at all.

ORDER **PHLEBOBRANCHIA** LAHILLE

(= Diktyobranchia Seeliger)

A large group containing both compound and simple ascidians, distinguished chiefly by the character of the branchial sac, which is flat, without large pleats or folds, though minute undulations may occur. A system of slender, tubular, internal longitudinal vessels (usually numerous and equally spaced) raised on supporting papillae is normally present on the inner surface of the sac, though in a few genera it has become rudimentary or lost. Branchial tentacles always simple; stigmata either straight or spiral in arrangement; gonads present on one side of the body only, usually situated in, or in close relation to, the intestinal loop. Test usually more or less gelatinous and translucent, though often tough.

FAMILIES OF PHLEBOBRANCHIA

A_1. Body in two divisions (thorax and abdomen) as in most compound ascidians; well-developed internal longitudinal vessels in branchial sac. Compound ascidians with large, partly embedded, or independent zooids . . . . Diazonidae

A_2. Body sac-like, undivided.

- B_1. Simple ascidians often of considerable size.
  - C_1. Body somewhat elongate; alimentary and reproductive organs extending more or less behind the branchial sac. Mantle muscles in a few broad, conspicuous, longitudinal bands . . . . Cionidae
  - C_2. Alimentary and reproductive organs wholly on left side of body; intestine bending dorsally beyond the stomach, forming an S-shaped curve anterior or dorsal to the stomach. Mantle muscles chiefly of narrow bands or fibers often forming a network.
    - D_1. Stigmata straight in parallel rows, internal longitudinal vessels of branchial sac well developed and usually bearing papillae . . . . . Ascidiidae
    - D_2. Stigmata in spirals. Internal longitudinal vessels wanting or rudimentary . . Agnesiidae
  - C_3. Alimentary and reproductive organs on the ventral and more or less on right side of body due to intestine bending ventrally beyond the stomach, passing back ventral to the latter. (For the characters of its genera, see p. 203) . . . . Rhodosomatidae
  - C_4. Imperfectly known abyssal family . . . . Hypobythiidae
- B_2. Compound ascidians with zooids resembling small Ascidiidae in most of their characters; zooids usually independent, budding from a vine-like stolon (in one species sometimes confluent) . . . . Perophoridae

FAMILY **DIAZONIDAE** GARSTANG, 1891

A small group of ascidians, some, though perhaps not all, of which reproduce by budding and form colonies. They are treated in many classifications as a subfamily (Diazoninae) and included in the Cionidae.

The body is elongate and divided by a constricted neck into an anterior part or thorax containing the branchial sac, and a posterior part or abdomen containing the stomach, intestinal loop, and gonads as in most compound ascidians.

The branchial sac has many rows of stigmata and numerous internal longitudinal vessels raised on supporting papillae to which the vessels are attached either at, or close to, the summits of the papillae. The dorsal lamina is represented by a series of languets.

Genus DIAZONA Savigny, 1816

The type and only well-known species of the genus (the European *D. violacea* Savigny, 1816) forms large, massive colonies in which the individuals, when adult, have only the posterior part of the body embedded in the common mass of test, the anterior part having its own separate covering of test.

The two American forms referred to it are only very unsatisfactorily known.

Diazona geayi Caullery, 1914

Diazona geayi Caullery, 1914, p. 204, fig. 1.

The single colony on which this species was based was of thick, flattened form and of elliptical outline, 13 by 19 cm. in diameter and 7.5 cm. thick, and of a light brown color. Surface smooth; the outer layer is tougher, the interior less resistant.

The zooids are in a condition of regeneration of the anterior part of the body, many consisting of little more than the abdominal part, and measuring in their incomplete condition 8 to 10 mm. long. There are no zooids in the deeper parts of the colony which, however, are penetrated by vascular processes from the rear end of the zooids. In some of the latter, regeneration of the branchial sac has proceeded to the extent of forming about 20 rows of stigmata, but these are still in the condition of small, rounded perforations.

Locality: French Guiana.

Caullery appears to have assigned this colony to the genus *Diazona* on the grounds of resemblance to a European colony of that genus in a similar stage of regeneration, whether correctly or not I am not able to say.

Diazona gigantea (Sluiter), 1919

Diazona gigantea Hartmeyer, 1922b, p. 321; Ärnbäck, 1925, p. 15, pl. 1, figs. 11–13.

Polycitor giganteus Sluiter, 1919, p. 10, pl. 1, figs. 18–20; Van Name, 1930, p. 450 (footnote).

Not *Clavelina gigantea* Van Name, 1921, p. 358, fig. 40.

Described by Sluiter, 1919, from a single colony and placed in the genus *Polycitor*, though there were papillae on the transverse vessels of the branchial sac, a character not elsewhere found in that genus. But Hartmeyer, 1922b, and Ärnbäck, 1925, after examining pieces of the type colony agreed that it is a *Diazona*, the internal longitudinal vessels borne on the papillae having been overlooked by Sluiter owing to the poor condition of the specimen or perhaps to their incomplete development in immature zooids.

According to Sluiter's description, the colony is a cylindrical mass of 12 cm. in height and 8 cm. in diameter and apparently was attached by one end. The test is cartilaginous, in general smooth, but it bears numerous tongue-like projections on its upper surface which show indications of regularity in their shape. The zooids are entirely buried in the common test; no systems, both apertures of the zooids open on the surface.

Some of the zooids reach the extraordinarily large size of 4.5 cm. in length, even in their preserved contracted condition. The apertures are on forwardly directed siphons, and exhibit quite irregular lobation which varies in different individuals (see Ärnbäck, 1925).

The tentacles number 32, according to Sluiter, and are of three orders regularly arranged; the dorsal tubercle has a U-shaped aperture with the open interval slightly obliquely forward, according to Sluiter; it was found S-shaped in the specimen studied by Ärnbäck. Dorsal lamina represented by numerous long, pointed languets which are closely placed. Forty rows of stigmata. Internal longitudinal vessels and their supporting papillae very numerous.

Stomach elongate oval with a conspicuous longitudinal raphe and numerous external ridges, mainly longitudinal in direction but very sinuous in their course; a short pyloric extension of the stomach is smooth. Gonads of both sexes well developed, in and beside the intestinal loop.

Locality: "West Indies," collected by van de Wege; no further particulars as to location.

No other records. It is now evident that *Clavelina gigantea* Van Name, 1921, has nothing to do with this species, though it also forms large, massive colonies.

GENUS **RHOPALAEA** PHILIPPI, 1843

Zooids large, completely, or nearly completely, separated, each enveloped in its covering of firm cartilaginous test. No large massive colonies like those of *Diazona* are found; the zooids are generally solitary or in small, slightly connected groups.

10.5 mm. in greatest width, the body, in its contracted state, when removed from the test, is only from one-half to two-thirds the external length.

The test is rather smooth externally, semi-transparent, somewhat cartilaginous but not very tough, though a thin capsule of much tougher consistency encloses the abdominal part of each zooid. The alcoholic specimens are pink or violet pink in color, shading to a deep carmine on the anterior part of the body, especially about the apertures. Sluiter's

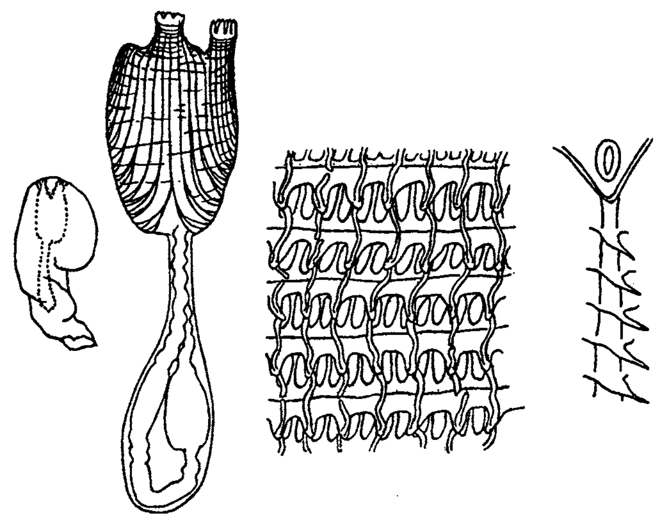


FIG. 77. *Rhopalaea abdominalis* (Sluiter). Left to right: Outline of individual, slightly enlarged. Individual removed from test, ×5.6. Piece of branchial sac, ×56. Dorsal tubercle and anterior part of median dorsal vessel with five dorsal languets, ×56.

Rhopalaea abdominalis (Sluiter), 1898
Text figure 77

Ciona abdominalis SLUITER, 1898, p. 8, pl. 1, figs. 3–8.

Rhopalaea abdominalis VAN NAME, 1921, p. 370, figs. 48–51; ÄRNBÄCK, 1926, p. 17; VAN NAME, 1930, p. 458, fig. 32.

In the few specimens of this animal that I have seen, the external form is variable and quite irregular owing to the great and uneven thickness of the test. The normal form is evidently club shaped, with the anterior end large and rounded and the posterior part more contracted, but irregularities in the thickness and outline of the test may alter these relations. One of the specimens consists of a group of several small individuals united at their base and may have been formed by budding; the others consist of single separate individuals but may perhaps have been broken apart. The largest is 24 mm. high and

type specimen was larger (35 mm. in length) and lacked the pink coloration, but may have become faded.

The apertures are on short, anteriorly directed tubes, the branchial rather irregularly lobed; the atrial has six deep, rounded lobes.

Mantle thin, with little musculature except the sphincters of the orifices and about 20 distinct and strong longitudinal bands on each side of the thorax; toward their posterior ends these bands curve toward the median dorsal or ventral line (according to whether they are nearer to the dorsal or ventral aspect), so that they become nearly transverse, and at the same time they divide into several narrower, somewhat diverging bands. The abdominal walls are thin and without conspicuous muscle bands.

Tentacles rather few in number, though several different sizes or orders are represented. Orifice of dorsal tubercle oval, longitudinally elongate. Dorsal lamina represented by narrow, triangular, transversely expanded languets arising directly from the median dorsal vessel.

Branchial sac with about 40 rows of very small and numerous stigmata; the rows are separated by transverse vessels bearing small triangular papillae which support a well-developed system of internal longitudinal vessels. These vessels connect with the supporting papillae a little below the tips of the papillae, so that the tips project into the branchial cavity a very little beyond the level of the internal longitudinal vessels. There are some 40 of these vessels on each side. With the transverse vessels they form meshes which appear usually to contain only two stigmata.

The intestinal loop is rather long and narrow; the stomach is oval; definite plications in its wall were not demonstrated.

The reproductive organs are situated beside the intestinal loop and consist of a saccular ovary containing a large number of small eggs and of very numerous, small, pear-shaped testes, the common duct from which accompanies the ascending branch of the intestine.

The specimens described here are from the following Gulf of Mexico localities: "Albatross" Stations 2413, 26° N., 82° 57′ 30″ W., 24 fathoms, fine sand and broken shells, three specimens (one consisting of several zooids; whether or not the others were part of the same colony is uncertain); 2138, 17° 44′ 05″, N., 75° 39′ W., 23 fathoms, coral and broken shells, one individual; "Fish Hawk" Station 7511, in Gulf Stream off Fowey Rocks Light, Florida, 45 fathoms, one individual. These are in the United States National Museum. Sluiter's *Ciona abdominalis* was based on a specimen from La Tortuga Island, Venezuela.

GENUS **TYLOBRANCHION** HERDMAN, 1886

A subantarctic and Antarctic genus not too well known, but apparently related to *Diazona,* having on the transverse vessels of the branchial sac papillae which fork into a pair of short branches that seem to represent rudimentary, incomplete, internal longitudinal vessels.

The zooids are large and have the body divided into thorax, abdomen, and a more or less elongate, tapering, posterior extension behind the main part of the abdomen in which the ovary and testes are contained. Herdman considered this a true post-abdomen and, therefore, included the genus in the Synoicidae (Polyclinidae in his nomenclature). But as this posterior extension does not contain the heart (see Ärnbäck, 1926, p. 5), as the post-abdomen of that family does, relationship to that group does not seem probable.

The zooids are completely embedded in the test, at least in the contracted preserved specimens. Apparently no systems, the zooids opening independently on the upper surface of the colony. Both apertures of the zooids six-lobed. Dorsal lamina represented by a series of languets. Taking into consideration the very minor character of the supposed differences between the species and the limited material on which they are based, it seems very doubtful whether more than one species can be recognized; the type species, *T. speciosum* Herdman, 1886, was from near Kerguelen Island, in 10 to 100 fathoms. Its name will have priority if that view proves to be correct.

Tylobranchion antarcticum Herdman, 1902

Text figure 78

Tylobranchion antarcticum HERDMAN, 1902, p. 193, pl. 20, figs. 1–6; SLUITER, 1906, p. 10, pl. 1, fig. 8, pl. 4, fig. 47; HARTMEYER, 1911b, p. 472, pl. 52, figs. 6–8; ÄRNBÄCK, 1926, p. 8, pl. 1, fig. 11.

? *Tylobranchion speciosum* HERDMAN, 1886, p. 157, pl. 22, figs. 1–17; ÄRNBÄCK, 1926, p. 5, pl. 1, figs. 9, 10.

? *Tylobranchion weddelli* ÄRNBÄCK, 1926, p. 2, pl. 1, figs. 1–8.

Colonies capitate or clavate, or irregularly wedge shaped, attached by the more or less narrowed base. They may be cleft into lobes or consist of several distinct heads. The upper parts of the colonies are gelatinous and somewhat transparent, the basal parts of firm consistency with incrusting and embedded sand. Sluiter gives the size of his largest specimen (which contained 18 zooids) 22 mm. wide and 10 mm. high; Ärnbäck, that of the largest specimen of *T. weddelli* as 34 by 21 mm.

The zooids in specimens from west Antarctica which Ärnbäck has described as *T. weddelli* were exceptionally large and well developed and give the best information on the structure of the zooids in this genus.

Their measurements are given as 14–15 mm. in body length exclusive of the posterior extension or stolon, the thorax measuring 7–8 mm. and the abdomen 7 mm.; width of thorax 5 mm. The thorax bears two short siphons ending in slightly lobed apertures; its walls have nine or 10 slender muscle bands extending longitudinally but bending ventrally and branching near the anterior end. Tentacles of three sizes, about six of each size. Dorsal lamina represented by languets.

Branchial sac with "apparently more than 20" transverse vessels, each of which bears numerous papillae, bifid at their free end. The stigmata are very numerous and vary from elongate to short and rounded. The anterior or cardiac part of the stomach is ovate and has well-marked longitudinal plications (14 in number, of which three are only half the length of the others, according to Ärnbäck); the posterior or pyloric part of the stomach is smooth and tapers rapidly into the intestine.

The reproductive organs overlie the intestinal loop on the left side but also extend much posterior to it. In the specimen described, the male glands were well developed and consisted of a great number of small pear-shaped testes. Their common sperm duct extended anteriorly close to the rectum, terminating beside the end of the latter. The ovary was poorly developed and the eggs small. It was also situated beside the intestinal loop and its oviduct, a thin-walled tube, extended anteriorly but ended near the beginning of the rectum.

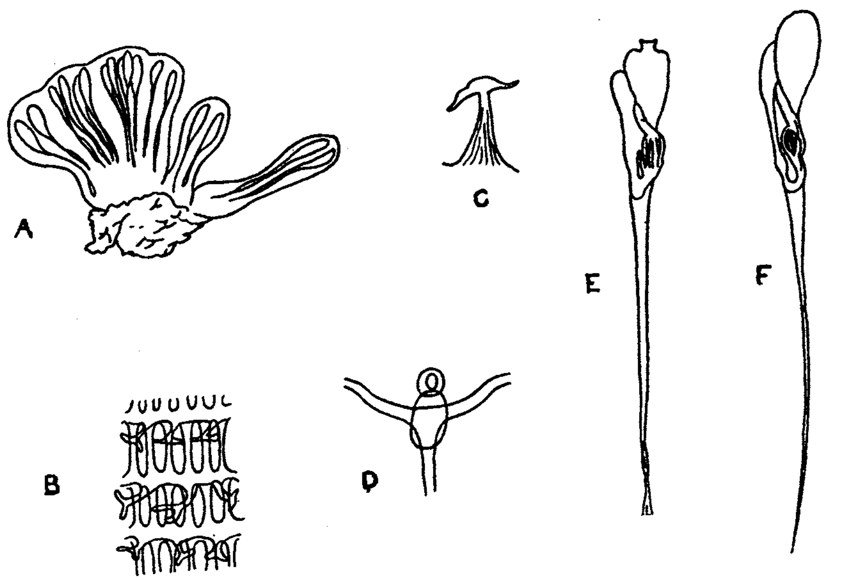


FIG. 78. *Tylobranchion antarcticum* Herdman. A. Colony somewhat reduced. B. Piece of branchial sac. C. Papilla of branchial sac. D. Dorsal tubercle. E, F. Outlines of zooids. After Herdman, 1902.

As its name indicates, *T. antarcticum* is an Antarctic species; it was described by Herdman, 1902, from specimens collected by the "Southern Cross" expedition near Cape Adare in 20 to 24 fathoms; reported also from the western Antarctic (Wiencke Island, 25 meters; Port Charcot, 40 meters; and Bramfield Sound) and from Kaiser Wilhelm II Land in 385 meters; while "*T. weddelli*" Ärnbäck, 1926, was based on specimens also from the western Antarctic (Paulet and Seymour Islands) in 100 to 150 meters.

FAMILY CIONIDAE LAHILLE, 1887

In the present work I am following what was until recently the usual course in confining this family to the genus *Ciona* (see below).

This seems best because *Ciona* does not fit well into any accepted family. Its resemblance to the Ascidiidae is evidently superficial to a greater extent than was realized by the older writers who placed it in that family, and while relationship to the Diazonidae is evident, the effort to bring that out does not seem to justify ignoring the very conspicuous differences and uniting both groups under the name Cionidae, as has been done in a number of recent, as well as some older, works.

GENUS **CIONA** FLEMING, 1822
Nomen Conservandum

There is only one well-known species (including a couple of varieties) of this genus, the common and very widely distributed *Ciona intestinalis* (Linnaeus). This may, in fact, be the only valid species. As it is described in more detail below, only a few of the characters of this rather peculiar ascidian will be mentioned here.

It is a rather large simple ascidian, with a more or less transparent and gelatinous test, having a superficial resemblance to an *Ascidia*, especially in the well-developed system of internal longitudinal vessels of the branchial sac which bear very prominent curved papillae. There are, however, important differences from that genus.

The ganglion and neural gland are close to the dorsal tubercle, instead of removed from it; the mantle has a few very stout, wide longitudinal muscle bands quite different from the rather diffuse musculature in *Ascidia*, and the alimentary loop with the gonads which are in close relation with it lies entirely or mainly posterior to the branchial sac which does not extend all the way to the end of the body. The tissues are, however, so soft and flaccid that these organs are easily displaced; it is often hard to tell in a preserved specimen just what the normal position of the alimentary loop during life really was. Evidently it is subject to considerable individual variation.

Nevertheless, the conspicuous longitudinal muscles and the more or less posterior position of the alimentary loop indicate a relation to the compound ascidians; another character of *Ciona* that is primitive is the retention in the adult of the epicardium, an organ of the developing stages of ascidians, in the form of two "perivisceral sacs" which envelop the digestive organs and gonads and remain in communication with the pharynx or cavity of the branchial sac at the posterior end of the latter.

Berrill (1936) considers *Ciona* the most primitive of existing ascidians, and would make it not only a separate family but a separate order in a classification he proposed (1936, pp. 64–66) based on the epicardium. I cannot, however, accept his view that that organ, an obscure structure which, when it survives in the adult ascidians, does so only in greatly changed forms, is satisfactory as the sole or main basis of classification of the Ascidiacea, nor can I take the extreme view of the primitive character of *Ciona* that he does. The possession of such a branchial sac as that genus has is certainly good evidence of a considerable degree of specialization, whether or not the epicardium is retained in an exceptionally primitive condition.

Ciona intestinalis (Linnaeus), 1767
Nomen Conservandum
Text figure 79

Ascidia canina O. F. MUELLER, 1777, p. 225.

Ascidia intestinalis LINNAEUS, 1767, vol. 1, p. 2, p. 1087; COUTHOUY, 1838, p. 111; DEKAY, 1843 (*Ascidea*), p. 259; SARS, 1851, p. 156; 1858, p. 64.

Ascidia ocellata AGASSIZ, 1850, p. 159; BINNEY, 1870, p. 24, pl. 24, fig. 332; DALL, 1870, p. 225.

Ascidia tenella (see below, p. 163).

Ciona canina TRAUSTEDT, 1880, p. 432.

Ciona intestinalis FLEMING, 1822, Philosophy of zoology, Edinburgh, vol. 2, p. 512; CASTLE, 1896, p. 201, etc., pls. 1–13; HARTMEYER, 1903, p. 297, pl. 12, fig. 13; VAN NAME, 1912, p. 606, fig. 43, pl. 66, fig. 130; HUNTSMAN, 1912, pp. 114, 119; 1912a, p. 108, pl. 14, fig. 4; RITTER, 1913, p. 500; OSBURN, SUMNER, AND COLE, 1913, p. 730; PRATT, 1916, p. 667, fig. 1012; RITTER AND FORSYTH, 1917, p. 457; HARTMEYER, 1924, p. 90; ÄRNBÄCK, 1934, p. 15, fig. 1; PRATT, 1935, p. 745, fig. 963; RICKETTS AND CALVIN, 1939, p. 249; MACGINITIE, 1939, p. 443.

Ciona intestinalis var. *ocellata* VAN NAME, 1912, p. 608; HARTMEYER, 1924, p. 104; ÄRNBÄCK, 1934, p. 17.

Ciona ocellata VERRILL, 1880, p. 251; MCDONALD, 1889, p. 858; HARTMEYER, 1903, p. 301.

Ciona sociabilis HARTMEYER, 1915, p. 321; 1915a, p. 254.

Ciona tenella (see below, p. 163).

Tethyum sociabile GUNNERUS, 1765, Skrif. Selsk. Trondhjem, vol. 3, p. 99, pl. 3, pp. 3–4.

For many other references and synonyms, see Hartmeyer, 1903 and 1924.

In most of the preserved material of this species, the test and internal structures are usually found in a very soft and flabby condition and subject to distortion in shape, and, in the case of some of the internal organs, to more or less displacement, conditions which are often aggravated by the unequal contraction of the strong mantle muscles.

Normally the body is elongate oblong and generally somewhat tapering toward the anterior end; compressed laterally, adhering by the larger (posterior) end or a part of one side; the orifices on short but usually distinct forwardly directed tubes, near together, the branchial the larger and terminal, the atrial smaller and shorter. The test is usually whitish or colorless, soft and flexible, of gelatinous appearance and of varying thickness; more or less transparent, showing clearly the mantle (which is pale yellowish during life) with its muscle bands, as well as the alimentary and reproductive organs. The branchial orifice has eight, and the anal orifice six red or orange spots (ocelli) about its margin, but these fade out in preserved specimens.

The musculature of the mantle is one of the most conspicuous characters. There are five to seven broad, strong longitudinal bands on each side extending nearly the whole length of the body which are usually visible through the test and serve to recognize the species. Outside these are fairly numerous but very narrow circular muscles, not gathered into definite bands. The sphincters of the siphons are well developed.

Tentacles simple, rather numerous, and of three sizes arranged with some regularity. Dorsal tubercle C-shaped with incurved or inrolled horns; open interval forward. Dorsal lamina replaced by a row of numerous narrow tentacle-like languets. Branchial sac without folds, though a slight degree of minute fluting or plication is sometimes noticeable. Transverse vessels numerous, of two sizes placed alternately, the smaller ones crossing without interrupting the stigmata. Internal longitudinal vessels numerous but slender; they bear long curved papillae at the intersections with all of the transverse vessels. The papillae at the intersections with the smaller vessels are slightly smaller than the others. A membrane is borne on the concave side of each papilla. The number of stigmata intervening between adjacent internal longitudinal vessels is very variable in different individuals as well as in different parts of the sac of the same one, but averages greater in large than in small or immature specimens. It varies from four or six in the latter, to six, seven, or occasionally eight in the former.

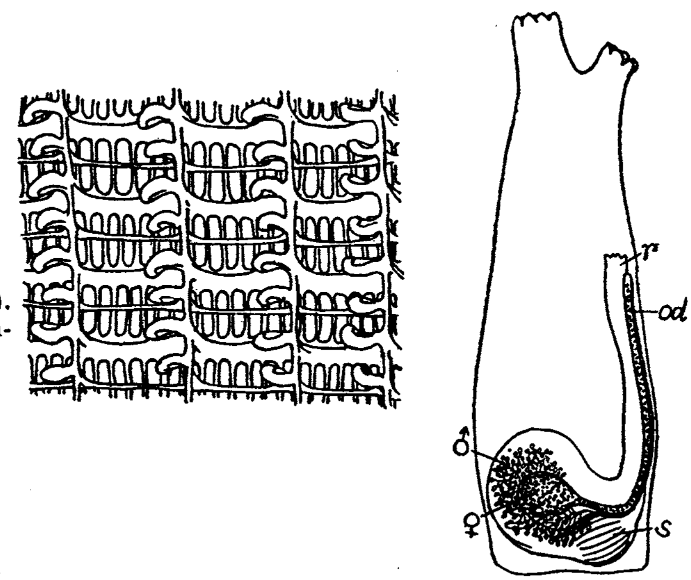


FIG. 79. *Ciona intestinalis* (Linnaeus). Left side of body, ×2, and piece of branchial sac, ×36.

Stomach small and short with a small number of moderately distinct longitudinal folds in its wall. Intestinal loop small, the rectum long. As stated under the genus, the stomach, intestinal loop, and gonads lie largely or entirely posterior to the branchial sac.

Ovary a pear-shaped mass, sometimes partly cleft into a few lobes, occupying the space in the loop of the intestine. At its narrow (dorsal) end it tapers off into the long, wide, tubular oviduct which accompanies the rectum, lying along its left dorsal side. The oviduct often becomes greatly distended with eggs, these apparently remaining in it some time. The testis consists of a great number of small pyriform or more or less lobed glands

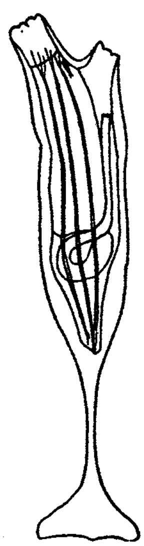


FIG. 80. *Ciona intestinalis longissima* Hartmeyer. About two-thirds natural size. After Hartmeyer, 1903.

connected by branching ducts, and ramifies over more or less of the surface of the intestinal loop and stomach, its duct uniting to form a common sperm duct which lies along the dorsal edge of the oviduct. Egg diameter 0.17 mm. (Berrill, 1937).

Ciona intestinalis is one of the larger ascidians of the United States coasts, examples often measuring 60 mm. or occasionally 80 mm. or more in length and up to 20 to 25 mm. transversely at the larger (attached) end, but its normal elongate tapering form may, as stated above, be much distorted.

DISTRIBUTION: The typical *Ciona intestinalis* is one of the most widely distributed and best known of all ascidians. In the Old World it occurs in the Mediterranean, the Black Sea, the waters of northern Europe and parts of the Arctic regions, though largely replaced in high latitudes by the forms or varieties *gelatinosa* and *longissima* dealt with below. On the American side, if we include the very doubtfully distinguishable var. *tenella*, it ranges from Greenland and Davis Strait south to southern Massachusetts and Rhode Island and on the Pacific coast from southern Alaska to the southern end of California.

It has also been found in many of the more important harbors in widely distant parts of the world such as Suez, Singapore, various Australian ports, in the Straits of Magellan, Japan, etc., probably owing to accidental transportation by ships, as it is not known in those regions elsewhere than in the harbors.

It ranges from the tidal zone where it grows on piles of wharves, floats, etc., sometimes in great abundance, forming large groups or clusters, alone or together with other ascidians, down to considerable depths, over 250 fathoms having been recorded for the typical *intestinalis*. It sometimes appears spontaneously and grows flourishingly in aquaria supplied with running sea water.

The first two of the following varieties or "forms," as they have been termed in recent works, are based on real peculiarities in the shape of the body and by geographical limitation in their distribution, being confined to the Arctic regions.

Form **longissima** Hartmeyer, 1899

Text figure 80

Ciona intestinalis var. *longissima* HARTMEYER, 1902, p. 205; 1903, p. 301, fig. 36; GRIEG, 1907, p. 534; HARTMEYER, 1921a, p. 73; 1924 ("form" *longissima*), p. 100; ÄRNBÄCK, 1934 ("form" *longissima*), p. 16, fig. 2.

Ciona longissima HARTMEYER, 1899a, p. 502, fig. 1, pl. 22, fig. 10, pl. 23, fig. 20.

Ciona sociabilis var. *longissima* HARTMEYER, 1914b, p. 1112.

In this variety the body tapers behind into a slender pedical which may be equal in length to one-third of the body or even more, and which expands again to form a base for the attachment of the animal. It is confined mainly to the Arctic regions of the Old

World, but has been recorded from both east and west Greenland and Davis Strait. In very high latitudes it mostly replaces the typical *intestinalis* and has been recorded from deeper water (over 600 fathoms) than the typical variety.

Form **gelatinosa** Bonnevie, 1896

Ciona gelatinosa BONNEVIE, 1896, p. 3, pl. 3, fig. 1; HARTMEYER, 1903, p. 306 (fig. 35 and pl. 12, fig. 13 represent this form).

Ciona intestinalis form *gelatinosa* HARTMEYER, 1924, p. 98; ÄRNBÄCK, 1934, p. 18, fig. 3.

In this variety there is no pedicel; the body is attached directly by the posterior end, but it is considerably elongated and has a posterior extension behind the region of the alimentary tract into which a large prolongation of the perivisceral cavity extends. It has usually been regarded as a connecting form between the typical *intestinalis* and *longissima.* This is an Old World Arctic form which has been recorded no nearer America than the Denmark Strait between Iceland and Greenland, and it accordingly hardly comes within the scope of this work. The reader is referred to Hartmeyer, 1924, and Ärnbäck, 1934, for information regarding it.

Form **"tenella"** (Stimpson), 1852

Ascidia tenella STIMPSON, 1852, p. 228; 1854, p. 20; 1860, p. 2; BINNEY, 1870, p. 24; DALL, 1870, p. 225.

Ciona intestinalis HUNTSMAN, 1912, p. 112.

Ciona intestinalis var. *tenella* VAN NAME, 1912, p. 608; HARTMEYER, 1924, p. 103; ÄRNBÄCK, 1934, p. 17.

Ciona tenella VERRILL, 1871, p. 99, figs. 12, 13; 1872, p. 6; 1872a, p. 214; 1873–1874, vol. 6, pp. 435, 440, vol. 7, pp. 413, 504; VERRILL AND SMITH, 1873, p. 698; VERRILL, 1880, p. 251; KINGSLEY, 1901, p. 183; WHITEAVES, 1901, p. 267; HARTMEYER, 1903, p. 301.

These citations and perhaps also a few others from northern New England and the neighboring British provinces refer to a form that was described by Stimpson, 1852, as a dictinct species (*Ascidia tenella,* type locality off Duck Island near Grand Manan at the mouth of the Bay of Fundy in 35 fathoms), and was believed by Verrill to be different from the "*Ciona ocellata*" of the southern New England coast. The latter is nothing more or less than the typical *C. intestinalis.* *C. tenella* was claimed to have a softer, more flabby test, to average smaller in size and to differ in its color, which is thus described by Verrill (1871, p. 99):

"Branchial orifice—with eight light orange eye-spots; from the angles between the eyes, light conspicuous white lines pass down the sides. Anal orifice—with six conspicuous eye-spots, like those of the branchial orifice. Color transparent, whitish, with flake-white lines; mantle transparent, with whitish dendritic markings, not spotted, pale yellowish, deeper above."

However, it should be remarked that Stimpson in his original description called the eye spots "red" not "orange," which disposes of one alleged difference.

I examined some of Verrill's specimens of "*tenella*" which, at least in the rather poor state of preservation that they were in, did not disclose any difference from those of the typical *intestinalis*, and I doubt its validity even as a variety, but I have not been able to examine fresh material, as *Ciona* appears to have disappeared almost completely from the region where "*tenella*" occurred, though common there in Stimpson's and Verrill's time.

Ciona mollis Ritter, 1907

Ciona mollis RITTER, 1907, p. 35, pl. 3, figs. 35–38.

Ritter's description is based on a single lot of specimens which he says were "very soft and flabby, all in a collapsed and more or less shriveled condition. Form variable, usually somewhat longer than broad, but never greatly so. Semi-transparent, the strong muscle-bands of the mantle and the digestive tract distinctly visible through the test. Siphons distinct though not long. Some of the specimens clinging to fragments of hexactinellid sponge by the posterior end and left side; others adhering to a compound ascidian, and still others to an anemone. Largest specimens about 2.5 to 3 cm. in length."

There is nothing in this statement of the external characters to differentiate it from *C. intestinalis*. The internal structure also leaves no doubt that it belongs in *Ciona* as the following quotation from the description shows:

"Branchial tentacles numerous, more than 200, filiform, of several lengths, the longer and shorter not regularly alternating. Hypophyseal mouth simple, narrow-elliptical, the long axis extending radially with reference to the tentacular circle; gland on ventral side of ganglion, smaller than the ganglion. Dorsal languets finger-like with broad transversely expanded bases, rather close together. Branchial sac with both longitudinal and transverse internal vessels; also with stout papillae. Transverse vessels of two sizes, the larger crossing the stigmata at their middle, the smaller in pairs one each side of each larger vessel, both crossing the stigmata. Longitudinal vessels slightly larger than the smaller transverse ones. Branchial membrane proper without folds, stigmata straight, long and narrow, in regular series, the vessels separating the series of two sizes, the larger and smaller alternating regularly. From four to six stigmata between each two internal longitudinal vessels.

"Digestive Apparatus: Situated on left side far toward the dorsum, general form that of an elongated open S. Oesophagus short, stomach regular, elliptical in longitudinal section, the long axis usually about twice the length that of the transverse; wall regularly and closely plicated, the plicae about twenty in number; situated at the extreme posterior end of the body, the long axis directed transversely to the antero-posterior axis of the animal. Intestine quite as long as the animal and of nearly uniform diameter throughout its length; anal opening near the atrial siphon, surrounded by about eight rounded lobes. No 'liver' present.

"Reproductive Organs: Ovary a compact mass situated in the posterior loop of the intestinal S, near the stomach. Testis not seen. Genital duct (oviduct?) running parallel with the intestine to open near the anus."

The most striking difference from *C. intestinalis* mentioned by Ritter is the presence of "internal transverse vessels." But such vessels are not known in any other ascidians, and his figure (fig. 38) of the branchial sac does not indicate their presence satisfactorily.

However, the deep-sea locality increases the probability that we have to deal with a form distinct from *intestinalis.*

LOCALITY: "Albatross" Station 4425, 21.8 miles off the east point of San Nicolas Island, California, in 1100 fathoms, green mud, sand, and globigerina. About a dozen specimens were taken in one haul of the dredge.

FAMILY **PEROPHORIDAE** GIARD, 1872

Text figures 81, 82

A small group of ascidians closely allied to *Ascidia* and sometimes regarded as a subfamily (Perophorinae) of the Ascidiidae, from which they differ chiefly in the much smaller size of the individuals and in reproducing by budding, although except in one species the

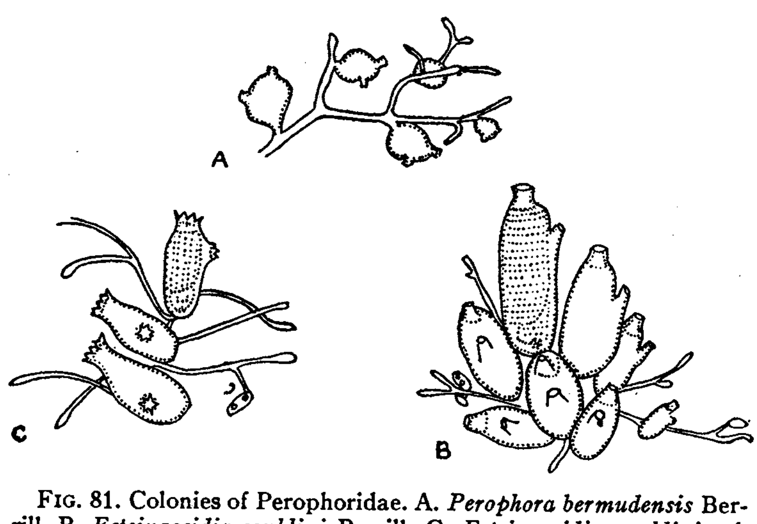


FIG. 81. Colonies of Perophoridae. A. *Perophora bermudensis* Berrill. B. *Ecteinascidia conklini* Berrill. C. *Ecteinascidia conklini minuta* Berrill. All about ×2.

zooids or individuals are separate and have their own covering of test, being connected together only by the stolon from which they arise as buds.

As in the Ascidiidae, the branchial sac has internal longitudinal vessels (sometimes very incompletely developed), but they do not bear papillae.

GENERA OF PEROPHORIDAE

A_1. Zooids small, ovate, not over three to five rows of stigmata . . . . . . *Perophora*

A_2. Zooids oblong or clavate, up to 200 mm. or more long and with 15 to 30 rows of stigmata when adult . . . . . *Ecteinascidia*

GENUS **PEROPHORA** WIEGMANN, 1835

Individuals or zooids of small size, and more or less rounded-ovate, somewhat laterally compressed form, borne on short branches of a vine-like tubular stolon from which they bud off and by which they remain connected with the other members of the colony. In one of our species, however, they may be enclosed in a common mass of test.

The test is transparent; the apertures lobed; the dorsal lamina represented by languets which, however, are joined together by a membrane on the median dorsal vessel. Tentacles simple, of several sizes.

The branchial sac has only a few (three to five) rows of stigmata, and an incompletely developed or rudimentary system of internal longitudinal vessels which do not bear papillae.

Stomach and intestine on the left side of the branchial sac, stomach elliptical in outline; gonads in the intestinal loop. The heart is a tubular organ in the posterior part of the body, and the members of this genus, owing to their small size and the transparency of their tissues, afford an exceptionally good opportunity for observing the pulsations of the heart and their periodical reversal, which is one of the peculiarities of the ascidians.

Perophora viridis Verrill, 1871

Text figures 82D, 83

Perophora viridis VERRILL, 1871, p. 359; 1872a, p. 212; VERRILL AND SMITH, 1873, pp. 703, 388, 401; VERRILL, 1879, p. 27; McDONALD, 1889, p

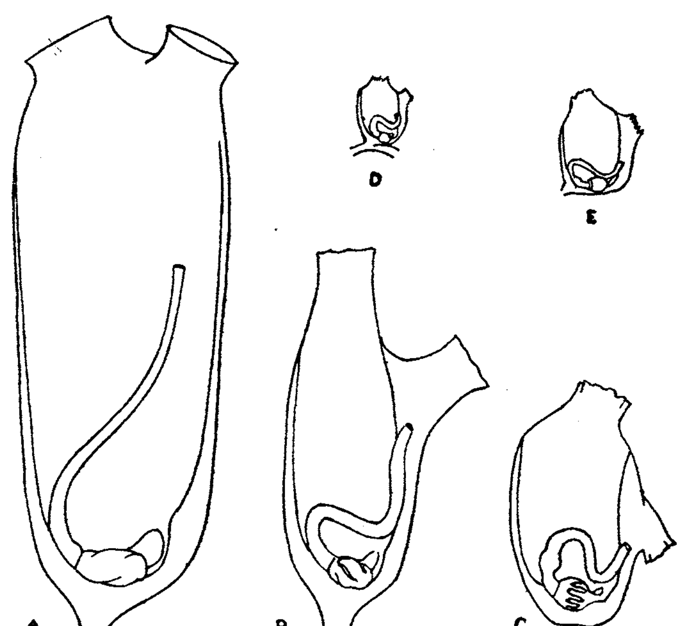


FIG. 82. Zooids of Perophoridae of different species found at the Dry Tortugas, × about 5, to show relative size attained and usual curvature of intestinal tract. A. *Ecteinascidia turbinata* Herdman. B. *E. conklini* Berrill. C. *E. tortugensis* Plough and Jones. D. *Perophora viridis* Verrill. E. *Perophora bermudensis* Berrill. After Plough and Jones, 1939.

858; HERDMAN, 1891a, pp. 158, 159; LEFEVRE, 1897, p. 474; 1898, p. 369; DAVENPORT, 1898, p. 687; BUMPUS, 1898, p. 853; WILSON, 1900, p. 354; METCALF, 1900, p. 508, pl. 34, fig. 14; VAN NAME, 1902, p. 337, pl. 47, fig. 8; 1910, p. 357, fig. 3; SUMNER, OSBURN, AND COLE, 1913, pp. 155, 158–160, 731, chart 193; PRATT, 1916, p. 668; VAN NAME, 1921, p. 373, fig. 52; 1930, p. 460, fig. 33; BERRILL, 1932, pp. 78, 80, fig. 2f, 2g; 1935, pt. 3, p. 280, fig. 12a–12d, pt. 4, p. 358; PRATT, 1935, p. 745, fig. 3; PLOUGH AND JONES, 1937, p. 100; 1939, p. 49, fig. 1d; RICHARDS, 1938, p. 254.

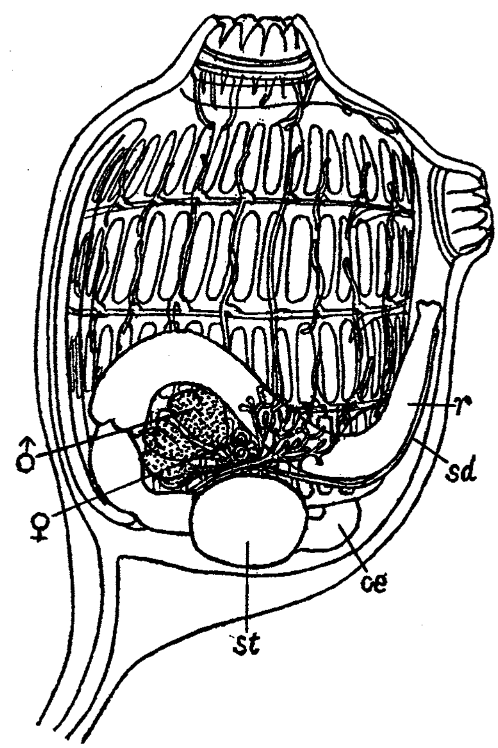


FIG. 83. *Perophora viridis* Verrill. Zooid, ×27.

See statements at end of description regarding the possibility of identity of this species with *P. listeri* of Europe.

The small ovoid, usually somewhat laterally compressed bodies of the zooids of this species, which measure from 2.5 to 3.5 mm. in greatest diameter (length), are borne on the tips of the branches of a slender stolon which grows like a vine over shells, algae, other ascidians, or other submerged objects in shallow water. The zooids have a thin, transparent covering of test; their tissues are usually transparent and colorless, except for some yellowish or green pigment contained in branching vessels in the mantle, which, aside from the sphincters of the apertures, has only a few slender longitudinal and oblique muscle bands. Apertures with a variable number of lobes.

Tentacles apparently in multiples of six. They number about 24, of three sizes or orders. Three languets are borne directly upon the median dorsal vessel. They are connected by a narrow, continuous, smooth-edged membrane.

Branchial sac with four rows of long stigmata; over 20 in a row on each side. Transverse vessels provided with inwardly projecting papillae which support an incompletely developed system of internal longitudinal vessels. They are separated by about the width of two stigmata. These vessels may be very rudimentary, represented only by short unconnected branches on the papillae. Near the endostyle and dorsal lamina they are always very rudimentary, or only the papillae may be developed, but on the lateral parts of the sac some of the vessels may be complete for all or most of the length of the sac.

Digestive tract forming a fairly large loop lying beside the branchial sac on the posterior part of the left side of the body, as in most simple ascidians. Stomach small, ellipsoidal.

Reproductive glands lying in the intestinal loop. Male glands pear shaped or cuneate, arranged in a fan-like manner about the origin of the common sperm duct with which they communicate by small individual ducts. Their number varies in different individuals; in some zooids several of the individual wedge-shaped glands are fused into one or more larger masses, which may be cleft into lobes representing the individual glands. The common sperm duct accompanies the rectum. The ovary lies, when small, beside the proximal part of the sperm duct. An oviduct is very hard to demonstrate, but is said to exist as a very thin-walled tube of considerable diameter extending dorsally and ending near the dorsal lamina. Egg diameter 0.24 mm. (Berrill, 1937).

DISTRIBUTION: Southern shores of Cape Cod, southward to southern Florida, Bermuda, and parts of the West Indies. It is abundant in and on the shores of Vineyard Sound, Massachusetts, growing on piles, algae, larger ascidians, rocks, etc., mostly in very shallow water, but also dredged in depths down to 12 fathoms in Vineyard Sound, and 15 fathoms in Buzzards Bay, where it is less common. It is abundant also at Beaufort, North Carolina, growing on the basal parts of hydroids, on larger ascidians and often directly on rocks on which it may spread over areas several centimeters across. In many of the colonies the zooids are quite crowded but never coalescent, and contain much green pigment in the vessels of the test and in the mantle. Such colonies may cover the rocks in patches measuring up to 5 cm. across. It is also common at the Tortugas. The American Museum of Natural History has specimens from Point Brea, Puerto Rico, dredged in 9.5 fathoms.

Throughout the extensive literature of this species as occurring in America, Verrill's name, *viridis*, has always been employed, but it must be admitted that it is hard to find reason for maintaining it as distinct from the European *P. listeri* Wiegman, 1835, found on the British coasts, or from *P. banyulensis* Lahille, 1887, of the Mediterranean, which is very likely not distinct from *P. listeri*. Harant, in his articles on the European ascidians, has consistently listed *viridis* as one of the synonyms of *listeri*, but does not indicate that he had made any study of American specimens, while Berrill (1935), who did study the development of both *viridis* and *listeri*, fails to combine them. I have not had any opportunity of comparing specimens of the two and am, therefore, following the time-honored custom of calling the American form *P. viridis* Verrill.

Perophora bermudensis Berrill, 1932

Text figures 81A, 82E, 84

Perophora bermudensis Berrill, 1932, pp. 78, 82, fig. 3a; 1935, pt. 4, p. 358, fig. 16a; Ärnbäck, 1935, pp. 4, 5, fig. 1; Plough and Jones, 1937, p. 100; 1939, p. 51, fig. 1e.

The colony is very similar to that of *P. viridis;* in many places the two species grow with their stolons inextricably entangled and their zooids intermingled; in some cases they are also intermingled with zooids of *Ecteinascidia conklini*.

The zooids average in diameter a fraction of a millimeter more than those of *P. viridis*, especially in their anteroposterior diameter, the body being a little more elongate oblong or ovate than in *viridis*. They are often more or less free of the yellowish or greenish color generally noticeable in that species, but the most easily observed difference is in having five rows of stigmata instead of four. The oozooids which develop from tadpoles have but four rows and the buds (blastozooids) that form the colonies have, when young, but four rows. The fifth row forms by transverse division of the first or anterior row by the formation of an additional transverse vessel. Usually, at least, this division is not complete for all the stigmata of the original first row; some of them remain of the original length extending through two rows, the newly formed transverse vessel being interrupted by them or reduced to a narrow parastigmatic vessel where it crosses them. These elongate stigmata are usually from three to six in number on each side of the sac; they do not appear to occur close to either the endostyle or the median dorsal vessels, and they are separated from each other by from one to three or four of the short stigmata. There are 20 or more stigmata in a row on each side; the transverse vessels bear papillae which are separated by little more than the width of one of the stigmata. They bear slender anteriorly and posteriorly extending processes at their summits; except near the endostyle and median dorsal vessel these processes unite to form a more or less complete system of internal longitudinal vessels.

Another very important difference separating this species from *viridis* is in the male part of the gonad. This is that the testis consists of a single more or less unevenly ovate gland, instead of a group of wedge-shaped glands. Egg diameter in this species is 0.24 mm. (Berrill, 1937).

Distribution: Described by Berrill from Bermuda where it is fairly common, growing in the same situations and often mingled with *P. viridis*. It also occurs on the east and west coasts of southern Florida, including the Tortugas (Plough and Jones, 1937, pp. 100, 101) and at Puerto Rico, along the shore near Ponce and off Point Brea in 9½ fathoms. Its occurrence elsewhere in the West Indies is, therefore, to be expected. A well-preserved colony growing in a piece of sargasso weed

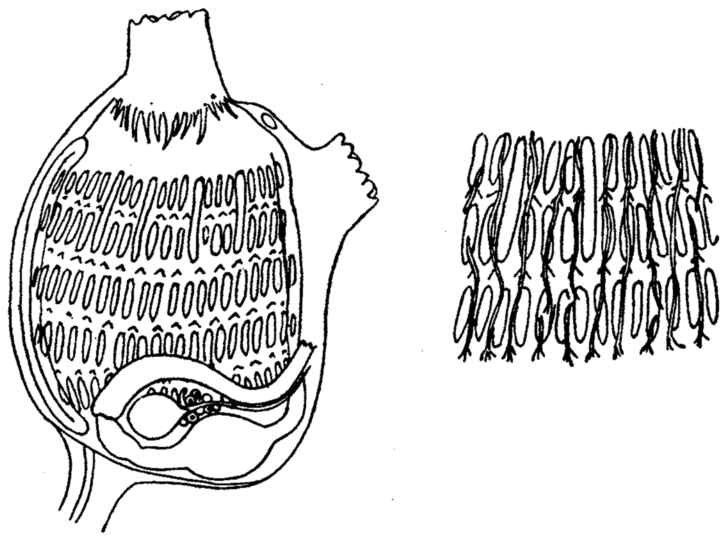


FIG. 84. *Perophora bermudensis* Berrill. Zooid (blastozooid), ×22, and part of the branchial sac seen from the inside to show the internal longitudinal vessels.

was received in the summer of 1941 from W. E. De Turk from Beaufort, North Carolina, where it was washed ashore after a storm. It does not appear to grow in that region.

Ärnbäck, 1936, has described a form that seems practically inseparable from *P. bermudensis* from the Misaki Biological Station, Japan, as a distinct species, *P. orientalis.*

Perophora annectens Ritter, 1893

Perophora annectens RITTER, 1893, pp. 37–85, pls. 1–3; 1895, pp. 366 ff.; 1896, pp. 187 ff., pl. 16, figs. 56–71, pl. 17; HUNTSMAN, 1912, p. 118; 1912a, p. 105, pl. 10, figs. 2, 3, pl. 14, fig. 1; RITTER AND FORSYTH, 1917, p. 464; JOHNSON AND SNOOK, 1927, p. 596, fig. 695; BERRILL, 1932, p. 82; PRATT, 1935, p. 745; RICKETTS AND CALVIN, 1939, p. 78.

Though a typical *Perophora* in the structure of its zooids, this species is apparently unique in the genus in often forming compact colonies in which the zooids, which are closely crowded, are as completely embedded in a common mass of test as is the case in most compound ascidians. Various degrees of fusion of the test of adjacent zooids may occur even in the same colony from zooids entirely separate, and united only by stolons, as in *P. viridis* and other species, through individuals with only the basal parts of the test fused, to those completely embedded, which may form masses measuring several centimeters across, though usually much smaller. But although the species is of rather wide distribution on the Pacific coast, the fused colony form of the species develops, as far as known, only in the vicinity of Monterey Bay, though the tendency is for the colonies, even when composed only of well-separated individuals, to be more compact, with the zooids closer together than in most species of the genus. Of the appearance of this species during life, Ricketts and Calvin, describing the compact colonies, say: "The dull green matrix of the colony is closely adherent to the rocks. When the animal is seen unmolested, the bright orange zooids will be well extended but it has powers of retraction most amazing for a tunicate. If disturbed *Perophora* pulls its delicate zooids away from danger, withdrawing them into the tough tunic of the matrix and thus almost instantly changing the color of the whole colony. The covering of the extended zooids is more transparent even than that of *Clavelina* and through a good hand lens the internal anatomy is quite apparent."

The zooids are much like those of *P. viridis* but average a little smaller; Huntsman gives the dimensions of the largest as 3 mm. long and 2 mm. wide, but these were measurements of separate individuals with their own covering of test, which was no doubt included in the measurement. In the compact colonies the bodies of the zooids in preserved contracted specimens are only 2 mm. or less in greatest measurement.

The branchial aperture is usually six-lobed, the atrial five- or six-lobed. There are four rows of stigmata (not three as stated by Berrill, 1932) with about 24 in a row on each side (Ritter gave a smaller number, 18 in a row). Tentacles "upwards of a dozen in two or three rows," according to Huntsman. The papillae on the transverse vessels of the branchial sac bear anterior and posterior processes, but both Ritter and Huntsman agree that the processes do not join to form continuous internal longitudinal vessels; neither was I able to demonstrate such vessels in specimens I have examined. The testis, according to Huntsman, usually has from two to five lobes which converge toward the ovary. Egg diameter 0.24 mm. (Berrill, 1937).

DISTRIBUTION: Pacific Coast from Ucluelet on the west coast of Vancouver Island, "growing over various objects on vertical, exposed rocks between tides" (Huntsman, 1912a) southward to San Diego. Monterey Bay, especially the vicinity of Pacific Grove, is, however, the center of abundance of the species and, as stated above, it is there only that the compact colonies develop. At Pacific Grove it is abundant on the intertidal rocks, especially on the parts uncovered only at spring tides, even where there is considerable wave action.

GENUS **ECTEINASCIDIA** HERDMAN, 1880

The zooids much resemble those of *Perophora* but are considerably larger, of more elongate form, and have many more rows of stigmata. The species are quite uniform in their structure, which is well exemplified by *E. turbinata*, described below.

The supposed genus *Perophoropsis* Lahille, 1890, which is intermediate between *Perophora* and *Ecteinascidia* in the size of the zooids and the number of rows of stigmata in their branchial sac, is probably based on the young of *Ecteinascidia*, as no one has reported finding examples with reproductive organs.

This is the view of Berrill, who figures (1932, p. 82, fig. 3b) such a zooid from Bermuda which he considers (probably correctly) to be a zooid of *E. conklini*. A somewhat older zooid figured in Van Name (1902, pl. 47, fig. 4) as an immature *E. turbinata* (the only species of *Ecteinascidia* known from Bermuda at that time) may also be *conklini*.

Ecteinascidia turbinata Herdman, 1880

Plate 20; text figures 82A, 85, 86

? *Ascidia claviformis* LESUEUR, 1823, p. 5, pl. 1, fig. 3.

Ecteinascidia turbinata HERDMAN, 1880, p. 724; 1882 (in part), p. 243, pl. 36, figs. 1–6; LEFEVRE, 1897, p. 474, figs. 1–6; 1897a, p. 433; VERRILL, 1900, p. 588; METCALF, 1900, pp. 507, 588, pl. 34, fig. 12, pl. 38, fig. 65; VAN NAME, 1902, p. 338, pl. 47, figs. 4, 6, not pl. 59, fig. 116; MICHAELSEN, 1918, p. 67; VAN NAME, 1921, p. 375, fig. 54; 1930, p. 461, fig. 34; BERRILL, 1932, p. 78, fig. 1; 1935, pt. 3, p. 282, figs. 12j, 13d, pt. 4, p. 358, fig. 16d; 1936, p. 61, fig. 13; PLOUGH AND JONES, 1937, p. 101; 1939, p. 51, fig. 1a.

See also remarks under distribution of this species.

The colony in this species consists of a dense group or cluster of elongate, somewhat club-shaped zooids, each with its own separate covering of test, which are connected by their tapering bases with a network of stolons that adheres to the surface of the object on which the colony grows. Mangrove roots and turtle grass are among the most frequent bearers of such colonies; in such cases the colony generally entirely surrounds the root or the grass, not infrequently for a length of 12 or 15 cm. (See pl. 20.)

Zooids ordinarily about 20 mm. long or less, but occasionally larger. They are of oblong form, truncate at the anterior end where the two apertures are situated, and rather abruptly tapered at the other end to a narrow pedicel containing the vessel that connects the individual with the rest of the colony.

Test transparent and colorless, thicker on the ends of the body. Mantle and internal organs also very transparent, but in the living zooids and in specimens not too long preserved, this shades into yellow, orange, or pinkish orange on the anterior part of the body, the color being largely due to pigment in cells in branching vessels in the mantle.

The intestinal loop is colored yellow or orange. A large colony of this species that the writer collected on mangrove roots at Plantation Key, Florida, had the zoids almost en-

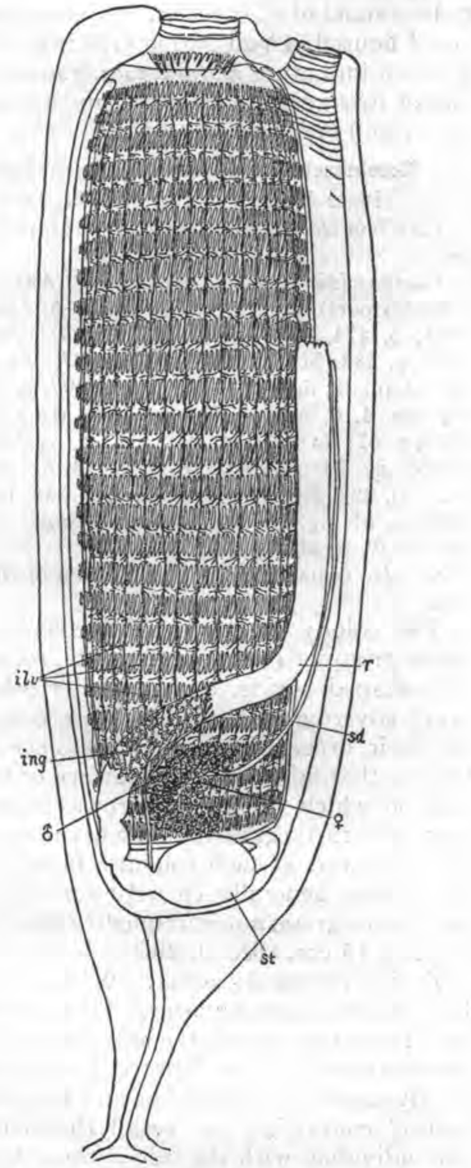


FIG. 85. *Ecteinascidia turbinata* Herdman. Zooid, × about 7.

tirely bright orange during life, but most of this color quickly faded out on preservation, remaining only on the anterior part of the body.

Apertures on short tubes or slight elevations which often do not project beyond the surface of the thick layer of test covering this end of the body. Margin of apertures thin; when expanded it varies from almost plain to quite deeply and irregularly sinuate. In contraction it is always more or less sinuate. The branchial aperture is larger and a little farther anterior than the atrial, though both are usually directed straight forward.

Mantle musculature slight. The sphincters of the apertures consist of slender, slightly separated bands, and numerous very narrow transverse bands cross the dorsal region and extend down the sides, but are wanting on the ventral regions. Tentacles filiform, quite

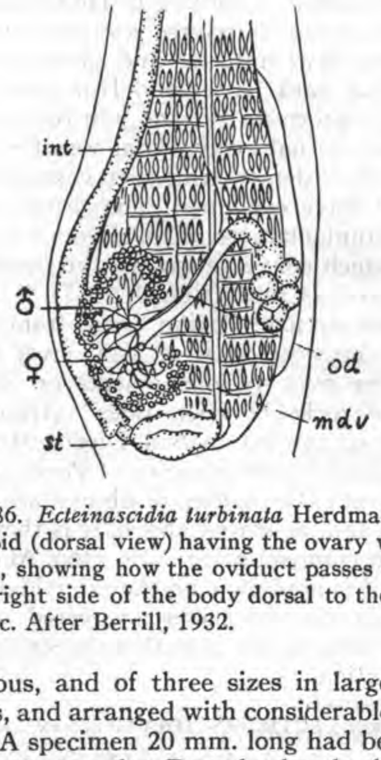


FIG. 86. *Ecteinascidia turbinata* Herdman. Part of a zooid (dorsal view) having the ovary well developed, showing how the oviduct passes around to the right side of the body dorsal to the branchial sac. After Berrill, 1932.

numerous, and of three sizes in large individuals, and arranged with considerable regularity. A specimen 20 mm. long had between 30 and 40 tentacles. Dorsal tubercle elongate oval. Dorsal lamina a continuous membrane which is extended into a well-developed languet at each transverse vessel, or it may be described as a series of languets connected by a basal membrane. It lies turned over toward the right side of the body.

Branchial sac long, barrel shaped, with about 27 to 30 rows of small, oval, or elongate stigmata. They are rather irregular in width and to some extent also in length. There are about 60 in a row. At intervals of about three or four stigmata the transverse vessels bear small papillae which support on their tips a system of exceedingly slender, yet in most parts of the sac completely developed, internal longitudinal vessels. The supporting papillae have their bases broad in a direction parallel to the transverse vessels. Along the sides of the endostyle and the median dorsal vessel, the first internal longitudinal vessel may be incompletely developed, or represented only by its supporting papillae.

Stomach elliptical, intestinal loop open dorsally, rectum long and stright, lying along the dorsal border of the branchial sac on the left side and ending about opposite the tenth row of stigmata from the anterior end in a slightly lobed aperture. Intestinal gland well developed. It encloses the ascending part of the intestinal loop for a considerable distance and consists of crooked branching tubules ending in minute bulbs. These tubules unite to a number of slender ducts which leave the intestine and converge to form a stout common duct that enters the intestine just beyond the pylorus, as in *Perophora*.

Reproductive organs in the bend of the intestinal loop. The male portion consists of a C-shaped or horseshoe-shaped group of small oval or lobed glands which lie more or less concentrically with the curvature of the intestine. The common sperm duct accompanies the rectum almost to the anus. The ovary consists of a cluster of eggs in the bend of the C-shaped group of testes. The oviduct extends to and beyond the middorsal line, discharging the eggs into the right side of the atrial cavity where they develop. Breeding season at Bermuda, June to August or September (Berrill, 1932).

Young zooids have the body shorter and more oval, the apertures more prominent and relatively farther apart, and the rows of stigmata less numerous than in the adult.

Ripe eggs of this species are 0.72 mm. in diameter, according to Berrill, 1937. The tadpole has as many as 12 rows of stigmata.

DISTRIBUTION: It is common and widely distributed in, and is one of the most conspicuous ascidians of, the West Indian region on account of the large size and bright color of the colonies. It occurs in the shallowest situations; its habit of growing on mangrove roots and turtle grass has already been mentioned.

It is common in Bermuda (the type locality); southern Florida (Tortugas, Plantation Key, Grassy Key, very abundant also on flats near Rabbit Key, Bay of Florida); and in the Bahamas (Andros Island). Lefevre (1897) collected it at Jamaica; the steamer "Albatross," at St. Thomas (shore).

Reports of it from Old World localities (see Rennie and Wiseman, 1906, Herdman, 1882, p. 245, and Michaelsen, 1918, p. 67) are to be mistrusted, as very probably referring to allied species.

This species may be identical with *Ascidia claviformis* Lesueur, 1823, from St. Vincent, but Hartmeyer, 1912a, has expressed a different opinion, identifying (doubtfully) *Clavelina oblonga* with Lesueur's species. Herdman (1906, p. 299) gives the present writer as authority for the statement that *Ecteinascidia thurstoni*, an Indian Ocean species, occurs at Bermuda. Herdman must have had in mind the present species (*E. turbinata*).

Ecteinascidia conklini Berrill, 1932

Text figures 81B, 82B, 87A, 87B

? *Ascidia albeola* LESUEUR, 1823, p. 3, pl. 2, fig. 1; VAN NAME, 1921, p. 482.

? *Ascidiella styeloides* VAN NAME, 1921, pp. 391, 483; 1930, p. 470, fig. 42.

? *Ecteinascidia albeola* HARTMEYER, 1909–1911, pp. 1412, 1630.

Ecteinascidia conklini BERRILL, 1932, pp. 78, 80, figs. 2a, 2c, 3b; 1935, pt. 3, pp. 257, 282, figs. 12e–12i, 13b, 13c, pt. 4, p. 358, fig. 16c; PLOUGH AND JONES, 1937, p. 101; 1939, p. 53, fig. 1b; ? VAN NAME, 1902, pl. 59, fig. 116.

Perophoropsis herdmani BERRILL, 1932, p. 82, fig. 3b. (See under genus *Ecteinascidia*.)

? *Phallusia styeloides* TRAUSTEDT, 1882, p. 277, pl. 4, fig. 5, pl. 5, fig. 16.

The colonies of this species are less compact and more irregular than those of *E. turbinata* and contain fewer zooids; these are attached to the straggling stolons by their narrowed posterior ends, as in that species.

The zooids are smaller, the body usually not over about 13 mm. long and of more ovate form, with a longer branchial siphon at the anterior end; the atrial siphon is prominent and diverging and situated some distance back on the dorsal side of the body. Berrill, 1932, writing of the species at Bermuda, mentions also the following differences from *turbinata:* it is found only on the under side of rocks, the color is green or yellow green with only a thin red ring around the siphons, sometimes absent; the rows of stigmata average about 20.

The eggs are smaller, 0.58 mm. (Berrill, 1937), and the tadpoles are also smaller and have but six rows of stigmata.

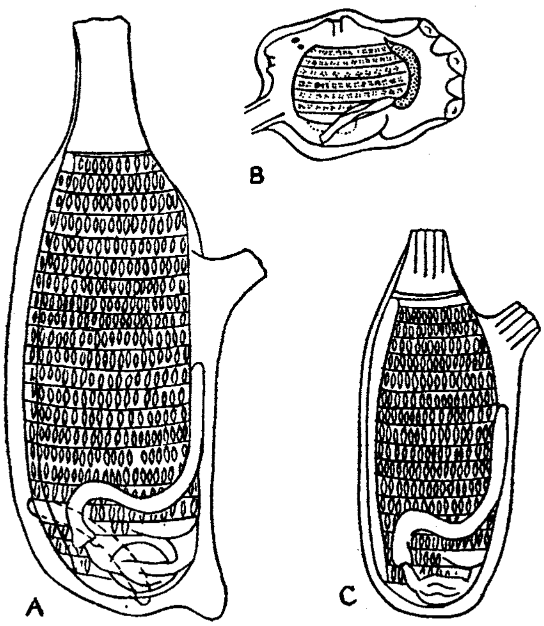


FIG. 87. *Ecteinascidia conklini* Berrill. A. Zooid, × about 8. B. Anterior end of tadpole larva of same. C. *Ecteinascidia conklini minuta* Berrill. Zooid, × about 8. After Berrill, 1932.

DISTRIBUTION: Besides occurring at Bermuda, the type locality, this species is found on both coasts of southern Florida, especially at Tortugas (Plough and Jones, 1937), and in the West Indies, where it is probably widely distributed. The American Museum of Natural History has specimens from Puerto Rico and Haiti, and I now believe that "*Phallusia styeloides*" of Traustedt, from St. Croix and St. Thomas, may be the present species, though his figure shows the intestine somewhat more curved than usual.

There can hardly be any question that Traustedt's species was an *Ecteinascidia*, but as to the species there is room for uncertainty, and I am, therefore, refraining from replacing Berrill's name, which has been established in use. Indeed, it may well be retained as a *nomen conservandum.*

In former articles (1921, 1930) I placed Traustedt's species in *Ascidiella*, an Old World genus related to *Ascidia* but resembling *Ecteinascidia* in having no papillae on the internal longitudinal vessels.

Ecteinascidia conklini minuta Berrill, 1932

Text figures 81C, 87C

Ecteinascidia conklini var. *minuta* BERRILL, 1932, pp. 78, 80, fig. 2b; 1935, pt. 3, p. 283, pt. 4, p. 358, fig. 16b; PLOUGH AND JONES, 1937, p. 101.

"This form was found with mixed colonies of *E. conklini typica* and *Perophora viridis*. . . . It is smaller; the number of rows of stigmata rarely exceeds fifteen; the atrial siphon is short and close to the branchial siphon, while both bear prominent ridges, and the eggs and larvae are smaller, although the tadpole possesses six rows of stigmata as in the other. The breeding season, as far as known, coincides with that of *E. conklini typica.*

"Probably the most definite feature distinguishing both *E. conklini typica* and *minuta* from *E. turbinata* is the curvature of the intestine in the former, tending to form a secondary loop. The intestine of *E. turbinata* is but very slightly curved in comparison" (Berrill, 1932, p. 80).

Berrill's figure 2 shows that *minuta* has about two-thirds the body length of the typical *conklini* and eggs of about three-quarters of the diameter of those of the typical *conklini.*

DISTRIBUTION: Described by Berrill from Bermuda. Plough and Jones, 1937, report it from Tortugas, Florida.

Ecteinascidia tortugensis Plough and Jones, 1939

Text figures 82C, 88

Ecteinascidia tortugensis PLOUGH AND JONES, 1937, pp. 100, 101, *nomen nudum;* 1939, p. 50, figs. 1c, 2, pls. 1–5.

A species with small zooids, averaging 5 to 6 mm. long, yet considerably larger than those of *Perophora.*

"The mode of attachment of *E. tortugensis* is peculiar, resembling some of the larger solitary species of *Ascidia*. It has no stalk, though stolons grow off from the posterior ventral border. The test however adheres to the adjacent rock by at least half its length along the ventral side. This makes it very difficult to remove from the rock uninjured. . . . The test is very thin along the area of attachment and is easily broken. Young budding colonies have the zooids scattered at intervals of 5 to 10 mm. connected by the thin branching stolons. Older colonies may have the zooids so crowded as to form a mat, with their tests adherent to each other as well as to the rock.

"Another character which distinguishes this species from other *Ecteinascidia* is the position of the siphons. These are placed on the dorsal side above the dorsal lamina, and opposite the area of attachment. The oral siphon is anterior but ordinarily opens upward, while the atrial siphon is placed dorsally about two-thirds of the way toward the posterior end of the body and is ordinarily directed away from the oral one. Such wide separation of the siphons is never found in *E. turbinata* though an approach to it may occasionally occur in *E. conklini*" (Plough and Jones, 1939, pp. 51–53).

This species has little color; with a lens the zooids appear to have a light yellowish green color. The colonies spread over the rock or other object to which they are attached and are often mixed with colonies of *Perophora bermudensis*.

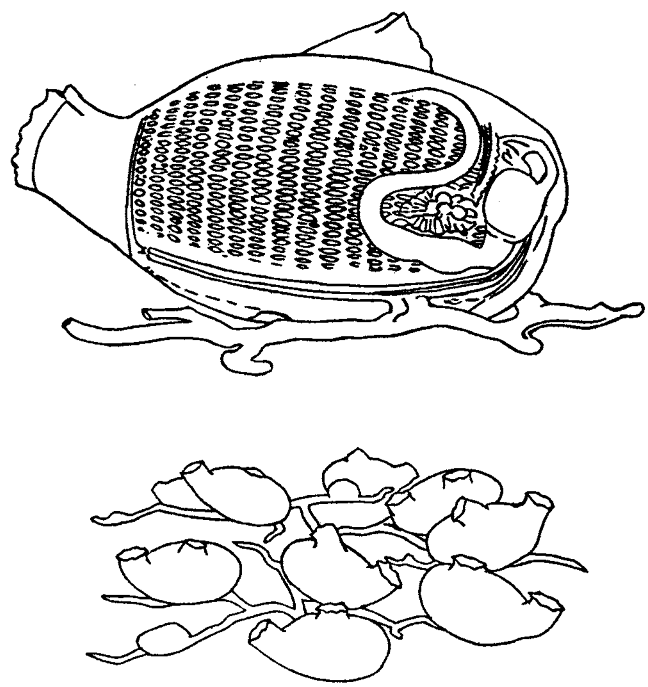


FIG. 88. *Ecteinascidia tortugensis* Plough and Jones. Zooid, ×30, and colony, ×5. After Plough and Jones, 1939.

The adult zooids usually have 20 to 30 tentacles of three sizes and 18 rows of stigmata, and can be distinguished from the other species of the region by the greater curvature of the intestine which is recurved almost down to the stomach. The rectum is short; it ends not farther forward than the anterior bend of the intestine. The testicular lobes are larger and less numerous than in *E. turbinata*. The short wide oviduct is difficult to see unless an egg is passing through it. The undivided eggs are about 0.5 mm. in diameter, in young larvae, four, later six, rows of stigmata are present in the tadpole larva. *E. tortugensis* reaches sexual maturity in July, about two weeks later than *E. conklini*. Stolon growth and budding begin after the period of sexual maturity.

DISTRIBUTION: Type and only locality thus far reported, the Tortugas, Florida, where it has been collected on several of the Keys, and in July, 1938, it was one of the commonest ascidians at the Tortugas.

This species was first recognized as distinct by Caswell Grave, though he did not publish a description. It was carefully described and illustrated and its development studied by Plough and Jones (1939). The type is in the American Museum of Natural History (A.M.N.H. No. 1445).

FAMILY ASCIDIIDAE HERDMAN, 1880
Nomen Conservandum
(= Phallusiidae auct. mult.)

This family, very extensive in older usage, is, as employed in the present work, coëxtensive with the genus *Ascidia* as far as any American ascidians are concerned. See under that genus for its characters.

It is distinguished from the Rhodosomatidae, the other large family of Phlebobranchia, by the course of the intestinal canal. In Ascidiidae its course is the usual and normal one in most ascidians; the proximal part of the intestine extends forward and bends dorsally after leaving the stomach, so that the intestinal loop is on the left side of the branchial sac, while in the Rhodosomatidae it bends ventrally, bringing the rest of the intestine on the ventral and more or less on the right side of the body.

As here employed, the Ascidiidae are exclusively simple ascidians with straight (not spiral) stigmata, the compound genera *Perophora* and *Ecteinascidia*, though closely related, being treated as a separate family.

GENUS ASCIDIA LINNAEUS, 1767
Nomen Conservandum
(= *Phallusia* auct. mult.)

This is the original Linnaean genus of ascidians, comprising, in the usage of many early authors, most of the simple ascidians. In the greatly restricted sense in which it is now employed, it is still the largest and most important genus of the order Phlebobranchia and of the family Ascidiidae. Many of its species attain considerable size.

Phallusia Savigny, 1816, although a very comprehensive group as that author used it, was much nearer to the modern concept of the group with which we are dealing and was used for it by many authors, including especially Traustedt (1882) and Hartmeyer (1909–1911) in the classification employed in Bronn's "Tier-reich," in which he tried to place the classification on a basis according with the International Rules of Nomenclature. I followed him in this in my articles of 1912, 1921, and 1924 on the eastern American ascidians, but in more recent works there has been an almost universal return to *Ascidia* as a *nomen conservandum*.

Typical members of the genus in its present restricted sense usually have the body somewhat elongate, oval, laterally flattened, and attached by the posterior part or much of the left side, the apertures on siphons, the branchial about eight-lobed and terminal, the atrial six-lobed and more or less back on the dorsal side, the test fairly tough but somewhat translucent or semi-transparent.

The mantle musculature consists of narrow bands and fibers running in various directions; their arrangement often affords specific characters; the muscles are best developed on the right side, the left side being in some species almost entirely without them except on the siphons.

The branchial tentacles are simple, usually numerous and of several sizes, the ganglion and neural gland some distance posterior to the dorsal tubercle and connected with it by a tubular duct; there is a continuous dorsal lamina which may, however, be more or less toothed.

The branchial sac is without folds but with a minute longitudinal fluting or undulation by which its functional surface is increased. The stigmata are straight, longitudinal in direction and in rows separated by transverse vessels usually of several sizes or orders. There is also a system of well-developed internal longitudinal vessels which bear prominent, often curved, papillae at the intersections with the transverse vessels and in some species smaller "intermediate" papillae halfway between them.

The alimentary tract lies on the left side of the branchial sac. The stomach, which is wide and laterally flattened, lies far back and is somewhat transverse; from it the intestine extends forward, then loops back toward the stomach before again bending forward or dorsally to form the rectum. The gonads are both branching organs ramifying over the intestinal loop and adjacent structures; the oviduct, which is a tube of large diameter serving to store the eggs for some time, and the slender common sperm duct both accompany the rectum. Numerous minute, closed, renal vesicles containing concretions are present in the vicinity of the digestive organs in many species.

Among the characters employed in distinguishing species are the arrangement of the mantle muscles, the presence or absence of intermediate papillae, the number of tentacles and internal longitudinal vessels, the character of the dorsal tubercle, the dentition or lack of it of the dorsal lamina, the development of the fluting or minute plications of the branchial sac, the degree of curvature of the intestinal loop, and whether or not the branchial sac extends posterior to the alimentary tract. All these may have taxonomic significance, but are often obscured by individual or age variation so that species determination is not always easy, and far too many species have been described. In spite of the comparative compactness of the group, it has not been exempt from efforts to split it up. (See Huntsman, 1912, 1912a.)

Ascidia prunum O. F. Mueller, 1776
Nomen Conservandum
Plate 4, figure 3; text figures 89, 90

The course adopted by Hartmeyer (1924) in retaining Mueller's (1776) name for this species is followed here. See remarks under *A. obliqua.*

The present species and *A. callosa* Stimpson, 1852, were confused in older works (including my own article of 1912 on the New England simple ascidians), until the differences were made clear by Hartmeyer (1924, pp. 25, 33, etc.). That author devoted much time and labor in an effort to determine to which species the numerous references to *prunum* and its synonyms applied, but found that the majority of them might refer to either species or both.

The following references except for the few of 1924 and later dates must, therefore, be understood as often probably applying, at least in part, to *A. callosa* as well as to *A. prunum* and, conversely, especially when they refer to the northeastern American region and waters about Greenland where both species are common.

Ascidia callosa. See remarks above.

Ascidia complanata FABRICIUS, 1780, p. 332; PACKARD, 1867, p. 276; VERRILL, 1870, p. 383; BINNEY, 1870, p. 26; DALL, 1870, p. 255; VERRILL, 1871, p. 98, fig. 11; 1872, pp. 3, 5; 1872a, p. 289; 1885, p. 529; KIAER, 1893, p. 36, pl. 1, fig. 12; 1896, p. 6; WHITEAVES, 1901, p. 266; KINGSLEY, 1901, p. 183; STAFFORD, 1912, p. 64; SUMNER, OSBURN, AND COLE, 1913, p. 730.

Ascidia glacialis JACOBSOHN, 1892, pp. 159, 167, 168.

Ascidia prunum O. F. MUELLER (see under *A. obliqua*), 1776, p. 225; KIAER, 1893, p. 38; HARTMEYER, 1903, p. 285, figs. 22–31, pl. 5, figs. 16, 17, pl. 13, figs. 1–5; BJERKAN, 1905, p. 15; REDIKORZEV, 1908, pp. 20, 29–30; BJERKAN, 1908a, p. 82; HARTMEYER, 1920, p. 130; 1921a, p. 69; 1922a, p. 17; 1924, p. 26, pl. 1, figs. 11–14; HUUS, 1930, p. 4, fig. 3; ÄRNBÄCK, 1934, p. 55, fig. 15, pl. 2, figs. 10, 11, pl. 6, fig. 42.

Ascidiopsis complanata (*complanatus* in some works) VERRILL, 1872a, pp. 214, 289; WHITEAVES, 1872, p. 348; VERRILL, 1873–1874, vol. 5, p. 101, vol. 7, pp. 39, 43, etc.; 1874, pp. 352, 355, etc.; WHITEAVES, 1874, p. 12; 1874a, p. 214; 1879, p. 27; VERRILL AND RATHBUN, 1879, p. 231; BAIRD, 1882, p. 806; MCDONALD, 1889, p. 856; KINGSLEY, 1901, p. 183.

Ascidiopsis nanaimoensis HUNTSMAN, 1912, pp. 113, 114, 119; 1912a, p. 115, pl. 10, fig. 6, pl. 14, fig. 6.

Cynthia complanata STIMPSON, 1860, p. 2.

Phallusia glacialis TRAUSTEDT, 1886, p. 426, pl. 37, figs. 16, 17, pl. 38, fig. 24, pl. 39, fig. 30.

Phallusia prunum KUPFFER, 1875, p. 211; HARTMEYER, 1912, pp. 439, 440; VAN NAME, 1912, p. 599, pl. 66, fig. 129, pl. 72, fig. 156 (not the other figures); HARTMEYER, 1914b, p. 1110.

This is one of three rather large and conspicuous species of *Ascidia* (the other two being *A. callosa* and *A. obliqua*) of the colder regions of both the Old and New Worlds, all of which are common in the waters of northeastern North America, and may be so much alike externally that even an experienced observer would often find it difficult to determine them with certainty without cutting the specimens open, especially when only preserved material is available.

All three of them have the body of more or less oval outline, generally attached by a considerable area on the left ventral region or often by the entire left side. The body is more or less compressed from side to side or in an oblique direction. The apertures are quite well separated, the branchial (normally eight-lobed) near the anterior end, the atrial (normally six-lobed) near the middle of the body. Both apertures may be nearly even with the surface or raised on papillae or very short tubes.

The test varies from translucent grayish to quite opaque; its thickness and consistency vary to some extent with the species, and also in individual specimens, and with the conditions and methods of preservation. When removed from the test, the body has in all three species a broad oval or oblong outline, truncated or somewhat rounded behind, and is almost entirely occupied by the branchial sac

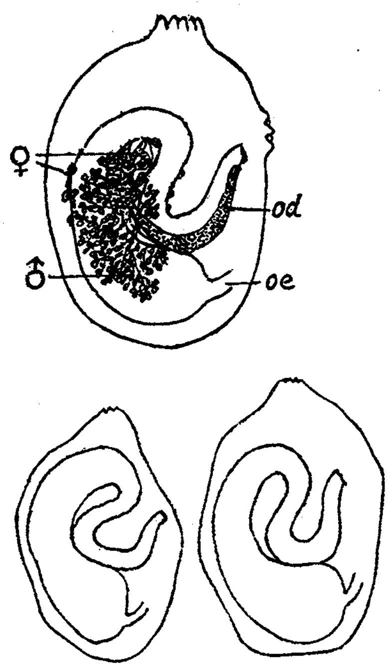


FIG. 89. *Ascidia prunum* Mueller. Somewhat enlarged, and outlines of two other individuals, nearly natural size.

and the alimentary tract which is beside it; the stomach with its axis transverse or slightly oblique in direction lies almost or quite at the end of the sac. Of these three species *A. obliqua* is at once distinguishable from the others by having papillae only at the intersections of the vessels of the sac, "intermediate" papillae being absent.

The subject of the present description, *A. prunum*, differs from *callosa*, the other of the two remaining species, in averaging of rounder (less oval or elongate) form having a thinner, more flexible, yet slightly cartilaginous test that is smooth in young specimens but more or less wrinkled and sometimes overgrown with other organisms in old ones. *A. prunum* does not usually reach as large size as *callosa*, a length of over 50 mm. being more or less exceptional and 40 to 45 mm. not usually exceeded. Yet Hartmeyer mentions one from west Spitzbergen 69 mm. long.

The test of *A. prunum* is grayish, often with a pale greenish or yellowish tinge, and varies from translucent to nearly opaque; in preservation it often becomes more decidedly brownish or yellowish.

Of the various internal characters in which *prunum* and *callosa* differ, one affords such an easy means of determination that it should be mentioned first. This is the number and spacing of the internal longitudinal vessels of the branchial sac. While in 13 specimens of *prunum* ranging in length from 11 to 43 mm. after removal from the test, Hartmeyer (1924) found these vessels to number from 37 to 58 on the left side and from 41 to 70 on the right side (the number usually increasing fairly regularly with the size of the specimen); the number in a similar lot of specimens of *callosa* of corresponding sizes ranged from 15 to 23 on the left side and 17 to 25 on the right

FIG. 90. *Ascidia prunum* Mueller. Piece of branchial sac.

side. This results in the meshes being nearly square instead of oblong and usually containing fewer (commonly about five to nine) stigmata in *prunum* than in *callosa*. The internal longitudinal vessels are more slender in *prunum*. Both species have papillae at the intersections of the vessels and smaller intermediate papillae on most parts of the sac; they are straight or only slightly curved and are usually better developed in *prunum* than in *callosa*. In *prunum* the small plications of the branchial sac are farther apart than the internal longitudinal vessels; the opposite condition prevails in *callosa*.

Other characters of *prunum* are a greater number of branchial tentacles, usually 40 to 50, representing four orders more or less regularly arranged, compared with a usual maximum of about 30 in *callosa*, a simpler U-shaped or crescent-shaped aperture to the dorsal tubercle instead of one with curved (usually incurved or often slightly inrolled) ends as usual in *callosa*. In both species the open interval is forward, and the ganglion only a little posterior to the tubercle. In both, the dorsal lamina has ribs (strongest on its left side) corresponding to the transverse vessels of the sac, and its free border is toothed in correspondence to the ribs; between their teeth there may be smaller ones developed, especially in *A. prunum*. In both species the dorsal lamina extends past to the left of the mouth of the oesophagus, which is situated a little way forward of the rear end of the sac. Anterior to the right side of the oesophagus mouth a similar but narrower lamina, also toothed (especially anteriorly), arises and extends toward the rear end of the sac.

The intestinal tract is voluminous in both species; though there is much individual variation, it may cover the greater part of the left side except near the anterior end, and the stomach, which is oval or pear shaped, tapering into the intestine, has a number of longitudinal plications in its wall, though the surrounding tissues often conceal this fact.

In average specimens of *prunum* the intestinal tract is bent into a somewhat more compact S-shaped curve, with the anterior loop bent more obliquely dorsally than in most examples of *callosa*, but this is far from being the case in all individuals.

In both species the small renal vesicles in the tissues in the region of the alimentary tract are abundant and conspicuous.

The ovary in both species lies chiefly between the intestinal loop and the branchial sac, being more or less visible in the anterior loop of the intestine; one or more branches of it may ramify on the outer aspect of the intestine (the side toward the mantle). The slender branches of the testes when well developed spread over both aspects of the intestine and parts of the stomach. The oviduct and sperm duct (the former usually distended with eggs) accompany the rectum lying along its dorsal aspect. Egg diameter of *A. prunum* 0.18 mm., according to Berrill, 1937.

DISTRIBUTION: A species of the Arctic and northern regions especially abundant in the Old World waters about Nova Zembla, Spitzbergen, Norway, etc., extending westward to Iceland and Greenland (both coasts) and the Newfoundland banks. It ranges southward to the Skagerak in the Old World and to the banks off Cape Cod and Nantucket on the American side. (Most southern record, United States Fish Commission Station 2580, 41° 25′ 30″ N., 69° 01′ W., 83 fathoms, sand.) It must be considered circumpolar if we follow Hartmeyer in including in it *A. nanaimoensis* Huntsman from Northumberland Straits, British Columbia, as I am doing in this work.

It is an inhabitant of moderate depths, and, on the northeastern American coast at least, it does not appear to occur near the tidal zone but in depths of at least a few fathoms. (Records from near low-water mark probably actually refer to *A. callosa*. See under that species.) The most favorable depths seem to be between 20 and 100 fathoms, though there are records of nearly double this depth. (See also remarks on distribution of *A. callosa*.)

Ascidia dijmphniana (Traustedt), 1886
Text figure 91

Ascidia dijmphniana JACOBSOHN, 1892, pp. 158, 159, etc.; HARTMEYER, 1903, p. 293; 1920, p. 131; 1924, p. 53, pl. 1, fig. 17; ÄRNBÄCK, 1934, p. 47, pl. 2, fig. 9.

Phallusia dijmphniana TRAUSTEDT, 1886, p. 424, pl. 36, figs. 3, 4, pl. 37, figs. 18, 19, pl. 38, fig. 23, pl. 39, fig. 29.

Probably not *Ascidiopsis dijmphniana* Huntsman, 1929, p. 5 (= *A. prunum*).

For other references, see Hartmeyer, 1924, p. 53.

A species closely related to *A. prunum* and similar to it in most respects, but having a much larger number of internal longitudinal vessels, when specimens of similar size are compared. A specimen of *dijmphniana* only 26 mm. long had, according to Hartmeyer (1924), 80 on the left and over 100 on the right side, while in a specimen of *prunum* of the same size there were only 47 on the left and 56 on the right. There is also said to be a difference in the curvature of the intestinal canal, the loop being bent more dorsally, coming almost in contact with the rectum, which is long, and with the upper border of the stomach. The ovary ramifies over the mesial aspect of the intestine, the testes over the surface of the stomach.

FIG. 91. *Ascidia dijmphniana* (Traustedt). Outlines of three individuals removed from test, somewhat enlarged. Left (type specimen) after Hartmeyer, 1924, and right, after Huus, 1929.

DISTRIBUTION: It is a rare Arctic species mainly of Old World waters, which has apparently been reported correctly only once (Ärnbäck, 1934) from America: Baffin Bay, 72° 37′ N., 56° 52′ W., 120 meters, stone and gravel. The type locality (Traustedt) is the Kara Sea. The depths recorded for it range frm 10 to 271 meters.

Ascidia callosa Stimpson, 1852

Plate 4, figure 5; text figures 92–94

Ascidia adhaerens RITTER, 1901, p. 227, pl. 27, figs. 1–5.

Ascidia (Ascidiopsis) columbiana ÄRNBÄCK, 1934, p. 53, figs. 13, 14.

Ascidia callosa STIMPSON, 1852, p. 228; 1860a, p. 2; PACKARD, 1863, p. 412; 1867, p. 276; BINNEY, 1870, p. 26, pl. 23, fig. 318; DALL, 1870, p. 255; HARTMEYER, 1915, p. 313; 1924, p. 41, pl. 1, figs. 15, 16; HUUS, 1930, pp. 1–7, figs. 1, 2, 4, 5; PROCTER, 1933, p. 284; ÄRNBÄCK, 1934, p. 49, fig. 12, pl. 4, figs. 19–26, pl. 6, figs. 43, 44; PRATT, 1935, p. 745.

Ascidia griffini HARTMEYER, 1916, p. 408.

Ascidia inornata VERRILL, 1879, p. 196; VAN NAME, 1912, p. 603; HARTMEYER, 1924, p. 50. Not Hancock, 1870.

Ascidiella griffini HERDMAN, 1898, p. 256, pl. 12, figs. 1–3.

? *Ascidiella incrustans* HERDMAN, 1898, p. 255, pl. 12, figs. 4–6.

Ascidiopsis columbiana HUNTSMAN, 1912, pp. 113, 114, etc.; 1912a, p. 110, pl. 10, fig. 5, pl. 14, figs. 5, 7, 8.

Ascidiopsis complanata VERRILL, 1872a, p. 289, pl. 8, fig. 8; 1879, p. 27.

Ascidiopsis prunum HUNTSMAN, 1912, p. 138; 1922, p. 3; 1922a, p. 5.

Phallusia adhaerens RITTER, 1913, p. 499.

Phallusia inornata VAN NAME, 1912, p. 603.

? *Phallusia koreana* TRAUSTEDT, 1885, p. 14, figs. 3, 4, pl. 2, fig. 15.

Phallusia olrikii TRAUSTEDT, 1883a, p. 19.

Phallusia patula TRAUSTEDT, 1880, p. 441. Not O. F. Mueller.

Phallusia prunum VAN NAME, 1912 (in part), fig. 42, pl. 65, figs. 124–126, pl. 66, fig. 132, pl. 72, fig. 157.

Phallusia suensonii TRAUSTEDT, 1885, p. 13, figs. 1, 2, pl. 2, fig. 14.

Besides the above, many others of the references to *Ascidia prunum* and its synonyms (*A. complanata*, *Ascidiopsis complanatus*, etc.) undoubtedly refer in part, at least, to this species, especially those from the more shallow waters of Greenland and northeastern America. (See statements below regarding its distribution.)

Ascidia callosa averages more elongate anteroposteriorly in proportion to its width and usually has a thicker test, of harder and more cartilaginous consistency, generally with a smoother and more even surface (sometimes strikingly so), but very old and large individuals often have the surface deeply wrinkled and incrusted with foreign matter and overgrown with other organisms including ascidians of its own or other kinds. Abnormally shaped specimens are, however, quite frequent. (*A. inornata* Verrill was based on such an individual.) The attachment is very apt to be by most of, or the entire, left side. It attains a larger size than *prunum*, especially in the Arctic seas, where individuals of 90 mm. length have been several times reported (maximum 95 mm.). It varies from nearly colorless and somewhat transparent in young examples to opaque brown or even reddish brown in old specimens in preservation. The apertures normally have eight (branchial) and six (atrial) lobes, respectively, and are slightly prominent and generally separated by about one-third the body length.

The mantle musculature of the right side is a dense network of fibers crossing in various directions, transverse forms predominating in the dorsal and especially in the ventral regions. Left side mostly free from musculature. The branchial tentacles are few. Hartmeyer gives the average as 32 of three sizes arranged with some regularity.

"Intermediate" papillae (usually quite small) are normally present on most parts of the sac. The internal longitudinal vessels are wider and much fewer than in *prunum;* and unlike those vessels in *prunum* they do not increase much in number with the age of the individual, 22 on the left and 25 on the right being the maximum found by Hartmeyer in an examination of 12 specimens ranging from

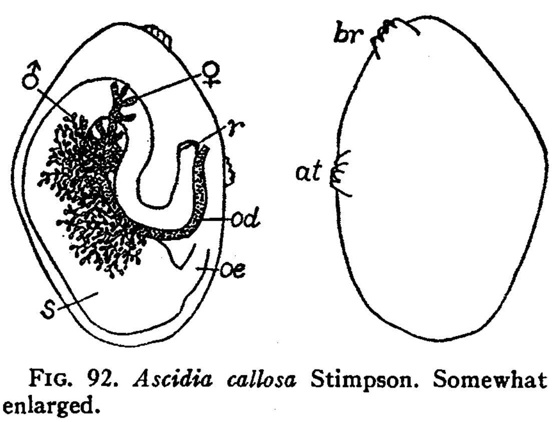


FIG. 92. *Ascidia callosa* Stimpson. Somewhat enlarged.

10 to 45 mm. long. The small plications of the wall of the sac are more numerous and nearer together than the internal longitudinal vessels, and the transverse vessels except the largest usually take part in the plications. The meshes are longer dorsoventrally, containing up to 15 or 20 stigmata in old and large specimens; the ribs and teeth of the dorsal lamina and supplementary lamina are shorter, blunter, or wanting, especially posteriorly, and intermediate teeth are often wanting.

The alimentary tract is usually somewhat less compactly curved, leaving more space

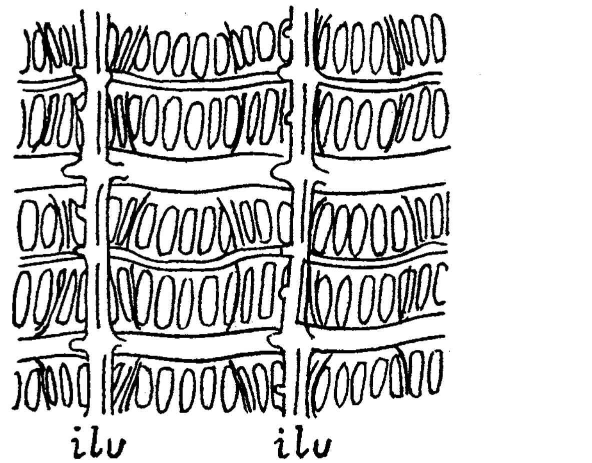


FIG. 93. *Ascidia callosa* Stimpson. Piece of branchial sac.

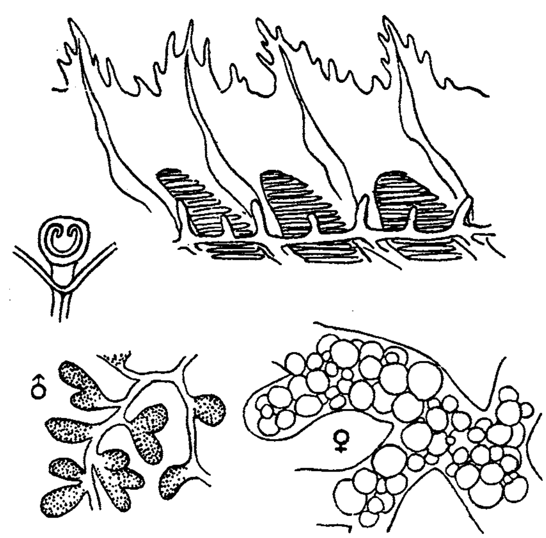


FIG. 94. *Ascidia callosa* Stimpson. Piece of dorsal lamina, dorsal tubercle, and parts of gonads.

between adjacent parts, and the anterior loop is frequently but little bent dorsally, though this is subject to great individual variation and does not afford a trustworthy distinguishing character. As in *A. prunum* the alimentary tract may be very voluminous, occupying most of the left side; the gonads are more or less alike in both forms. A number of branches of the ovary are commonly visible in the anterior loop of the intestine, coming out upon the outer surface of adjacent parts of the intestine.

This species differs from the other members of *Ascidia* found in the northern seas in being viviparous. Developing eggs and larvae are often to be found in the peribranchial cavity of specimens collected in summer. The eggs attain a diameter of 0.175 mm., exclusive of the follicle. (See Huus, 1930.) Numerous small renal vesicles are commonly present in the tissues about the alimentary tract.

DISTRIBUTION: Like its ally, *A. prunum*, this is a species of the Arctic and northern waters of both hemispheres though it is more or less rare or local in Old World waters. It is common in the waters about Greenland and northeastern North America, ranging south to off Cape Cod; most southern record, United States Fish Commission Station 264, 42° 10′ N., 69° 56′ 30″ W., 80 fathoms. A report of this species from Buzzards Bay, Massachusetts, is probably not correct; in such latitudes it would occur in only somewhat deeper water off the coast. It occurs in Norwegian waters, in Bering Sea, on the Alaska and British Columbia coasts, and in Puget Sound, as well as on the Asiatic side, having been described from these regions under various names which Hartmeyer (1924), apparently correctly, has included in *callosa* (*Phallusia suensonii* and probably also *P. koreana* Traustedt, 1884, from Korea; *Ascidiella griffini* Herdman, 1898, from Puget Sound; *Ascidia adhaerens* Ritter, 1901, from Alaska; *Ascidiopsis columbiana* Huntsman, 1912, from British Columbia).

This is a species of shallow water or very moderate depths. It most frequently occurs in depths of less than 30 fathoms, about 80 fathoms being the maximum. On the northern New England and eastern Canadian coasts it is often to be found near low-water mark and is the one the ordinary collector usually obtains, while its ally, *A. prunum*, must be sought for in water at least a few fathoms deep. This fact enables us to refer certain records of so-called "*A. prunum*" to the present species, notably Huntsman's (1912) report of "*prunum*" in large masses at low-tide mark in the vicinity of St. Andrews, New Brunswick.

Ascidia obliqua Alder, 1863

Nomen Conservandum

Plate 4, figures 1, 2; text figures 95, 96

? *Ascidia compressa* RATHKE, 1806, p. 12, pl. 130, fig. 4.

Ascidia falcigera HERDMAN, 1880, p. 469; 1882, p. 211, pl. 32, figs. 1–6; WHITEAVES, 1901, p. 267.

Ascidia gelatinosa KIAER, 1893, p. 30, pl. 1, figs. 1–5, pl. 4, figs. 46–47; BJERKAN, 1895, p. 14; KIAER, 1896, p. 6; HARTMEYER, 1903, p. 295.

Ascidia lurida MOELLER, 1842, p. 95; STIMPSON, 1860, p. 2; HARTMEYER, 1903, p. 294, pl. 12, fig. 6.

Ascidia mollis VERRILL, 1873–1874, vol. 6, p. 440 (n. sp.), vol. 7, pp. 409, 413, 504; 1874, pp. 348, 352, 390, pl. 1, fig. 5; 1879, p. 27; VERRILL AND RATHBUN, 1879, p. 231; BAIRD, 1882, p. 805; McDONALD, 1889, p. 846; KINGSLEY, 1901, p. 183. Not *A. mollis* Hancock, 1870.

Ascidia obliqua ALDER, 1863, p. 154; KIAER, 1893, p. 28, pl. 1, fig. 13; 1896, p. 5; HARTMEYER, 1903, p. 280, pl. 5, fig. 18, pl. 12, figs. 7–12; BJERKAN, 1905, p. 14; ALDER AND HANCOCK, 1905, vol. 1, p. 124, pl. 11, fig. 10, pl. 18, fig. 6; HARTMEYER, 1921a, p. 71; 1922a, p. 16; 1924, p. 57. Not Rennie and Wiseman, 1906.

? *Ascidia prunum* O. F. MUELLER, 1776, p. 225 (not Kupffer, 1875); 1778, p. 42, pl. 34, figs. 1–3.

Phallusia obliqua HARTMEYER, 1909–1911, p. 1403; 1912c, p. 276; VAN NAME, 1912, p. 596, fig. 41, pl. 65, fig. 127, pl. 66, figs. 128, 131, pl. 72, figs. 154, 155; HARTMEYER, 1914b, p. 1111.

Phallusioides obliqua HUNTSMAN, 1912, p. 139; ÄRNBÄCK, 1934, p. 38, fig. 10, pl. 1, figs. 5, 6, pl. 6, fig. 40.

The majority of authors (including Hartmeyer, 1924) agree in the application of Alder's (1863) name *obliqua* to the present species in spite of the strong probability that this is the species to which Mueller's name *prunum* was originally given, as it is very common in Mueller's type locality, Christiania (Oslo) Harbor. Hartmeyer (1924, p. 58) considered other possibly available early names, *compressa* Rathke, 1806, and *lurida* Moeller, 1842, as not determined with too great certainty, and refused to abandon long-established usage and introduce new confusion on the basis of probabilities. This course seems to me to be the correct one.

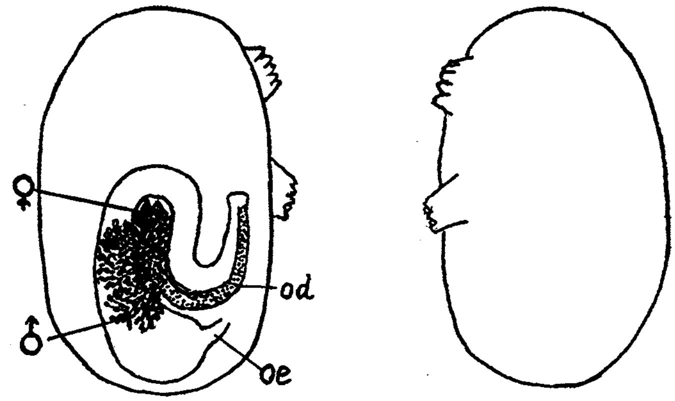


FIG. 95. *Ascidia obliqua* Alder. Somewhat enlarged.

In external characters, form, size, and manner of attachment, this species much resembles *A. prunum* (see the description of that species) and is often found together with it, but it is distinguishable by its thinner, softer, and more flabby test, which is very easily torn or broken. The external surface, though sometimes smooth, is usually roughened by small irregular wrinkles, and the apertures are often raised on high papillae or short tubes.

In size it averages a little larger than *A. prunum*, but in most places 45 to 50 mm. in greatest diameter is not usually exceeded, though Ärnbäck, 1934, mentions a specimen 90 by 57 mm. in measurements. Its usual color in life is greenish or olive, varying from translucent to opaque, but it fades to dull grayish or brownish in preservation.

In internal structure it is at once distinguished from *prunum* and *callosa* in having papillae only at the intersections of the vessels of the branchial sac.[1] These papillae are usually noticeably curved dorsally. The internal longitudinal vessels are fairly numerous, forming rather small meshes with few (commonly not over four to seven) stigmata in each. A specimen 47 mm. long had between 60 and 70 internal longitudinal vessels on one side, and about 90 transverse vessels; the branchial tentacles numbered 32, comprising two orders placed alternately, with additional third-order tentacles in two or three of the intervals. As in *A. prunum*, the dorsal tubercle is of quite simple form; its opening is often merely crescent shaped or horseshoe shaped, with the opening forward. Ganglion close behind the dorsal tubercle. The margin of the dorsal lamina is smooth or merely uneven anteriorly, and usually only weakly denticulate farther back; it ends beside (to the left of) the mouth of the oesophagus, which is located near the rear dorsal corner of the branchial sac.

The stomach has a longitudinally plicated

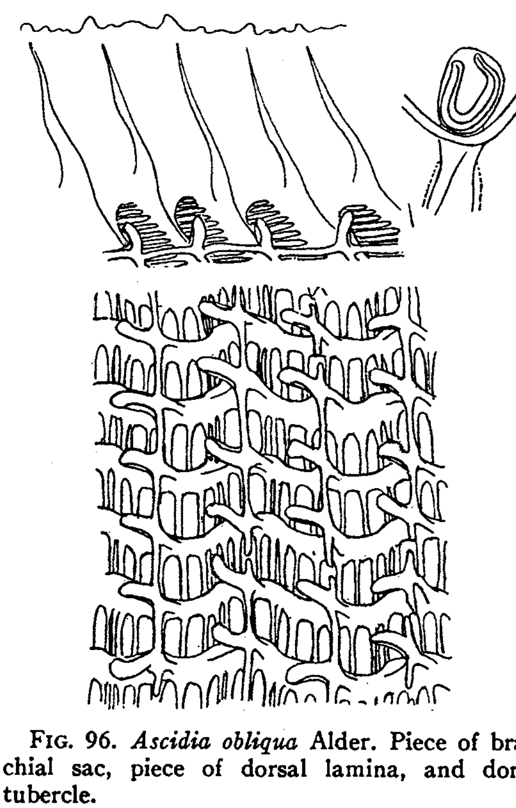


FIG. 96. *Ascidia obliqua* Alder. Piece of branchial sac, piece of dorsal lamina, and dorsal tubercle.

[1] Where a new transverse vessel is developing, its papillae may begin to appear a little in advance of the vessel; these should not be mistaken for intermediate papillae.

wall. Compared to that of *A. prunum*, the alimentary tract is small, covering only the rear half, or less, of the left side of the branchial sac, and commonly forms a rather open loop, the anterior end not being usually much, if at all, bent dorsally toward the rectum, but individuals vary so much that it is difficult to make any definite statement about the form of the alimentary tract. The ovary lies chiefly between the intestine and the branchial sac, some of its branches visible in the anterior intestinal loop, while the testis ramifies more or less on the external aspect of the proximal part of the intestine and part of the stomach. Renal vesicles were not observed in the specimens examined and appear to be difficult to demonstrate in this species, but that they are absent, as was claimed by Huntsman (1912, p. 139), I do not feel sure.

DISTRIBUTION: This species is widely but irregularly distributed on the Arctic and northern regions of both hemispheres, ranging from the Siberian Arctic Ocean westward across to Greenland (both coasts), Newfoundland, and southward to off Cape Cod (chiefly on the fishing banks off the coast) on the American side, where the southern record is from United States Fish Commission Station 371, 41° 35′ 30″ N., 69° 35′ W., 34 fathoms off Chatham, Massachusetts, and to Scotland and the Skagerak on the European side.

It is principally a species of fairly deep water and is not found near the tidal zone. American records range from 33 (oftener from not less than 50 fathoms) to 244 fathoms off Newfoundland and 289 fathoms in Davis Strait; the Old World records indicate an even wider range in depth.

Ascidia interrupta Heller, 1878

Plate 12, figure 4; text figure 97

Ascidia hygomiana VAN NAME, 1930, p. 464, figs. 36, 37; PLOUGH AND JONES, 1937, p. 101.

Ascidia interrupta HELLER, 1878, p. 89, pl. 2, fig. 9; SLUITER, 1898, p. 6.

? *Ascidia prostrata* HELLER, 1878, p. 90, pl. 1, fig. 4 (locality Jamaica).

Phallusia hygomiana TRAUSTEDT, 1882, pp. 280, 286, pl. 4, fig. 7, pl. 5, fig. 18; VAN NAME, 1921, p. 383, figs. 59–61; 1924, p. 27; PEARSE, HUMM, AND WHARTON, 1942, p. 188.

? *Phallusia prostrata* VAN NAME, 1921, p. 486.

"*Ascidia* species," Coues, 1871, p. 130, and Wilson, 1900, p. 354, may also refer to this form.

External shape and appearance very variable; form usually rather elongate, the branchial aperture terminal on the somewhat narrowed anterior part of the body, the atrial aperture rather far back (often near the middle of the dorsal border) on the short tube which usually extends out at a considerable angle from the long axis of the body. Body generally considerably compressed laterally; in the more regularly shaped specimens the dorsal, ventral, and posterior borders are thick and rounded, but the body is very liable to distortion, or to irregular depressions, folds, or furrows which often greatly disturb its symmetry and baffle all attempts to give a description which would cover all the variations. Attachment usually by the left posterior ventral region, or more or less of the left side, but individuals vary greatly in this respect. Some of the above irregularities in form and point of attachment are evidently due to the pressure of other individuals, for the species often grows in clumps or groups of individuals of its own or of other species, but in many cases they seem to be merely manifestations of individual variation. As a rule the anterior part of the body is considerably elongated and narrower than the posterior half; this character is still more pronounced on removing the animal from the test, as the latter is proportionally thicker on the anterior half of the body. Young individuals are commonly of more oval form than old ones.

Size of the specimens usually from 40 to 50 mm. long and from 20 to 25 mm. in dorsoventral diameter, though occasionally more; the amount of lateral compression is very variable. From Andros Island, Bahamas, there are several that are very large. The three largest measure 105 mm. by 38 mm., 106 mm. by 37 mm., and 77 mm. by 32 mm., respectively. The Puerto Rican specimens rarely exceed 60 mm.

Test usually rather thick (thinner in many of the Puerto Rican specimens), firm, and rigid in the alcoholic material yet rather easily broken; its outer surface often fairly even but generally not shiny, often having a slightly rough, fibrous texture. It is often discolored by a very thin coating of fine mud, and in old and large specimens it may be somewhat incrusted with calcareous algae or other foreign bodies, but usually not to any great extent. In preservation the color of the test is commonly a rather characteristic yellowish gray or yellowish brown; even in very young individuals it has a cloudy character; in older ones usually little or nothing can be seen through it. Fresh specimens often have a yellow or pink tint on the siphons. Especially in large specimens there may be more than the usual number (eight and six) of lobes in the two apertures.

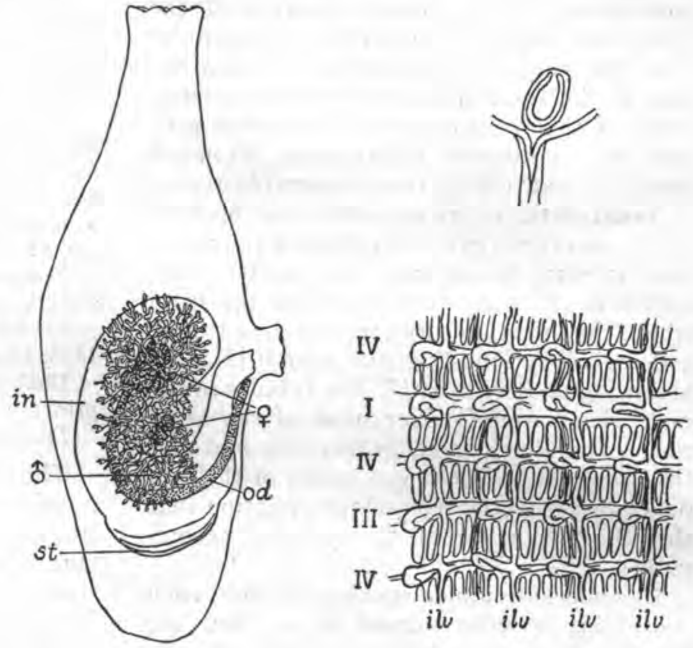


FIG. 97. *Ascidia interrupta* Heller. Left side of body, ×3. Part of branchial sac and dorsal tubercle.

Mantle musculature in most respects rather similar to that of *A. nigra*, but the greater part of the left side is almost entirely free from muscles; a few longitudinal bands extend back a little way from the anterior end, though in most individuals they do not reach far. On the right side there are a small number of long longitudinal bands and a very much larger number of narrow, irregularly transverse or somewhat oblique bands forming an irregular network.

Tentacles numerous, considerably over 100 in some individuals. They are of at least four orders and often show considerable regularity in their arrangement.

Dorsal tubercle having a horseshoe-shaped orifice with the open interval turned more or less directly forward and the horns incurved. The ganglion is situated a long distance behind it.

Dorsal lamina with transverse ribs along its left side; the free edge is rolled over to the right and is plain anteriorly but denticulate farther back. It extends a long distance past (to the left of) the oesophageal opening; only a narrow supplementary lamina is developed on the right side.

Banchial sac usually narrow and tapering in the anterior part. The posterior part normally extends back a considerable distance beyond the stomach and is also usually somewhat narrowed, its extreme posterior end being truncate or extended into a rather narrow rounded apex, but there is great variation in its shape in different individuals. Intermediate papillae are wanting; a minute plication of the sac is developed to an extent very similar to the condition in *A. nigra*.

The internal longitudinal vessels are numerous (35 to 40 in individuals of 35 mm. length; over 70 in old and large specimens); the transverse vessels likewise numerous, forming small square meshes, usually with four to 10 stigmata depending on the extent of the plication, as in *A. nigra*, which it resembles in most of the small details of the sac. One difference distinguishing it from *A. nigra* is that the alimentary tract is smaller, covering in most individuals a smaller proportion of the left side, though the intestinal loop is usually bent a little more than in that species, and its anteriorly extending loop is opened out a little more. Near the end the rectum often makes an abrupt dorsal bend, conforming to the dorsal direction of the atrial tube. Most of the Bahaman specimens have the part of the intestine between the apex of the anterior loop and the commencement of the rectum greatly distended with mud into a saccular enlargement. Stomach small, its wall with a few obscure plications.

A part of the ovary is visible in the opening of the anteriorly extending loop of the intestine; in some specimens a part of it is also visible in the secondary loop near the bend where the intestine turns from a posterior to a dorsal direction. Egg diameter 0.17 mm., according to Berrill, 1937. The tubules of the male glands ramify over most of the anteriorly extending loop of the intestine and over the proximal half (or even more) of the oviduct; also over the part of the intestine that the above portion of the oviduct accompanies.

In some individuals small renal sacs, each containing a very minute concretion, are abundantly scattered in the region between the intestine and the adjacent body wall, but in most cases, these, if present, are very minute and difficult to demonstrate.

DISTRIBUTION: It ranges from the vicinity of Beaufort, North Carolina, and both the east and west coasts of Florida (Miami, Key West, Cedar Keys) to São Sebastião Island on the southern part of the Brazilian coast, and has been reported from Jamaica (type locality of *interrupta*), the Bahamas, Cuba, Puerto Rico, St. Thomas, Curaçao. It is very common in many places and often grows on piles of wharves, forming clusters with other ascidians, mussels, worm tubes, etc., besides numbers of its own species. There are no records from Bermuda. I know of no records from depths of more than a few feet.

Ascidia nigra (Savigny), 1816

Plate 15, figures 1, 2; text figure 98

Ascidia atra LESUEUR, 1823, p. 2, pl. 1, fig. 2; METCALF, 1897, p. 143; SLUITER, 1898, p. 7; METCALF, 1900, pp. 500, 502, figs. A–D; VAN NAME, 1902, p. 398, pl. 63, figs. 138, 139; HECHT, 1916, pp. 429, etc.; PRATT, 1916, p. 667; HECHT, 1918, pp. 229, etc.

Ascidia nigra HELLER, 1878, p. 92; HERDMAN, 1880, p. 466; 1882, p. 210; VON DRASCHE, 1884, p. 383, pl. 8, figs. 5–7; VERRILL, 1900, p. 588; VAN NAME, 1930, p. 463, fig. 35, pl. 7, upper figure; PRATT, 1935, p. 745; PLOUGH AND JONES, 1937, p. 101.

Phallusia atra TRAUSTEDT, 1882, pp. 278, 286, pl. 4, fig. 6, pl. 5, fig. 17.

Phallusia nigra SAVIGNY, 1816, p. 163, pl. 2, fig. 2, pl. 9, fig. 1 (reprinted in Isis, 1820, p. 803, figs. on pls. 9 and 11); HARTMEYER, 1916, p. 408, figs. 5–9; MICHAELSEN, 1918, p. 60; 1919b, p. 113; VAN NAME, 1921, p. 379, figs. 55–58; 1924, p. 27; GRAVE, 1935, pp. 215, etc., pl. 2, figs. 5–9.

Phallusia violacea GOULD, 1852–1856, p. 495, atlas, p. 16, pl. 42, fig. 610.

Phallusiopsis nigra HARTMEYER, 1909–1911, pp. 1408, 1630, etc.; 1912b, pp. 361, 363.

Thallusia nigra HARTMEYER, 1908, p. 111 (misprint).

Tunica nigra HILTON, 1913, p. 113.

The body is oval or elongate and usually more or less flattened from side to side, its free edges thick and rounded. The atrial aperture is usually on a short, anteriorly directed tube or prominence a little way back from the anterior end. The whole anterior part of the body is very commonly curved dorsally so as to bring the two apertures quite close together. This seems to be more or less characteristic of this species. Attachment by an area on the posterior or left posterior part of the body, sometimes by much of the left side. Irregularities of form are frequent, but even in such cases rough angular ridges or prominences are not usually formed, the outlines and surfaces being curved.

The test is thick and firm but not very tough. The color is blue black; the surface is smooth and shiny, with the exception of a few shallow furrows. The color, which pervades many of the internal structures as well as the test, is retained in preserved specimens. Very young specimens are colorless, but the dark pigment usually begins to appear when they are still very small; about 10 to 12 mm. in body length, though individuals vary in this respect.

It reaches quite a large size, sometimes exceeding 100 mm. in length (110 mm. according to Sluiter, 1898), but a length of over 60–70 mm. is not usual in most localities.

Mantle dark colored, provided with many narrow longitudinal muscle bands crossed by slenderer and more closely placed transverse and oblique bands forming a fine network. On the right side the musculature extends the whole length of the body; on the left side the muscles disappear on the region covering the stomach and intestine.

Dorsal lamina with transverse ribs along its left side and with small, sharp serrations on its free margin except near its anterior end. It extends past on the left of the opening of the oesophagus. No well-developed supplementary lamina was found on the right side; a series of very small languets appears to replace it.

Branchial sac with minute plications or undulations well developed. Internal longitudinal vessels numerous; 104 were counted on one side in a specimen 91 mm. in external body length. They bear rather long curved papillae at their intersections with the transverse vessels; intermediate papillae are not present. Transverse vessels of several sizes or orders, arranged with a variable degree of regularity. Stigmata in each mesh usually four to eight. The branchial sac extends a little way posterior to the stomach.

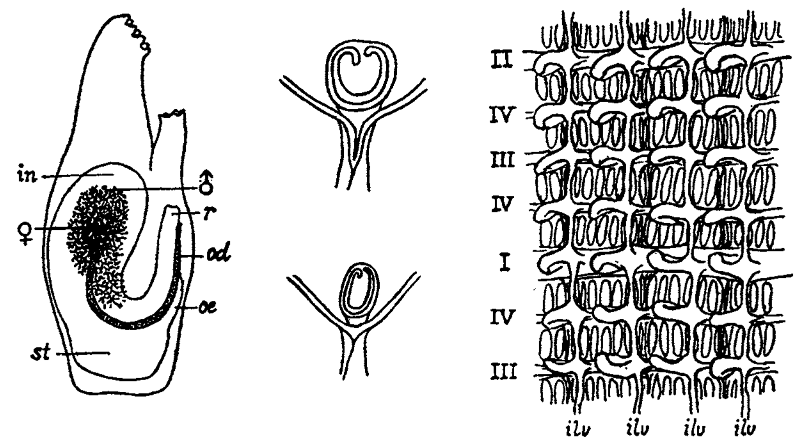


FIG. 98. *Ascidia nigra* (Savigny). Left side of body a little reduced, dorsal tubercle of two individuals, and piece of branchial sac.

Tentacles of three or four sizes or orders, often arranged with some degree of regularity. The number is very variable (50 to more than 100 in fairly large specimens) and depends largely on the extent to which the small tentacles are developed, these being often almost or entirely wanting in some parts of the circle.

The dorsal tubercle was small and simple; usually with a U-shaped or horseshoe-shaped orifice, having the open interval directed forward with the horns more or less incurved, in the Bermuda and West Indian specimens in which this character was studied by the writer. Metcalf (1897) found numerous minute accessory openings leading from, and situated along, the neural duct in two large specimens from Jamaica; the orifice of the dorsal tubercle itself was of the normal form in these specimens. The ganglion and neural glands are very far back from the dorsal tubercle in this species, and the neural duct is, in consequence, very long.

Digestive tract rather large and strongly curved; stomach large. The whole tract covers more than half the area of the left side. Numerous small renal sacs containing concretions occur in the region of the digestive tract in many specimens, especially old ones.

Reproductive organs only indistinctly visible through the mantle on account of the dark color of the latter. Some of the convoluted branches of the ovary are visible in the anteriorly extending loop of the intestine; the branching tubules of the male gland ramify over the visible parts of the ovary and the portions of the intestines adjacent to the ovary and proximal part of the oviduct. Egg diameter 0.17 mm. (Berrill, 1937). (For culture methods, see Grave, 1937, pp. 561–563.)

DISTRIBUTION: An easily recognized species, widely distributed and common in shallow water, that has been reported from Bermuda, Florida, Haiti, Cuba, Puerto Rico, Jamaica, St. Croix, St. Thomas, St. Vincent, Guadaloupe, Curaçao, and the coast of Brazil.

At Puerto Rico it was found common in Guanica Harbor on piles and mangrove roots. The United States National Museum collection contains specimens from various Cuban localities, from off the west coast of Florida (21 fathoms), and from São Sebastião, Brazil. It is also found in the Red Sea (Savigny's type locality), the Gulf of Aden, and on other parts of the Arabian coasts.

Ascidia curvata (Traustedt), 1882

Text figure 99

Ascidia curvata SLUITER, 1898, p. 6; VAN NAME, 1902, p. 400, pl. 56, figs. 80–82, pl. 63, figs. 145, 146; HARTMEYER, 1908, p. 111; VAN NAME, 1930, p. 466, fig. 38; BERRILL, 1932, p. 78; PLOUGH AND JONES, 1937, p. 101.

Phallusia curvata TRAUSTEDT, 1882, pp. 281, 286, pl. 4, figs. 8–10, pl. 5, fig. 19; VAN NAME, 1921, pp. 389, 479, figs. 66–68; 1924, p. 27.

A small species of more delicate structure than *A. interrupta*, with a nearly colorless test which is often of almost glassy transparency. The very slight development of muscle bands on the left side of the mantle and the smaller intestinal tract, which is bent into a more compact mass, are characters distinguishing the present species from *interrupta*.

The following description is based chiefly on specimens collected by the writer at Bermuda.

Body long and narrow, tapering to the branchial aperture at the anterior end and more or less truncate at the posterior end; usually attached by a large part of the left side, the tubes being turned more or less to the right or exposed side. Atrial tube far back, often beyond the middle of the body, usually rather short. Test very thin on attached side, thicker on the other, pale gray or colorless, and sometimes very transparent; markings of light orange-brown about the apertures are present in many living specimens. Some individuduals have the external surface smooth and clean; others are wrinkled, or more or less completely covered with small shell fragments rather loosely adherent or slightly embedded.

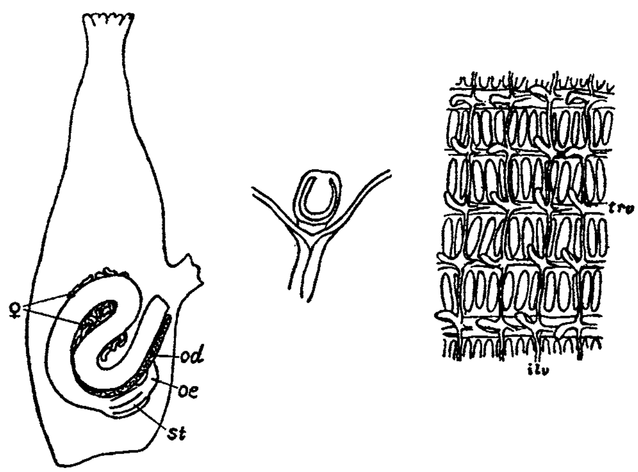


FIG. 99. *Ascidia curvata* (Traustedt). Left side of body, ×2.2, dorsal tubercle, and piece of branchial sac.

Mantle delicate and transparent. The sphincters of the tubes consist of a number of slender circular bands separated by slight intervals and crossed by some narrow longitudinal bands, which do not, however, extend much onto the sides of the body. Body musculature weak and mainly confined to the right side, where it consists of a delicate and rather open network of transverse and oblique fibers or very narrow bands crossing each other at various acute angles. These muscles have rather crooked courses. The network is rather denser along the dorsal and ventral regions, owing to the somewhat stouter and more numerous transverse bands present there, but these do not encroach much, if at all, upon the left side of the body. Apertures prominently lobed. Length of largest specimen, 50 mm.

Tentacles moderately numerous, of several sizes arranged with some regularity according to the usual scheme. Dorsal tubercle simple, U-shaped, or horseshoe shaped, with the open interval forward in the specimens studied. The ganglion is a considerable distance behind it.

Dorsal lamina with a toothed margin and conspicuous transverse membranes along its sides.

Branchial sac of a simple type, the small plications or areolations conspicuous in many allied species being comparatively little developed in this form, though not altogether wanting. Transverse vessels of several sizes. Internal longitudinal vessels slender and separated in most places by only three or four, seldom five, stigmata. They bear rather long curved papillae at their crossings with the transverse vessels. No intermediate papillae. The branchial sac extends a varying distance posterior to the stomach in different specimens.

Alimentary loop proportionately rather small, and considerably bent, forming a fairly compact mass chiefly or entirely in the posterior half of the body. Stomach small with a few longitudinal plications, yellow or brownish in living specimens.

The reproductive organs, both male and female, lie between the branchial sac and the alimentary tract, mostly concealed by the latter, but visible in one of the best-preserved specimens along the anterior edge of the anterior loop of the intestine as well as between the branches of the loops formed by the latter. The male glands did not appear to spread over the surface of the intestine next to the branchial sac to any considerable extent in the specimens studied. Egg diameter 0.17 mm., according to Berrill, 1937.

DISTRIBUTION: This species was described by Traustedt from St. Thomas. I found it one of the commonest simple ascidians at Bermuda in shallow water along the shore, attached to stones, shells, etc. Other localities are Tortugas, Florida (Hartmeyer, 1908), rocks in San Juan Harbor, Puerto Rico (Van Name, 1921), Curaçao (Van Name, 1924).

Ascidia corelloides (Van Name), 1924

Text figure 100

Ascidia corelloides VAN NAME, 1930, p. 469, figs. 40, 41.

? *Ascidia rhabdophora* SLUITER, 1904, p. 45, pl. 6, figs. 19–23.

Phallusia corelloides VAN NAME, 1924, p. 27, figs. 2–4.

The body is ovate, more or less flattened; the test is transparent, nearly colorless or slightly brownish; its substance tough and permeated by branching blood vessels, thick (especially toward the anterior end) and with the surface smooth and free from foreign matter, without many folds or wrinkles. Size of the largest specimen, about 19 by 8 mm.

The mantle musculature is mainly confined to the right side and consists of a few oblique bands (see fig. 100); the alimentary tract occupies more than half of the left side.

The tentacles are few, not over 20 in all, two sizes alternating; the dorsal tubercle is very small, with a simple orifice, which appears U-shaped in one specimen. The dorsal lamina is plain edged, but with well-developed transverse buttress membranes arising from each transverse vessel; these are higher than the dorsal lamina itself, and those of opposite sides unite to form a tooth or languet where they meet over the dorsal lamina.

The branchial sac has papillae on the internal longitudinal vessels at the points of crossing the transverse vessels, and additional somewhat smaller papillae at the points midway between the transverse vessels.

"Branchial sac wide and truncated at the rear end, which is extended a little distance posterior to the region covered by the alimentary tract. It is not noticeably plicated. The transverse vessels are of at least three orders; the internal longitudinal vessels are only moderately numerous (about 22 to 24 on one side of the body) and are separated by from four to six stigmata in most cases. They bear stout papillae where they cross the transverse vessels and much smaller intermediate papillae half way between them.

"Alimentary tract large, covering more than half the left side. Stomach rounded; both it and the intestine are so distended with renal sacs, each containing a minute rounded concretion of a brown color, so that the stomach surface has a speckled appearance. A few of these sacs are thinly scattered over the more anterior parts of the intestinal loop.

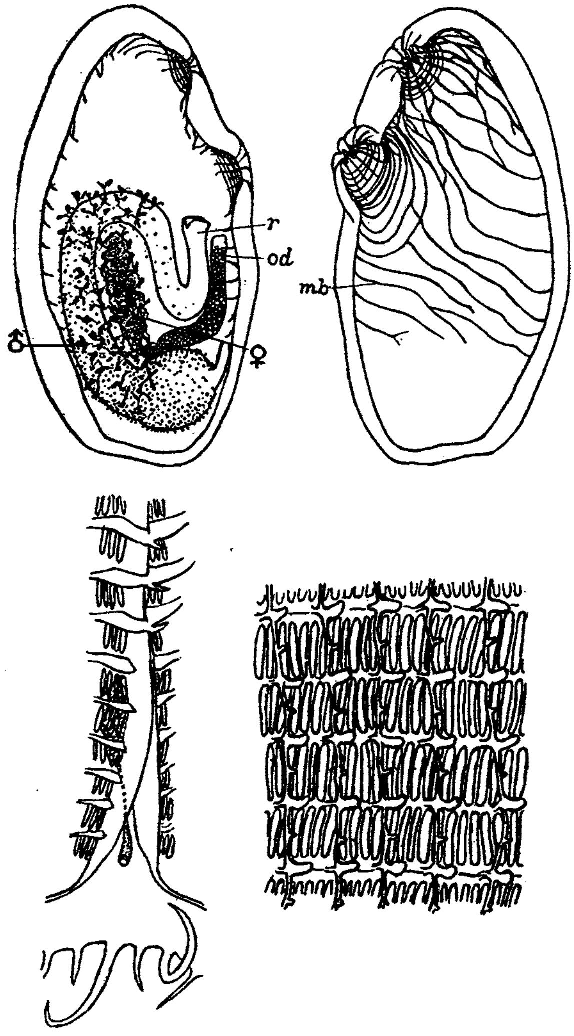


FIG. 100. *Ascidia corelloides* (Van Name). Left and right sides of body, ×3.5, piece of branchial sac, and anterior part of dorsal lamina and adjacent structures.

mud that any plication of the wall, if such be present is not noticeable. The stomach and proximal three-fourths of the intestine form a rather open C-shaped loop. As the intestine again approaches the stomach, it bends more or less abruptly forward parallel to itself with a U-shaped flexure to form the rectum, which terminates in a smooth-margined, two-lipped orifice. The exposed surface of the stomach and proximal part of the intestinal loop is densely covered with minute transparent

"The ovary is a tube of rather large diameter, densely convoluted into an elongate mass. It lies in the intestinal loop along the proximal (longitudinally directed) part of the intestine. From its posterior end the oviduct arises. The latter evidently serves to retain the eggs for some time, as in all the specimens it is densely packed and greatly distended with them. It runs dorsally along the dorsal border of the stomach and then bends anteriorly to accompany the rectum. The male glands ramify over much of the intestinal loop, including its extreme anterior part, but not much could be made out of their details" (Van Name, 1924, pp. 28, 29).

This species was described from Curaçao where four specimens were obtained in shallow water in Caracas Bay by Van der Horst (see Van Name, 1924). Type in the American Museum of Natural History (A.M.N.H. No. 730). A single small specimen (12 mm. long) was afterward collected by William Beebe in Port au Prince Bay, Haiti.

This is evidently a very close ally of *Ascidia rhabdophora* Sluiter (1904, p. 45, pl. 6, figs. 19–23) obtained by the Siboga expedition at Damar Island in the East Indies in 45 fathoms. Sluiter's species was based on only one specimen 30 mm. long. It would seem premature to assume that the two forms are identical until more is known about the East Indian form, although a number of ascidians are common to both the East and West Indies.

Ascidia sydneiensis Stimpson, 1855

Text figure 101

Ascidia canaliculata HELLER, 1878, p. 84, pl. 1, fig. 1; MICHAELSEN, 1918, p. 59; 1921, p. 5.

Ascidia divisa SLUITER, 1904, p. 30, pl. 5, fig. 20.

Ascidia longitubis SLUITER, 1898, p. 8, pl. 1, figs. 1, 2.

Ascidia pyriformis HERDMAN, 1882, p. 219, pl. 34, figs. 1–6.

Ascidia sydneiensis STIMPSON, 1855a, p. 387 (orig. descr.); HERDMAN, 1899, p. 15; HARTMEYER, 1919, p. 98, pl. 2, fig. 50; HARTMEYER AND MICHAELSEN, 1928, p. 285; VAN NAME, 1930, p. 468, fig. 39.

Phallusia canaliculata HARTMEYER, 1911b, p. 576, pl. 57, figs. 13, 14.

Phallusia longitubis TRAUSTEDT, 1882, pp. 277, 283, pl. 4, figs. 11, 12, pl. 5, figs. 20–22; 1885, p. 16; TRAUSTEDT AND WELTNER, 1894, p. 10.

Phallusia sydneiensis VAN NAME, 1921, p. 386, figs. 62–65.

For other references and synonyms, see Hartmeyer and Michaelsen, 1928.

The body is commonly moderately elongate (this being in part due to the large and long branchial tube into which the anterior end tapers) and moderately compressed; the posterior end broad and rather truncate or slightly rounded. The atrial tube is well developed, situated far back, and is often directed obliquely backward or bent in that direction. Attachment by a considerable part of the left side. Branchial aperture with seven or eight lobes, the atrial with six lobes. Test colorless and quite transparent in young individuals and in some older ones of rather firm, rigid consistency (in alcoholic specimens at least), and in the specimens at hand it is quite smooth externally and free from incrusting foreign matter, though this is not always the case. Size of largest American individual examined (from Cabañas, Cuba): total length, 53 mm.; dorsoventral diameter, 27 mm.; thickness, 12 mm. Much larger specimens are recorded from localities in the Eastern Hemisphere.

The species is most readily recognized by the characteristic musculature of the mantle. The large branchial and atrial tubes have conspicuous and numerous circular muscle bands and a few longitudinal ones. Longitudinal muscles are insignificant elsewhere on the body. The whole left side is nearly free from muscles, the mantle being thin, colorless, and transparent. The greater part of the right side is in the same condition, but all around the dorsal, ventral, and posterior margins of the right side there is a wide border of short, stout muscle bands extending inward from the margin for a varying distance. They lie for the most part parallel to each other and at right angles to the margin, but curve and cross each other irregularly to a slight extent.

Tentacles numerous, probably 60 to 70, of several sizes.

Dorsal tubercle heart shaped, long and very narrow, open interval forward, horns inrolled. In large specimens the aperture may be variously curved or convoluted, producing complex figures. The ganglion lies a little behind the dorsal tubercle.

Dorsal lamina with a nearly plain or more or less toothed edge rolled over toward the right side. It extends past the opening of the oesophagus on the left side of the latter.

Branchial sac not extended much beyond the digestive tract posteriorly, its anterior part narrow, the posterior part broad. Transverse vessels of at least three or four orders, but even the smallest are fairly stout. None of them take any part in the minute plication of the sac, which is characteristic of the genus. This plication, therefore, assumes the appearance (when seen from the interior of the sac) of numerous small, deep, oblong pits or depressions instead of a series of ridges and furrows. Internal longitudinal vessels regular and complete but very delicate. At their intersections with the transverse vessels they bear small, narrow, much bent or hooked papillae. Intermediate papillae (between transverse vessels) are wanting. The internal longitudinal vessels are separated by an interval equal in width to four or five stigmata in most places, but the intervening number of stigmata is quite variable, owing to the minute plication above mentioned.

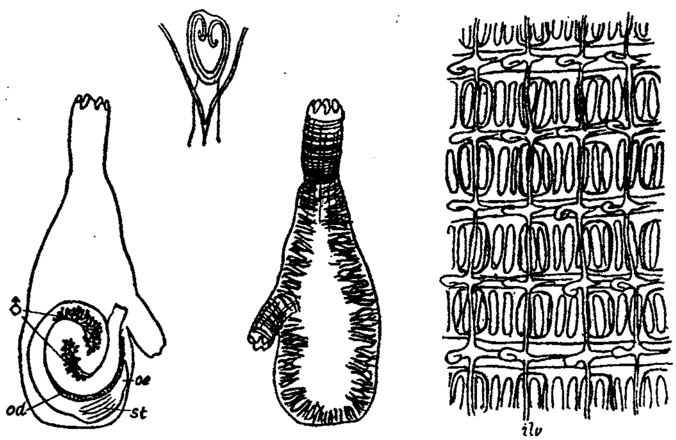


FIG. 101. *Ascidia sydneiensis* Stimpson. Left and right sides of body, ×1.6. Dorsal tubercle and part of branchial sac.

Digestive tract fairly large, covering most of the posterior half of the left side. Stomach rather small, its wall apparently somewhat plicated longitudinally. Intestinal loop large but strongly convoluted into a compact mass so that the parts overlap each other more or less. This is quite different from the condition in *A. nigra* and *A. interrupta*.

Reproductive organs almost entirely concealed by the intestine when viewed from the left side. Some of the ramifications of the testes appear upon its surface from between the coils. Of the female organs only the oviduct can be seen from that aspect; it accompanies the rectum in the usual manner.

DISTRIBUTION: Widely distributed in the warmer regions of the world. The only American records of the typical form are from the West Indian region, where it appears to be rare, but has been reported from St. Thomas, Vieques, Puerto Rico, Cuba, and Santa Marta, Colombia. It is a shallow-water species, 28 meters being the deepest record that I am aware of. The West Indian specimens I have seen were dredged in 10 to 25 feet except one from St. Thomas, which grew on a pile. A few specimens from the Gulf of California appear to be separable as the following subspecies.

Ascidia sydneiensis protecta, new subspecies

Four specimens of *Ascidia* from three different stations in the Gulf of California are evidently allied to *A. sydneiensis* described above but appear to be separable from it as a subspecies.

They are all of fairly large size, measuring from 50 to 66 mm. in length and 28 to 40 mm. dorsoventrally; they are all more or less flattened from side to side, though in all but one case somewhat obliquely. The test is fairly firm and cartilaginous, translucent yellowish in color, with the surface varying from smooth to somewhat rough, but without much incrustation. Area of attachment extensive, posteriorly located, and including much of one side of the body.

The characters which appear to separate them from the typical *A. sydneiensis* are as follows:

The siphons (the branchial nearly terminal, the atrial fairly far back) arise from an elongate and narrow oval area on the anterior and anterodorsal region of the body, which in the two best of the four specimens is bounded by a pair of long elevated ridges, one on each side, suggestive of a pair of lips. On one of the specimens and possibly on a second one, these ridges are so developed that it is not impossible that during life they could close together and serve to protect entirely the retracted tubes, like the two shells of a bivalve mollusk. In a third specimen the ridges are distinctly noticeable, though not developed enough to serve any protective purpose; the fourth specimen (which is irregular in form and surface) has no more than indications of them, chiefly on one side.

When removed from the test, all the four specimens, even to some extent the last-mentioned one with poor indications of the ridges externally, agree in having the siphons arising from an elongate oval area in which the mantle is thin and its musculature slight and mainly transverse. This area is bounded by a raised and thickened border with a heavy musculature of short parallel fibers which resemble those that border the right side of the body in *A. sydneiensis*, but in this form they border the above-described area on the dorsal part of the body in which the siphons arise. Elsewhere, except on the siphons, the mantle is thin and more or less transparent with little musculature.

The body is, except in one of the specimens, shorter and wider than usual in *A. sydneiensis* and without the extension of the anterior part which is usual in specimens of that species.

Most points of the internal structure are quite in accord with the description of that species given above.

In one of the largest specimens there were counted 58 branchial tentacles of various sizes, irregularly arranged, besides a few that were mere papillae; it had 41 internal longitudinal vessels on the left and 47 on the right side.

The alimentary tract is bulky, covering much of the left side, its loops compactly disposed with the branches in most places in close contact.

DISTRIBUTION: The Gulf of California. Type locality, Concepcion Bay (two specimens) "on stones and *Pinna* shells" just below low-water level (type, A.M.N.H. No. 1711). Other specimens from Puerto Escondido (latitude 25° 28′ N.), and from Puerto Refugio on Angel de la Guardia Island in the northern part of the Gulf. All the examples were collected and presented by E. F. Ricketts.

The typical *A. sydneiensis* has not, so far as I am aware, been reported from the west coast of America, though widely distributed in warm regions and occurring at Hawaii.

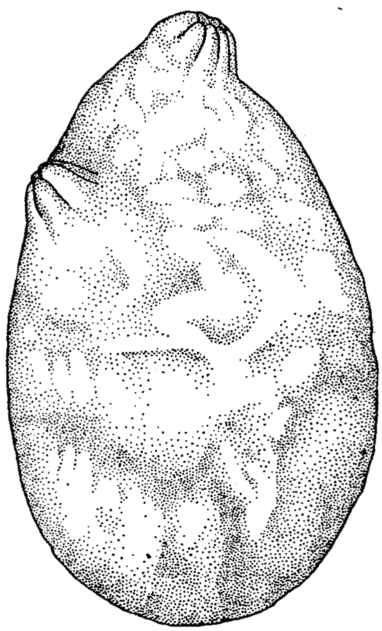


FIG. 102. *Ascidia meridionalis* Herdman. Two-thirds natural size. After Herdman, 1882.

Ascidia meridionalis Herdman, 1880

Text figures 102, 103

Ascidia meridionalis HERDMAN, 1880, p. 465; 1882, p. 207, pl. 31, figs. 4–8; MICHAELSEN, 1907, p. 74; HERDMAN, 1923, pp. 28, 29.

? *Ascidia tenera* HERDMAN, 1880, p. 467; 1882, p. 213, pl. 32, figs. 7–10; MICHAELSEN, 1900, p. 12; 1907, p. 74.

Phallusia meridionalis HARTMEYER, 1909–1911, p. 1403.

See also remarks at end of description of *Ascidia challengeri*.

This species, known only from Herdman's descriptions and figures, is of large size, reaching 14 cm. in length and 8 cm. in width, generally of oval outline, more pointed in front and laterally flattened; the brachial aperture is terminal, the atrial one-third of the way back, both conspicuously lobed and raised on conical processes. Attachment is by the posterior end and part of the left side.

Surface slightly velvety, otherwise smooth but more or less creased and seamed. Color light brown or horn color. Test softish and easily torn. Mantle moderately muscular. Tentacles simple, filiform, about 60 in number and placed long and short alternately. Dorsal lamina broad, ribbed transversely, the margin serrated. Dorsal tubercle crescentic in shape, with the horns pointing anteriorly.

Branchial sac slightly plicated longitudinally. Three small transverse vessels occur between each pair of large ones. The internal longitudinal vessels are strong and bear short stout papillae at the angles of the meshes, and also small, conical intermediate ones. The meshes contain each six to eight stigmata.

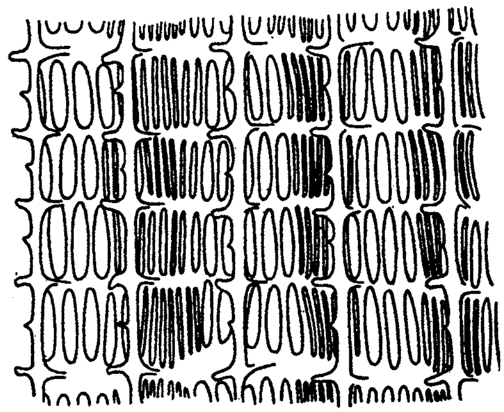


FIG. 103. *Ascidia meridionalis* Herdman. Part of branchial sac. After Herdman, 1882.

The alimentary genital and renal viscera form a large but flat mass upon posterior half of the left side.

Herdman failed to figure the form of the intestinal tract. From his description it would correspond closely to that of *A. challengeri.* He describes the renal gland as "of great extent covering almost the entire stomach and intestine, composed of vesicles of large size, each inclosing one or more yellowish brown concretions."

LOCALITIES: *A. meridionalis* was based on a dozen or more large specimens ranging from 14 to 5.5 cm. in length, dredged at "Challenger" Station 320, off Buenos Aires, 37° 17′ S., 53° 52′ W., 600 fathoms. Herdman also assigns to this species two specimens from the Strait of Magellan, "Challenger" Station 313, 52° 20′ S., 68° 00′ W., 55 fathoms.

The correspondence in localities (in one case exact) of *Ascidia tenera* with *A. meridionalis* and their close resemblance in characters, well within the limits of probable individual variation, make it seem in the highest degree improbable that when more material becomes available the two forms can be maintained as distinct. *A. tenera* is reported nearly as large as *meridionalis*, reaching 11.5 cm. in length.

It was collected at "Albatross" Station 320 off Buenos Aires in 600 fathoms where *meridionalis* was also obtained, and in the western part of the Strait of Magellan at "Challenger" Station 311 (type locality) 52° 50′ S., 73° 53′ W., in 245 fathoms. Michaelson, 1900, also reported a number of specimens from the western part of Magellan Strait and Smyth Channel. I am, therefore, treating *A. tenera* as a probable synonym of the present species.

Ascidia challengeri Herdman, 1882

Text figures 104, 105

Ascidia challengeri HERDMAN, 1882, p. 202, pl. 30; 1923, p. 28, pl. 13, figs. 1–4; ÄRNBÄCK, 1938, p. 46.

Ascidia charcoti SLUITER, 1905, p. 471; 1906, p. 34, figs. 2, 3, pl. 2, figs. 33, 34, pl. 4, fig. 50; HERDMAN, 1912, p. 96; 1923, p. 29.

Phallusia challengeri HARTMEYER, 1912b, p. 283, pl. 42, figs. 12, 13.

Phallusia charcoti HARTMEYER, 1911b, p. 466, pl. 45, fig. 11, pl. 51, figs. 10, 11, pl. 52, figs. 1–4; 1912b, pp. 286, 287; SLUITER, 1914, p. 26.

See also the statement regarding *A. meridionalis* Herdman, 1880, at the end of this description.

The body in this species is of oblong outline, sometimes rather elongate oblong, tapering anteriorly and usually attached by the posterior end or by part of the left side. In the collapsed condition usual in museum specimens the body is very flat from side to side but with the dorsal and ventral margins often thicker and rounded. The branchial aperture is terminal, the atrial may be back one-quarter to one-third or more of the body length. Either or both apertures may be somewhat produced. This species reaches a large size, specimens measuring 8 to 9 cm. anteroposteriorly and half that dorsoventrally are not at all uncommon, and Herdman's type from Kerguelen Island was 17 cm. long and 5.5 cm. wide.

The body surface may be fairly smooth, except for shallow, irregular furrows, usually mostly longitudinal in direction, or more or less wrinkled. Young individuals often bear scattered conical papillae (usually very small) especially in the vicinity of the apertures; these often persist to some extent in older specimens.

The test is yellowish in preservation and somewhat transparent; in life numerous corpuscles of a bright red color are often contained in the blood vessels of the branchial sac, mantle, and test, at least in specimens from the high latitudes of the Antarctic, suffusing the animal with a pink or reddish color. I have found considerable reddish coloration retained in the vessels of the mantle and branchial sac in specimens from Antarctica that had been in alcohol for a couple of years, but eventually this will undoubtedly fade out.

Neither the mantle musculature nor the minute plication of the branchial sac usual in this genus is very strongly developed. The tentacles are usually quite few, the larger ones numbering only about 12 to 20 in most cases, and may be fairly uniform in size or exhibit some degree of alternation in length. Smaller tentacles, if present, usually rather few. The dorsal tubercle has an aperture of simple form, C- or U-shaped, the open interval forward; the horns may, especially in older individuals, be bent in or outwardly, either both the same way or each differently, but are not coiled. The ganglion is but a short distance from the tubercle (one-twenty-eighth to one-thirty-second of the body length, according to Hartmeyer, 1912b).

The dorsal lamina is ordinarily smooth margined but occasionally has a few dentations, especially posteriorly. It extends past the oesophageal aperture, which is itself fairly far back.

Old and large specimens have intermediate papillae, considerably smaller than those at the intersections, present throughout much of the area of the sac, but in young individuals they occur only locally and are sometimes hard to find at all, a small papilla, when present, being often accompanied by a slender, often parastigmatic, transverse vessel, showing that it is really a developing intersection papilla. The latter are curved and of only moderate size. In a specimen 70 mm. long (external measurement), about 38 internal longitudinal vessels were counted on the left side and about 46 on the right side of the branchial sac. Ärnbäck found smaller numbers (30 and 32) but neither of her specimens was over 43 mm. in length.

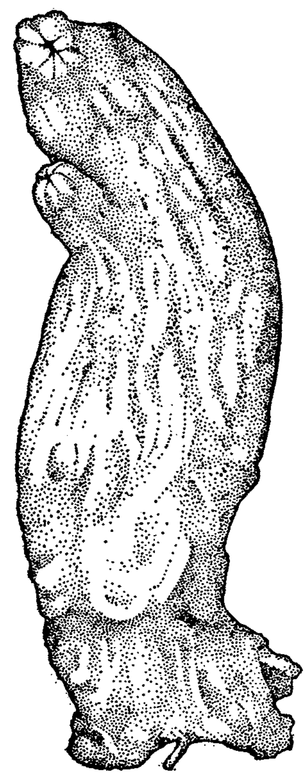


FIG. 104. *Ascidia challengeri* Herdman. Two-thirds natural size.

The alimentary tract varies in size and curvature in different individuals but is moderate in its development and does not extend in length more than half that of the branchial sac, often considerably less. The sac extends behind it a little way. The branches of the alimentary tract are usually chiefly anteroposterior in direction, the loop as a whole not being bent much, if at all. Unless much distended with ingested matter, its branches are commonly a little separated from each other. Nothing unusual in the location of the reproductive organs was noted; they spread over a considerable part of the alimentary tract. No renal vesicles containing concretions were noted.

DISTRIBUTION: This large species, apparently the commonest and most widely distributed *Ascidia* in the Antarctic in both

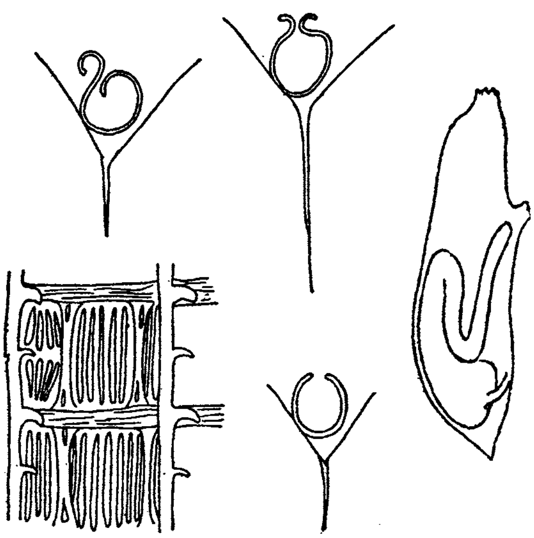


FIG. 105. *Ascidia challengeri* Herdman. Detail of branchial sac, and variation in the opening of the dorsal tubercle in three individuals, and outline of body removed from test. After Sluiter, 1906.

hemispheres, occurs in the Subantarctic regions of the Eastern Hemisphere, being common about Kerguelen Island, Herdman's type locality, and also recorded from near Tasmania, but does not appear to have been found (it may be safer to say not recognized) in the Magellanic region. In the area covered by this work, it has been collected at various points in the western Antarctic (especially in the Palmer Archipelago and in the South Shetlands). In depth the records range from 36 to 385 meters; in one case, 637 meters.

In a much later work, Herdman (1923) expresses the opinion that "when larger series of specimens from many southern seas have been examined, it may be found that *A. meridionalis* can be united by intermediate forms with *A. challengeri*." Should this eventually prove to be the case, the specific name *meridionalis* will have to replace *challengeri*.

In regarding *A. charcoti* Sluiter, 1905, as identical with Herdman's *challengeri*, I am following Ärnbäck, 1938, and the strongly expressed belief of Hartmeyer (1912b).

Ascidia dispar Ärnbäck, 1938

Text figure 106

Ascidia dispar ÄRNBÄCK, 1938, p. 48, fig. 11.

Ärnbäck described this species from a single specimen from Grytviken, South Georgia, in 22 meters depth. It measures 5.8 cm. anteroposteriorly and 2.5 cm. dorsoventrally and presents no external differences to distinguish it from such species as *A. challengeri* or *translucida*. It has some microscopic, pointed papillae on the test in the vicinity of the apertures; the apertures are prominent and conically produced.

Tentacles about 50, of various sizes, aperture of dorsal tubercle curved, of subcircular shape, with an open interval directed forward. Ganglion about 2 mm. removed from the dorsal tubercle. The dorsal lamina has an even margin and extends far beyond the oesophageal aperture to the end of the sac.

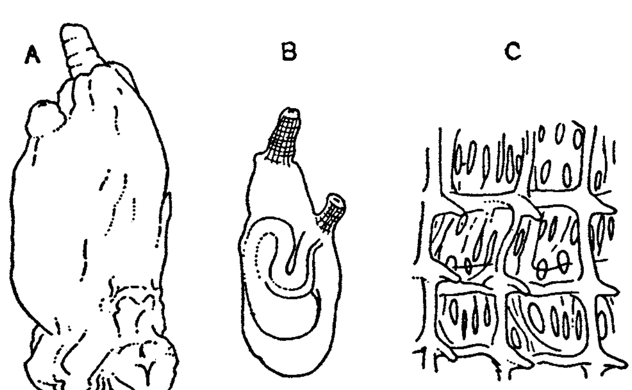


FIG. 106. *Ascidia dispar* Ärnbäck. A. Two-thirds natural size. B. Body removed from test. C. Piece of branchial sac. Outlines from Ärnbäck's figure.

On the other side of that opening there is a thin lamina with an almost even margin.

The branchial sac extends 6 mm. behind the stomach. It has 40 internal longitudinal vessels on the left side and 50 or a few more on the right. No intermediate papillae could be discerned. The stigmata are mostly short and are irregularly longitudinally arranged. The intestinal loop is compact and slightly bent dorsally.

More material will be needed to determine whether its peculiarities are individual or of specific importance.

Ascidia translucida Herdman, 1880

Plate 23, figure 3; text figure 107

Ascidia translucida HERDMAN, 1880, p. 466; 1882, p. 215, pl. 33, figs. 1–6 (not Sluiter, 1890); ÄRNBÄCK, 1938, p. 45, pl. 3, fig. 23.

Phallusia translucida HARTMEYER, 1912b, p. 287, pl. 37, fig. 2, pl. 42, figs. 8–11.

I have not seen this species, which much resembles *A. challengeri* in most of its characters, both external and internal, and likewise reaches a large size (110 mm. long by 50 to 60 mm. wide, according to Ärnbäck). However, none of the writers who have dealt with it have questioned its distinctness, though apparently basing their opinion largely on the peculiarities of the dorsal tubercle, which is of large area and has a varying number of small apertures, mostly narrow and variously curved in a serpentine manner, differently in every individual. This is in strong contrast to the simple aperture found in *A. challengeri*. Ärnbäck gives the number of internal longitudinal vessels as 34 to 35 on the left and a few more (up to 39) on the right side.

Hartmeyer (1912b) thus sums up the more important distinctions between the two species:

"*Phallusia translucida* appears to be not distantly related to *P. challengeri*, but is well characterized as an independent species. It differs especially in the structure of the dorsal tubercle which appears to afford a reliable specific character.

"The branchial sac is less highly specialized than in *P. challengeri* in that the intermediate papillae do not appear everywhere even in old age, while they are present everywhere in adults of *P. challengeri*. Also, the ganglion is much farther removed from the dorsal tubercle in *P. translucida* than in *P. challengeri*. In the former the distance equals one-ninth, in the latter one twenty-eighth to one thirty-second of the body length (these averages were obtained by measuring a number of examples in each case). In many external characters and in the form of the intestinal loop both species exhibit much that corresponds, yet the intestinal loop of *P. translucida* is somewhat less strongly developed than that of *P. challengeri*."

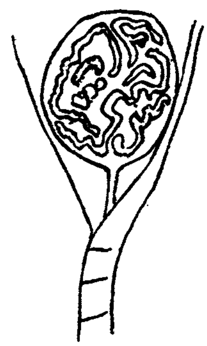


FIG. 107. *Ascidia translucida* Herdman. Dorsal tubercle, example of the complex pattern of the apertures which is alike in no two individuals.

DISTRIBUTION: Type locality, Kerguelen Island, 28 fathoms (Herdman); also obtained by the Valdivia expedition in the Gazelle Basin at the same island. Ärnbäck, 1938, reports it from stations at South Georgia, in 20, 22, and 250 meters depth.

Ascidia vermiformis (Ritter), 1913

Text figure 108

Ascidia (Phallusia) vermiformis RITTER AND FORSYTH, 1917, p. 441.

Phallusia vermiformis RITTER, 1913, p. 496, pl. 36, fig. 42.

A species based by Ritter on four specimens, all from the same dredging station off southern California.

It is described as "long and irregularly cylindrical, the general appearance being considerably that of the tubes of some of the tubicolous worms." Length of the longest specimen, 140 mm., width, 30 mm.; surface uneven, with incrusting and embedded foreign matter. Test rather thick, opaque white, semi-cartilaginous. Animal apparently attached along the whole right side.

Except that the alimentary tract is much smaller and somewhat more compact and that the branchial sac extends in a rather narrow pouch a long distance posterior to (even farther than it does anterior to) the alimentary organs, the internal structure is of the same type as in *A. ceratodes* described below.

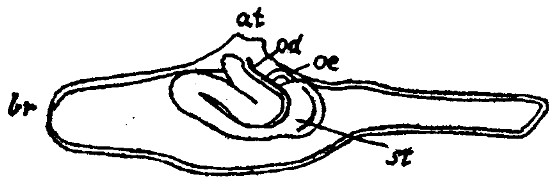


FIG. 108. *Ascidia vermiformis* (Ritter). Outline of body.

The branchial tentacles number 100 to 150; the opening of the dorsal tubercle is horseshoe shaped, with one end bent inward; the stomach has its inner wall longitudinally furrowed (furrows about 14 in number).

LOCALITY: The only specimens were from "Albatross" Station 2945, off southern California, latitude 34° N., longitude 119° 29′ 30″ W., 30 fathoms, pebbly bottom. Type, U.S.N.M. No. 5792.

Ascidia ceratodes (Huntsman), 1912

Text figure 109

Ascidia californica RITTER AND FORYSTH, 1917, p. 454, pl. 38, fig. 6, pl. 41, figs. 24–27; JOHNSON AND SNOOK, 1927, p. 593, fig. 692; PRATT, 1935, p. 745; MACGINITIE, 1939, pp. 443, 446.

Ascidia eiseni MICHAELSEN, 1923, p. 38, fig. 8.

Phallusia ceratodes HUNTSMAN, 1912, pp. 114, 121; 1912a, p. 117, pl. 10, fig. 9, pl. 15, figs. 3, 4, 7.

This species, in which I include Ritter and Forsyth's *A. californica*, is the Pacific coast representative of *A. interrupta* of the West Indian region, and is so like it that were a number of examples of the two forms to be mingled together it would be hard to separate them all correctly. Yet the present form is apparently a distinct species. For one thing it is a species which ranges into much colder waters, while *A. interrupta*, if not strictly tropical, is nearly so and is confined to quite warm regions.

The body, as in *interrupta*, is more or less oval, elongate, or often somewhat narrower anteriorly, laterally compressed and usually attached by much of the left side, but as in *interrupta* irregularities in the shape and proportions are the rule rather than the exception. The atrial tube is usually quite far back, near, or behind, the middle of the body and directed more or less at right angles to the body axis. It is a much smaller species than *interrupta*. Huntsman gives the greatest length of British Columbia specimens as 70 mm., while the largest example I have seen from southern California was 47 mm. long, though this is perhaps not a maximum for that region. Judging by the considerable number of specimens I have compared, the body is proportionately broader and less elongated than in *interrupta*, but in individual cases the reverse often occurs, and in the present species the test is more transparent (yellowish horn color in transmitted light, often somewhat orange about the apertures).

On the right side of the body the mantle musculature is composed of fibers crossing in various directions; near the margin of the body these run prevailingly at right angles to the margin. On the left side the musculature

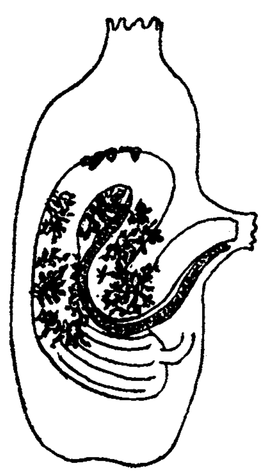


FIG. 109. *Ascidia ceratodes* (Huntsman). Outline of body removed from test, × about 1.5.

is almost wanting except on the siphons, and the mantle is thin and transparent. The branchial tentacles are very slender, numerous, and closely crowded, the number reaching 150 or even 200 or more in some individuals.

The aperture of the dorsal tubercle is horseshoe shaped, with the open interval forward, the ends usually incurved or sometimes slightly coiled in large examples. The ganglion is placed several times the diameter of the tubercle behind the latter. The dorsal lamina is wide, ribbed on the left side, and varying in different parts from nearly smooth margined to more or less denticulate or toothed. It extends past to the left of the oesophageal opening to the rear end of the sac; no secondary lamina or series of languets is developed on the right side.

The internal longitudinal vessels usually number from 30 to 45 on a side in ordinary-sized individuals, but Huntsman records 54 on the right side, and Ritter and Forsyth 60 in large specimens. The number of stigmata is usually three to six or even more in a mesh. Papillae are present at the intersection of the vessels only; the papillae often have near their base a little projection on each side.

The alimentary tract is usually proportionately larger and more bent than in *interrupta*, resembling that in *A. nigra*. The stomach has longitudinal plications, though these are not conspicuous externally. The reproductive organs resemble those of *interrupta*, some branches of the ovary being visible in the anterior or primary loop of the intestine and usually to a small extent in the secondary loop also. I failed to demonstrate renal vesicles in many rather young specimens examined, but they were numerous in an old specimen from Lower California.

DISTRIBUTION: If, as seems correct, we unite Huntsman's and Ritter and Forsyth's species, the known range is from British Columbia (Departure Bay and Northumberland Straits, in 10 to 30 fathoms growing in masses attached to stones, shells, etc.) south to the Gulf of California (Puerto Refugio). Ritter and Forsyth mention many California localities, from Tomales Bay on the north to San Diego on the south, including San Clemente Island. It occurs both near low-water mark on rocks, piles, and floats and in deeper water (down to 30 meters off San Diego) and is one of the common or even abundant ascidians in some of the bays and harbors, often growing in groups or masses. This species appears spontaneously in aquarium tanks with running sea water at the Kerchkoff Marine Laboratory at Corona Del Mar.

The United States National Museum has many rather small specimens from Salinas near Puerto Santa Elena, Ecuador, and also from Tocopilla, northern Chile, which appear to be of this species, though the mantle musculature is coarser and heavier than usual in California specimens.

A careful and detailed description of this species based, however, on only one specimen, is given by Michaelsen, 1923.

Ascidia clementea Ritter, 1907

Text figure 110

Ascidia clementea RITTER, 1907, p. 32, pl. 3, figs. 31–34 (not fig. 30).

Phallusia clementea HARTMEYER, 1909–1911, p. 1401; 1912b, pp. 374, 379.

"General Characters: Somewhat pear-shaped, the small end bearing the branchial orifice, turned to the dorsal side. Outline rather regular, and surface even. Area of attachment at posterior end, and to some extent on left side. Siphons distinct even in contracted state; probably prominent in life. Branchial turned to the dorsal side; atrial on the dorsal side about midway the length of the body. The lobes of both orifices large, the ventral ones (uppermost from the bent-over position of the siphon) of the branchial orifice, larger. Eight lobes to the branchial orifice, and six to the atrial. Test semi-transparent, thickness moderate and nearly uniform in all parts of the body, rather soft. Length of largest specimen 11 cm., greatest thickness 6 cm., distance between orifices 5.5 cm. Musculature of mantle nowhere highly developed, wholly wanting on most of the left side; the constituent fibers without regular arrangement.

"Branchial tentacles 75 or more, simple, filiform, and situated on the edge of a broad, rather thick membrane or velum. Hypophysis mouth horseshoe shaped, the open end directed forward. The right horn turned in slightly in the specimen examined. Gland rather large, situated behind the hypophysis mouth a little more than its own length. Ganglion long and narrow, the anterior end immediately over the gland. The peribranchial groove narrow, outside the tentacular corona a distance about equal to the width of the membrane that carries the tentacles. Dorsal lamina a broad membrane with numerous ribs on its sides, and short processes on its edge" (Ritter, 1907).

The branchial sac appears from Ritter's description and figures to be quite regular in structure. Plications developed in some parts. The transverse vessels are mostly uniform in size but with a very large one at intervals. Intermediate papillae are present on the internal longitudinal vessels.

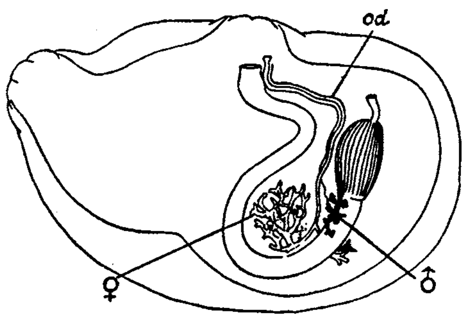


FIG. 110. *Ascidia clementea* Ritter. Outline of body from Ritter's illustration. ×2.

The digestive tract is a simple loop, transverse and rather widely open, the secondary loop being represented by only a bending of the rectal portion. The stomach has longitudinal plications. The ovary is situated chiefly in the intestinal loop; the testis on and immediately behind the stomach. The renal organs, consisting of clear vesicles each containing a concretion, spreads over the entire area of the digestive tract, extending beyond its border all around.

DISTRIBUTION: This is a deep-sea species obtained, as far as I know, only by the steamer "Albatross" off the California coast near San Clemente Island at Station 4405 in 654 to 704 fathoms and at Station 4425, 21.5 miles from San Nicolas Island in 1100 fathoms, green mud, sand, and globigerina (seven specimens).

In the explanation of plate 3 of Ritter's 1907 article, figure 30 is wrongly stated to represent a "fragment of the branchial network" of this species. It actually represents *Benthascidia michaelseni.*

Ascidia paratropa (Huntsman), 1912

Text figure 111

Ascidiopsis paratropa HUNTSMAN, 1912, pp. 114, 120; 1912a, p. 113, pl. 10, fig. 4, pl. 15, figs. 1, 2.

A species of cylindrical form; attachment by the posterior end; both apertures at the anterior end and directed forward, the branchial on a short papilla, the atrial on a contractile siphon which extends farther forward than the branchial aperture.

Test transparent and colorless, its surface with rather thickly scattered, rough, prominent, and conspicuous tubercles of various sizes.

The species is a large one, reaching, according to Huntsman, a length of 11 cm. in anteroposterior diameter and 4 cm. transversely.

The following table given by Huntsman shows that the branchial sac considerably resembles that of *A. callosa*, though with more

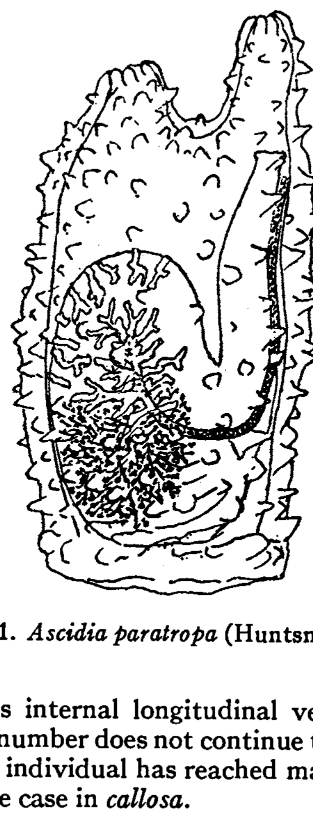


FIG. 111. *Ascidia paratropa* (Huntsman). Natural size.

numerous internal longitudinal vessels, and that the number does not continue to increase after the individual has reached maturity, as is also the case in *callosa.*

LENGTH OF BODY	VESSELS ON LEFT SIDE	VESSELS ON RIGHT SIDE
2.0 cm.	28	32
4.2	34	39
7.0	36	42
9.5	33	42
10.0	36	41
11.0	34	42

The stigmata in a mesh generally number from four to 12; there may be 30 or more tentacles; the ganglion is a little removed from the dorsal tubercle. The details of the dorsal lamina, alimentary tract, and gonads do not appear to exhibit distinctive characters not also found in *callosa*. The anterior loop of the intestine is, according to Huntsman's statements (and also in the two specimens I have examined), directed forward, not bent toward the rectum; the latter, in conformity with the forward position of the atrial siphon, is quite long. (See Huntsman, 1912a, for additional details of its structure.)

DISTRIBUTION: Huntsman obtained 32 specimens of various sizes on the British Columbia coast (Departure Bay, Ucluelet, Banks Island, and Goose Island) in 10 to 20 fathoms on gravelly or shelly bottom. The American Museum of Natural History has one large one, 9.5 cm. long, from Friday Harbor, Washington, collected many years ago by E. C. Starks, that corresponds well both in external and internal characters with Huntsman's description and figures; the United States National Museum has a still larger one from Unga Strait, Alaska, 37 to 47 fathoms.

It should be noted that *A. callosa* sometimes has the external surface more or less papillated or tuberculated. Huntsman, 1912, reports papillated examples of his "*Ascidiopsis columbiana*" (which is apparently a synonym of *A. callosa*) but does not question the distinctness of the present species, *paratropa*.

Ascidia unalaskensis (Ritter), 1913

Ascidia unalaskensis HARTMEYER, 1924, p. 68; ÄRNBÄCK, 1934, p. 43.

Phallusia unalaskensis RITTER, 1913, p. 497, pl. 36, figs. 43–45.

Described by Ritter from a single specimen from rather deep water. Body elongate, subcylindric, attached at posterior end, measuring 6 by 2.5 cm. The branchial sac has few internal longitudinal vessels (about 25 on each side, separated by six to 15 stigmata) and a small number of tentacles (24). Intermediate papillae present in some places but more often wanting. The ganglion is a little removed from the dorsal tubercles whose opening is horseshoe shaped with the interval forward and the horns incurved. Alimentary tract voluminous, intestine considerably bent in an S-shaped curve. Renal vesicles numerous on the wall of the stomach and first part of the intestine.

LOCALITY: "Albatross" Station 3315, Bering Sea, north of Unalaska Island, 277 fathoms, green mud and sand. Type in the United States National Museum.

This seems to be related not to *A. obliqua*, as Ritter believed, but rather to *A. callosa*.

FAMILY AGNESIIDAE HUNTSMAN, 1912

A family established to contain the genus *Agnesia* previously included in the Rhodosomatidae, from which it differs in having the alimentary tract located on the left side of the body and resembling that of *Ascidia* and most other simple ascidians in its course; also in the absence or reduction to mere rudiments of the internal longitudinal vessels of the branchial sac.

The recently described allied genus *Caenagnesia* Ärnbäck (see below) must now be also included in it.

GENUS AGNESIA MICHAELSEN, 1898

Superficially much like *Corella*. Body ovate, sometimes with a pedicel; test substance very transparent, though this is often obscured by a coating of sand grains.

Mantle transparent, its musculature not heavy. Tentacles simple; dorsal tubercle of simple form; dorsal lamina represented by languets. Branchial sac resembling that of *Corella* in its general features, but internal longitudinal vessels are entirely wanting, though the transverse vessels bear a membrane along their internal aspect that is raised at intervals into large, more or less hook-shaped projections (usually 10 to 12 on each vessel on each side of the sac) suggesting the supporting papillae found in genera having internal longitudinal vessels.

The principal transverse vessels of the sac usually about six in number; they are separated by two rows of small infundibula on which the stigmata form simple spirals of a few turns. Adjacent spirals in same transverse row coil in opposite directions; their free or outer end may develop into a small accessory spiral. The vessels of each spiral are usually crossed and supported by four radial vessels converging at the summit of the infundibulum (center of spiral). The whole, or at least the central part, of each spiral is composed of one elongate stigma making a few (three to five) turns, when turns are more numerous (six or seven, rarely more) there may be interruptions so that the outer turns are composed of several stigmata end to end.

Intestinal tract on left side of body, the middle part of the intestine passing above (dorsal to) the stomach and proximal part. Gonads in or beside intestinal loop, both ovary and testes of branching structure but the ovary much more compact. The genital ducts are long and accompany the intestine.

The writers that have dealt with this genus have left our knowledge of it in a confused and unsatisfactory state, a number of species distinguished only by minor characters of very dubious taxonomic importance and reliability having been established. As far as the Western Hemisphere species are concerned, I cannot concede recognition to more than two, one of the Magellanic region, and of the northern Pacific and Bering Sea region. To the latter the two Japanese species described by Oka, *A. himeboja* and *A. sabulosa*, are very closely related, not to make any stronger statement.

The genus exhibits a striking case of bipolarity, the northern and southern representatives being so much alike that their wide geographical separation rather than any known structural difference provides the justification for separating them.

Agnesia glaciata Michaelsen, 1898

Agnesia glaciata MICHAELSEN, 1898, p. 370; 1900, p. 6, pl. 3, figs. 20–22; 1907, p. 75.

? *Agnesia krausei* MICHAELSEN, 1912, p. 181, figs. 24, 25.

Agnesia glaciata from Haberton Harbor, Tierra del Fuego, in 7 fathoms, is the type of the genus *Agnesia*. Michaelsen had but one good specimen, a rather large one (18 by 15 by 13 mm. in diameter); he was uncertain of the identity of several very small ones that accompanied it.

In a much later work he described two much smaller specimens, the largest 9 mm. in greatest diameter, the other much less, obtained on the East Patagonian Bank, as a distinct species, *A. krausei*. The smaller number of turns in the spirals of the branchial sac of *krausei*, four or five instead of seven or eight or even nine in the type of *A. glaciata*, and the absence of interruptions in the stigmata forming the spirals in *krausei*, is no more than one would expect in much smaller and presumably younger individuals. In *A. glaciata* the central turns of the spirals are continuous without interruptions. That some interruptions would appear as additional turns developed is most probable.

In view of the great individual variation which Ritter, 1913, emphasized in his description of *A. beringia* (= *A. septentrionalis* Huntsman) from Bering Sea, I must consider Michaelsen's two Subantarctic species as only very doubtfully distinct from each other. In both of them the aperture of the dorsal tubercle is described as a circular arc, or a punctured ("durchbohrter") opening, while in the northern species it is usually elongated and curved.

DISTRIBUTION: Magellanic region in quite shallow water (see above).

Agnesia septentrionalis Huntsman, 1912

Text figures 112–114

Agnesia beringia RITTER, 1913, p. 493, pl. 36, figs. 37–41.

Agnesia septentrionalis HUNTSMAN, 1912, p. 118; 1912a, p. 106, pl. 10, fig. 1, pl. 14, figs. 2, 3.

Shape varying from elongate to short oval, more or less laterally compressed; the apertures both on or near the anterior end, usually little if at all prominent, the branchial usually somewhat in advance. Lobing of the orifices commonly somewhat obscure, about six or eight lobes generally distinguishable. Test colorless, and when surface is clean and smooth sometimes of glassy transparency, but often opaque with a continuous coating of sand attached to minute processes of the test, or more or less embedded. Attachment usually by the posterior end often aided by small branching process, or on a single slender peduncle, usually not very long, may be developed. Size of the largest specimen 3.7 cm. in greatest diameter, according to Ritter; this is not frequently attained; a greatest diameter of 12 to 15 mm. does not seem to be exceeded in most cases.

The mantle musculature consists of slender bands forming a rather open network; on and near the siphons the usual circular and radiat-

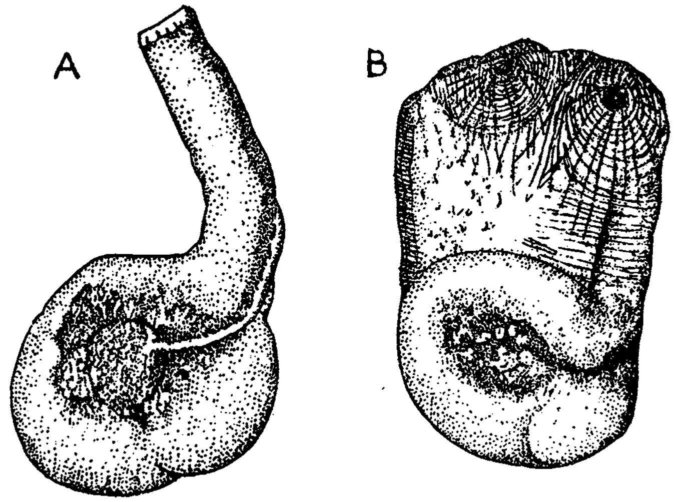


FIG. 112. *Agnesia septentrionalis* Huntsman. Left side of body. A. Intestinal tract and gonad, ×2.5. B. Left side of body removed from the test, ×2. After Ritter.

ing bands are present; transverse bands are numerous on most parts of the dorsal and ventral regions, but the greater part of the right and left sides of the body is virtually devoid of muscles.

Tentacles simple, slender, but thick at the base, and of various sizes, reaching 30 to 50 in total number. Aperture of dorsal tubercle transverse, curved, the concavity forward. Dorsal lamina represented by languets placed a little to the left of the median line, these, according to Huntsman, are opposite the 2d, 4th, 6th, 8th, 9th and 10th and 11th or 12th transverse vessels. Usual number of turns in the spirals not over four or five. Small, secondary spirals also present. Stomach smooth walled, intestine forming a rather close loop, in and upon which the gonads lie. The rounded, rather compact ovary is central and is surrounded by the much more ramified testis; both ducts accompany the rectum.

DISTRIBUTION: Dredged by the "Albatross" at many stations in the southeastern part of Bering Sea, in from 15 to 43 fathoms (Ritter) where it is evidently common; 10 miles south of Stephen Island, British Columbia (Huntsman's type locality); but its range apparently extends much farther south, as the American Museum of Natural History has three small, densely sand-covered specimens dredged by G. E. MacGinitie off the mouth of Newport Harbor, southern California, that are apparently of this species.

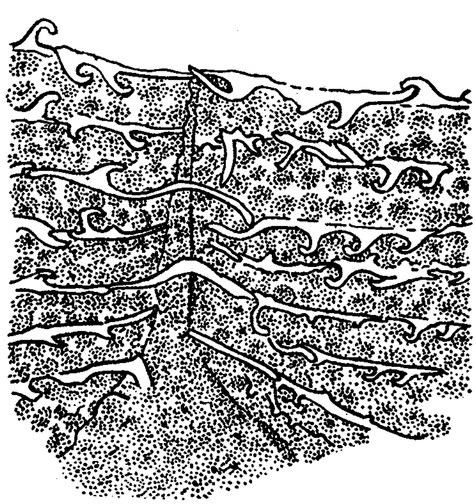


FIG. 113. *Agnesia septentrionalis* Huntsman. Interior of branchial sac. Dorsal lamina and transverse vessels. After Ritter.

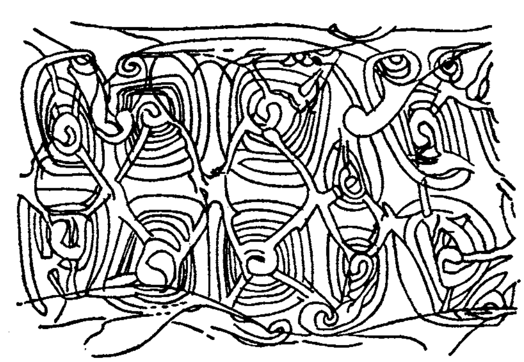


FIG. 114. *Agnesia septentrionalis* Huntsman. Small piece of branchial sac showing two of the principal transverse vessels. After Ritter.

Ritter reports that one of the Bering Sea specimens was labeled as attached to the back of a shrimp of the genus *Crago.*

This species is very close to the type of the genus *A. glaciata* Michaelsen, from Tierra del Fuego, but the wide geographical separation supports the view that the species are distinct.

Genus CAENAGNESIA Ärnbäck, 1938

Differs from *Agnesia* in having bifid, triangular papillae on the transverse vessels of the sac, their two branches apparently representing rudimentary internal longitudinal vessels, and in having the dorsal lamina a continuous membrane. It is thus intermediate between *Agnesia* and *Ascidia* and is a connecting link between the Rhodosomatidae and Ascidiidae.

Though *Caenagnesia* was proposed by Ärnbäck only as a subgenus of *Agnesia,* the two above-mentioned differences seem to me to be of generic importance.

Caenagnesia bocki Ärnbäck, 1938

Text figure 115

Caenagnesia bocki Ärnbäck, 1938, p. 41, pl. 2, figs. 20–22.

Body of squarish form in a lateral view, the lower part narrowed and keel shaped and apparently serving to anchor the animal in the sand or clay of the sea bottom. Apertures six- or seven-lobed, some distance apart on the upper surface; no distinct siphons. Size of largest specimen, 20 mm. long, 17 mm. in height, and 13 mm. from side to side.

Test cartilaginous and transparent. Mantle musculature of narrow, separated bands; circular bands well developed about the apertures; transverse bands on the sides weak. Radial bands extend down the sides, forking at their lower ends.

Tentacles simple, of several sizes, the smaller ones inserted nearer the aperture, total number 50 or more. No atrial tentacles observed. Dorsal tubercle small and rounded.

Dorsal lamina a broad, plain-edged membrane. Branchial sac (studied by Ärnbäck in a single specimen) had the sitgmata coiled in spirals of three to five turns, forming small infundibula, each spiral usually consisting of two stigmata, a long one composing the inner turns and a short one composing part of the outer turn. Four slender vessels radiate from the center of each spiral. Twelve transverse rows of spirals were found on each side of the specimen examined, with 13 or 14 in a row and a few accessory spirals near the dorsal lamina. Eleven transverse vessels separated the rows of spirals; there were besides these a few incomplete vessels. The complete ones bore on each side 37 to 38 bifid papillae whose two branches apparently represent rudimentary (interrupted) internal longitudinal vessels.

Mouth of oesophagus at end of branchial sac; oesophagus short, stomach globular, sharply marked off from the intestine, its

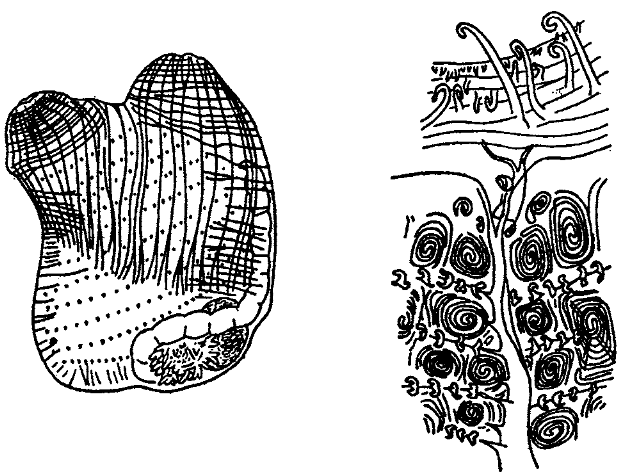


Fig. 115. *Caenagnesia bocki* Ärnbäck. Body removed from the test, ×3. Anterior part of sac, dorsal lamina, tentacles, etc., ×9. Outlines from Ärnbäck's figures.

wall with small, irregular areolations. Intestinal loop small, open, horizontal in direction, on posterior part of left side; rectum long, at a right angle to the rest of the intestine.

Gonads in the intestinal loop. Ovary central, surrounded by the testis which is ramified and composed of numerous elongated glands, mostly cleft into lobes. The testis also spreads over parts of the stomach and intestine. Both genital ducts accompany the rectum.

LOCALITY: Based on three specimens from the Graham region of the Antarctica, 65° 19′ S., 56° 48′ W., depth 400 meters, collected by the Swedish Antarctic expedition, 1901–1903.

FAMILY **RHODOSOMATIDAE** HARTMEYER, 1908

(Syn. Corellidae auct. mult.)

A rather small group of ascidians related to the family Ascidiidae, resembling it in the character of the test, which is more or less transparent or translucent, and the simple tentacles. The branchial sac is without folds, but in most genera has internal longitudinal vessels raised on supporting papillae, although these vessels do not bear papillae themselves.

The important distinguishing characters of this family are the situation of the digestive tract more or less on the right side of the body, and the course of the intestine, which after leaving the stomach bends ventrally and passes the stomach on the ventral side to turn dorsally toward the atrial region. The gonads are situated in, or in close relation to, the intestinal loop, the testis being very extensively ramified.

GENERA OF RHODOSOMATIDAE

A. Body elongate, both apertures in an oblique cleft near the anterior end capable of being closed by a movable cover. Branchial sac with straight stigmata and internal longitudinal vessels . . . . *Rhodosoma*

B. Apertures both near together on an ovate, disk-like, distinctly bounded area which in all but one species (*inaequale*) is protected by definitely arranged thin horny plates. Stigmata curved or in small spirals. . . . . *Chelyosoma*

C. Body sac-like, without protective structures, sometimes with a short pedicel for attachment; test transparent, stigmata in small, often very perfect spirals regularly arranged.

D_1. Internal longitudinal vessels numerous and well developed. . . . . *Corella*

D_2. Imperfectly known abyssal genera related to *Corella* . . . . (see pp. 215, 217). . . *Corynascidia* and *Benthascidia*

D_3. Arctic genera related to *Corella*, internal longitudinal vessels incomplete (see p. 214) . . . . *Corelloides* and *Corellopsis*

SUBFAMILY **RHODOSOMATINAE** SEELIGER, 1907

This appears to comprise only the following genus:

GENUS **RHODOSOMA** EHRENBERG, 1855

Distinguished by having the body elongate and both apertures in an oblique cleft near the anterior end which may be closed by a movable cover. The stigmata are straight and arranged in dorsoventral rows as in *Ascidia*. Internal longitudinal vessels present. It appears to have only one valid species.

Rhodosoma turcicum (Savigny), 1816

Text figures 116, 117

Chevreulius callensis LACAZE-DUTHIERS, 1865, Ann. Sci. Nat., Paris, ser. 4, vol. 4, p. 293, pl. 5.

Phallusia turcica SAVIGNY, 1816, pp. 102, 105, pl. 10, fig. 1 (see Hartmeyer, 1909–1911, p. 1389).

Rhodosoma papillosum VAN NAME, 1918, p. 113, figs. 68–71.

Rhodosoma pellucidum VAN NAME, 1918, p. 113, figs. 68–71; 1921, p. 392, figs. 69, 70; 1924, p. 29.

Rhodosoma pyxis TRAUSTEDT, 1882, pp. 274, 285, pl. 4, fig. 4, pl. 5, figs. 15a, 15b.

Rhodosoma seminudum HELLER, 1878, p. 91, pl. 1, fig. 5; SLUITER, 1898, p. 10; HARTMEYER, 1901, p. 162, pl. 4, figs. 1–7.

Rhodosoma turcicum VAN NAME, 1930, p. 471, fig. 43.

Rhodosoma verecundum EHRENBERG, 1828, Symbolae physicae, Zool. I, Praefactio, p. 3.

Schizascus pellucidus + *S. papillosus* STIMPSON, 1855, p. 377.

See Hartmeyer, 1901, for other references and information.

Body more or less irregularly oblong, not much compressed laterally, tapering toward the posterior end and commonly attached by the posterior part of the right side. The anterior end of the body is obliquely truncated, and just behind the anterior margin a deep, obliquely transverse cleft partially separates the anterior wall of the body which thus forms a hinged lid or cover (hinged at the right side) capable of being quite tightly closed down and shutting in the two apertures which are situated in the soft, flexible test that lines the cleft. The branchial aperture has about eight obscurely defined lobes and is slightly more prominent than the atrial which has but six.

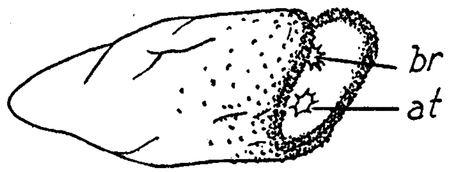


FIG. 116. *Rhodosoma turcicum* (Savigny). ×3.

Commonly the test is rather transparent, colorless or yellowish in preserved material, though said to be suffused with a pink shade in life, and has a fairly smooth surface, except for minute conical points or papillae, which are usually quite numerous toward the anterior end of the body, especially on the somewhat thickened lips or margins of the cleft. This species attains a length of 50 mm. or more but is usually very much smaller.

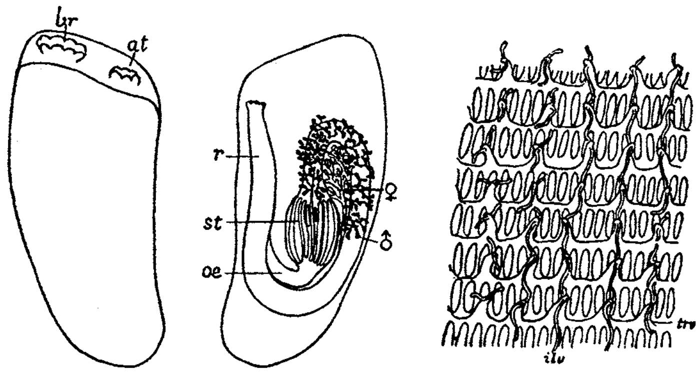


FIG. 117. *Rhodosoma turcicum* (Savigny). Outline of body and internal organs, ×2, and piece of the branchial sac, ×38.

Specimens such as just described are quite easily recognized, but in some cases pressure of other organisms growing near there or other causes may distort or cause folds or wrinkles in the body surface, and sand or mud in the water may discolor, roughen, or incrust the surface of the test. It is surprising how easily the cleft may be overlooked in wrinkled or irregularly shaped specimens when it is tightly closed.

The mantle is thin and almost devoid of muscles in most parts except in the vicinity of the apertures, and at each end of the hinge where a group of a few short, thick bands for moving and holding closed the lid extends a little way down on each side.

The tentacles are simple and of several sizes and, counting small ones, may reach about 50 in number. Dorsal tubercle usually horseshoe shaped with the open interval forward and the horns incurved. Dorsal lamina replaced by a series of rather long, narrow, triangular languets.

Branchial sac without folds or minute plications, but with numerous slender internal longitudinal vessels which are sometimes interrupted or incomplete on parts of the sac. The stigmata are straight.

The numerous transverse vessels show a tendency to alternate in size; they bear rather high papillae for the support of the internal longitudinal vessels. The papillae extend just a trifle above the points of union with the internal longitudinal vessels. The latter are spaced at intervals dividing the sac into small square meshes containing four or five stigmata. The bases of the supporting papillae arising from the same transverse vessel are connected by a narrow membrane; indeed the papillae (which are somewhat flattened) may be described as triangular projections of the free border of such a membrane.

Alimentary tract forming an oblong loop on the right side of the body, the intestine curving so as to pass the stomach on the ventral side. The stomach is small, with about 20 conspicuous longitudinal folds and a well-marked typhlosole; the latter may be traced through much of the intestinal tract. Rectum slender, its opening lobed. The intestinal gland surrounds the duodenal part of the intestine; its minute tubules end in small bulbs.

Ovary of branching form, situated in the intestinal loop anterior to the stomach, its duct accompanying the distal part of the intestine. The testis is an extensive, ramifying organ spreading over the part of the intestine lying anterior and ventral to the stomach on the side of the intestine next to the mantle.

DISTRIBUTION: There appears to be but one valid species of this genus, which is widely distributed in the warmer parts of the Old World (Mediterranean, Red Sea, Malay region, China) but has been known in American waters only from the West Indian region. However, a very imperfect specimen in the American Museum collection from Monterey Bay, California, 50 to 60 fathoms is evidently a *Rhodosoma* and is of this species, as far as I can tell. Though recorded from many points (Jamaica, St. Croix, St. Thomas, Puerto Rico, Curaçao, and also in 26 fathoms off the west coast of Florida, at "Albatross" Station 2406), it is not common and only single individuals, not clusters, are usually found. Curaçao seems to be an exception to this statement, where a considerable number were collected by C. J. Van der Horst, some in clusters with individuals of its own or other species, in the Spanish Water, a shallow bay. Most of the records give no depth, but it seems to be a species of quite shallow water.

SUBFAMILY **CHELYOSOMATINAE** HARTMEYER, 1908

This comprises the remaining genera of the Rhodosomatidae, distinguished from the Rhodosomatinae by lacking the protecting cover to the apertures and by having the stigmata curved, often forming perfect spirals. The development of the internal longitudinal vessels varies from a completely developed system to rudimentary or wanting.

GENUS **CHELYOSOMA** BRODERIP AND SOWERBY, 1830

Related to *Corella* (see below) and resembling it in its internal anatomy, but having a large part, or the whole dorsal side, of the body modified into an oval, definitely bounded disk in which the two apertures, both six-lobed, are situated. The disk (except in one species) is covered by thin horny plates more or less definite in number and arrangement.

Tentacles simple and very numerous; branchial sac without folds but with numerous slender internal longitudinal vessels; stigmata curved and in most species arranged in small spirals; dorsal lamina represented by slender languets. Intestinal loop more elongate and more displaced ventrally than in *Corella*, so that it encroaches on the left side of the body but belongs properly to the right side (see Huntsman, 1912a, pp. 122, 123).

The gonads lie in, and ramifying over, the surface of the alimentary loop. The ovary consists of a few stout branches, the testis of a much more extensive system of tree-like ramifications, which unite to form a common efferent duct. The latter, as well as the oviduct, accompanies the distal part of the intestine.

In some species of this genus the plates show concentric lines of growth giving an indication of the age of the individual (see Huntsman, 1921).

Chelyosoma macleayanum Broderip and Sowerby, 1830

Text figure 118

Ascidia geometrica STIMPSON, 1852, p. 229; 1854, p. 20.

Chelyosoma geometrica STIMPSON, 1860, p. 2; VERRILL, 1879, p. 27; KINGSLEY, 1901, p. 183.

Chelyosoma geometricum BINNEY, 1870, p. 26; DALL, 1870, p. 255; VERRILL, 1873–1874, vol. 7, p. 43; 1874, pp. 361, 363, pl. 1, fig. 6; WHITEAVES, 1901, p. 267; STAFFORD, 1912, p. 64 (*geomtericum*).

Chelyosoma macleayanum BRODERIP AND SOWERBY, 1830, p. 46, pl. 3, figs. 4–6; H. P. C. MOELLER, 1842, p. 95; ESCHRICHT, 1842, p. 3, pl. 1; RINK, 1857, p. 104; M. SARS, 1859, p. 66; LÜCKEN, 1875, p. 138; TRAUSTEDT, 1880, p. 429; 1885, p. 7, pl. 1, figs. 1–3, pl. 2, fig. 13; JACOBSOHN, 1892, pp. 158, 166; KIAER, 1893, p. 44; 1896, p. 7; HARTMEYER, 1899, p. 498, fig. J, pl. 23, figs. 9, 17; 1903, pp. 269, 374; BJERKAN, 1905, p. 13; REDIKORZEV, 1907, pp. 141, 152, 154; 1907a, p. 521; 1908a, p. 39; BJERKAN, 1908a, p. 75; REDIKORZEV, 1911a, p. 149, fig. 10; VAN NAME, 1912, p. 591; HUNTSMAN, 1912, pp. 113, 139; HARTMEYER, 1914b, p. 1108; 1921, p. 68; 1924, p. 2; HUNTSMAN, 1921, p. 27, fig. 1; 1922a, pp. 3b, 7b; ÄRNBÄCK, 1934, p. 76, pl. 5, figs. 27–33; HUUS, 1937, p. 672, fig. 576.

Note: This specific name has been variously written or misspelled: *mac leayanum* (two words), *macleajanum*, *ı aclayanum*, *macleayana*, *macleyanum*, etc.

Chelyosoma sp. STIMPSON, 1864, p. 161.

?*Phallusia sutherlandi* HUXLEY, 1852, *in* Sutherland, Jour. Voy. Baffin's Bay, vol. 2, p. 213; HARTMEYER, 1903, p. 295.

In this species the body is low and flattened dorsoventrally and attached by the whole lower surface, which corresponds to the ventral, or more exactly the left ventral, aspect; the upper (dorsal) surface is almost entirely occupied by the disk, which is slightly oblique to the dorsoventral axis and not quite symmetrical, the two apertures being displaced to the left of its middle line. Each

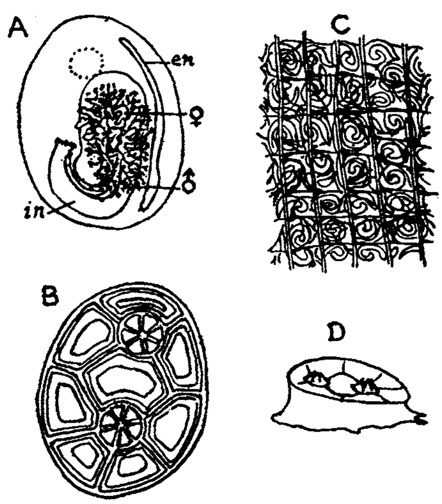


FIG. 118. *Chelyosoma macleayanum* Broderip and Sowerby. A. Intestinal tract and gonad, ×1.5. B. Plates of disk, ×1.5. C. Piece of the branchial sac. D. Lateral view of animal, natural size.

aperture is surrounded, and rendered slightly prominent, by a circle of six small, valvelike triangular converging plates. The rest of the disk is normally covered by eight plates, of which seven are marginal and only one central (between the apertures), though some specimens have one or two additional marginal plates; less frequently individuals with only six marginal plates occur. In this species the normal number of plates is at the minimum; most other species have more.

The test is transparent and nearly colorless in young examples; in older specimens it becomes yellow or pale horn color and opaque. In the Arctic regions this species reaches a considerable size, the long diameter of the disk measuring 20 to 30 mm. or more (Huntsman, 1921, and Ärnbäck, 1934, mention examples up to 44 and 45 mm.), but in most southern latitudes it is usually small, not over 10 to 12 mm. in diameter of the disk.

The chief mantle muscles are short, thick bands about the margin of the disk, extending down the sides a little way.

Branchial tentacles simple, very numerous (over 100 in number), of unequal sizes. Dorsal tubercle with a crescentic or U-shaped aperture, the open interval forward, the horns not inrolled. Dorsal lamina represented by a series of numerous slender languets.

Branchial sac with a well-developed system of slender, internal longitudinal vessels borne on rather low supporting papillae, though they themselves bear no papillae, and likewise with a quite regular system of slender transverse vessels which show a tendency to alternate in size. The stigmata are curved and usually form small simple spirals of one to three turns; the spirals are somewhat irregularly arranged and do not for the most part exactly correspond in number and position with the meshes formed by the abovementioned vessels. Stomach wall areolated or pitted. Gonads as described under the genus.

DISTRIBUTION: A circumpolar Arctic species of quite rare occurrence in most of its range, but there are many records from the west coast of Greenland, and a considerable number of examples were collected by R. A. Bartlett in Bering Strait in 1924, in a very limited amount of dredging. It is not known to range south of the strait into Bering Sea, at least not on the Alaskan side, but it has been reported from the Sea of Okhotsk, whether correctly or not I do not feel certain.

On the east coast of North America it ranged much farther south than anywhere else, though in that region only a few specimens (all small ones) have ever been found. Stimpson (1852) and Huntsman (1912) have reported single examples from the region of the mouth of the Bay of Fundy, and Verrill (1874) one from Casco Bay, Maine, 16 fathoms; the United States National Museum has one from off Chebucto Light, Nova Scotia, 50 fathoms, and one from off Cape Ann, Massachusetts (42° 33′ N., 70 41′ 30″ W., 15 fathoms), the most southern record.

Though it has been found to within 1 meter of low-water mark, the usual range in depth is from 10 to 50 fathoms. Hartmeyer (1921, 1924), however, reports one station on the southwest coast of Greenland in the exceptional depth of 565 meters.

This species, the type of the genus, is one of those in which the plates exhibit lines of growth by which the age of the individual may be determined (see Huntsman, 1921). They indicate that it sometimes reaches an age of between four and five years.

Chelyosoma productum Stimpson, 1864

Text figures 119, 120

Chelyosoma producta STIMPSON, 1864, p. 161; RITTER, 1900, p. 605.

Chelyosoma productum VON DRASCHE, 1884, p. 381, pl. 7, figs. 5–9; TRAUSTEDT, 1885, p. 7; HERDMAN, 1898, p. 252; BANCROFT, 1898, pp. 309–332, pl. 18; 1899, p. 74; HUNTSMAN, 1912, pp. 114, 115, 124; 1912a, p. 123, pl. 11, figs. 1–4, pl. 16, figs. 2, 4, 7; RITTER, 1913, p. 437; RITTER AND FORSYTH, 1917, p. 456; HUNTSMAN, 1921, p. 34, fig. 2, pl. 1, figs. 2, 3; JOHNSON AND SNOOK, 1924, p. 594, fig. 693; ÄRNBÄCK, 1934, pp. 79, 80.

As excellent descriptions of this species have been given by von Drasche, 1884, Bancroft, 1898, and Huntsman, 1912a, it will be dealt with only briefly here by mentioning the chief differences separating it from *Ch. macleayanum*.

The most striking difference is the elongation of the body in a direction obliquely perpendicular to the plane of the disk. The body is thus more or less cylindrical (often with a more or less strongly curved axis) attached by one end, and obliquely truncated at the other by the oval disk containing the apertures. In preserved specimens the disk is often somewhat concave with a raised rim. It is usually flat or curved in life, according to Bancroft. The surface of the rest of the body is usually more or less smooth and transparent in young examples, and largely or wholly opaque and wrinkled, and yellowish or brownish in color in old ones. Young examples have the body depressed more like that of *C. macleayanum*, though the disk is more oblique. It lengthens gradually with age into adult form. The largest example whose measurements are given by Huntsman, 1912a, had a disk of 27 mm. by 18 mm. and a height obliquely perpendicular to the disk of 36 mm. Bancroft, 1898, illustrates one in which the

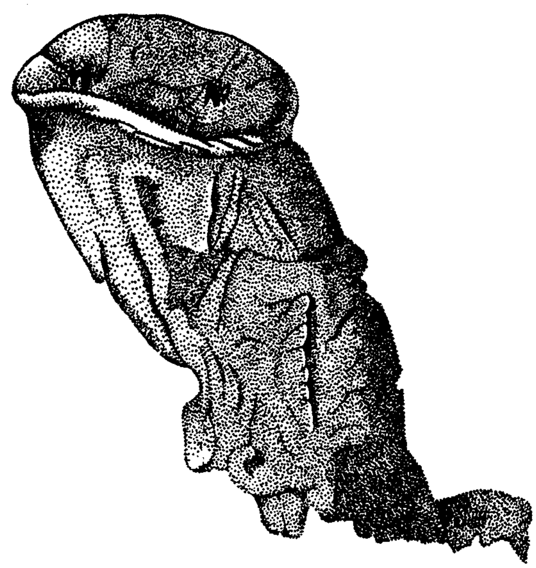


FIG. 119. *Chelyosoma productum* Stimpson. Old specimen with elongated body, ×1.5.

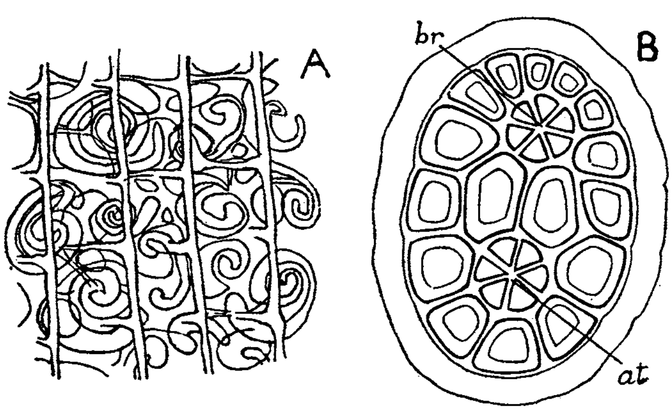


FIG. 120. *Chelyosoma productum* Stimpson. A. Piece of branchial sac. B. Plates of the disk, ×3.

latter measurement was over 50 mm. According to Huntsman's (1921) observations of the lines of growth on the plates, this species grows vigorously for the first two years and continues to grow, but much less vigorously, beyond the third year.

The disk has a larger and more variable number of plates than in *macleayanum*, there being from 13 to 20 in addition to the siphonal plates. There are usually two central plates side by side (with rarely a third median one) between the circles of siphonal plates and about 12 marginal plates. There may be one or several additional intermediate plates, often present on the right side only.

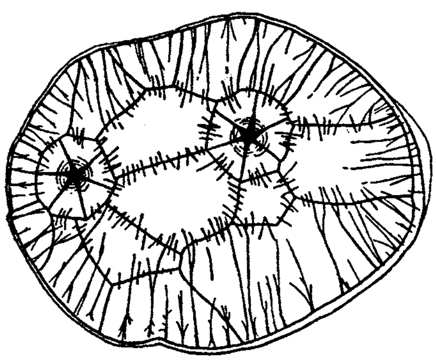


FIG. 121. *Chelyosoma columbianum* Huntsman. Plates of disk showing connecting muscles characteristic of this species, ×4. After Huntsman.

Both von Drasche and Bancroft describe the muscular system of the mantle as differing from that of *C. macleayanum* by the absence of short muscles connecting adjacent plates and by the greater development of the peripheral radial muscles of the disk, some of which extend into the central parts of the disk, reaching to the under side of the central plates and siphonal plates, as well as down on the sides of the body.

The oral tentacles number 75 to 125, and the internal longitudinal vessels, in a specimen 20 mm. in longest diameter of the disk, numbered 39 on the right and 30 on the left side, according to Huntsman, 1912a. The spirals and the infundibula of the branchial sac are usually fairly well developed in young specimens, but the structure of the sac becomes more irregular and complex in its details in old specimens, and the stigmata are obscured by the enlargement of the transverse vessels and the development of branches from them, producing an irregular network overlying them as viewed from the interior of the sac. This takes place to a varying extent in different individuals and in different parts of the branchial sac of the same individual.

DISTRIBUTION: This species is of much more southern distribution than *C. macleayanum*. It ranges from northern British Columbia to southern California, and is found from between tides to 25 fathoms or more. It reaches a maximum of numbers and size in the region of Puget Sound, and often grows in groups attached together with other individuals of its species or other kinds of ascidians.

Chelyosoma columbianum Huntsman, 1912

Text figure 121

Chelyosoma columbianum HUNTSMAN, 1912, pp. 114, 124; 1912a, p. 126, pl. 11, figs. 2, 3, pl. 16, figs. 3, 5, 6; RITTER, 1913, p. 486; HUNTSMAN, 1921, p. 35, fig. 3, pl. 1, fig. 4; ÄRNBÄCK, 1934, pp. 80, 81.

Not having seen specimens that I could identify with this species, I quote the following from Huntsman's (1912a) description:

"External Features: Usually much flattened and depressed. Attached by a broad area on the side opposite the disk. The attachment may be by a small area or by means of radicoid processes as long as body, as in the case of some specimens obtained by Professor Macoun from a bed of Hexactinellid sponge. The diameter perpendicular to disk may be nearly as great as the length of the disk; the body in that case is elongated in a direction making an angle of about 45 degrees with the disk. There is sometimes a rounded ridge behind disk along course of rectum.

"Surface smooth. Test yellowish or occasionally quite clear and transparent. Margin of disk sharper than in *C. productum*, not raised above the level of the disk in contracted individuals.

"Disk somewhat elliptical, usually broader behind. Apertures near the right margin and the anterior end. Siphonal plates retracted to level of disk.

"What appears to be the typical condition of the plates is obtained by taking the typical condition in *C. productum* and interposing two intermediate plates on the left side and rearranging the left marginal plates."

"Not more than half of the individuals exhibit this. The remainder are more or less irregular. There are typically 2 central, 2 intermediate on the left side and 12 marginal plates. There may be an additional central plate, only one or several additional intermediate plates on the left side, intermediate plates on the right side, larger or smaller number of marginal plates, etc."

"Musculature: Siphonal and marginal muscles as in *C. productum*, but in addition there are short thick strands crossing all those lines that are some distance from the margin. Narrowing of the disk may result in the fusion with the marginal fibres of all except those connecting the central plates.

"The arrangement of the vessels is similar to that in the preceding species. Stigmata: Usually two are coiled together to form a small infundibulum, but these may be broken up into many short ones.

"Intestinal Canal: Stomach, narrow, its diameter slightly greater than that of intestine; wall with folds, these for the most part longitudinal, but they may be quite irregular."

"This species does not attain the size of the preceding one. It reaches maturity at a smaller size, is more depressed, the surface is smoother, the margin of the disk is not definitely raised and the disk is always asymmetrical. It can always be distinguished from *C. productum* by the presence of the series of short muscle strands connecting the two central plates."

In large specimens the disk measures about 15 mm. in largest diameter. The plates do not show lines of growth in this species.

DISTRIBUTION: Described by Huntsman from stony bottoms in 10 to 20 fathoms on the coast of British Columbia (Departure Bay, Northumberland Straits, and Burrand Inlet). The only other record known to me is that of Ritter, 1913, who refers specimens from "Albatross" Station 2876, off Cape Flattery, Washington, 59 fathoms; and "Albatross" Station 2866, 171 fathoms, both near the entrance of the Strait of Juan de Fuca to this species.

Chelyosoma inaequale Redikorzev, 1913

Chelyosoma inaequale REDIKORZEV, 1913, p. 206, fig. 2; HARTMEYER, 1924, p. 10; ÄRNBÄCK, 1934, p. 80.

Though a typical *Chelyosoma* in every other respect, the disk is not divided up into definitely distinguishable plates separated by distinct sutures, but the apertures are surrounded by the usual six-pointed lobes which are quite rigid and prominent. Under low magnification the surface of the disk may have a slightly indicated, irregularly tessellated appearance due to numerous somewhat thickened or hardened spots irregular in appearance and distribution.

The body is somewhat elongated at an oblique angle to the plane of the disk, as in *C. productum*, but not to so great an extent. The disk is somewhat concave and depressed and is surrounded by a prominent raised margin. The mantle musculature is well developed, the short thick bands transversely crossing the margin of the disk especially so. According to Redikorzev, the infundibula of the branchial sac are of various sizes and project prominently into the interior of the sac, and are often divided at the summit. The dimensions attained are, according to that author, length up to 66 mm., width up to 45 mm., height to 43 mm.

DISTRIBUTION: Redikorzev based his description on seven specimens from the Sea of Okhotsk in 14 to 26 meters on stony bottoms.

Nothing like it has thus far been recorded from the American side, but three rather small specimens in the American Museum of Natural History from the Alaskan coast north of Bering Strait (one from Teller, Alaska, 65° 16′ N., 166° 25′ W., 5 fathoms, and two from off Point Hope, 20 fathoms) collected by W. Williams, agree quite well with Redikorzev's description. Two of them, which were opened, have the spirals of the branchial stigmata very well formed.

Besides these, the "Albatross" obtained specimens at two deep-sea stations in the Pacific which may represent an allied species rather than the present one, but are too poorly preserved to justify establishing a new species. One was dredged at Station 3883 off Panama, 07° 21′ N., 79° 02′ W., in 1832 fathoms, and two at Station D 5695 off southern California, 33° 31′ N., 120° 17′ 30″ W., in 534 fathoms. These specimens are of fairly good size (disk 20 mm. or more in diameter). Though poorly preserved, a spiral arrangement of the stigmata could be seen.

Genus CORELLA Alder and Hancock, 1870

Body usually oblong and somewhat laterally compressed, often produced into a short peduncle at the posterior end. Branchial and atrial apertures apparently normally seven- or eight- and six-lobed, respectively, but their lobation may be irregular or little developed. Test more or less transparent or translucent, colorless in preservation, but during life often handsomely tinted with violet, pink, or other shades.

Tentacles filiform, numerous, of two or three sizes. Aperture of dorsal tubercle usually simple C-shaped or crescentic, the concavity forward. Dorsal lamina represented by languets which often alternate in length.

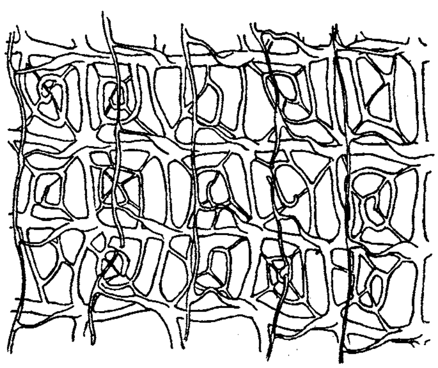


FIG. 122. *Corella borealis* Traustedt. Piece of branchial sac, ×30.

The branchial sac is marked off into small, square, or oblong areas by the transverse vessels and narrow longitudinal vessels. In each of these squares the stigmata usually form a single primary spiral of a few turns, which may be composed of several stigmata, end to end, or of only one or two. Radial supporting vessels cross the stigmata; the spirals may be very regular, uniform, and perfect, or more or less irregular, with secondary or accessory spirals, usually very small and incomplete, present between them. The primary spirals of adjacent squares, both in the transverse and longitudinal rows, curve in opposite directions, so that the free or outer ends of the spirals of four groups (four adjacent squares) lie near a common point.

In addition there is a system of slender but well-developed internal longitudinal vessels raised on quite tall papillae arising from the transverse vessels. They do not necessarily correspond in number or position with the longitudinal vessels between the spirals.

Stomach with a few longitudinal plications. The gonads ramify over much of the intestinal loop and part of the stomach. The sperm duct and oviduct accompany the rectum to near its end.

This genus is difficult to deal with from a taxonomic point of view. Unquestionably there are at least four distinct species in the region this work attempts to cover, but there is much uniformity in the main points of their structure and great variability in minor points, such as the exact position of the apertures or of the alimentary loop, the number of turns and degree of regularity of the spirals, the number of tentacles, etc., so that it is most difficult to find reliable distinguishing characters.

Corella borealis Traustedt, 1886

Text figure 122

Corella borealis Traustedt, 1886, p. 423, pl. 36, figs. 1, 2, pl. 38, fig. 22, pl. 39, fig. 28; Hartmeyer, 1903, p. 271; Van Name, 1912, p. 593, pl. 65, fig. 123; Hartmeyer, 1914b, p. 1109; 1924, p. 14; Ärnbäck, 1934, p. 71. Not Derjugin, 1910, p. 109.

This small species of the Arctic and northern regions much resembles *C. minuta*, described below, externally and internally. The body is of oblong form attached by the posterior end which is sometimes prolonged into a peduncle. Hartmeyer mentions specimens with body diameters of 19 by 12 mm., and 20 by 16 mm.

The mantle muscles are slight but better developed than in the specimens of *C. minuta* that I have seen; in the only example I have had the opportunity to examine there were, besides those about the siphons, a few (about a dozen) narrow bands extending transversely about halfway around the body. Several of these bands forked or divided into two branches in the ventral region. The tentacles in this specimen numbered about 50 of three sizes quite regularly placed.

The branchial sac was quite similar to that of *C. minuta*, but the spiral character still more poorly developed in most parts. According to Hartmeyer, 1924, the considerably larger number of internal longitudinal vessels (about 40 on each side in a specimen 16 mm. long) is a character distinguishing it from *C. parallelogramma* Mueller, 1776, of northwestern Europe and the Mediterranean, but not known from America, which is also distinguished by its well-formed branchial spirals, often with six to eight turns.

DISTRIBUTION: Chiefly an Arctic species which has been found at very few places: the Kara Sea, the Spitzbergen region, between the Faeroe and Shetland Islands, the east and west Greenland coasts and Baffin Land coast. One specimen was, however, obtained much farther south, near Cape Ann, Massachusetts (United States Fish Commission Station 236, 42° 28′ N., 70° 31′ W., 28 fathoms). The recorded depths range from 50 to 459 meters.

Corella minuta Traustedt, 1882

Text figure 123

Corella minuta TRAUSTEDT, 1882, pp. 271, 285, pl. 4, fig. 1; VAN NAME, 1921, p. 395, figs. 71, 72; 1924, p. 29; 1930, p. 473, fig. 44.

This small and rare species is of very delicate structure, and museum specimens are apt to be found in a collapsed condition but, judging from the material at hand, the normal form of the body is ovate or oblong, obliquely attached by a considerable area on the posterior part of the left side, and more or less produced at the anterior end into a tube or siphon bearing the branchial aperture at its end. The atrial aperture is dorsal, little if at all produced. Both apertures are rather long, oval openings, with the margin scalloped or lobed, but so obscurely that the lobes are difficult to count.

Test thin, flexible, whitish, and somewhat transparent, its surface smooth and clean except for numerous wrinkles and folds, many of which, however, are probably caused by shrinking and are not present during life. Size of largest specimen, 28 mm. long by 18 mm. in greatest dorsoventral diameter.

Mantle very thin and transparent, almost free from muscles. Tentacles long and slender; their number was not determined. (Traustedt gives 26 as the number in the type.) Dorsal tubercle small, its aperture of simple form. Dorsal lamina represented by a series of large and rather long and narrow languets.

Branchial sac divided into small square meshes by transverse and longitudinal vessels. In each mesh there is normally a slender spiral vessel making usually from two to four complete turns. These spirals arise from every alternate transverse vessel and are supported by a few small radial vessels. The greater part of the area of the meshes is, therefore, open and represents a wide, spirally

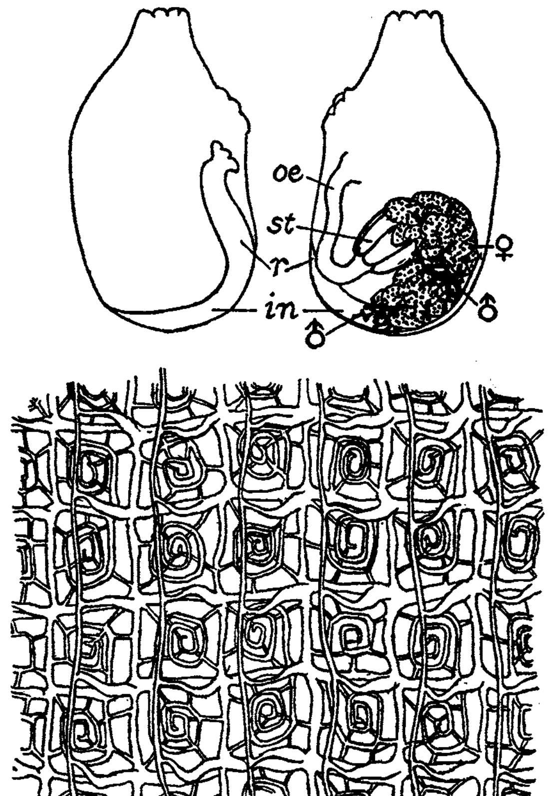


FIG. 123. *Corella minuta* Traustedt. Outline of left and right sides of body, showing intestinal tract and gonads, ×2.5, and piece of branchial sac, ×45.

curved stigma whose turns the spirally coiled vessels separate.

The alimentary tract lies chiefly on the right and posterior aspect of the body. The oesophagus is long and curved and opens into the oval stomach whose wall has a few deep plications. Extending forward from the stomach, the intestine curves ventrally, thus passing the stomach on the ventral and posterior side, where it curves forward to form the rather long rectum whose aperture has a reflexed and distinctly lobed margin.

The ovary forms a broad, flattened layer composed actually of thick, branching lobes, but these divisions are so closely crowded when the organ is distended with eggs that the ovary forms an almost continuous sheet covering that aspect of the pyloric part of the stomach and of parts of the intestinal loop (except the rectum) which lies toward the mantle. The testis is likewise a branching organ; its branches and lobes are narrower and smaller than those of the ovary, among and between which they ramify.

DISTRIBUTION: A shallow-water species of the West Indian region of which but few specimens have been found.

Traustedt's type was from St. Thomas. One example was collected by C. Van der Horst at Curaçao (Van Name, 1924), one by Beebe in Port au Prince Bay, Haiti, in 1927, and nine were dredged by the "Albatross" at Station 2406 (28° 46′ N., 84° 49′ W., 26 fathoms, coarse sand and coral) off the west coast of Florida. The last is the deepest record.

I know of no other specimens being found, but it seems possible that Traustedt's (1882) supposed record of *C. eumyota* from Bahia, Brazil, was based on a specimen of this species, which may be expected to range south along the tropical part of the east coast of South America.

Corella eumyota Traustedt, 1882

Plate 22, figures 2, 3

Corella antarctica SLUITER, 1905b, p. 471; 1906, p. 31, fig. 1, pl. 2, figs. 29–32, pl. 5, fig. 56.

? *Corella benedeni* VAN BENEDEN AND SELYS-LONGCHAMPS, 1913, p. 9, pl. 1; ÄRNBÄCK, 1938, p. 41.

Corella dohrni VAN BENEDEN AND SELYS-LONGCHAMPS, 1913, p. 15, figs. a, b, pl. 2; HERDMAN, 1923, p. 30; ÄRNBÄCK, 1938, p. 41.

Corella eumyota TRAUSTEDT, 1882 (but not specimen from Bahia), pp. 271, 273, pl. 4, figs. 2, 3, pl. 5, figs. 13, 14; 1885, p. 9; SLUITER, 1898a, p. 40, pl. 5, fig. 14; MICHAELSEN, 1900, p. 10; 1907, p. 74; HERDMAN, 1910, p. 16, pl. 3, figs. 1–6; HARTMEYER, 1911b, p. 458, pl. 45, fig. 8, pl. 51, figs. 6–9; SLUITER, 1914, p. 26; HARTMEYER, 1920a, p. 132; VAN NAME, 1921, pp. 397, 483; HERDMAN, 1923, p. 30, pl. 13, figs. 7, 8; ÄRNBÄCK, 1929, p. 7, pl. 1, figs. 10–14; 1938, p. 40.

Corella novarae VON DRASCHE, 1884, p. 382, pl. 8, figs. 1–4.

Body normally ovate to somewhat elongate oblong, more or less compressed laterally and attached by the rear end, which may be produced into a short peduncle, or by a large part of either side. Branchial aperture at the more or less narrowed anterior end of the body, the atrial a varying distance back on the dorsal side. The apertures are usually not very prominent externally; they are commonly rather distinctly seven- or eight-lobed and six-lobed, respectively.

Test colorless in preservation and often quite transparent, somewhat gelatinous, its surface smooth or more or less wrinkled.

This is the largest species of the genus. An anteroposterior diameter up to 30 to 40 mm. is not uncommon, but occasional specimens of very large size have been reported from the Antarctic, and from New Zealand Sluiter records one 13 by 7 cm. Hartmeyer and Ärnbäck record examples of 10 by 5.5 cm. and 9 by 5 cm., respectively.

Mantle thin and somewhat transparent. The siphons have well-developed circular and longitudinal muscles on the body; these are rather narrow, mostly transverse or oblique bands, the musculature best developed in the dorsal region and on the left side. The tentacles number from about 50 to 100 and are of two, sometimes three, sizes.

The internal characters conform to the statements made under the genus and, in most cases, do not appear to afford distinguishing specific characters.

The branchial sac is subject to such great variation individually and with age that it is difficult to give a description covering all cases. In young individuals the spirals formed by the stigmata are very numerous, small, and of but few turns (usually one to three or four only), and in most specimens there is a good deal of irregularity, rudimentary spirals or merely curved stigmata being numerous in parts of the sac. Older examples usually have spirals with more turns and arranged in more regular rows. Small secondary spirals crowded in between the larger primary ones are sometimes very numerous, especially in old individuals. The internal longitudinal vessels do not correspond in number to the primary spirals in the transverse rows but are considerably more numerous in some parts of the sac; they may be nearly twice as numerous. In a large Antarctic specimen 9 cm. in anteroposterior diameter, Ärnbäck found about 60 internal longitudinal vessels on each side. The type specimen of *C. dohrni*, 19 mm. long, had about 45 on each side. This specimen had 40 transverse rows of spirals with about 40 on each side. Counts of such details can be made only in unusually well-preserved specimens, and the data available are very insufficient.

DISTRIBUTION: Assuming that it is correct to consider the above-listed forms as synonyms, *C. eumyota* is of circumpolar distribution in the colder waters of the Southern Hemisphere. It occurs on the South American coasts from Valparaiso and the Juan Fernandez Islands south through the Magellanic region, the Falkland Islands, and north on the east coast at least to Puerto Madryn, Argentina. It extends south into the Antarctic (Graham Land region, Kaiser Wilhelm II Land). It is recorded also from the Cape of Good Hope; St. Paul Island, Indian Ocean; New Zealand (Cook Strait), and the Aukland Islands, and Tasmania. The depths are usually in quite shallow water, but Hartmeyer, 1912a, records it from 385 meters and Herdman, 1923, from 358 fathoms. In many places it is a common species, sometimes forming clusters or masses of a great many individuals.

C. eumyota was described by Traustedt, 1882, who gave two localities for it, Bahia, Brazil (the first mentioned), and Valparaiso, Chile; but his description was based on the Valparaiso specimen (39 mm. long), which was the largest, so that that place is the type locality. I am quite in agreement with Ärnbäck in rejecting Bahia, which is far within the tropics, as a locality for this cold-water species. (See remarks under *C. minuta.*)

Herdman, 1910, Hartmeyer, 1911b, and Ärnbäck, 1938, agreed in considering *eumyota, novarae*, and *antarctica* as synonyms, and Herdman, 1923, and Ärnbäck, 1938, suggest the probability of *dohrni* being also synonymous. The last-named author also questions (I think with good reason) the distinctness of *C. benedeni* described from a single specimen from the Antarctic, although the description and figure show much more regularity in the spirals of the branchial sac than anyone could expect to find in *C. eumyota*, also a complete absence of secondary spirals. In fact, such perfect regularity as the figure shows cannot be found in nature in any ascidian, and we must consider the figure as largely diagrammatic in character.

Corella willmeriana Herdman, 1898

? *Corella inflata* HUNTSMAN, 1912, pp. 114, 123; 1912a, p. 121, pl. 10, fig. 8, pl. 15, fig. 8, pl. 16, fig. 1.

Corella rugosa HUNTSMAN, 1912, pp. 114, 115, 122; 1912a, p. 120, pl. 10, fig. 7, pl. 15, figs. 5, 6.

Corella willmeriana HERDMAN, 1898, p. 252, pl. 11, figs. 1–4; RITTER, 1900, p. 604, pl. 18, fig. 15; HUNTSMAN, 1912, p. 122; 1912a, p. 119; RITTER, 1913, p. 487; HARTMEYER, 1924, p. 17; CHILD, 1927, p. 467.

Corella sp. RITTER, 1913, p. 490.

Body oblong, somewhat rectangular, laterally compressed anteroposterior diameter of largest specimen 45 mm., a length of about 30 mm. frequent. Branchial aperture on the anterior end; the atrial also on or near that end, sometimes slightly produced, both apertures more or less distinctly lobed.

Test transparent, colorless or nearly so in preservation, in life, according to Huntsman, yellowish with a tinge of pink or scarlet, according to Herdman "flecked with red pigment," smooth externally (*willmeriana*) or "irregularly wrinkled with fine irregular processes which vary much in degree of development" (*rugosa*). Mantle thin. Well-developed siphon muscles from which bands extend down on the body are described by Huntsman. Tentacles 50 to 80. Dorsal tubercle with horseshoe-shaped or crescentic aperture, the concavity forward. Fourteen to 20 dorsal languets. Branchial sac with 25 to 30 transverse rows of spirals which make four or six turns without many interruptions. Twenty to 24 internal longitudinal vessels on each side.

The alimentary tract and gonads conform to the statements under the genus.

DISTRIBUTION: Puget Sound region and waters surrounding Vancouver Island, British Columbia, extending north to Hecate Strait, and Loring, at the extreme end of the southern extension of Alaska. Herdman's type locality, Port Townsend, Washington. Depths from tidal levels to 25 fathoms. Huntsman mentions specimens growing on floating sea weed (*Macrocystis*) at Ucluelet, Vancouver Island. Child, 1927, who studied the development, states that the eggs are ordinarily retained in the atrial cavity until they hatch. He reports the species abundant on piles and floats at Friday Harbor, Washington.

C. inflata Huntsman, here treated as probably not distinct, was from Departure Bay, Vancouver Island, and was based on specimens of shorter, more square outline, 40 mm. maximum length, the same in breadth, and with 16 to 18 internal longitudinal vessels on a side, some of them incomplete, gonads less extensively spread over the alimentary tract.

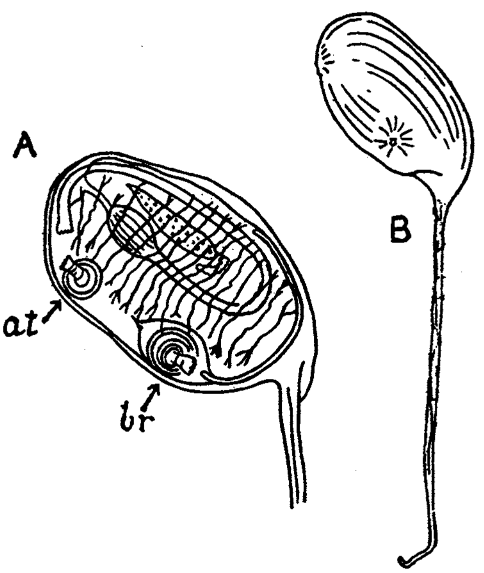


FIG. 124. *Corellopsis pedunculata* Hartmeyer. A. Outline of body, showing intestinal tract and gonads. B. Entire animal, ×1½.

GENUS **CORELLOIDES** OKA, 1926

See below, under *Corelloides molle*.

Corelloides molle Oka, 1926

Corelloides molle OKA, 1926, pp. 67, 68.

This species and its genus were based on two specimens dredged by the "Albatross" at Station 4770, in Bering Sea, 54° 31′ N., 179° 15′ E., 247 fathoms, near the west end of the Aleutian Chain and hardly within the area covered by this work.

The specimens resemble the genus *Corella* in nearly all respects, in their ovoid form without a peduncle, and their smooth gelatinous test. They have about 16 tentacles, the dorsal tubercle has a horseshoe-shaped aperture directed forward, the dorsal lamina is represented by languets, the intestine is on the right side, and the gonads in its loop as in that species.

The difference is in the branchial sac. The internal longitudinal vessels are incomplete, represented by branches of various lengths borne on the papillae. In these respects it resembles *Corellopsis* Hartmeyer, but differs in that the papillae have a distal part projecting beyond the point at which the incomplete internal longitudinal vessels arise, this projecting part of the papillae thus corresponding to the papillae in the sac of the genus *Ascidia*. The present genus, however, has the stigmata in small spirals as in *Corella*.

The specimens are of considerable size, one measuring 68 mm. by 36 mm., the other only a little smaller. They were attached to a siliceous sponge.

GENUS **CORELLOPSIS** HARTMEYER, 1903

A group containing, as far as known, only the following Arctic species, which differs from *Corella* in having the internal longitudinal vessels of the branchial sac reduced to short rudiments borne on the papillae of the branchial sac and in having a slender stalk arising as in *Boltenia ovifera* from the anterior end of the body. For difference from *Corelloides*, see that genus. In the branchial sac there is a strong resemblance to *Caenagnesia* Ärnbäck, but a very close relationship between those genera is excluded by the different course of the alimentary tract and the continuous dorsal lamina of the latter genus.

Corellopsis pedunculata Hartmeyer, 1903

Text figures 124, 125

Corella borealis (not Traustedt, 1886) REDIKORZEV, *in* Derjugin, 1910, p. 109.

Corellopsis pedunculata HARTMEYER, 1903, p. 273, pl. 5, fig. 15, pl. 12, figs. 1–5; REDIKORZEV, 1907, p. 522; 1908a, p. 40; DERJUGIN, 1911, p. 62; RITTER, 1913, p. 491; DERJUGIN, 1915, p. 570; HARTMEYER, 1924, p. 18; ÄRNBÄCK, 1934, p. 75.

The body is elliptical in outline, borne on a slender straight stalk, which may attain twice the length of the body. The stalk arises from the anterior ventral region. The branchial aperture is not far from the origin of the stalk; the atrial is near the opposite end. The test is thin, transparent, smooth, and free from incrusting material. Size of type: 19 by 11 mm., with a stalk 49 mm. long.

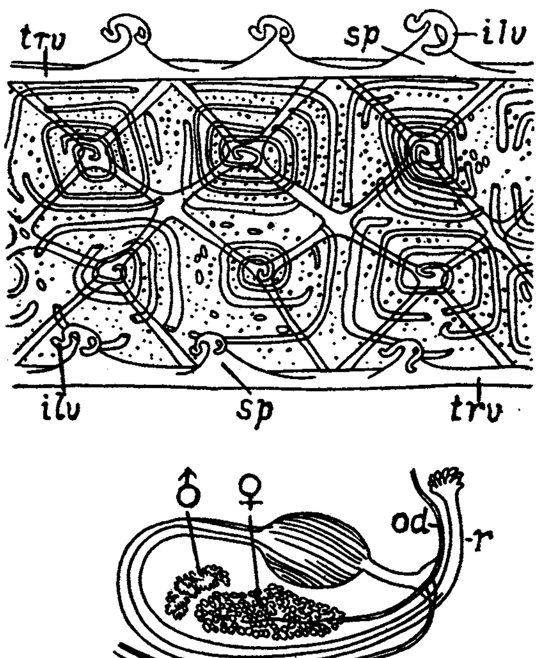


FIG. 125. *Corellopsis pedunculata* Hartmeyer. Piece of branchial sac and intestinal tract and gonad; *sp*, supporting papilla of rudimentary internal longitudinal vessels.

Tentacles of two sizes, 17 to 19 in total number, the smaller ones inserted nearer the aperture. Dorsal tubercle small, cup shaped. Dorsal lamina represented by a series of languets. Branchial sac without folds. It has well-developed transverse vessels, bearing a membrane whose margin is produced into papilla-like projections each dividing at their tip into two branches which evidently represent rudiments of a sytem of internal longitudinal vessels such as are present in *Corella*. The stigmata are arranged in small, often interrupted spirals of five turns or less. There are two transverse rows of these spirals between each two transverse vessels. Course of the alimentary tract as in *Corella*. Gonads in the intestinal loop, the ovary rather compact, the testes much more ramified.

This rare species is known from a few Old World localities within or near the Arctic Circle (King Charles Land, Spitzbergen, 105 meters, Kola Fjord, 126 to 144 meters, Siberian Arctic Ocean, 76° 08′ N., 95° 06′ 30″ E., 18 to 20 meters) and requires inclusion in this work only on account of a single specimen

FIG. 126. *Corynascidia suhmi* Herdman. Entire animal, two-thirds natural size. After Herdman.

recorded by Ritter from "Albatross" Station 2842 near Akutan Island, Aleutian Chain, 72 fathoms.

GENUS **CORYNASCIDIA** HERDMAN, 1882

An abyssal genus closely allied to *Corella* and perhaps worthy of only subgeneric status. See under the type species *C. suhmi.*

Corynascidia suhmi Herdman, 1882

Text figures 126, 127

Corynascidia suhmi HERDMAN, 1882, p. 186, pl. 25; TRAUSTEDT, 1885, p. 8; HARTMEYER, 1911b, p. 462, pl. 46, fig. 4, pl. 51, figs. 4, 5; 1912b, pp. 277, 379; 1924, p. 19; ÄRNBÄCK, 1934, p. 75.

The body is of clavate form, much compressed laterally, borne on a stalk into which the anterior end of the body tapers. The apertures are not conspicuously lobed; the atrial aperture is at or near the opposite end, the branchial more or less removed on what Hartmeyer considered to be the ventral aspect. The stalk enlarges at its end and may give off root-like processes for attachment. It is penetrated by a slender tubular extension of the mantle. The body, exclusive of the stalk, reaches 7 to 8 cm. in length.

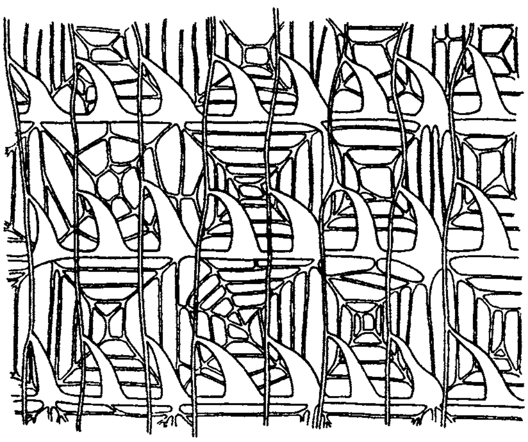


FIG. 127. *Corynascidia suhmi* Herdman. Part of branchial sac.

The test is somewhat gelatinous and transparent. The internal structure corresponds to that of *Corella* except that the spiral and radiating vessels of the branchial sac are extremely slender and delicate, suggesting the threads of a spider's web in appearance, according to Herdman's statement; and that the alimentary tract, which is proportionally small, is crowded into a small part of the posterior end of the body away from the origin of the stalk and ventral to the atrial opening.

DISTRIBUTION: Besides the type locality, "Challenger" Station 299, 33° 31′ S., 74° 43′ W., 2160 fathoms, between Juan Fernandez Islands and Valparaiso, the known localities of this species in the Southern Hemisphere include "Challenger" Station 146 (46° 46′ S., 45° 31′ E., 1375 fathoms) also north of Kaiser Wilhelm II Land, 3397 meters (Gauss expedition), and north of Enderby Land, 4636 meters (Valdivia expedition); in the Northern Hemisphere one in Davis Strait, 1435 fathoms, and south of Cape Farewell, Greenland, 1330 fathoms (Ingolf expedition).

Sluiter, 1904, has described an allied stalkless species (*C. sedens*) from near the Paternoster Islands, East Indies, in 694 meters.

Corynascidia herdmani Ritter, 1913

Text figure 128

Corynascidia herdmani RITTER, 1913, p. 491, pl. 35, figs. 31–36; HARTMEYER, 1924, p. 20; ÄRNBÄCK, 1934, p. 75.

Based on a single specimen from Bering Sea near Unalaska Island ("Albatross" Station 3326, 53° 40′ N., 167° 41′ 40″ W., 576 fathoms, muddy bottom). In size and general form (length of body 4 cm., of stalk 5 cm.) and many internal characters, it corresponds to *C. suhmi*, but it is much more irregular in shape, and the branchial orifice is on a very short siphon "with a wide thin tip or flange subtending nearly its dorsal semi-circumference." The atrial orifice, on a long, tube-like, backwardly curved siphon, has "five broad thin scallop-like lobes" with irregular smaller ones between some of the larger ones. "Stigmata very large and long, the prevailing direction of the long axes being lengthwise of the sac, but in places at right angles to this and in some areas the quadrangular arrangement of the vascular network characteristic of

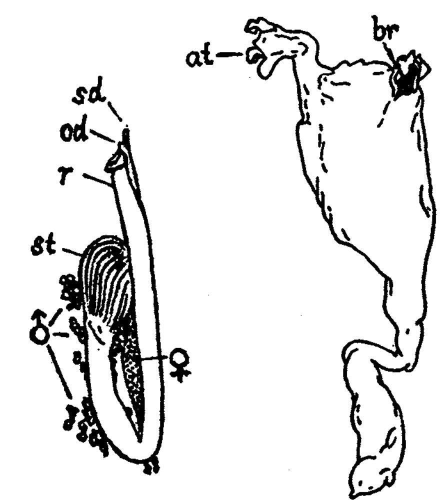


FIG. 128. *Corynascidia herdmani* Ritter. Outline of only specimen, natural size, and diagram of intestinal tract and gonads.

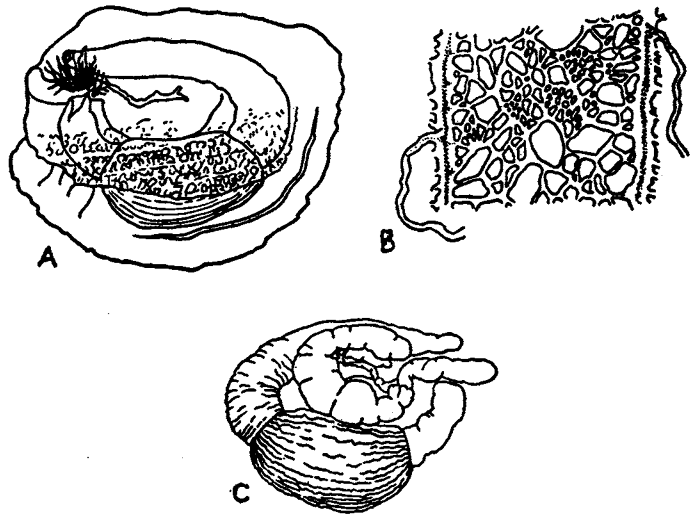


FIG. 129. *Benthascidia michaelseni* Ritter. Internal details reproduced from Ritter's figures. A. "Outline of the digestive tract, showing the tuft of filiform appendages near the esophageal orifice and a fragment of the branchial membrane attached" (Ritter). B. "A fragment of the branchial network." C. Digestive tract and gonad.

the genus may be seen." (See figure reproduced from Ritter, 1913.)

GENUS **BENTHASCIDIA** RITTER, 1907

The little that is known about this abyssal form is discussed under the only species.

Benthascidia michaelseni Ritter, 1907

Text figure 129

Benthascidia michaelseni RITTER, 1907, p. 24, pl. 2, figs. 24–29, pl. 3, fig. 30; HARTMEYER, 1909–1911, p. 1395; 1912b, pp. 374, 379.

Known only from Ritter's description, based on two specimens which he states "were too much mutilated to permit clear recognition of what the general form of the body was. Unfortunately too, a number of important anatomical points could not be made out with certainty."

The body is borne on a peduncle (about 220 mm. long) which enlarges toward the base where it bears a great number of small root-like processes. Toward the upper end it gradually enlarges "to pass insensibly into the body."

Apparently the specimens were not in condition to show the dimensions and form of the body, which must have been of considerable size, as the visceral mass composed of the intestinal loop and the gonads beside it is about 35 by 40 mm. in diameter. Whole animal (body and peduncle) "hyaline to transparent"; test for the most part very thin and soft.

Branchial orifice very large (35 mm. in diameter), no siphon. "Atrial orifice not found, apparently far remote from the branchial." Branchial tentacles minute and very numerous, 300 or 400, simple but irregular in shape, many larger at the free end and somewhat flattened.

Branchial sac exceedingly delicate, composed of an irregular network of delicate vessels all in the same plane, through which at intervals run larger vessels of more regular course. The direction of these large vessels with reference to the sac as a whole was not determined. No folds or internal papillae present. Dorsal languets doubtful; perhaps narrow thread-like processes.

Digestive tract consisting of a single loop; its form is shown in the figure. Reproductive organs beside and within the loop. "Ovary a large curved sac, containing ova of about 2 mm. in diameter—giant size for tunicate eggs," Sperm duct consisting of half a dozen or more vasa efferentia, as they might be called, running together at a common center. From this center the sperm duct proper arises and takes a nearly direct course parallel with the rectal portion of the intestine, but extending some distance beyond the anus.

For further details the reader must be referred to Ritter's article, but it is evident that even that author could form but a very imperfect idea of the animal from such poor specimens. Ritter placed the genus near *Corynascidia*. Hartmeyer, 1909–1911, in discussing it, was inclined to suspect a relationship to the Molgulidae, but concluded to leave it for the present ("vorlaüfig") where Ritter placed it.

DISTRIBUTION: Only locality, "Albatross" Station 4390, 33° 02′ N., 120° 42′ W., at the foot of the continental shelf off San Diego, California, 2182 fathoms, bottom gray mud. Two mutilated specimens.

FAMILY **HYPOBYTHIIDAE** SLUITER, 1895

This family consists solely of the following genus:

GENUS **HYPOBYTHIUS** MOSELEY, 1879

A genus of deep-sea simple ascidians, two specimens of which (representing different species) were obtained by the "Challenger."

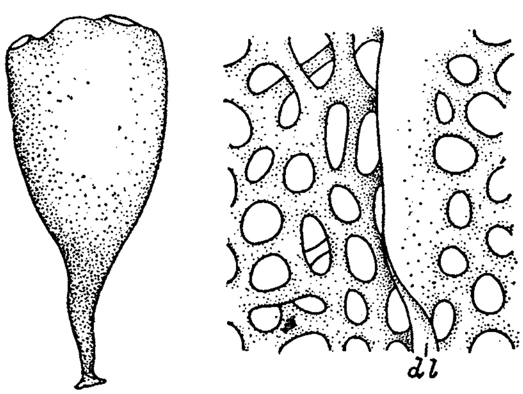


FIG. 130. *Hypobythius moseleyi* Herdman. Outline of body, about one-half natural size, and part of branchial sac including the dorsal lamina. After Herdman.

The body is pyriform or ovate, raised on a stalk or peduncle which is expanded for attachment at its lower end. Both apertures on the wide upper end. Branchial sac without folds or regular transverse or longitudinal vessels; its walls are pierced by irregularly distributed oval or slit-like stigmata. Dorsal lamina smooth. Intestinal tract forming an elongated loop on the dorsal edge of the branchial sac. Gonads in the intestinal loop.

Hypobythius moseleyi Herdman, 1882

Text figure 130

Hypobythius moseleyi HERDMAN, 1882, p. 231, pl. 37, figs. 6–9; HARTMEYER, 1912b, p. 379.

The single specimen of this species obtained was in such a poor and damaged condition that not much about its structure could be made out.

Both apertures on anterior end, apparently not lobed. Surface smooth, test soft, semitransparent. Body length 9 cm., including the short peduncle into which it tapers. Mantle with a few chiefly longitudinal muscle bands on each side of the body.

LOCALITY: "Challenger" Station 320, near the mouth of the La Plata River, 37° 17′ S., 53° 52′ W., 600 fathoms, hard ground.

(See Herdman, 1882, for additional information.)

ORDER **STOLIDOBRANCHIA** LAHILLE

(=Ptychobranchia Seeliger)

The most highly specialized order of ascidians. It contains both compound and simple forms. The body is never divided into a thorax and abdomen; the digestive tract and reproductive organs always lie beside, or project only slightly behind, the branchial sac, which has internal longitudinal vessels and a few large longitudinal folds or plications (rudimentary or lost in a few forms). The tentacles are sometimes branched, a character not found in other orders, and the neural gland is dorsal to the ganglion instead of ventral to the latter as usual in most ascidians.

The internal longitudinal vessels are more numerous and closely placed on the folds or plications of the branchial sac than on the flat parts. These vessels, which are often of flattened cross section, may be raised on low papillae, but never bear papillae themselves. The gonads are commonly attached to the inner surface of the mantle, not to the digestive tract.

When budding occurs it is of the so-called "palleal type," the buds or stolons producing them being outgrowths of the lateral part of the body.

FAMILIES OF STOLIDOBRANCHIA

A_1. Simple ascidians, often large; body sac-like, larger tentacles branched; branchial sac with internal longitudinal vessels and a small number of large, curved, pleat-like folds (reduced or obsolete in some cases). Alimentary tract on left side of body.

B_1. Body sessile or sometimes borne on a stalk or pedicel. Test tough, wrinkled, opaque and often minutely (sometimes coarsely) spinous; both apertures commonly conspicuously square or four-lobed. Color often red or reddish during life, especially about the apertures. Branchial sac usually with more than four large folds on each side, stigmata usually straight (spiral in a few cases); stomach elongate, tapering into the intestine, and bearing a hepatic organ of small tubes. Gonads few (usually but one on each side), elongate, hermaphroditic, the left commonly in, or partly in, the intestinal loop. No renal sac . . . . Pyuridae

B_2. Body usually sessile; often unattached and living buried in sand or mud. Test often covered with hair-like processes, and with much adherent sand or mud. Branchial aperture commonly with about six lobes, atrial with four lobes or square. Branchial sac with five to seven folds on each side; in some genera these are obsolete and indicated only by a small group of internal longitudinal vessels or a single large one. Stigmata mostly in large spirals, sometimes very perfectly formed and raised into inwardly projecting conical infundibula. Dorsal lamina continuous, often with a dentate margin. Stomach elongate, a part of its wall modified into a glandular organ. Usually one large hermaphroditic gonad on each side. A large closed renal sac on the right side of the body . . . . Molgulidae

A_2. Simple or compound ascidians; tentacles always simple; dorsal lamina always a continuous membrane; branchial folds usually but four (rarely a rudimentary fifth one) on each side; there may be less than four, some or all being obsolete. The simple species often resemble Pyuridae in their thick, tough, wrinkled test, often reddish about the apertures, which are commonly both four-lobed. Stigmata always straight; stomach rather short, rounded or ovate, often with a longitudinally plicated wall and a small caecum, but no hepatic gland. Gonads vary in number from one to many; usually hermaphroditic (sometimes of one sex in the small compound species), attached to the inner surface of the body wall. No renal sac . . . . Styelidae

A_3. Compound ascidians closely related to the Styelidae; test gelatinous, zooids small and arranged in the common test in systems discharging by common cloacal cavities and apertures. Branchial sac with no folds and only three internal longitudinal vessels on each side. Male and female gonads separate . . . . Botryllidae

Family **BOTRYLLIDAE** Verrill, 1871

A small but widely distributed group of compound ascidians evidently belonging to the same stock as the Styelidae and quite closely related to some of the compound members of that family, in which Michaelsen and others, following the suggestion by Ärnbäck, 1923, have recently included them as a subfamily, Botryllinae. They differ from the compound Styelidae in having the zooids, or most of them, arranged in well-developed systems with common cloacal canals discharging by common cloacal apertures, instead of having the atrial aperture of the zooids opening separately on the surface of the colony; also in the gonads and budding.

The male and female gonads are separate. There may be one or several ovaries, each consisting in its later stages of little else than one very large egg, on each side of the body. There is but one testis on each side, a group of rounded lobes united at their bases and discharging by a short common duct.

The branchial sac is without folds and with no more than three internal longitudinal vessels on each side. The tentacles are simple. The dorsal lamina is a plain membrane. The colonies are soft, smooth, and fleshy, usually thin and incrusting, but sometimes thick and produced into lobes, or irregular, especially when growing on irregularly shaped objects. The systems in which the zooids are arranged may be small, circular, or oval groups with a common cloacal aperture in the center of each group, or may be elongate and irregular (often branched) and composed of many zooids.

Living colonies are often very strikingly and beautifully colored objects. In many of the species numerous color variations exist but seem to be without significance as specific or even subspecific characters. The bright colors and conspicuous markings fade out after death. In preserved specimens the test is usually more or less transparent (pale grayish or purplish, or yellowish) and the zooids some shade of purple, purplish brown, or brown, sometimes pale, sometimes dark, in a few species occasionally almost black. The test (as also in *Symplegma* and allied genera among the Styelidae) contains branching blood vessels ending in enlarged bulbs. These are commonly most numerous and conspicuous near the margins of the colony.

Until recently the classification of this family was not well understood. Genera were based upon very superficial characters, and a multitude of supposed species were distinguished only by color, which is not to be relied on at all. The difficulty of determining specimens of this group is much increased by the fact that as a rule only a few colonies out of a large number of specimens will have both the male and female gonads (which furnish the most important distinguishing characters) well developed.

Genera of Botryllidae

Ovaries one or several on each side; anterior or dorsal to the testes; no incubatory pouch, the embryos developing in the peribranchial cavity. . . . . *Botryllus*

Ovary one on each side, situated posterior to the testes. The egg develops in a sac-like incubatory pouch; formed as an outgrowth of the body wall . . . . *Botrylloides*

Genus **BOTRYLLUS** Gaertner, in Pallas, 1774

In its present restricted sense this genus is confined to forms having the ovaries anterior or dorsal to the testis and which develop no incubatory pouches, the embryos developing in the peribranchial cavity. The anterior margin of the atrial orifice, which often forms a short wide siphon, is usually produced into a large languet.

Botryllus schlosseri (Pallas), 1766

Plate 9, figure 4; text figure 131

Alcyonium schlosseri Pallas, 1766, p. 355.

Botryllus gouldii Verrill, 1871, pp. 211, 212, figs. 14–19; 1872a, p. 213; Verrill and Smith, 1873, pp. 375, 389, 702, etc., pl. 33, figs. 252, 253; Verrill, 1879, p. 27; Verrill and Rathbun, 1879, p. 231; McDonald, 1889, p. 858; Metcalf, 1900 (*gouldi*), p. 522, pl. 37, figs. 38–40; Hartmeyer, 1909–1911, p. 1378.

Botryllus namei (in part) Hartmeyer and Michaelsen, 1928, pp. 330, 334, 335.

Botryllus polycyclus Savigny, 1816, pp. 47, 84, pl. 4, fig. 5, pl. 21.

Botryllus schlosseri Savigny, 1816, p. 200, pl. 20, fig. 5; Binney, 1870, p. 3, pl. 23, fig. 319; Dall, 1870, p. 255; Bancroft, 1903, p. 137, pl. 17, figs. 1–3; Hartmeyer, 1909–1911, p. 1379; Van Name, 1910, p. 350, fig. 1, pl. 39, fig. 10; Sumner, Osburn, and Cole, 1913, p. 731; Pratt, 1916, p. 669, fig. 1013; Michaelsen, 1921a, p. 108 (in part, not fig. 3); Van Name, 1921, p. 398, fig. 73; Ärnbäck, 1922–1929 (1923), p. 12, pl. 1, figs. 5–12, text figs. 5–8; Van Name, 1930, p. 477, figs. 46, 47; ? Berrill, 1932, p. 78; Pratt, 1935, p. 746, fig. 964; Huus, 1936, p. 12; Richards, 1938, p. 254, fig. 45; Plough and Jones, 1937, p. 101; Grave, 1937, p. 563.

Botryllus schlosseri forma *typica* Hartmeyer, 1923, p. 344; Harant and Vernières, 1923, p. 37, figs. 18, 53; Harant, 1927, p. 245; 1927b, p. 9; 1931, p. 342.

Botryllus stellatus Gaertner, *in* Pallas, 1774, p. 37, pl. 4, figs. 1–5; Couthouy, 1838, p. 11; Gould, 1841, p. 320.

Not *Botryllus schlosseri* forma *aureus* Hartmeyer, 1923, p. 354 (=*Botrylloides aureum* Sars, 1851). Probably not *B. schlosseri* Berrill, 1932, p. 78.

Probably no other ascidian has been described under so many specific names or has been divided into so many varieties or subspecies as the present one. Thick and fleshy colonies of this species are the type of Lamarck's (1815) genus *Polycyclus*.

Nearly all these numerous synonyms and varieties refer to the species as occurring in European waters. They are briefly but by no means completely considered in Hartmeyer (1923, pp. 344 and following). The names given above are chiefly those used in works dealing especially with it as an American species.

Verrill says of this species (Verrill and Smith, 1873, p. 375) that when young it "forms thin, soft, circular or oval incrustations . . . . These young colonies begin to appear in June and grow very rapidly, new individuals being formed by buds that originate from the first ones in rapid succession, so that in two or three weeks the small colonies will increase from a quarter of an inch in breadth up to three or four inches, if they be situated on a flat surface, and have room to spread. If upon a stem or leaf of the eel-grass, algae or stems of hydroids, these are often completely covered up by the luxuriant growth of this curious compound animal. The colors of this species are extremely variable and often very elegant, and it is seldom that two colonies can be found with precisely the same pattern of color. Growing upon the same leaf of eel-grass, many different colonies may often be found, each showing a different arrangement of the colors."

Verrill then goes on to describe the principal color varieties, to seven of which he assigns names: vars. *bicolor*, *farinacea*, *annulata*, *atrox*, *variegata*, *albida*, and *stella*. In nearly all these forms the zooids are dark colored, usually deep purple or purplish brown. This color also pervades the bulbs of the test vessels and suffuses to a greater or less degree the test substance during life, but when the animal dies the test becomes light colored and more transparent. During life, in addition to this dark pigment, the zooids, especially their anterior ends and dorsal portions, and the bulbs of the test vessels, are marked with a light-colored pigment, which mostly disappears after death. To the varied shades and distribution of this pigment much of the variation in the color of different colonies is due.

The numerous color variations seem to be entirely without taxonomic significance. The same variations may often be found in widely separated places in the Old and New Worlds. Bancroft (1903) says: "*Botryllus* at Wood's Hole and at Newport (in America) exactly resembles *Botryllus* at Naples."

The zooids are of moderate size (the individual figured measuring about 1.75 mm. long). They lie in the colony either on their ventral surface with the anterior end somewhat turned up, or in an inclined position, as shown in the figure. The systems in which they are arranged contain from five to about 20 individuals, rarely more.

The branchial aperture is without lobation, or nearly so. The atrial cavity is quite capacious and opens into the common cloacal cavity by the large dorsally situated atrial opening, the upper lip of which is produced into a more or less prominent languet. The tentacles number 16, the rows of stigmata about nine (10 in Verrill's figure), the internal longitudinal vessels three on each side. The latter are separated by about four stigmata. Each side of the endostyle there are five, or six or seven stigmata before the third internal longitudinal vessel is reached, and each side of the median dorsal vessel, six or sometimes seven stigmata.

The stomach resembles that of *B. planus* in many respects; it is elliptical but contracts more toward the pyloric end than in that species and has about nine or 10 longitudinal, somewhat spirally directed, glandular folds. One of these is produced near the pyloric end into a tubular caecum which is much curved and enlarged at the distal end. The caecum is not much more than half the length of that of *B. planus;* it has been well described as retort shaped.

The male reproductive organs resemble those of *B. planus*, the testes being cleft into a large number of small lobes (often about 20) united at their bases into a rosette-like or

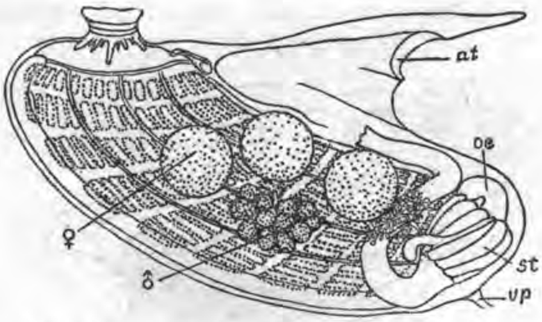


FIG. 131. *Botryllus schlosseri* (Pallas). Zooid, ×36.

more or less fan-like cluster. The short sperm duct arises at or near its dorsal border. The adult female organs usually consist of from one to three ovaries containing one large egg each, on each side of the body. They form a more or less curved row dorsal to the testis (extending both anterior and posterior to the latter). There may be four or, it is said, even five or six ovaries on one side, but in such cases the other side has a smaller number. Eggs reach 0.42 mm. in diameter, according to Berrill, 1937. For culture methods, see Grave, 1937.

When no eggs are present, or but one is developed on each side, the species may be confused with *B. planus*. In such cases, however, the difference in the pyrloric caecum should prevent this.

DISTRIBUTION: This is the most handsome and conspicuous compound ascidian found on the eastern coast of the United States. Its soft velvety appearance and striking and varied colors (which, however, fade with death or even with any removal from its natural environment) attract the notice of even casual observers. The growth of colonies in favorable places during the warm season of the year is very rapid.

It is, however, very probably an introduced species brought here on the bottoms of ships. It is widely distributed in European waters from the Faeroe Islands and southern Norway and the coasts of the British Islands and western France to the Mediterranean, Adriatic, and Black seas. Hartmeyer and Michaelsen (1828, p. 330) assign specimens from southwest Australia and New Zealand to this species.

On the American coast it occurs from Portland, Maine, southward and is locally abundant and conspicuous from the vicinity of

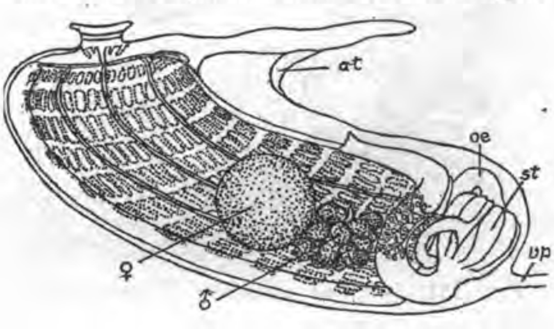


FIG. 132. *Botryllus planus* (Van Name). Zooid, ×36.

Boston to New Jersey, inclusive. It is also locally abundant on the west coast of Florida, including the Tortugas, but the only record from intermediate points that has thus far come to my notice is the probable one of Pearse, Humm, and Wharton (1942, p. 188) who report a *Botryllus* sp. from Beaufort, North Carolina.

It grows best in the shallowest water, on piles of wharves, eel grass, the bottoms of boats or floats anchored for some time in one place, etc. The American records I have are all in depths from less than 10 fathoms, and the Old World records are, with a few exceptions, from equally shallow water if the depth is given.

Botryllus namei Hartmeyer and Michaelsen (1928, p. 335) is not a valid species, being based partly on specimens of *B. planus* and partly on those of *B. schlosseri*. I feel much doubt about the "*B. schlosseri*" reported by Berrill, 1932, from Bermuda, believing that his specimens may really have been *B. planus*. See also the statements under *Botrylloides aureum*. It is uncertain what the "*Botryllus arenata*" reported by Visscher (1927, p. 199) as fouling ships' bottoms may have been.

Botryllus planus (Van Name), 1902

Plate 21; text figures 132, 133A, 133B

Botrylloides nigrum planum HARTMEYER AND MICHAELSEN, 1928, p. 345.

Botrylloides nigrum var. *planum*+*B. n.* var. *concolor* VAN NAME, 1902, pp. 377, 378, pl. 53, figs. 53, 55, pl. 59, fig. 110.

Botryllus namei (in part) HARTMEYER AND MICHAELSEN, 1928, pp. 330, 334, 335.

Botryllus niger (in part) VAN NAME, 1921, p. 399, fig. 74; MICHAELSEN, 1921a, p. 107.

Botryllus planus VAN NAME, 1924, p. 30, figs. 5, 6; 1930, p. 476, text figs. 45, 49a, pl. 8; PLOUGH AND JONES, 1937, p. 101.

See note on *Botrylloides chazaliei* Sluiter, 1898, under *Botrylloides nigrum*.

Colonies incrusting, or irregular outline often several centimeters in greatest diameter, but rather thin, frequently so thin that the zooids, which do not average over 1.5 to 1.75 mm. in length in the more or less contracted, preserved condition, are forced to assume either an inclined position or one somewhat parallel to the surface (the anterior end being upturned), but in other cases the colony is thick enough to allow the zooids to assume a nearly upright position. The systems are of irregular outline, usually elongate and often rather extensive.

The color very variable during life; in most cases the colony is dark colored, the zooids being some shade of purple, purplish brown, or blackish with a white, pale green, or golden yellow area surrounding the branchial orifice of each zooid. These light-colored markings fade out after death, the zooids generally becoming some shade of purple or brownish purple. Some specimens collected at Bermuda were bright orange when alive, this color suffusing the test as well as the zooids. The young zooids produced by budding are in many colonies differently colored than the adult ones from which they developed. A difference between the rows of young and adult zooids can be plainly noticed in the two colonies shown enlarged on plate 21, though they are not reproduced in color. In alcohol the test lost its color, and the zooids became reddish brown.

Not more than eight tentacles were demonstrated in the individuals studied. The number or rows of stigmata is somewhat variable, from 11 to 13 being usual.

The reproductive and digestive organs furnish the easiest means of distinguishing this species. The male organs consist of a single testis on each side of the body, situated posterior to the middle and so deeply cleft into numerous (10 to 20) rounded lobes that it appears like a rosette-shaped mass of small separate glands. The female organs, at least in the adult state, consist of a single ovary on each side, each containing a large egg situated close, and directly anterior, to the testis.

The stomach is oblong or barrel shaped (though tapering somewhat more toward the pyloric end) with about nine complete glandular folds and one incomplete one, which increase gradually in prominence toward the œsophageal end, and a very long tubular curved pyloric caecum that is slightly enlarged at the extreme end. Compare with descriptions of *B. schlosseri* and *Botrylloides nigrum*.

DISTRIBUTION: A littoral and shallow-water species now known from Bermuda, Florida, and Curaçao, and which will doubtless be found in other parts of the West Indian region. At Bermuda it is found both on the under side of stones along the shore and on corals, gorgonians, etc. The Florida records are from Loggerhead Key, on rocks, off Bahia Honda Key in 11 to 11½ fathoms and Cedar Keys (no depth given). Those from Curaçao were from shallow water in Caracas Bay.

This species and *Botrylloides nigrum* Herdman, also found at Bermuda and in Florida and the West Indies, were confused in my earlier articles (1902, 1921), although in the former paper specimens of *planus* were described as distinct varieties of *nigrum*. The characters separating the two species are given in Van Name, 1924 and 1930, and in the present work under *Botrylloides nigrum*.

Botryllus primigenus Oka, 1928

Text figure 134

Botryllus primigenus OKA, 1928, p. 303, figs. a, b; VAN NAME, 1931, p. 210, figs. 2, 3; GRAVE, 1932, p. 146.

In 1928 I received from Caswell Grave specimens from Florida of a *Botryllus* having poorly developed systems (some of the zooids opening directly on the surface) and but four rows of stigmata—the only Atlantic coast species with so few rows. It corresponds so closely with a Japanese species, *B. primigenus* Oka, that I was unwilling to describe it as new, in spite of the widely separated localities.

The colonies form very thin incrusting sheets of irregular outline, growing upon stones, dead coral, etc. Test translucent (in alcoholic material almost colorless), the zooids arranged for the most part in circular or oval groups with their posterior ends toward the center. These groups are usually composed of seven to nine individuals, occasionally more, though in some cases two or more adjacent groups are confluent. Between these groups of zooids, which are usually somewhat separated, the test is very thin or sometimes absent altogether, so that the colony becomes in some parts an irregular network rather than a continuous sheet. Owing to the greatly flattened form of the zooids, the colony, even where thickest (where the zooids are situated), does not greatly exceed

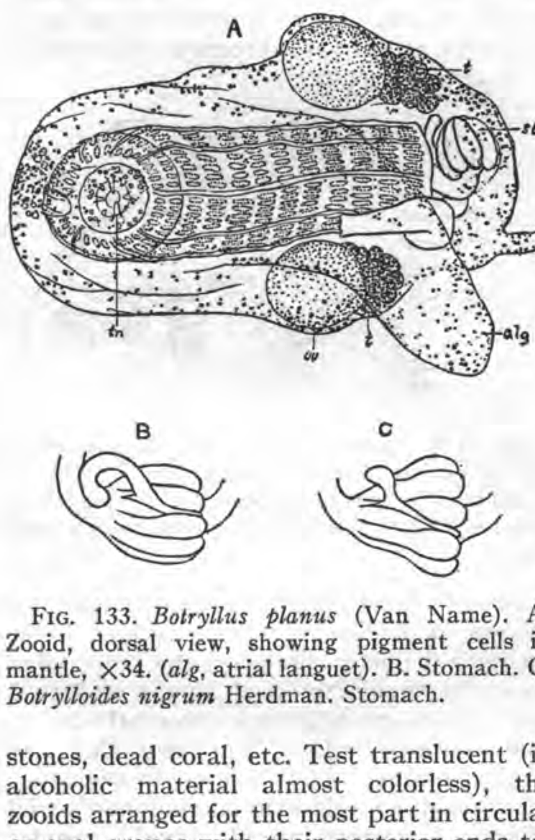


FIG. 133. *Botryllus planus* (Van Name). A. Zooid, dorsal view, showing pigment cells in mantle, ×34. (*alg*, atrial languet). B. Stomach. C. *Botrylloides nigrum* Herdman. Stomach.

1 mm. in the preserved material. The usual branching vessels connecting the zooids and the different groups or systems of zooids are present in the test. The terminal bulbs which they bear are often of quite elongate form.

In the preserved material, the zooids are olive greenish, the test, as above stated, nearly colorless and quite transparent and its branching vessels and thin bulbs pale grayish except where filled with dark-colored corpuscles. The colonies attain considerable size. The largest colony, though not entire, measures 85 mm. across and appears to have measured even more in the direction transverse to that measurement.

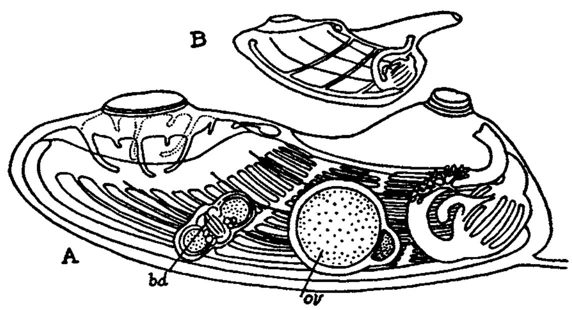


FIG. 134. *Botryllus primigenus* Oka. A. Zooid having an independent atrial aperture, ×45. B. Zooid forming part of a system and having a long atrial siphon to reach the common cloacal cavities, ×14.

Grave's notes describe living specimens as follows: "Colonies irregular in outline. Three inches in diameter. Translucent. Composed of zooids in circular or oval groups of 7 to 8 zooids each, except groups apparently undergoing reorganization into two daughter groups. Groups about 5 mm. in diameter; each zooid with individual oral and atrial orifices. A narrow line of grayish granular pigment passes between oral and atrial openings, the remaining part of surface of zooid brownish."

Well-expanded zooids in preserved specimens measure up to about 2 mm. long. They are proportionately rather wide and are flattened dorsoventrally. They lie horizontally or very obliquely in the colony, with the ventral surface down and the anterior end sharply bent up. The branchial apertures are round or oval and but little, if at all, prominent. The atrial apertures are apparently provided with stronger sphincter muscles and are sometimes raised on a slight papilla. Attention should be called to the fact that only a part of the zooids are provided with individual atrial apertures on the surface of the colony, as in many groups the atrial orifices open into a common cloacal cavity which may be incomplete (a mere depression into whose sides the zooids open), or be well formed, with a rather large, but (in the preserved material) not very conspicuous, aperture in the center of the group. In such cases the zooids may have a more or less well-developed atrial siphon with the aperture at its end, in order to reach the common cloaca.

Ten tentacles, five larger and five smaller ones alternating, one of the larger ones being in the ventral median position.

Branchial sac very wide and flaring at the anterior end, but much narrowed behind. There are but four rows of stigmata, which are rather long. The usual three internal longitudinal vessels are present. About four stigmata intervene between these vessels. A strip along each side of the endostyle is free from stigmata. In several zooids the arrangement of the stigmata and vessels was determined to be as follows in the anterior row:

mdv 3 v 4 v 4 v 5 en

The stigmata are probably about the same in number in the posterior rows, though narrower, but are less easily accurately counted there on account of the presence of the alimentary and reproductive organs.

The stomach is short and wide and rather regularly elliptical in outline. It is thin walled, with rather poorly marked longitudinal folds. These folds are narrow and well separated, about eight in number, besides the narrow ridge terminating in the caecum and an additional incomplete fold beside it. The caecum is tubular and much curved, and ends in a small enlarged bulb. It is similar to, but not over two-thirds as long as, that of *Botryllus planus* (Van Name), a species also occurring in Florida waters. The ridge bearing the caecum is somewhat oblique to the axis of the stomach; the other folds are parallel to the axis. The rectal part of the intestine is quite short.

In nearly all the zooids in the specimens at hand there is a single, very large egg or developing embryo projecting prominently on each side of the body a little behind the middle. It is enclosed in an evagination of the body wall, which closely invests it. On the posterior median aspect of the egg and closely applied to it, there is a small dome-shaped mass of cells which stain quite darkly and perhaps represent a remnant of the follicle which encloses the egg in earlier stages.

Many zooids bear a bud on each side, farther forward than the egg. These buds, even when very small, bear a group of eggs on each side of their body. Older buds have one large egg on each side enclosed in a thick follicle and close to it a few small cells, probably the degenerating remains of the other eggs.

In regard to the male organs, I can state nothing definite, as none were found in any of the numerous individuals examined, unless possibly rudiments of them may be present in some of the young buds close to the large eggs.

Grave writes of the larvae of this species that they "are much smaller than those of *B. schlosseri* and *B. niger* and much more embryonic in the development of the definite organs of the adult form."

LOCALITIES: Tortugas Islands, Florida, in very shallow water. Three colonies, collected in 1928 and 1929 by Caswell Grave, are in the collection of the American Museum of Natural History. Type locality of the species: Bay of Tateyama, Province Awa, Japan (Oka). See Van Name, 1931, for further discussion of Oka's species of *Botryllus.*

Botryllus tuberatus Ritter and Forsyth, 1917

Text figure 135

Botryllus tuberatus RITTER AND FORSYTH, 1917, p. 461, pl. 39, figs. 10, 12, pl. 40, fig. 22.

"Colony thin, encrusting, usually not more than 3 or 4 cm. in expanse and 1 to 2 mm. in thickness. Number of zooids in circular systems varies between three and ten; systems close together. Zooids usually black from pigment although variations occur, and colonies with comparatively little pigment are found. Zooids of a system communicate with common atrial orifice by long spout-like siphons; openings of siphons varying from small and oval in younger zooids to large and gaping in older ones; edges of upper portions of openings unite to form the common cloacal orifice. . . . At intervals along margin of colony occur exceedingly dense pedunculated branches of ectodermal ampullae, each ampulla having its own long ectodermal vessel running into body of colony; young zooids often occurring among the ectodermal ampullae. . . .

"Zooids, length about .8 mm. General shape cylindrical but curved, concave side being dorsal. . . . Branchial sac cylindrical, a little longer than broad; four series of stigmata; three longitudinal vessels on each side;

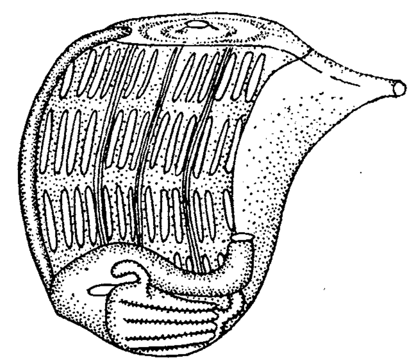


FIG. 135. *Botryllus tuberatus* Ritter and Forsyth. Zooid, ×36. After illustration of those authors.

about fourteen stigmata in each half series; usually three stigmata in spaces between longitudinal vessels and four between endostyle and its adjacent vessels, and four between dorsal lamina and its adjacent vessels. Sixteen branchial tentacles of which eight larger ones alternate with eight very small ones . . .

"Stomach longer than broad, and tapering toward oesophageal end; was thrown into seven distinct longitudinal folds; a tubular caecum attached to stomach near its posterior end and upper side. . . . No reproductive organs were seen in the colonies investigated. . . . " (Ritter and Forsyth, 1917, pp. 461, 462).

DISTRIBUTION: As far as known, *B. tuberatus* is confined to the coast of southern California (south of Point Conception); type locality, Santa Barbara, on leaves of kelp. Despite much search in the kelp beds off San

Diego, the animal was not found there, but at La Jolla the species occurs in considerable abundance at times on the rocks at extreme low tide. Specimens from that locality are usually devoid of the tube-like masses of ectodermal ampullae commonly present in specimens from Santa Barbara. I failed to find this species at Newport Bay, or at Pacific Grove, California, though those places are within its range, and have seen no specimens of it.

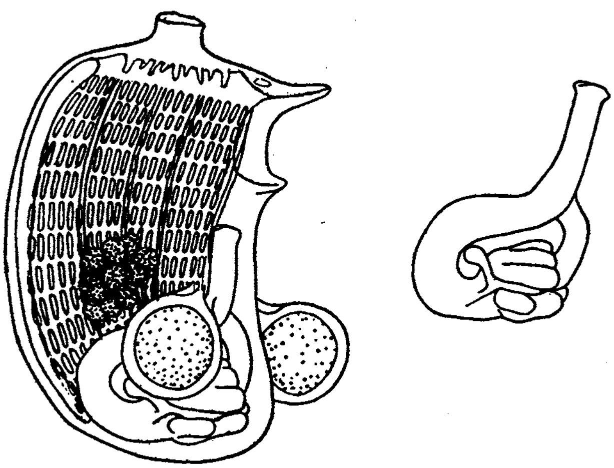


FIG. 136. *Botrylloides aureum* Sars. Zooid, ×22, and stomach and intestine. Outlined from illustration of Ärnbäck.

GENUS **BOTRYLLOIDES** MILNE EDWARDS, 1841

(Syn. *Metrocarpa* Ärnbäck, 1923)

This genus is here employed, in the emended sense proposed by Michaelsen, for species having a single ovary with one large egg on each side of the body situated posterior to the testis. The egg passes by means of a short oviduct into a sac-like incubatory pouch that develops as an outgrowth of the body wall for its reception. In these pouches, which extend from the posterior lateral part of the body on each side, the development of the embryo takes place. As thus used, *Botrylloides* is equivalent to *Metrocarpa* Ärnbäck, 1923, but as the types of both genera seem to be the same, the earlier name is employed here.

Botrylloides aureum Sars, 1851

Text figure 136

Botrylloides aurea SARS, 1851, p. 153; 1858, p. 66; ÄRNBÄCK, 1924, pp. 285, etc.

Botrylloides aureum VAN NAME, 1910, p. 354, fig. 2; HUNTSMAN, 1912, p. 113; VAN NAME, 1930, p. 479.

Botrylloides rugosum GOTTSCHALDT, 1874, p. 344, pl. 24, fig. 1.

Botryllus aureus HARTMEYER, 1915, p. 252; 1921a, p. 67; MICHAELSEN, 1921a (in part), p. 112, figs. 3, 6 (in part).

? *Botryllus magnus* RITTER, 1901, p. 255, pl. 30, figs. 33–37; HARTMEYER, 1923, p. 361.

Botryllus schlosseri var. *aureus* HARTMEYER, 1923, p. 354; HARTMEYER AND MICHAELSEN, 1928, p. 330 (in part, not the Australian specimens).

Botryllus sp. VERRILL, 1873–1874, vol. 6, p. 440, vol. 7, p. 413; 1874, pp. 348, 352; 1879, p. 27; WHITEAVES, 1901, p. 266.

Metrocarpa aurea ÄRNBÄCK, 1924, pp. 288, etc., figs. 1–3; 1925, p. 1; 1930, pp. 1, etc., pl. 1, figs. 1–5.

Sarcobotrylloides aureum HUITFELDT-KAAS, 1896, p. 25; VANHOEFFEN, 1897, p. 184; HARTMEYER, 1903, p. 263, figs. 17–21, pl. 6, figs. 15, 16, 20, pl. 11, figs. 13–19; BJERKAN, 1905, p. 13; DERJUGIN, 1906, p. 155; REDIKORZEV, 1908, pp. 20, 27; BJERKAN, 1908a, pp. 74, 115; DERJUGIN, 1912, p. 888; HARTMEYER, 1914b, p. 1108 (*aurea*); DERJUGIN, 1915, p. 570.

See also *Botrylloides magnum* (Ritter), below.

Compared to the colonies of *Botryllus schlosseri*, to which this species bears much superficial resemblance, those of this species average smaller in extent and form thinner incrustations. Diameters of 30 to 40 mm. and a thickness of 1.6 to 1.75 mm. are apparently not very often exceeded. The systems are more irregular and more extensive than in *schlosseri*, and (in preserved material at least) their limits are often hard to distinguish, especially as the systems and their zooids are often crowded together. In some colonies oval systems are recognizable, but elongate ones in which the zooids appear to be arranged in rows appear to be more frequent. The color of the zooids in preserved specimens varies from reddish purple to purplish black, being usually darker than in *B. schlosseri*. Its color in life and the variations it is subject to do not appear to be recorded.

The zooids are fairly large, reaching nearly 3 mm. in length when well expanded, and are rather wide and short. The branchial aperture is not appreciably lobed; the form of the atrial aperture is very variable, being much influenced by the position of the zooid in relation to the cloacal canal or cavity into which it discharges, and may be a wide transverse slit, a more or less rounded aperture, or be produced into more or less of a tube. The anterior border of the aperture may or may not be produced into a languet; if so, it is usually small and short.

Adult zooids have 16 branchial tentacles regularly arranged (1-3-2-3-1-3, etc.), and 11 to 14 rows of stigmata, usually 12 or 13. The stomach has about eight longitudinal folds (one incomplete) and a rather small retort-shaped caecum. It much resembles that of *B. schlosseri*. Small aggregations of dark pigment along each side of the endostyle at the regions of the transverse vessels of the branchial sac are often noticeable in this species.

The testis of each side, when fully developed, consists of a rosette-like group of a dozen or more rounded lobes united at their bases. "The short sperm duct projects from the center of its mesial side" (Ärnbäck, 1928, p. 290). In young individuals the lobes are fewer and the group is better described as fan-shaped. But one egg develops on each side of the body, although the ovaries when young contain a number of small eggs. Each egg is received into a sac-like brood pouch in which it undergoes development. These pouches extend out into the test from the posterior dorsal part of the body (see fig. 136).

Distribution: This is a more northern species and an inhabitant of deeper water than *Botryllus schlosseri*.

It is a common species in that part of the Arctic region between Davis Strait and the Kara Sea, there being numerous records from both coasts of Greenland, Iceland, Spitzbergen, the Murman coast, etc. Possibly it occurs in Alaskan waters (see *B. magnum* below).

South of the southern end of Greenland records on the American side are very few. It has been obtained in the Gulf of St. Lawrence, and on the Newfoundland Banks. There is one record from Casco Bay, Maine, in 50 fathoms, and one from Cash's Ledge in the Gulf of Maine, 42° 53′ 30″ N. in 30 to 40 fathoms, which are the most southern localities.

In depth the records range from about 2.5 to over 400 fathoms, but it is less often found above the 25-fathom level than below it. It grows attached to shells, rocks, hydroids, simple ascidians, etc.

Hartmeyer, in his latest work, treated this species as a subspecies of *Botryllus schlosseri*. The incorrectness of this course and the generic distinctness of the two forms were proved by Ärnbäck (1924, 1930).

Stimpson (1854, p. 19) mentions a bright green ascidian from Grand Manan, New Brunswick, which "approximated in character the genus *Botrylloides*." No other member of the group than this species is known from that region. A color variety of it, olive green when alive, may not be an improbability in view of great variety of colors occurring in related forms, but a really bright green would certainly be something unusual.

Botrylloides nigrum Herdman, 1886

Text figures 133C, 137

Botrylloides chazaliei Sluiter, 1898, p. 11; Ärnbäck, 1922–1924 (1923), p. 22.

Botrylloides nigrum Herdman, 1886, p. 50, pl. 1, fig. 8, pl. 3, figs. 19–21; ? 1906, p. 333, pl. 7, fig. 25; Van Name, 1930, p. 480, figs. 48, 49b; Berrill, 1932, p. 78 (*niger*); Plough and Jones, 1937, p. 101.

Botrylloides nigrum (in part) + *B. n.* var. *sarcinum* Van Name, 1902, pp. 374, 378, pl. 53, fig. 54 (not figs. 53, 55, pl. 59, fig. 110, pl. 61, fig. 125, which represent *Botryllus planus*).

Botryllus niger Michaelsen, 1919b, p. 105, fig. 19; 1921a, p. 107, fig. 2; Van Name, 1921, p. 399, in part only (not fig. 74 = *Botryllus planus*); 1924, p. 30, fig. 7; Hartmeyer and Michaelsen, 1928, p. 345; Grave, 1928–1930, p. 274; 1932, p. 146.

This species forms incrusting colonies with the zooids arranged in extensive, often branching systems much as in *Botryllus planus*, although in many cases the colony becomes considerably thicker than in that species. I have no color notes that certainly refer to this species when alive; after death the test is more or less transparent so that the zooids, which are purple or brownish purple, sometimes so dark as to be almost black, show conspicuously through it. Often, however, they are so crowded, at least in parts of the colony, that the outlines and limits of the systems are not easily traceable.

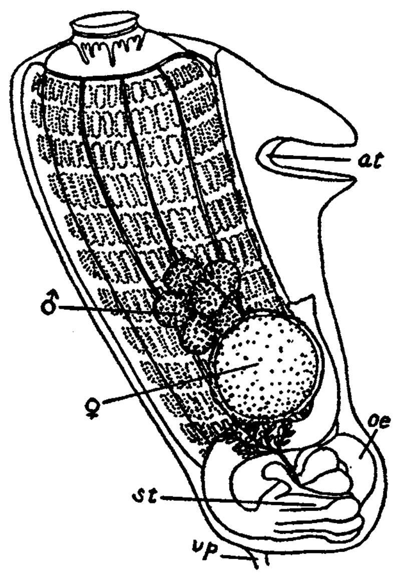


FIG. 137. *Botrylloides nigrum* Herdman. Zooid, ×40.

The zooids are of about the same size as those of *Botryllus planus* (1.5 to 1.75 mm. long), or perhaps averaging a trifle smaller, but are usually of more elongate form and are placed more at right angles to the surface of the colony. The mantle has many slender longitudinal muscle bands. The branchial aperture is rounded; the atrial may be rounded or may have the form of a large transverse slit, whose anterior margin may or may not be produced into a short languet.

Adult zooids have eight tentacles with (often at least) eight additional small or rudimentary ones in the intervals. The two lateral tentacles of the first order are often distinctly the largest, exceeding the two medium ones. There are, as usual, three internal longitudinal vessels on each side which are separated from each other by two to four stigmata and from the endostyle and dorsal lamina by about five or six stigmata.

If the female reproductive organs of the zooids are well developed, this species can be easily distinguished from *B. planus* found in the same region, but even if that is not the case, the stomach furnishes an easy means of distinguishing them. It usually has nine or 10 glandular folds, exclusive of the narrow, somewhat oblique ridge from which the caecum arises. The caecum is short, enlarged toward the blind distal end and often but little curved. The stomach is, moreover, of conspicuously conical form, its cardiac end wide and truncated, the ends of the folds forming conspicuous and prominent rounded bulbous projections at that end; it tapers rapidly toward the pyloric end. Only on the cardiac part are the folds very prominent, for at a point a little way back from the end they decrease in height quite abruptly, though they continue to the pyloric end with diminishing distinctness.

Another but less constant distinguishing character is in the testis, which has a smaller number of lobes, often not more than six to nine.

In many colonies only male organs are found, at least in a well-developed state. In some colonies many of the zooids also have a large egg or developing embryo on each side of the body (or on one side only) contained in a more or less protruding brood pouch posterior to the testis. Egg diameter 0.26 mm., according to Berrill, 1937. (See Michaelsen, 1919b, p. 109; 1921a, p. 107.)

DISTRIBUTION: The type of this species was collected by the "Challenger" expedition "near the Island of Bermuda." It is a common shallow-water species at Bermuda and in various parts of the West Indian region, including both coasts of Florida; off northern Yucatan; various localities about Puerto Rico, Port au Prince, Haiti, also Vera Cruz, Mexico; Cienfuegos, Cuba, and Cartagena, Colombia, on the authority of Michaelsen.

It appears to be widely distributed in Old World waters (especially the Gulf of Suez, East Africa, the Malay region, and many Australian localities) appearing in literature under several different names. For the information available in regard to its occurrence in regions lying outside the scope of this work, see Michaelsen, 1919b, 1921a, and Hartmeyer and Michaelsen, 1928.

As far as I know, it is found only in shallow water (low-water mark to 18 fathoms).

Botrylloides chazaliei Sluiter, 1898, from Margarita Island, Venezuela, is evidently the present species, not *Botryllus planus*, in view of information kindly supplied by Dr. Ärnbäck Christie-Linde, who examined a small, poorly preserved fragment of Sluiter's material and states that the stomach had the "cardiac caeca bent outwards."

B. perspicuum var. *rubicundum* Herdman, 1886, a Philippine form, was listed among the Bermuda species by Hartmeyer (1909–1911, p. 1633) evidently by mistake.

Botrylloides diegense Ritter and Forsyth, 1917

Plate 29, figure 2; text figure 138

Botrylloides diegensis RITTER AND FORSYTH, 1917, p. 462, pl. 43, figs. 46–49; JOHNSON AND SNOOK, 1927, p. 595, fig. 694; RICKETTS AND CALVIN, 1939, pp. 249, 300.

Colony flat and incrusting, usually of very irregular outline and often several centimeters in expanse, and commonly not over 5 mm. thick in most parts. The test is soft and, in preserved specimens, is rather transparent and without much color, and the zooids and bulbs of the test vessels are purple or brown and more or less distinctly visible through the test, giving the colony, when not closely examined, a general purple or dark-brown coloration, but in living colonies the colors are conspicuous and varied. The test is then less transparent, but the positions of the zooids are rendered conspicuous by a small ring-shaped or somewhat irregular area of brightly colored pigment surrounding the branchial aperture of each zooid. The color, width, and appearance of this ring of pigment varies in different colonies; often it is different in those growing side by side, but is usually uniform throughout each colony.

The shades of color that I have noted in the pigment are white, pale, or deeper yellow of various shades; orange, lighter or deeper, and flesh color; in other cases some shade of greenish white or light green and in extreme cases a rather deep leaf green. These bright colors contrast strongly against the ground color of the colony, which is usually more or less dark and of a purplish, brown, or grayish shade or, in colonies having orange pigment about the branchial aperture, the test may be so suffused with orange that the whole colony appears to have a general orange color. The colors, except the purple or brown, disappear quickly after death.

The systems are of various sizes and forms, oval or elongate, or branched. The small ones may have 8 to 15 or more zooids; the limits of the larger systems are hard to make out. In the marginal parts of the colonies the bulbs

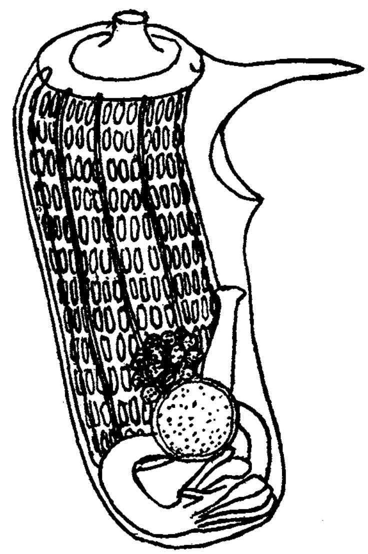


FIG. 138. *Botrylloides diegense* Ritter and Forsyth. Zooid, ×32.

terminating the test vessels are numerous and often quite elongate in form.

Zooids cylindrical, placed vertically where the colony is sufficiently thick; in the preserved and somewhat contracted state they may measure 2 to 2.5 mm. long. The branchial aperture is smooth and circular; the atrial is a large, widely gaping opening whose anterior border extends out into a languet of varying size and length, which is truncated or sometimes more or less notched at the end. Tentacles 16, of three sizes in fully developed zooids; of the four longest tentacles those at the right and left are larger than the median ones. There are usually 10 to 12 series of stigmata; and as usual, three internal longitudinal vessels are present which are separated by two to three stigmata.

The stomach has nine or 10 plications ending at the cardiac end, as in *B. nigrum*, in conspicuous bulbous expansions, but the pyloric part of the stomach is less tapered than in that species, and on the left aspect there is a triangular, smooth (unplicated) area, narrow at the cardiac, but quite wide toward the pyloric end, the adjacent plications diverging toward that end. The caecum is very small, not much curved, narrow, and tubular, and may easily be overlooked. It arises from a narrow ridge along one border of the abovementioned unplicated area of the stomach wall.

In a number of colonies which I collected in various parts of Newport Bay, California, in early July, 1939, the zooids, both immature and adult, had well-developed testes consisting of a rosette-shaped group of about a dozen lobes (more or less) on each side of the body, that of the right side being situated well toward the posterior end. A very short sperm duct arises from the middle of the group on the aspect toward the branchial sac. The female organs, if present, were usually not sufficiently developed to be conspicuous. In some of the colonies, however, many zooids, both adult and young and small ones, had in addition a rounded brood pouch posterior to the testes on both sides or oftener on only one side, each containing a single large egg or developing embryo.

DISTRIBUTION: Southern California, in shallow sheltered waters. Abundant on piles, floats, etc., in San Diego Bay (the type location) and also in Newport Bay in similar situations. I know of no records from outside these limits. It is, however, an extremely close ally of *B. leachi* Savigny, 1816, widely distributed on the European coasts from the North Sea to the Mediterranean, of which a detailed description is given by Michaelsen (1921a, pp. 101–107), though a later article by Ärnbäck (1923, pp. 5–12) gives a more satisfactory description of the reproductive organs and their development.

Botrylloides magnum (Ritter), 1901

? *Botrylloides aureum* SARS, 1851 (see description above).

Botryllus magnus RITTER, 1901, p. 255, pl. 30, figs. 33–37; HARTMEYER, 1923, p. 361.

Ritter, 1901, described and figured under the name *Botryllus magnus*, a form from the Alaska Peninsula (Kodiak Island, 20 fathoms; also from rocks at low tide at Popoff Island) whose close resemblance to *Botrylloides aureum* was recognized by Hartmeyer, 1923, and which I am inclined to believe to be identical with *B. aureum*, thus making the range of the latter circumpolar.

The specimens on which Ritter's species was based have immature and poorly developed gonads, but his figures and description strongly suggest *B. aureum.* Though he says that the systems are distinct, circular, regular, his figure 33 indicates that more or less irregular elongate systems also occur. The larger zooids, "3.5 mm. or more long" may be due to a relaxed state of the mantle muscles which he describes as "exceedingly weak." No other member of the group has been reported from the Alaskan or British Columbian region. Oka, 1927a, has given names to no fewer than five new species of "*Botrylloides*" from Japan, but without giving any adequate descriptions for their recognition.

FAMILY **STYELIDAE** SLUITER, 1895

(=Tethyidae Hartmeyer, 1909–1911; not Huntsman, 1912)

This is a large family found in all parts of the world and including in recent usage both compound and simple forms. Its members have both apertures square or four-lobed, simple filiform tentacles, a continuous dorsal lamina, and usually four large curved longitudinal folds on each side of the branchial sac, which always has straight longitudinal stigmata.

In older classifications it was confined to the simple forms and ranked as a subfamily (Styelinae) of the old family Cynthiidae, a group which included also the Pyuridae of modern classifications.

Its typical members are simple ascidians, mostly of moderately large size, with a tough, opaque, wrinkled, leathery test commonly more or less red or reddish during life, especially about the apertures, but fading to dull brownish or yellowish on long preservation.

Though four is the usual number of branchial folds, a rudiment of a fifth one occurs in a very few cases. Fewer than four folds, due to one or more of them being reduced, rudimentary, or wanting, is, however, quite frequent; rarely, all the folds have disappeared.

The alimentary loop is usually well back on the posterior left side, the stomach short, ovate, and with its wall longitudinally plicated; a small curved gastric caecum is often present.

The gonads, which vary in number, are attached to the inner surface of the mantle. There is much variation in their shape, but a similarity in type is generally recognizable throughout most of the family. They are usually, though not always, hermaphroditic, consisting of a tubular or flask-shaped (less often branched) ovary attached to the mantle, discharging at one end through a short oviduct. The testes are small, lobed, or pyriform glands which border the ovary, being attached to the body wall along or near the sides of that organ, or else lying more or less under the ovary (between it and the body wall), forming with the ovary a compact gonad of tubular or flask-like shape (sometimes branched). The slender sperm ducts from the individual testes run to the unattached or free surface of the ovary, upon which they successively unite into a single common sperm duct that usually has its termination and aperture on a papilla beside the aperture of the oviduct. There are in some genera modifications of this plan of structure, which, however, is one of the most widely occurring family characters. It is well exemplified in figures 160, 188, 190, and others.

The species that reproduce by budding have individuals of small size and more or less simplified structure, the folds of the branchial sac being often reduced or sometimes (though rarely) entirely wanting. Some of the compound styelids closely approach Botryllidae in appearance and character, but considering the absence of common cloacal cavities and apertures in the Styelidae and their presence, at least in some colonies, in almost, if not quite all, the Botryllidae, also the peculiarities of the gonads of the latter family, it seems better justified, as well as more convenient, to keep the two families separate, though often united in recent works.

I am not, however, in favor of separating the compound from the simple Styelidae as a separate family (Polyzoidae, syn. Polystyelidae) or even as a subfamily (Polyzoinae, syn. Polystyelinae) as was done in many older works. The compound species do not form a natural group, being in many cases closer allies of species that do not bud than to others that do bud.

One other character may be mentioned here because most conspicuous in the Styelidae, though it occurs in the Pyuridae also, and, it is said, in a few Molgulidae. That is the frequent presence of so-called "endocarps"—soft, flabby, semi-transparent, wart-like papillae scattered on the inner surface of the mantle and projecting into the peribranchial cavity. Their function is not known. They vary much in size, shape, and number in different individuals of the same species, being sometimes very abundant. Their presence or absence is not known to be of taxonomic significance. In the genus *Polycarpa* there is often a very large rounded endocarp located within the bend of the intestinal loop (though arising from, and attached only to, the body wall).

GENERA OF STYELIDAE

A_1. Simple ascidians.
  B_1. Gonads on both sides of the body.
    C_1. Gonads few, sometimes only one on each side; the ovary is somewhat elongate flask-shaped or tubular, sometimes branched, attached to the inner side of the body wall; the numerous small testes attached to the body wall near to (alongside or around the end of) the ovary but separately from it.
      D_1. Branchial folds well developed. . . . . *Styela*
      D_2. No branchial folds. Each gonad elongate U-shaped. . *Pelonaia*
    C_2. The ovary and testes of each gonad form a compact body often enclosed in a membranous capsule or tube.
      D_1. Gonads thus formed few in number, elongate, sometimes branched . . . *Cnemidocarpa*
      D_2. Gonads numerous on each side of the body (especially on the right side) of shorter, ovate, or rounded form. . . *Polycarpa*
  B_2. One gonad (of the *Cnemidocarpa* type) present on the right side, none on the left. . . . . *Dendrodoa*
    C_1. Gonad branched . . . . typical species of *Dendrodoa*
    C_2. Gonad unbranched . . . . Subgenus *Styelopsis*
A_2. Compound ascidians; zooids small, sometimes

embedded in a common test, in other cases more or less independent.

B_1. Branchial sac without folds, and with only a few (three to 16) internal longitudinal vessels on each side.

C_1. One gonad on each side composed of an ovary and two testes. Test gelatinous, similar to that of *Botryllus* . . . . *Symplegma*

C_2. A gonad on the left side only, composed of an ovary and two groups of testes, in a sac-like outgrowth of the body wall. An incubatory pouch also developed . . . *Kükenthalia*

C_3. A row of gonads each side of the endostyle, each gonad with an ovary and one testis . . . . *Polyzoa*

C_4. A row of gonads each side of the endostyle, each of one sex, female on the right, male on the left side . . . . *Alloeocarpa*

C_5. Gonads mostly of one sex, those in the anterior part of the body female, in the posterior part male . . . . *Metandrocarpa*

B_2. Branchial sac with folds.

C_1. Gonads hermaphroditic, present on both sides of the body.

D_1. Each gonad with several or many testes . . . . *Polyandrocarpa*

D_2. Each gonad with only two testes. . . . . Subgenus *Eusynstyela*

C_2. A gonad on the right side only, peculiar in having the oviduct opening into the cavity of the branchial sac. . . . . *Gynandrocarpa*

GENUS SYMPLEGMA HERDMAN, 1886

A genus of the Styelidae which approaches the Botryllidae in its small zooids without branchial folds and with only four internal longitudinal vessels on each side, and whose colonies, in the gelatinous character of the test and the bright coloration of the zooids during life, are strongly suggestive of the Botryllidae in their appearance. The structure of the gonads (see below under *S. viride*) furnishes the best reasons for including it in the Styelidae rather than in the Botryllidae.

Symplegma viride Herdman, 1886

Plate 18, figure 2; text figures 139, 140C, 140D

Diandrocarpa botryllopsis VAN NAME, 1902, p. 383, pl. 54, fig. 68, pl. 59, figs. 120, 121, pl. 60, fig. 123; SEELIGER, 1903–1907, pp. 1145, 1146, fig. 214; MICHAELSEN, 1904, p. 43.

Diandrocarpa brakenhielmi MICHAELSEN, 1904, p. 50.

Symplegma elegans (part) MICHAELSEN, 1934, p. 154.

Symplegma viride HERDMAN, 1886, p. 144, pl. 18, figs. 7–14; VAN NAME, 1902, p. 378, pl. 50, fig. 22; MICHAELSEN, 1904, p. 23; 1918, p. 39; 1919b, p. 101 (+forma *brakenhielmi*, p. 105); VAN NAME, 1921 (+*S. viride brakenhielmi*), pp. 404, 407, figs. 75, 76; GRAVE, 1925, p. 225; 1927, p. 218; VAN NAME, 1930, p. 482, figs. 50, 51; GRAVE, 1932, p. 146; BERRILL, 1932, pp. 78, 86, 88, fig. 5b, 5d, 5e; 1935, pt. 3, pp. 257, 273, fig. 3k, pt. 4, p. 360, fig. 17d; GRAVE, 1935, pp. 215, etc., pl. 1, fig. 2; 1937, p. 560; PLOUGH AND JONES, 1937, p. 101; BERRILL, 1940, pp. 272 ff., figs. 1–5.

Colony normally thin and incrusting, usually not averaging over 2 to 2.5 mm. in thickness but sometimes measuring 60 to 90 mm. across. It is occasionally of very irregular form and thickness in some parts, when growing on regular objects; when on branching algae, bryozoans, etc., it may surround the stems.

Its general characteristics, its soft, transparent, gelatinous test usually allowing the dark-colored zooids to be distinctly visible, the branching vessels ramifying in the test and ending in enlarged ampullae in the marginal parts of the colony, the varied and often bright coloration of the zooids during life, all

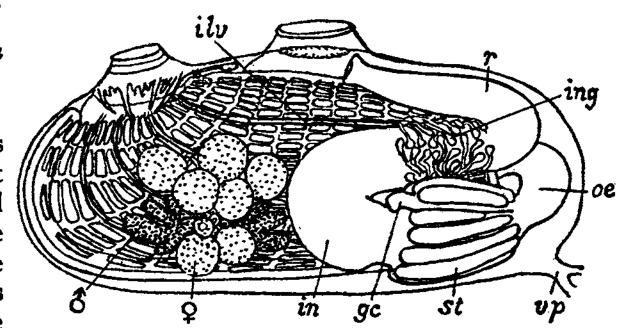


FIG. 139. *Symplegma viride* Herdman. Zooid with developing eggs, ×35.

combine to give it a strong resemblance to the genus *Botryllus*. The zooids are, however, not arranged in systems and do not conform to the botryllid type in their gonads. They are of ovate outline, narrower in front and more or less depressed dorsoventrally; both apertures are oval, on the dorsal surface and somewhat prominent, not lobed, but sometimes minutely denticulate. The branchial is near, or almost at, the front end; the atrial is much larger and near the middle of the back.

Adult zooids range from about 2.5 mm. to nearly 4 mm. long and 1.3 to 1.8 mm. wide. In preserved material the zooids are usually some shade of purple, varying from pale to dark, a brownish, blackish, or occasionally olive or greenish. During life an area of light-colored and of brilliantly conspicuous pigment surrounds the branchial aperture of each zooid, white, greenish white, yellow, orange, or pale salmon in the colonies I have collected, but these colors quickly fade out after death. The surface of the test is usually a little raised over the bodies of the zooids; the raised areas may or may not be definitely bordered by a slight groove; they are rendered more conspicuous by the slightly raised apertures of the zooids.

Mantle musculature slight, chiefly transverse. Normal number of branchial tentacles 24, of which six are large and long (three of them more so than the others); those of the smaller orders may be few or rudimentary. A circle of minute thread-like atrial tentacles borne on the edge of a circular membrane or velum can sometimes be demonstrated. Dorsal lamina a plain membrane. Branchial sac without folds; it is similar to that of *Botryllus* but has four instead of three internal longitudinal vessels on each side. About 13 rows of stigmata separated by transverse vessels of uniform size; the transverse vessels of the right and left sides do not meet the medium dorsal vessel exactly opposite each other. There are usually from five to seven stigmata between the internal longitudinal vessels (next to the endostyle and dorsal lamina sometimes 10 or 11).

The intestine is of large diameter; the stomach has usually from 11 to 14 plications, and a fairly large curved pyloric caecum. The rectum bends forward quite abruptly; the anal margin is not lobed.

One gonad on each side; that on the left side farther forward than the other. Each gonad consists of two pear-shaped or lobate testes with the small ends near together, and an ovary attached to the mantle walls. A short individual duct from each testis unites with that from the other to form a common duct, but it is extremely short. The ovary, when small, lies between the testes and is bridged over by the sperm ducts. This is a simplification of the structure found in members of the Styelidae having more complex gonads, where the individual sperm ducts run onto the inner (free) surface of the ovary and there unite to form a large common sperm duct. No oviduct was demonstrated in this species. When the eggs become large, though they are not very numerous, the ovary spreads over a considerable space on each side of the body. Ripe eggs, 0.44 mm. diameter, according to Berrill, 1937. For culture methods, see Grave, 1937.

DISTRIBUTION: Bermuda (type locality) where it is common on stones, algae, other ascidians, etc., along the shore and in shallow water; the West Indies (Puerto Rico at Guanica Harbor, in shallow water; east coast of Jamaica on piles); coasts of the southeastern states including North Carolina (specimen washed up on the beach near Beaufort, August, 1904), South Carolina (Blackfish Banks off Charleston, and 32° 51′ 05″ N., 78° 59′ W., 14 fathoms), and Florida (including Biscayne Bay, banks near Soldiers Key, Miami Harbor, and the Tortugas, and various localities on the west coast in depths down to 27 fathoms).

Michaelsen's type of *S. brakenhielmi* was from Vera Cruz, Mexico; I do not think that it can be maintained as even subspecifically distinct from *S. viride*. Allied forms, whose specific distinction from *S. viride* have been questioned or denied, have been described from the Indian Ocean and Malay region (see Michaelsen, 1904, 1919b, and Herdman, 1906). Some of them have a much longer, slenderer common sperm duct. The exact status of these Old World forms does not seem to be satisfactorily settled, and is too much outside the scope of this work to be discussed here.

Symplegma viride stolonica Berrill, 1932

Text figure 140A, 140B

Symplegma viride stolonica BERRILL, 1932, pp. 87, 88, fig. 5a, 5c; 1935, pt. 4, p. 362, fig. 17e.

Symplegma viride var. *minuta* PLOUGH AND JONES, 1937, p. 101 (*minuta* an error for *stolonica*, according to the authors).

Berrill (1932, p. 87), describing the colors of *Symplegma viride* at Bermuda, mentions an orange variety which differs in other respects besides color from the typical form and is the basis of the present subspecies.

In the typical form "all colonies are very compact and sheet-like as in *botryllids*, the adult zooids being pressed together, young buds appearing in large numbers together with clusters of ampullae at the colony margin. The orange variety, however, is different. Instead of the budding stolons being very short, they are even longer than in *Stolonica socialis*, with the result that the zooids are often widely separated from each other while the individual zooids assume a comparatively vertical position. It may, in view of this difference, be worth recognizing this form as a definite variety. If so, it is suggested that it be named *Symplegma viride stolonica*" (Berrill, 1932, pp. 87, 88).

I have not found or seen specimens of this form, but as Plough and Jones, 1937, report it also from the Tortugas, Florida, the adoption of Berrill's proposal appears to be well justified.

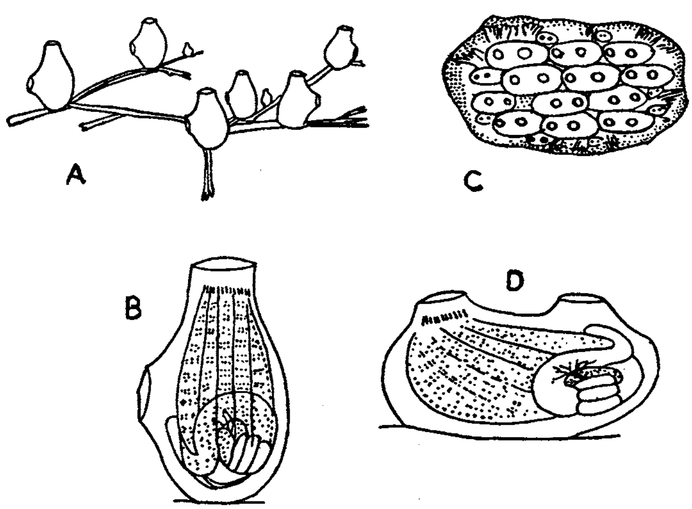


FIG. 140. *Symplegma viride stolonica* Berrill. Compared with typical *S. viride.* After Berrill, 1932. A. Colony of *S. v. stolonica.* B. Zooid of same. C. Colony of typical *S. viride* seen from above. D. Zooid of same.

GENUS **KÜKENTHALIA** HARTMEYER, 1903

Related to *Symplegma* but quite different in the gonad which is present on the left side only. The following is the only species.

Kükenthalia borealis (Gottschaldt), 1894
Text figure 141

Goodsiria borealis GOTTSCHALDT, 1894, p. 361, pl. 1, fig. 5; RITTER, 1896, pp. 152, 155, etc.

Goodsiria coccinea BONNEVIE, 1896 (not Cunningham, 1871), p. 13, pl. 4, figs. 32–34.

Goodsiria spec. HERDMAN, 1892, Proc. Liverpool Biol. Soc., vol. 6, p. 91.

Gynandrocarpa (?) *borealis* MICHAELSEN, 1900, p. 31.

Kükenthalia borealis HARTMEYER, 1903, p. 260, figs. 12–16, pl. 11, fig. 12; MICHAELSEN, 1904, p. 113; BJERKAN, 1905, p. 12; REDIKORZEV, 1907, pp. 138, etc.; 1908, pp. 20, 27; BJERKAN, 1908a, p. 72; HARTMEYER, 1909–1911, p. 1377; 1914b, p. 1107; 1921a, p. 65; ÄRNBÄCK, 1921, p. 187, figs 1–8; 1922, p. 51, figs. 5–6, pl. 3, figs. 47–56; HUNTSMAN, 1922a, p. 10; ÄRNBÄCK, 1922–1924 (1923), p. 23; HARTMEYER, 1923, p. 335.

The colonies of this species are usually small, rarely exceeding 20 to 25 mm. in any dimension and are of very various shapes, ranging from capitate, attached by a narrowed base or by a distinct pedicel, through ovate or dome-shaped forms sessile by a broad base, to flattened and incrusting types, which in the case of young colonies with but few zooids may be very thin.

The test is translucent and gelatinous within and traversed by the stolons which arise from the zooids; on the surface it is tougher, especially when it covers the zooids, and less transparent. The color of the colonies is said to be scarlet red in life; preserved specimens fade to a bluish or yellowish gray. The test contains minute irregularly stellate spicules.

The zooids are flattened dorsoventrally and form slightly raised elliptical areas usually about 4.5 to 5.5 mm. in longest diameter on the surface of the colony. On these areas the two square or four-lobed apertures of the zooid may be seen. The zooids are usually placed quite close together, but they cover only the upper surface or part of it, leaving the rest of the surface of the colony and its interior unoccupied. The branchial aperture is situated near the anterior end of the zooid, the atrial at or behind the middle. There are no systems, and the number of adult zooids in a colony is small (about 12 to 20 in colonies of the usual size).

There are about 40 slender branchial tentacles, and smaller atrial tentacles are also present. Dorsal tubercle simple, cup shaped. Dorsal lamina smooth margined.

Branchial sac without folds. Four stout internal longitudinal vessels form meshes containing about seven or eight stigmata. These are crossed by narrower transverse vessels that alternate with the longer ones.

The intestinal tract is situated more or less ventrally and to the left side. The small rounded stomach has about 10 or more longitudinal folds and a small curved pyloric caecum. The intestine, which is of large diameter, forms an S-shaped curve, the distal branch ending near the atrial aperture in a nearly smooth-margined opening.

The reproductive organs are peculiar and were first described by Ärnbäck in 1921, and at greater length (with many illustrations) by the same author in 1922. They are contained in a sac-like, narrow-necked outgrowth of the mantle (the genital pouch) which extends down into the common test from the left side anterior to the end of the intestine. This pouch contains two groups of elongate pyriform testes. Each group may have a separate sperm duct but these usually join to form a single common duct which enters the peribranchial cavity. The ovary is situated beside the male glands, the oviduct passing between the two sperm ducts before they unite. A large brood pouch into which the oviduct opens is developed at the base of the genital pouch already described. In it the embryo develops (apparently only one at a time). The brood pouch projects independently into the common test alongside the genital pouch.

DISTRIBUTION: Found in a part of the Arctic region comprising Spitzbergen, the northern coast of Norway, the Faeroe Islands, Iceland, and both sides of Greenland including Baffin Bay and the Fox Channel, but does not range south of Greenland and the Faeroes. Inhabits rather deep water (the records ranging from about 10 to over 400 fathoms) attached to stones, worm tubes, shells, etc., or the stems of large algae.

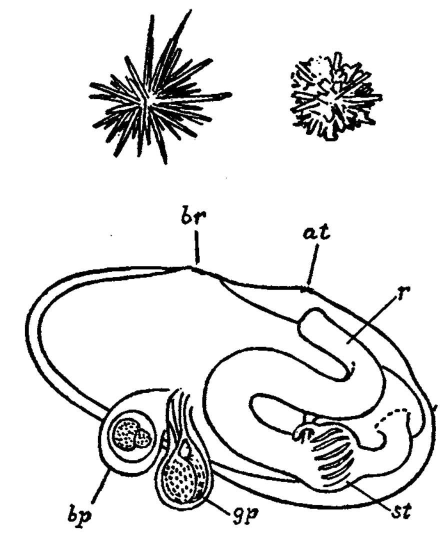


FIG. 141. *Kükenthalia borealis* (Gottschaldt). Zooid, ×9, and spicules from the test, ×125. After Ärnbäck, 1921. (*bp*, brood pouch; *gp*, genital pouch.)

GENUS **GYNANDROCARPA** MICHAELSEN, 1900

A genus of compound Styelidae of the African coasts having the branchial sac with three folds on each side and only one gonad, which is hermaphroditic, situated on the right side, and is peculiar in having a long oviduct which discharges into the interior of the branchial sac.

Gynandrocarpa placenta (Herdman), 1886

Plate 22, figure 1

Goodsiria (*Gynandrocarpa*) *placenta* HARTMEYER, 1909–1911, p. 1369; HERDMAN, 1912, p. 95.

Goodsiria placenta HERDMAN, 1886, p. 328, pl. 43, figs. 1–10, pl. 44, figs. 4, 8–10.

Goodsiria placenta var. *fusca* HERDMAN, 1886, p. 333, pl. 44, figs. 5–7.

Gynandrocarpa placenta +vars. *fusca* and *unilateralis* MICHAELSEN, 1900, p. 29.

The typical form of well-developed colonies is that of a rather thick, fleshy, rounded, or oval disk borne on a short pedicel arising from a point on its margin. Colonies reach a diameter up to 12 cm.

The zooids are from 3.5 to 5 mm. long. They have three branchial folds on each side and a considerable number of internal longitudinal vessels. The stomach has about 19 longitudinal plications in its wall and a small caecum. The single gonad contains one ovary and numerous small testes.

The only report of this peculiar form from American waters is Herdman's (1912) statement that several colonies from the vicinity of Port Stanley, Falkland Islands, "seem to agree closely with this South African species." A reëxamination of the specimens would be desirable, if they are still extant, to confirm this identification.

Genus POLYZOA Lesson, 1830

(Syn. *Goodsiria* Cunningham, 1871, Herdman, 1886)

As restricted in Hartmeyer's (1909–1911) classification, the genus contains compound Styelidae having the branchial sac without folds, with eight internal longitudinal vessels on each side, and a number of hermaphroditic gonads forming a row on each side near the endostyle, each gonad consisting of an ovary and a single testis.

In order to include *P. translucida*, the above diagnosis must be modified in respect to the number of longitudinal vessels on each side, which is only three in *translucida*.

Polyzoa opuntia Lesson, 1830

Plate 24, figures 1, 4

Colella nov. sp. Pfeffer, 1889, p. 4.

Goodsiria coccinea Cunningham, 1871a, p. 489, pl. 58, fig. 3a–3e; Herdman, 1886, p. 337, pl. 45, figs. 1–19. Not Pfeffer, 1889, p. 4 (=*Alloeocarpa incrustans*).

Goodsiria pedunculata Herdman, 1886, p. 335, pl. 44, figs. 1–3.

Goodsiria sp. Cunningham, 1871, p. 126.

Polyzoa opuntia Lesson, 1830a, p. 437; Michaelsen, 1900 (+*P. herdmani, P. coccinea, P. gordiana, P. lennoxensis, P. pictonis, P. pictonis* var. *georgiana, P. pictonis* var. *waerni*), pp. 27–29, 44–52, 56–68, pl. 1, except figs. 3, 4, 9; 1904 (+ subs. *patagonica, pictonis, waerni, opuntia, gordiana, lennoxensis, coccinea*), pp. 58–65; 1907 (+ subs. as in Michaelsen, 1904), pp. 77, 78; Hartmeyer, 1909–1911 (+subs. as in Michaelsen, 1904), p. 1372.

Polyzoa opuntia subsp. *coccinea* Herdman, 1912, p. 95.

Polyzoa opuntia subsp. *gordiana* Sluiter, 1932, p. 2.

Polyzoa pictonis +*P. p.* var. *waerni* +*P. cunninghami* Michaelsen, 1898, pp. 368, 369.

Polyzoa pictonis patagonica Herdman, 1912, p. 102.

The colony in this species consists typically of a varying but generally small number of heads which may be of considerable size and are borne on pedicels of more or less elongated stalks arising from a common expanded basal mass or a network of anastomosing stolons by which the whole colony is attached.

The most characteristic and one of the commonest forms of these heads is obovate (to use a botanical term) or pyriform in outline, wide and rounded at the free end and narrowing into the pedicel at the other end, and much flattened from side to side, so that its shape is often strongly suggestive of the joints of the common "prickly pear" cactus (genus *Opuntia*). It often is so also in size, as the larger heads may reach 10 to 15 cm. in length, about 4 or 5 cm. in width, and 1.5 to 2 cm. thick in some cases, and occasionally even larger measurements.

The pedicel is usually rather short and thick and of rounded cross section, or it may be extended into a stalk 5 or 6 cm. in length and quite slender.

The shape of the heads is, however, subject to infinite variation and irregularity of form; in many colonies no two of the heads may correspond in form, size, or length of pedicel; in other colonies there is a good deal of uniformity in their shape. The surface of the colonies is usually not much incrusted and is moderately even, except that there are small, usually slightly convex oval elevations over the ends of the zooids. These are much more prominent and well defined in some colonies than in others, and are scattered usually quite evenly and quite close together over all parts of the heads but not on the pedicel or base. They are from 2.5 to 4 mm. in long diameter in most colonies, and each bears the two slightly raised apertures of the zooid beneath it. These apertures are in many cases distinctly square or four-lobed.

In life the color is apparently most often some shade of red or sometimes flesh colored or reddish brown, the small areas over the zooids, especially about their apertures, being more deeply colored.

The zooids are ovate in form and vary much in size in different colonies and often in parts of the same colony. A maximum diameter of about 4 or 5 mm. is not exceeded in most colonies, though Michaelsen mentions a maximum of 8 mm. long. It is usually difficult to remove the zooids entire.

The mantle musculature is moderately developed, comprising slender circular and longitudinal bands. A few small endocarps are often present.

The branchial tentacles vary greatly in number and in the degree of regularity of arrangement of the different sizes; counts in different colonies indicate a range from about 24 to over 40. There is also a circle of small atrial tentacles.

The dorsal tubercle is longitudinally elliptical with a slit-like or somewhat curved aperture. The branchial sac is flat without folds; there are eight slender internal longitudinal vessels on each side, which are nearer together in the dorsal parts of the sac than in the ventral part. There is, in consequence, an increase in the usual number of stigmata in the meshes as the endostyle is approached. Parastigmatic transverse vessels often present.

The alimentary tract forms a rather small, somewhat open loop. The stomach is short and rounded and has about 16 obliquely longitudinal folds in its wall in addition to the sutural ridge which bears a small curved caecum. The intestine ends in a very short rectum; the anal margin is approximately smooth.

There is a row of hermaphroditic gonads along and near the endostyle on each side. Both rows begin near the anterior end, but that on the left extends only about half the length of the body on account of the intestinal loop, and it may have as few as four or five gonads. On the right side it extends much farther and may have 11 or 12 gonads, if not more. Michaelsen describes one colony in which the posterior part of the row on the right side curved outward away from the median line and forward at its end.

Each gonad is composed of a single sac-like testis closely attached to the mantle, and an ovary consisting of a small group of eggs of which one is often very large (reaching, according to Michaelsen, 0.35 mm. in diameter when ripe). The ovary occupies the medial parts of the gonad and ends in a short oviduct; the slender sperm duct ends near, but a little short of, the end of the oviduct. Both ducts are directed laterally (away from the endostyle).

This genus was very carefully studied by Michaelsen. In his work of 1900 he attempted to divide this species into several closely related species and varieties. (See list of synonyms above.) In later works (1904, 1907) he reduced them all to subspecies, having evidently become doubtful of the importance and constancy of the supposed distinguishing characters. Their importance does not seem to me to warrant taking space for their discussion in the present work. The reader who may be interested in them is referred to Michaelsen's works mentioned above, especially that of 1904.

DISTRIBUTION: A common species of the region of the Strait of Magellan; east and south coasts of Tierra del Fuego; and north along the Patagonia coast to Bahia Blanca; the Falkland Islands (Lesson's type locality is Soledad Bay in that group); South Georgia Island. There is one record of 100 fathoms (Martha Bank, Strait of Magellan), but it seems to be chiefly a species of rather shallow water and is often washed up on the beaches by storms.

Polyzoa reticulata (Herdman), 1886

Chorizocormus reticulatus HERDMAN, 1886, p. 346, pl. 46, figs. 1–8; PFEFFER, 1889, p. 4.

? *Polyzoa falclandica* MICHAELSEN, 1900, p. 52, pl. 1, fig. 3; 1904, p. 68; 1907, p. 79.

Polyzoa falclandica var. *repens* MICHAELSEN, 1900, p. 55, pl. 1, fig. 4 (perhaps also fig. 9; see Michaelsen, 1904, p. 65).

Polyzoa reticulata MICHAELSEN, 1904, p. 65, pl. 1, figs. 6a–6d, 7; 1904a, p. 244; 1907, p. 78.

The zooids of this species appear to correspond closely with those of *P. opuntia* in size and internal structure, but they are either entirely separate, each with its own covering of thin leathery test, or sometimes united in very small groups. The individuals, which are rough externally, rounded, oval or dome shaped, and the small, close groups they frequently form are connected by creeping stolons, some of which often radiate out irregularly from the central denser parts of the colony to a distance of several centimeters, bearing at intervals small knot-like enlargements containing a developing zooid. Such colonies, when growing on an expanded surface, as of a smooth stone or a large shell or simple ascidian, have a very characteristic appearance.

The color in life is said to be pale red or rose red.

DISTRIBUTION: Herdman's type locality for his *Chorizocormus reticulatus* was at Kerguelen Island, in 30 fathoms. In 1900 Michaelsen described his "*Polyzoa falclandica*" and "*P. f. repens*," both from Port Stanley, Falkland Islands, and both are a good deal alike, though the absence of secondary (parastigmatic) transverse vessels in the branchial sac, also larger zooids and shorter connecting stolons are given by Michaelsen as characters differentiating the typical *falclandica* from the variety. Later, having examined some of Herdman's typical material, Michaelsen concluded that the var. *repens* was identical with the Kerguelen species (see Michaelsen, 1904, 1904a). Considering the individual variability in this group of ascidians, it seems to me very probable that the typical *falclandica* may belong in Herdman's species also. Pfeffer and Michaelsen also give South Georgia Island as a locality for *P. reticulatus*. The United States National Museum has colonies growing on specimens of *Pyura legumen* and *Corella eumyota* from the Argentina coast ("Albatross" Station 2768, 42° 24′ S., 61° 38′ 30″ W., 43 fathoms) that seem referable to this species. It has not been recorded from deep water.

Polyzoa translucida Ritter and Forsyth, 1917
Text figure 142

Polyzoa translucida RITTER AND FORSYTH, 1917, p. 460, pl. 38, fig. 7, pl. 42, figs. 36–38.

"Composed of zooids joined by short strands to a basal network and, in older colonies, with individuals so close together that considerable portions of the tests of neighboring zooids adhere to each other. Zooids generally roughly egg-shaped, although in the largest individuals the two siphons on anterior end may be quite prominent. Zooids colorless and semi-transparent; the largest 5 to 6 mm. long and 3 to 4 mm. thick. Tests tough but thin and transparent. Mantle with numerous, fine longitudinal and transverse muscle fibers."

"Branchial siphon 4-lobed, in middle of anterior end. Atrial siphon also 4-lobed, near branchial siphon or dorsal side of anterior end. Branchial tentacles about thirty, alternating long and short. Atrial tentacles about twenty, very small. Branchial sac without folds, with twelve rows of stigmata each having thirty to forty stigmata in a half series; three longitudinal vessels on each side; greatest number, about fourteen, of stigmata between the endostyle and first longitudinal vessel; about eight stigmata in each of remaining intervals. . . .

"Stomach considerably broader than long, made up of eleven or twelve prominent folds on side turned away from sac. . . . A caecum from near the pyloric end of stomach is joined by a fine duct to a pyloric gland which ramifies over intestine.

"Gonads hermaphroditic 'polycarps,' those on right disposed in row along the endostyle, as many as twelve in large individuals; on left about five, situated near endostyle in anterior half of sac. In large individuals the peribranchial cavities contain numerous eggs and larvae. In such cases the large oviduct forms a conspicuous portion of the hermaphroditic gonad. A small tentacle-like sperm duct terminates the male gonad near oviduct" (Ritter and Forsyth, 1917).

From the illustrations, it appears that each gonad contains a single large testis.

LOCALITY: Known only from wharf piles in San Diego Bay, California, "where it occurs interwoven with hydroids and other animals which inhabit the piles. The only specimens were taken in June" (Ritter and Forsyth, 1917).

This species resembles the genus *Chorizocarpa* Michaelsen, 1904, in the branchial sac with only three internal longitudinal vessels on each side, but that genus has only one gonad on each side.

GENUS ALLOEOCARPA MICHAELSEN, 1900

As amended by Michaelsen, 1922, this genus consists of compound Styelidae having the branchial sac without folds and a small

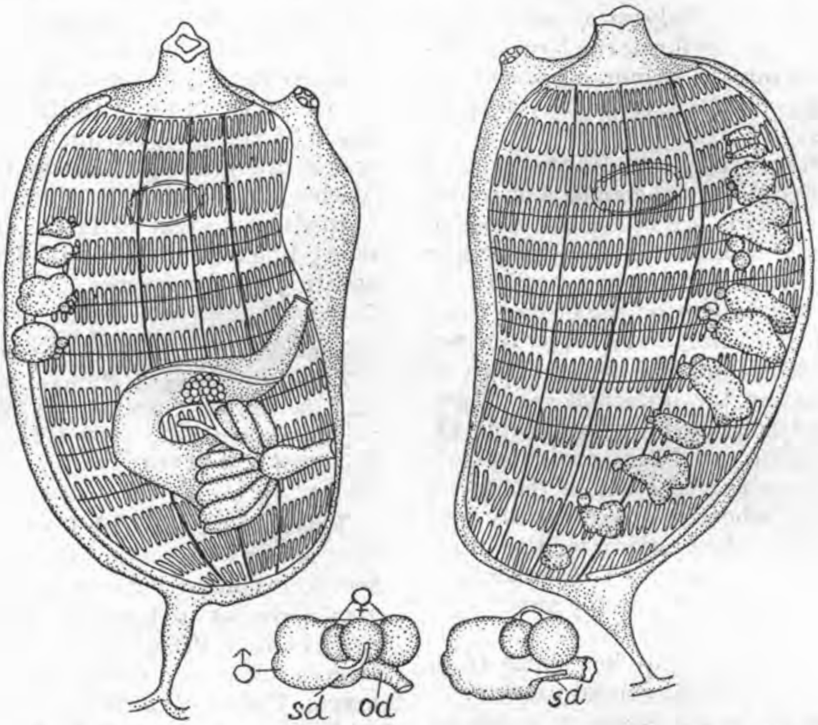


FIG. 142. *Polyzoa translucida* Ritter and Forsyth. Right and left sides of a zoid, × about 16, also two gonads more enlarged.

number (about five to 16) of internal longitudinal vessels on each side.

The gonads are each of a single sex, the female on the right side of the body, the male on the left side. *A. incrustans* (see below) is the type of the genus.

Alloeocarpa incrustans (Herdman), 1886

Alloeocarpa emilionis MICHAELSEN, 1900, p. 35, pl. 2, fig. 21.

Alloeocarpa incrustans MICHAELSEN, 1900, p. 25; 1904, p. 88, pl. 1, fig. 13; 1907, p. 76; VAN BENEDEN AND SELYS-LONGCHAMPS, 1913, p. 41, pls. 9, 10.

? *Alloeocarpa intermedia* MICHAELSEN, 1900, p. 39, pl. 2, fig. 18; 1904, p. 91; 1907, p. 77.

Alloeocarpa zschaui MICHAELSEN, 1900, p. 32, pl. 2, fig. 20; 1904, p. 88; 1907, p. 76; SLUITER, 1932, p. 2.

Goodsiria coccinea PFEFFER, 1889, p. 4 (not Cunningham, 1871).

Synstyela incrustans HERDMAN, 1886 (in part; not Philippine specimens), p. 342, pl. 46, figs. 9–14; 1912, p. 95. Not Sluiter, 1895.

The colony in this species is very variable in appearance but normally of the flat, incrusting type, usually not over 5 or 6 mm. thick, and consisting of a single layer of zooids. When it grows on a small object or the stem of a seaweed, it often encloses it, and an apparently massive colony with zooids on all sides is formed. The largest colonies I have examined measure about 55 mm. in the widest direction, but Herdman mentions colonies over 20 cm. in length. The test is tough and leathery, and the colonies during life are red in color, often quite strongly so.

The zooids may be partially separate, forming small dome-shaped elevations connected only by a comparatively thin sheet of common test, but more often they are fully embedded in the test so that its surface is comparatively even, though their size and location are shown by more or less well-defined oval areas, somewhat convex or level with the surface or, when the zooid they cover is collapsed, slightly depressed. In them the two apertures of the zooid are located; they are four-lobed or occasionally merely short, transverse slits. The zooids, though very variable in size, average considerably larger than in *Polyzoa opuntia.* They are sac-like or ovate in form; the largest individuals reach 8 mm. to 10 mm. in greatest diameter in some colonies, though they are generally smaller.

In most internal characters (the generically important differences in the gonads of course excepted) the zooids are much like those of *Polyzoa opuntia,* though the tentacles appear to average fewer, generally not over 20 to 24, which may include two or sometimes three orders in respect to size, and a larger but not constant number of internal longitudinal vessels are present in the branchial sac. These generally number from 10, or more often 12, to about 16 (18 in very large zooids) on each side. They are nearer together in the dorsal part of the sac, where they are usually separated by two or three stigmata, the intervening stigmata increase to five or six (or, along the endostyle, eight) in the ventral region.

The stomach wall usually has about 16 to 18 folds and a very small curved caecum.

The gonads of the two sexes are separate; the male glands form a row or an irregular group on the left side, the female glands on the right side of the body, attached to the inner surface of the mantle.

The male glands may number more than 20, but more often not so many. They each consist of a single sac-like gland discharging by a very small, short, terminal sperm duct. Usually they are of simple rounded, oblong, or very short, thick, sausage-like form attached by one end, but occasionally of somewhat irregular outline. Michaelsen, 1900, separated *A. intermedia,* which I have included above as perhaps a synonym of this species, chiefly on the character of having the testes partially divided by clefts into two or more lobes, but it seems likely that this may be a matter of individual variation. The female glands are usually more numerous than the male glands. They each contain a few eggs, and each discharges by a rather wide oviduct which is often expanded at the distal end.

DISTRIBUTION: Region of the Strait of Magellan and Tierra del Fuego; also the Falkland Islands; common in shallow water but recorded also down to 50 and 55 fathoms. The distribution must, I believe, be extended to include South Georgia Island, as *A. zschaui* Michaelsen does not appear to be sufficiently distinguished from *incrustans.*

Type locality, "Challenger" Station 212, near the east entrance to the Strait of Magellan in 55 fathoms (Herdman). Some of Herdman's original material was reëxamined by Michaelsen.

In spite of great variation in different colonies, I have not found sufficient grounds for splitting up this species.

Alloeocarpa bridgesi Michaelsen, 1900

Alloeocarpa bridgesi MICHAELSEN, 1900, p. 41, pl. 2, fig. 19, pl. 3, figs. 10, 11; 1904, p. 92; 1907, p. 77; HARTMEYER, 1909–1911, p. 1374; VAN BENEDEN AND SELYS-LONGCHAMPS, 1913, pp. 47, 49.

This species, to which I give acceptance in the present work on the authority of Michaelsen, forms incrusting colonies with embedded zooids similar to those of *A. incrustans.* Its color in life is described as cinnabar red. The largest colony mentioned is not over 28 mm. across. The zooids form low convex elevations on its surface.

In size, form, and structure they resemble those of *A. incrustans* in most respects; the chief differences appear to be the smaller number (about five or six) of internal longitudinal vessels on each side of the branchial sac, and the male gonads. Each consists of a single gland which, however, is divided into much-branched lobes. Its ramifications are compacted into a spherical mass from which the small sperm duct projects. The male gonads (but not the female ones) are stated to be very few, not over five, sometimes only one.

DISTRIBUTION: The localities given for this species are within the distribution area of *A. incrustans:* Smyth Channel, Puerto Bueno, Ushuaia, and Haberton Harbor on southern Tierra del Fuego, and Banner Cove on Picton Island.

Alloeocarpa bacca Ärnbäck, 1929

Plate 24, figure 3; text figure 143

Alloeocarpa bacca ÄRNBÄCK, 1929, p. 4, pl. 1, figs. 5, 6.

The colony "consists of a great many individuals, closely aggregated and apparently separate from each other but in reality united by a very thin basal membrane spread over the shell to which the colony is attached. The individuals are of different size, small ones being scattered among those of greater size in the colony and at its margins" (Ärnbäck, 1929).

The dimensions of the larger individuals are given as 4 by 4 mm. Except for their almost complete degree of separation and rounded or dome-shaped form, they conform to those of *A. incrustans* in most characters, except in those of the gonads (see below), but have fewer internal longitudinal vessels, six on the left and seven on the right side. These are nearer together in the dorsal than in the more ventral part of the sac. Parastigmatic transverse vessels are present alternating with the larger ones. There are 12 large tentacles alternating with as many smaller ones. The stomach has 12 longitudinal folds besides the raphe and a well-developed, relatively large caecum.

Regarding the female gonads (which resemble those of *A. incrustans*), Ärnbäck states that they "consist of 5–6 small ovaries or polycarps arranged in a bow. Most of them are placed on the right side and a couple on the left." It is not clear, however, from the illustration which that author gives that any of them are on the left side. Some endocarps are present.

The male gonads are thus described: "The testis is in the form of a 5-parted—sometimes 4-parted—but continuous gland; situated on the left side of the body in front of the alimentary organs. Apparently it is composed of 4–5 coherent groups of testicular glands, each having a short vas deferens." Eggs and tadpole larvae were found in the peribranchial cavity.

LOCALITY: This species was based on a single colony, measuring about 35 mm. across, found off Guaitecas Islands, Chile (latitude about 44° S.) in 23 meters.

GENUS **METANDROCARPA** MICHAELSEN, 1904

As amended by Michaelsen, 1922, this genus consists of compound Styelidae with zooids having the branchial sac without folds; with a small number (about five to 10) of internal longitudinal vessels on each side.

The gonads are mostly, if not all of them, each of a single sex, and are present on both sides of the body, the female only in the anterior part, the male in the posterior part. The male gonads consist each of a single testis.

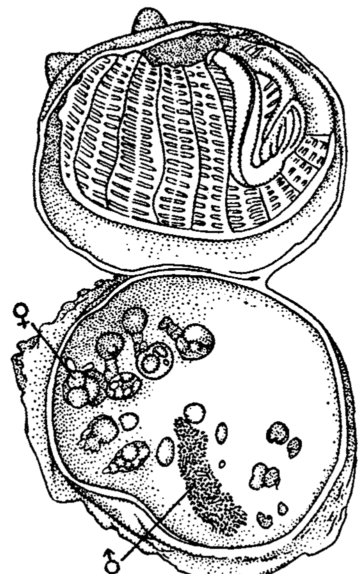


FIG. 143. *Alloeocarpa bacca* Ärnbäck. Zooid, cut open, ×1.5.

Metandrocarpa dura (Ritter), 1896

Goodsiria dura RITTER, 1895, p. 364 (*nomen nudum*); 1895a, p. 716 (no descr.); 1896, pp. 150 ff., pls. 12–15.

Metandrocarpa dermatina HUNTSMAN, 1912, p. 128; 1912a, p. 140, pl. 12, fig. 7, pl. 18. figs. 7, 8.

Metandrocarpa dura MICHAELSEN, 1900, p. 26; 1904, p. 70, pl. 1, fig. 8; RITTER AND FORSYTH, 1917, p. 457; JOHNSON AND SNOOK, 1927, p. 595; PRATT, 1935, p. 747.

Young colonies are of the flat, incrusting type; older ones may develop projecting lobes. This is often due to their enveloping the stems and branches of sea weeds, their form thus depending on that of the object on which they grow. The colonies may become quite large, measuring 60 to 80 mm. or more in maximum length or width.

In life they are uniformly red or purplish red in color and quite conspicuous, fading to brown in preservation. The surface of the colony is covered with quite closely placed, low, dome-shaped elevations of oval outline from 2 to over 4 mm. in longest diameter, each one caused by the body of a zooid and bearing on its upper surface its two apertures situated a little way apart. These are rounded, sometimes slightly prominent, and in contraction become transverse clefts. The test is quite tough and leathery, and the mantle of the zooids usually adheres to it so that it is often difficult to get the zooids out entire. It is permeated by vessels ending in somewhat enlarged bulbs. Even in thick parts of the colony the zooids are confined to the superficial layer.

The zooids are oval and somewhat depressed dorsoventrally, and lie horizontally in the colony. Their mantle musculature is thick and diffuse. The branchial tentacles number 40 or less, representing at least two sizes, and small atrial tentacles are present. The dorsal tubercle has a small, longitudinally elliptical opening (though Huntsman calls it a "transverse slit"). The dorsal lamina is plain.

Branchial sac without folds; five internal longitudinal vessels (Nos. 1 and 2 being closer together than the others), usually separated by about five or six stigmata but in some of the meshes sometimes by nine or 10. About 12 rows of stigmata are present. The posterior rows of stigmata are short and their stigmata small. Additional very slender transverse vessels crossing the stigmata are sometimes demonstrable.

The digestive tract forms a rather small open loop on the left side; the rectum is curved, only moderately long, and with a two-lipped aperture. The stomach is short and rounded, with 12 to 16 longitudinal folds forming rounded projections at the oesophageal end of the stomach. In addition there is a narrow ridge which bears the moderately large, somewhat curved caecum. The two or three folds next to this ridge on each side are oblique and end against it, not reaching the pyloric part of the stomach.

There is a more or less regular row of small gonads on each side of the body, that on the right side being parallel and near to the endostyle; on the left side, however, the posterior part of the row bends dorsally to avoid the region occupied by the intestinal loop. The gonads in the anterior part of each row are female; in the posterior part male; their number is variable; there may be a total of from half a dozen to a dozen on the right, but usually not so many on the left side. The ovaries were not fully mature in the specimens I have examined and were small, irregularly rounded bodies containing only very small eggs. No oviduct was demonstrated. The male gonads were much larger and apparently in a functional state and were oval sac-like bodies, each with a short, slender, dorsally directed duct which opened into the peribranchial cavity. They form rounded prominences on the ventral surface of the body, received into corresponding depressions in the test.

DISTRIBUTION: Coast of southern California and northward at least to Tomales Bay. Type locality, Santa Barbara, where Ritter reports finding it growing on the large simple ascidian *Styela montereyensis*, but more commonly it grows on kelp a little way off shore in water a few meters deep and is observed only when the plants are washed up on shore by storms. I believe, however, that it is of wider distribution, for *M. dermatina* described by Huntsman (1912, 1912a), found at Hope Island, British Columbia, washed up on the beach seems to be insufficiently distinguished from this species, as Huntsman himself suspected (1912, p. 129; 1912a, p. 141), the differences being well within the limits of individual variation. I find variation to be greater in such matters as the number of tentacles, plications of the stomach wall, rows of stigmata, number of stigmata in a mesh, gonads, etc., than either Ritter or Huntsman seems to have realized.

Metandrocarpa taylori Huntsman, 1912

? *Metandrocarpa michaelseni* RITTER AND FORSYTH, 1917, p. 458, pl. 38, fig. 8, pl. 39, fig. 14, pl. 42, figs. 41–45.

Metandrocarpa taylori HUNTSMAN, 1912, p. 129; 1912a, p. 141, pl. 2, fig. 9.

The colony of this form is of the "social" type, each zooid with its separate covering of test instead of being embedded in a common mass. The zooids are somewhat hermispherical, attached by the flattened ventral side with their apertures on the dorsal surface, close together, or, if on a broad surface some distance apart, and connected by branching stolons.

According to Huntsman, the zooids average longer than in *dura;* the two largest, of which he gives measurements, were 7 mm.

long by 5 mm. wide by 4.5 mm. dorsoventrally, and 6 mm. by 4 mm. by 4.5 mm., respectively. They are practically identical with those of *dura* in internal structure, though Huntsman found more stigmata (sometimes 11 to 14) in the meshes of the branchial sac, which is not surprising considering the larger zooids. Rows of stigmata, 12 to 13. "Color of colony grayish or brownish in formalin, but pure white when fresh."

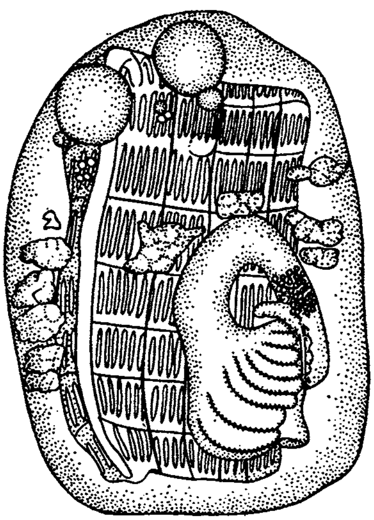


FIG. 144. *Metandrocarpa michaelseni* Ritter and Forsyth. Lower or attached side (chiefly the left side) of a zooid removed from the test, ×16.

LOCALITY: China Hat, British Columbia. "Dredged in a few fathoms attached to shell, worm-tubes, etc. Several colonies."

I think it extremely probable that this and the next following species (*michaelseni*) are not distinct. If they are not, the name *taylori* must be used.

Metandrocarpa michaelseni Ritter and Forsyth, 1917

Text figures 144, 145

Metandrocarpa michaelseni RITTER AND FORSYTH, 1917, p. 458, pl. 38, fig. 8, pl. 39, fig. 14, pl. 42, figs. 41–45.

? *Metandrocarpa taylori* HUNTSMAN, 1912, p. 129; 1912a, p. 141, pl. 11, fig. 9.

A species forming colonies of the "social" type similar to those of *M. taylori*, from which it may perhaps not be distinct.

Its external appearance is well described by Ritter and Forsyth as follows:

"Superficial Characteristics: Zooids appearing as rounded mounds, the larger ones averaging about 4 mm. in diameter through base and from 2 to 3 mm. high; never embedded in a common test but probably always a film of test passing between them; adherence to substratum, usually the under side of rocks, very close. Color bright cherry-red to hardly more than a tinge of that color; cherry far more common. Siphons short and always deeper red than body. In large colonies, which may be half a square foot in extent, zooids come to be close together, almost covering the substratum, but these irregularly distributed with no intervention of common test. Blastozoids seem always to move away some distance, three, four, five or more millimeters and a delicate trail of test with a strand can be made out connecting bud and parent. Large, numerous ectodermal vessels in test film around blastozoid."

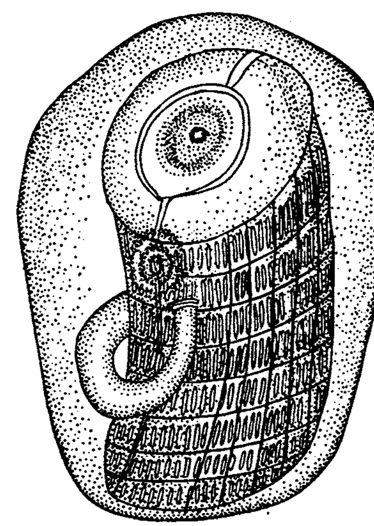


FIG. 145. *Metandrocarpa michaelseni* Ritter and Forsyth. Upper or superficial side (chiefly the right side) of a zooid removed from the test, ×16.

The zooids correspond so closely to those of *M. dura* described above, that there is no need of repeating what is said there. My own observations are in accordance with Ritter and Forsyth's statements in respect to most characters.

They describe the reproductive organs as follows:

"Reproductive System: Gonads in form of 'polycarps' attached to mantle on both sides of body. About three ovaries anteriorly situated on each side of endostyle. About five testis masses on right side in a row along the endostyle; on the left side usually four or five masses arranged around end of intestinal loop. From the summits of male gonads extend short vasa deferentia into the peribranchial cavity.

"Breeding Habits: Embryos and advance tadpoles retained in peribranchial chamber; breeding during midwinter months."

In regard to the number of branchial tentacles, the basic arrangement seems to be four of the first order with two second-order tentacles in each quadrant, making 12 large tentacles. The number of additional smaller tentacles is very variable. The one character which Ritter and Forsyth name as the "most positive difference" between the zooids of the two species (*M. dura* being supposed to have 12 or 13 and *michaelseni* only nine rows of stigmata) is unfortunately just as unreliable as any other, for I have repeatedly found 12 or 13 rows in zooids of *michaelseni*. The largest zooids which I found measure externally about 4.5 mm. in maximum basal diameter and fully as much in height, inclusive of the test.

DISTRIBUTION: "Typically on the under side of stones everywhere on the coast of southern California, probably though not certainly as far north as San Francisco. Type locality La Jolla" (Ritter and Forsyth, 1917).

If this species is not distinct from *M. taylori* Huntsman, the range extends north to British Columbia, and Huntsman's name will be the valid one.

I have collected it on the intertidal rocks at Pescadero Point near Pacific Grove, California. A large colony was also found on an abalone taken near Pacific Grove.

GENUS **POLYANDROCARPA** MICHAELSEN, 1904

Characters the same as in *Polycarpa* (see below) except that the zooids produce buds and form colonies. The gonads, though small, are similar to those of that genus. In the typical subgenus of *Polyandrocarpa* each gonad contains several or many testes; in the subgenus *Eusynstyela* Michaelsen, 1904, only two.

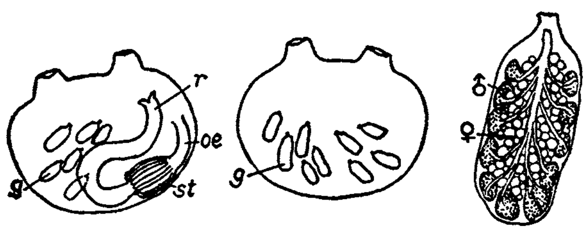


FIG. 146. *Polyandrocarpa maxima* (Sluiter). Left and right sides of body, ×2.6. Gonad (side next to branchial sac).

Polyandrocarpa maxima (Sluiter), 1904

Text figure 146

Gynandrocarpa maxima SLUITER, 1904, p. 93, pl. 15, figs. 5–7.

Polyandrocarpa maxima VAN NAME, 1918, p. 103, pl. 31, fig. 33, text figs. 56, 57; 1921, p. 412, figs. 82, 83; PLOUGH AND JONES, 1937, p. 101.

Colony an irregularly ovate mass of closely crowded zooids; area of attachment variable, usually not of very great extent. Surface uneven, often much wrinkled. Zooids sometimes deeply embedded, their location indicated chiefly by the two four-lobed apertures which are on small, rough, more or less prominent papillae. In other cases the dorsal part of the zooids bearing the apertures projects above the surface, separated from that of adjacent zooids by a not very deep cleft.

Test tough, opaque, often more or less incrusted with sand on the surface, yellowish and often discolored with mud in preserved examples, but probably more or less reddish, at least around the apertures, when living. Except for the numerous apertures, the colony often looks like a large, rough, simple ascidian.

The colonies reach considerable size (examples from São Sebastião, Brazil, 50 to 65 mm. or more in greatest diameter) and may contain more than 100 zooids. When a colony is cut open the zooids are seen to be separated (except in their dorsal parts) by quite thin lamellae of test substance. Vessels are present in parts of these lamellae, though I was not able to demonstrate vascular connection between zooids.

The structure of the individual zooids is exactly that of a typical *Polycarpa*. The body is rounded oval, seldom much elongated, and usually considerably compressed from side to side. They often vary greatly in size in the same colony; the largest may reach about 20 mm. in greatest diameter, but half this diameter or less is more usual, even in fully adult zooids.

The mantle is thin with scanty, largely transverse musculature; the branchial tentacles are of three or four orders (4+4+8+ a varying number of small ones), the larger ones arranged with some regularity; dorsal lamina plain edged; dorsal tubercle rounded with a C-shaped aperture, the open interval on the forward side and one or both horns incurved in the specimens in which this character was examined.

The branchial sac has four distinct but low folds on each side separated by a wide, flat interval. The second fold is usually well developed, often nearly as much so as the third. Distribution of internal longitudinal vessels in two moderately large examples:

Left	1 (13) 4 (16) 4 (18) 4 (13) 6
Right	1 (14) 4 (18) 4 (18) 4 (13) 5
Left	4 (14) 7 (16) 6 (18) 5 (13) 5
Right	6 (14) 6 (16) 5 (19) 6 (13) 7

The rows of stigmata commence close to dorsal lamina and endostyle. Transverse vessels of about four orders, often quite regularly arranged, the smallest crossing the stigmata; generally four or five stigmata in a mesh on the flat parts of the sac (six to 10 near the endostyle).

The alimentary tract forms a rather small loop; the stomach is short and rounded, its walls with 20 or more plications; caecum wanting or merely vestigial; anal aperture two lipped or somewhat lobated.

Gonads hermaphroditic, oblong or short, thick, sausage-shaped, of the usual *Polycarpa* structure, not numerous, commonly about six to 10 on each side, and very loosely attached to the mantle.

DISTRIBUTION: Described by Sluiter (1904) from Salibabu Island, Dutch East Indies (reef), and found also in the Philippines off Jolo Light, 29 fathoms (Van Name, 1918). I have seen specimens apparently referable to it from two American localities: a small colony from the entrance to Key West Harbor, Florida, 7½ fathoms, coral sand, and large ones from São Sebastião Island, São Paulo, Brazil (specimens in the United States National Museum and the American Museum of Natural History). Plough and Jones, 1937, report it from Tortugas, Florida.

Polyandrocarpa zorritensis (Van Name), 1931

Text figure 147

Stolonica zorritensis VAN NAME, 1931, p. 218, fig. 6.

The colonies consist of more or less closely crowded masses or clusters of club-shaped zooids of various sizes, arising from a basal tangled mass of branching and root-like stolons, which evidently serve to anchor the colony in the sand of the sea bottom. The zooids are enclosed in an individual covering of test; though toward the posterior or basal ends the tests of adjacent individuals may be more or less adherent, they are actually in connection with each other only by means of the stolons in the base of the colony. Test thin, tough, and densely incrusted and permeated with sand.

Individual zooids are club-shaped, of oval cross section (being slightly compressed from side to side), larger at the free or anterior end, and tapering posteriorly, the narrow posterior part beng composed of test only, except that it is traversed by the stolon connecting the zooid with its neighbors. The anterior end is rounded or more or less truncated, and bears the two four-lobed apertures which are near together and either almost even with the surface (in strongly contracted specimens) or raised on papillae. The zooids in the colonies at hand are of various sizes, but only the larger ones have the reproductive organs developed. The maximum length of the largest

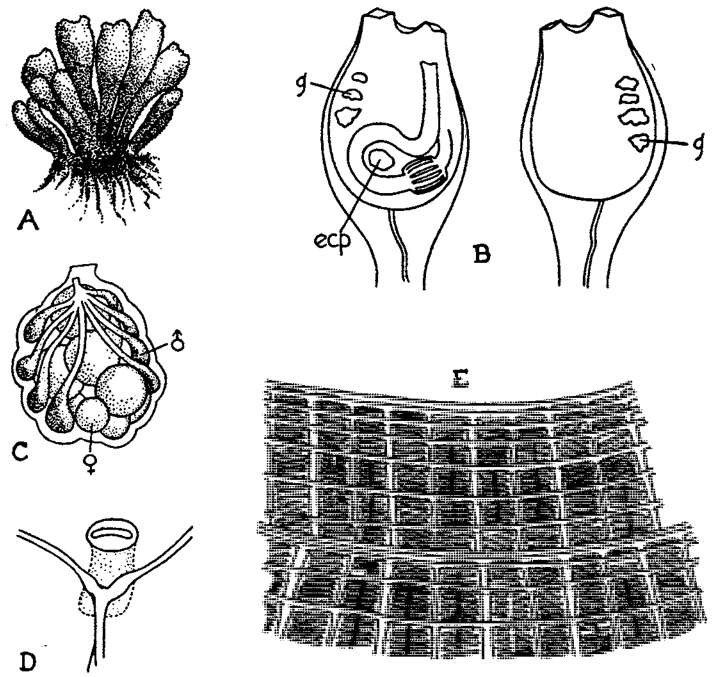


FIG. 147. *Polyandrocarpa zorritensis* (Van Name). A. Group of zooids, natural size. B. Outline of left and right sides of zooid, ×4.5 (*ecp*, endocarp). C. Gonad. D. Dorsal tubercle. E. Piece of branchial sac.

zooids is about 20 mm., the greatest dorso-ventral diameter about 3.8 mm., but most of them are considerably less, and a considerable part (sometimes about one-half) of the length is occupied by the more or less narrowed basal extension of the test mentioned above.

The apertures are square or four-lobed. The mantle is thin and semi-transparent, with thin, even, muscular layers, longitudinal and transverse (the latter outside), composed for the most part of very slender threads which in many cases appear to be only a single fiber in thickness. There are probably normally about 32 larger tentacles representing two, if not three, orders and arranged with more or less regularity. In many of the intervals, there are additional small tentacles of a higher order. The dorsal tubercle has an orifice that is usually of transversely directed slit-like form and slightly curved. The dorsal lamina is plain edged and rather wide in the anterior part.

Branchial sac with four folds on each side, though the most ventral one is often low and incomplete. On the flat parts of the sac the internal longitudinal vessels are often very slender and poorly developed though well developed on the folds. In two large zooids their distribution was about as follows:

A	Right	0	(6)	1	(7)	2	(5)	2	(3)	1
	Left	1	(6)	1	(6)	2	(5)	1	(4)	0
B	Right	1	(6)	2	(5)	2	(5)	2	(3)	1
	Left	0	(5)	1	(6)	2	(5)	2	(2)	1

The larger transverse vessels, comprising two sizes placed alternately, number about 18. Very small vessels crossing the stigmata are present in some places. Except near the endostyle and dorsal lamina, there are usually not over six or seven stigmata in the meshes of the flat parts of the sac.

Intestinal tract forming a loop in the posterior part of the body. It often encloses a large endocarp. Rectum rather long and straight and ending with a smooth margin. Stomach short, oval, with about 15 longitudinal folds; no caecum observed.

Many of the larger zooids contain gonads in the ventral region each side of the endostyle, usually about four or five gonads on the right side, and three on the left side, where they lie in front of the stomach and intestine. Normally the gonads are of saccular form, fairly large, and are hermaphroditic, containing a small number of eggs and several pairs of pyriform male glands, the structure of the gonad being that usual in the genus *Poly-*

carpa. Some large single eggs may often be found attached to the walls of the peribranchial cavity and encysted there, but these I regard as probably eggs that have been discharged from the gonads, not as representing unicellular female gonads. Their apparently entirely fortuitous distribution does not favor the latter supposition; the species, therefore, seems more in place in *Polyandrocarpa* than in *Stolonica* where I originally placed it.

LOCALITY: Zorritos, Peru, collected by F. H. Bradley.

Type colony in the Peabody Museum of Yale University; pieces of it in the American Museum of Natural History (A.M.N.H. No. 870).

Polyandrocarpa sabanillae Van Name, 1921

Text figure 148

Polyandrocarpa sabanillae VAN NAME, 1921, p. 409, figs. 77–81; 1924, p. 31; PLOUGH AND JONES, 1937, p. 101.

? *Styela* (*Polycarpa*) *asiphonica* SLUITER, 1898, p. 17, pl. 1, figs. 16–18 (from Rio Hacha, Goajira, Colombia).

? *Styela* (*Polycarpa*) *cartilaginea* SLUITER, 1898, p. 16, pl. 1, figs. 13–15 (from Gairaca, Santa Marta, Colombia).

Except for the fact that this species grows in irregular groups or clusters which appear to have been formed by budding, it has no characters differentiating it from the genus *Polycarpa*. The individuals are of very irregular, rather elongate form, attached by a large part of the ventral region and more or less closely united to adjacent individuals of the group or colony by a larger or smaller part of the body surface, but not so firmly that they cannot usually be torn apart without much injury. The groups or colonies contain only about six to 10 individuals (the exact number is not readily distinguishable without separating the individuals), but may have been parts of larger groups. Several separate individuals that were with them were probably originally part of the groups. Vascular connection between individuals was not found and would be difficult to demonstrate on account of the tough, opaque test; it may exist only in the early stages of a colony. Test tough and leathery, opaque, somewhat pearly within, the outer surface rough and wrinkled, of a dirty brownish color, more or less covered with mud and overgrown with foreign matter.

Size of largest individuals, about 22 mm. long and 11 mm. in transverse diameter. Though some were considerably smaller than this, all those examined appeared to be adult, having well-developed gonads.

Mantle thick and opaque, its muscles forming continuous sheets or layers. Color light brown, deeper and somewhat purplish about the apertures, which are four-sided.

Oral tentacles slender, of about three orders arranged with a moderate degree of regularity. The total normal number appears to be 32. The interior of the low conical projection bearing the atrial aperture is provided at its base with a circular membrane or velum, on which, as well as on the interior of the cone between the velum and the aperture, many very small slender atrial tentacles are irregularly distributed. Dorsal tubercle large and rounded, but not very prominent. Its orifice is a slit having a different curvature in each specimen examined; some modification of the C or V form seems to be the normal form. Dorsal lamina a rather narrow, plain-edged membrane.

Branchial sac with four complete folds, of which the first and third are the best developed. Transverse vessels numerous and stout; of three orders (in the ventral region four orders) quite regularly arranged. Small vessels crossing the stigmata are wanting on most parts of the sac. Internal longitudinal vessels numerous but slender. Their distribution in a large individual was about as follows:

Left	2	(17)	2	(9)	3	(15)	3	(8)	2
Right	4	(17)	3	(10)	2	(13)	2	(7)	3

On the flat parts of the sac the meshes contain six to 10 or more stigmata, the large meshes along the endostyle sometimes 18 to 20 or more.

Digestive tract rather large. Stomach oval and provided with a small pyloric caecum; its outer surface shows but little indication of plication. The intestine runs forward from the stomach, then backward beside the stomach, then bends forward, forming a rather long rectum. Margin of anus with about 10 to 12 rather conspicuously developed lobes.

Gonads numerous on each side of the body in the ventral region near the endostyle. On

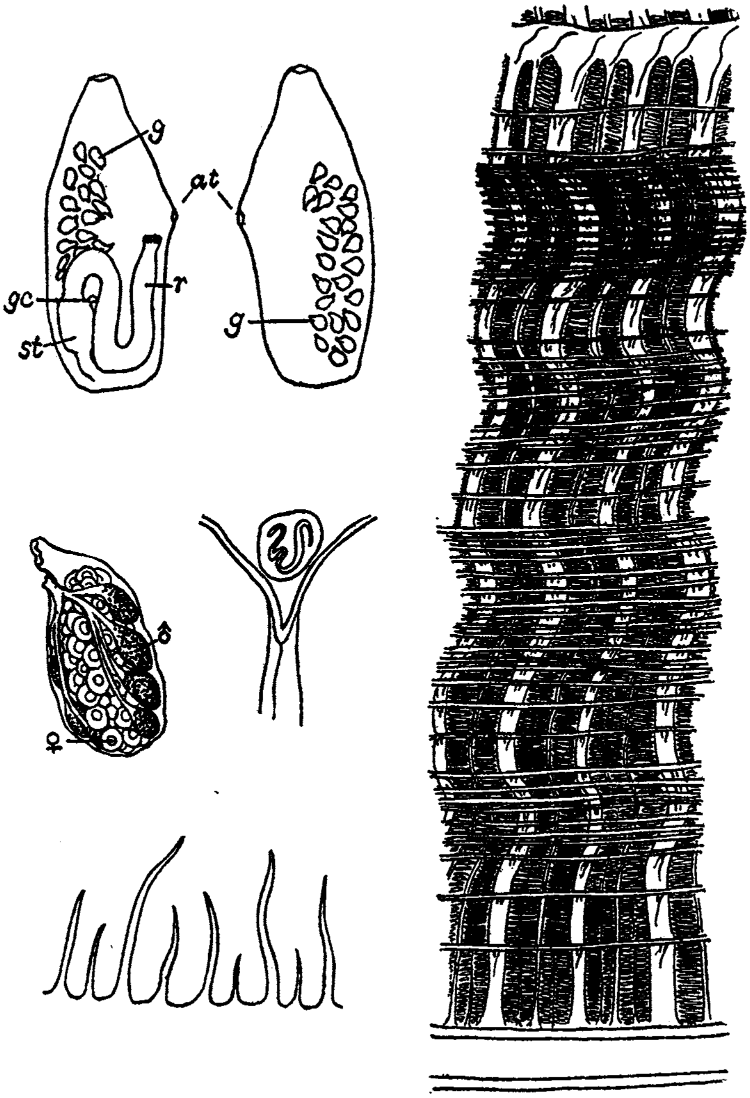


FIG. 148. *Polyandrocarpa sabanillae* Van Name. Left and right sides of zooid, ×2.2; gonad, dorsal tubercle, part of circle of tentacles, and part of branchial sac.

the left side they are confined to the region not occupied by the alimentary organs. Each gonad is a small oval sac of the usual *Polycarpa* type containing many eggs and a few small, pear-shaped, or elongate testes. Many small endocarps are present among the gonads and on the dorsolateral parts of the body wall.

DISTRIBUTION: The specimens (several small groups and some detached individuals) were collected at Sabanilla, Colombia, March 16–22, 1884, by the steamer "Albatross." One of the colonies is attached to a shell. From their condition they appear to have come from a muddy bottom. It has also been reported from Curaçao (Van Name, 1924) and Tortugas, Florida (Plough and Jones, 1937).

There seems to be a possibility that either *Styela* (*Polycarpa*) *cartilaginea* or *S.* (*P.*) *asiphonica*, or both of them, described by Sluiter, 1898, from the Colombian coast near the type locality of the present species may be identical with it, though that author does not indicate that his forms may be colonial ones, and evidently held no such opinion.

Polyandrocarpa pilella (Herdman), 1881

Polycarpa pilella HERDMAN, 1881, p. 73; 1882, p. 174, pl. 22, figs. 11–15; VAN NAME, 1921, p. 487. Not Herdman, 1899, pp. 50–51 (Specimens from Australia), according to Michaelsen, 1912, pp. 159, 164.

The type specimen consists of a close cluster of small, completely sand-covered individuals growing on a slender stem of some kind. Their shape is rounded or ellipsoidal, occasionally rather pyriform, the attached posterior end narrower; the body is erect, not compressed; both apertures at anterior end not far apart. Length of body, 6 mm.; breadth of body, 5 mm.

Tentacles filiform, about 20 large ones with one or two smaller ones between each pair. Dorsal tubercle very variable in shape. Dorsal lamina a plain membrane with an irregular edge. Branchial sac with four folds on each side. About eight internal longitudinal vessels on the folds and the same number in the interspaces. Usually three stigmata in a mesh. The oesophagus is short and curved and opens into a globular stomach. The intestine does not bend back close to the stomach "but slants across dorsally and anteriorly to reach the neighborhood of the atrial aperture." No information whatever regarding the gonads.

LOCALITY: About a dozen specimens (probably all in one cluster) were obtained by the "Challenger" off Bahia, Brazil, in 7 to 20 fathoms (number of the dredging station not given).

In the absence of information regarding the gonads (Herdman does not even state whether present or absent), we cannot place this form generically. Absence of gonads might indicate that it was a group of young individuals of one of the larger simple Styelidae, but the close grouping of the individuals suggests a colonial form and the internal characters, as far as given, indicate very probable relationship to *Polyandrocarpa*, where I have placed it provisionally.

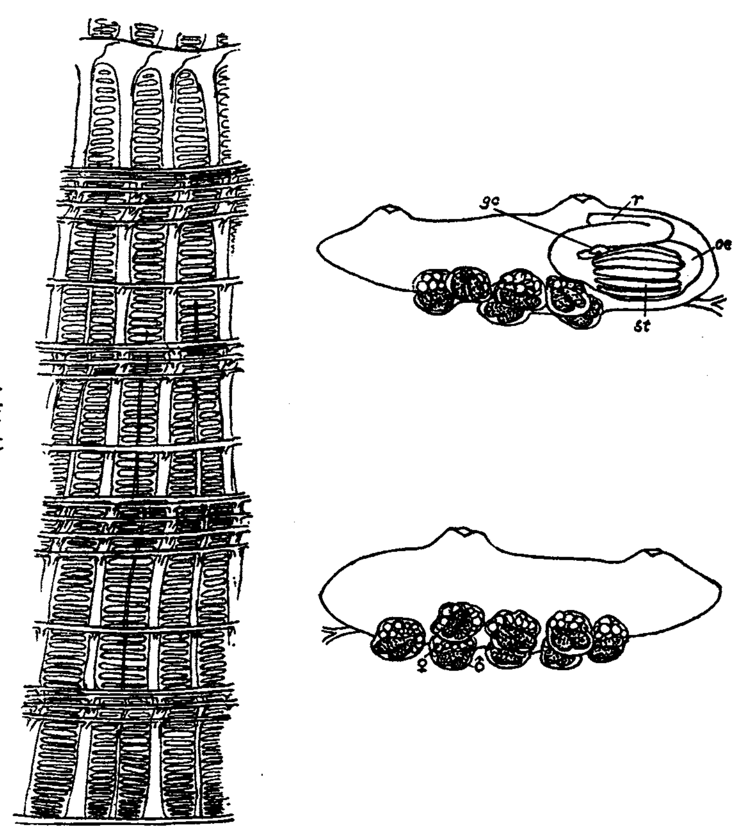


FIG. 149. *Polyandrocarpa (Eusynstyela) tincta* (Van Name). Part of branchial sac, ×45. Left and right sides of zooid, ×9.

SUBGENUS EUSYNSTYELA MICHAELSEN, 1904

As this group appears to differ from *Polyandrocarpa* only in the smaller zooids and the reduction of the testes to two in each gonad, the rank of a subgenus seems sufficient for it.

Polyandrocarpa (Eusynstyela) tincta
(Van Name), 1902
Text figure 149

Eusynstyela tincta MICHAELSEN, 1904, p. 37; HARTMEYER, 1909–1911, p. 1370; MICHAELSEN, 1918, p. 38; 1919b, p. 96.

Michaelsenia tincta VAN NAME, 1902, p. 381, pl. 54, figs. 61, 63, pl. 59, fig. 109.

Polyandrocarpa tincta VAN NAME, 1921, p. 414, figs. 84–86; GRAVE, 1927, p. 218; 1928–1930, pp. 274, 284; VAN NAME, 1930, p. 484, fig. 52; BERRILL, 1932, p. 78; GRAVE, 1932, p. 146; BERRILL, 1935, pt. 3, pp. 257, 270, fig. 3n, pt. 4, p. 360, fig. 17a; GRAVE, 1937, p. 560; PLOUGH AND JONES, 1937, p. 101.

Colony ordinarily of the flattened incrusting type and commonly of small size, often consisting only of from half a dozen to a dozen zooids. Such colonies measure 2.5 to 3.5 mm. in greatest thickness and 15 to 20 mm. in greatest diameter; they commonly have a rather thick, rounded border and uneven upper surface. The specimens usually found on stones, etc., along the shore are of this character. It forms, however, under favorable conditions (especially when growing in water a few feet in depth), much more extensive colonies containing 100 individuals or over. When these grow on some branching object, as a gorgonian, they may entirely surround the branch or two or more adjacent branches and form a much thicker mass of irregular shape, having all or nearly all its surface exposed and bearing zooids on all its aspects, as well as in such clefts or depressions as may exist in its contour. One such colony in the United States National Museum collection, dredged on the banks off Cedar Keys, Florida, in about 10 fathoms, forms an irregular ovoid mass 55 mm. by 37 mm. by 28 mm. in diameter.

Surface of colony very slightly rough and finely wrinkled; generally the number and position of the zooids are indicated chiefly by the pairs of small rough papillae on which their apertures are situated.

Test very tough and leathery and very opaque, so that neither the zooids nor the branching vessels which ramify in the test and end in elongate club-shaped bulbs are visible through it. Color of test during life varying from rose pink to carmine red, deepest about the apertures of the zooids, but fading to pink or yellowish in the marginal and basal parts of the colony in many cases. Test substance yellowish in the interior of the colony. The red color soon fades out in preserved material.

Zooids few in most of the colonies and not at all equal in size. In most colonies none of them exceed about 6 mm. long and 2.4 mm. wide, but the largest may sometimes reach 8 or 9 mm. long. They are flattened dorsoventrally and are often quite closely crowded or overlapping each other to some extent. Both apertures square when expanded, situated widely separated on the dorsal side of the zooid, and more or less prominent on the surface of the colony which is often roughened and irregularly granular immediately about them.

Mantle not very muscular, the fibers forming a thin sheet; it is more or less carmine in color due to the pigment grains in its cells. Tentacles numerous (over 30), slender, of at least three sizes. A circle of minute atrial tentacles is present. Dorsal tubercle oval, orifice generally elongated in an anteroposterior but sometimes in an oblique direction.

Branchial sac with four folds on each side, of which the first and third are the highest. Transverse vessels of two or three sizes. The smallest are generally stout enough to interrupt the stigmata, but in some places they cross them without doing so. Internal longitudinal vessels slender on the folds; those on the flat parts of the sac are thicker. The following scheme shows their distribution in a rather large zooid:

Left	0	(9)	1	(4)	1	(7)	1	(4)	0
Right	0	(8)	1	(5)	1	(8)	1	(4)	0

In the meshes on the flat parts of the sac there are generally about eight stigmata. On the right side the first fold is quite far from the median dorsal vessel, and about 15 stigmata intervene in some places before the first internal longitudinal vessel is reached. The fold is nearer the median dorsal vessel on the left side. The meshes along the endostyle are also wide, containing often 10 or 12 stigmata.

Stomach rather long and narrow with about 13 or 14 well-defined longitudinal folds and a small curved pyloric caecum. The stomach is yellow or brown during life. Rectum rather long and straight, its orifice with two well-marked lips, each slightly lobed.

Gonads especially well developed in some of the Florida specimens. Each is a small, rounded sac containing two large, elongate testes and a varying number of eggs. The testes are in the part of the gonad next to the mantle. In most specimens they are of simple, elongate oval form, but sometimes one or both of them may be deeply cleft into two lobes. Occasionally there appear to be three or four separate testes in a gonad; that this never occurs would be unsafe to assert, yet in several such cases a careful examination showed that the appearance was due to a deep lobation of one or both of the two which are normally present. Eggs 0.21 mm. in diameter, according to Berrill, 1937.

The gonads are attached to the inside of the mantle of the ventral region in the usual way. They are present on both sides of the body and may form more than one row on each side of the median line. They often project out into the test beyond the general surface of the ventral regions enclosed in small knob-like or rounded evaginations of the body wall, which may be more or less constricted at their connection with the body. Some endocarps are usually present.

DISTRIBUTION: At Bermuda, the type locality, this species is found attached to stones on the shore near low-water mark though nowhere in great abundance. On the east coast of Florida I have collected it in Biscayne Bay on stones along the shores of Ragged Keys and on calcareous algae on the banks near Soldiers Key. Plough and Jones, 1937, report it from the Tortugas. The United States National Museum has specimens, some of them of considerable size, from deeper water, 10½ feet to about 10 fathoms at stations off the west coast of Florida from the latitude of Cedar Keys to the Bay of Florida; also one from off northwestern Florida, 30° 14′ N., 86° 15′ W., 15½ fathoms.

Michaelsen (see 1919b) expresses doubt of the distinctness from *tincta* of several species of this genus described from the Red Sea, Mozambique, Ceylon, and the Malay region. This question I am not now in a position to settle, but even should all or any of them prove to be inseparable, the name *tincta* will still have priority.

Polyandrocarpa (Eusynstyela) gravei
Van Name, 1931

Plate 18, figure 1; text figure 150

Polyandrocarpa (Eusynstyela) gravei VAN NAME, 1931, p. 215, figs. 4, 5.

Polyandrocarpa gravei GRAVE, 1932, p. 146; 1935, pp. 215, etc., pl. 1, fig. 1; 1937, p. 560; PLOUGH AND JONES, 1937, p. 101.

Closely allied to *P. tincta* if really distinct from it. I described it on the basis of specimens and information received from Caswell Grave from Tortugas, Florida, where he had studied the specimens in a living state and believed them distinguishable from *E. tincta*, by much larger zooids and somewhat larger larvae (see below).

The colonies are flat and incrusting in form. The largest (the type) measures about 55 by 48 mm. across and contains about 20 large zooids mostly arranged around the marginal part of the colony with their anterior ends outward; a second colony, about 25 by 30 mm. across, contains about a dozen zooids. In life the color of the colony is, according to a letter from Grave, "scarlet, glistening smooth in young colonies, but in the older colonies the zooids becoming fuzzy, either from the outgrowth of hairlike papillae or from the attachment of algae, etc. My impression is that *P. tincta* is a darker red than the new species."

In the preserved specimens at least, the outlines of the zooids are easily discernible as oblong or elliptical areas on the surface of the colony, from the difference in the character and color of the surface above described. This is not the case in *P. tincta*, where indications of the location and size of the zooids are usually furnished only by the small papillae on which the apertures are borne. The apertures (which are four-sided) are raised on small papillae in the present species also, the branchial papillae being larger and higher than the atrial. Both of them bear, or are surrounded by, small nodules or verrucae, making them appear rough and irregular.

The zooids lie upon their ventral surface and are greatly flattened dorsoventrally,

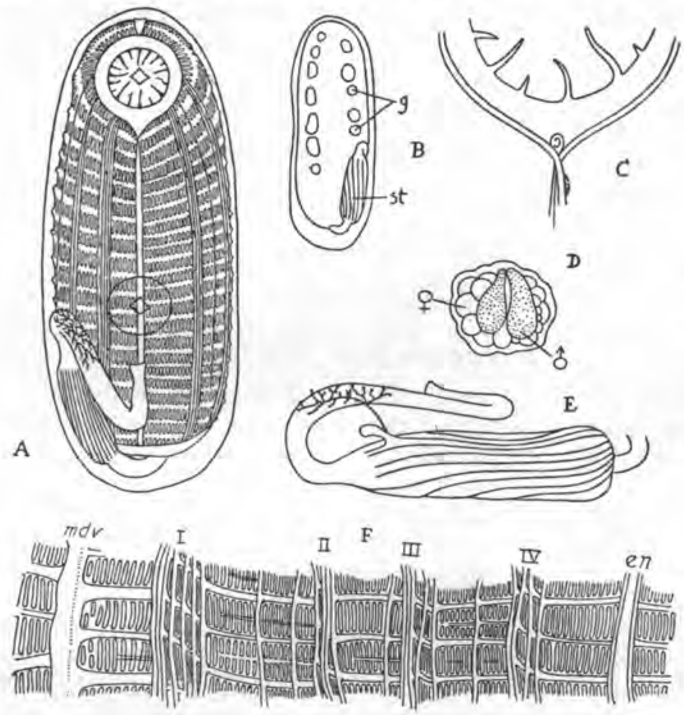


FIG. 150. *Polyandrocarpa (Eusynstyela) gravei* Van Name. A. Dorsal aspect of zoid, ×6. B. Outline of ventral surface of zooid showing position of stomach and gonads. C. Dorsal tubercle and part of circle of tentacles. D. Gonad, exterior (ventral) aspect. E. Alimentary tract. F. Part of branchial sac.

much more than is usual in *P. tincta*. The largest ones measure about 17 mm. long by 5 mm. wide in the type colony, though most of them are not more than 10 to 12 mm. long. The papilla bearing the branchial orifice is on the dorsal aspect only a little removed from the anterior end of the body; the atrial orifice is sometimes nearly half the body length from the posterior end.

In their internal structure, the zooids resemble those of *P. tincta* very closely, though the larger ones may have a slightly larger number of internal longitudinal vessels. Arrangement in an individual 11 mm. long:

Right	0	(9)	2	(5)	1	(10)	1	(5)	0
Left	0	(10)	2	(5)	0	(8)	0	(5)	0

In the alimentary tract and the gonads it corresponds closely with *P. tincta*. The gonads form a longitudinal row on each side of the median line and may project as evaginations, as in that species. Those in the same row are sometimes so crowded as to be difficult to count, and appear confluent, though probably merely in close contact.

In the above-mentioned letter Grave gives the larva of *tincta* as measuring 1.16 mm. long, that of *gravei* 1.32 mm. For culture methods, see Grave, 1937.

LOCALITY: Tortugas, Florida, attached to stones in shallow water. The type and a cotype are in the American Museum of Natural History (A.M.N.H. No. 879).

Polyandrocarpa (Eusynstyela) floridana Van Name, 1921

Text figure 151

Polyandrocarpa floridana VAN NAME, 1921, p. 417, figs. 87–89.

Colony diffuse, consisting of many domeshaped zooids of different sizes, which often lie some distance apart, connected only by a thin sheet of irregular strands of test substance. Zooids of elliptical outline, when seen from above, and sometimes sufficiently convex on the upper surface to form one-half (or even a slightly greater part) of a sphere, but in most cases they are of lower, more flattened form. In some parts of the colony they may lie so close together as to be in contact, but there is always a distinct furrow of demarcation between them, and usually they may be easily pulled apart. Size of the largest (type) colony about 55 mm. by 40 mm.

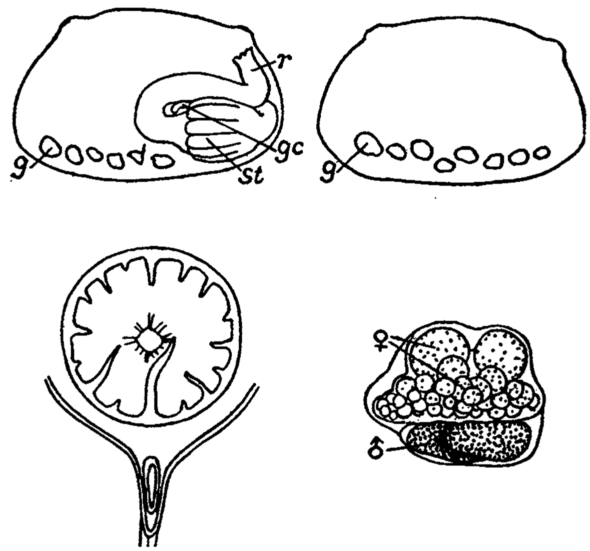


FIG. 151. *Polyandrocarpa* (*Eusynstyela*) *floridana* Van Name. Left and right sides of zooid, ×6; circle of tentacles and dorsal tubercle, and gonad (lateral aspect).

across. Test thin, tough, rather opaque, showing a fibrous structure when torn, its outer surface quite smooth. Color in alcohol yellowish white, becoming bluish gray with a slight pearly luster on the parts covering the zooids; in some places it shows a pinkish or reddish tinge even in the preserved specimens, indicating that the colonies are red or reddish during life.

Zooids covered by a thin, nearly smooth layer of test. They lie on their flattened ventral surface; the two apertures are on the dorsal surface quite far apart and both well removed from the ends of the body; they are but very slightly, if at all, prominent in most specimens and are four-sided, though showing in the contracted condition little evidence of this shape. Size of the largest zooids in any of the specimens, 8 mm. long by 5 mm. across, but these, though containing some well-developed gonads, may not have reached the maximum size.

Approximate distribution of the internal longitudinal vessels in two rather large zooids:

A	Left	0	(11)	3	(6)	2	(15)	2	(6)	1
	Right	2	(11)	2	(6)	2	(16)	2	(6)	1
B	Left	1	(13)	3	(7)	3	(14)	2	(8)	1
	Right	2	(14)	2	(9)	3	(15)	3	(8)	1

The meshes formed by the vessels are small; those on the flat parts of the sac contain (except immediately along the endostyle or dorsal lamina) usually only two to four stigmata.

Oesophagus short and curved; stomach short, with about 12 deep plications and a small curved pyloric caecum. Intestine large; it loops back beside the stomach and then bends abruptly forward and dorsally into a very short rectum whose orifice is very slightly lobed.

Gonads few and small in the specimens studied, attached on the inside of the mantle along each side of the median ventral line. They are small oval or irregular sacs containing a few large eggs and many small ones, and two elongate oval testes. No more than two testes were found in any gonads studied.

DISTRIBUTION: Gulf of Mexico, off the west coast of Florida. Type locality, "Fish Hawk" Station 7151, 29° 43′ 40″ N., 83° 49′ 45″ W., 5¼ fathoms, coral. Five other colonies were dredged in the same region at stations from Anclote Keys northward in depths from 21 to 27 fathoms. The type and several others were growing on the simple ascidian *Polycarpa circumarata*, common in that region.

GENUS POLYCARPA HELLER, 1877

Nomen Conservandum

(=*Pandocia* Fleming, 1822, Hartmeyer, 1909–1911, Van Name, 1912, 1921, 1924)

Text figure 179B

Simple Styelidae conforming in most respects to the genus *Styela* but having numerous (in some species very many) small hermaphroditic gonads irregularly scattered over the inner surface of the body wall on each side of the body, those of the left side mostly anterior to the area occupied by the alimentary loop. Sluiter allowed *Polycarpa* only the rank of a subgenus of *Styela* in most of his works.

The gonads are ovate or phial shaped in the more typical species and comprise a central ovary and a number of small pyriform or slightly lobed testes enclosed in a sac-like membrane produced into a short, papilla-like duct.

In their structure they conform to the plan usual in the Styelidae; the testes occupy largely or entirely that part of the gonad which is between the ovary and the body wall; the ovary occupies the more central and superficial part. The individual ducts from the testes embrace the ovary and unite upon its free surface to a common sperm duct which ends in a small papilla beside, and a little short of, the end of the oviduct.

See also statement under genus *Cnemidocarpa*, below.

Polycarpa fibrosa (Stimpson), 1852

Plate 2, figure 6; text figures 152–154, 179B

Cynthia comata ALDER, 1863, p. 163; KUPFFER, 1875, p. 217.

Glandula fibrosa STIMPSON, 1852, p. 230; 1860, p. 2; BINNEY, 1870, p. 22 (but not his fig. 323, which may be *Eugyra glutinans*); DALL, 1870, p. 255; VERRILL, 1873, p. 440; 1873–1874, vol. 7, pp. 409, 413; 1874, p. 352; WHITEAVES, 1874, p. 12; 1901, p. 267.

Pandocia comata MICHAELSEN, 1912, p. 137.

Pandocia fibrosa VAN NAME, 1912, p. 575, fig. 38, pl. 63, figs. 107, 110, pl. 64, fig. 112, pl. 70, fig. 147; HUNTSMAN, 1912, p. 146; 1913, p. 500, fig. v.

Pandocia libera REDIKORZEV, 1916, p. 336, fig. 76, pl. 7, figs. 1, 2.

Polycarpa comata BONNEVIE, 1896, p. 9, pl. 4, figs. 28, 29; BERRILL, 1928, p. 162.

Polycarpa fibrosa HARTMEYER, 1921, p. 40, fig. 7; 1923, p. 263; SLUITER, 1927, p. 63; BERRILL, 1929, pp. 52, 57, fig. 11f–11h.

Polycarpa libera KIAER, 1893, p. 62, pl. 3, figs. 26–30; BONNEVIE, 1896, p. 8; HARTMEYER, 1903, p. 226, pl. 5, fig. 7; BJERKAN, 1905, p. 11, pl. 2, figs. 5–7; 1908a, p. 68; ÄRNBÄCK, 1922, p. 37, pl. 2, fig. 33.

Tethyum fibrosum HARTMEYER, 1909, p. 146; 1909–1911, p. 1360.

For other names and references, see Hartmeyer, 1923, pp. 263, 264.

Body rounded, somewhat longer than broad, and more or less noticeably compressed in a dorsoventral direction in many individuals. Siphons rather near together, forming papillae on the dorsal surface of the body; the branchial, which is the smaller,

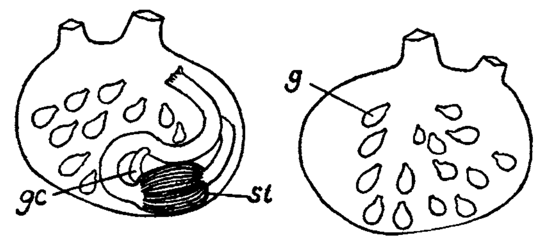


FIG. 152. *Polycarpa fibrosa* (Stimpson). Left and right sides of body, ×2.3.

near the anterior end of the body; the anal near the middle. Both orifices four-lobed. Surface of test rough and granular, a large part of the ventral region bearing an abundant growth of long, fine, branching hairs along whose length grains of sand and mud become attached, and which form with this foreign matter a matted and tangled mass that extends up around and encloses most of the body, except the part which bears the siphons, making it appear like a ball of mud of about double the size that it actually is. The test is exceedingly strong and tough. The largest specimens measure (when the above-mentioned mass of mud and hair is removed) about 18 mm. long and somewhat less in the other diameters.

The above description will fit most specimens. Occasionally two or more individuals will be found more or less closely attached together, or they may be attached to shells or other objects.

Musculature of mantle well developed on nearly all parts of the body. The superficial layer consists mainly of a sheet of closely placed fibers which are not gathered into bands. The deeper layer consists of rather loose and irregular bands radiating from about the bases of the siphons. The mantle generally adheres firmly to the test.

Tentacles numbering at least 50 or 60, of various sizes arranged with little appearance of regularity. A few very small tentacles, which, however, have the same tapering elongated form as the large ones, are present here and there in the intervals between the larger ones. Hartmeyer, 1921a, describes a circle of slender atrial tentacles. Dorsal lamina a plain-edged, rather narrow membrane. Dorsal tubercle conspicuous, rounded, opening usually C-shaped, with its horns not inrolled or much incurved; open interval turned toward the left.

Branchial sac with four well-marked folds on each side of the body. Of these the first and third are the highest and the fourth the least well developed. Transverse vessels of

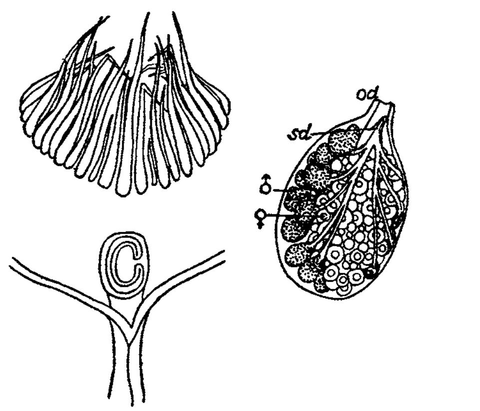


FIG. 153. *Polycarpa fibrosa* (Stimpson). Part of circle of tentacles and dorsal tubercle, and gonad seen from side next to the branchial sac.

four orders quite regularly arranged according to the scheme: 1, 4, 3, 4, 2, 4, 3, 4, 1, etc. Those of the first three orders number 40 or more in large specimens. Those of the fourth order generally cross without interrupting the stigmata. Distribution difficult to state exactly as there is no way of determining at what points the folds should be considered to begin. The total number of vessels in a rather large specimen on one side was as follows:

1 (25) 4 (13) 5 (17) 5 (9) 3

Smaller individuals have fewer.

The stomach has numerous (22 to 30) longitudinal folds and a long pyloric caecum. The intestine forms a rather short wide loop. The anus has its margin provided with numerous rounded lobes.

Gonads (as well as numerous endocarps) irregularly distributed over the inside of the mantle on both sides of the body. Well-developed gonads may number a dozen or more on each side. They are small oval sacs tapering at one end to a narrow neck through which the eggs are discharged. Beside this neck is the opening of the common sperm duct upon a small papilla. The eggs occupy the portion of the gonad which lies against the branchial

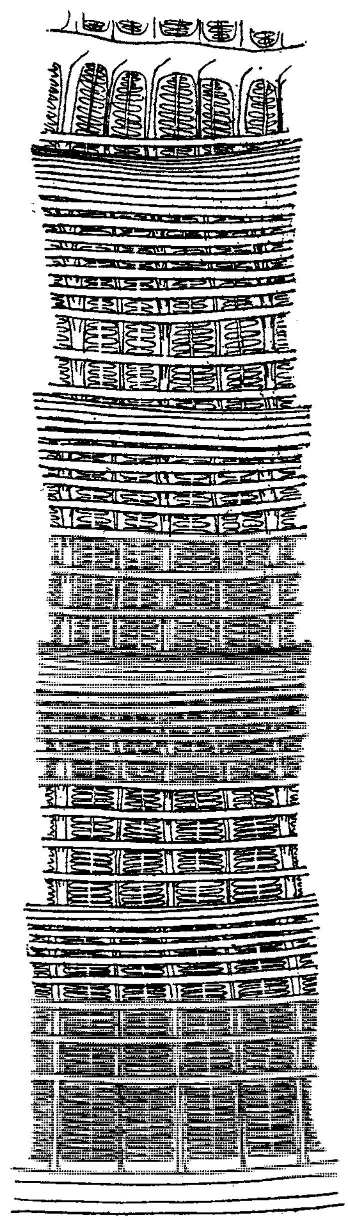


FIG. 154. *Polycarpa fibrosa* (Stimpson). Part of branchial sac, ×16.

sac, the small pyriform or two- or three-lobed testes the portion which lies against the mantle. The ducts leading from them are long and do not all unite to a common sperm duct until close to the base of the papilla upon which the common duct opens.

DISTRIBUTION: This is a species of wide range on both sides of the North Atlantic extending north into the Arctic seas (both coasts of Greenland, northern Norway, Spitzbergen, etc.), but is not known to be circumpolar. It is commoner in warmer latitudes, ranging south to the English Channel and coast of Portugal, and even (in deep water) to beyond the Strait of Gibraltar. On the American side it ranges south (off the coast) to the latitude of Nantucket, Massachusetts, or possibly farther. Type locality, Hake Bay, Grand Manan Island, New Brunswick, 35 fathoms, muddy bottom (Stimpson).

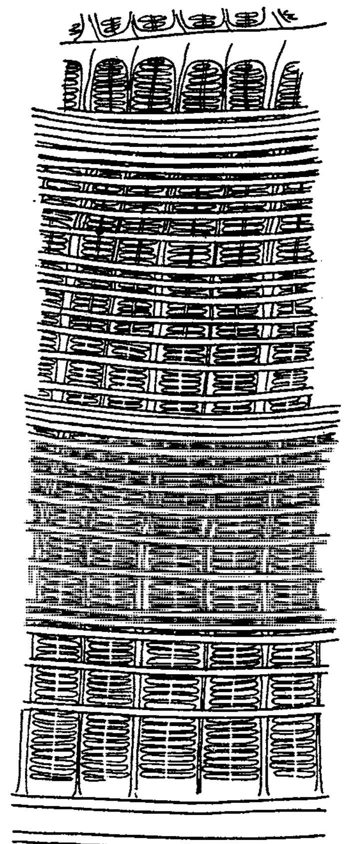


FIG. 155. *Polycarpa albatrossi* (Van Name). Part of branchial sac, ×18.

It is found chiefly on soft, more or less muddy bottoms in which it buries itself, extending out its siphons, and has been recorded from depths ranging from a few feet to about 300 fathoms. It was found common at many dredging stations off northern New England in depths from 30 to 100 fathoms or more.

Polycarpa albatrossi (Van Name), 1912

Plate 2, figure 5; text figure 155

Pandocia albatrossi VAN NAME, 1912, p. 579, pl. 63, fig. 111, pl. 64, fig. 113, pl. 70, fig. 146; HARTMEYER, 1912b, pp. 374, 378.

Polycarpa albatrossi HARTMEYER, 1923, p. 273.

The supposed "molgulas" from deep water mentioned by Verrill (1885, p. 529) were mostly of this species, which in spite of its deep-sea habitat differs little from littoral forms.

Body not attached, considerably flattened dorsoventrally, so that it has an oblate spheroidal form. Orifices (both four-lobed) on very low conical elevations rather near together on the dorsal surface. Ventral portion of body covered with a thick growth of long, tangled, branching hairs to which fine sand, *Globigerina* shells, etc., adhere. These materials also cover the dorsal surface except close to the orifices. The ventral hairs are, however, not so long and numerous as in *P. fibrosa.* Largest specimens about 14 mm. long, the same in width, and 10 mm. in dorsoventral diameter. Mantle musculature weaker than in *P. fibrosa,* the transverse and radiating bands narrower, though more numerous, and the outer longitudinal fibrous layer less compact.

Tentacles at least 40 to 50, of several sizes or orders. They are fewer, longer, and distributed with more approach to regularity according to the usual scheme (1, 4, 3, 4, 2, 4, etc.) than in *P. fibrosa.* Dorsal tubercle small and difficult to distinguish; apparently simply C-shaped with a small open interval whose direction is very variable in different individuals. Dorsal lamina a plain membrane, commonly found thrown into lateral undulations by the contraction incident to preservation.

Branchial sac similar to that of *P. fibrosa* except that there are but two folds developed on each side, the first and third. The second and fourth are merely rudimentary, or absolutely wanting, and their position is indicated only by a few more closely grouped internal longitudinal vessels. This condition was found constant in a number of specimens examined. Maximum number of internal longitudinal vessels on a fold about 12 to 18.

Stomach with somewhat fewer longitudinal folds (not over 25) than in *P. fibrosa*. Gastric caecum present. Intestinal loop rather wide and short. Margin of anus with a number of small but irregular lobes. Gonads and endocarps similar to those of *P. fibrosa*, but not very numerous in the specimens dissected.

Exclusively a deep-sea species known only by specimens dredged by the steamer "Albatross" in a limited area off the east coast of the United States, especially at Station 2714 (38° 22′ N., 70° 17′ 30″ W., 1825 fathoms, brown ooze) where many specimens were collected. The other stations, all in the same region, range in depth from 1420 to 2033 fathoms (see Van Name, 1912, p. 580).

Polycarpa obtecta Traustedt, 1883

Plate 14, figures 2, 3; text figure 156

Pandocia obtecta HARTMEYER, 1909–1911, p. 1364; VAN NAME, 1918, p. 103.

Polycarpa multiphiala VERRILL, 1900, p. 592, pl. 9, fig. 7 (from Bermuda).

Polycarpa obtecta TRAUSTEDT, 1883, pp. 126, 134, pl. 5, figs. 7, 8, pl. 6, fig. 15; VAN NAME, 1902, p. 386, pl. 57, figs. 88, 89, 92–94, pl. 63, figs. 140, 144, pl. 64, figs. 151, 153; HARTMEYER, 1908, p. 111; VAN NAME, 1921, p. 420, fig. 90; 1924, p. 31; 1930, p. 486, figs. 53, 54; BERRILL, 1932, p. 78; 1935, pt. 3, pp. 257, 270, fig. 3h; PLOUGH AND JONES, 1937, p. 101.

Polycarpa rugosa VON DRASCHE, 1884, p. 38, pl. 7, figs. 3, 4 (from Rio de Janeiro).

? *Polycarpa tumida* HELLER, 1878, p. 103, pl. 2, fig. 15.

? *Styela* (*Polycarpa*) *appropinquata* SLUITER, 1898, p. 18, pl. 1, figs. 19–21 (from La Tortuga Island, Venezuela); VAN NAME, 1921, p. 486.

? *Styela* (*Polycarpa*) *asiphonica* SLUITER, 1898, p. 17, pl. 1, figs. 16–18 (from Rio Hacha, Goajira); VAN NAME, 1921, p. 486.

Styela (*Polycarpa*) *brevipedunculata* SLUITER, 1898, p. 15, pl. 1, fig. 12 (from Curaçao); VAN NAME, 1921, p. 486.

? *Styela* (*Polycarpa*) *cartilaginea* SLUITER, 1898, p. 16, pl. 1, figs. 13–15 (Gairaca, Santa Marta); VAN NAME, 1921, p. 487.

? *Styela* (*Polycarpa*) *friabilis* SLUITER, 1898, p. 13, pl. 1, fig. 11 (from Kingston, Jamaica); VAN NAME, 1921, p. 487 (may be *P. spongiabilis*).

Styela (*Polycarpa*) *fuliginea* SLUITER, 1898, p. 12, pl. 1, fig. 10, pl. 3, fig. 45 (probably from near La Tortuga Island, Venezuela); VAN NAME, 1921, p. 487.

Styela (*Polycarpa*) *insulsa* SLUITER, 1898, p. 14, pl. 3, fig. 43 (from Los Testigos Islands); VAN NAME, 1921, p. 487.

? *Styela* (*Polycarpa*) *nivosa* SLUITER, 1898, p. 12, pl. 1, fig. 9, pl. 3, fig. 46 (from Gairaca, Santa Marta, Colombia); VAN NAME, 1921, p. 487 (this may be *P. spongiabilis*).

Styela (*Polycarpa*) *obtecta* SLUITER, 1898, p. 11 (from Santa Marta, Colombia).

Styela (*Polycarpa*) *seminuda* SLUITER, 1898, p. 19, pl. 2, figs. 22, 23 (from La Tortuga Island, Venezuela); VAN NAME, 1921, p. 487.

The above species of Sluiter, 1898, appear also in Hartmeyer's (1909–1911) list under the genus name *Pandocia* and in Van Name, 1921, pp. 486, 487, under the genus name *Polycarpa*.

Body rounded-oblong, often with the dorsoventral diameter exceeding the length; when not distended with water, the flexibility of the test permits the sides to collapse so that it is quite narrow from side to side. The apertures, which may be raised on conical elevations or in contracted specimens may be nearly flush with the external surface, are both conspicuously four-sided; the branchial

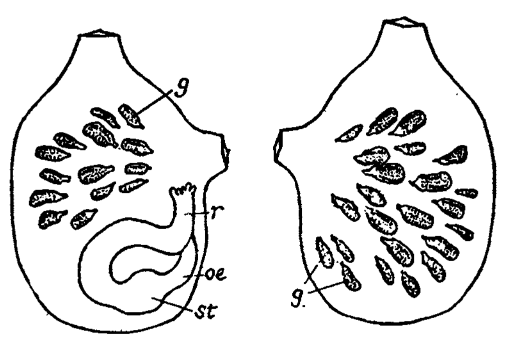


FIG. 156. *Polycarpa obtecta* Traustedt. Left and right sides of body, natural size.

aperture is situated at, or close to, the anterior end; the atrial is forward of the middle of the dorsal region. Body usually attached by a small area on the posterior or ventral part of the body, where the test may be produced into a sort of rudimentary peduncle, or may develop some root-like processes or irregular projections to assist in the attachment. Size of the largest specimens studied, about 50 mm. long by 45 mm. in dorsoventral diameter, exclusive of the short tubes, but it sometimes becomes still larger.

Test rather thin except in the dorsal region, where it becomes very thick. Color of the outer surface yellowish or brownish gray, usually more or less stained with mud, darkening to red, brown, or purplish brown about the apertures in fresh specimens. Some individuals have the entire surface or parts of it incrusted with sand and shell fragments, but in a majority of the specimens it is virtually bare, fairly smooth in some parts, but with more or less extensive areas which are rough, wrinkled, and warty, or it may even develop patches of short, irregular, moss-like processes. Other specimens may have the entire surface wrinkled. Internally the test is grayish with a slight pearly cast. Test substance strong, yet soft and flexible when fresh, and even in material long preserved in alcohol it has less tendency to become hard and rigid than in many other allied ascidians.

Mantle smooth and often of a somewhat gelatinous appearance, conspicuously brown in color in most individuals, and provided with a rather weak musculature consisting of longitudinal, transverse, and oblique fibers, of which only the longitudinal ones radiating from the bases of the tubes are gathered into bands of any size. The brown coloration just mentioned pervades many of the internal organs as well as the mantle, and is in part due to granules of pigment in some of the cells.

The tentacles vary much in number but may be rather numerous, often 40 to 60 in large individuals (55 to 58, respectively, were counted in two large specimens), and may represent four or more orders in respect to their size and length. In many individuals only the larger ones show any degree of regularity in their distribution, the small ones being few and irregularly placed.

Dorsal tubercle rather large but not very prominent above the surface of the prebranchial region. It varies in relative size and shape in different individuals, as its orifice does also. The latter is a very narrow cleft usually bent in a C or sometimes an S-shape; in the former case with the open interval forward or more or less to the left and the horns unequally curved (both in, or one in and one out). Dorsal lamina a plain-edged membrane; endostyle very wide and thick.

Branchial sac with the four folds on each side usually present in Styelidae well developed and sharply defined. Owing to the short deep outline of the body, they and also the endostyle are very greatly curved. In many individuals there is, on the right side of the body only, a small additional fold between the dorsal lamina and the first one of the normally present folds. It bears but few internal longitudinal vessels.

In two large individuals from Florida the following counts were made of the internal longitudinal vessels:

A	Left	3 (12) 4 (13) 4 (13) 4 (11) 3
	Right	0 [3] 1 (10) 4 (13) 4 (12) 4 (10) 3
B	Left	3 (14) 3 (13) 3 (14) 3 (12) 3
	Right	0 [3] 2 (9) 1 (14) 3 (14) 4 (8) 3

An individual from Puerto Rico, though smaller, has more vessels:

Left	2 (13) 3 (13) 3 (17) 4 (11) 3
Right	0 [3] 0 (11) 3 (15) 3 (17) 5 (11) 3

An example about 40 mm. long from off the west coast of Florida has still more:

Left	3 (19) 3 (21) 5 (23) 6 (19) 6
Right	0 [5] 3 (17) 5 (22) 5 (24) 6 (19) 4

Though near together at the summits of the folds, these vessels form meshes of variable width, sometimes with from seven to 12 stigmata in them on the flat parts of the sac; along the endostyle the meshes are often still wider. Transverse vessels of several orders, but parastigmatic vessels are not much developed.

Stomach small and short, oval, its longitudinal plications often rather inconspicuous externally. The intestine forms a small open loop which does not extend much, if at all, forward of the middle of the body. Margin of anus irregularly lobed. A large endocarp connected both with the mantle and the branchial sac is commonly present in the bend of the intestinal loop.

Gonads oblong or flask shaped, of the typical *Polycarpa* type (see under genus), produced into a short neck with the ovarian opening at its end; the opening of the sperm duct is on a small papilla beside the neck of the gonad. The number of gonads is very variable; in large individuals they become very numerous; 20 or more on the right side is usual in ordinary-sized examples, but it may reach at least 100; on the left side, where they are chiefly confined to the region anterior to the intestinal tract, they are considerably fewer. Egg diameter 0.18 mm. (Berrill, 1937).

DISTRIBUTION: This is one of the common and widely distributed ascidians of the West Indian region, including Bermuda, occurring from Beaufort, North Carolina (one small specimen), and both coasts of Florida (especially on the west coast and at Tortugas) and ranging south along the east coast of South America beyond Rio de Janeiro (islands of São Sebastião and São Francisco). I have examined specimens from the following West Indian islands: St. Thomas (Traustedt's type locality), Cuba, Puerto Rico, Santo Domingo, Curaçao, and Jamaica. Though a shallow-water species, it appears to be commoner in water a few feet deep than near low-water mark; 37½ fathoms is the deepest record that has come to my notice. At Bermuda, where it is common, a great many were found washed up on the shore at Somerset Island after a storm. Specimens are generally found growing singly. I do not recall finding it in groups or clusters.

It is exceedingly probable that this species is the unsatisfactorily described and figured *Polycarpa tumida* of Heller, 1878 (locality Jamaica), but the matter is not certain, and it would seem that in any case the name *obtecta*, which has been almost universally used since the publication of Traustedt's excellent description and figures, should be retained as a *nomen conservandum*.

In most parts of the West Indian region this species (*obtecta*) is the only one that can be found, or at least that is common enough to be likely to be collected. It is, therefore, very astonishing that Sluiter, in his 1898 report on the ascidians collected by the "Chazalie" in the Caribbean region, reported only two specimens of *P. obtecta* and described no fewer than nine new species of that genus from that limited area. Nothing is said about the number of individuals on which these species are based; very likely but one in most cases. I do not feel hesitation in listing the majority of these supposed species as synonyms or probable synonyms of *obtecta*.

P. obtecta is represented by allied forms, in some of the warmer parts of the Old World, but I do not have enough information about them to discuss them in the present work.

Polycarpa spongiabilis Traustedt, 1883

Plate 19, figure 3; text figure 157

Pandocia spongiabilis HARTMEYER, 1909–1911, p. 1364.

Polycarpa spongiabilis TRAUSTEDT, 1883, pp. 125, 134, pl. 5, fig. 9; VAN NAME, 1921, p. 424, figs. 91–95; 1930, p. 488, fig. 55; PLOUGH AND JONES, 1937, p. 101.

? *Styela* (*Polycarpa*) *friabilis* SLUITER, 1898, p. 13, pl. 1, fig. 11 (from Kingston, Jamaica).

? *Styela* (*Polycarpa*) *nivosa* SLUITER, 1898, p. 12, pl. 1, fig. 9, pl. 3, fig. 46 (from Gairaca, Santa Marta).

The above species of Sluiter appear also in Hartmeyer's (1909–1911) list under the genus name *Pandocia* and in Van Name, 1921, p. 487, under *Polycarpa*.

In spite of closely resembling *P. obtecta* in its internal structure, the present species appears to be distinct from it, having a sponge-like appearance due to the rough fibrous surface of those parts of the body free from foreign matter, the rigid yet easily broken test and the non-contractile character of the tubes and apertures, which gives them in the alcoholic specimens at least, a resemblance to the oscula of sponges.

Shape of body very variable in the specimens available for study, which were collected at Puerto Rico; strongly compressed from side to side in the small ones, but tumid in the larger ones. Tubes of varying length, mere conical eminences in two of the individuals, large, cylindrical, and very long in other cases. Orifices somewhat square, not contracted in any of the specimens. The tubes arise near together on the dorsal part of the body, but curve apart so as to form a widely diverging angle (in one case nearly 180 degrees). Largest specimen, 40 mm. long, 35 mm. in dorsoventral diameter, and about 28 mm. wide, exclusive of the tubes. Color of test yellowish or brownish, becoming reddish or purplish on the tubes.

Test in the alcoholic specimens opaque; its surface rough, uneven, and fibrous, but not greatly incrusted with foreign matter on the upper half of the body or on the tubes, though in the two larger specimens some minute bivalve mollusks are embedded in its substance. Upon the ventral half of the body there may,

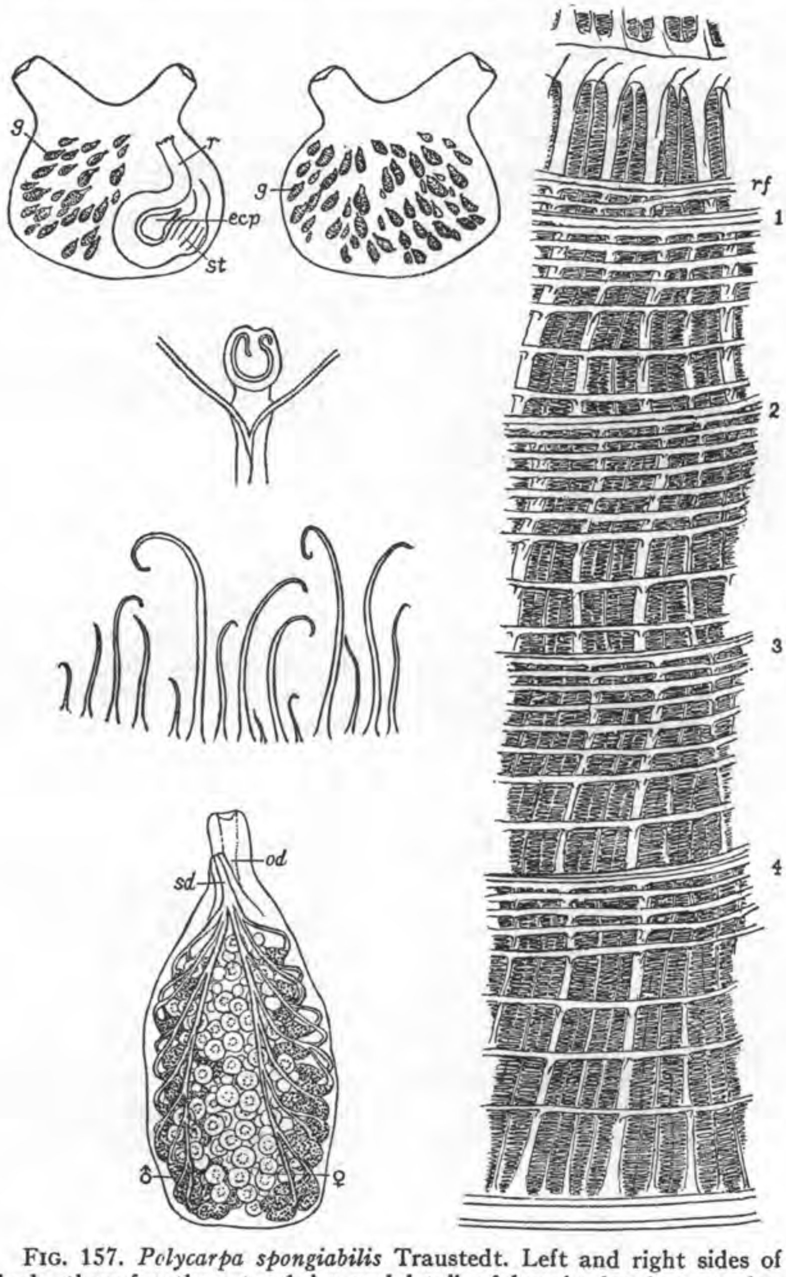


FIG. 157. *Polycarpa spongiabilis* Traustedt. Left and right sides of body, three-fourths natural size, and details of dorsal tubercle, tentacles, gonad, and branchial sac.

however, be a tangled growth of hair-like processes to which sand grains, shell fragments, mud, etc., adhere, and which evidently serve to anchor the animal.

The internal anatomy was described at some length in my article of 1921, but it corresponds in its details so closely to that of *P. obtecta* that I shall not take the space to repeat the description here.

The additional branchial fold next to the dorsal lamina frequent in *P. obtecta* on the right side was found in the largest Puerto

Rico specimen of *P. spongiabilis* also, but not in a small specimen that was also studied. In the large individual there were over 50 gonads on the right side and about 30 on the left side of the body.

DISTRIBUTION: Traustedt (1883) gives the localities of his specimens as West Indies and Brazil. A total of six specimens were dredged by the American Museum expeditions at Puerto Rico, as follows: entrance to Guanica Harbor, 10 to 25 feet, mud, one specimen; Condado Bay, San Juan Harbor, 16 to 22 feet, sand and mud, three specimens (large); Salinas Cove (east of Parguera) off Don Luis Cayo, 5 to 4½ fathoms, coral, mud, two specimens.

Plough and Jones, 1937, report it from Tortugas, Florida.

Polycarpa circumarata (Sluiter), 1904

Plate 11, figure 2; text figure 158

Pandocia circumarata HARTMEYER, 1909–1911, p. 1363; VAN NAME, 1918, p. 92, fig. 46, pl. 26, fig. 7, 8.

Polycarpa circumarata VAN NAME, 1921, p. 428, figs. 96, 97; 1924, p. 31.

Styela circumarata SLUITER, 1904, p. 70, pl. 1, fig. 4, pl. 9, fig. 1.

Though subject to great individual variation in shape and manner of attachment, the body in this species is usually elongate, oblong, somewhat abruptly tapered at the front end, and strongly flattened from side to side. It is usually extended at the posterior end or in the posterior ventral region into a very short, broad, laterally compressed peduncle for attachment; this peduncle may break up into, or be replaced by, a number of root-like processes. Less often the body is sessile and directly adherent to the object on which it grows; in a few of the specimens there is no lateral compression of the body. The largest American specimen I have seen was 55 mm. in body length and 35 mm. in transverse diameter.

Test moderately thick, tough, and very opaque; its substance white with a pearly lining; the outer surface yellowish brown to brassy yellow in color in preservation; more or less red during life. Its surface is wrinkled or furrowed; these furrows are rather few and mainly longitudinal in most individuals, being separated by rounded ridges irregularly broken by short transverse furrows into small rounded elevations; in some individuals, however, the wrinkles are closer together and mainly transverse. Some parts of the surface, especially the peduncle, incrusted with foreign matter.

Mantle thick and opaque, the muscular layers forming thick continuous sheets. It is light colored, the other internal organs also. Normal number of tentacles apparently 32, in three orders, but those of the smallest

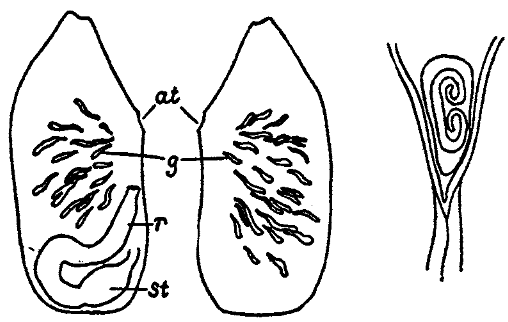


FIG. 158. *Polycarpa circumarata* (Sluiter). Left and right sides of body, natural size, and dorsal tubercle.

order often poorly developed or wanting in some places. Dorsal tubercle large and elongate; the usual form of its orifice seems to be C-shaped with the open interval to the left and the horns inrolled, but some irregular variation of this form often occurs instead of the usual one. Dorsal lamina a plain membrane widest in its posterior portion.

Branchial sac with four well-defined and moderately high folds separated by wide flat intervals. Internal longitudinal vessels very numerous, and on the folds very closely crowded, and numerous also on the flat intervals where they are usually separated by from five to eight stigmata (by more along the endostyle and dorsal lamina).

Distribution of these vessels in a specimen 36 mm. long:

Left	6 (37) 7 (37) 8 (33) 9 (26) 5
Right	5 (38) 8 (34) 8 (34) 6 (28) 5

in one 48 mm. long:

Left	5 (40) 9 (36) 8 (39) 9 (29) 6
Right	8 (42) 8 (36) 8 (38) 7 (32) 4

Transverse vessels also very numerous; in some places five or six orders fairly regularly arranged may be observed; in other places the large ones are irregularly distributed and the small ones more or less uniform in size. Parastigmatic vessels occur only occasionally.

Oesophagus short; stomach oval, rather short, its exterior surface showing but little plication. No pyloric caecum. Intestine of large diameter but forming a rather narrow compact loop lying somewhat transversely of the body axis. No very abrupt bend at the beginning of the rectum, which is rather short. Margin of anus with many minute, rather inconspicuous lobes.

Gonads hermaphroditic, small and numerous, irregularly distributed on both sides of the body, but so deeply buried in the tissues of the body wall, and so much less prominent than the numerous small endocarps, which arise between them and partially conceal them, that they are readily overlooked. They are elongate or phial shaped, often irregularly curved, and sometimes forked or branched. They contain a variable number of small, ovoid, or pear-shaped testes and many still smaller, rounded eggs.

DISTRIBUTION: In spite of the difference of locality, there do not appear to be any characters separating the specimens here described from Sluiter's species from the Philippines, where it is recorded from depths from 16 meters to 20 fathoms.

It is represented in the United States National Museum collection by about 30 specimens of various sizes, dredged in the Gulf of Mexico off the west coast of Florida, by the steamers "Albatross" and "Fish Hawk," at stations from Deadman's Bay to near Sarasota Point, in depths from 5¾ to 30 fathoms on sandy and coral bottom. Most of the specimens were obtained at Station 2405 by the steamer "Albatross" (28° 45′ N., 85° 02′ W., 30 fathoms, gray sand and broken coral), where a large number of examples of *P. obtecta* were also dredged. A large specimen in the United States National Museum is from farther north in the Gulf (29° 56′ N., 86° 07′ 30″ W., 18 fathoms). Several of the individuals of this species are partially overgrown with colonies of *Polyandrocarpa floridana*.

In the Caribbean Sea it occurs at Curaçao (Van Name, 1924), north of La Tortuga Island, Venezuela, and near Colon, Isthmus of Panama.

Polycarpa aspera Herdman, 1886

Pandocia aspera HARTMEYER, 1909–1911, p. 1363; 1912b, pp. 374, 378.

Polycarpa aspera HERDMAN, 1886, p. 415, pl. 47, figs. 3–5.

Based on a single small specimen of oblong-ovate form attached by one end with a spreading margin, the apertures, which are inconspicuous, at the other end. Test thick, leathery, transversely wrinkled. Length and breadth about 1 cm., width rather less.

Mantle with a dense network of bands. Tentacles of two sizes regularly alternating with additional small ones in the intervals. Dorsal tubercle with a C-shaped aperture; the ends somewhat spirally incurved, open interval posterior. Dorsal lamina narrow, plain edged. Branchial sac with four well-developed folds on each side, which bear numerous internal longitudinal vessels. Transverse vessels of two sizes alternating; usually three stigmata in the meshes. Stomach fusiform with many longitudinal plications.

Gonads, which are of rather long, narrow form, numerous on both sides of the body. Many endocarps also present.

Locality of only specimen, "Challenger" Station 320, off Buenos Aires, 37° 17′ S., 53′ 52′ W., 600 fathoms bottom green sand.

Pfeffer (1889, p. 3) reports a specimen from South Georgia Island which he doubtfully assigns to *Polycarpa viridis* Herdman, 1881, an Australian species, without giving any reasons for assigning it to that species or even to *Polycarpa* at all. No *Polycarpa* is known from South Georgia or other part of the Magellanic region, except the present species of Herdman.

GENUS **CNEMIDOCARPA** HUNTSMAN, 1913
Text figure 179A

Gonads similar in structure to those of *Polycarpa* described above, but of more or less elongate, often tubular form, occasionally branched. They are also larger and few in number (sometimes but one or two on each side of the body), but the ovary and testes are in close contact with each other and enclosed in a sheathing membrane, which distinguishes these groups from *Styela* in which the testes are attached to the body wall separately from the ovary. From *Polycarpa* the present genus is not so definitely distinguished, there being some intermediate species.

In some species of this genus the gonads are in close contact with, or more or less buried in, the body wall; in others they are somewhat loosely held to it by a narrow membranous connection.

122, figs. 72–76, pl. 37, fig. 15, pl. 39, fig. 9, pl. 43, figs. 4–5, pl. 48, fig. 17.

Tethyum arenicolum HARTMEYER, 1909, p. 147, figs. 1–3.

Tethyum molle HARTMEYER, 1909, p. 145; VAN NAME, 1912, p. 571, fig. 37, pl. 62, fig. 106, pl. 63, fig. 109, pl. 71, fig. 149.

Body ellipsoidal, sometimes nearly spherical, the small apertures (both square) situated rather near together on the anterior dorsal portion, either raised on conical papillae or nearly level with the surface in contracted specimens. Test thin but tough, thickly and evenly coated with sand grains which adhere firmly. A few hair-like processes from the ventral region assist in anchoring the animal in the sand in which it lies buried, but it is not otherwise attached. Size of an average specimen: 9 mm. long, 7 mm. deep, and 5 mm. to 6 mm. from side to side. Largest specimen about 14 mm. long.

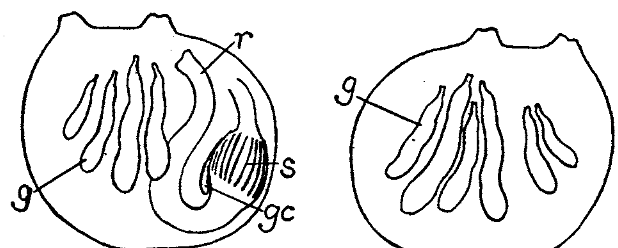


FIG. 159. *Cnemidocarpa mollis* (Stimpson) Left and right sides of body, ×5.3.

Cnemidocarpa mollis (Stimpson), 1852

Plate 6, figure 2; text figures 159, 160

Cnemidocarpa mollis HUNTSMAN, 1912, pp. 112, 145; 1913, p. 500; REDIKORZEV, 1916, p. 265, figs. 57, 58; HUNTSMAN, 1922, p. 10; HARTMEYER, 1923, p. 240; HUUS, 1936, pp. 14, 15.

Cnemidocarpa vestita HUNTSMAN, 1912, p. 145.

Cynthia vestita ALDER, 1860, Trans. Tyneside Field Club, vol. 4, p. 335.

Glandula arenicola VERRILL, 1872a, pp. 211, 288; 1873–1874, vol. 5, p. 10, vol. 7, pp. 39, 413; VERRILL AND SMITH, 1873, pp. 502, 701; VERRILL, 1874, pp. 352, 355; 1879, p. 27; VERRILL AND RATHBUN, 1879, p. 231; WHITEAVES, 1901, p. 267; KINGSLEY, 1901, p. 183; SUMNER, OSBURN, AND COLE, 1913, p. 730.

Glandula mollis STIMPSON, 1852, p. 230; VERRILL, 1870, p. 424; BINNEY, 1870 (part), p. 22, pl. 22, fig. 317 (not pl. 24, figs. 328, 329); DALL, 1870, p. 255; VERRILL, 1872a, p. 213; 1879, p. 27; TRAUSTEDT, 1880, p. 420; WHITEAVES, 1901, p. 267; KINGSLEY, 1901, p. 183; HARTMEYER, 1915, p. 313.

? *Glandula* sp. undetermined, VERRILL AND SMITH, 1873, pp. 502, 701; SUMNER, OSBURN, AND COLE, 1913, p. 730. (May be young of this species.)

Styela mollis HARTMEYER, 1915, pp. 308, etc.

Styela vestita ALDER AND HANCOCK, 1907, p.

Musculature of mantle rather diffuse, transverse fibers predominating. Tentacles, 32 or more, quite regularly arranged; eight of the first, eight of the second, and 16 of the third order. Fourth-order tentacles in a few of the intervals only. Slender atrial tentacles, inserted on the edge of a velum, are also present. Dorsal tubercle having a C-shaped opening with the open interval directed to the left. Horns not incurved. Dorsal lamina plain, rather narrow.

Branchial sac with four rather slight folds on each side, of which the second is more or less rudimentary. Internal longitudinal vessels confined to the folds or lying so close to their bases as to make it evident that they should be counted as belonging to a certain fold. Between the second and third folds, however, there is usually, on each side of the

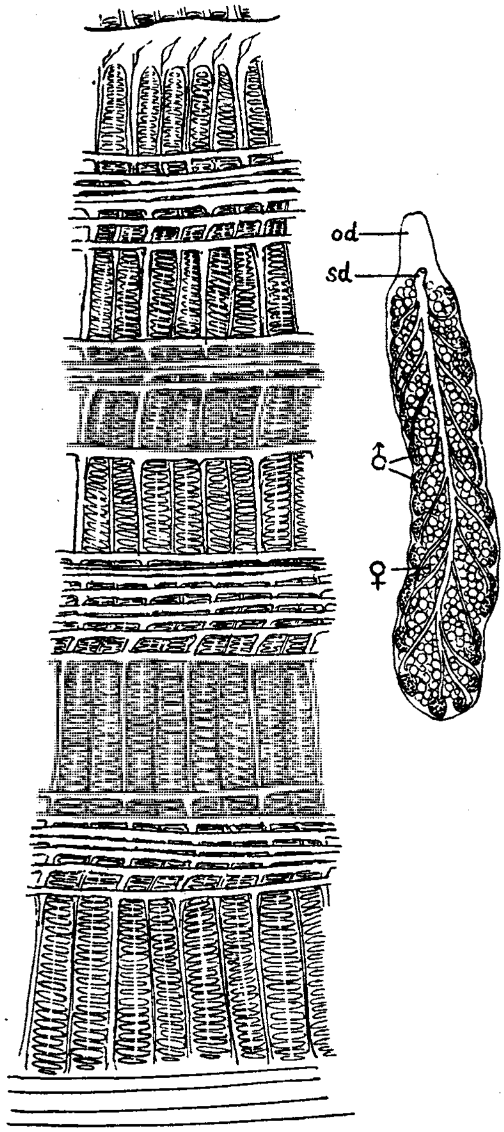


FIG. 160. *Cnemidocarpa mollis* (Stimpson). Part of branchial sac, ×2.5, and gonad (side next to branchial sac).

sac, one stout vessel on the interspace nearly midway between the folds. Counting all the other vessels as belonging to the nearest fold, the scheme in several specimens studied was about as follows:

0 (8 to 10) 0 (4) 1 (8 to 11) 6 (6 to 7) 0
total 27 to 33

Very large individuals may have several more on each side.

Transverse vessels of three orders, the smallest merely crossing the stigmata and incomplete in many parts of the sac. There are 30 or more rows of stigmata in a good-sized specimen; 12 to 25 stigmata on the interspaces between folds in the widest part of the sac.

Stomach rather broad, well differentiated from the oesophagus and intestine, with a small, curved, pyloric caecum and about 25 longitudinal folds in its wall. Intestinal loop small; anus with a sinuate margin, or somewhat two lipped.

Gonads phial shaped, tapering to a short neck with a terminal aperture for the discharge of the eggs at the dorsal end. Testes small, pyriform, or somewhat lobed, occupying the part of the gonad adjacent to the mantle. Their ducts embrace the ovary (which occupies the part of the gonad adjacent to the branchial sac) and unite with a common sperm duct running along the free side of the ovary (next to the branchial sac) and opening on a papilla at the side of the neck of the gonad. Gonads placed so that their orifices are directed toward the base of the atrial siphon, those of the left side usually four in number, situated anterior to the alimentary tract. On the right side, the gonads are more numerous, usually six in number, or sometimes seven.

Cnemidocarpa mollis lives buried in the sand or sandy mud of the sea bottom, resembling many members of the Molgulidae both in habits and appearance. It may be worth mentioning that preserved specimens are of rather firm consistency, so that the name *mollis* does not seem descriptive.

DISTRIBUTION: It occurs about the northern parts of the British Islands ("*C. vestita*," Alder) and in American waters from the east coast of Hudson Bay (Huntsman) and the Gulf of St. Lawrence to the eastern part of Long Island Sound in depths ranging from a few fathoms down, according to Verrill, to depths of 150 fathoms, and appears to be common on the southern Massachusetts coast at many points. Stimpson's type locality was off Cheney's Head, Grand Manan Island, New Brunswick, in 10 fathoms.

For discussion of the supposed genus *Glandula*, in which this species was formerly placed, see Hartmeyer, 1909, page 147.

Cnemidocarpa rhizopus (Redikorzev), 1907

Cnemidocarpa cirrata ÄRNBÄCK, 1922, p. 34, pl. 2, figs. 27–32.

Cnemidocarpa mollis sabulifera REDIKORZEV, 1916, p. 269, fig. 59.

Cnemidocarpa rhizopus REDIKORZEV, 1916, p. 271, fig. 60, pl. 5, fig. 16; HARTMEYER, 1921, p. 39; ÄRNBÄCK, 1922, p. 30, fig. 3, pl. 1, figs. 18–30, pl. 2, fig. 22; HUNTSMAN, 1922, p. 9; 1922a, p. 12; HARTMEYER, 1923, p. 245; HUUS, 1936, p. 15.

Cnemidocarpa rhizopus americana HUNTSMAN, 1922, p. 10.

Cnemidocarpa rhizopus var. *murmanensis* REDIKORZEV, 1916, p. 275, figs. 61, 62, pl. 5, fig. 17; ÄRNBÄCK, 1922, p. 32, pl. 1, fig. 21.

Cnemidocarpa sabulifera HARTMEYER, 1923, p. 253.

Cynthia villosa KUPFFER, 1874, p. 244 (not Fabricius, 1780).

Styela rhizopus REDIKORZEV, 1907a, p. 523; 1908a, p. 32, pl. 1, fig. 12, pl. 2, figs. 29–31; HARTMEYER, 1914b, p. 1105.

Styela sabulifera RITTER, 1913, p. 475, pl. 34, figs. 24–26.

A densely sand-covered form closely related to *C. mollis* and separable from it by only minor and perhaps not very reliable characters, though the almost exclusively Arctic distribution of the present form furnishes an additional reason for considering them distinct.

While the rounded or oval form of *C. mollis* is quite constant, a lot of specimens of *C. rhizopus* may include examples varying greatly in shape, though an ovate form, somewhat flattened at the larger (anterior) end where the two apertures are situated, is the most usual one in contracted preserved material. The smaller (posterior) end is evidently habitually buried in the sand of the sea bottom during life. The test is provided at that end with root-like, branching processes to help anchor it in the sand. These processes most often take the form of tufts of fine, very crooked branching hairs, but they may arise as a few or even as only one stout root-like process which may be of considerable length and does not break up into slender branches until near the end. The different forms of the body above alluded to include, besides the usual ovate one, more or less cylindrical specimens, others that are spindle shaped, and still others that are somewhat conical, being wide at the basal end and narrow at the end bearing the apertures. I believe that most of these variations in shape are largely caused by muscular contraction at the time of fixation of the specimen and do not necessarily indicate permanent differences. In size this form appears to exceed *mollis* to a small extent, perhaps 2 or 3 mm. more in average diameter.

The most conspicuous internal difference is a greater simplification of the branchial sac, which is virtually flat, the folds being represented only by groups of internal longitudinal vessels; these groups in the case of folds II and IV may be reduced to two vessels or even to a single one. The total number of vessels, though varying with the size and age of the specimen and almost always a little larger on the right than on the left side, averages less than in similar-sized specimens of *mollis*.

Hartmeyer (1923, p. 248) gives a table of the number of distribution of these vessels in a considerable number of specimens from different localities. The total number on one side usually ranges from 12 to 17 in medium-sized and large specimens. These vessels are confined to the folds.

The following are examples of their distribution. In a specimen of 13-mm. body length:

Left	0 (5) 0 (2) 0 (3) 0 (2) 0 total 12
Right	0 (6) 0 (1) 0 (3) 0 (2) 0 total 12

In an exceptionally large one, 19-mm. body length:

Left	L 0 (6) 0 (3) 0 (4) 0 (3) total 16
Right	R 0 (8) 0 (3) 0 (4) 0 (4) total 19

In young or small individuals there may be only eight or nine vessels on each side.

The number of branchial tentacles is also fewer than in *mollis*, but a reported difference in the dorsal tubercle is an error; it is normally C-shaped with the open interval to the left in both species.

The stomach is often more or less distorted in form by the muscular contractions of the body. A character described by Redikorzev, 1908a, and Ritter, 1913, is well developed in some of the Alaskan specimens I have examined. This is an abrupt, transverse, right-angled bend in the ventral wall of the stomach near the oesophageal end which results in the proximal parts of the longitudinal folds of the stomach wall running nearly transversely to the main axis of the stomach, and the same folds being obliquely longitudinal on the rest of the stomach. There is a small, curved, pyloric caecum.

The gonads are not usually quite so numerous as in *C. mollis*, commonly four on the left and five, sometimes six, on the right. It should be remarked here that Redikorzev, 1907a, 1908a, described the gonads incorrectly, mistaking the small endocarps commonly present in their vicinity for the male glands.

DISTRIBUTION: Circumpolar in northern regions, chiefly within the Arctic Circle. It occurs on both coasts of Greenland, ranging south in Bering Sea to Bristol Bay and Kiska Island (if I am correct in including *C. sabulifera* Ritter here), to Hudson Bay (Huntsman, 1922), and, according to Ärnbäck, 1922, to the Cattegat.

C. rhizopus is an inhabitant of very moderate depths, the records mostly ranging from a few feet to not more than 20 fathoms, though there is one from west Greenland of 120 fathoms.

Cnemidocarpa finmarkiensis (Kiaer), 1893

Plate 1, figure 1; text figures 161–163, 179A

Cnemidocarpa finmarkiensis REDIKORZEV, 1916, p. 256, figs. 54, 55; ÄRNBÄCK, 1922, p. 27; HARTMEYER, 1923, p. 256.

Cnemidocarpa joannae HUNTSMAN, 1912, p. 133; 1912a, p. 159, pl. 12, fig. 6, pl. 20, figs. 2, 3; 1913, pp. 495, 500, figs. i, ii, xi, xiii.

Cynthia coriacea STIMPSON, 1864, p. 160 (not Alder and Hancock, 1848).

Polycarpa finmarkiensis KIAER, 1893, p. 60, pl. 2, figs. 20–25; PRATT, 1935, p. 748.

Styela elsa HARTMEYER, 1906a, p. 10, fig. 5.

Styela finmarkiensis HARTMEYER, 1903, p. 224.

Styela joannae HERDMAN, 1898, p. 264, pl. 13, figs. 5–9.

Styela stimpsoni RITTER, 1900, p. 602, pl. 18, figs. 11, 12, pl. 19, fig. 26, pl. 20, figs. 27, 28; JOHNSON AND SNOOK, 1927, p. 593, fig. 691; SHELFORD, 1935, pp. 282, etc.

Tethyum finmarkiense HARTMEYER, 1909–1911, p. 1359; REDIKORZEV, 1910, p. 128; VAN NAME, 1912, p. 567, fig. 35, pl. 61, figs. 101–103, pl. 73, fig. 159.

Further references and synonyms will be found in Hartmeyer, 1923, complete to that date.

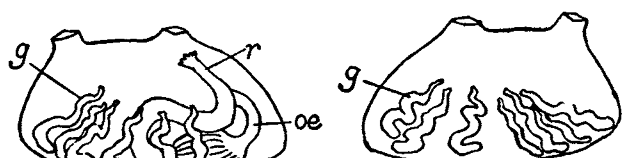


FIG. 161. *Cnemidocarpa finmarkiensis* (Kiaer). Left and right sides of body, ×1.6.

The body is rounded, hemispherical, or dome shaped, attached by a broad, oval, often expanded base, corresponding more or less with the ventral side of the animal. The openings are on the upper surface a short distance apart, raised on papillae or short tubes, which in contracted specimens may be drawn in flush with the surface.

Body surface usually smooth, free or nearly so from conspicuous wrinkles or incrusting matter; bright red or orange red in life, fading to yellowish or grayish in preservation. The largest specimen of which I find a definite record (Hartmeyer, 1906) was 33 by 21 mm. in diameter and 25 mm. in height. Johnson and Snook (1927) give the length as "3–4 cm." Test rather thin, tough, said to be somewhat transparent in life, but opaque in alcoholic specimens. The following description of the internal anatomy is from a speci-

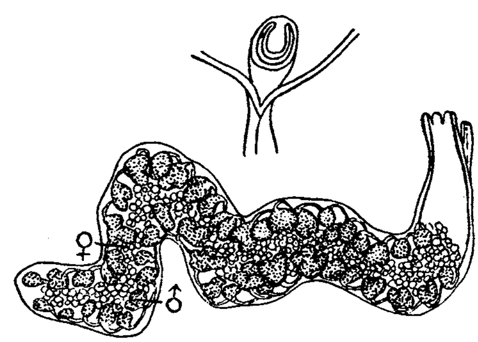


FIG. 162. *Cnemidocarpa finmarkiensis* (Kiaer). Gonad (side next to mouth), ×14, and dorsal tubercle.

men from "Albatross" Station 2466, 45° 29′ N., 55° 24′ W., 67 fathoms, coral, and seems to be typical of the species. This specimen measured 26 by 17 mm. wide by 10 mm. high.

"Mantle rather thin; its musculature not greatly developed. Tentacles rather large, and not very numerous; at least two sizes, arranged with some regularity. Dorsal tubercle small, horseshoe-shaped, the open interval directed forward. Dorsal lamina a broad membrane whose margin is raised into small, quite regular, narrow teeth.

"Branchial sac with four well developed folds on each side and very numerous internal longitudinal vessels. The first folds are a little the highest, the second and third about equal, the fourth decidedly lower. It is impossible to decide just how many vessels should be reckoned as belonging to the folds or to the interspaces, as the folds begin so gradually, but the following schemes show their approximate distribution:

Left 5 (23) 5 (18) 3 (16) 3 (11) 5
Right 2 (24) 5 (19) 5 (17) 5 (10) 5

"There are four orders of transverse vessels even in the dorsal part of the sac. The smallest merely cross the stigmata. On the interspaces from five to seven stigmata intervene between the internal longitudinal vessels; close to the endostyle and median dorsal vessel a greater number (ten or more) intervene.

"Stomach short and rounded, with a rather small number of longitudinal folds. No pyloric caecum was observed. Intestinal loop small and short; margin of anus with about ten rounded lobes" (Van Name, 1912, p. 568).

The gonads are not closely appressed to the body wall and are of crooked tubular form constricted into a neck at the dorsal end. They consist of a central tubular ovary bordered by the small pyriform testes which are generally cleft into several lobes. The testes lie between the ovary and mantle, overlapped or nearly covered by the ovary. Their efferent ducts embrace the latter and unite on the aspect of the ovary which lies against the branchial sac to form the common sperm duct, which opens on a papilla beside the neck or short oviduct in which the ovary ends.

The gonads vary in different individuals from five to 12 on a side (usually more on the right than the left). They occasionally branch, or apparently fuse with adjacent ones, but are usually separate.

DISTRIBUTION: A species of northern waters, though not exclusively Arctic. It is known from west Greenland to Barents Sea, with a single record from the Banks of Newfoundland (the specimen described above) but is a rare species in those regions. In the Pacific region it is much more common, extending south to Puget Sound (where it is said to be abundant) on the American side and to Japan on the Asiatic side. It occurs

FIG. 163. *Cnemidocarpa finmarkiensis* (Kiaer). Part of branchial sac, ×15.

chiefly on rocky or hard bottoms, and ranges from low-water mark to 20 fathoms, according to Huntsman, but has often been found in much deeper water (234 meters at Upernivik, Greenland, and 540 meters in Sagami Bay, Japan, according to Hartmeyer, 1923).

specimens; the rest of the sac is flat with a number of internal longitudinal vessels separated in most cases by two to four stigmata. A slightly closer grouping of several of these vessels in some specimens may represent a vestige of another fold.

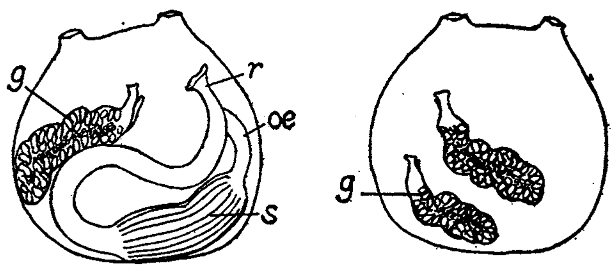


FIG. 164. *Cnemidocarpa mortenseni* (Hartmeyer). Left and right sides of body, ×2.5.

Cnemidocarpa mortenseni (Hartmeyer), 1912
Text figures 164–166

Cnemidocarpa mortenseni ÄRNBÄCK, 1922, p. 28; HARTMEYER, 1923, p. 253; ÄRNBÄCK, 1931a, p. 1, pl. 1, figs. 1–6; HUUS, 1936, p. 15.

Tethyum mortenseni HARTMEYER, 1912c, p. 268, fig. 3; VAN NAME, 1912, p. 565, fig. 34, pl. 61, figs. 98–100.

A small species of rounded or oval form attached by a ventral area which may have a few small processes for that purpose. Apertures well apart on the dorsal surface, small, four-lobed, little if at all raised above the general surface, at least in the contracted condition. Size up to 19 mm. in greatest diameter, usually not over 10 to 13 mm.

Test thin but tough, its outer surface usually free from wrinkles or incrusting matter, in preserved specimens yellowish gray or brownish, but possibly it may be more or less red during life.

Mantle thin, its musculature slight. Branchial tentacles of several sizes quite numerous (up to about 60 if the small ones are counted). A row of slender atrial tentacles is present; they arise from the edge of a velum. Dorsal tubercle with a curved slit-like aperture, which usually appears to form a closed ring. Dorsal lamina a plain membrane.

The most striking feature of the species is the branchial sac, which has only one fold on each side. This represents the first or most dorsal of the four usually present in the Styelidae. It is quite high and bears from 14 to 20 internal longitudinal vessels in large

The alimentary tract is much bent, forming an S-shaped curve. The stomach is elongate and longitudinally plicated. Hartmeyer figures a very small pyloric caecum (not found by Ärnbäck or Van Name).

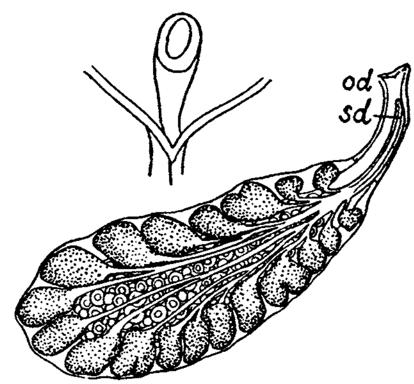


FIG. 165. *Cnemidocarpa mortenseni* (Hartmeyer). Gonad (side next to branchial sac), ×18, and dorsal tubercle.

There are in all three elongate, irregularly flask-shaped gonads, of the structure described in the genus *Polycarpa*, two on the right side and one on the left, the latter anterodorsal to the intestinal loop.

DISTRIBUTION: A comparatively rare species of the northern seas of both hemispheres, chiefly in rather deep water. Four American records, the most northern at the southern entrance to Davis Strait in 582 fathoms, the most southern off Cape Ann (United States

Fish Commission Station 237, 42° 31 N., 70° 29′ W.) in 38 fathoms.

Cnemidocarpa annectens (Hartmeyer), 1921

Dendrodoa annectens HARTMEYER, 1921a, p. 58, figs. 14–16; 1923, p. 313.

Based on three specimens from the southwest Greenland coast. They have the body ovate or short cylindrical with the branchial aperture on the rather wide anterior end and the atrial aperture not far removed from it; the test is thin, translucent, and smooth externally. In the preserved specimens the apertures are not raised on papillae, and the color is milk white. Their maximum diameters range from 10 to 16 mm.

Internally the structure corresponds well with *Dendrodoa aggregata* within such limits of individual variation as may be expected to occur, except for their gonads.

As in *Dendrodoa* those organs are present only on the right side of the body, but these form three or four partly, or entirely separate (in one specimen all entirely separate), elongate crooked gonads with their oviducts pointed in the general direction of the atrial aperture.

On the information furnished by the description and figures, I am not convinced of the correctness of Hartmeyer's view that these gonads correspond to the branches of the single gonad of *Dendrodoa*, as those branches are directed away from the atrial aperture with their blind ends toward it. Neither am I ready to accept his theory that the branched gonads of *Dendrodoa* are formed by the fusion of originally separate ones.

It seems to me that *annectens* is more in place in *Cnemidocarpa*, in spite of the fact that it lacks the gonad or gonads usually present on the left side in that genus.

LOCALITY: The three known specimens are from stations in the Nordre Stroem Fjord and Edgesminde on the southwest Greenland coast, in 35 to 98 fathoms.

Cnemidocarpa ohlini (Michaelsen), 1898

Styela ohlini MICHAELSEN, 1898, p. 366; 1900, p. 80, pl. 2, fig. 17; 1907, p. 75.

Tethyum ohlini HARTMEYER, 1909–1911, p. 1359.

Described by Michaelsen on the basis of a single specimen.

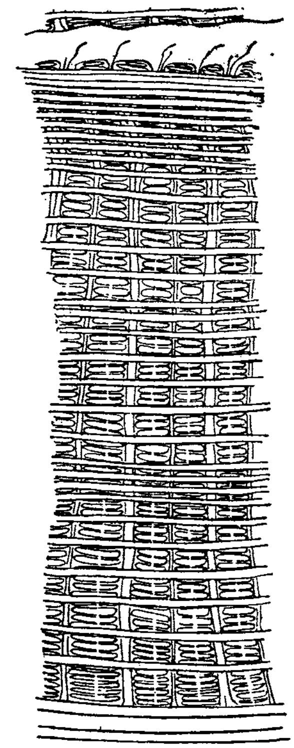


FIG. 166. *Cnemidocarpa mortenseni* (Hartmeyer). Part of branchial sac, ×12.

Body ellipsoidal, 26 mm. long, 18 mm. wide, 16 mm. high dorsoventrally, attached by the flattened ventral side. Both apertures four-lobed ("small cross-shaped slits" in the contracted condition), the branchial on the forward part of the body, the atrial on about the middle of the dorsal surface.

Test thin, hard, and tough, weakly translucent. Color whitish, with a slight flesh tint and a pearly luster.

Mantle thin with diffuse musculature. About 32 tentacles of various sizes, larger and smaller showing a tendency to alternate. Dorsal tubercle small, its aperture a curved slit whose horns are curved inward so that they meet in front ("beide Hörner der spaltformigen Flimmergrube so weit einwärts gebogen dass sie vorn aneinander stossen"); basis of the tubercle very narrow. Dorsal lamina wide, not ribbed, its margin somewhat uneven. Branchial sac with four folds on each side. The dorsal ones are the highest, having about 30 internal longitudinal vessels; these diminish to about 10 in the ventralmost folds; on the flat intervals the maximum number of vessels is about eight. On most parts of the sac the transverse vessels are of two sizes alternating, generally with additional parastigmatic vessels. Usual number of stigmata in a mesh on the flat parts of the sac, about six.

Stomach pear shaped, its wall with about 20 longitudinal plications.

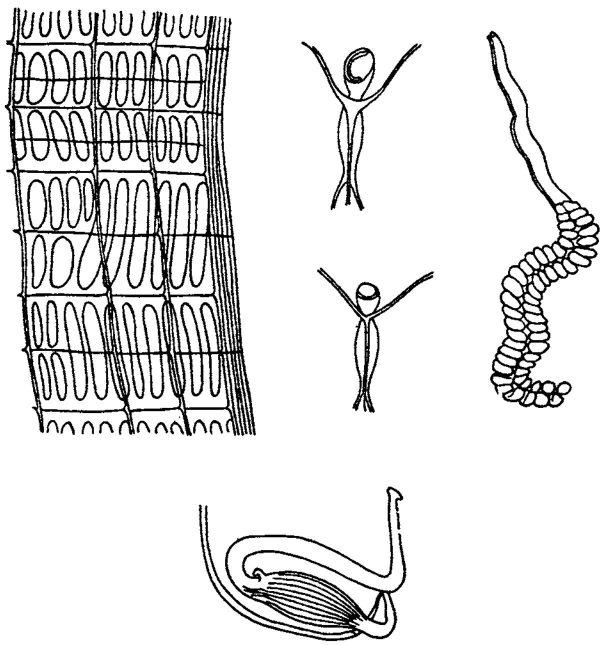


FIG. 167. *Cnemidocarpa drygalskii* (Hartmeyer). Part of branchial sac, dorsal tubercles of two specimens, gonad (side next to mantle), and alimentary tract. After Hartmeyer.

Gonads sausage shaped, more or less curved, loosely attached between the mantle and branchial sac; seven on the left and 10 on the right side. In each gonad the testes form a layer in the part next to the mantle, the ovary in the part next to the branchial sac.

LOCALITY: Magellan Strait (Puerto Harris on Dawson Island) in 15 fathoms.

Cnemidocarpa drygalskii (Hartmeyer), 1911

Text figure 167

Styela drygalskii SLUITER, 1914, p. 17, pl. 2, fig. 19.

Tethyum drygalskii HARTMEYER, 1911b, p. 452, pl. 45, fig. 6, pl. 50, figs. 6–10.

Hartmeyer described this small species from only four specimens, but one of which had the gonads fully developed.

They varied much in shape; the type and largest, described as obtusely conical, was evidently considerably flattened laterally and obliquely. It adhered to, and surrounded, the stem of a bryozoan; measurements, 15 by 12 by 10 mm. Apertures 7 mm. apart on low, verrucose elevations. Two young and small specimens were depressed dorsoventrally and attached by a large base.

The test is thin and skin-like ("hautartig"), finely roughened externally, especially in the vicinity of the apertures, becoming smoother near the base. Color light yellowish brown, becoming whitish on the smoother parts.

Mantle musculature only moderately developed, in the larger specimens composed of fairly continuous sheets of longitudinal and circular bundles of fibers. Branchial tentacles 30 to 40 in number in the larger specimens, of several sizes; dorsal tubercle simple, its aperture in the form of a slit of crescentic or nearly completely circular curvature; dorsal lamina plain edged.

Four branchial folds in the larger specimens, the first the highest, having about 30 internal longitudinal vessels in the type; the last fold had only about eight. In the young and small specimens only the first fold was much developed.

Stomach spindle shaped, with a small, curved pyloric caecum best developed in the young examples. Anal margin with two smooth lips.

In the type, one gonad was demonstrated on the left and two on the right side, though they were not mature. In the next largest specimen, designated as "example B" by Hartmeyer, there was only one gonad on each side. This was the only specimen with well-developed gonads. They were distinctly of the *Cnemidocarpa* type, long, sinuous, flattened-tubular in form with the testes in a continuous double series in the part lying against the mantle and largely covered on the mesial aspect by the ovary, which is produced into a long, narrow, oviducal extension reaching to near the atrial aperture.

DISTRIBUTION: Recorded only from the Antarctic. Hartmeyer's specimens were from the eastern Antarctic in the Kaiser Wilhelm II region, 380 and 385 meters. Sluiter, 1914, records one agreeing well in its main characters, including the gonads, with Hartmeyer's "example B" from the Marguerite Bayr egion in the western Antarctic, 230 meters.

The United States National Museum has a rather small specimen, with a thin, parchment-like test, rather smooth except in the region of the apertures, which agrees quite closely with the present species, from "Albatross" Station 3382, 06° 21′ N., 80° 41′ W., off Panama (Pacific side), 1793 fathoms. It was attached to the stem of a glass sponge and was in a damaged and very fragile condition, but much of its internal structure could be clearly made out and agrees so well with the above description that I would be at a loss how to base a new or different species upon it. The gonads resemble those of Hartmeyer's "example B" except that the testes are considerably subdivided into lobes, which form a layer rather than a double series, on the side of the gonad which lies against the mantle. I could not distinguish the condition of the anal margin, of which Hartmeyer makes an important specific charcater in his description of *drygalskii*, but personally I would attribute very little weight to that character.

While admitting the considerable improbability of identity of an Antarctic and a tropical species, such a thing is not an impossibility when the latter is abyssal, and I will leave the establishment of a new species for this specimen to some future investigator in case more material proves it to be necessary.

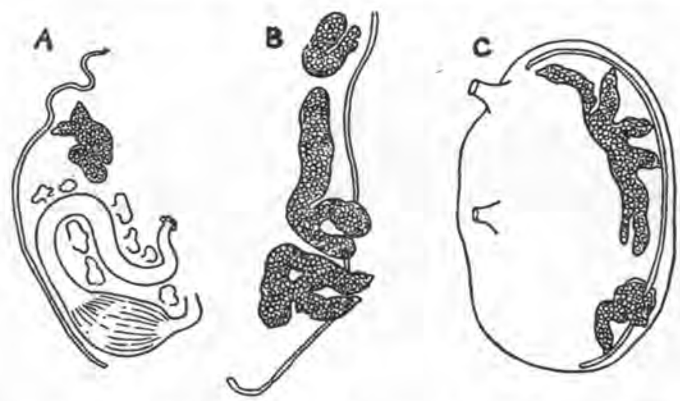


FIG. 168. *Cnemidocarpa robinsoni* Hartmeyer. A. Alimentary tract and gonad of left side. B, C. Right gonads of two specimens. After Hartmeyer.

Cnemidocarpa robinsoni Hartmeyer, 1916

Text figure 168

Cnemidocarpa robinsoni HARTMEYER, 1916a, p. 224, figs. 10–13; 1920a, p. 131; HARTMEYER AND MICHAELSEN, 1927, pp. 173–175.

? *Styela humilis* HELLER, 1878, p. 108, pl. 1, fig. 7.

See also remarks below, at end of the description of this species.

Hartmeyer described this species from five specimens from shallow water at Juan Fernandez, two of which were made the subject of study of the internal parts and are the basis of this description. They were of ovate or bluntly conical shape, the short branchial siphon at the upper or unattached end, the atrial a little way back, the largest 18 mm. high by 13 mm. in transverse diameter. The test, though thin, was tough, opaque, and externally rough and wrinkled, color yellowish white or yellowish gray.

Mantle thin, its muscle bands mainly longitudinal. Dorsal tubercle with a horseshoe-shaped aperture, open interval anterior. Branchial tentacles of four orders, about 64 in number, atrial tentacles present. Branchial sac with four well-developed folds. Hartmeyer gives the distribution of the internal longitudinal vessels as follows:

0 (9) 2 (11) 2 (11) 2 (9) 0
0 (9) 2 (10) 2 (11) 3 (9) 1

Transverse vessels of three orders, the smallest often parastigmatic. Usually eight or nine stigmata in a mesh (about 12 near the endostyle).

The primary intestinal loop is rather open; the whole intestine is bent to form a secondary loop also. Stomach spindle shaped, its wall plicated. No pyloric caecum.

The gonads in Hartmeyer's specimens number one on the left and two or three on the right side. They are evidently compound, each being composed of from two to five irregularly curved tubular elements of the type characteristic of the genus *Cnemidocarpa*, fused together into a single gonad of irregular branching or lobed outline. Usually at least, the tubular elements composing it retain their own ovarian apertures (which are directed toward the endostyle) and their own system of sperm ducts.

The left gonad is small, composed of only two elements; each of the right gonads contains from two to five elements. All the gonads are attached to the mantle close to the mid-ventral line, so close in fact that some of the branches actually cross it and invade the opposite side of the body to that to which the gonad belongs.

The figures show the number and form of the gonads in the individuals studied by Hartmeyer. It must not be expected that other specimens will have gonads exactly similar in shape, grouping, number of branches, etc.; great individual variation must be expected.

DISTRIBUTION: Described by Hartmeyer, as above stated, from Juan Fernandez, evidently from shallow water.

It is closely related to, if distinct from, *Styela humilis* Heller (1878, p. 108, pl. 1, fig. 7) from New Zealand. In case future investigation proves it inseparable, the specific name *humilis* must be adopted. *Styela cerea* Sluiter (1900, p. 24, pl. 3, figs. 9–11), also from New Zealand, and *Dendrodoa gregaria* Kesteven (1909, Proc. Linnaean Soc. New South Wales, vol. 34, p. 291, pl. 25, figs. 1–3, pl. 26, fig. 7, pl. 27, figs. 1–5) from Tasmania are probably identical with Heller's *humilis*. Hartmeyer examined types or cotypes of these three forms. They are discussed and placed in the genus *Cnemidocarpa* in Hartmeyer and Michaelsen (1927, pp. 173–180). Another closely related form is *C. assymetra* (Hartmeyer), 1912, from South Africa.

Cnemidocarpa verrucosa (Lesson), 1830

Plate 25, figures 1–3

Ascidia verruscosa DUJARDIN, 1840, *in* Lamarck, Histoire naturelle des animaux sans vertèbres, ed. 2, Paris, vol. 3, p. 536.

Cynthia verrucosa LESSON, 1830, p. 151, pl. 53, fig. 2; 1830a, p. 434; CUNNINGHAM, 1871a, p. 488.

Styela flexibilis SLUITER, 1905b, p. 473; 1906, p. 36, figs. 4, 5, pl. 3, fig. 36, pl. 5, fig. 54.

Styela grandis HERDMAN, 1881, p. 67; 1882, p. 153, pl. 19, figs. 1, 2.

Styela lactea HERDMAN, 1881, p. 68; 1882, p. 156, pl. 19, figs. 7, 8; 1902, p. 192, pl. 19, figs. 3–8; 1912, p. 93, pl. 4, figs. 1–8; 1923, p. 23; HARTMEYER AND MICHAELSEN, 1927, p. 183, fig. 14.

Styela spectabilis HERDMAN, 1910, p. 4, figs. 1, 2, pl. 1, figs. 1–9.

Styela spirifera MICHAELSEN, 1898, p. 366; 1900, pp. 83, 94, pl. 2, fig. 12; 1907, p. 76.

Styela steineni MICHAELSEN, 1898, p. 365; 1900, p. 92, pl. 2, fig. 15; 1907, p. 76.

Styela verrucosa MICHAELSEN, 1898, p. 365; 1900, p. 86, pl. 2, fig. 11, pl. 3, fig. 5; 1907, p. 76; SLUITER, 1914, p. 15.

Tethyum lacteum HARTMEYER, 1911b, pp. 447, 525; 1912b, p. 250, pl. 41, fig. 4.

Tethyum spectabile HARTMEYER, 1911b, p. 447.

Tethyum spiriferum HARTMEYER, 1911b, p. 447.

Tethyum steineni HARTMEYER, 1911b, p. 447.

Tethyum verrucosum HARTMEYER, 1911b, p. 444, pl. 45, fig. 5, pl. 51, figs. 1–3.

A large, stout-bodied species, broadly ovate, ellipsoidal or barrel shaped, often looking as if inflated; attached by the posterior end. Usually not compressed laterally. Young and small individuals often approach a spherical form. The two four-lobed or square apertures are variously placed on the anterior part of the body; they may be raised on irregular conical projections or (at least in the presumably more or less contracted preserved specimens) practically flush with the surface. The area of attachment at the posterior end is generally somewhat contracted and not infrequently produced into a pedicel, which is usually short and thick in old individuals; in young ones it is often longer but rarely approaches the body diameter in its length.

This is one of the largest of the Styelidae, specimens measuring 6 to 7 cm. in length (inclusive of the pedicel, if any) and 5 cm. or more transversely are apparently not infrequent, and very much larger ones occur. Herdman (1910) described an enormous specimen, 18 cm. long, 9.5 cm. dorsoventrally, and 7 cm. in lateral diameter, obtained by the "Discovery" expedition, making it the type of a species *Styela spectabilis*, which is, however, apparently not distinct from this species.

The test, though tough, is usually rather thin and somewhat soft and flexible. It is not at all transparent. Young individuals, and occasionally fairly large ones also, are usually white or nearly so in preservation, accounting for one of its names (*lactea*); in older specimens the surface is more or less stained, becoming yellowish or brown or some shade of gray. The surface is generally free from incrusting growths except on the pedicel and basal part of the body. In life the white test has a rosy tinge, becoming a bright yellow around the apertures (Lesson).

The body surface may be smooth, but usually it is more or less rough with minute papillae or verrucae, which are usually best developed on the anterior parts, and by minute but sharply defined wrinkles and furrows, usually best developed in the posterior half of the body where they are frequently numerous, parallel, and transverse in direction, so that the body appears to be encircled by small corrugations. This may be in part due to contraction of the body muscles.

In young specimens (10 to 15 mm. in diameter or less) the above-mentioned papillae of the body surface are often relatively large, conical, and often tipped with one or more minute spines; often they have one or two more laterally placed spines also. Herdman describes such specimens as "little globular spiny balls," but as the individuals grow older the character of the papillae changes, they gradually lose their spines and become low, rounded, irregularly shaped verrucae which, where small and numerous, often give the surface a coarsely granulated appearance. On old specimens it may be hard to find any that have retained the spines. Often there occur here and there among the small verrucae a few larger sac-like excrescences, translucent and suggestive of small endocarps in their appearance; they doubtless develop from the small verrucae.

In spite of its large size, the internal structure is not easy to study. The mantle is thin and delicate, and more than one writer has mentioned its tendency to cling to the surface of the test. Its musculature consists of very distinct bands. On the dorsal part of the body the circular bands and those radiating from the bases of the siphons cross each other more or less at right angles, forming a very open network of characteristic appearance (see Michaelsen, 1900, p. 87), while on the ventral regions they become slender and irregular.

The branchial tentacles usually number from 30 to 40; they are of two or three sizes. A velum bearing a large number of minute slender atrial tentacles (Michaelsen counted 70) is present at the base of the atrial siphon. The dorsal tubercle has a horsehoe-shaped or C-shaped aperture with the open interval forward and the horns commonly more or less spirally inrolled.

The branchial sac is very delicate and difficult to dissect out entire, but is of help in recognizing the species, as the folds (four on each side, as usual) are comparatively low and separated by wide, flat intervals, and the internal longitudinal vessels are unusually few for such a large species—six to 10 on the folds and two to four on the flat intervals, according to Hartmeyer (1911b). As a consequence the meshes are very long in a dorsoventral direction and often contain 25 to 30 or more stigmata (or even 40, according to Herdman, 1882, this probably only in meshes along the endostyle). These transverse vessels, of which there are several sizes, are placed at the usual intervals; the smallest are frequently parastigmatic.

The stomach is elongate, smooth externally but with about 25 prominent longitudinal folds on the inside. No caecum is present in adults. Hartmeyer found a very small one in young examples. The intestinal loop is rather narrow; the intestine loops back so as to run alongside the stomach, at least in many individuals. The anal margin is conspicuously lobed.

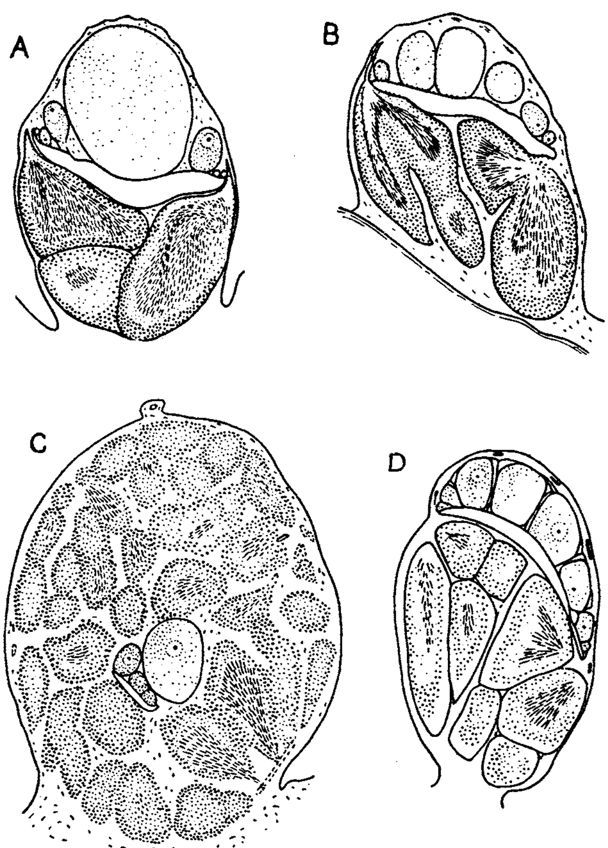


FIG. 169. Cross sections of gonads of species of *Dendrodoa*. A. *D. lineata* (Traustedt). B. *D. grossularia* (Van Beneden). C. *D. aggregata* (Rathke), ×20. D. *D. pulchella* (Verrill), ×21. After Huus, 1929.

The gonads are tubular, with an enclosing membrane, and are rather loosely attached to the inner surface of the mantle by a narrow membranous connection extending along their length. When in an active functional condition they are of circular cross section, the male and female parts apparently more or less intermingled, but the testes lie mainly in the part toward the mantle. The gonads are apparently usually two in number on each side or occasionally but one; on the right side, at least, there may be a third small one. They have their distal or oviducal ends directed toward the atrial siphon, though they often end far from it. The sperm ducts of each gonad unite into a common duct on the mesial aspect of the gonad and open on a papilla beside that of the short oviduct. Usually the gonads are of very unequal length; the longer ones have a sinuous or often a strongly serpentine course. Some large endocarps of irregular shape are commonly present, especially on the posterior part of the body wall near the endostyle.

The structure of the gonads evidently makes it necessary to transfer this species to *Cnemidocarpa*, if we recognize that genus.

DISTRIBUTION: This large and conspicuous species is known from many points in the Subantarctic and Antarctic regions of both the Eastern and Western Hemispheres. It is evidently common in shallow water in many places, but extends down to depths of at least 300 to 385 meters (Hartmeyer, 1911b).

Lesson's tye of *Cynthia verrucosa* was from the Falkland Islands; Sluiter's type of *Styela flexibilis* was from Booth Wandel Island in the Graham Land region; Herdman's of *S. lactea* and *S. spectabilis* were from Kerguelen Island; Michaelsen's of *S. steineni* from South Georgia, and of *S. spirifera* from Tierra del Fuego.

GENUS **DENDRODOA** MACLEAY, 1824

Text figure 169

A genus confined to the Arctic and northern regions; related to *Cnemidocarpa*, but having one gonad only, which is located on the right side of the body. The gonad is structurally similar to that of *Cnemidocarpa* but consists, in the typical species, of several branches which connect with, and discharge their eggs through, a ventrally situated, obliquely longitudinally extending branch, which opens at the posterior end and is often extended into a short oviduct. According to Huus (1929, p. 8), the sperm ducts fail to unite into one large common duct but open at several points on the gonad.

The folds of the branchial sac may be considerably reduced in this genus.

In the subgenus *Styelopsis* Traustedt, 1883, the gonad is unbranched.

Dendrodoa aggregata (Rathke), 1806

Text figures 169C, 170, 174A

Ascidia aggregata RATHKE, 1806, p. 11, pl. 130, fig. 2.

Cynthia aggregata SARS, 1858, p. 65.

Dendrodoa aggregata HARTMEYER, 1903 (in part), p. 235, pl. 5, fig. 8; BJERKAN, 1905, p. 12; REDIKORZEV, 1907, p. 136; 1908, p. 26; 1908a, p. 36; BJERKAN, 1908a, p. 70; REDIKORZEV, 1910, p. 131; HARTMEYER, 1912, pp. 439, 440; 1912c, p. 274; VAN NAME, 1912, p. 584; REDIKORZEV, 1916, p. 302, fig. 69, pl. 6, figs. 4, 11; HARTMEYER, 1921a, p. 45, figs. 8–13; ÄRNBÄCK, 1922, p. 43, pl. 2, figs. 39, 40, pl. 2, figs. 43, 44; HARTMEYER, 1923 (in part), p. 288; HARTMEYER AND MICHAELSEN, 1927, p. 193; HUUS, 1929, pp. 6, 8, figs. 5, 6 (in part), 7. (Some of these references may apply in part to *Dendrodoa pulchella*.)

Dendrodoa aggregata var. *cylindrica* ÄRNBÄCK, 1922, p. 45.

Dendrodoa aggregata var. *subpedunculata* ÄRNBÄCK, 1922, p. 46.

Dendrodoa aggregata var. *tuberculata* ÄRNBÄCK, 1922, p. 45.

Dendrodoa cylindrica BJERKAN, 1908, p. 7, pl. 1, figs. 1–6; HARTMEYER AND MICHAELSEN, 1927, p. 194.

Dendrodoa glandaria MACLEAY, 1825, p. 547, pl. 20; HARTMEYER, 1899, p. 268; 1899a, p. 484, fig. f, pl. 22, fig. 4, pl. 33, figs. 6, 10.

Dendrodoa subpedunculata RITTER, 1899, p. 514, figs. 6–8; HARTMEYER AND MICHAELSEN, 1927, p. 194.

Dendrodoa tuberculata RITTER, 1899, p. 512, figs. 1–5; HARTMEYER, 1903, p. 243 (misprint *tubercalata*), pl. 5, fig. 9; RITTER, 1913, p. 480, pl. 34, fig. 27; HARTMEYER AND MICHAELSEN, 1927, p. 194; OKA, 1935, p. 456, figs. 27, 28.

Styela aggregata KIAER, 1893, p. 49, pl. 2, figs. 14–19; 1896, p. 9.

? *Styela arctica* SWEDERUS, 1887, p. 108.

Not *Dendrodoa aggregata* var. *pulchella* Van Name, 1912 (= *D. pulchella*).

Not *Styela aggregata* var. *americana* Metcalf, 1900 (= *Styela partita*).

In the present work I am following Huus, 1929, in restricting this species to the forms which have in normally developed individuals a gonad of at least four branches (in addition to the short and often hardly noticeable branch formed by the oviduct), excluding from it and referring to *D. pulchella* those with a three-branched gonad, or regarding such specimens as abnormal. See description

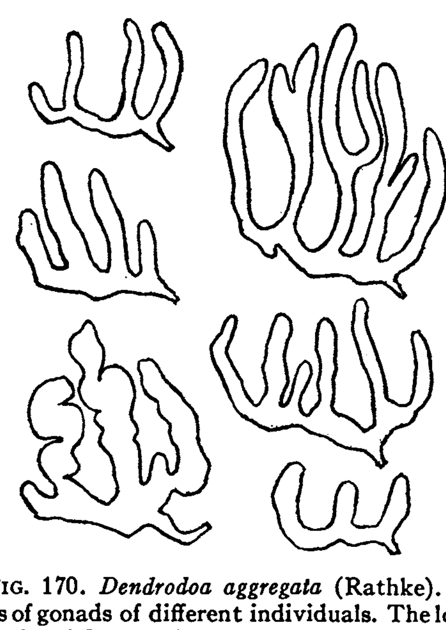


FIG. 170. *Dendrodoa aggregata* (Rathke). Outlines of gonads of different individuals. The lowest right-hand figure, with only three branches, is not normal for *D. aggregata* (normal for *D. pulchella*). After Hartmeyer.

of that species for other distinguishing characters.

The body in this species is usually more or less regularly oval, occasionally nearly globular in outline, attached by one end, with the branchial aperture at the other end and the atrial aperture usually quite close beside it. Both apertures are four-sided and on papillae which, at least in the contracted preserved specimens, are usually small and low. Specimens sometimes grow in clusters, as its name indicates; often young specimens are attached to older ones.

The body may be extended at the attached end so as to be somewhat penduncculated, especially when individuals grow in a crowded cluster.

The test is tough and leathery, commonly only moderately opaque (semi-transparent in young individuals) and not very thick. Its surface is rather smooth in young specimens; in older ones it is more or less wrinkled, especially toward the attached end of the animal, but in the majority of individuals the body has a comparatively smooth appearance unless rather closely examined. The prevailing direction of the wrinkles may be transverse or longitudinal, or they may cross so as to divide the body surface into small rectangular fields which become smaller and more numerous toward the anterior end. There are, however, occasional quite rough individuals, especially in Bering Sea, where Ritter, 1899, established a species *D. tuberculata* mainly on this character. That form, however, can hardly rank as more than a mere variety.

Preserved specimens vary much in color; yellowish, brownish, and reddish shades are the most frequent but probably do not represent the colors during life.

It attains a fairly large size in the Arctic regions. Ritter, 1913, records a specimen of his variety *tuberculata* measuring 70 by 35 mm., but this is an extreme; a specimen over 30 mm. in maximum (anteroposterior) diameter must be regarded as a large one in most localities where it occurs.

Except that there is but one gonad, which is on the right side, the internal structure is that of a *Styela*. The mantle has rather thin diffuse musculature; the branchial tentacles number only "25–32 seldom more," according to Huus, 1929. They vary in size, but very small ones are noticeable only here and there.

The dorsal tubercle has a horseshoe-shaped opening, the open interval generally directed obliquely forward or more or less directly to the left. The branchial sac has four folds on each side, the first the highest, the third the next highest. In a large example 34 mm. in length, Huus, 1929, found the following distribution of the internal longitudinal vessels:

Right	2 (18) 3 (9) 3 (11) 4 (8) 2
Left	2 (18) 2 (9) 3 (11) 4 (5) 2

In one 16 mm. long:

Right	1 (11) 1 (6) 1 (9) 2 (6) 2
Left	1 (11) 1 (7) 1 (8) 2 (6) 2

In young specimens they are fewer and confined chiefly to the folds.

The stomach has longitudinal ridges on the inner surface, the number, according to Hartmeyer, usually not over 20 to 22; apparently they become less visible on the external surface with age. A small, curved, pyloric caecum is present in most individuals but, according to Hartmeyer, it tends to disappear with age. Anal margin usually smooth.

The gonad, spreading over a considerable part of the inner side of the mantle on the right side, consists of a ventral longitudinally or obliquely extending part ending posteriorly in a short oviduct (often so short as to be hardly noticeable) and in normal specimens at least four or five narrow, more or less irregularly parallel branches extending dorsally from it, and ending blindly. One or more of them may fork, so that the total number of end branches may be five or six or (rarely) still more. A cross section of one of these branches shows that the ovary occupies the central part or core; the numerous small testes (themselves of lobed form) surround it more or less completely on all sides (compare with description of gonad under *D. pulchella*). Fewer than four branches is rare and abnormal in the present species. The sperm ducts (small and delicate tubes) from the numerous testes unite to some extent into common ducts on the unattached aspect of the gonad, but not to the extent of forming a common duct for the whole gonad.

Huus (1929, pp. 10, 11) enumerates several other differences between *D. aggregata* and

D. pulchella which are explained under the latter species.

DISTRIBUTION: *D. aggregata* is a circumpolar form, mainly Arctic in range but extending considerably south of the Arctic Circle. It is known from the coasts and waters about Spitzbergen, northern Norway (south to the Lofoten Islands), the Faeroes, Iceland, east and west Greenland, Ellesmere Land, Bering Sea, and Alaskan Peninsula, the Aleutian Islands (Unalaska), Kamchatka, etc. It occurs chiefly in moderate depths, about 15 to 80 fathoms, though recorded from as deep as 393 fathoms. Yet it seems probable that a large part of the records of "*aggregata*" from 100 fathoms or more belong really to *D. pulchella*. It lives on hard and more or less muddy bottoms, provided that objects for its attachment are present.

Dendrodoa pulchella (Verrill), 1871

Plate 2, figure 1; text figures 169D, 171–173, 174B

Cynthia adolphi KUPFFER, 1874, p. 244.

Cynthia pulchella VERRILL, 1871, pp. 98, 211.

Dendrodoa adolphi HARTMEYER, 1903, p. 244, pl. 10, fig. 10; REDIKORZEV, 1910, p. 131, fig. 22; RITTER, 1913, p. 484; REDIKORZEV, 1916, p. 297, fig. 67, pl. 6, fig. 3; HUNTSMAN, 1922, p. 11.

Dendrodoa aggregata (in part) HARTMEYER, 1923, p. 288, figs. 21, 23, 24, 27, 30, 31.

Dendrodoa aggregata var. *adolphi* ÄRNBÄCK, 1922, p. 45.

Dendrodoa aggregata var. *groenlandica* ÄRNBÄCK, 1922, p. 45, pl. 2, fig. 42, pl. 3, figs. 45, 46.

Dendrodoa aggregata var. *pulchella* VAN NAME, 1912, p. 581, fig. 39, pl. 65, figs. 120–122, pl. 70, fig. 142; ÄRNBÄCK, 1922, p. 45, pl. 2, fig. 41.

Dendrodoa kükenthali HARTMEYER, 1899, p. 268; 1899a, p. 493, fig. h, pl. 22, fig. 7, pl. 23, fig. 8; 1903, p. 246; REDIKORZEV, 1907a, p. 521; 1908, p. 26; 1908a, p. 36, figs. 7, 8, pl. 1, fig. 13, pl. 2, figs. 32–34; 1910, p. 133, fig. 24; 1916, p. 315, fig. 72, pl. 6, figs. 7, 14.

Dendrodoa kükenthali var. *pectenicola* MICHAELSEN, 1912, p. 132.

Dendrodoa pulchella HUUS, 1929, p. 5, figs. 3, 4, part of 6.

Halocynthia pulchella VERRILL, 1879, p. 27; 1879a, p. 148; 1879b, p. 147.

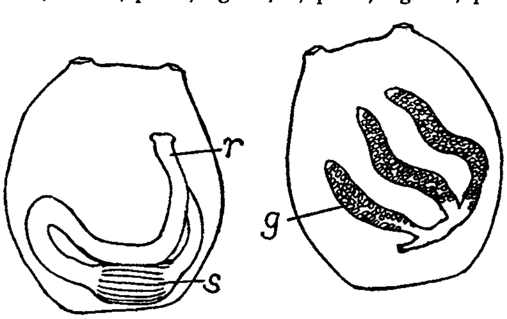


FIG. 171. *Dendrodoa pulchella* (Verrill). Left and right sides of body, ×2.2.

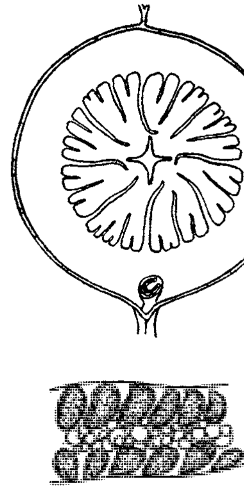


FIG. 172. *Dendrodoa pulchella* (Verrill). Circle of tentacles and dorsal lamina, ×7. Piece of a branch of the gonad (side next to branchial sac), ×15.

Cynthia pulchella Verrill, 1871, was described by that author on the basis of external characters only, with the result that it long remained an uncertain species. Examination of original material of Verrill showed that it was a *Dendrodoa* allied to *D. aggregata* which was considered by the present writer (Van Name, 1912) as a variety (*pulchella*) of that species. This view was adopted by the majority of writers since that time, though Hartmeyer, 1923, united it with *aggregata*, not considering any of the described varieties of that species as worthy of recognition.

In 1929 Huus, after further study of the group, concluded that *pulchella*, including *D. kükenthali* Hartmeyer, 1899, and *D. adolphi* Kupffer, 1874, which were evidently identical with it, constituted a species distinct from *aggregata*.

The most easily recognized distinguishing character of those that Huus discovered is that the gonad has normally only three (in exceptional cases only two) branches, not counting the branch formed by the oviduct, while in *aggregata* it normally has four or five branches.

There is likewise a difference in the structure of the gonad; in *pulchella* the testes lie against the mantle and the ovary lies upon them on the unattached side of the gonad (that next to the branchial sac). In *aggregata*

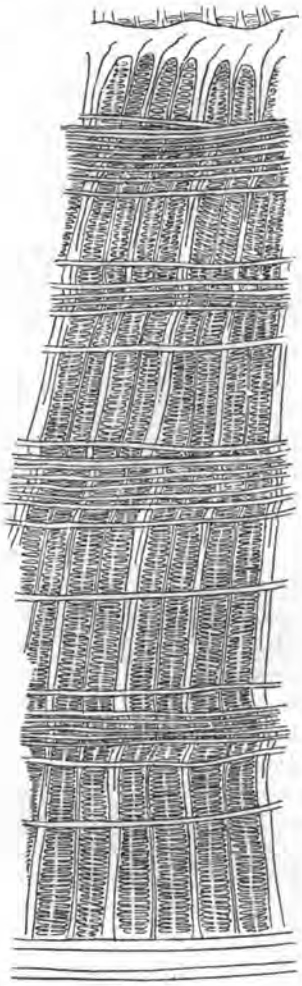


FIG. 173. *Dendrodoa pulchella* (Verrill). Part of branchial sac, ×11.

the ovary forms the axial or central part of each branch, and as may be seen in cross sections of the organ, it is surrounded on all, or nearly all, sides by the testes which are more lobed or branched than in *pulchella*. This difference is apparently a more fundamental one than the number of branches and, when the development and preservation of the specimen is such that it can be accurately observed, it appears to be a more certain means of distinguishing the species, since individual abnormality in the number of gonad branches may be very deceptive. Such abnormalities do occur, a *D. aggregata* occasionally having but three, while in *D. pulchella*, one of the three branches may divide.

The observations I have been able to make indicate that these differences hold good. Other differences are mentioned by Huus which are also observable, at least in many cases.

D. pulchella is a smaller species (usual maximum diameter 10 to 16 mm., seldom reaching 25 mm.). The body is usually more nearly globular, and the wrinkling of the surface finer, producing a smoother surface. Very rough specimens, such as occur in *aggregata*, are not frequent, if they occur at all. The branchial tentacles are also much more numerous (usually 50 to 60), as compared with 25 to 32 (seldom more) in *aggregata*. I have not, however, verified differences in the branchial sac by which the species can be distinguished. It is closely similar in both species; the development of the folds and the numbers of internal longitudinal vessels vary with age and size, and individually. In young specimens of either species, folds II or IV or both may be flattened and so reduced as to be represented only by a small group of, or even by only one or two, internal longitudinal vessels.

Neither can I vouch for the constancy of differences in the form of the stomach in the two species claimed by Huus to exist (see fig. 174A, 174B), though I have found such a difference more or less well marked in some cases.

DISTRIBUTION: This is a circumpolar Arctic species, having much the same distribution as *D. aggregata*. Not only do both often occur in the same region, but if we may judge by the number of gonad branches, both may often occur at the same exact station. But *D. pulchella* differs conspicuously in extending much farther south on the eastern American coast. While *aggregata* is not reliably reported south of Greenland, *pulchella* ranges southward to the St. Lawrence estuary, the Newfoundland Banks, the coast of Nova Scotia

(Halifax Harbor and Bedford Basin), and the region about the mouth of the Bay of Fundy and Eastport, Maine (the type locality); in all this region the depth, if reported, is in rather shallow water (15 to 40 fathoms). I have not been able to confirm, and do not accept as correct, any reports from localities farther south.

On the Alaska coast I do not have evidence of its ranging south beyond Nunivak Island, hence not so far as *D. aggregata* does, though *pulchella* is represented by numerous specimens in the American Museum of Natural History from St. Lawrence Island and Bering Strait, and farther north.

While the localities mentioned above are in shallow water, this species is by no means confined to small depths, as Hartmeyer, 1923, records specimens with three-branched gonads from "Ingolf" Station 35, in 352 fathoms and Station 27 in 393 fathoms, both in Davis Strait. It seems to be as well represented in deep water as *D. aggregata*, if not better, in cases where the depths are recorded.

Dendrodoa lineata (Traustedt), 1880

Text figure 169A

Dendrodoa lineata HARTMEYER, 1899, p. 268; 1899a, p. 487, fig. g, pl. 22, figs. 5, 6, pl. 23, figs. 7, 14; 1903, p. 248, pl. 5, figs. 10–11; REDIKORZEV, 1908, pp. 20, 26; 1916, p. 319, fig. 73, pl. 6, figs. 8, 15; ÄRNBÄCK, 1922, p. 46; HUUS, 1929, p. 12, fig. 8.
Styela lineata TRAUSTEDT, 1880, p. 413; KIAER, 1893, p. 53.

The only claim of this species, which I have not seen myself, to a place in this work rests on one record from Greenland, so that it can be briefly dealt with here.

It bears, both in its very variable but usually more or less short cylindrical form, a general resemblance to *D. aggregata* though of smaller size (maximum length recorded, 24 mm., more often 10 to 15 mm.).

The body usually has a few prominent longitudinal ridges on each side, but the special peculiarity of the species is the presence of a few (four to eight) large, wart-like tubercles on the anterior partof the body, each of them having a pit or depression on the top, so that they are described as simulating additional apertures.

Internally it differs from *aggregata* in the more numerous tentacles (35 to 40) and in the reduction of the folds and vessels of the branchial sac. Fold II is virtually obsolete and usually represented by only two vessels; fold IV is also much reduced. The total number of internal longitudinal vessels is fewer, and they are confined to the folds.

The gonad, as in *aggregata*, is four- or five-branched, but Huus, 1929, describes and figures it as resembling that of *D. pulchella* and *D. grossularia* in the relative position of the ovary and testes.

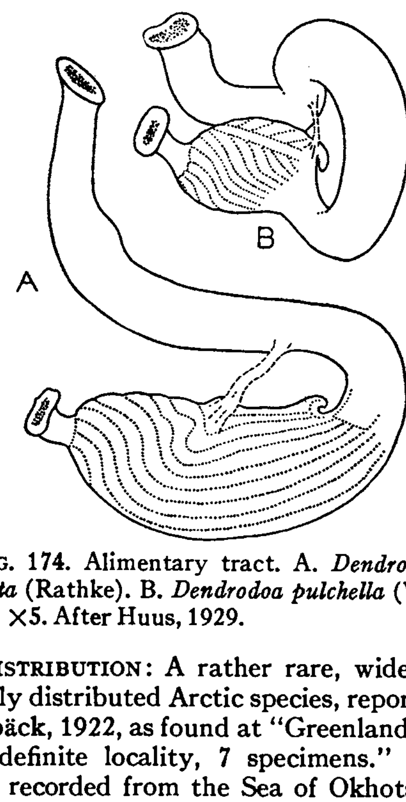


FIG. 174. Alimentary tract. A. *Dendrodoa aggregata* (Rathke). B. *Dendrodoa pulchella* (Verrill). Both ×5. After Huus, 1929.

DISTRIBUTION: A rather rare, widely but locally distributed Arctic species, reported by Ärnbäck, 1922, as found at "Greenland, without definite locality, 7 specimens." It has been recorded from the Sea of Okhotsk and the Asiatic coast of Bering Sea. Range in depth down to 100 fathoms.

SUBGENUS **STYELOPSIS** TRAUSTEDT, 1883

This is a well-marked subgenus of *Dendrodoa*, characterized by having the gonad of tubular form and unbranched and by the reduced condition of the folds of the branchial sac, only the first fold on the right side (none on the left) showing any actual plication, the other folds being represented, if at all, only by closely placed internal longitudinal vessels. These vessels are also very greatly reduced in number.

Dendrodoa (Styelopsis) grossularia
(Van Beneden), 1846
Text figures 169B, 175, 176

Ascidia grossularia VAN BENEDEN, 1846, p. 61, pl. 4, figs. 7–11.

Dendrodoa grossularia HARTMEYER, 1906, p. 122; 1912, p. 440; 1912c, p. 273; VAN NAME, 1912, p. 588, pl. 64, figs. 118, 119; HARTMEYER, 1914b, p. 1107; 1921a, p. 63; ÄRNBÄCK, 1922, p. 40, pl. 2, figs. 34–38; HARTMEYER, 1923, p. 314.

Styela grossularia KIAER, 1893, p. 55; 1896, p. 11.

Styelopsis grossularia TRAUSTEDT, 1883, p. 115; JULIN, 1892, p. 208; LACAZE-DUTHIERS AND DELAGE, 1892, p. 178, pls. 10, 11; RIEDLINGER, 1902, pp. 1–62, pls. 1–6; HARTMEYER, 1903, p. 253, pl. 5, figs. 12, 13; BJERKAN, 1905, p. 12; 1908a, p. 71; RITTER, 1913, p. 479; REDIKORZEV, 1916, p. 284, figs. 63, 64, pl. 6, fig. 2.

Styelopsis sp. HUNTSMAN, 1922a, p. 10.

For other references and synonyms, see Hartmeyer, 1923, p. 314.

This small ascidian is found in two rather well-marked forms, the solitary and the ag-

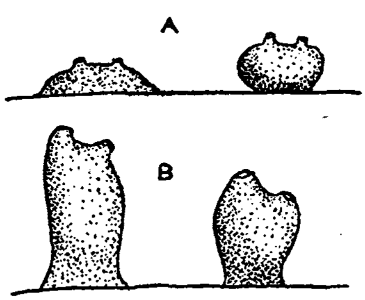


FIG. 175. *Dendrodoa (Styelopsis) grossularia* (Van Beneden). Outlines of lateral aspect of individuals of solitary form (A) and the aggregated form (B). About natural size.

gregated, differing in shape and in the number of internal longitudinal vessels in the branchial sac. The *aggregated* form (not reported from American waters) grows, as its name indicates, in close groups or clusters, often consisting of large numbers of individuals. In that form the body is typically ovate or short cylindrical, attached by one end; the branchial siphon is at the opposite end and the atrial a little way back from it. Internally the aggregated form is distinguished by having more internal longitudinal vessels, a total number of 28 or 29 on the right side of the sac and about 20 on the left side being sometimes found, but all authors appear to be agreed that it is not possible to separate the two forms as distinct varieties or subspecies.

The solitary form has a fewer number of internal longitudinal vessels than the aggregated form, though more than *D. carnea* described below, and has the body more or less depressed dorsoventrally, usually dome shaped and attached by the entire ventral surface. In external characters and appearance as well as in internal characters excepting the branchial, it corresponds so exactly

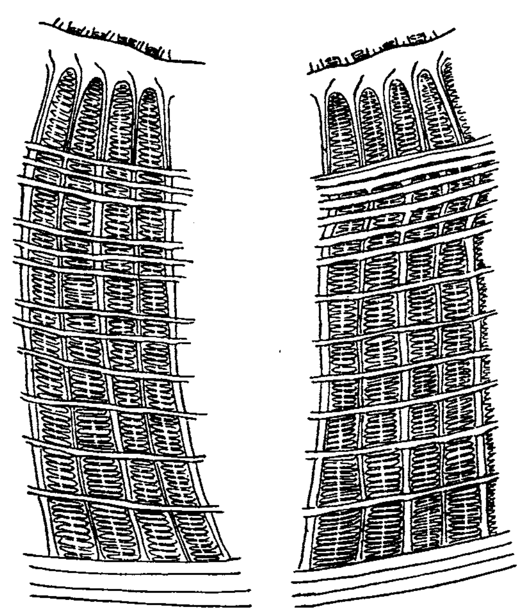


FIG. 176. *Dendrodoa (Styelopsis) grossularia* (Van Beneden). Solitary form. Part of left and right sides of branchial sac, ×10.

to *D. carnea* that I shall not take the space for what would be mere repetition. In size it apparently sometimes exceeds *carnea*, as European authors have recorded examples 20 mm., even more, in greatest diameter, but over 15 mm. is certainly somewhat unusual.

It is only by an examination of the branchial sac that it can be distinguished from *carnea*. As in that species, fold I of the right side is the only one in the whole sac showing any actual plication, but some, or even all, of the other folds are often indicated by a close grouping of the internal longitudinal vessels.

Instead of a total of eight (very rarely nine) of these vessels on the right side and four (very rarely five) on the left, as is apparently invariable in *carnea*, we have in the largest of several American specimens of *grossularia* the following arrangement: 17 on the right side and 16 on the left, these being so grouped as to indicate distinctly four folds on each side:

Right	0 (7) 0 (3) 0 (4) 0 (3) 0 total 17
Left	0 (4) 0 (4) 0 (4) 0 (4) 0 total 16

Huntsman (1912, p. 146) indicates the distribution in a specimen from St. Andrews, New Brunswick, which I think is clearly of the present species, as follows:

Right	0 (4) 1 (3) 0 (2) 0 (1) 0 total 11
Left	0 (2) 1 (2) 1 (2) 0 (2) 0 total 10

The total number in the specimens I have seen, and in all the numerous specimens from various localities whose vessels are tabulated by Hartmeyer, 1923, is considerably in excess of the number present in *D. carnea* and does not exhibit the constancy characteristic of that species.

DISTRIBUTION: Chiefly an Old World species found in that part of the Arctic which lies north of Europe, ranging south to the coasts of the British Islands (where it is an abundant species) including both coasts of the English Channel. In American waters it occurs sparingly about Greenland, especially in Davis Strait (there is also a record from Gaase Fjord in Ellesmere Land) and ranges south to the Gulf of St. Lawrence, where it is not uncommon, the Banks of Newfoundland and (rarely) to the vicinity of Eastport, Maine, thus only very slightly overlapping the range of the more southern *D. carnea*. Ritter (1913, p. 479) reports a single group of specimens from Bering Sea (St. Paul Island).

This wide range is that of the solitary form only. The aggregated form occurs only in the more southern parts of its range in European waters, especially where the species is abundant (see Hartmeyer, 1923, Lacaze-Duthiers and Delage, 1892).

D. grossularia is a species of shallow, or at least comparatively shallow, water, usually growing from a little below extreme low-water mark down to depths of 20 to 30 fathoms, below which it becomes less common, though occasionally found in considerable depths (300 meters down to an extreme of over 600 meters, according to Hartmeyer, 1923).

Dendrodoa (Styelopsis) carnea

(Agassiz), 1850

Plate 4, figure 4; text figures 177, 178

Ascidia carnea AGASSIZ, 1850, p. 159; DALL, 1870, p. 255; BINNEY, 1870, p. 25, pl. 24, figs. 334, 335.

Cynthia carnea VERRILL, 1871a, p. 362; 1872, p. 5; 1874a, p. 60; SUMNER, OSBURN, AND COLE, 1913, p. 730; PRATT, 1916, p. 666, fig. 1010.

Cynthia carnea (in part) VERRILL, 1871, p. 94, fig. 9 (not figs. 7, 8); 1872a, p. 213; VERRILL AND SMITH, 1873, pp. 495, 701, pl. 33, fig. 247 (not fig. 248); WHITEAVES, 1874, p. 12; METCALF, 1900, p. 511, pl. 35, figs. 17, 18.

Cynthia gutta STIMPSON, 1852, p. 231; VERRILL, 1870a, p. 424; DALL, 1870, p. 255; BINNEY, 1870, p. 19; BJERKAN, 1908, p. 7. Not Sars, 1859; not Lutkin, 1861.

Cynthia (*Halocynthia*) *tuberculum* KINGSLEY, 1901, p. 183.

Dendrodoa aggregata (in part) HARTMEYER, 1903, p. 235; 1909–1911, p. 1361.

Dendrodoa carnea VAN NAME, 1912, p. 585, fig. 40, pl. 64, figs. 114–117, pl. 72, fig. 158; HUNTSMAN, 1912, pp. 112, 146; PRATT, 1935, p. 748.

Dendrodoa grossularia form *carnea* ÄRNBÄCK, 1922, p. 42; HARTMEYER, 1923, p. 328.

Halocynthia tuberculum (in part) VERILL, 1879, p. 27; 1879b, p. 197; WHITEAVES, 1901, p. 269.

Styelopsis carnea HUNTSMAN, 1913, p. 499, fig. 11.

See remarks under *Styela coriacea* on the use of the name *carnea* for that species also.

Body flattened dorsoventrally, having the form of a very depressed dome or cone, or often almost disk-like, attached by the entire ventral surface, and having the small square apertures on low elevations a little way apart on the upper surface. Outline of body when seen from above rounded or elliptical, 11 mm. long by 9.5 mm. broad in the largest specimen

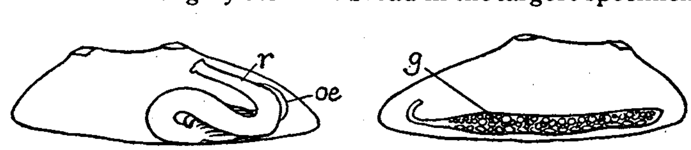


FIG. 177. *Dendrodoa* (*Styelopsis*) *carnea* (Agassiz). Left and right sides of body, ×4.5.

studied. Test thin and parchment-like, generally nearly smooth to the naked eye, though finely wrinkled under magnification. Old individuals may be more coarsely wrinkled. The test spreads out on the surface to which the animal is attached, forming a border often 2 mm. wide. This part of the test is penetrated by club-shaped vascular processes of the mantle. Color when alive pinkish to bright red, often appearing like a drop of blood. The color fades out in preservation.

Mantle thin, with slight musculature. Tentacles about 32, of two sizes alternating with some regularity, a few still smaller tentacles often present. Dorsal lamina plain edged. Dorsal tubercle small, oval, its aperture also oval or elongated anteroposteriorly.

Branchial sac with only one actual fold (fold I) on the right side of the body; none on the left side. The fold bears four (rarely more) internal longitudinal vessels; on the rest of the right side of the sac there are three widely spaced vessels. On the right side there are usually four widely spaced vessels. Assuming that these separated vessels represent folds, the usual distribution of vessels may be written as follows:

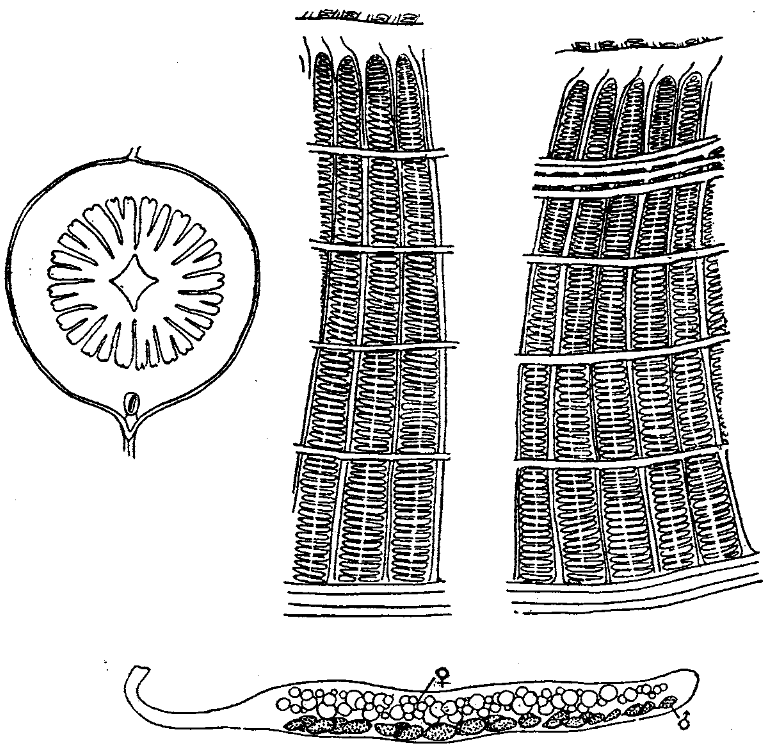


FIG. 178. *Dendrodoa* (*Styelopsis*) *carnea* (Agassiz). Circle of tentacles and dorsal tubercle, part of left and right side of branchial sac, and gonad (lateral aspect).

Right 0 (4) 0 (1) 0 (1) 0 (1) 0 total 7
Left 0 (1) 0 (1) 0 (1) 0 (1) 0 total 4

or occasionally in large individuals:

Right 0 (5 or 6) 0 (1) 0 (1) 0 (1) 0 total 8 or 9
Left 0 (1 or 2) 0 (1) 0 (1) 0 (1) 0 total 4 or 5

In large individuals, about 15 stigmata may intervene between the separate vessels. About 22 transverse vessels alternating in size were present in a moderately large specimen, also additional parastigmatic vessels.

Stomach short and wide, with 12 to 16 longitudinal folds and a small, narrow, curved, pyloric caecum.

Intestinal loop small, margin of anus two-lipped and reflected, but not lobed.

Gonad a slender, anteroposteriorly directed

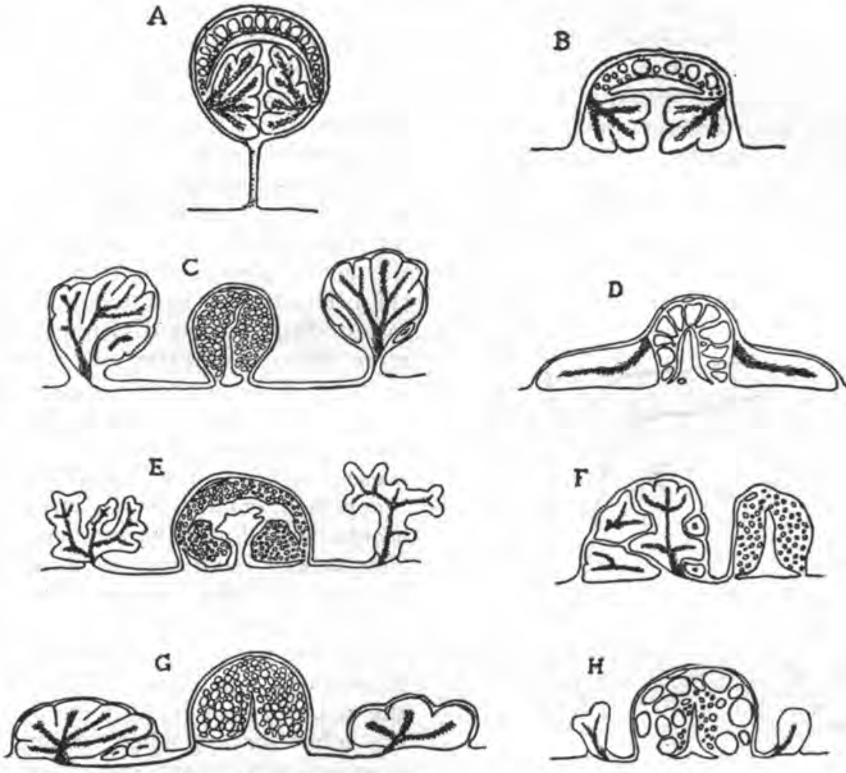


FIG. 179. *Styela* and allied genera. Cross sections of gonads. A. *Cnemidocarpa finmarkiensis*. B. *Polycarpa fibrosa*. C. *Styela rustica*. D. *Pelonaia corrugata*. E. *Styela partita*. F. *Styela coriacea*. G. *Styela atlantica*. H. *Styela yakutatensis*. After Huntsman, 1913.

tube in the right ventral part of the body, ending in a curved oviduct. The small oval testes occupy the part against the mantle.

DISTRIBUTION: Found from the Banks of Newfoundland ("Albatross" Station 2444, 45° 59′ N., 49° 45′ 30″ W., 39 fathoms) and the Bay of Fundy region south to Long Island Sound, New York; rather common in many places in shallow water, on stones, dead mussel shells, etc., and conspicuous for its very bright red color. The above record of 39 fathoms is the deepest that I know of. In the Gulf of St. Lawrence and northward it appears to be replaced by the solitary form of *D. grossularia*.

Ärnbäck, 1922, and Hartmeyer, 1923, have reduced it to the status of a form of *D. grossularia*, and its close relationship to that species is in favor of such a course, but the constancy of the characters in which it differs as well as its different (more southern) geographical range, which overlaps that of *grossularia* only a little, should, I think, entitle it to recognition as a species.

GENUS STYELA FLEMING, 1822
(= *Tethyum* Hartmeyer, 1909–1911; Van Name, 1912)

Even in its present restricted usage (excluding *Cnemidocarpa*), this is a large genus of simple Styelidae. The body is variously shaped, sometimes produced at the rear end into a short stalk or pedicel, sometimes ovate or dome shaped and attached by a broad base. The apertures are both four-lobed or square; the test is usually opaque, leathery, and rough or wrinkled externally. All four of the branchial folds are well developed in most of the species. The gonads are few, though present on both sides of the body, often but one on each side, and differ from those of *Cnemidocarpa* in the ovary and testes being more separated. The ovary is more or less elongate or tubular, occasionally branched, and is produced into a short oviduct; the testes, which are small, usually lobed or branched glands, sometimes confluent at their basal ends into dense clusters, are attached to the body wall alongside or near the ovary or grouped about its closed end. Their ducts extend to the ovary and rising onto its free surface (that next to the branchial sac) unite on its surface to a common duct which ends on a papilla beside, but just short of, the opening of the oviduct.

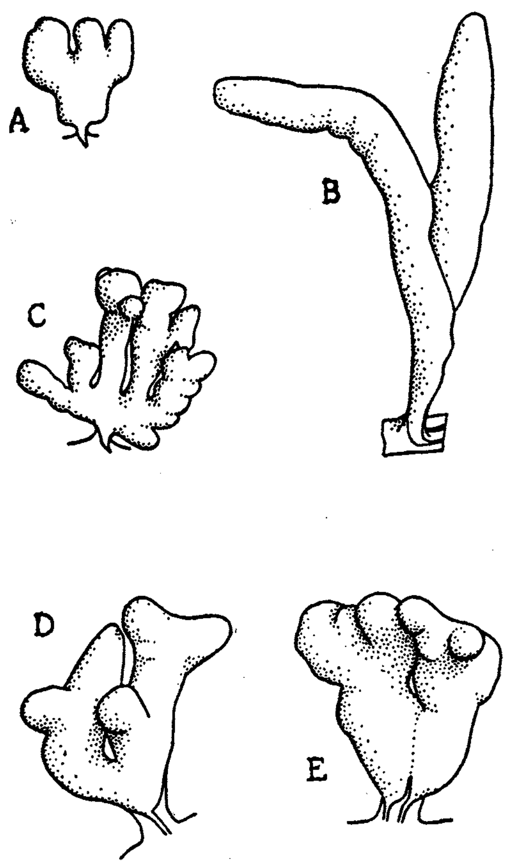


FIG. 180. Genus *Styela*. Typical form of the male glands in well-developed gonads of the following species: A. *Styela truncata*. B. *Styela clavata*. C. *Styela partita*. D. *Styela montereyensis*. E. *Styela yakutatensis*. After Huntsman, 1913.

The structure of the gonads of *Styela* is sufficiently different from that found in *Cnemidocarpa* to make it justifiable from a morphological point of view, as well as a matter of convenience, to recognize both those genera as distinct, but I am in accord with the view of Hartmeyer in being unwilling to concede generic rank to the other groups into which Huntsman (1912a, 1913) split up *Styela* on the basis of small details in the structure of the gonads, believing that their recognition as more than minor subdivisions involves losing sight of the homogeneous character of the genus *Styela*, and that if more species than Huntsman had available were taken into account such a division would be much more difficult to carry out satisfactorily on account of species with intermediate characters. The new groups to which he accorded generic rank are (besides *Styela* in a restricted sense, including the American species *partita*, *gibbsii*, *montereyensis*, and *plicata*): *Goniocarpa*, including *coriacea* (type) and *rustica*; *Botryorchis*, including *atlantica* (type); and *Katatropa*, including *vancouverensis* (type), which is a synonym of *truncata*, and *yakutatensis*. Huntsman's groups (except the last mentioned, *Katatropa*) are distinguished by the manner in which the individual testes are lobed or branched, or in some cases grouped into clusters or masses. For details, the reader is referred to Huntsman's article of 1913, but figure 179 of the present work shows cross sections of the gonads of typical examples of his groups. His other group, *Katatropa*, is likewise based on a very minor though interesting character: that the distal or oviducal end of the ovaries, which are elongate, bends somewhat ventrally (toward the endostyle) instead of toward the base of the atrial siphon as in most members of the genus *Styela*.

Styela gelatinosa Traustedt, 1886

Goniocarpa gelatinosa HUNTSMAN, 1913, p. 498; REDIKORZEV, 1916, p. 227, figs. 45, 46.

Styela doliolum BJERKAN, 1905, p. 8, pl. 1, figs. 7, 8, pl. 2, figs. 1–4; 1908a, p. 65; ÄRNBÄCK, 1922, p. 12.

Styela gelatinosa TRAUSTEDT, 1886, p. 429, pl. 36, figs. 8–11, pl. 38, fig. 27; HARTMEYER, 1903, p. 207; MICHAELSEN, 1904a, p. 236; ÄRNBÄCK, 1922, p. 12; HARTMEYER, 1923, p. 213, pl. 1, figs. 9, 10.

Styela rustica (?) BONNEVIE, 1896, p. 4, pl. 3, fig. 5 (not Linnaeus, 1767).

Tethyum doliolum HARTMEYER, 1909–1911, p. 1359; 1912b, pp. 374, 378.

Tethyum gelatinosum HARTMEYER, 1909–1911, p. 1359; REDIKORZEV, 1910, p. 124; HARTMEYER, 1912b, p. 257.

A species variable in form; usually pear shaped, barrel shaped, or cylindrical, often extended at the lower end into a short peduncle by which it is attached. Apertures near together at the opposite end, nearly even with the surface or raised on papillae. It reaches quite a large size. Hartmeyer, 1923, records examples 67 mm. high by 2.3 mm. wide, and 84 mm. high by 30 mm. wide, but these are extremes; the majority do not exceed 30 to 40 mm. in height.

The surface varies from fairly smooth to quite rough and wrinkled (usually transversely) and is usually not much incrusted with foreign matter. Color in preservation yellowish gray to brown; test translucent in many specimens.

Mantle musculature slight in young specimens, fairly well developed in adult ones. Traustedt gives the number of branchial tentacles as 42, of three sizes. Hartmeyer found but 30 in a large specimen. Small atrial tentacles present. Dorsal tubercle horseshoe shaped, the open interval forward or obliquely to the left, according to the majority of reports. Margin of dorsal lamina more or less toothed or uneven. Branchial sac with four well-developed folds, although folds II and IV are lower than the others. They bear numerous internal longitudinal vessels, 30 to 40 or more on the higher folds, and many, sometimes 20 to 25, on the flat intervals. The meshes are consequently small, usually containing only two or three, less often four, stigmata.

The stomach is far back in the body, extending beyond the branchial sac. It is ovate with numerous (36 to 40) distinct longitudinal plications in its wall.

There is a single gonad on each side, each with a very long tubular ovary which terminates near the atrial aperture after extending much of the length of the body. The testes are small and numerous, pyriform or more or less cleft, and are entirely confined to, and compactly clustered around, the somewhat enlarged closed end of the ovary. Their common sperm duct accompanies and lies upon the unattached aspect of the ovary in the usual manner.

DISTRIBUTION: This is chiefly an Old World Arctic species, but it has to be included in this work as there are several records from Greenland waters (deeper parts of Davis Strait from 66° 35′ N. to 63° 30′ N.; also from Hurry Inlet, 70° 36′ N.) It is not a common species and occurs chiefly in deep water (deepest records, 1100 and 1312 meters), but in high latitudes in water as shallow as 90 meters. Type locality, the Kara Sea.

Styela coriacea (Alder and Hancock), 1848

Text figures 179F, 181–183

Ascidia lovenii SARS, 1851, p. 157.

Cynthia carnea (in part) VERRILL, 1870a, p. 424; 1871, p. 94, figs. 7, 8 (not fig. 9); 1872a, p. 213; WHITEAVES, 1873, p. 17; VERRILL AND SMITH, 1873, p. 701, pl. 33, fig. 248 (not fig. 247); VERRILL, 1873–1874, vol. 7, pp. 43, 413, 504; 1874, pp. 352, 363; WHITEAVES, 1874, p. 12; PACKARD, 1891, p. 397.

Cynthia coriacea ALDER AND HANCOCK, 1848, p. 195. Not Stimpson, 1864.

Cynthia lovenii SARS, 1859, p. 64.

Cynthia placenta PACKARD, 1867, p. 277; BINNEY, 1870, p. 19, pl. 23, fig. 322; DALL, 1870, p. 255.

Cynthia tuberculum (in part) KINGSLEY, 1901, p. 183.

Goniocarpa coccodes HUNTSMAN, 1912, pp. 114, 131; 1912a, p. 154, pl. 12, fig. 8, pl. 13, fig. 1, pl. 19, fig. 8, pl. 20, fig. 1.

Goniocarpa coriacea HUNTSMAN, 1912, p. 131; 1912a, p. 154; 1913, p. 498, figs. 3, 7, 13; REDIKORZEV, 1916, p. 244, figs. 52, 53, pl. 5, figs. 13–15.

Goniocarpa lovenii HUNTSMAN, 1922, p. 8; 1922a, p. 12.

Goniocarpa placenta HUNTSMAN, 1912, p. 113.

Halocynthia tuberculum (in part) VERRILL, 1879, p. 27; 1879a, p. 148; 1879b, p. 197; WHITEAVES, 1901, p. 269.

Styela coriacea ALDER AND HANCOCK, 1907, p. 109, pl. 37, figs. 1–4, pl. 39, figs. 2, 3, pl. 41, figs. 4, 5; HARTMEYER, 1923, p. 220.

Styela lovenii KIAER, 1893, p. 46; 1899, p. 8; HARTMEYER, 1903, p. 209 (*loveni*), pl. 5, figs. 4–6, pl. 11, figs. 6–9; RITTER, 1913, p. 477 (*loveni*); HARTMEYER, 1914b, p. 1105 (*lovenii*); 1921a, p. 36 (*lovenii*); 1922a, p. 44 (*lovenii*); ÄRNBÄCK, 1922, p. 15 (*lovenii*), pl. 1, figs. 3, 4.

? *Styela* sp. RITTER, 1913, p. 478.

Tethyum coriaceum HARTMEYER, 1912, p. 440; VAN NAME, 1912, p. 560, fig. 33, pl. 58, figs. 86–88, pl. 73, figs. 164, 165.

Tethyum loveni HARTMEYER, 1912c, p. 267.

Not *Cynthia coriacea* Stimpson, 1864.

For other synonyms and citations, see Hartmeyer, 1923.

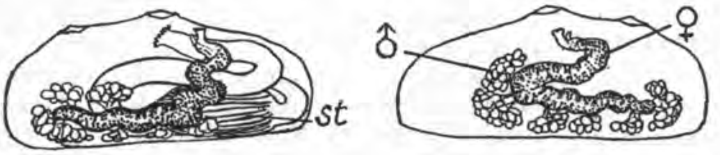


FIG. 181. *Styela coriacea* (Alder and Hancock). Left and right sides of body, ×2.5.

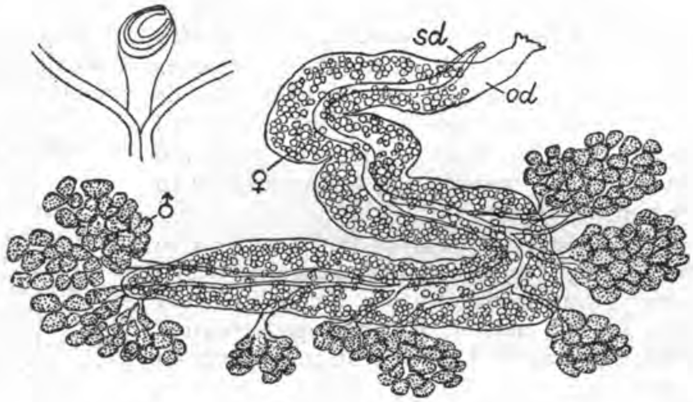


FIG. 182. *Styela coriacea* (Alder and Hancock). Right gonad (side next to the branchial sac), ×7, and dorsal tubercle.

FIG. 183. *Styela coriacea* (Alder and Hancock). Part of branchial sac, ×18.

When alive this species is very contractile and able to change its shape greatly. Aside from this, it is subject to much individual variation in form. Living extended specimens are often rather tall and cylindrical with the four-lobed apertures on prominent, divergent tubes arising from the upper part of the body. This condition will rarely be found in preserved specimens, which are generally much contracted and often have a low, dome-shaped, or flattened conical form of circular or oval outline when seen from above. Such individuals are attached by a broad expanded base, and the apertures may be but little raised above the body surface. The test commonly spreads out a little on the surface to which the animal is attached.

Alcoholic specimens are commonly of a dull gray or brown color. When alive it is "dark reddish brown or orange-brown, darker below, the wrinkles lighter than the interstices and often salmon colored; the upper parts, especially the summit between the apertures are deep salmon. The apertures are orange within and surrounded by a ring of bright red" (Verrill, 1871).

The test is rough, finely wrinkled, or verrucose; one feature of aid in recognizing the species because observable on a large proportion of the specimens is that the body surface, especially on the upper parts, is usually studded with minute, round (hemispherical) tubercles which are generally translucent and under magnification look like grains of smooth, water-worn sand projecting from the test, or like small blisters. They are additional to, and often borne on, the larger wrinkles or elevations of the surface.

The largest specimens I have studied were dome shaped and measured from 18 to 20 mm. in longitudinal diameter and 13 to 15 mm. transversely, but in contracted condition only 5 to 9 mm. high.

Mantle musculature moderately developed on the dorsal parts but weak on the ventral region. Tentacles numerous, 50 or more in large specimens, of various sizes. Dorsal lamina plain edged. Dorsal tubercle horseshoe shaped, the open interval to the left or somewhat forward in the specimens studied.

Branchial sac with four well-developed folds. Internal longitudinal vessels fairly numerous on, as well as between, the folds; counts on two quite large specimens:

3 (14) 4 (9) 5 (12) 4 (6) 3
4 (22) 6 (14) 5 (18) 6 (10) 8

In smaller specimens the number of vessels is considerably less. The meshes of the sac are small, containing usually only two, three, or four stigmata.

Stomach rather wide, with numerous plications and often with a small rudiment of a pyloric caecum. Intestinal loop fairly large, but the parts of the intestine become somewhat crowded together and displaced by the flattening of the body in contraction.

Gonads one on each side, each consisting of an elongated, very sinuously curved ovary and a number of small male glands gathered into compact groups along one or both sides (especially the ventral side) of the ovary, but a little removed from it. The general direction of the ovaries is horizontal, with the open end bent dorsally. That of the right side bends very abruptly, often doubling forward almost parallel to the main part for a little distance. Figure 182 shows the course of the sperm ducts.

DISTRIBUTION: Widely distributed in the Arctic and northern regions, including both coasts of Greenland; probably it is completely circumpolar. In European waters it ranges south to both shores of the British Channel; on the American side to the Banks of Newfoundland, the Maine coast, and Massachusetts Bay (most southern stations, United States Fish Commission Station 21, off Bakers Island, near Salem, Massachusetts, 21 fathoms, and United States Fish Commission Station 236, off Cape Ann, Massachusetts, 42° 28′ N., 70° 31′ W., 28 fathoms). On the Pacific side it is common in the vicinity of Bering Strait; it ranges south along the whole British Columbia coast (Huntsman, 1912, 1912a), and is represented by a very closely allied variety (*hemicaespitosa*) off southern and Lower California.

This species is the type of Huntsman's genus *Goniocarpa*, which includes also *Styela rustica*.

Verrill held the mistaken belief that the present species and *Ascidia carnea* Agassiz (=*Dendrodoa carnea* of the present article) were one and the same, *carnea* being the young, which resulted in the use of *Cynthia carnea* by him and a few others for both species. (See Van Name, 1912, p. 563.)

Styela coriacea hemicaespitosa Ritter, 1913

Styela hemicaespitosa RITTER, 1913, p. 471, pl. 34, figs. 21–23.

Although Hartmeyer, 1923, refused to recognize this form and united it with *S. coriacea*, it is a geographic race differing so strikingly from the typical *coriacea* in appearance that its recognition as a subspecies seems to be worth while. The differences are mainly in external characters which Ritter describes as follows:

"Posterior half or less of body covered by a dense mat composed of short, filiform or more or less intertwined processes growing on the test, this carrying among and clinging to the processes a quantity of fine greenish earth, anterior half or more wholly devoid of the processes, the test here varying from nearly smooth in the flat form to pronouncedly tuberculate, particularly around the orifices, the tubercles are generally somewhat soft and blister-like, often low and flat and separated from one another by considerable intervals. Form varying from flat elliptical to high conical or cylindrical."

DISTRIBUTION: All the specimens of this variety except two (see below) recorded by Ritter were from off the coast of southern California or Lower California: "Albatross"

Station 2972 (type locality), 34° 18′ 30″ N., 119° 41′ W., 61 fathoms (about 40 specimens, mostly of the flat form); Station 2971, 34° 20′ 30″ N., 119° 37′ 50″ W., 29 fathoms; Station 2838, 28° 12′ N., 115° 09′ W., 44 fathoms (about 20 specimens, all of the

FIG. 184. *Styela rustica* (Linnaeus). Exterior view, natural size.

pyramidal form). Very characteristic specimens of the tall pyramidal form have been collected off Balboa, California, in 18 fathoms by G. E. MacGinitie.

The two other specimens recorded by Ritter were from a quite northern locality, "Albatross" Station 3227, in Bering Sea near the end of the Alaskan Peninsula, in 225 fathoms, thus widely overlapping the southern limits of the range of typical *coriacea*.

Styela rustica (Linnaeus), 1767

Plate 3, figures 3, 4; text figures 179C, 184–187

Ascidia monoceros H. P. C. MOELLER, 1842, p. 95; SARS, 1851, p. 157.

Ascidia quadridentata LINNAEUS, 1767, p. 1087.

Ascidia rustica LINNAEUS, 1767, p. 1087.

Cynthia condylomata PACKARD, 1867, p. 277; BINNEY, 1870, p. 19, pl. 23, fig. 324; DALL, 1870, p. 255.

Cynthia monoceros STIMPSON, 1860a, p. 2 (*monocera*); VERRILL, 1871, p. 93; 1872a, p. 214; WHITEAVES, 1874, p. 12; 1874a, p. 214; PACKARD, 1891, p. 396.

Cynthia rustica RINK, 1857, p. 104; LÜTKEN, 1875, p. 138.

Goniocarpa rustica HUNTSMAN, 1912, p. 131; 1913, p. 498, fig. 3; REDIKORZEV, 1916, p. 229, figs. 47–49, pl. 5, figs. 9–11; HUNTSMAN, 1922, p. 9; 1922a, p. 13.

Halocynthia rustica VERRILL, 1879, p. 27; 1879a, p. 147; 1879b, p. 197; WHITEAVES, 1901, p. 268; STAFFORD, 1912, p. 60.

Styela rustica TRAUSTEDT, 1883a, p. 480, pl. 36, figs. 18, 19; KIAER, 1893, p. 47; 1896, p. 8; HARTMEYER, 1903, p. 217, pl. 5, figs. 2, 3; 1914b, p. 1104; 1920, p. 129; 1921a, p. 33; 1922a, p. 11; ÄRNBÄCK, 1922, p. 12, pl. 1, figs. 1–2; HARTMEYER, 1923, p. 196.

Tethyum rusticum HARTMEYER, 1910a, p. 234; 1912, pp. 439, 440; 1912c, p. 266; VAN NAME, 1912, p. 459, fig. 30, pl. 59, figs. 89–91, pl. 69, fig. 138.

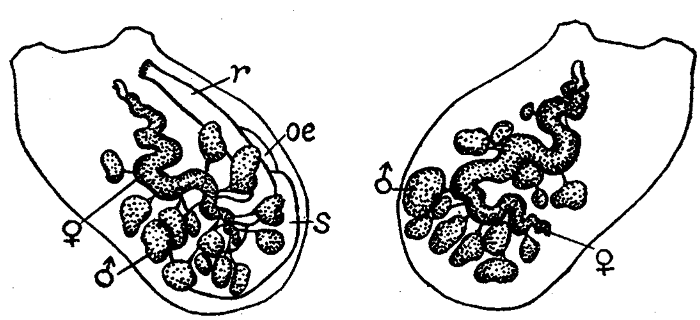
Not *Ascidia rustica* Couthouy, 1838; Gould, 1841; De Kay, 1843 (*Ascidea r.*); Binney, 1870.

See Hartmeyer, 1923, for extensive list of citations to that date.

Ordinary shape of the body somewhat elongated ovate, larger near the anterior than at the posterior (attached) end. Apertures on small (often inconspicuous) elevations; the branchial is terminal, the atrial a little way back from the end. Yet low, rounded individuals attached by a broad base also occur, and some are even greatly flattened dorsoventrally, so that their shape is that of a very flat cone, the test spreading out beyond the border of the body on the surface to which they are attached.

The most conspicuous external character of the species, observable in a large proportion of the specimens, is a spine or projection of the test commonly of irregular conical or

FIG. 185. *Styela rustica* (Linnaeus). Left and right sides of body, ×1.4.



pointed form and sometimes 5 mm. or more high, situated between the two siphons. Its presence will be found a virtually certain means of identifying this species; its absence or reduction is, however, quite frequent, more so in old and large specimens, and is not of significance.

The test is thick and leathery, especially anteriorly, strongly wrinkled in a transverse direction; anteriorly the wrinkles usually break up into rounded prominences. Color reddish or brownish, especially near the apertures; the color often retained to a considerable extent in preservation. Size very variable, largest eastern North American specimens examined were 46 to 55 mm. high and 25 mm. or more dorsoventrally. Generally distinguishable from *Styela partita* by larger size and thicker test with more coarsely and deeply wrinkled surface, even when the pointed process between the apertures is wanting.

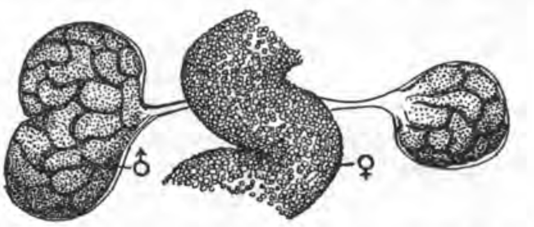


FIG. 186. *Styela rustica* (Linnaeus). Part of a gonad, ×10.

Mantle thick, with heavy musculature, the circular layer being especially thick. Tentacles rather few; about 14 large tentacles probably representing two orders were counted in a large individual, which also had additional small ones in the intervals. Dorsal lamina plain; dorsal tubercle with U- or horseshoe-shaped aperture, one or both horns often inrolled; the open interval forward or obliquely to the left.

Branchial sac with four well-developed folds usually narrow in comparison to the flat intervals. Internal longitudinal vessels numerous, usually separated by from five to eight stigmata (or by a larger number near the endostyle) on the flat intervals. Distribution of internal longitudinal vessels on the right side in a rather large specimen:

7 (19) 8 (17) 6 (18) 6 (14) 3

FIG. 187. *Styela rustica* (Linnaeus). Part of branchial sac, ×10.

On the left side the first fold was closer to the dorsal lamina and separated from it by only three vessels.

Stomach fairly long, wide at the cardiac end, curved and narrowed rather gradually into the intestine which forms a rather compact loop. Stomach wall minutely and not very regularly plicated. Rectum long, the margin of its opening lobed.

One gonad on each side of the body. The ovaries are tubular, bent in deep, sinuous curves, and more or less longitudinal in direction with respect to the body, though the posterior part of the right ovary is usually abruptly bent posteriorly. The testes are rounded oval or bean-shaped bodies, each composed of crowded lobes of irregular shape; some lie close to the ovary, some at a distance. The ovary and testes are not so closely attached to the mantle as in *S. coriacea*, and the testes are of more spherical form, but, as in that species, there is a single system of sperm ducts for the whole gonad.

DISTRIBUTION: A circumpolar Arctic species, found to be common in most parts of that zone where much collecting has been done, especially about Greenland, Spitzbergen, and the White Sea. On the European side it extends southward to Denmark but does not reach the coast of the British Islands. On the American side it reaches Labrador, the St. Lawrence estuary, and the Banks of Newfoundland, where it is common, but not so far as the Bay of Fundy or the New England coast. In Bering Sea it is mainly but, according to Redikorzev, not entirely replaced by the variety *macrenteron*. Its extreme range in depth is given as 0 to 432 meters, but between 10 and 100 meters is more usual.

Styela rustica macrenteron Ritter, 1913

Goniocarpa macrenteron REDIKORZEV, 1916, p. 240, figs. 50–51, pl. 5, fig. 12.

Styela macrenteron RITTER, 1913, p. 466, pl. 34, figs. 18–20.

Styela rustica var. *macrenteron* ÄRNBÄCK, 1922, p. 14.

This cannot be given higher rank than a subspecies or variety of *S. rustica*. In most characters, including the usual presence of a spine or at least a very prominent tubercle between the siphons, it is the same as that species.

It is of larger size (often reaching 90 mm. in length), in general, cylindric in form, the length from two to three times the diameter. Usually attached by the whole posterior end and rising column-like. Smaller specimens more nearly spherical, often in clusters.

Test thin and parchment-like, but the outer surface presenting a great number of nearly parallel circular ridges; "in addition to the ridges the surface of the test bearing short thick somewhat fleshy processes, on some areas of the surface so close together as to give the appearance of plush or velvet, occasionally areas devoid of ridges or processes, being left smooth and glistening. Color light gray" (Ritter).

As would be expected in larger specimens, the tentacles and branchial vessels are somewhat more numerous than usual in the typical *rustica*, but the chief internal difference is in the alimentary tract, as the name indicates.

The development of those organs relative to the body size is much greater; the stomach is long and narrow, reaching from the very base of the body to above its middle; it has from 25 to 50 prominent internal longitudinal plications which are visible externally also. "Intestine remarkable for its great length and its convolutions, the latter being at least two in number, the coils again often increased in length by their tortuous course" (Ritter).

DISTRIBUTION: As stated above, this form largely, but not entirely, replaces the ordinary *rustica* in Bering Sea, being especially common in the southeast part, occurring also in the eastern part of the Siberian Arctic Ocean, Sea of Okhotsk, etc., but does not appear to occur in the other parts of the extensive range of *rustica*.

Styela partita (Stimpson), 1852

Plate 3, figures 7, 8, plate 10, figure 3; text figures 179E, 180C, 188

? *Ascidia microcosmus* COUTHOUY, 1838, p. 111 (not Cuvier, 1815); DEKAY, 1843, p. 259.

? *Ascidia rugosa* AGASSIZ, 1850, p. 159 (description insufficient); BINNEY, 1870, p. 20; DALL, 1871, p. 255.

Cynthia partita STIMPSON, 1852, p. 231; BINNEY, 1870, p. 18; DALL, 1870, p. 255; VERRILL, 1871a, p. 362; 1872a, p. 213, pl. 8, fig. 7; VERRILL AND SMITH, 1873, pp. 311, 701, etc., pl. 33, fig. 246; COUES AND YARROW, 1878, p. 304; HOWARD, 1883, p. 304; BUMPUS, 1898, p. 853; HARTMEYER, 1915, p. 313. Not Verrill, 1885, p. 259 = *S. atlantica*.

Cynthia stellifera VERRILL, 1871, p. 93, figs. 5, 6.

Halocynthia partita VERRILL, 1879, p. 27; 1879a, p. 148; 1879b, p. 197; MCDONALD, 1885, p. 858.

Styela aggregata var. *americana* METCALF, 1900, pp. 516, 588.

Styela canopoides HELLER, 1877, p. 254, pl. 6, figs. 1–3; TRAUSTEDT, 1883a, p. 478, pl. 36, figs. 13–18, pl. 37, figs. 8, 11; VERRILL, 1900, p. 589; VAN NAME, 1902, pp. 327, 389.

Styela partita VERRILL, 1901, pl. 9, fig. 8a–8c; HARTMEYER, 1903, p. 216, pl. 11, figs. 1–5; SUMNER, OSBURN, AND COLE, 1913, p. 730, chart 192; HUNTSMAN, 1913, pp. 492, 496, fig. iv; HARTMEYER, 1915, p. 327; VAN NAME, 1924, p. 31; HARANT, 1927, p. 243, fig. 15; 1927a, p. 6; HARTMEYER AND MICHAELSEN, 1927, p. 187; BERRILL, 1928, p. 162; 1929, pp. 44, 45, etc., figs. 4a, 4b, 10; VAN NAME, 1930, p. 490, figs. 56, 57; BERRILL, 1931, p. 333; HARANT, 1931, p. 342; BERRILL, 1932, p. 78; HARANT AND VERNIÈRES, 1933, p. 29, fig. 47; BERRILL, 1935, pt. 3, p. 270; HUUS, 1936, p. 9, fig. 6b; PLOUGH AND JONES, 1937, p. 101; GRAVE, 1944, pp. 173–191, figs. 1, 2, pl 1.

Styela partita +*S. p.* var. *bermudensis* VAN NAME, 1902, p. 338, pl. 55, fig. 69, pl. 56, figs. 76–78, pl. 64, figs. 147–149, pl. 60, figs. 70–75, pl. 63, figs. 142, 143; 1921, pp. 431, 435, figs. 98–101.

Styela variabilis HANCOCK, 1868, p. 318; ALDER AND HANCOCK, 1907, p. 117, pl. 37, figs. 10–12, pl. 43, fig. 1, pl. 48, fig. 14; HUNTSMAN, 1913, pp. 490, 496.

Tethyum partitum +*T. p.* var. *bermudense* HARTMEYER, 1909–1911, pp. 1359, 1619; 1911–1912, pp. 189, 191; VAN NAME, 1912, p. 556, fig. 32, pl. 59, figs. 94, 95, pl. 60, fig. 97, pl. 69, fig. 141, pl. 71, fig. 153.

The identity of the "*Styela* sp., believed undescribed by Dr. Ritter" from Vineyard Sound, Massachusetts, reported by Sumner, Osburn, and Cole, 1913, p. 730, is unknown.

Form largely dependent on whether the animal is attached singly or, as is a common habit in this species, in a crowded group of several or many individuals of different sizes. In the former case the body may be attached by much of the ventral surface and the branchial aperture situated on the dorsal surface slightly back from the anterior end; in the latter case the body is usually attached by only a small area near the posterior end, and the branchial aperture is situated at the anterior end, with the atrial aperture a short distance from it on the dorsal surface. When so attached as to grow symmetrically, the body is somewhat elongated, tapering anteriorly, and the apertures are on low rough prominences, not always conspicuous in contracted preserved specimens among the rough excrescences which are commonly found on that part of the body. These may have the form of transverse wrinkles which break up into small irregular tubercles. The posterior part of the body is usually less rough. Frequently a few algae, bryozoans, etc., grow upon the surface.

Color usually grayish or yellowish posteriorly, becoming brown, purplish, or red anteriorly, especially about the apertures, which occasionally exhibit the striping mentioned in Stimpson's original description. "The tubes are very beautifully marked exteriorly by alternating triangular areas of white and purple arranged as in the shell of a Balanus; the white ones having their bases, and the purple ones their apices, on the margin of the apertures" (Stimpson, 1852, p. 231). These colors and markings, of course, fade out in alcoholic specimens.

Test very variable in thickness, but thicker near the siphons; tough and leathery, smooth internally, rough and more or less fibrous externally. Length of largest specimens, 25 mm. to 30 mm.

Mantle rather thin but strong, not adherent to the test in preserved specimens. Musculature light, the superficial layer an almost continuous sheet of fibers, the deeper muscles gathered into imperfect bands which radiate from the bases of the siphons.

Tentacles rather numerous (40 to 50 in large specimens) of several sizes arranged with a variable degree of regularity. Dorsal tubercle very variable in form, but usually of a modified U-shape (often with one horn much incurved), the open interval pointing anteriorly or more or less to the left. Dorsal lamina plain and rather narrow. Branchial sac with four folds which are narrow in comparison to the intervening spaces. The first fold is highest, the fourth lowest of all. Transverse vessels numerous and slender, of at least four orders, arranged with some regularity. Those of the third order merely cross the stigmata in the dorsal part of the sac (those of the fourth order are wanting there) but become stout and separate the stigmata in the ventral region, and fourth-order vessels appear in the intervals there. Internal longi-

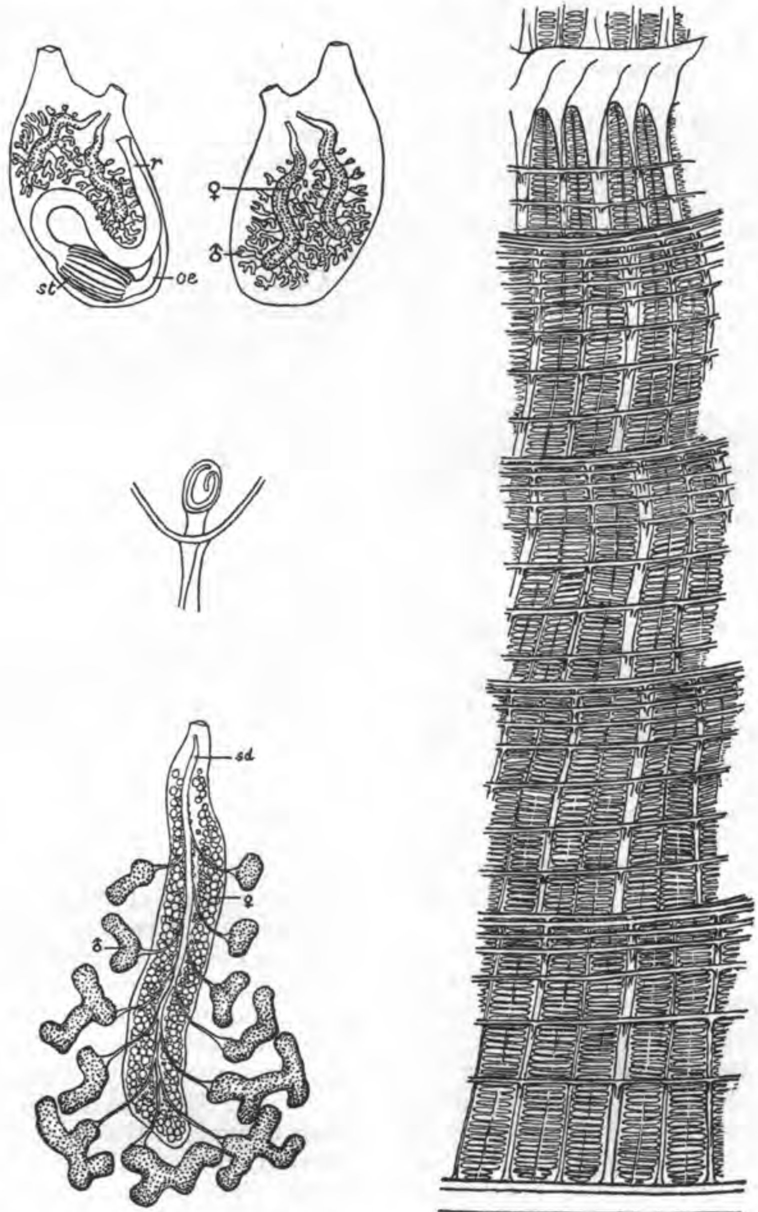


FIG. 188. *Styela partita* (Stimpson). Left and right sides of body, ×2; dorsal tubercle; gonad of a small specimen, ×20; part of branchial sac, × 14.

tudinal vessels slender and not very numerous, generally separated by from eight stigmata in the ventral region to five or six in the dorsal region on the flat spaces, but quite close together on the upper part of the folds. A medium-sized individual of average characters had them distributed thus on the right side:

5 (18) 4 (13) 4 (14) 5 (9) 2

On the left side the first fold began nearer the median dorsal vessel, and only two vessels intervened instead of five.

Stomach somewhat elongated, with 18 to 30 longitudinal folds in the wall. Intestinal loop moderately large. Margin of anus sinuous or with a variable number (often about a dozen) rounded lobes.

Gonads two on each side. Each comprises an elongated, sinuously curved ovary, having the end with the orifice directed toward the atrial siphon but not much produced into an oviduct. The ovary is bordered along each side by a comparatively small number of testes which are of varying shape, often with several irregular branches. They lie a little distance from the ovary; their ducts run to the ovary, upon whose free surface they unite to form the common sperm duct, which extends along on the middle line of the ovary, ending a little short of the termination of the latter. The testes become smaller, of simpler form, and fewer toward the dorsal ends of the ovaries and are sometimes wanting altogether along that part of them. Egg diameter 0.15 mm. (Berrill, 1937).

The gonads, which are readily seen through the thin mantle when the animal is removed from the test, furnish the easiest means of recognizing the species. The characteristic tuberculation of the test on the anterior part of the body is often helpful.

DISTRIBUTION: On the American coast it is found from Massachusetts Bay (Stimpson's type locality was Boston Harbor in 4 fathoms) to both coasts of Florida, and the West Indies, including Cuba, Puerto Rico, (where it is abundant on piles of wharves and mangrove roots), and Curaçoa, also at Bermuda where it is fairly common. The var. *bermudensis* Van Name, 1902, described as representing it at Bermuda is, I now believe, insufficiently distinguished from the typical form to merit recognition.

On the coast of southern New England it is, next to *Molgula manhattensis*, the commonest simple ascidian. It grows in large groups in masses with other ascidians (especially *Amaroucium constellatum*, *Didemnum lutarium*, and *Perophora viridis*) on the piles of wharves in the Woods Hole and Vineyard Sound region.

On the European side of the Atlantic, where it has commonly been called *Styela variabilis* or *S. canopoides*, it ranges from the Channel Islands and west coast of France to the Cape Verde Islands and tropical west Africa, including the Mediterranean, Adriatic, and Sea of Marmora. A report from west Australia (Hartmeyer, 1919) was based on specimens from the bottom of a ship, and there is no reason to believe it a native of that region. A couple of small specimens which I collected under stones at Tobagilla Island, Bay of Panama, appear to be of this species.

Styela partita is a strictly shallow-water species occurring at, or close to, low-water mark and down to depths of a few fathoms only, not more than 15 fathoms in the case of American records. Roule, however, reports it from 70 meters in the Mediterranean.

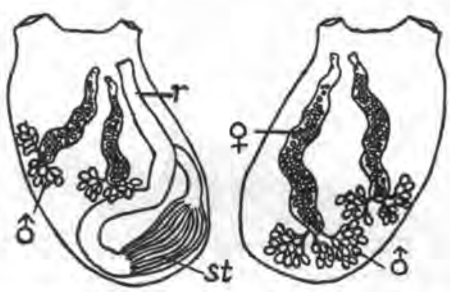


FIG. 189. *Styela atlantica* (Van Name). Left and right sides of body, ×1.3.

Styela atlantica (Van Name), 1912

Plate 8, figure 3; text figures 179G, 189–191

Botryorchis atlanticus HUNTSMAN, 1913, pp. 498, 499, fig. 4.

Cynthia partita ("apparently") VERRILL, 1885, p. 529.

Styela atlantica VAN NAME, 1921, p. 440, fig. 106; HARTMEYER, 1923, p. 237; HARTMEYER AND MICHAELSEN, 1927, p. 185; HUUS, 1936, pp. 5–17, figs. 1–5, 6a.

Tethyum atlanticum VAN NAME, 1912, p. 552, fig. 31, pl. 59, figs. 92, 93, pl. 60, fig. 96, pl. 68, fig. 135.

This species much resembles *Styela partita* in external characters but averages larger, often 40 mm. or more in length, and has a rougher, more deeply wrinkled test. In internal structure, it is distinguished from that species by the very much more numerous internal longitudinal vessels, these being sometimes 40 on a fold and 10 or more on some of the flat intervals forming more numerous meshes with fewer stigmata in each than in

FIG. 190. *Styela atlantica* (Van Name). Gonad (side next to branchial sac), ×8.

S. partita; in the transverse vessels of the sac being less regular and often more or less convergent on the folds (see fig. 191); the more elongated stomach, and especially by the structure of the gonads. The ovaries, numbering two on each side, are similar to those of *S. partita*, but the male glands are small, rounded, or pyriform bodies, forming several compact clusters quite closely adherent to the body wall, grouped around the closed or ventral ends of the ovaries, instead of arranged along a considerable part of the sides of the latter.

DISTRIBUTION: This species was until lately known only from moderately deep water (62 to 397 fathoms) far off the coast of the middle United States, chiefly in latitudes between 38° and 40° N., and longitudes between 69° and 73° W., where it was dredged by the steamer "Albatross," but has recently been reported from the southwest coast of Norway in depths of 100 to 150 meters (Huus, 1936).

It is the type of Huntsman's subgenus *Botryorchis* (see under genus *Styela*).

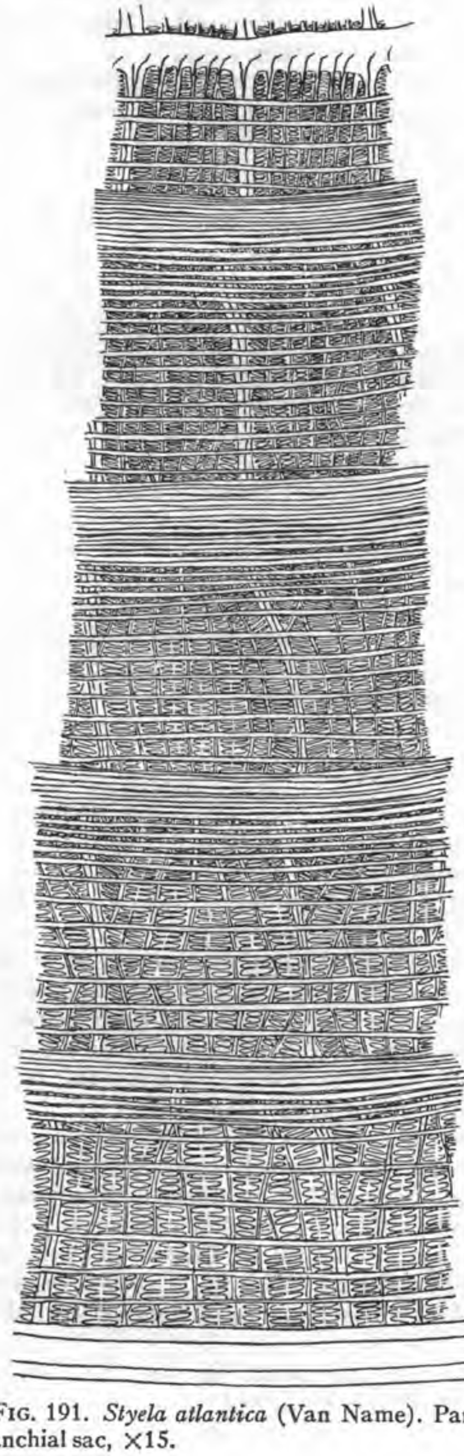


FIG. 191. *Styela atlantica* (Van Name). Part of branchial sac, ×15.

Styela plicata (Lesueur), 1823

Plate 12, figures 1–3; text figures 192–194

Ascidea plicata DEKAY, 1843, p. 259.

Ascidia plicata LESUEUR, 1823, p. 5, pl. 3, fig. b.

Styela gyrosa HELLER, 1877, p. 255, pl. 3, figs. 7–12, pl. 4, figs. 1–8.

Styela plicata TRAUSTEDT, 1883, pp. 123, 134, pl. 5, fig. 6, pl. 6, fig. 16; 1883a, p. 478, pl. 36, fig. 12; 1885, p. 44; METCALF, 1900, p. 516, pl. 36, figs. 24, 25; HARTMEYER, 1905, p. 384; HUNTSMAN, 1912a, p. 149; 1913, pp. 489, 497, fig. 13; REDIKORZEV, 1916, p. 197, pl. 5, figs. 1, 2, text figs. 37, 38; VAN NAME, 1918, p. 88; MICHAELSEN, 1918, p. 36; VAN NAME, 1921, p. 435, figs. 102–105; HARANT, 1927, p. 243; 1927a, p. 7; VAN NAME, 1930, p. 492, figs. 58, 59; HARANT AND VERNIÈRES, 1933, p. 31, fig. 46; PRATT, 1935, p. 748; PEARSE, HUMM, AND WHARTON, 1942, p. 188.

? *Styela* sp. WILSON, 1900, p. 354.

Tethyum plicatum HARTMEYER, 1909–1911, pp. 1359, 1630; VAN NAME, 1912, p. 569, fig. 36, pl. 62, figs. 104, 105, pl. 63, fig. 108, pl. 68, fig. 136; COIFMANN, 1933, p. 6.

This is a much larger species than *S. partita* and is very variable in external appearance. Sometimes the body is broader in the anterior part or near the middle and narrowed toward the posterior end by which it is attached; the test at this end of the body may, especially in examples that grew in a crowded group, be so produced that it may be described as forming a short, stout pedicel. Some specimens are strongly compressed laterally, others scarcely at all. In other examples, the general outline of the body is merely oval or rounded and attached by one side or near the posterior end. Young indi-

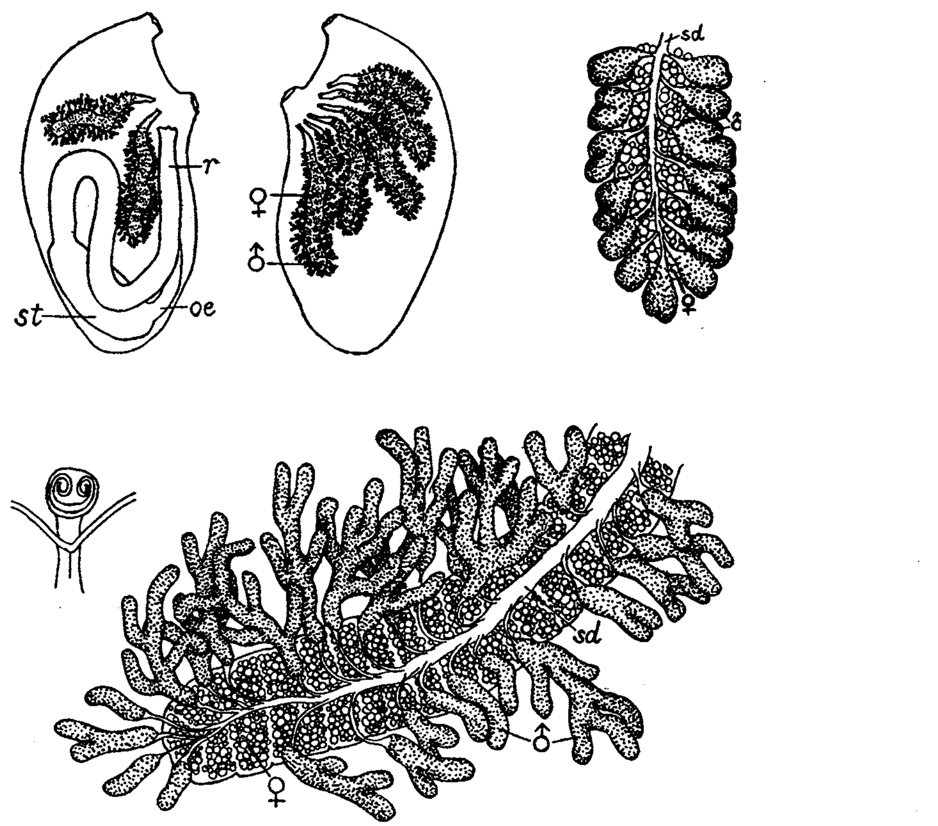


FIG. 192. *Styela plicata* (Lesueur). Left and right sides of body, slightly enlarged; terminal part of a gonad of a comparatively young individual with testes of simple form (side next to branchial sac), ×16; dorsal tubercle and part of gonad of an old and large individual with much-branched testes, ×12.

viduals are shorter and much wider proportionately than old ones.

The branchial orifice is terminal, or nearly so, the atrial a little way back on the dorsal side; both are usually surrounded by four rounded eminences corresponding to the four sides of the square aperture, which lies in the depression between them. In small young individuals these eminences are relatively enormously large. In many individuals there is a conspicuous curvature of the long axis of the body by which the apertures are brought towards each other, and the ventral side of the body becomes more convex.

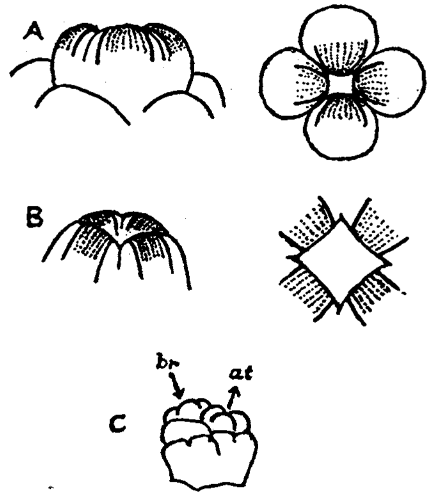


FIG. 193. *Styela plicata* (Lesueur). Apertures closed, seen from one side and from above, almost closed (A) and rather widely open (B), showing radial striping of the apertures. C. Outline of a young individual showing stout compact form and relatively large lobes around the apertures, somewhat enlarged.

The most conspicuous external characters of the species are furnished by the test and the body surface. The test when not discolored is of a dull white color, quite opaque in alcoholic material, but more or less translucent in formaldehyde; the lobes surrounding the apertures marked with radiating purple brown lines during life. Surface usually fairly clean, though ascidians and other organisms sometimes grow upon it. In some individuals the surface is merely irregularly furrowed, or there are a few conspicuous, rather widely spaced furrows whose direction is longitudinal and which are separated by broad, rounded ridges running toward the apertures and ending in the eminences surrounding the latter which have already been mentioned. In many individuals the ridges are broken, especially on the anterior part of the body, into low but rather large, dome-shaped elevations, giving the body surface, or parts of it, an appearance suggesting a coarse, unevenly laid cobblestone pavement. Such specimens are very characteristic and easily recognized.

A number of the largest specimens measured ranged from 45 to 72 mm. long and from 25 to 38 mm. in greatest dorsoventral diameter, but still larger examples (80 by 38 mm., 85 by 45 mm., 93 by 43 mm.) may sometimes be found.

Mantle of only moderate thickness; in some individuals quite thin. The outer layer of muscles encircles the body, and its fibers form a nearly continuous sheet. The deeper muscles extend from the tubes toward the posterior end of the body and are gathered into distinct, rather closely placed bands.

Tentacles difficult to count in the material studied on account of the contraction of the strong sphincter muscles. The number mentioned in Traustedt's (1883) description (25 to 30) seems to be exceeded in many of the Puerto Rican specimens, these apparently having a total of 40 or more, of at least three or four orders, the smaller ones being irregular in their distribution and wanting in many of the intervals. Dorsal tubercle C-shaped with the open interval forward and the horns strongly inrolled in all the specimens in which this character was studied. Dorsal lamina plain edged. Branchial sac with four quite sharply defined folds separated by rather wide flat intervals. The first three folds do not differ greatly in height and bear over 20 internal longitudinal vessels in most individuals. The ventral fold is somewhat lower. Transverse vessels numerous, of at least five orders in the ventral parts of the sac, the smallest crossing without interrupting the stigmata. They are stout and rather closely placed and so prominent upon the inner surface of the sac that the meshes containing the stigmata are quite deeply depressed. The presence of two second-order vessels instead of one between two first-order vessels and other similar irregularities may be observed in some parts of the sac in many individuals. Internal longitudinal vessels of rather broad, flattened cross section; they are noticeably stouter on the flat intervals between folds than upon the upper parts of the folds.

Distribution of these vessels in two moderately large individuals:

A	Left	2 (25) 5 (24) 7 (20) 6 (14) 5
	Right	5 (20) 6 (20) 8 (22) 7 (17) 6
B	Left	2 (22) 6 (20) 5 (22) 4 (19) 3
	Right	5 (24) 7 (22) 6 (25) 5 (17) 4

The meshes on the flat portions of the sac between the folds contain, for the most part, from six to nine stigmata.

Stomach large, more elongate than in *S. partita*, its walls with from 30 to 40 longitudinal folds, which do not, however, show very conspicuously on the exterior surface. Intestinal loop large but proportionately narrow, its middle part extending back so as to lie beside the stomach. Margin of anus irregularly lobed in some individuals, but only slightly sinuous in others.

Gonads usually two in number on the left side, one anterior to the intestine, the other extending down between the rectum and the descending part of the intestine. A third gonad on the left side may occasionally be found. On the right side the number of gonads is variable; usually there are from four to seven. They are placed with their necks converging toward the base of the atrial tube. The individual gonads vary greatly in size in the same individual, even when fully mature. Sometimes one or more of them divide into two branches. Some specimens obtained at Puerto Rico afford excellent material for studying the details of the structure of the gonads and confirm the statement of Huntsman (1913, p. 489) that this species is a typical *Styela* related to *S. partita*. Each gonad consists of a central, elongate, more or less sinuously curved ovary, along each side of which the small male glands are arranged. The sperm ducts follow a similar course to that described above in *S. partita*, and the individual male glands have, as in that species, a branching form, if well developed. There is, however, this difference in the arrangement: the individual sperm ducts leading from the testes are comparatively short, so that the testes, instead of lying attached to the mantle at a little distance from the ovary, lie close against the latter. The testes are of about the same actual size as in *S.*

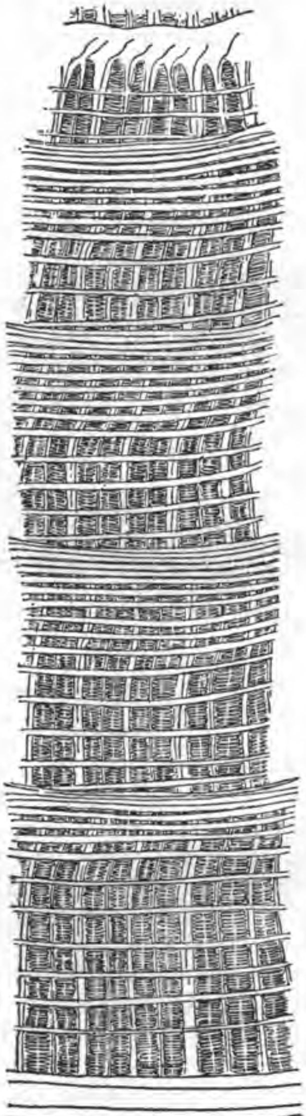


FIG. 194. *Styela plicata* (Lesueur). Part of branchial sac, ×12.

partita but much more numerous. Egg diameter 0.15 mm. (Berrill, 1937).

The reader must not expect to find the testes always so numerous or of such lobate form as in the large example shown in figure

192. In many specimens, even when the reproductive organs are adult and evidently functional, the testes are merely small oval glands not much divided into lobes, lying close upon and against, or even more or less embedded in, the ovary (see fig. 192, upper right-hand part). All intermediate conditions will also be found.

DISTRIBUTION: This is a well-known species, widely distributed on the coasts of the warmer parts of the Atlantic, Pacific, and Indians oceans, including the Mediterranean, but not recorded from the west coast of America. Lesueur's type specimen was from Philadelphia from the bottom of a ship that must doubtless have come from some more southern port, as the water at Philadelphia is too fresh and cold for it, and there are, moreover, no other records from the American coast north of Fort Macon, near Beaufort, North Carolina. From there it ranges through Florida (where it is very common in places on the west coast though Plough and Jones, 1937, did not find it at Tortugas) and the West Indies (St. Thomas, St. Croix, St. Vincent, Cuba, and Puerto Rico) to Rio de Janeiro and Montevideo (Traustedt, 1883). Only one record exists from Bermuda, probably from a ship's bottom, as it does not seem to have become established there. It inhabits shallow water; in Guanica Harbor, Puerto Rico, it was found abundantly on wharf piles in clusters containing other ascidians as well. The greatest depth recorded for any of the specimens I have examined is 15 fathoms (off the South Carolina coast). Wilson (1900) reports a large *Styela*, "doubtless *Cynthia vittata* of Stimpson's list," from Beaufort, North Carolina. The number of branchial folds given by Stimpson shows that *C. vittata* Stimpson is not a *Styela*. Wilson's species, if a *Styela*, was probably the present one.

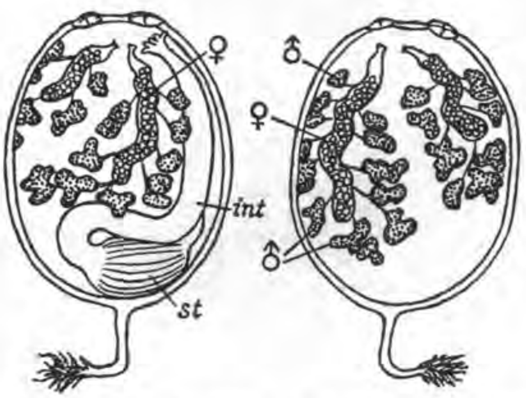


FIG. 195. *Styela schmitti*, new species. Left and right sides of body, ×6.

Styela schmitti, new species

Text figure 195

This very small species has the body of regularly ellipsoid form with both apertures very close together at one end, while a small pedicel or more or less elongate stalk, serving to anchor the animal in the sand, arises at the other end. The two apertures, both four-lobed, are in the contracted preserved specimens little, if at all, prominent above the surface, which is completely covered with a coating of coarse sand grains firmly embedded in the test; only the lobes of the apertures and the pedicel or stalk are left bare; in one specimen the pedicel also was sand covered. Body dimensions of the largest specimen, 8 mm. long by 6.3 mm. dorsoventrally and a little less from side to side; even these figures hardly do justice to the unusually small size of this species, as the measurements include the coating of large sand grains.

The pedicel or stalk is really the most characteristic feature of the species; though in comparison with the body it is so small or so slender and insignificant looking that it may at first escape notice, it is surprisingly strong and tough. It is a cylindrical flexible process, arising abruptly from the sand-incrusted body surface. Its color is white; it has a smooth or slightly transverse wrinkled surface that gives it a worm-like appearance. When elongate it is so slender and flexible that (when not magnified) it looks like a piece of coarse thread or slender string, and can evidently not prevent the body resting on the sea bottom. When very short it is stouter. In all cases it gives off laterally or breaks up into a bunch of small root-like branches or more or less flattened processes at the free end which aid in anchoring the animal.

As far as the internal structure is concerned, this species is a very typical and very ordinary *Styela* related to the well-known and widely distributed *S. partita*. The mantle musculature is diffuse and not heavy enough to interfere much with the transparency of the mantle. The contracted condition of the anterior end prevented any accurate count of the tentacles, which are of various sizes not regularly arranged; there may be 35 or 40 tentacles in all. The dorsal tubercle is fairly large, rounded, and prominent; its aperture is somewhat complex and obscure in its curvature, but in one case was evidently a modification of the C-shape with the open interval to the left. In spite of the closeness together of the two apertures, the dorsal lamina is long; it is narrow anteriorly and widens toward the rear; its margin is undulated and not entirely even.

There are the usual four branchial folds, but the first, especially on the right side, is considerably the highest; the fourth may be reduced and flattened.

In a large individual there may be about 20 closely placed internal longitudinal vessels on the first fold, on the others usually about half that number or less; the vessels are also quite numerous (about five to eight) on the intervals between folds. It is, however, impossible to draw up an exact scheme of their distribution on account of the undulating character of the folds, which show no exact demarcations between the folds and the adjacent intervals. As is frequently the case in this family, the first fold on the left side is nearer the dorsal lamina than that on the right side. The transverse vessels are slender and do not vary greatly in size; the meshes are generally crossed by a parastigmatic vessel. There are but two or three stigmata in the majority of the meshes between folds; on the folds the internal longitudinal vessels are very close together. Along the right side of the dorsal lamina there is a single row of very wide meshes, also fairly wide ones along the endostyle.

The stomach is elliptical, with about 20 sharply defined longitudinal plications besides the raphé; their course is practically parallel to the latter. The stomach and intestine form a compact, nearly transverse loop from which the long rectum extends anteriorly. Its aperture is expanded and cleft into a number of deep rounded lobes.

There are apparently normally two gonads on each side, though in one case I found only one on the left side. They are placed as in *Styela partita;* the elongate, sinuously curved ovary is attached to the mantle by its somewhat flattened outer aspect and with its open end directed toward the atrial siphon; the testes are scattered very irregularly along both sides of it and around its closed end, but separated and often considerably removed from it, though connected by the sperm ducts. The testes are of more compact form than usual in *S. partita*, being better described as irregularly lobed rather than branched, and are of relatively large size.

LOCALITY: Nine specimens were dredged by the "Albatross" at Station 2764 off Montevideo, Uruguay, 36° 42′ S., 56° 23′ W., 11½ fathoms, sand and broken shells. Type in the American Museum of Natural History (A.M.N.H. No. 1860).

This species is named for Dr. Waldo L. Schmitt of the United States National Museum.

Styela oblonga Herdman, 1881

Text figure 196

? *Styela flava* HERDMAN, 1881, p. 64; 1882, p. 160, pl. 20, figs. 1–6.

Styela oblonga HERDMAN, 1881, p. 65; 1882, p. 159, pl. 20, figs. 7–9; HARTMEYER AND MICHAELSEN, 1927, p. 183, figs. 15–16.

? *Tethyum flavum* HARTMEYER, 1912b, pp. 374, 378.

Tethyum oblongum HARTMEYER, 1912b, pp. 374, 378.

Herdman described in the "Challenger" reports three species of *Styela, S. flava, S. oblonga,* and *S. glans* (page priority in that order), all from single specimens and all obtained from a single haul of the dredge in quite deep water off the Argentine coast. The differences in shape, one oblong attached by the narrowed posterior end, another "rudely spherical," the third "between conical and hemispherical," do not seem significant; in greatest diameter they range from 3.5 (*S. oblonga*) to 1.5 cm. In all three the test is tough and opaque though thin, with a finely wrinkled, roughened, or (in *S. flava*) a minutely scaly surface; the apertures are four-lobed, not raised above the surface, and the mantle is delicate without heavy musculature.

There are differences in the number of tentacles, in the margin of the dorsal lamina, which is toothed on the edge in *S. flava*, and in the dorsal tubercle, which, however, is of very simple form in all, but I cannot attribute much weight to any of these differences in view of the fact that they were observed in single specimens only and that the three supposed species, all collected at one time and place, agree in the following striking peculiarity of the branchial sac.

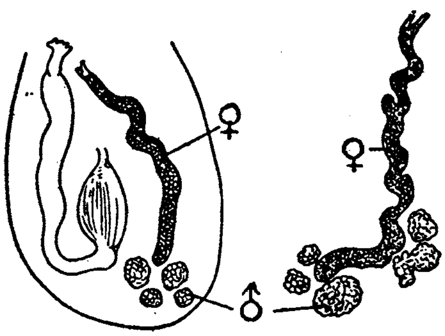


FIG. 196. *Styela oblonga* Herdman. Alimentary tract and left and right gonads of type. After Hartmeyer and Michaelsen, 1927.

There is scarcely any actual plication of the wall of the sac, though the usual four folds on each side are indicated by close crowding of a number (five to 10) of the internal longitudinal vessels in the area of each fold. On the other parts of the wall these vessels are separated by three or four stigmata. The transverse vessels alternate in size on most parts of the sac; slender parastigmatic vessels also occur in many places.

Herdman's descriptions and figures failed to give any information on the form of the stomach or gonads, and as far as can be judged from his work there would appear to be reasons for believing that all three species are identical.

But subsequently Hartmeyer (see Hartmeyer and Michaelsen, 1927) reëxamined and sketched the gonads of the type and only specimens of *S. oblonga* and *S. glans*. He did not record anything concerning *S. flava;* presumably the specimen could not be found. His examination disclosed the fact that the type of *oblonga* had one gonad on each side, each consisting of a long, sinuous, tubular ovary and several small clusters of testes situated about the closed end of the ovary but not in contact with it. The gonads of *S. glans* differed sufficiently to make it seem necessary to treat that species as a distinct one, though evidently closely allied (see below).

LOCALITY: "Challenger" Station 320, off the coast of northern Argentina near the mouth of the La Plata River, 37° 17′ S., 53° 52′ W., 600 fathoms, hard ground.

I believe that *S. flava* (whose name has page priority) is probably the same as this species, but in the absence of any information as to its gonads it must be regarded as an insufficiently described form, and I am, therefore, employing the name *oblonga.*

Styela milleri Ritter, 1907, is a closely allied Pacific Ocean abyssal form.

Styela glans Herdman, 1881

Text figure 197

Styela glans HERDMAN, 1881, p. 65; 1882, p. 162, pl. 20, figs. 10–13; HARTMEYER AND MICHAELSEN, 1927, p. 183, figs. 11, 12.

Tethyum glans HARTMEYER, 1912b, pp. 374, 378.

Described from a single specimen resembling, though of smaller size (1.5 by 1.2 cm.), the type of *S. oblonga* described above in most characters except the gonads.

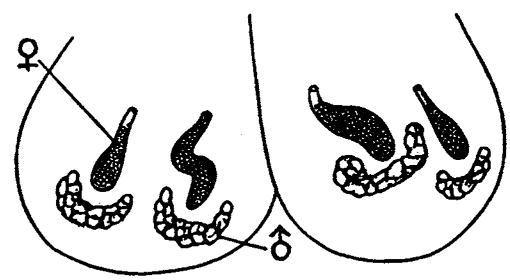


FIG. 197. *Styela glans* Herdman. Left and right gonads of type. After Hartmeyer and Michaelsen, 1927.

Hartmeyer (see Hartmeyer and Michaelsen, 1927) in a subsequent examination of the types of the two species found that *S. glans* had two gonads on each side, which are of elongate, flask- or bottle-shaped form instead of one long, sinuous, tubular gonad on each side as in the type of *oblonga;* the testes form a compact, somewhat crescent-shaped group around the closed end of each ovary.

The gonads are, therefore, actually of the same general type as those of *S. oblonga*, and the fact must also be kept in mind that only a single specimen of each species is available. Yet unless we are to assume an unusual individual variability in the number and shape of the gonads in *S. oblonga*, it seems necessary with the information at present available to treat *S. glans* as distinct from that species.

LOCALITY: The same as for *S. oblonga:* "Challenger" Station 320, off the coast of northern Argentina near the mouth of the La Plata River, 37° 17′ S., 53° 52′ W., 600 fathoms, hard ground.

Styela magalhaensis Michaelsen, 1898

Styela canopus var. *magalhaensis* MICHAELSEN, 1898, p. 367; 1900, p. 73, pl. 2, fig. 13; 1907, p. 75.

Styela magalhaensis ÄRNBÄCK, 1929, p. 3.

? *Styela melincae* ÄRNBÄCK, 1929, p. 2, pl. 1, figs. 1–4.

? *Tethyum canopus* var. *magalhaense* HARTMEYER, 1911b, p. 552, pl. 57, figs. 18–20. Not Coifmann, 1933.

Tethyum magalhaensis HARTMEYER, 1911–1912, p. 192.

This is a species very variable in form and external appearance and, except for the part dealing with the gonads, the description of *Styela paessleri* given below applies just as well to this species also, though possibly the internal longitudinal vessels average fewer, and the stomach is generally shorter and wider. I shall, therefore, confine myself to describing the gonads of the present species.

These are normally two in number on each side, sometimes only one on the left side, each gonad consisting of a long, tubular, more or less sinuous ovary and a dense mass of testes attached to the inside of the mantle around the proximal end of the ovary. The distal ends of the ovaries converge toward, and open near, the base of the atrial siphon. The arrangement of the testes is, as in *S. paessleri*, that which is characteristic of the subgenus *Goniocarpa* Huntsman.

Thus the distinction between *S. paessleri* and the present species is apparently mainly that in the former the ovaries are of branching form while in this species they are simple sinuous tubes extending a considerable part of the length of the body. It may well be asked whether this justifies the separation of the species, especially as they have much the same geographical range. To this I can only reply that Michaelsen, who had much material, considered them distinct, and such specimens as I have studied supported that view, being definitely referable to either one species or the other.

DISTRIBUTION: Coasts of southern South America. Michaelsen, 1900, 1907, reports it from a number of points in the Strait of Magellan (including Punta Arenas), and Smyth Channel, from kelp roots and in depths from 8 to a maximum of 100 fathoms. This range is extended by a few specimens obtained by the "Albatross" at Station 2768 off the Argentine coast (42° 24′ S., 65° 38′ 30″ W., 43 fathoms). Hartmeyer's (1911b) specimens from St. Paul, Indian Ocean, seem very doubtful. I cannot believe that the specimens from "San Nicolas (Magellano)" referred to this species by Coifmann, 1933, really belong here, as her illustration shows compact gonads of the *Cnemidocarpa* type. See remarks under *Styela nordenskjöldi.*

I include *Styela melincae* Ärnbäck, 1929, as a probable synonym of this species. It has gonads of the same type, and the characters in which it differs are minor ones (more elongate shape, longer siphons, longitudinally wrinkled test, fewer internal longitudinal vessels, shorter stomach, etc.) subject to much individual variation and may, I think, be disregarded in view of the fact that Ärnbäck based her species on a single specimen only. It was from the Guaitecas Islands, southern Chile, in 18 to 27 meters, and if included here extends the range northward on the Chilean coast to latitude 44° S.

S. magalhaensis was originally described as a variety of *S. canopus* Savigny, 1816, a Red Sea species, to which, however, it has, as was pointed out by Hartmeyer, 1911–1912, no close relationship but merely superficial resemblance. Hartmeyer, 1911b, assigns to this species four very small and evidently immature specimens from St. Paul Island, Indian Ocean.

Styela paessleri Michaelsen, 1898

Text figure 198

? *Polycarpa viridis* PFEFFER, 1889, p. 36 (not Herdman, 1881, 1882).

Styela paessleri MICHAELSEN, 1898, p. 368;

1900, p. 69, pl. 2, fig. 9, pl. 3, fig. 4; 1907, p. 75; HERDMAN, 1912, p. 94, pl. 4, figs. 12–14.

? *Styela pfefferi* MICHAELSEN, 1898, p. 367; 1900, p. 77, pl. 2, fig. 16, pl. 3, figs. 6, 7; 1907, p. 75. (This name may have priority.)

Tethyum paessleri MICHAELSEN, 1911, p. 124.

Preserved specimens of this species vary a great deal in shape, ranging from low dome-shaped, through barrel-shaped to higher, irregularly ovate forms attached by a narrowed end or obliquely by one side. During life it is

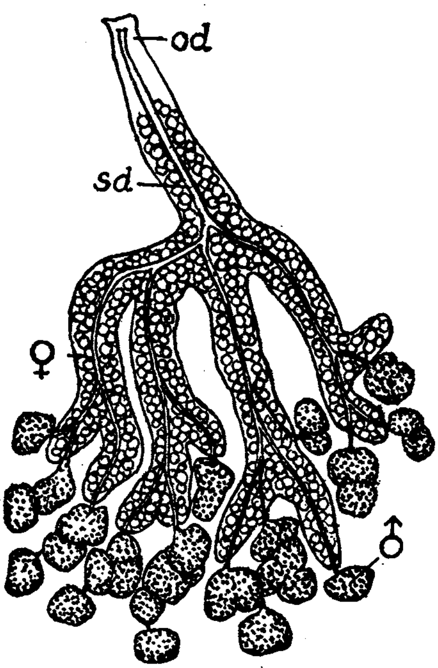


FIG. 198. *Styela paessleri* Michaelsen. One of the various forms of branched gonads occurring in this species.

probably capable of considerable change of shape by the contraction of the mantle muscles and of protruding or drawing in its siphons. The test is of varying thickness in different specimens, leathery and usually some shade of brown or yellow externally, and usually has a rough, uneven surface, verrucose anteriorly and irregularly wrinkled elsewhere; the furrows and ridges on the posterior part of the body are largely transverse or encircling.

The four-lobed apertures are a varying distance apart and may be prominent on low, wide papillae or, in other cases, difficult to find among the rough, variously shaped tubercles and projection on that part of the body, some of which have been described by Michaelson as "cauliflower-like," and do present such an appearance under a little magnification. See Michaelson, 1900, for more details regarding the external appearance.

A specimen in the United States National Museum collection measures 38 by 26 mm.; this is apparently uncommonly large. Michaelson had none over 16 mm. in greatest measurement.

The mantle usually readily separates from the test in preserved specimens. Its muscles, especially those of the outer, circular layer, form a nearly continuous sheet. There are many small endocarps scattered on its inner surface. The branchial tentacles are of several sizes, longer and smaller ones showing a tendency to alternate; the total number may be about 60. Dorsal tubercle wide, with an opening which is usually some rather simple modification of the C shape, with the open interval directly or obliquely forward. Branchial sac with four folds on each side, which are usually rather low and narrow in comparison with the flat intervals between them. The internal longitudinal vessels are, however, numerous; on the folds they are closely crowded and in large specimens may number from 12 to about 20 on the higher folds, and six or eight may sometimes be present on the flat intervals. The transverse vessels are of at least four orders, the smallest parastigmatic, and often show considerable regularity in arrangement. The meshes commonly contain five to eight stigmata, occasionally more.

The oesophagus is rather short; the stomach quite long and somewhat cylindrical, with from 16 to 20 or more longitudinal folds in its wall, noticeable externally as well as internally. The intestinal loop is narrow, the intestine bending back and running close to, often in part alongside of, the stomach. The rectum is usually rather short with a lobed aperture.

The gonads are often of quite complex form and require more investigation than they have yet received. Unfortunately the material I have had available was limited both in quantity and quality and insufficient for clearing up all the details.

Apparently the gonads normally number

two on each side and are attached to the mantle near the endostyle. Hartmeyer and Michaelsen (1927, p. 186) state that the oviducal aperture is directed toward that organ as in the subgenus *Katatropa* Huntsman.

The ovaries are considerably branched, especially those of the right side; those of the left are smaller and simpler. The branching is sometimes of a character justifying Michaelsen's description of it as antler-like ("geweihartig"), but in other cases it is very irregular; including short projections there may be as many as eight or nine terminal branches. The form of the ovaries is best made out in specimens in which the testes are not greatly developed. The latter are attached to the mantle between and about the ends of the branches of the ovary, most of them in small compact groups composed of numerous lobes united at the basal or attached part. The sperm ducts form a branching system corresponding to the ramifications of the ovary. When the testes are well developed and numerous they fill in the spaces between the branches of the ovary and around their ends, so that a compact mass of crowded testes is developed in which the branches of the ovaries are often so overlapped and concealed that their arrangement and connections are difficult to make out, and it is possible that in some cases the ovaries of adjacent gonads may become united. I believe that *Styela pfefferi* Michaelsen, from South Georgia, was based on a specimen of the present species having the gonads in the condition just described. Similar specimens were dredged by the "Albatross" at Station 2768 off the Argentine coast, 42° 24′ S., 65° 38′ 30″ W., in 43 fathoms.

DISTRIBUTION: This is a shallow-water species of the regions of the Strait of Magellan, Tierra del Fuego, and the Falkland Islands, probably also occurring at South Georgia (see remarks on *S. pfefferi* above). It grows attached to stones, shells, kelp roots, etc., often in groups or clusters of different-sized individuals, sometimes with other species of ascidians.

Herdman, 1912, refers to this species about 20 specimens, the largest up to 3 cm. long, from the Falkland Islands (depth, 6 fathoms), without the slightest allusion to the gonads, the most conspicuous specific character.

See also remarks concerning *S. paessleri* in the description of *S. magalhaensis.*

Styela nordenskjöldi Michaelsen, 1898

? *Cynthia magellanica* CUNNINGHAM, 1871a, p. 488, pl. 58, fig. 2.

Styela curtzei MICHAELSEN, 1900, p. 94, pl. 2, fig. 8.

? *Styela drygalskii* SLUITER, 1914, p. 17, pl. 2, fig. 10.

Styela nordenskjöldi MICHAELSEN, 1898, p. 365; 1900, p. 97, pl. 2, figs. 14, 18a, pl. 3, figs. 1–3; 1907, p. 76.

? *Tethyum canopus* var. *magalhaense* COIFMANN, 1933, p. 5, fig. 4. Not Hartmeyer, 1911b.

Tethyum curtzei HARTMEYER, 1909–1911, p. 1359.

? *Tethyum drygalskii* HARTMEYER, 1911b, p. 452, pl. 45, fig. 6, pl. 50, figs. 6–10.

Tethyum nordenskjöldi HARTMEYER, 1909–1911, p. 1359; MICHAELSEN, 1911, p. 124.

Body varying from ovate or cushion shaped to dome shaped or low conical, attached by a wide, flattened ventral area beyond the margin of which the test spreads out. Apertures near together, almost flush with the surface on the upper convex aspect or somewhat raised, the atrial about the middle, the branchial more forward. Surface even and appearing smooth but showing granulation and minute wrinkling on magnification, usually free from foreign matter. Color in preservation gray to yellow or yellowish brown. Color of living specimens taken at Puerto Bridges, Tierra del Fuego, noted as orange, reddish in the apertures. Largest specimens are ovate, one 47 by 40 mm. and 18 mm. high; a nearly spherical one, 35 mm. in diameter. Test thin, leathery, opaque.

Mantle fairly thick and muscular. Branchial tentacles about 44, of different sizes. Dorsal tubercle aperture usually C-shaped, opening forward, or a nearly complete circle. Dorsal lamina short, edge somewhat uneven.

Branchial sac with four high folds with 10 to 12 internal longitudinal vessels on each, and four to six on the intervals, where they are rather widely spaced. Sometimes 12 stigmata in a mesh, more often not over five to eight.

Stomach quite elongate, about 16 to 21 longitudinal plications in its wall. Intestinal loop long and narrow, margin of anus with petal-like lobes.

One elongate sinuous gonad on each side (or two on the right side), firmly attached to, or somewhat embedded in, the inner surface of the mantle along near the endostyle. At its rear end the ovary is produced into a tubular oviduct likewise adherent to the mantle, which extends dorsally to end near the atrial aperture. The gonads approach the *Cnemidocarpa* type, the testes in a layer against, or embedded in, the mantle, the ovary in the superficial or mesial part. When well developed, the testes project beyond the margin of the ovary along both its sides.

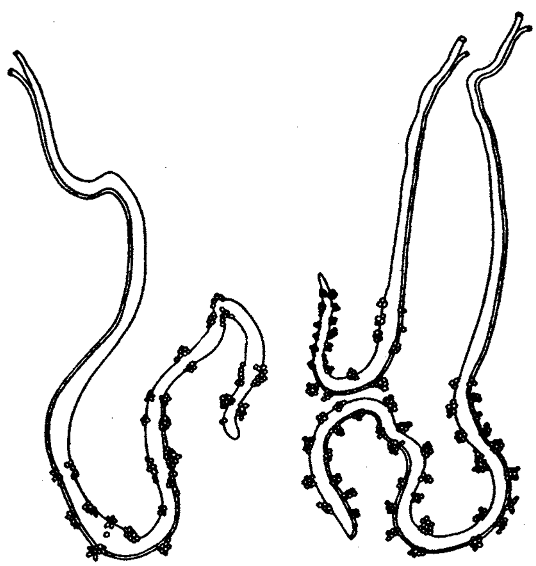


FIG. 199. *Styela insinuosa* (Sluiter). Left and right gonads, as figured by Sluiter, 1914.

DISTRIBUTION: Recorded by Michaelsen from points in the Strait of Magellan and on the coast of Tierra del Fuego. One specimen was dredged by the "Albatross" at Station 2773 in 10 fathoms, and three at Station 2775 in 29.5 fathoms, both in the eastern part of the Strait of Magellan. The greatest recorded depth is 50 fathoms at Puerto Bridges, Tierra del Fuego. The type locality of Cunningham's *C. magellanica* was Peckett's Harbor, eastern part of Strait of Magellan. His description and figure are inadequate; his name would have priority if identity could be proved. Hartmeyer (1911b, p. 519) assigns a specimen from St. Paul Island, Indian Ocean, to this species.

Except that they supposedly have two gonads on each side, the specimens from "San Nicolas (Magellano)" referred by Coifmann (1923, p. 5, fig. 4) to *Tethyum canopus* var. *magalhaense* (=*S. magalhaensis*) would fit much better into the present species, to judge by the form of the gonads shown in her figure.

Tethyum drygalskii was described by Hartmeyer from several small specimens (only one of them adult) from Kaiser Wilhelm II Land, eastern Antarctic, 380 to 385 meters, and reported from Jenny Island, Marguerite Bay, western Antarctic, in 250 meters, by Sluiter (one specimen). It resembles *S. nordenskjöldi* in many respects, including the structure of the gonads, and until more material is obtained and studied it must be regarded as a possible synonym of it.

Styela insinuosa (Sluiter), 1912

Text figure 199

Styela insinuosa SLUITER, 1914, p. 24, pl. 2, figs. 28–32, pl. 3, figs. 33–35, pl. 4, fig. 44.
Tethyum insinuosum SLUITER, 1912, p. 457.

The body in the six specimens which Sluiter had available was of cylindrical form, rounded at the ends and attached by one of them. Both siphons near together on the anterior part, rather short. Apertures four-lobed.

Body surface minutely furrowed; the furrows cross each other to form small, somewhat square or oblong areas ("compartiments") on the surface. Color grayish yellow. Size of specimens ranging from 60 mm. long and 20 to 25 mm. wide down to 9 mm. long. The small specimens have a smoother surface. Test thin but leathery.

Mantle musculature strong. Dorsal lamina narrow with a smooth margin. Dorsal tubercle with a horseshoe-shaped opening, the horns coiled in large specimens. Tentacles in large specimens 32, regularly arranged.

The branchial sac is unique in structure. There are no folds but in their stead four wide internal longitudinal vessels on each side. No other internal longitudinal vessels. The transverse vessels are at the usual distances apart. They are of two sizes, alternating in small individuals, and of three sizes with additional parastigmatic vessels in large individuals.

The meshes of the branchial sac are, therefore, greatly elongated dorsoventrally, and may contain 20 or more stigmata in small individuals and as many as 90 in large ones. Irregularities in these vessels are frequent.

The stomach is long, with about 20 longitudinal plications, and is longitudinally placed in the body. The intestinal loop is narrow; anal aperture expanded and lobed.

One gonad on the left side, two on the right. Each consists of a long, slender, tubular ovary whose posterior part makes large, sinuous curves. The small testes form small, rounded groups along the sides of, and in close contact with, the posterior parts of the ovaries. Their ducts unite and discharge by a common sperm duct opening on a papilla beside the ovarian aperture.

LOCALITY: Collected by the second Charcot expedition in the South Shetland region of the Antarctic in 75 meters.

Styela grahami Sluiter, 1905

Text figure 200

Styela grahami SLUITER, 1905b, p. 473; 1906, p. 39, pl. 2, fig. 35; 1914, p. 17.

Tethyum grahami HARTMEYER, 1911b, pp. 456, 457.

Described by Sluiter on the basis of 13 specimens obtained in the Graham Land region by the first Charcot expedition; 21 more specimens obtained by the second Charcot expedition gave Sluiter (1914) the opportunity for further statements on its characters.

It is of cylindrical form attached by the posterior end, with the two siphons short and directed forward. It attains a large size. One example was 90 mm. high and 40 mm. wide; others reached 70 to 75 mm. in height. The surface is furrowed, dividing it into small areas ("compartiments"). Color gray, more or less yellowish. Test thin, tough, and leathery.

Mantle with moderately strong musculature. Tentacles 10 to 20, the latter number in large examples. Dorsal lamina narrow and smooth margined. Dorsal tubercle with a horseshoe-shaped aperture, the horns spirally inrolled.

Branchial sac with four narrow folds separated by wide, flat intervals. The folds bear but very few (three or four) internal longitudinal vessels. In some large specimens Sluiter found them still more reduced, only one being complete, the others imperfect or rudimentary. On the flat intervals the internal longitudinal vessels are fairly numerous (see figure reproduced from Sluiter, 1914). The meshes are fairly wide dorsoventrally, often containing a dozen or more stigmata.

One greatly elongated gonad on each side of the body. The tubular ovary is irregular in its course, the closed or ventral end often bending back to the middle of the body. The testes are arranged in small groups close against the sides of the ovary at different points on its length.

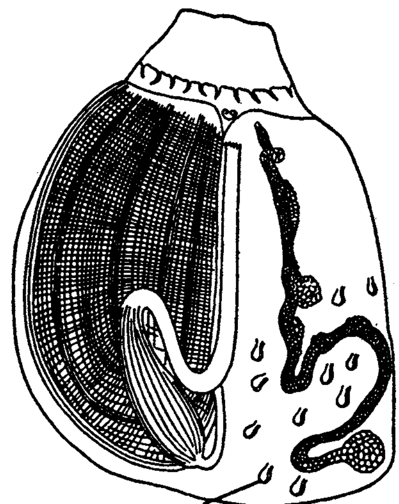


FIG. 200. *Styela grahami* Sluiter. Chief internal organs, as figured by Sluiter, 1914. Somewhat enlarged.

DISTRIBUTION: Graham Land and South Shetland regions of the Antarctic; greatest depth recorded, 110 meters at Biscoe Bay.

Styela serpentina (Sluiter), 1912

Text figure 201

Styela serpentina SLUITER, 1914, p. 20, pl. 2, figs. 22–24.

Tethyum serpentinum SLUITER, 1912, p. 456.

The largest of the 10 specimens on which Sluiter based this species was about 45 mm. long and 15 to 17 mm. wide. The siphons were short, directed forward, and about 10 mm. apart. The body surface was smooth and free from foreign matter, feebly furrowed in a longitudinal direction. Color in alcohol whitish.

Mantle strongly muscular. Branchial tentacles 14, of about the same size. Dorsal tubercle rounded, aperture horseshoe shaped, with incurved horns. Dorsal lamina narrow and smooth edged.

The peculiarities of the species are in the intestinal tract and gonads. Stomach long and narrow, with 18 plications. The part of the intestine between the primary bend and

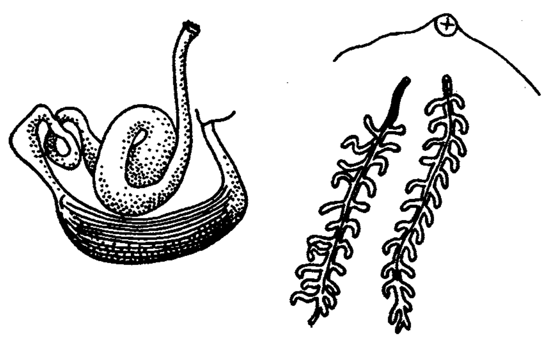


FIG. 201. *Styela serpentina* (Sluiter). Alimentary tract and gonads of right side, as figured by Sluiter, 1914.

the beginning of the rectum is very long and usually bent into two spiral turns (in one individual, three turns).

The gonads, two on each side, have the ovary elongate and tubular and provided along each side with about a dozen short, recurved branches arising at regular intervals. Nothing is said in the description regarding the male glands; possibly this species may be related to *Cnemidocarpa* rather than *Styela*.

LOCALITY: Ten specimens were obtained by the second Charcot expedition in the South Shetland region of the Antarctic, all at one station, in 75 meters.

Styela tholiformis (Sluiter), 1912

Text figure 202

Styela tholiformis SLUITER, 1914, p. 18, pl. 2, figs. 20, 21, pl. 4, fig. 42; HARTMEYER AND MICHAELSEN, 1927, p. 191.

? *Styela orbicularis* SLUITER, 1904, p. 71, pl. 1, fig. 5, pl. 9, figs. 2, 3.

? *Tethyum orbiculare* HARTMEYER, 1909–1911, p. 1359.

Tethyum tholiforme SLUITER, 1912, p. 455.

Described by Sluiter from a single, dome-shaped specimen 22 mm. in maximum diameter, attached to a shell and having a rough, granular surface, the apertures but slightly prominent, the branchial at the summit, the atrial halfway down the dorsal side.

Mantle musculature feeble. Dorsal tubercle horseshoe shaped, the horns curved, one in, one outward, 30 tentacles alternating in size with some regularity. Dorsal lamina narrow, smooth margined.

Branchial sac with four moderately developed folds on each side, six internal longitudinal vessels on each, and six on the intervals. Stomach fairly large, with longitudinal ridges. Anal margin smooth. The intestine forms an extra loop, the distal part crossing the proximal part just beyond the stomach.

One gonad on each side. Ovary tubular; the ventral or proximal end abruptly much narrower. The small testes are attached to the mantle on each side of, and for some distance beyond, this end of the gonad.

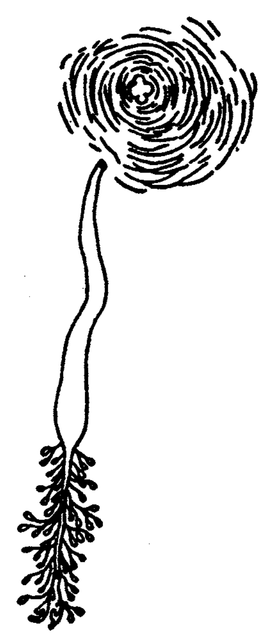


FIG. 202. *Styela tholiformis* (Sluiter). One of the gonads showing relation to the atrial aperture, as figured by Sluiter, 1914.

Locality of the only specimen, Charcot Land region of the Antarctic, in 460 meters depth.

Sluiter, 1914, points out the close relationship and possible identity of this species with *S. orbicularis*, which he had previously described from two specimens collected by the Siboga expedition southeast of Java in depths of 538 and 694 meters, respectively. The considerable depth of all the stations makes such identity seem possible in spite of the difference in latitude of the localities and of the existence of minor differences in the gonads. Hartmeyer and Michaelsen, 1927, suggest that *Styela bythia* Herdman, 1881, collected by the "Challenger" south of Australia in 2600 fathoms is also a member of this group of allied forms.

Styela wandeli (Sluiter), 1911

Styela wandeli SLUITER, 1914, p. 18.

Tethyum wandeli SLUITER, 1911, p. 37; HARTMEYER, 1911b, pp. 456, 457.

Body conical, the branchial aperture at the summit, and the atrial aperture back one-third the length of the dorsal side. Height of type specimen, 20 mm.; basal diameter, 15 mm. exclusive of a 2-mm. wide expansion of the test on the rock to which it was affixed. Test leathery; surface smooth except near the apertures; color yellowish gray.

Branchial tentacles of three sizes regularly arranged but only 12 in total number. Atrial tentacles present. Dorsal tubercle simply horseshoe shaped, the open interval forward and slightly to the left. Internal longitudinal vessels rather numerous; approximate count in a specimen examined by Hartmeyer:

Right	6 (12) 5 (10) 5 (10) 5 (8) 4
Left	1 (12) 6 (10) 5 (10) 4 (8) 3

Four to eight stigmata in the meshes.

Stomach rather elongate, pear shaped, with about 24 plications in its wall and a small, curved, pyloric caecum.

Two gonads on each side of the body, each consisting of a sausage-shaped ovary "accompanied on each side by a row of testicular follicles. The space between the two ovaries is insufficient for two complete rows of follicles so that the anterior row of the posterior gonad is very short and only reaches to the middle of the ovary."

Based on a total of six specimens which, according to Sluiter's statement, were all much alike and of about the same size, collected in the Charcot Land region and Palmer Archipelago of the western Antarctic by the two Charcot expeditions. Type locality, Booth Wandel Island. See also *Styela quidni* (below).

Styela quidni (Sluiter), 1912

Text figure 203

Styela quidni SLUITER, 1914, p. 22, pl. 2, figs. 25–27, pl. 4, fig. 43.

Tethyum quidni SLUITER, 1912, p. 456.

Based on only two specimens and, by Sluiter's own admission, very similar to *S. wandeli*. "With more abundant material," he says, "one might find transitional forms and could then unite the two species."

Body of somewhat truncated conical form attached by a broad base, the branchial siphon terminal, the atrial beside it and also directed forward, though not so long. Color whitish gray. Test thin but tough and of fibrous texture. Its surface has a number of deep transverse furrows. Mantle musculature feeble. Six large tentacles and additional small ones (20 in all). Dorsal tentacle with a horseshoe-shaped aperture; open interval forward. Branchial sac with four narrow folds on each side. Dorsal lamina narrow, plain edged. Arrangement of the internal longitudinal vessels, which are fewer than in *S. wandeli*, as follows:

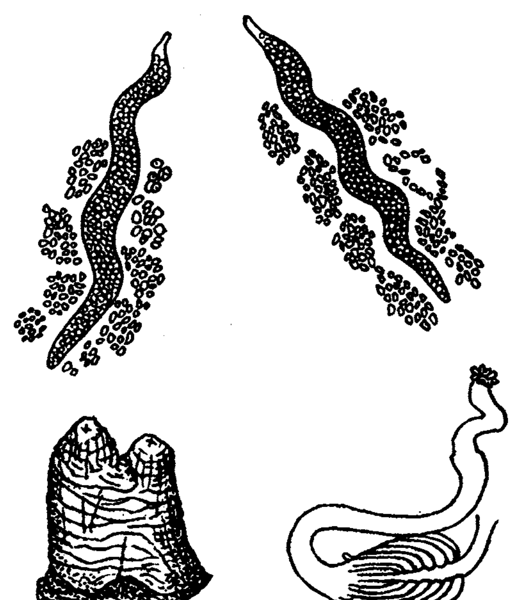


FIG. 203. *Styela quidni* (Sluiter). Two gonads, lateral view of body (× about 2) and alimentary tract. After Sluiter, 1914.

2 (7 to 8) 4 (7 to 8) 4 (7 to 8) 4 (7 to 8) 2

Intestinal loop narrow, stomach with a small, almost rudimentary, caecum.

Two gonads on each side, each consisting of a long ovarian tube of serpentine curvature with groups of testicular vesicles along both sides; the groups are separate, without common efferent vessels, according to Sluiter.

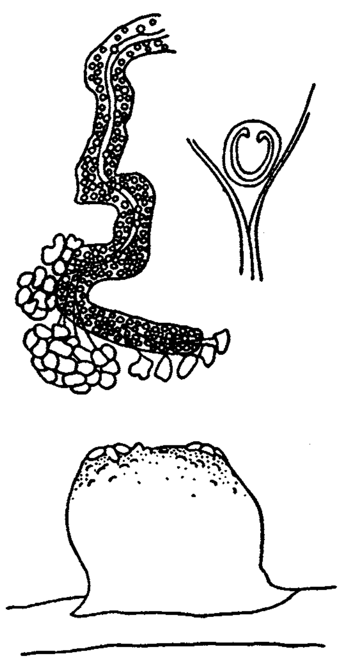


FIG. 204. *Styela milleri* Ritter. Terminal part of gonad, dorsal tubercle, and outline of body (lateral view, ×1.5).

This description of the gonads (shown also in the figure) does not agree particularly well with the description of those of *S. wandeli*. No figure of that species has been published. Sluiter's failure to observe common sperm ducts might, however, be due to poor preservation of the material rather than to their real absence.

LOCALITY: Near King George Island of the South Shetland group, western Antarctic region, depth 75 meters.

Styela milleri Ritter, 1907

Text figure 204

Styela milleri RITTER, 1907, p. 21.

Tethyum milleri HARTMEYER, 1912b, pp. 374, 378.

I quote here Ritter's description which, although from a single specimen, is an excellent one.

"Superficial Characters: Cylindric-ovoid, attached by a small area at posterior end; orifices both brancial the atrial somewhat toward the dorsal side. No siphons, but orifices distinct, both regularly four-lobed. Surface broken by a few irregular low wrinkles anteriorly, by large patches of indurated or warty thickenings posteriorly; the area of attachment bearing many short filamentous processes. Color yellowish brown, the warty areas darker. Length 22 cm., thickness 1.2 cm. Test very thin but parchment-like, readily detachable from the mantle; dull white on inner surface. Mantle thin, muscle fibers uniformly distributed, longitudinal and circular, not disposed in definite bands, the longitudinal generally somewhat stronger.

"Branchial Apparatus: Siphons entirely wanting, both orifices with clear-cut lobes. Tentacles of several lengths, about thirty, long and slender ones of nearly equal length, and probably as many more shorter, but of unequal lengths. Dorsal tubercle prominent, bearing the broad simple horseshoe shaped hypophysis mouth. Branchial membrane with four folds on each side, all broad except the one next the endostyle on the right side, two of the folds on each side next the endostyle drawn out anteriorly into long processes. Internal longitudinal vessels numerous and large, the largest folds having eighteen or twenty on each face. Transverse vessels consisting of a series of large and strong ones of nearly but not quite equal size, and between many of these, others very delicate, usually crossing the stigmata. Stigmata long and slender, with the intervening vessels also very narrow. Dorsal lamina a broad thin membrane not thin nor toothed, but closely crimped. Endostyle heavy, irregularly tortous throughout.

"Intestinal Tract: On the left side of the animal. Stomach regular, elongate-melon shaped, the wall thrown into numerous close, regular ridges or folds. A short duodenal section of the intestine bent closely back upon the stomach, and from this a much longer rectal section having at about the middle of its length a short flexure extending forward along the dorsal side of the body almost to the atrial orifice.

"Gonads: Ovaries consisting of a single, much elongated cylindrical mass on each side, extending from antero-dorsal to postero-ventral. Testes consisting of closely crowded nodular masses grouped around the posterior ends of the ovaries" (Ritter, 1907).

Having had other specimens available for examination, I can add to Ritter's description that some examples are dome shaped, others are attached by a smaller ventrally situated area. There is a tendency for the test to spread out in a thin border upon the surface to which the animal is attached, or if growing on a narrow object, as a bryozoan stem, to clasp it. The degree of roughness of the surface is variable, but the granulations or verrucose elevations caused by irregularly intersecting furrows are too small to affect much the general contour of the body surface, though they are larger near the apertures. On some examples there are scattered, very minute spines.

In adult specimens the internal longitudinal vessels are very closely crowded on the folds and numerous on the intervals also. It is hard to say just where a fold begins, and they are better described as undulations (though sometimes quite high ones) than as actual folds.

There may be 140 or more internal longitudinal vessels on one side of the sac, and even on the intervals between folds they are commonly separated by only one or two stigmata, though in some of the ventral parts of the sac sometimes by three or four stigmata. Young individuals have the internal longitudinal vessels much fewer in number and may have the folds, except the first, low and more or less rudimentary. This species is evidently allied to *S. oblonga* Herdman, likewise from deep water (600 fathoms).

DISTRIBUTION: Ritter's type of this abyssal species was dredged by the "Albatross" at Station 4396, 33° 01′ N., 121° 32′ W., off southern California, in 2228 fathoms, red mud. Other specimens (now in the United States National Museum or the American Museum of Natural History) were dredged by the "Albatross" at Station D5692, 31° 23′ 45″ N., 118° 31′ 30″ W., 1076 fathoms, gray mud, and Station D5691, 31° 08′ 20″ N., 118° 29′ 30″ W., 868 fathoms, gray mud, off San Diego, California, Stations D5693, D5695, off San Nicolas Island, California, 451 and 534 fathoms, respectively; Station 3382, 06° 21′ N., 80° 41′ W., 1793 fathoms, and Station 4621, 06° 36′ N., 81° 45′ W., 581 fathoms off the Bay of Panama; Station 4709, 10° 15′ S., 95° 41′ W., off Peru, 2035 fathoms. I think that one from the southern part of the Chilean coast ("Albatross" Station 2785, 48° 09′ N., 74° 36′ W., 449 fathoms) is also referable to this species.

Styela barnharti Ritter and Forsyth, 1917

Plate 30, figure 1; text figure 205

Styela barnharti RITTER AND FORSYTH, 1917, p. 452, pl. 38, fig. 2, pl. 42, figs. 39, 40.

Ritter and Forsyth had but one rather small specimen (40 mm. long), which was far from being a typical example, and two very young ones on which to base their description, and a very poor idea of the size and usual character of the species is obtainable from their work.

Large individuals of *S. barnharti* are often little inferior in bulk to those of *S. montereyensis* but have the stalk shorter and the body stouter. The largest specimens I have seen have the body proper 85 to 90 mm. in length and with a maximum transverse diameter of 35 to 38 mm., but the body is more cylindrical than in *montereyensis*, maintaining its maximum transverse diameter for a much greater distance from the anterior end; it tapers more abruptly into the stalk, and the latter is almost invariably shorter than the body proper, often in old and large specimens less than half as long.

Another difference is in the apertures. They are, as in *montereyensis*, both on the anterior end, but in *barnharti* both are usually directed forward, and are often so little prominent as to be hard to find among the tubercles and ridges of that part of the body surface. On the other hand, there are occasional specimens in which the branchial aperture is tubular and more or less diverging, thus showing a tendency toward the condition that prevails in *montereyensis*.

A third difference is that though wide longitudinal furrows on the body surface often occur in the present species, they are usually confined to the posterior third or half of the body and are obscured and obliterated by the development of transverse and oblique ridges and furrows on the anterior part, or often by

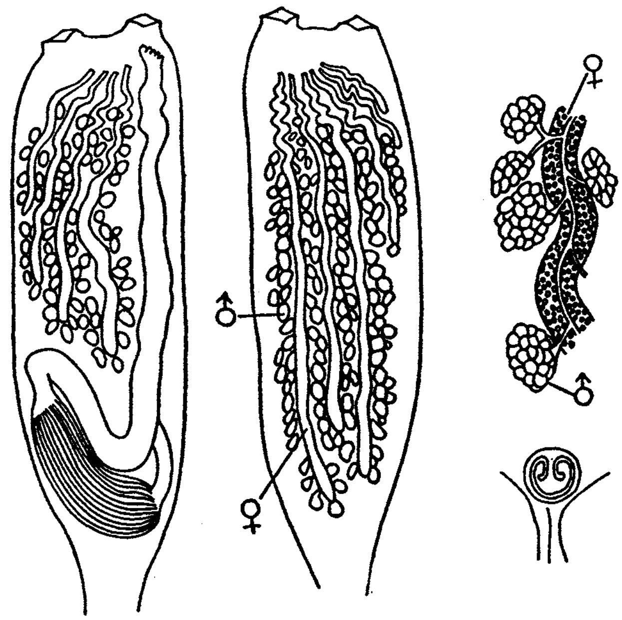


FIG. 205. *Styela barnharti* Ritter and Forsyth. Left and right sides of body (natural size of large specimens), piece of gonad, and dorsal tubercle.

rounded tubercles near the apertures. But occasional individuals may have most of the body longitudinally plicated, acquiring a deceptive resemblance to *montereyensis*, though the much shorter stalk and the direction of the apertures distinguish them. (Ricketts and Calvin's, 1939, fig. 107 would represent such a specimen better than a typical *montereyensis*.)

The color in old specimens is brown or yellowish brown, showing very little reddish except perhaps about the apertures, if indeed the growth of bryozoans, algae, compound ascidians, or other organisms that usually cover them does not entirely obscure the coloration. Young specimens have the test translucent yellowish in the posterior part of the body, becoming rose pink, red, or brownish red anteriorly. Young specimens of 10- to 15-mm. body length or less are more or less ovate and are directly sessile by the posterior end of the body, which becomes narrowed into the stalk as the animal grows older. Such young specimens do not have the gonads developed, at least not to an extent so that they are easily demonstrated.

Mantle rather opaque with thick and diffuse musculature. As in *montereyensis* there is a tapering prolongation extending down into the stalk. Dorsal tubercle relatively small, C-shaped with the horns somewhat inrolled in old individuals, and the open interval forward or more or less obliquely to the left. The number of branchial tentacles reaches at least 70 in large examples. Dorsal lamina relatively narrow for most of its length; it extends far behind the oesophageal opening. The digestive tract and the branchial sac are too much like those of *montereyensis* to need repeating the description, but the internal longitudinal vessels are more numerous and closely placed, as may be seen from the following count in an individual of about 85-mm. body length (compare with that of a specimen of greater length, 100 mm., given in the description of *montereyensis*).

Right	15 (33) 11 (28) 11 (32) 9 (19) 8
Left	8 (37) 9 (29) 11 (33) 10 (18) 7

In their general form and arrangement the gonads are similar in the two species but are considerably more numerous in the present one. The number varies in different individuals, but usually on the right side instead of only two elongated longitudinally directed gonads there are several, besides additional shorter ones in the anteroventral part of the body placed more obliquely, all with the open ends inclined toward the base of the atrial siphon. On the left side the gonads are usually fewer, shorter, more sinuous, and confined chiefly to the region in front of the digestive tract. They are oblique in their direction, though one may extend down, as in *montereyensis*, into the secondary loop of the intestine alongside the rectum. The individual gonads vary greatly in relative length and slenderness, etc., in the same specimen, and the peculiarities of this kind described by Ritter and Forsyth in the type specimen with the idea that they were specific characters were merely individual.

Just how great the limits of variation in number of the gonads might prove to be if a large quantity of material were examined I cannot say, but from three to five gonads on the left and five to nine on the right side would probably cover the majority of cases.

The testes are numerous and are attached to the inner side of the mantle along the sides of the ovaries for most of their length and around their closed ends. They differ from the comparatively simply branched testes of *montereyensis* in being composed of a multitude of short lobes compacted together into low dome-shaped masses, from the lower part of which the efferent duct extends, eventually to join the common sperm duct that accompanies the ovary. The structure of the testes conforms or approximates to that of Huntsman's (1913) subgenus *Botryorchis*.

DISTRIBUTION: This is a species of very shallow water and sheltered situations on the southern California coast. Type locality, San Diego Bay, where, however, it does not appear to be common, as Ritter and Forsyth had only one moderate-sized specimen from a pile and two very small ones from the back of a crab.

The United States National Museum has some small specimens labeled "Albatross" Station 3035?, which is in the northern part of the Gulf of California. The depth (30 fathoms) is much greater than recorded for this species and provides additional reason to doubt the correctness of the locality.

In Newport Bay, California, it is the most abundant and conspicuous of the ascidians, reaching a maximum size and growing in abundance on floats and on piles below low-water mark, also occasionally on shore rocks. I have found small examples on the piles of the ocean pier at Newport Beach, but usually it is not found where exposed to the force of the ocean surf. How far north it extends I do not know. It was not represented in the collection made in 1939 by W. G. Hewatt at Santa Cruz Island of the Santa Barbara group. From its considerable resemblance to *S. montereyensis* it may have been overlooked in some places where it occurs.

Styela montereyensis (Dall), 1872

Text figures 206, 207

Clavellinopsis rubra FEWKES, 1889, p. 134, fig. 1.

Cynthia montereyensis DALL, 1872, p. 157.

Styela montereyensis RITTER, 1893, p. 39; BANCROFT, 1899, pp. 72, 83; HUNTSMAN, 1912, pp. 115, 131; 1912a, p. 151 (misprinted *montereynsis*), pl. 12, figs. 4, 10, pl. 19, figs. 3, 9; 1913, pp. 486, 497, fig. viii; RITTER AND FORSYTH, 1917, p. 448, pl. 38, fig. 1, pl. 41, figs. 28–34; JOHNSON AND SNOOK, 1927, p. 592, fig. 690; HARTMEYER AND MICHAELSEN, 1927, p. 189; PRATT, 1935, p. 748; RICKETTS AND CALVIN, 1939, pp. 77, 238, fig. 107 (figure looks like *Styela barnharti*).

Styela rubra RITTER, 1896, p. 152.

Tethyum montereyense HARTMEYER, 1909–1911, pp. 1359, 1654.

This is the largest and most elongate of the stalked *Styelas* of the North American Pacific coast. The body is shaped like a very narrow inverted cone tapering into a narrow stalk that is usually noticeably longer than the body itself, though this is not the case in many old and large specimens. Very young ones have the stalk short or wanting, being sessile by the posterior end. Large specimens may attain a total length of about 1 foot (300 mm.) inclusive of the stalk; the largest I have examined had the body 130 mm. long by 31 mm. wide. The stalk was incomplete and only 60 mm. long, the lower part of it having been broken off. The stalk is flexible but very tough and strong. In its upper part it is hollow and contains a narrow tubular extension of the rear end of the body; its lower end expands abruptly into an irregular base for attachment. The body surface is usually conspicuously longitudinally grooved by sharply depressed furrows separated by rounded ridges. These reach near, or almost to, the anterior end, where they either fade out or become broken up into tubercles by irregular transverse folds. The grooves may continue on the stalk. The two apertures are terminal on short tubes or papillae arising from the truncated anterior end of the body. The atrial is directed straight forward; the branchial is on a short tube which makes a more or less complete semicircular bend so that the oral aperture is directed obliquely or even straight downward toward the pedicel.

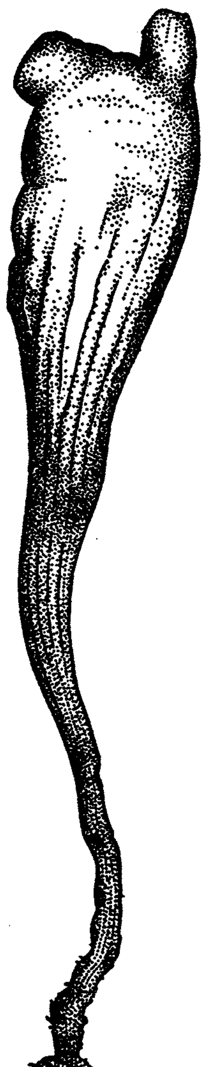


FIG. 206. *Styela montereyensis* (Dall). Large specimen, less than natural size.

The test is tough and leathery, opaque except in young specimens and more or less red in color, becoming yellowish posteriorly unless, as is often the case in old and large specimens, it is so covered with Bryozoa, algae, barnacles, or adherent foreign matter that little of the surface is visible. The mantle has rather thick and diffuse musculature. Branchial tentacles numerous (sometimes much exceeding 100), of different sizes, closely placed but not all exactly in one row. Slender atrial tentacles occur. Dorsal tubercle of C or horseshoe shape, with the open interval to the left, often irregular and with more or less incurved or inrolled horns.

Of the four folds on each side of the branchial sac, the first is usually the highest. The flat intervals between them are fairly wide. The internal longitudinal vessels form rather small meshes with about three to nine stigmata on the flat parts of the sac. Both Huntsman, 1912a, and Ritter and Forsyth, 1917, give counts of the vessels in a number of specimens.

In one of 80-mm. body length (exclusive of the stalk), Ritter and Forsyth found their distribution as follows:

Right	7	(22)	9	(16)	13	(16)	10	(14)	7
Left	7	(22)	11	(16)	12	(16)	15	(14)	6

A young one 25 mm. in body length had on the left side:

2 (8) 3 (4) 3 (6) 5 (4) 3

The stomach is long and narrow, placed longitudinally in the left ventral and posterior part of the body; its wall has 30 or more distinct longitudinal folds. From its anterior (pyloric) end the intestine bends posteriorly, forming a deep and narrow U-shaped loop. The rectum is long and straight, ending in a lobate aperture close to the base of the atrial tube.

The usual number of gonads is two on each side of the body, each consisting of a long tubular ovary with numerous small, sometimes considerably lobed or branched testes, attached to the mantle along each side for most of its length. All the four gonads end close to the base of the atrial tube. Those of the right side are fairly straight. The dorsal is the longer one and reaches nearly to the rear end of the body. On the left side the dorsal gonad is likewise straight, lying alongside the rectum, its posterior part in the U-shaped loop of the intestine; the other left gonad is shorter and is obliquely placed anterior to the stomach and has a more sinuous ovary.

DISTRIBUTION: Known from British Columbia (Ucluelet and Hope Island, Hunts-

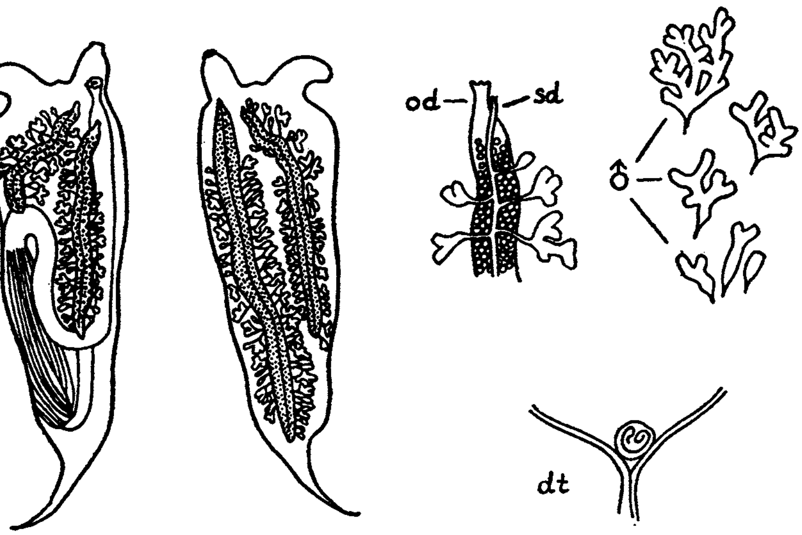


FIG. 207. *Styela montereyensis* (Dall). Details of gonads, alimentary tract, and dorsal tubercle.

man) to the southern boundary of California. Type locality, Monterey, California. It is a shallow-water form, though dredged in depths down to 12 to 17 fathoms off Corona Del Mar, California, by G. E. MacGinitie, and is occasionally washed up on ocean beaches. It grows also on shore rocks at extreme low water and is able to resist considerable wave action but is reported to grow most luxuriantly and reach extreme size on piles and breakwaters in more sheltered localities. I did not find it myself in the places where I collected, but Huntsman obtained it "in quantity" on the west coast of Vancouver Island, and others have reported it in "abundance" on piles, breakwaters, etc., in the vicinity of Los Angeles and especially at Santa Barbara and Santa Cruz, California, where it is said to reach the maximum size.

Styela gibbsii (Stimpson), 1864

Text figure 208

Cynthia gibbsii STIMPSON, 1864, p. 159.

Styela gibbsii HERDMAN, 1898, p. 261, pl. 13, figs. 1–4; RITTER, 1900, p. 604, pl. 18, figs. 13–14; 1907, p. 23 (perhaps only in part); MICHAELSEN, 1911, p. 122 (*gibsii*); HUNTSMAN, 1912, pp. 114, 131; 1912a, p. 149, pl. 12, fig. 5, pl. 19, figs. 10, 11; 1913, pp. 483, 497; RITTER, 1913, p. 477; JOHNSON AND SNOOK, 1927, p. 593; HARTMEYER AND MICHAELSEN, 1927, p. 188; PRATT, 1935, p. 748; WISMER AND SWANSON, 1935, p. 341; RICKETTS AND CALVIN, 1939, p. 160.

Tethyum gibsii HARTMEYER, 1909–1911, pp. 1359, 1634.

Body elongated-cylindrical, often slightly curved, both apertures on short papillae close together at the anterior end, the atrial a little removed backward. Attachment directly by the posterior end, which may or may not be somewhat narrowed and from which a few root-like processes to aid in the attachment often extend out. Usually there is no pedicel, though a short one is occasionally developed.

Test opaque, tough but not very thick, its outer surface with numerous wrinkles which are mainly longitudinal or oblique but are generally crossed by less prominent circular ones on some parts of the body. Toward the anterior end and on the bases of the papillae bearing the apertures, they break up into tubercles. Color brownish or brownish yellow, usually more or less discolored with mud, shading into red or reddish about the apertures; often there is adhering sand on the posterior part of the body. It often has a superficial resemblance to *Pelonaia corrugata* Goodsir and Forbes.

The largest specimen at hand is a little less than 60 mm. long and about 17 mm. in greatest width. The width is proportionately greater in many of the smaller specimens. It often grows in clusters or masses which may contain also other ascidians.

Mantle thin and with inconspicuous musculature, allowing the internal organs to be seen through it. Branchial tentacles mod-

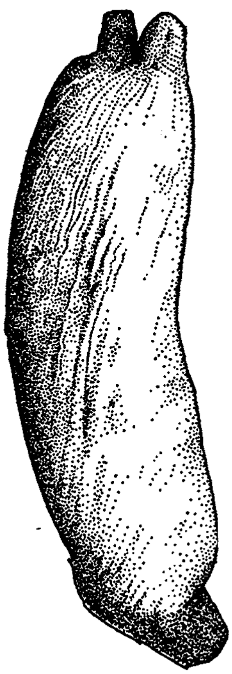


FIG. 208. *Styela gibbsii* (Stimpson). Exterior view (left side), × about 2. After Huntsman.

erately numerous (25 to 40, according to Huntsman). Dorsal tubercle horseshoe shaped, with one or both horns usually curved in (sometimes outward), but not spirally coiled. The open interval usually obliquely or more or less directly toward the left.

The branchial sac has an elongate form corresponding to that of the body; at its posterior end it becomes very narrow. Four well-developed folds on each side, of which the first (most dorsal) is usually the highest and the third the next highest. Internal longitudinal vessels numerous. Huntsman gives their distribution in two large specimens as follows:

LENGTH		
5 cm.	Right	6 (15) 4 (8) 5 (12) 4 (6) 2
	Left	4 (16) 5 (8) 5 (9) 5 (5) 2
7 cm.	Right	12 (13) 6 (8) 5 (9) 5 (5) 2
	Left	5 (17) 6 (7) 3 (8) 5 (5) 2

The transverse vessels are quite regular in arrangement and of about four orders, counting the smallest which cross the stigmata. The meshes they form with the longitudinal vessels are rather small, ordinarily with not over five to seven stigmata.

Stomach elliptical in outline, about twice as long as wide and placed more or less longitudinally (anteroposteriorly) in the posterior part of the body. It has numerous (up to about 30) well-defined longitudinal folds. The intestine, leaving its anterior end, bends back parallel to the stomach for much of the length of the latter, then bends forward again to form the rectum which extends much of the length of the body. Margin of anus lobed.

Normally there are two gonads on each side, each consisting of a long, moderately straight tubular ovary and numerous small, somewhat elongate and irregularly shaped testes ranged along the posterior third or posterior half of the ovary on both sides of it and around its end. On the right side of the body the ovaries are quite long, extending for a large part of the length of the body. On the left side they are somewhat shorter and more anterior in position, especially the more ventral one of the two.

DISTRIBUTION: From British Columbia (Departure Bay, Northumberland Straits, Huntsman) to southern California (San Diego, Johnson and Snook). It appears to grow chiefly in water a few fathoms deep. Huntsman (1912a, p. 150) expressed doubt (perhaps with justification) over a statement by Ritter (1907) that it grows abundantly on shore rocks above low-water mark in Puget Sound, believing that Ritter confused this species and "*S. vancouverensis*" (=*Styela truncata* Ritter, 1901). On the southern California coast, Johnson and Snook report it rare along the shore but common in 40 to 50 fathoms.

Though there is considerable superficial resemblance to *S. truncata*, the body in the present species is normally more elongate and attached by a more narrowed base.

Styela truncata Ritter, 1901

Text figure 209

Katatropa uclueletensis HUNTSMAN, 1912, pp. 115, 130; 1912a, p. 146, pl. 12, fig. 2, pl. 19, fig. 4; 1913, pp. 486, 497.

Katatropa vancouverensis HUNTSMAN, 1912, pp. 114, 115, 130; 1912a, p. 144, pl. 11, fig. 10, pl. 12, fig. 1, pl. 19, figs. 1, 2, 6; 1913, pp. 494, 497, figs. vi, ix, xii, xiii.

? *Styela gibbsii* RITTER, 1907, p. 23 (in part: the specimens from Puget Sound above low-water mark).

Styela truncata RITTER, 1901, p. 241, pl. 27, figs. 22, 23.

Tethyum truncatum HARTMEYER, 1909–1911, p. 1360.

The body commonly has the form of a rather short cylinder whose axis is usually somewhat curved. The apertures may be on short, forward directed papillae near together on the anterior end, but in some cases are less conspicuous than the surrounding tubercles; the attachment is by the whole of the other end which is somewhat obliquely truncated. Specimens that are rather low dome-shaped or conical and obliquely depressed also occur. Even those of the more usual cylindrical form are proportionately shorter and wider than is commonly the case in the externally somewhat similar *Styela gibbsii*.

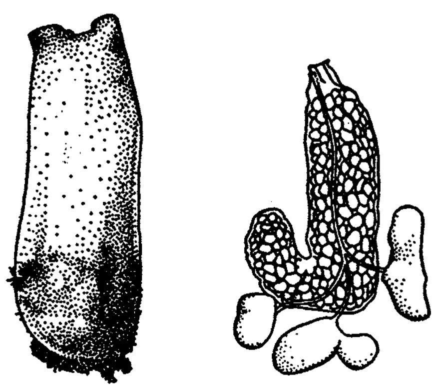


FIG. 209. *Styela truncata* Ritter. External view, × about 2; and gonad (side next to branchial sac). Adapted from figures of Huntsman, 1912, 1913.

Surface slightly rough, frequently much overgrown with Bryozoa or algae. Near the anterior end there are small irregular tubercles, reddish in color and irregularly scattered. Larger ones are often found on the siphons opposite the angles of the apertures. In addition, large irregular thickenings of the test occur wherever Bryozoa and other growths are attached. Exceptionally, the attachment may be by a short pedicel at the posterior end. Color brownish, yellowish, or pale orange, usually masked by dirt; siphons usually more red. It reaches 25 to 30 mm. in length and 12 mm. or more in diameter.

Muscles of the mantle not thick, but forming fairly continuous layers, the inner being longitudinal.

The oral tentacles are rather few, usually about 20 or 22 with a simple C-shaped or horseshoe-shaped aperture with the open interval turned toward the left.

The branchial sac extends nearly to the rear or attached end of the body. It has four well-developed folds, the first usually the highest, the third fold next highest. Huntsman (1912a) gives schemes of the distribution of the vessels in several specimens as follows:

BODY LENGTH		
17 mm.	Right	1 (11) 1 (6) 1 (9) 1 (6) 1
	Left	0 (12) 1 (4) 1 (8) 1 (6) 1
20 mm.	Right	2 (10) 1 (0) 1 (9) 1 (6) 1
	Left	0 (11) 1 (6) 1 (8) 1 (5) 1
20 mm.	Right	1 (7) 1 (3) 1 (6) 1 (3) 1
	Left	0 (8) 0 (2) 1 (5) 1 (2) 1

Ritter (1901) gives the following counts in two different specimens:

1 (10) 1 (6) 1 (8) 1 (6) 1
1 (11) 1 (8) 1 (8) 1 (8) 1

The presence of a single internal longitudinal vessel (usually quite stout) on each of the flat intervals between folds is evidently one of the conspicuous specific characters. There are three orders of transverse vessels, the smallest crossing the stigmata. Usually from six to 12 stigmata in the meshes on the flat parts of the sac.

A part of the oesophagus and the stomach, which is rather elongated, lies posterior to the branchial sac. The wall of the stomach has rather few longitudinal folds (12 to 18 according to Huntsman, about 15 according to Ritter).

On the left side the ovary of the ventral gonad is anteroposterior in direction and in front of the stomach; that of the dorsal gonad, horizontally directed and above the intestinal loop. On the right side they are obliquely directed and are farther back, the dorsal larger than the ventral. On each side they end close together posterior to the middle of the endostyle. This ventrally directed position of the ovaries is the principal character of Huntsman's genus *Katatropa*, of which he made this species the type.

The testes are comparatively few in number, thick in proportion to their length, and usually not very much lobed; they lie alongside, but not overlapping, the ovaries, usually more along the ventral than the dorsal side of the latter.

DISTRIBUTION: Ritter described his *S. truncata* from about 50 specimens found on the rocks at extreme low tide on Khantaak Island, Yakutat Bay, southern Alaska. Huntsman records his "*vancouverensis*" species only from British Columbia (Departure Bay and Ucluelet). It is found, he says, "between tides on exposed rocks or on the roofs of caverns, usually overgrown with sea weeds, polyzoa, etc." (See also remarks on the distribution of *S. gibbsii.*)

Katatropa uclueletensis Huntsman (1912a, p. 146) was based on only two specimens, closely corresponding with this species, dredged in about 9 fathoms near Ucluelet, British Columbia, one of the localities where "*vancouverensis*" (=*truncata*) was obtained. I can hardly question its identity with this species.

What I consider to be this same species occurs on the California coast. I have received several specimens from G. E. MacGinitie, the largest measuring 30 mm. long by 24 mm. transversely, from Elkhorn Slough near Monterey (therefore from shallow water), one dredged outside Newport in 40 to 70 feet, and some from W. G. Hewatt from outlying rocks off Santa Cruz Island, and I obtained some myself from piles of the ocean wharf at Newport Beach, California, exposed to heavy surf.

Styela clavata (Pallas), 1774

Ascidia clavata PALLAS, 1774, p. 25, pl. 1, fig. 16. Not O. F. Mueller, 1776, O. Fabricius, 1780, and others; they refer to *Boltenia ovifera*.

Katatropa clavata REDIKORZEV, 1916, p. 204, figs. 39–40, pl. 5, fig. 3.

Katatropa greeleyi HUNTSMAN, 1912, p. 130; 1912a, p. 146; 1913, p. 497, figs. ix, xiii.

Styela clavata HARTMEYER, 1903, p. 208; OKA, 1918, p. 394, 1 fig.; ÄRNBÄCK, 1922, p. 21; HARTMEYER AND MICHAELSEN, 1927, p. 189.

Styela greeleyi RITTER, 1899, p. 516, figs. 9–13; HARTMEYER AND MICHAELSEN, 1927, p. 189.

Tethyum clavatum REDIKORZEV, 1910, p. 124.

See also *S. yakutatensis* Ritter, below, which is very close to, if distinct from, this species.

The best available descriptions of *S. clavata* are those of Redikorzev, 1916, and Ritter, 1899; the former is in Russian but with a Latin diagnosis and two figures. Ritter's description is quoted here.

"General Characteristics: Body elongated, somewhat flattened; tapering slightly toward both ends, at the posterior abruptly contracted into a slender peduncle, which is from one and a half to two times as long as the body. Dimension of one of the largest specimens: length of body, 1.8 cm.; greatest diameter, 1.1 cm.; length of peduncle, 4.3 cm. Color, yellowish brown, tinged with red on the anterior half. Siphons, bright orange red. Surface covered with longitudinal folds, which are less pronounced on the peduncle. Transverse folds present on the anterior half, but these possibly due to contraction.

"Test: Tough, coriaceous, but scarcely 1 mm. thick even through the folds. Dull grayish white on the inner and cut surfaces.

"Mantle: Closely attached to test; musculature weak.

"Branchial Apparatus: Siphons projecting slightly, both placed at anterior end close together, the atrial pointing straight forward, while the branchial is bent over so that the opening is directed ventrally. Branchial tentacles simple, of two sizes arranged in two concentric circles, the other circle containing about 15 large and the inner about 30 small ones. Circles close to the peripharyngeal band. Atrial tentacles filiform, numerous. Dorsal tubercle inconspicuous, the mouth of the hypophysis irregularly horseshoe-shaped, close to the tentacles, which nearly hide it. Branchial sac with four folds on each side, the development of these folds varying with the size (age?) of the specimen. In smaller (younger?) specimens the folds on the left side more strongly developed than those on the right. In specimens 3.1 to 6.7 cm. (including peduncle), pair of folds next the endostyle had about 12 bars and those next dorsal lamina about 20. In specimens 0.85 to 1.8 cm. folds next endostyle had about 6 and those next dorsal lamina about 12 bars. Folds closely placed, only 3 to 5 bars between them. Transverse vessels of three sizes, a wide one occurring at irregular intervals, and two narrower ones, which usually alternate with each other. Intermediate transverse vessels sometimes present, often dividing the series of stigmata into two. Meshes nearly square or longitudinally elongated with 4 to 6 (usually 5) long narrow stigmata. Dorsal lamina ribbed on one side by the vessels passing round the oesophagus.

"Digestive Tract: Situated on the left side of branchial sac and making a narrow turn. Oesophagus short, opening from the dorsal side of the branchial sac near its posterior end. Stomach long and narrow, with numerous internal folds which show on the surface as longitudinal markings. Anal opening bilobed, each half cut into about six lobes.

"Sexual Organs: Gonads on each side of the body. Ovaries long, sausage shaped, ending in a short oviduct, those on the right side longer than those on the left. One of those on the left side placed in the loop of the intestine, the other beginning higher up and extending down under the stomach. Testis small, clustered in bunches over the ovaries. Endocarps rather numerous on the mantle" (Ritter, 1899, pp. 516, 517).

This is a member of Huntsman's genus *Katatropa* (see under genus *Styela*).

According to Huntsman, 1913, the individual testes in this species are elongate sausage shaped and usually unbranched, projecting freely into the peribranchial cavity, thus providing a character distinguishing it from *S. yakutatensis* in which the testes are cleft into diverging lobes. But in five specimens, apparently all *clavata* from the Pribilof Islands, I found them unbranched, or nearly so, in three specimens, while in the fourth and fifth most of the testes were short and cleft into lobes or branches. Individuals vary much in the relative length of the stalk and body proper.

It should also be added that Redikorzev's scheme of the internal longitudinal vessels of the branchial sac shows a larger number (eight, instead of three to five) on the flat parts of the sac between the folds. The siphonal spinules are long and pointed in this species.

DISTRIBUTION: This is a species of the Bering Sea region. Pallas gave "Kamchatka" as his type locality. Redikorzev had it from Bering and Medny Islands; Ritter and Hartmeyer, from the Pribilofs; Oka reported it from "Albatross" Station 4777 near the Aleutian Islands (52° 11′ N., 179° 47′ E., 52 fathoms) and the United States National Museum sent me for examination a specimen from Kiska Island in the Aleutian chain, dredged in 5 to 12 fathoms. It is apparently chiefly an inhabitant of shallow water.

This species is entirely distinct from *Styela clava* Herdman, 1881, another stalked species from the eastern Asiatic coast which belongs to Huntsman's subgenus *Botryorchis*. (With regard to *S. clava*, it may be noted here that the locality 31° N., 128° W. on p. 58 of Traustedt's 1885 article is a misprint. It should be, according to p. 46 of that article, 125° E., therefore near Japan.)

It if proves necessary to include *S. yakutatensis* in the present species, its range will be extended south to include the west coast of Vancouver Island.

Styela yakutatensis Ritter, 1901

Text figures 179H, 210

Katatropa yakutatensis HUNTSMAN, 1912, p. 130; 1912a, p. 147, pl. 12, fig. 3, pl. 19, figs. 5, 7; 1913, p. 497, fig. iv.

Styela yakutatensis RITTER, 1901, p. 239, pl. 27, figs. 20, 21; HARTMEYER AND MICHAELSEN, 1927, p. 190.

Tethyum yakutatense HARTMEYER, 1909–1911, p. 1360.

This is another stalked form with much resemblance to *S. clavata* not only externally but in internal structure as well, if really distinct from it.

"External Features: Body cylindrical, tapering rather abruptly at the posterior end into a stalk, which is usually shorter than the body.

"Apertures at the anterior end; atrial at the dorsal angle at the end of a short straight siphon, directed anteriorly, oral at the ventral angle at the end of a short siphon which is bent into a semicircle and hence directed posteriorly.

"Surface smooth but longitudinally furrowed and irregularly wrinkled.

"Colour dark red anteriorly, fading into a yellowish red posteriorly and on stalk" (Huntsman, 1912a, p. 147).

Externally the most conspicuous difference is that the stalk in this species is shorter than the body (in the ratio of 1 to 1.8, according to measurements of 22 specimens made by Ritter) and quite stout. Ritter's and Huntsman's largest specimens measured 57 mm.

FIG. 210. *Styela yakutatensis* Ritter. External view, ×1.5. After Huntsman.

and 61 mm., respectively, in total length, of which the stalk occupied 20 mm. and 21 mm., respectively.

Huntsman gives the tentacles as 30 to 40 in number, the internal longitudinal vessels in a large specimen (body length, 38 mm. exclusive of the stalk) as follows:

Right	4 (15) 4 (7) 4 (11) 4 (7) 3
Left	3 (17) 4 (7) 4 (8) 4 (6) 3

Transverse vessels of four or five sizes, the smallest crossing the stigmata. There are usually three to five stigmata in a mesh between folds. Stomach long and narrow, with 25 to 31 narrow deep folds in the wall.

"Gonads: About $\frac{1}{3}$ length of body or slightly more; all about the same length, their anterior ends directed ventrally toward endostyle. On the left side, the dorsal is placed between intestinal loop and rectum, while the ventral extends some distance behind anterior end of intestinal loop and thus lies partly on the left side of the loop. Ventral gonad of each side placed farther forward than dorsal. The testicular lobes are placed along either side of posterior $\frac{3}{4}$ or somewhat more of each ovary.

"In many specimens the peribranchial cavities are filled with eggs or larvae."

"*Styela greeleyi* Ritter, 1899, from the Pribilof Islands, differs from this species in having a much larger stalk, as well as in certain anatomical details" (Huntsman, 1912a, p. 149).

These "certain anatomical details" are made more clear in a later article by Huntsman (1913, p. 492) in which he includes this species among those in which the testes are cleft into diverging lobes, while in "*greeleyi*" (*clavata* of this work) they are described as sausage shaped and virtually unlobed (but see remarks under *S. clavata*). Another difference reported is in the siphonal spinules, which are figured as very short and squarely truncated at the end in *yakatutensis* but in *greeleyi* (*clavata*), prolonged into a tapering spine. This species is a member of Huntsman's genus *Katatropa* (see under genus *Styela*).

DISTRIBUTION: Known only from Yakutat Bay, southern Alaska (Ritter, 1901), and Ucluelet, Vancouver Island. Ritter's specimens, about 70, of all sizes, were all taken from a reef near Khantaak Island; Huntsman's, 43 in number, were "attached to lower surface of overhanging rocks on exposed shore."

GENUS **PELONAIA** GOODSIR AND FORBES, 1841

Text figure 179D

Consists only of the following species, unique among the simple species of Styelidae in the entire loss of the folds of the branchial sac. It is actually more closely related to *Styela* than to *Cnemidocarpa*, the testes being attached to the body wall alongside the ovary.

Pelonaia corrugata Goodsir and Forbes, 1841

Text figures 179D, 211, 212

Pelonaia arenifera STIMPSON, 1851, p. 49; PACKARD, 1863, p. 412; 1867, p. 277; BINNEY, 1870, p. 27; WHITEAVES, 1873, p. 17; 1874, p. 12; 1874a, pp. 216, 218; VERRILL, 1879, p. 27 (*Pelonaea c.*); WHITEAVES, 1886, p. 34; PACKARD, 1891, p. 397; WHITEAVES, 1901, p. 269; HARTMEYER, 1915, p. 313.

Pelonaia corrugata GOODSIR AND FORBES, 1841, p. 138; FORBES AND GOODSIR, 1841, p. 30, pl. 1, fig. 1; HARTMEYER, 1903, p. 203, pl. 5, fig. 14; ALDER AND HANCOCK, 1907, p. 145, figs. 81, 82, pl. 46, figs. 15, 16, pl. 47, pl. 48, fig. 18; VAN NAME, 1912, p. 545, fig. 29, pl. 58, figs. 84–85; HUNTSMAN, 1912, pp. 113, 132; 1912a, p. 157, pl. 12, fig. 9; 1913, p. 498, figs. iii, vi, xiii; RITTER, 1913, p. 486; HARTMEYER, 1914b, p. 1105; 1915, p. 308; REDIKORZEV, 1916, p. 210, figs. 41–42, pl. 5, figs. 4–6; HARTMEYER, 1921a, p. 39; 1923, p. 187; ÄRNBÄCK, 1922, p. 21, pl. 1, figs. 10–13.

Pelonaia glabra GOODSIR AND FORBES, 1841, p. 138; FORBES AND GOODSIR, 1841, p. 30, pl. 1, figs. 2, 3; ALDER AND HANCOCK, 1907, p. 146, figs. 83, 84.

For other names and references, see Hartmeyer, 1923, p. 187.

Body elongated cylindrical or more or less club shaped, attached by the larger end, which often is rounded, and has root-like processes. The two apertures are close together on small elevations at the narrower end.

The test is tough and more or less opaque, with transverse wrinkles which may be so small and numerous as to leave the surface fairly smooth, or coarse, so as to leave it quite rough. The wrinkles are probably due in part to muscular contraction and are less prominent in living and expanded specimens.

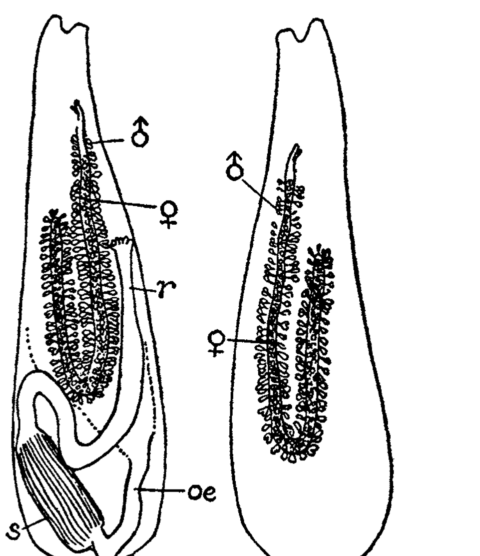


FIG. 211. *Pelonaia corrugata* Goodsir and Forbes. Left and right sides of body, ×6.

The color of the surface in preserved specimens is grayish or reddish brown, but it is often obscured by a more or less complete coating of adhering sand except immediately about the apertures. In some of the northern regions it reaches a considerable size, 110 to 120 mm. long or even more; in other places, 30 to 40 mm. is not exceeded.

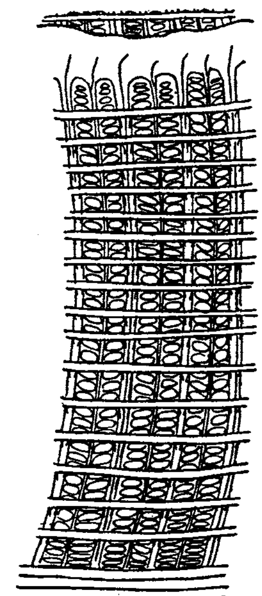


FIG. 212. *Pelonaia corrugata* Goodsir and Forbes. Part of branchial sac, ×25.

The inner (longitudinal) muscular layer of the mantle is well developed, the external circular layer being much weaker. Branchial tentacles not numerous (20 to 30) but of several sizes. Dorsal tubercle of simple C or horseshoe shape, the open interval variable in its direction. Dorsal lamina long and narrow with a rather smooth margin.

The branchial sac does not reach all the way to the rear end of the body, so that the oesophagus and stomach extend partly behind it. According to Huntsman (1913a) the sac forms a small pocket posterior to the oesophageal aperture.

Branchial sac without folds. From 16 (in a small specimen) to about 20 internal longitudinal vessels on each side, fairly evenly spaced. Transverse vessels numerous, of three distinct orders quite regularly arranged forming small meshes with only two or three stigmata in them in most parts of the sac.

Stomach rather elongate with 20 or more longitudinal folds and placed somewhat oblique to the anteroposterior axis of the body. The intestinal loop is rather short; the rectum does not extend far forward. Margin of anus lobed.

One elongate gonad on each side, each consisting of a long tubular ovary bent in a narrow U-shaped curve at the rear end, the dorsal branch forming the longer part of the ovary. In young specimens the ovary may be straight. At its anterior end the dorsal branch is produced into a short oviduct. The numerous small pyriform testes lie along each side of the ovary for most of its length, separated from it by a little interval in young specimens but closer to, or even overlapping, the ovary when the gonads are well developed. Their ducts unite to form a common sperm duct extending forward on the surface of the ovary next to the branchial sac, which opens on a papilla beside, but a little short of, the end of the oviduct. The left gonad is situated anterior to the intestinal loop; the right gonad is not quite so far forward.

DISTRIBUTION: Probably completely circumpolar in the Arctic regions, extending south to the coasts of the North Sea in Europe. Records from the English Channel are considered doubtful by Hartmeyer. On the American side extending to Labrador and the Gulf of St. Lawrence and the waters off the eastern end of Nova Scotia. Specimens were obtained in 1934 and 1935 from the Northeast Bar, Sable Island. Stimpson has one record from about 10 miles east of Boston, Massachusetts, in 15 fathoms, which is the only record from near the New England coast. In the north Pacific region it extends south to the sea of Japan and British Columbia (Rose Spit, Huntsman).

Although its range is so wide, it is very local in its distribution, preferring sandy or somewhat muddy bottoms. In depth the records range from about 4 to nearly 100 fathoms, most of them in not over 20 to 30 fathoms.

FAMILY **PYURIDAE** HARTMEYER, 1908

(Syns. Cynthiidae minus the Styelidae of older authors, Halocynthiidae Verrill and many recent authors; Tethyidae Huntsman, 1912; not Hartmeyer, 1909–1911, or Van Name, 1912.)

A family consisting of simple ascidians exclusively, many species attaining considerable size. Its usual characters include the following:

Body attached; sometimes borne on a stalk.

Test tough and leathery, usually opaque; rough externally, sometimes with remarkably developed spines or processes, often tinged with a red or reddish color, especially about the apertures. The test and internal organs may contain calcareous spicules.

Apertures both four-lobed or square, sometimes reduced to a transverse slit. Larger tentacles almost always compound. Dorsal lamina sometimes continuous, oftener divided into a series of pointed languets.

Branchial sac with wide longitudinal folds, usually at least five or six on each side, and many internal longitudinal vessels; the stigmata are usually small, straight longitudinal slits, but on the folds a spiral arrangement occasionally occurs, and in one aberrant genus (*Heterostigma*) may be highly developed; in another genus (*Boltenia*) the stigmata are dorsoventral in direction.

Intestinal tract forming a simple longitudinal loop in the left or left ventral side of the branchial sac; the stomach is elongate, tapering gradually into the intestine, and bearing one or more large groups of hepatic tubules.

Gonads hermaphroditic, one or more on each side of the body. Renal organs not certainly distinguished; never a large renal sac.

The thin invaginated layer of test that lines the distal part of the siphons bears numerous very minute scale-like spines (called "Schuppendornen" by Michaelsen). They are of more or less flattened or concave cross section and vary from short and triangular to slender and awl shaped. Michaelsen considered that their exact shape and size afforded important characters for distinguishing species, a belief which I do not share, and I do not think that their reliability for that purpose justifies the considerable trouble in preparing them for microscopic study, or the mutilation of good specimens involved in getting them out. They are not entirely confined to the present family but occur in some Styelidae and Molgulidae also.

Genera of Pyuridae

A_1. Branchial folds well developed (usually six or more on each side) and bearing internal longitudinal vessels.
- B_1. Dorsal lamina cleft into a series of narrow teeth or languets.
  - C_1. Stigmata longitudinal, arranged in transverse rows. Intestine forming a large open loop.
    - D_1. Gonads one (rarely two) on each side, usually consisting of small separated sacs containing an ovary and testes arranged along the oviduct and common sperm duct, but sometimes of more compact structure. . . *Pyura*
    - D_2. Gonads one on each side, consisting of a long sinuous ovary bordered by the small testes. Needle-like spicules covered with small appressed spines in mantle and internal organs . . . . . . *Herdmania*
    - D_3. Gonads several on each side; flask shaped or tubular, their distal ends directed anteriorly and lying across the intestine . . . . *Halocynthia*
  - C_2. Stigmata transverse (unique among ascidians) crossed by the internal longitudinal vessels . . . *Boltenia*
  - C_3. Abyssal species, body borne on slender flexible stalk arising from the anterior end or on a shorter pedicel. Branchial sac consisting mainly of transverse and internal longitudinal vessels only . . . . *Culeolus, Fungulus*
- B_2. Dorsal lamina a continuous membrane. Left gonad partly in intestinal loop.
  - C_1. Stigmata straight . . *Microcosmus*
  - C_2. Stigmata curved or in spirals on the folds . . . . *Hartmeyeria*
- B_3. Abyssal and Antarctic forms having body surface with converging rows of minute papillae bearing spicules. Stigmata small, irregular . . . . . *Bathypera*

A_2. Branchial folds obsolete, stigmata in large flattened infundibula . . . *Heterostigma*

Genus **PYURA** Molina, 1782

(= *Cynthia* Savigny, 1816, in part, and *Halocynthia* Verrill, 1879, in part; not *Halocynthia* as used in the present work)

This is the type and largest genus of the family; both sessile and some stalked species are included, as that external character is no longer regarded as of generic importance. Type, *Pyura chilensis* Molina, 1782.

In this genus, as now employed, the stigmata are always longitudinal in direction, except that in a few species they may assume a somewhat spiral arrangement at the extreme summit of the branchial folds. In a few species there are branching spicules in some of the tissues and organs. Dorsal lamina cleft into a series of languets or serrations.

Gonads usually but one on each side, that of the left side between the somewhat widely separated branches of the intestinal loop; rarely two gonads on one or both sides. The gonads do not lie across the intestine as in *Halocynthia* and *Microcosmus*.

Gonads composed in most species of small sacs, each containing an ovary and a number of small testes; the sacs are arranged along (usually on both sides of) a long slender oviduct and a common sperm duct accompanying the oviduct.

In some species, however (including *Pyura legumen* and its close allies, also *P. stubenrauchi*, *P. setosa*, and *P. mirabilis*), the gonads are of less specialized structure, no separate sacs being formed. The gonads are elongate bodies with an axially situated oviduct and ovary, the latter divided into a series of segments or lobes which are surrounded by the small testes.

As has been suggested by Ärnbäck (1938, p. 28), that may provide a ground for removing these species from *Pyura*, but I think that such a step may await more investigation, as *P. legumen* is the only one of these species of which much material has been collected.

Pyura vittata (Stimpson), 1852

Plate 16, figure 5; text figures 213–215

Cynthia chazaliei Sluiter, 1898, p. 22, pl. 2, figs. 29, 30.

? *Cynthia discrepans* Sluiter, 1898, p. 23, pl. 2, figs. 31–34, pl. 3, fig. 44.

Cynthia laevigata Heller, 1878, p. 93, pl. 2, fig. 11; Sluiter, 1898, p. 20, pl. 2, fig. 24.

Cynthia riiseana Traustedt, 1883, pp. 118, 132, pl. 5, fig. 13, pl. 6, fig. 19.

Cynthia torpida Sluiter, 1898, p. 21, figs. 25–28.

Cynthia vittata Stimpson, 1852, p. 230; 1860,

p. 443 (not Wilson, 1900); OKA, 1932, p. 259, figs. A, B; 1935, p. 439, figs. 8, 9.

Halocynthia karasboja OKA, 1906, p. 48.

Halocynthia riiseana VERRILL, 1900, p. 590; HARTMEYER, 1908, p. 111.

Halocynthia rubrilabia VERRILL, 1900, p. 589, fig. 7; RENNIE AND WISEMAN, 1906, p. 904, pl. 64, figs. 1–6, 8.

Halocynthia rubrilabia + *H. riiseana* var. *munita* VAN NAME, 1902, pp. 393, 394, pl. 54, figs. 83, 84, pl. 57, figs. 85–87, 90, pl. 62, fig. 133, pl. 63, fig. 141, pl. 64, figs. 150, 152.

Pyura vittata VAN NAME, 1921, p. 446, figs. 112–122; 1924, p. 31; HARANT, 1929, pp. 65, 66; VAN NAME, 1930, p. 496, figs. 60–62; BERRILL, 1932, p. 78; PLOUGH AND JONES, 1937, p. 101.

Forms listed above in genus *Cynthia* are listed in *Pyura* in Van Name, 1921, pp. 487, 488.

External form and characters so varied that it is almost impossible to give any description covering them; often the species can be recognized only by dissection. Body more or less oval, but often very irregularly so, sometimes laterally compressed, sometimes not. Attachment variable, occasionally by the whole of the ventral surface, in other examples by the posterior end (which may be produced into a very short extension or peduncle), or by one side. Apertures square, generally rather far apart, raised on papillae which in some specimens are produced into more or less elongate tubes.

Test, especially in old specimens, tough and opaque, sometimes remarkably so, and often much wrinkled. The wrinkles and folds, though separated by narrow, sharply defined furrows, generally have the upper edge rounded. The outer body surface may be incrusted with sand or shell fragments, or overgrown by other organisms, or be nearly clean; around the apertures the surface is usually more or less nodulose and bears many minute short spines, visible only on some magnification. The fresh specimens I have seen vary from yellow to reddish or reddish brown, the color becoming more intense (often bright red) near the apertures, but often obscured or concealed by the incrusting material. In preservation in alcohol the colors fade to a dirty yellowish or yellowish brown. One small alcoholic specimen from Pensacola, Florida, in the United States National Museum collection is a bright brassy yellow externally but was probably red when alive. The inner surface of the test is more or less pearly. This species reaches a large size; a specimen from Puerto Rico measures 49 mm. long and 35 mm. dorsoventrally; one in the

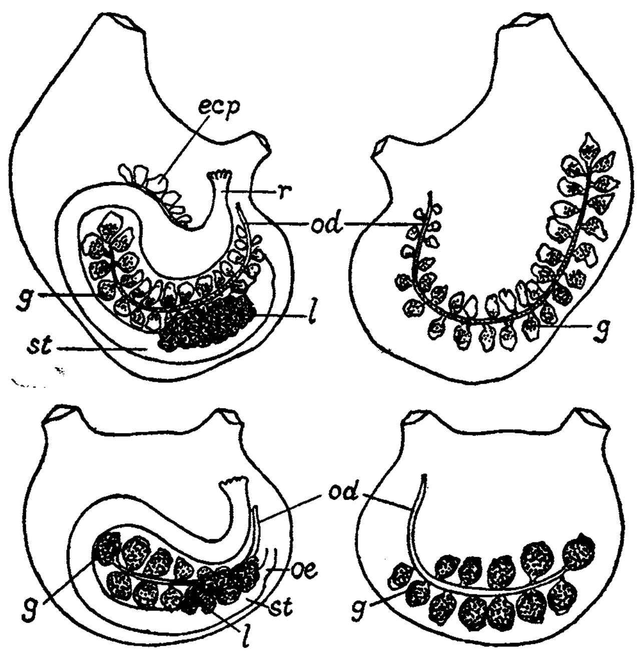


FIG. 213. *Pyura vittata* (Stimpson). Upper figures, left and right sides of a large individual, slightly enlarged; lower figures, left and right sides of a smaller individual with gonad sacs more distended. ×1.6.

Yale University collection from Fort Macon, North Carolina, collected by H. C. Yarrow, is 65 mm. long and 48 mm. in dorsoventral diameter.

Mantle with numerous narrow, closely placed muscle bands which extend down on the sides of the body from the bases of the tubes; those from the two tubes cross each interval straight or obliquely forward, the horns incurved or spirally rolled, or sometimes one curved inward and the other outward; but in large and old individuals the apertures may have the form of some more complex and often very irregular curve. Dorsal lamina a series of rather narrow pointed languets.

FIG. 214. *Pyura vittata* (Stimpson). Details: dorsal tubercles of three individuals, tentacles from two different individuals, groups of hepatic tubules; two gonad sacs, one of them distended and one only partly filled with the reproductive glands.

other obliquely on the flanks. These are crossed by more superficial longitudinal muscles not gathered into such definite and conspicuous bands.

Tentacles rather numerous, usually about a dozen large ones two or three times pinnate and several orders of smaller and less-branched ones. They may be arranged with some degree of regularity. In some individuals the tentacles are less well developed, even the largest being mostly of simply pinnate tapering form. Dorsal tubercle normally with a U-shaped or C-shaped aperture, the open

Branchial sac normally with six folds on each side. The transverse vessels are of four or five orders, the smallest crossing the stigmata. They are slender and numerous. The degree of regularity in the distribution of the several orders varies in different individuals and in different parts of the sac of the same specimen. The internal longitudinal vessels are very slender and generally not especially numerous in moderate-sized individuals, but there is much individual variation in this respect. In a fairly large specimen they had this distribution:

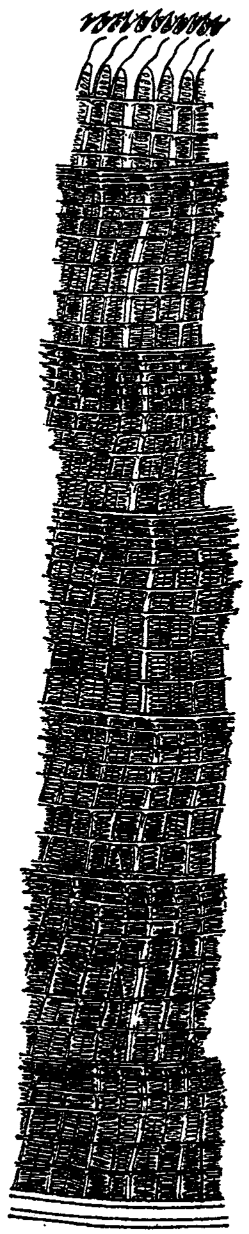


FIG. 215. *Pyura vittata* (Stimpson). Part of branchial sac, ×7.5.

Left	4 (17) 4 (16) 5 (18) 5 (17) 4 (14) 4 (11) 5
Right	5 (17) 5 (17) 4 (18) 5 (19) 5 (16) 5 (11) 5

In an extremely large one:

Left	4 (28) 5 (26) 5 (32) 6 (26) 4 (18) 4 (14) 3
Right	5 (25) 4 (28) 5 (31) 5 (26) 6 (18) 5 (12) 3

On the flat parts of the sac there are only four or five (sometimes only three) stigmata in a mesh in some individuals, while in others, especially in old and large ones, there are often six or eight, or even nine.

Digestive tract in the form of a simple loop, the branches of which are more opened out in some specimens than in others. The distal branch of the intestine, near where it passes the stomach, often becomes distended with mud into a very wide saccular enlargement. Rectum usually short, its orifice usually with rounded lobes. Stomach long and narrow, tapering gradually into the intestine at the pyloric end. Its dorsal and lateral aspects are covered for a considerable distance by the liver, a massive organ consisting of several main lobes, each comprising many rounded lobules built up of numerous short, thick, blunt-ended, radially disposed secreting tubules, some of which divide into two nearly parallel branches.

There is a large gonad on each side, that of the left side lying within the intestinal loop. Each consists of an elongated oviduct accompanied by the common sperm duct and having a curved course, terminating near the base of the atrial tube. Along each side of the ducts (and connecting by very short lateral branches) small reproductive sacs are located. These sacs vary in number from 40 to 50 on each side (there are usually more on the right than on the left) to a dozen or less on each side; when fully developed they contain a central ovary surrounded by numerous small testes. If partially or wholly empty, the sacs resemble endocarps in their character and irregular shape; if fully distended by the development of the eggs and the male glands, they assume a more nearly spherical form, but may bear even then a distal endocarp-like prolongation. Egg diameter 0.16 mm., according to Berrill, 1937.

Often there is a conspicuous row of endocarps along the dorsal side of the distal branch of the intestinal loop which may look more or less like an additional gonad. I believed at one time that this was their nature, and it may be that it is so sometimes, but attempts that I have lately made to demonstrate reproductive elements in those endocarps have not succeeded.

The number of reproductive sacs in the

gonads is naturally usually greater in large specimens. The degree of curvature of the gonad as a whole and also that of the intestinal tract is variable and depends also on the amount of curvature of the body axis and approximation together of the apertures. So much variability raises the question whether more than one species is not being confounded, but if so I would be at a loss to name the distinguishing characters.

DISTRIBUTION: The known range of this species in American waters is from North Carolina (Stimpson's type locality: Oak Island Beach near Smithville) and Bermuda (type of Verrill's *H. rubrilabia*), southward throughout much of the West Indian region. I have examined specimens from Florida (both coasts), Bahamas, Cuba, Haiti, Puerto Rico, St. Thomas, Jamaica, Gairaca, and Santa Marta, Colombia, and Curaçao. It is a shallow-water species and is often found attached to stones or coral at, or near, low-water mark, but it is recorded from 80 feet off Pensacola, Florida.

Although I was not able to find any other shallow-water *Pyura* than the present one in the large amount of West Indian material that I have examined, Sluiter, 1898, described no fewer than four (three of them new) in the material collected by the "Chazalie" in a small area of the Caribbean. The description that he gives of the anatomy of one of them (*discrepans*) is evidently based on an abnormal individual in respect to the development of the branchial sac and gonads, and I am very strongly inclined to include it as well as the others in the present species.

This species is not confined to American or Atlantic waters, as Oka, 1932, unites *Halocynthia* or *Cynthia karasboja*, a common species on the Japanese coasts which he had previously (1908) described, with *vittata*, and Rennie and Wiseman, 1906, reported it (as "*H. rubrilabia*"), and also Harant, 1929, from the Cape Verde Islands. *P. kiramosa* Sluiter, 1904, from the East Indies, and *P. gangelion* Savigny, 1816 (see Michaelsen, 1919) are certainly closely allied.

Crediting the European species *Cynthia dura* Heller [=*Pyura squamulosa* (Alder) var. *dura*, according to Hartmeyer, 1911–1912, p. 16] to the West Indies by Heller (1878, p. 251) was evidently an error.

Pyura antillarum Van Name, 1921

Text figure 216

Pyura antillarum VAN NAME, 1921, p. 451, figs. 123–128.

A deep-water species of which only a single specimen has been recorded.

The body is elliptical in outline, 40 mm. in longest (anteroposterior) diameter, apertures, which are four-lobed and raised on low papillae, on its dorsal aspect. Between the apertures a rather high, irregular, transverse ridge crosses the body from side to side; this may, however, be only an individual peculiarity. Its exterior surface is wrinkled and covered with sand and Foraminifera shells. It was apparently attached by a small area on the ventral surface.

Mantle thin, its musculature formed of slender, separated bands developed chiefly on the dorsal parts. The tissues of the mantle and the vessels of the branchial sac contain numerous spicules with a varying number of long, tapering, acute branches suggesting those of a deer's antlers.

Tentacles rather few, the larger ones not more than twice pinnate; their branches short. Dorsal tubercle very small and poorly developed (perhaps an individual abnormality).

Branchial sac of very delicate structure, the stigmata small and narrow, and the interstigmatic and other vessels wide and flat, giving the appearance of a membrane pierced by the stigmata rather than of a structure built up of vessels. There are six rather high folds on the left side and possibly seven on the right. Distribution of the internal longitudinal vessels on the left side of the sac:

1 (23) 3 (22) 4 (26) 4 (22) 5 (19) 5 (5) 5

The internal longitudinal vessels are usually separated by from five to seven stigmata on the flat parts of the sac. They are very thin and flat and are not raised off the surface of the sac on distinct papillae.

The alimentary tract forms a rather small, somewhat transversely placed loop; the stomach is elongate, with a very well-developed liver.

Gonads one on the right and two on the left side (one within, one anterior to, the intestinal loop). They are elongate bodies di-

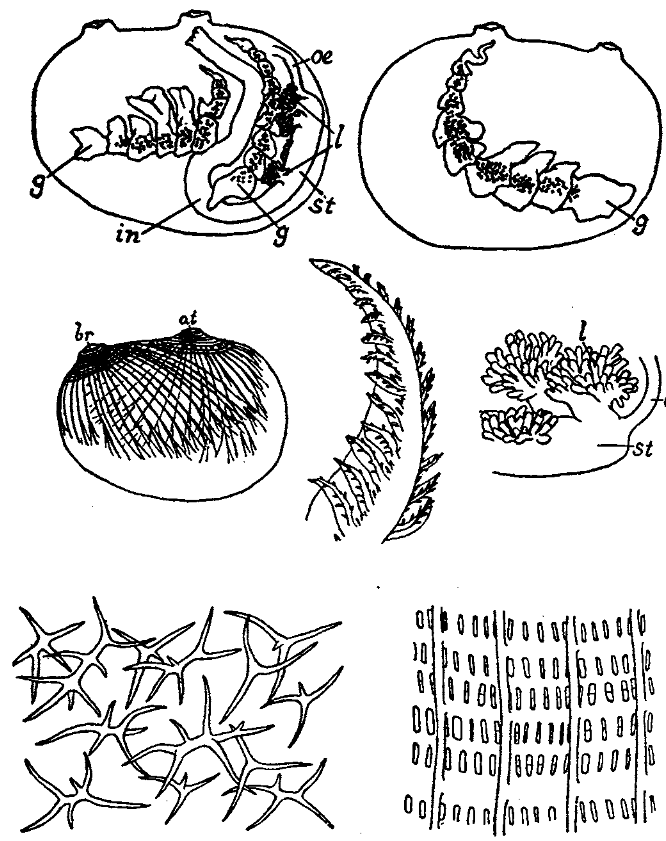


FIG. 216. *Pyura antillarum* Van Name. Left and right sides of body, about ×1.5; arrangement of chief muscle bands of mantle; large tentacles; part of stomach showing liver; spicules from mantle and vessels of branchial sac, ×125; small piece of one of the flat intervals of the branchial sac between folds.

vided by transverse constrictions into a series of irregularly shaped segments in whose central part both eggs and testes are found. No doubt these would more completely fill the segments if the organs were in a more actively functional condition.

LOCALITY: The only specimen was dredged by the "Albatross" at Station 2750 (18° 30′ N., 63° 31′ W., 496 fathoms, fine gray sand) off the north end of the chain of the Lesser Antilles.

Pyura legumen (Lesson), 1830

Text figure 217

Boltenia coacta GOULD, 1852, p. 496, atlas (1856), p. 16, pl. 52, fig. 612. Misprinted *coarcta* in Herdman, 1882, p. 88.

Boltenia legumen LESSON, 1830, p. 149, pl. 53, fig. 1; 1830a, p. 433; CUNNINGHAM, 1871, pp. 111, 262, pl. 4; 1871a, p. 489; HERDMAN, 1881, p. 81; 1882, p. 88; MICHAELSEN, 1898, pp. 363, 364 (+formae or vars. *delfini*, *ohlini*, and *cunninghami*); 1900, pp. 109–118 (+vars. *delfini*, *ohlini*, and *cunninghami*), pl. 2, figs. 1–4, pl. 3, fig. 19; 1907, pp. 79, 80 (+vars. *delfini*, *ohlini*, and *cunninghami*); 1911, p. 180 (var. *ohlini*); HERDMAN, 1912, p. 90.

Pyura legumen HARTMEYER, 1909–1911, p. 1340; VAN NAME, 1921, p. 488; ÄRNBÄCK, 1938, p. 33, fig. 9, pl. 4, figs. 33, 34.

The body in this species is usually somewhat elongate-elliptical; the long diameter is anteroposterior; the two apertures, which may or may not be somewhat prominent, are widely separated on the dorsal aspect, more or less removed from the ends of the body yet far apart; they are either four-lobed or square, or transversely slit-like. It reaches a considerable size, up to 60 or even 70 mm. in anteroposterior, and 35 mm. in dorsoventral, diameter; the transverse diameter is very variable. The body is borne on a stalk which is often rather narrow but usually comparatively short, arising from the anterior ventral part of the body; at its farther end it expands into a wider base or into branching processes for the attachment of the animal. In large adult specimens the stalk is usually between one-third to one and one-third times the body length, but I have seen specimens, apparently true *Pyura legumen*, in which the stalk was fully three times the body length.

The test is roughened externally and is often covered by a fairly thick growth of minute, very short, tapering bristles or flexible spines which are themselves roughened along their sides by minute points or incipient branches. In old specimens the surface may be smoother, perhaps because of the spines wearing off. It is, however, in most individuals much furrowed by wrinkles which, on the ventral part of the body and often also over much of the sides, are mainly longitudinal and parallel and somewhat curved. But on the dorsal aspect they become irregular and broken up, producing a rough, uneven surface on that part of the body.

The test is tough, leathery, and opaque, brown or yellowish brown externally in preserved material, but often more or less red in life. It may be incrusted with foreign growths, but usually not heavily so. This describes the average specimen, but there is considerable individual variation in the shape of the body, the character of its surface, the point of origin of the stalk, etc.

The mantle musculature is diffuse and moderately thick; there is a close layer of dorsoventral bands overlaid by a thinner one of longitudinal and oblique ones. Only a small, short protuberance of the mantle extended into the base of the stalk in the specimens I examined for that character.

The large branchial tentacles are two or three times pinnate and number about 12 to 16. They alternate larger and smaller with some regularity, and additional small or rudimentary ones may be present. The dorsal tubercle is rounded with a C-shaped aperture, having the horns incurved or slightly coiled. In some individuals its curvature is more irregular. The dorsal ganglion, according to Ärnbäck, is unusually elongate.

There has been a lack of agreement in regard to the dorsal lamina of this species. In beautifully preserved adult specimens of fairly large size I found it a rather high, thick ridge. Its free edge was thin and cut into a series of many small, mostly acutely pointed teeth better described as serrations (though very distinct ones) of the edge of the membrane than as separate languets. The teeth are small and delicate structures and are undoubtedly developed to a variable extent in different individuals, and may perhaps be nearly absent in occasional cases.

The branchial sac is quite regular in its structure, with seven high folds on each side

FIG. 217. *Pyura legumen* (Lesson). Almost one and one-half times natural size. After Ärnbäck, 1938.

bearing numerous (often 20 to 25) closely placed internal longitudinal vessels. The flat intervals between the folds are narrow, they bear a few, perhaps four or five, of the vessels (though often it is hard to say whether a vessel belongs to an adjacent fold or not) which form rather wide meshes containing 10 or more stigmata with the transverse vessels. Of the latter, at least four orders arranged with much regularity in most parts are present.

The alimentary tract forms a long, rather narrow, parallel-sided loop extending anteroposteriorly. The stomach is wide at the oesophageal end but tapers off into the intestine. Its wall has longitudinal folds on the interior surface and bears tufts of hepatic tubules externally.

The gonads, which are elongate, irregular in outline, and of very variable diameter in different parts, are more or less conspicuously divided by clefts into a series of irregular segments. The ovary and oviduct occupy the axial part on the aspect attached to the mantle, covered and more or less surrounded on the side toward the branchial sac by the masses of small testes. There is a common sperm duct accompanying the terminal part of the oviduct. On the left side the gonad occupies the intestinal loop.

In adult specimens of this species there are, at least in many individuals, three conspicuous masses of yellowish vascular tissue on the inner surface of the mantle near the atrial aperture, one anterior and one on each side of it. These are termed "atrial organs" by Ärnbäck. In many individuals of this and several closely related species there is a large, elongate mass of vascular tissue on each side

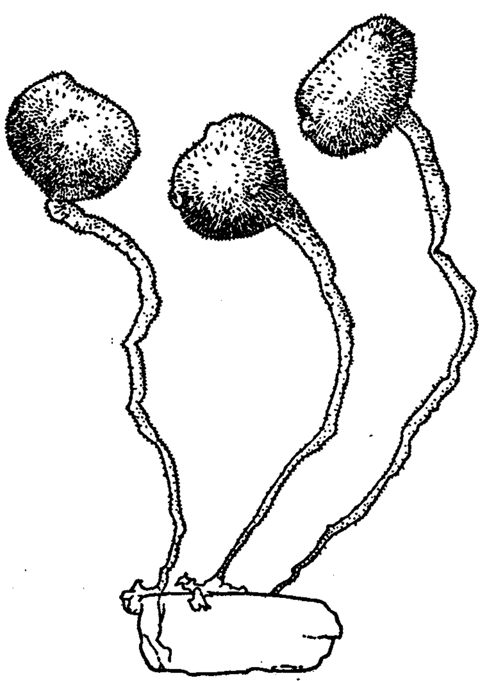


FIG. 218. *Pyura georgiana* (Michaelsen). Three individuals attached to a stone, about two-thirds natural size. After Ärnbäck, 1938.

of the body, on the inner surface of the mantle dorsal to the gonads and intestine, the "parietal organs" of Ärnbäck. Their function is not understood, but it has been suggested that they may take the place of the endocarps which occur in many other ascidians.

DISTRIBUTION: Region of the Strait of Magellan and coasts of Tierra del Fuego, extending north on the east coast of Patagonia at least to 42° 24′ N. ("Albatross" Station 2768); also the Falkland Islands.

In those regions it is one of the common and conspicuous species of the shallow waters. Its recorded range in depth is 1.8 meters to 90 meters, but most records do not exceed 30 meters. It is often broken loose and washed up on the beaches by storms. The reported occurrence of this species in the Gulf of Mexico and the West Indies (Hartmeyer, 1909–1911, pp. 1629, 1633) is entirely erroneous.

The several varieties established by Michaelsen (see synonymy above) appear to me to be based on too few specimens and on characters too superficial and variable to justify their discussion here. I do not except his var. *cunninghami* (Michaelsen, 1900, p. 117, pl. 2, fig. 3), supposed to be distinguished by a smooth-edged dorsal lamina, as he verified that character in only one individual. (See remarks above on the dorsal lamina of this species.) The types of these varieties are listed by Michaelsen, 1908, as being in the Hamburg Museum.

Pyura georgiana (Michaelsen), 1898

Text figure 218

Boltenia georgiana MICHAELSEN, 1898, p. 364; 1900, p. 118, pl. 2, fig. 5; 1907, p. 80.

Pyura georgiana HARTMEYER, 1909–1911, p. 1340; ÄRNBÄCK, 1938, p. 35, fig. 10, pl. 4, fig. 31.

Ärnbäck, 1938, gives a description of this species based, according to her statement, on a large number of specimens. It is a very near ally of, if distinct from, *P. legumen*.

The body is cordate or globular, apertures four-lobed at a great distance apart, on low but conspicuous siphons. The stalk is of great length, in some individuals up to five times the height of the body, but generally somewhat shorter. It projects from about the middle of the ventral side, sometimes rather broad in its upper part, for the rest narrow, attaching the animal to the substratum by the expanded basal end.

Test thin and of leathery consistency. It is of dark gray color, with a coating of slender hairs all over the surface, also on the stalk and on the short siphons. An average specimen measures about 32 mm. baso-apically and 29 mm. dorsoventrally, the stalk 70 mm.; the largest ones measure 30 by 38 mm., the stalk 90 mm. In one specimen the stalk is 140 mm.

in length. The mantle continues into the stalk by a long prolongation.

Its internal structure appears to correspond too closely to that of *P. legumen* to require to be discussed here. According to Ärnbäck, the "dorsal lamina is represented by closely placed large, tapering languets in its posterior part, more sparsely arranged in the anterior part . . . the stigmata are short and not always of regular shape and arrangement . . . the stomach is short and well marked off from the intestine." "Atrial organs" (see remarks under *P. legumen*) were not observed.

DISTRIBUTION: Bays and fiords of South Georgia Island, range in depth from 16 to 25 meters. Ärnbäck also assigns to this species two specimens from off the Argentine coast much farther north but in the region of the cold Falkland current; 37° 50′ S., 56° 11′ W., depth 100 meters. See also *Pyura turqueti*, below, which is an allied species.

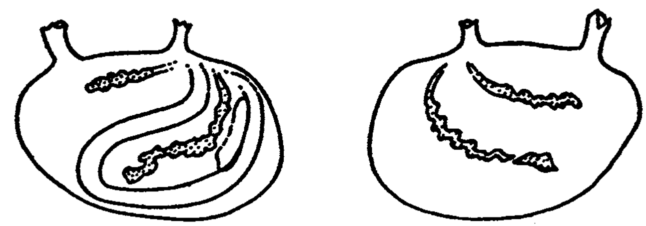


FIG. 219. *Pyura paessleri* (Michaelsen). Left and right sides of body, ×2.5. Outline from figure of Ärnbäck, 1938.

Pyura paessleri (Michaelsen), 1900

Plate 23, figure 6; text figure 219

Cynthia paessleri MICHAELSEN, 1900, p. 106, pl. 2, fig. 6.

Halocynthia paessleri MICHAELSEN, 1907, p. 79.

Paracynthia distincta ÄRNBÄCK, 1938, p. 22, figs. 7, 8, pl. 2, figs. 12–14.

Pyura paessleri MICHAELSEN, 1908, p. 231; HARTMEYER, 1909–1911, p. 1340.

Body elliptical in outline, the longest diameter anteroposterior; apertures on the dorsal side, the branchial near the anterior end, the atrial a varying distance behind it; they are either raised on short siphons, or not conspicuously prominent. Size of largest specimen, 34 by 28 mm., by about 18 mm. from side to side. The specimens were apparently only lightly attached.

Test tough and leathery, only moderately thick, opaque, and quite rough and uneven externally, the roughness increased by adhering sand grains and minute debris. Internally it is smooth and bluish.

Mantle thin but well provided with muscle bands, of which the most important extend down the sides from the siphons well toward the ventral margin, dividing up into delicate bundles of fibers in their ventral portion. These bands are overlaid with well-developed circular ones about and near the bases of the siphons.

Tentacles of unequal sizes, once or twice pinnate, about 14 to 18 in number. Dorsal lamina a close series of small, pointed languets; dorsal tubercle rounded, its aperture C-shaped, with the open interval forward or to the left.

Branchial sac with six well-developed folds on each side. Except the most ventral folds, they are quite high, and commonly bear 16 to 20 internal longitudinal vessels; the flat interval between the folds usually bears from two to five vessels. Transverse vessels numerous and of different sizes. Six to eight stigmata are commonly present in the larger meshes on the flat parts of the sac.

The intestinal tract forms a large, broad loop enclosing a considerable area of the left side of the mantle, ending in a short, dorsally directed rectum. Stomach long and narrow with a fairly voluminous hepatic gland consisting of several masses composed of very short, sac-like, secreting tubercles.

There are two elongated gonads on each side, adhering and closely appressed to the inner side of the mantle. Each gonad has a long, central, tubular oviduct, thin walled and of moderately large diameter, along both sides of which saccular lobes of irregular outline are unevenly, but usually rather closely, arranged. These contain both eggs and small pear-shaped testes, the eggs in the part lying against the mantle, the testes chiefly toward the mesial side.

The gonads are more or less obliquely placed, their distal ends converging to near the atrial siphon; their oviduct and common sperm duct end side by side. The ventral gonad of each side of the body is much the largest and longest and is considerably curved in its course. The dorsal gland is shorter and straighter. On the left side the more ventral gonad lies in the intestinal loop, the dorsal one above and a little removed from the intestine.

These statements are based on Ärnbäck's description. The lobes of the gonads seem to have been more compactly crowded together in Michaelsen's only specimen. He describes the gonads as very elongate, their outline with deep clefts and rounded projections.

DISTRIBUTION: Known only from the Falkland Islands. Port Stanley, type locality (Michaelsen); Port Louis, Greenpatch, in water a few meters deep (Ärnbäck); Port William, 8 to 10 fathoms. The type is in the Hamburg Museum (Michaelsen, 1908).

Ärnbäck (1938) makes this the type of a new genus *Paracynthia* on account of its having two gonads on each side, in which character it is, however, not unique. In every other respect it seems to be a typical *Pyura*, and a separate genus does not seem to be needed.

Pyura stubenrauchi (Michaelsen), 1900

Plate 23, figure 4

Cynthia stubenrauchi MICHAELSEN, 1900, p. 102, pl. 2, fig. 7.

Halocynthia stubenrauchi MICHAELSEN, 1907, p. 79.

Pyura echinops ÄRNBÄCK, 1938, p. 25, pl. 2, figs. 15, 19.

Pyura stubenrauchi ÄRNBÄCK, 1938, p. 27.

Pyuropsis stubenrauchi MICHAELSEN, 1912, p. 112.

Described by Michaelsen from a single specimen of elliptical cushion shape, the anteroposterior diameter the longest, the apertures (not prominent) wide apart on the dorsal surface; attachment by the opposite surface. Measurements, 15 mm. long, 14 mm. wide, 3.5 mm. dorsoventrally.

The body is covered with spines, some of them branched, the longer ones sometimes 5 mm. long, its appearance thus suggesting the Arctic species *Boltenia echinata*, but in its internal structure it conforms to *Pyura*, the stigmata of the branchial sac having the usual longitudinal direction.

It possesses, however, a peculiarity unusual in *Pyura*, having only four branchial folds on each side. Those are well developed, the first the highest, the last the lowest, the internal longitudinal vessels on a fold varying from a dozen down to five. Such vessels are also present between the folds, forming meshes which usually contain four or five stigmata. Dorsal tubercle horseshoe shaped, the open interval forward, dorsal lamina membranous with an irregular, posteriorly toothed margin.

Stomach elongated, with a liver composed of irregular glandular folds, Intestinal loop very narrow and very elongate, horizontal in direction. Tentacles numerous, the large ones twice or sparingly three times pinnate; many small, simple tentacles.

Gonads one on each side, the left in the intestinal loop. The small, pyriform testes occupy the surface attached to the mantle; the very elongate ovary is on the free aspect. The ovary ends posteriorly in a short, upwardly and forwardly bent oviduct; the common sperm duct opens on a papilla beside the oviduct.

Ärnbäck, 1938, described, also from a single but larger specimen (maximum diameter 25 mm.), *Pyura echinops*, which conforms so closely in essential characters that its identity with Michaelsen's form can hardly be doubted, though the spines of the body surface are relatively shorter and more branched and, as would be expected in a larger example, the internal longitudinal vessels more numerous.

LOCALITIES: Admiralty Sound, Strait of Magellan, 50 fathoms (Michaelsen). Ärnbäck's specimen was from off the coast of Argentina much farther north (37° 50′ S., 56° 11′ W., 100 meters), but in the region of the cold Falkland current and at about the same depth as Michaelsen's specimen.

I think the question may well be raised whether the possession of but four folds is not an occasional individual variation and that this and *P. setosa* are really one species. If so, the name *stubenrauchi* will have priority.

Michaelsen, 1912, made this species the type of a genus *Pyuropsis*, which he placed in the Styelidae, a course with which I cannot possibly agree.

Pyura turqueti (Sluiter), 1905

Plate 24, figure 2

Boltenia antarctica VAN BENEDEN AND SELYS-LONGCHAMPS, 1913, p. 23, pls. 3–8; HERDMAN, 1923, p. 17, pl. 10, figs. 7–9; ÄRNBÄCK, p. 38.

? *Boltenia bouvetensis* MICHAELSEN, 1904a, p. 216, pl. 10, fig. 6, pl. 11, figs. 23–24.

Boltenia salebrosa SLUITER, 1905b, p. 473; 1906, p. 45, fig. 10, pl. 3, figs. 42, 43, (misprint *Bollenia*, p. 50); 1906a, p. 554.

? *Boltenia scotti* HERDMAN, 1910, p. 10, pl. 7, figs. 1–11.

Boltenia turqueti SLUITER, 1905b, p. 473; 1906, p. 43, fig. 9, pl. 3, figs. 38–41, pl. 5, fig. 58; 1906a, p. 554.

Pyura turqueti HARTMEYER, 1909–1911, p. 1342; SLUITER, 1914, p. 11; ÄRNBÄCK, 1938, p. 37, pl. 4, fig. 32.

This is another long-stalked form closely allied to *P. legumen* and especially to *P. georgiana.*

The following quotations are from the description given by Ärnbäck, 1938, based on five specimens collected off Graham Land by the Swedish Antarctic expedition. The largest of them measured 42 by 24 mm., with a stalk more than 300 mm. long, though its basal part was broken off. The smallest measured 10 by 10 mm. with a stalk 20 mm. long.

"In larger individuals the body is elongated in dorso-ventral direction, in those of smaller size the body shape is almost square, somewhat compressed from side to side. The stalk proceeds from the anterior ventral part; it is slender and always of great length, usually many times the length of the body. It ends in a tuft of branched processes, by which the animal is attached to the substratum.

"The test is less regularly folded than is shown in the figure given by Sluiter; its surface looks rather rough, being provided with small round elevations bearing a short spine-like bristle each. In one specimen it is smoother. Also on the stalk the test is horizontally wrinkled or irregularly rugose. It is of leathery consistency. The apertures are on distinct siphons, at a great distance from each other; the branchial siphon is usually bent down."

In this species also the mantle extends for some distance down into the stalk as a narrow process.

The internal structure appears, from the descriptions, to be very similar to that of *P. legumen* and *georgiana*. It will be found described in very great detail and beautifully illustrated by plates showing minute structural and histological characters in the work of Van Beneden and Selys-Longchamps under the name *Boltenia antarctica*. Their specimens were from Charcot Land (70° 01′ S., 81° 04′ W.) in 580 meters depth. The eggs of one of these specimens are recorded as measuring 0.224 to 0.24 mm. with the follicle, and 0.175 to 0.192 mm. without it.

Well-developed "parietal organs" (see remarks under *P. legumen*) occur in this species, but "atrial organs" do not appear to have been observed.

DISTRIBUTION: An Antarctic form of high latitudes collected (chiefly in deep water) by both Charcot (French Antarctic) expeditions, the Belgian and the Swedish Antarctic expeditions at points near the west coast of Graham Land and west Antarctica, and off Charcot Land, thus in the region lying directly south of Cape Horn. The recorded depths range from 20 to 40 meters down to 340 fathoms. Its actual range may be very much wider, for it seems probable that *P. bouvetensis* (Michaelsen), 1904a, from near Bouvet Island, 54° 29′ S., 03° 43′ E., in 567 meters, is this same species, and that *P. scotti* (Herdman), 1910, from South Victoria Land, may be based on the young of this species. If *bouvetensis* and *turqueti* are proved identical, the former name will have priority.

Pyura setosa (Sluiter), 1905

Halocynthia setosa SLUITER, 1905b, p. 472; 1906, p. 40, figs. 7, 8, pl. 3, fig. 37, pl. 5, fig. 57; 1906a, p. 554; HERDMAN, 1910, p. 7, pl. 2; 1912, p. 91; 1923, p. 22.

Pyura setosa HARTMEYER, 1911b, p. 442, pl. 45, fig. 10.

See also remarks at end of description of *Pyura stubenrauchi.*

This widely distributed Antarctic species is so similar to *P. stubenrauchi* previously described by Michaelsen (1900) that it seems strange that none of the authors who have dealt with it has mentioned the fact that virtually the only difference of importance appears to be the six well-developed branchial folds instead of four.

It becomes quite large, attaining 75 mm. in anteroposterior diameter. It is reported to be occasionally attached by a short peduncle. The body surface is covered with slender processes better described as hairs than spines, being more or less flexible and ordinarily not branched; they bear small, thorn-like projections along their sides. In large specimens some of these hairs become 18 to 21 mm. long.

Sluiter's original description was detailed, and Herdman, owing to the numerous large and evidently well-preserved specimens obtained by the "Scotia" and "Discovery" expeditions, was able to give good figures and an excellent, though short, description.

In internal structure it corresponds quite closely in many characters with *P. stubenrauchi*. The first of the six branchial folds is reported by Herdman to be the largest; the internal longitudinal vessels are, as would be expected in larger specimens, more numerous. Herdman found 23 on the third fold of one specimen and seven on the adjacent interspace. The meshes of the sac often contain nine to 12 stigmata, and transverse vessels of four orders were recognized, the three larger sizes regularly arranged. Thirty-two tentacles of three orders were counted; the dorsal tubercle was large, horseshoe shaped, with the open interval forward and the horns incurved and coiled.

LOCALITIES: In the western Antarctic, obtained by both Charcot expeditions in the Graham Land region (type locality, Booth Wandel Island, 40 meters, Sluiter), and at the South Orkney Islands by the "Scotia" expedition (numerous specimens of large size, Herdman, 1915). Found also in the eastern Antarctic near Kaiser Wilhelm II Land, 380 meters, and by the "Gauss" expedition at McMurdo Bay, 10 to 20 fathoms, at the east end of the Ice Barrier in 100 fathoms by the "Discovery" expedition, and off Adelie Land.

Pyura squamata Hartmeyer, 1911

Pyura squamata HARTMEYER, 1909–1911, p. 1337 (*nomen nudum*); 1911b, p. 439, pl. 45, fig. 12, pl. 50, figs. 1–5; SLUITER, 1914, p. 8.

This is a small Antarctic ascidian, the details of which are known only from the type specimen described and figured by Hartmeyer, 1911b. It is of low, somewhat flattened form, 15 mm. in greatest measurement, with widely separated, only moderately prominent apertures, its chief external peculiarity being that the surface of the test, which is thin but tough, is divided up into small oblong or polygonal scale-like areas. Internally its chief peculiar feature is that only five folds on each side of the branchial sac are fully developed, the sixth being incomplete. The dorsal tubercle has a C-shaped aperture, the concavity forward.

In most of its characters it apparently does not differ much from small specimens of *P. discoveryi;* but for details I must, for lack of space, refer the reader to Hartmeyer's 1911b article.

Hartmeyer had also a much smaller specimen also showing the scaly external surface.

LOCALITIES: Hartmeyer's two specimens were from Kaiser Wilhelm II Land, in 385 and 350 meters' depth. This species is included in the present work because Sluiter (1914) has reported a considerably damaged specimen from near Charcot Land, western Antarctic, in 460 meters.

Pyura discoveryi (Herdman), 1910

Plate 23, figures 1, 2

Holocynthia discoveryi HERDMAN, 1910, p. 9, pl. 4, figs. 6–12; 1923, p. 19, pl. 11, figs. 10–13.

Pyura discoveryi HARTMEYER, 1911b, p. 436, pl. 45, fig. 9, pl. 49, figs. 10–12; ÄRNBÄCK, 1938, p. 29, pl. 4, fig. 35.

Pyura discoveryi var. *septemplicata* SLUITER, 1914, p. 8, pl. 1, fig. 8, pl. 4, fig. 40.

Hartmeyer (1911b) has called attention to the considerable similarity and evident near relationship of this Antarctic species to *P. haustor* Stimpson, of the western North American coast. In form and size, in the somewhat elongated body, the large and long siphons arising well apart and often bent or curved, the tough, leathery, much wrinkled test, yellowish or brownish externally, the resemblance is striking, though judging from the illustrations the wrinkles are usually less coarse and prominent in the present species than in *haustor*, but more numerous and evenly distributed. The siphons are strongly and conspicuously transversely wrinkled. The usual body length does not exceed about 40 mm., though Herdman (1923) records one of 60 mm.

In the internal structure the most conspicuous difference is the presence in *discoveryi* of seven branchial folds on each side (not six as in the original description of Herdman), though in small and perhaps young specimens the seventh fold may be represented only by a few internal longitudinal vessels. The average arrangement of these vessels is given by Ärnbäck as follows:

2 (15) 2 (15) 2 (17) 2 (17) 2 (15) 2 (13) 2 (8) 1

The aperture of the dorsal tubercle may, especially in small or young specimens, be of simple or somewhat modified C-shape, but in a large proportion of older specimens it is an elongate, irregularly sinuous cleft transversely placed, which may be more or less coiled at one or both ends.

The tentacles are not very numerous, and even the large ones are not very profusely branched.

The alimentary loop and the gonads resemble those of *P. haustor*. The total number of sacs composing a gonad may exceed 50 in large individuals. A specimen described by Hartmeyer with a gonad on the right side only was evidently abnormal.

For more details the reader is referred especially to the article by Ärnbäck, 1938.

DISTRIBUTION: Evidently common and of wide range in the Antarctic regions; type locality, McMurdo Bay, South Victoria Land, in shallow water. In the region covered by the present work, it has been obtained in the western Antarctic region from Alexander I Land to the Graham Land region; South Shetland Islands; in depths from 70 to 250 meters, and at South Georgia. Frequent in rather shallow as well as deep water, sometimes growing in groups or clusters. Greatest depth recorded, 358 fathoms.

Pyura obesa Sluiter, 1912

Pyura obesa SLUITER, 1912, p. 454; 1914, p. 14.

Described from a single specimen, never figured.

It was of very large size, diameter 16 by 13 by 10 cm., surface smooth, of a dull white color. Apertures near together, not prominent, both four-lobed. Test thick and somewhat cartilaginous.

Tentacles about 21 in number, apparently not much branched; dorsal tubercle not distinguished owing to damage to specimen; median dorsal vessel short and endostyle very long owing to curvature of body axis; dorsal languets short.

Branchial sac with six folds. Arrangement of internal longitudinal vessels on one side:

4 (21) 6 (20) 6 (20) 8 (20) 9 (16) 6 (16) 3

Seven or eight stigmata in the meshes.

Stomach not much wider than the intestine, which is of large diameter. Intestinal loop rather narrow. Structure of gonads "typical for *Pyura*."

LOCALITY: King George Island, South Shetlands, 75 meters.

Pyura chilensis Molina, 1782

Ascidia pyura GMELIN, 1791, vol. 6, p. 3125.

Cynthia chilensis JOHANNES MÜLLER, 1851 (see note below).

Cynthia clavigera TRAUSTEDT, 1883, p. 117, pl. 6, fig. 20; MICHAELSEN, 1908a, p. 246, pl. 1, figs. 4–7.

Cynthia nodulosa VON DRASCHE, 1884, p. 375, pl. 4, figs. 8–11, pl. 5, fig. 1.

Cynthia socialis TROSCHELL, 1852, p. 304; HARTMEYER, 1909–1911, p. 1341.

Halocynthia chilensis MICHAELSEN, 1904, p. 15, one fig.

"*Piure*" (no specific name used) CUNNINGHAM, 1871, p. 430 (*fide* Michaelsen, 1904).

Pyura chilensis MOLINA, 1782, pp. 196, 349; DE BLAINVILLE, 1825, p. 585.

Pyura clavigera MICHAELSEN, 1912, p. 178.

Pyura clavigera + *P. clavigera* var. *simplex* MICHAELSEN, 1908a, p. 246, pl. 1, figs. 4–7.

Pyura molinae DE BLAINVILLE, 1824, Dictionnaire des sciences naturelles, vol. 32, p. 365; CUNNINGHAM, 1871a, p. 489.

Good illustrations of this species given by Schacht, 1851, p. 6, figs. 8–10; but he uses no scientific name for it. A footnote in his article, p. 201, put in by the editor, Johannes Müller, correctly identifies the species as "*Cynthia chilensis.*"

The general form of the body in this species is irregularly ovate or sac-like, but more frequently somewhat pear shaped, narrowed below by pressure from other individuals, as it is commonly found growing together in masses in which the lower two-thirds (the attached part) of the body of the individuals is closely crowded together, only the upper third, which bears the apertures, extending up above the common mass. The individuals are separated from each other by deep clefts or furrows and are easily pulled apart without injury. Those in clusters described by Michaelsen, 1904, measured on an average about 20 mm. high and 15 mm. wide, but examples often become very much larger; the largest specimen in the material examined by von Drasche, 1884, was 4.5 cm. high and 3 cm. wide. The two four-lobed or square apertures are well apart on the wide upper end, usually not prominent enough to be conspicuous on the rough body surface. The parts not in contact with some other object, or with other individuals of a cluster, are extremely rough and uneven with coarse wrinkles and folds and irregular projections and papillae of various shapes. Some of these are very large and of irregularly clavate or capitate form, widened and rounded at the end and narrowed near the base. Some of them may be divided or more or less branched. The body surface between and on the basal parts of these excrescences is usually incrusted with mud and sand.

The musculature of the mantle is composed of almost continuous longitudinal and circular layers in which, however, stout bands radiating from the siphons take a part. The mantle is in most individuals quite thick and of a red color in fresh specimens. The larger tentacles vary in number, usually from 16 to about 24, two or three sizes being represented; most of them are not more than twice pinnate. The dorsal tubercle is large and wide, its aperture normally of modified C-shape, with the open interval forward and the horns spirally inrolled, but in some individuals very irregular in its curves and spirals.

Branchial sac with six well-developed folds on each side; the third usually the highest, the sixth the lowest. Typical arrangement of internal longitudinal vessels as given by Michaelsen:

3 (17) 2 (9) 0 (21) 0 (16) 0 (15) 3 (4) 2
2 (16) 1 (10) 1 (20) 1 (16) 2 (15) 2 (6) 2

Transverse vessels irregular in size; small parastigmatic vessels are present. Median dorsal vessel bears a transversely ribbed membrane, having its border cleft into a close row of slender pointed languets.

Stomach elongate, merging gradually into the intestine which forms a wide loop occupied by the left gonad and in its posterior part also by the voluminous mass of short hepatic tubules borne on the wall of the stomach.

The gonads (one on each side) consist, as usual in this genus, of many small hermaphroditic sacs arranged in a series along each side of the oviduct and common sperm ducts.

Distribution: Southern parts of the coast of Peru (Mollendo) and the Chilean coast, according to Cunningham, 1871a, at least as far south as Chiloe Island (latitude about 42° S.), in shallow water. Under the name "piure" it is used for food, the mantle and its contained structures being the part eaten.

Michaelsen (1908a, p. 248) established a variety *simplex* based on specimens with few but very large club-shaped excrescences on the test. I cannot regard it as deserving of recognition as a subspecies.

Pyura bradleyi Van Name, 1931

Text figures 220, 221

Pyura bradleyi Van Name, 1931, p. 221, figs. 7, 8.

When not distorted by the pressure of other individuals or objects crowding it, the body has the form of an inverted, laterally compressed cone attached by the small end, which expands and extends out into root-like processes for attachment. The flattened upper surface is soft and flexible and bordered by a rim of stiffer, harder test, and bears the two erect tubes which are rather rigid, though the whole upper surface can be pushed down into the lower conical part to some extent. The atrial tube is the largest and longest; both the apertures are four-lobed.

The external surface is densely covered with sand grains. A large specimen (the type) measures 18 mm. high to the edge of the hard rim and 26 mm. anteroposteriorly.

When removed from the test, the body exhibits a corresponding raised, but soft, flexible rim about the upper surface bearing the tubes. On the tubes, closely placed circular bands are developed, but (in conformity with their non-retractile character) scarcely any longitudinal muscles. Longitudinal bands commence, however, on the bases of the tubes

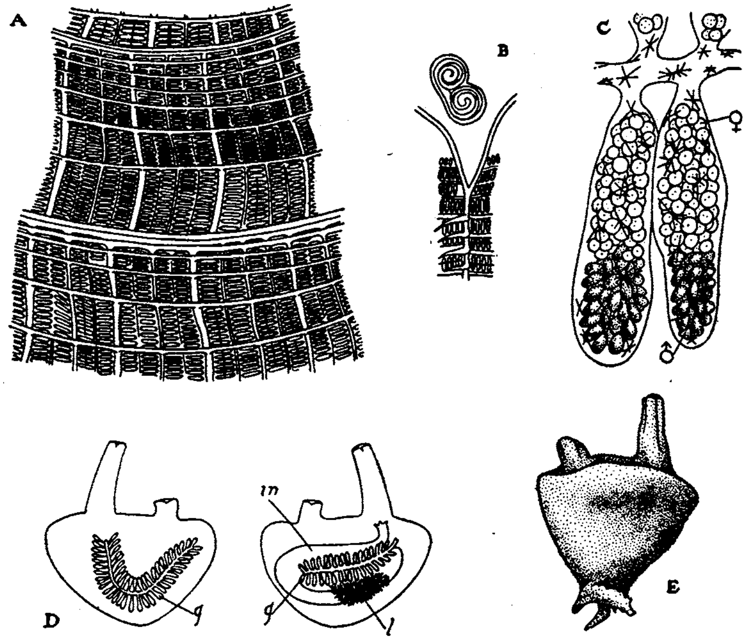


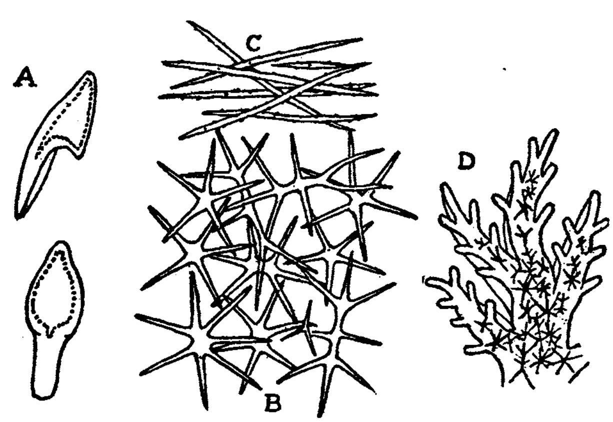
FIG. 220. *Pyura bradleyi* Van Name. A. Part of branchial sac. B. Dorsal tubercle and part of dorsal lamina. C. Part of a gonad, showing spicules in the enclosing tissues. D. Left and right sides of body. E. External view of body, about natural size.

and spread out on the upper body surface, curving down over the rim, where they become quite wide and strong, but tapering off and ending on the sides a little below the rim. Lower down, the mantle is thin and transparent, allowing the internal organs to show through plainly, and is virtually devoid of muscle.

The tissues of the mantle and the internal organs (also the tentacles) contain calcareous spicules in varying numbers, in some places very abundantly. In most of these tissues and organs they are of stellate or elongate branched forms with slender, sharply pointed branches. In the walls of the vessels composing the branchial sac, along with these branching spicules, there also occur many long, straight, needle-like forms, unbranched or nearly so (Van Name, 1931, pp. 222–223).

The branching spicules range up to 0.3 or

FIG. 221. *Pyura bradleyi* Van Name. Details: A. Two views of one of the minute spines from the lining of the distal part of branchial siphon, ×900. B. Calcareous spicules of the type found in the mantle, tentacles, and most of the internal organs, ×54. C. Needle-like spicules from the walls of the branchial vessels, ×54. D. Part of one of the large tentacles, ×70.



0.4 mm. long, the needle-like ones, which are usually nodular on their surface, up to 0.6 or 0.7 mm. long. The minute spines of the test lining the branchial tube have the apical part flattened and slightly hollowed or concaved and with a bluntly rounded-off tip.

The largest of the oral tentacles (about seven or eight seem to deserve consideration as being of the first order) are four or five times compound and densely branched. The dorsal tubercle in this specimen was found to be C-shaped, the opening to the right and the horns spirally inrolled.

The branchial sac has six well-developed folds on each side, which decrease in height with a fair degree of regularity from the dorsal to the ventral part of the sac. Approximate distribution of the internal longitudinal vessels in a large specimen:

Right	1	(19)	2	(19)	3	(18)	3	(17)	3	(14)	2	(10)	2
Left	2	(17)	1	(17)	1	(17)	2	(16)	3	(14)	2	(11)	2

On the flat parts of the sac the meshes may contain 12 to 15 stigmata.

The stomach is little more than a somewhat enlarged part of the intestine into which it gradually tapers off. It bears large masses of branching hepatic tubules on its dorsal aspect. The intestinal loop is large, extending the whole length of the body. The rectum is short, with an irregularly lobed aperture.

One gonad on each side. Each consists of a long tubular oviduct accompanied by a slender common sperm duct, bearing along each side a series of elongate-oval or sausage-shaped sacs, about 50 in the gonad of the right side where the whole gonad is curved in an unequal-sided U form, and somewhat fewer on the left where it is much straighter and is enclosed by the intestinal loop. The small sacs contain both eggs and small oval testes, the latter chiefly in the distal parts of the sacs.

The specimens on which the above description was based were collected many years ago at Zorritos, Peru, for the Peabody Museum of Yale University, where the type is preserved. A cotype is in the American Museum of Natural History (A.M.N.H. No 871). I have since seen some somewhat larger and less regularly shaped examples from the coast of Ecuador (Bay of Santa Elena).

Not in its external form or internal structure or its smooth branching calcareous spicules does this species show relationship to *Herdmania* (syn. *Rhabdocynthia*). It is a typical *Pyura*. In its spicules it shows relationship to *P. pachydermatina* Herdman, 1881, of the Australian region, and in the hard rim surrounding the tube-bearing region it is related to *P. stolonifera* and *P. praeputialis* described by Heller, 1878, from South Africa and Australia, respectively, which, however, are not described as possessing spicules.

Pyura lignosa Michaelsen, 1908

Text figure 222

Pyura lignosa MICHAELSEN, 1908a, p. 256, pl. 1, fig. 9, pl. 2, figs. 20, 21.

Michaelsen described this species from only two large and evidently very old individuals found growing on piles at Puntarenas, west coast of Costa Rica. It is closely related to *P. vittata* of the West Indian region.

The largest of these examples measured 90 mm. in length and 80 mm. in height; apertures half the body length apart; siphons not prominent externally. Outer surface irregularly ridged and wrinkled, in part overgrown with sponges and bryozoans. It bears, on some parts, small, slightly curved thorns or spines, 0.08 mm. long and 0.014 mm. wide at their bases. Test cartilaginous and very hard, almost woody in consistency, gray brown in color externally.

Mantle thick with closely spaced but slender muscle bands. Tentacles 16 or more, the largest three or, to a slight extent, four times

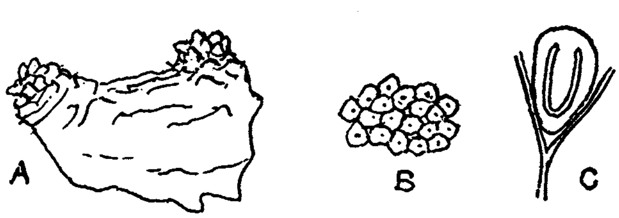


FIG. 222. *Pyura lignosa* Michaelsen. Specimen from the Gulf of California. A. Lateral view, natural size. B. Tesselated surface of the body, ×3. C. Dorsal tubercle.

compound. The dorsal tubercle, as figured by Michaelsen, is evidently an abnormally developed structure but, as he suggests, the aperture may have developed from a U-shaped figure with inrolled, anteriorly directed horns.

Six branchial folds on each side; internal longitudinal vessels quite numerous. Michaelsen gives the following scheme:

6 (28) 6 (28) 6 (30) 6 (32) 5 (28) 6 (18) 4

The meshes contain up to five stigmata on the flat parts of the sac.

The gonads consist of small hermaphroditic sacs (14 to 20 on each side) arranged along the genital ducts, the left gonad in the intestinal loop as usual in typical members of *Pyura*.

I am considerably in doubt as to how the comparatively few specimens of *Pyura* from the west coast of Mexico and Central America that I have examined should be treated. They are all smaller and younger specimens than Michaelsen's type material of *lignosa* but, making allowance for that, they are certainly very closely allied to it and come from the same general region, so it seems reasonable to refer them to it provisionally, especially as I cannot see any justification for establishing a new species for them.

Specimens from the Gulf of California were quite uniformly red when fresh and retain a carmine red or deep pink color after a couple of years of preservation in formalin. They are all of rather small size, the largest about 32 mm. in maximum (anteroposterior) diameter, the body of somewhat elongate form, attached to shells, coral, etc., by a considerable area on the ventral surface or more or less on one side. The apertures, which may or may not be much elevated above the surface, are widely apart, the branchial at the anterior end.

The external surface varies from rather smooth to moderately wrinkled, but always more or less rough and raised into tubercles near the apertures. It is free from incrusting matter. The above-mentioned external characters would not serve to differentiate it from some specimens of *P. vittata* of the West Indian region, but on examination of the body surface with the magnification of a hand lens, a tesselated or squamous condition of the surface is seen to be present (at least on parts of the body) which I do not recollect having found or seen mentioned in the case of *P. vittata*, nor can I find it on any of a considerable number of examples of *P. vittata* or *P. haustor* in the American Museum of Natural History collection which I have reëxamined for that purpose.

The tesselated or squamous condition may be quite conspicuous and cover much of the body (it is independent of the wrinkles or other elevations of the body surface occurring on them as well as elsewhere) or it may be very local, inconspicuously developed, and require search to discover it. Where it is well developed, the body surface exhibits small scale-like areas about a millimeter in diameter, sometimes larger, sometimes smaller, often of quite noticeably polygonal outline. They may have a small elevation or boss in the center; it is possible that these may represent the small spines described on *P. lignosa* by Michaelsen.

A conspicuously tesselated or squamous surface has been described in certain Old World species of *Pyura*, with which, however, I do not find justification for identifying the present species in any case.

The following are the principal internal characters observed in the largest specimen, 32 by 19 by 15 mm. in measurements.

Mantle opaque, more or less reddish on the tubes, with a musculature of quite closely placed bands, the strongest of which radiate from the tubes and extend down on the sides where those from the branchial and atrial tubes cross each other in a close diagonal network. Farther down on the sides these bands break up into narrower, nearly dorsoventrally directed bands. Musculature on ventral part of body weaker and more diffuse.

The largest tentacles, which are slender and bi-pinnately branched, number about nine. There are about as many more moderately large ones and occasionally small simpler ones in the intervals. Dorsal tubercle with aperture elongate, horseshoe shaped, the open interval forward. Dorsal lamina with very numerous slender, rather acute teeth along its margin. Branchial sac with six narrow, high folds on each side separated by very narrow, flat intervals. Internal longitudinal vessels narrow but not very closely spaced even on the folds. Four to six stigmata are the usual number in a mesh on the flat parts of the sac.

Transverse vessels of at least four orders, arrangement not always regular; parastigmatic vessels present in some places. Approximate distribution of the internal longitudinal vessels:

Left	1 (13) 3 (14) 4 (17) 4 (14) 3 (12) 2 (8) 2
Right	3 (12) 3 (14) 3 (17) 3 (13) 2 (10) 2 (9) 2

The intestinal loop is horizontal in direction and rather narrow; the liver is composed of two principal masses of short green tubules. Reproductive organs composed of many hermaphroditic sacs, *Pyura* type, that of the left side situated in the intestinal loop. That of the right side is much longer and is bent in a U curve.

LOCALITIES: The species (except the doubtful Nicaraguan specimens mentioned below) are from the Gulf of California, and, as far as recorded, from quite shallow water. The largest (A.M.N.H. No. 1727) is from Ventana Bay (13 to 15 fathoms), collected by F. E. Lewis. E. F. Ricketts obtained examples at Coronado Island. Several small specimens apparently of this species, which were collected by the "Albatross" expedition of 1911, are of a dull brassy yellow color, which may, however, be due to long preservation in alcohol. Two of them were from pearl oyster shells; one was found on the beach at San Francisquito Bay.

There are also in the American Museum collection four rather small specimens of *Pyura* from the Nicaraguan west coast (12° 48′ N., 87° 00′ W., 12 fathoms, collected by F. E. Lewis) which differ considerably in shape from those described above but have a well-developed tesselated condition of the surface and may belong in this species.

The body is rounded ovate in a lateral view, the siphons large (especially the branchial one) and of truncated conical form in the preserved specimens. Attachment by an area on the right side. On and near the basal parts of the siphons numerous wrinkles cross each other more or less at right angles, producing small, somewhat square papillae; elsewhere the wrinkles are irregular. The test is hard and tough, brassy yellow externally. It was probably red during life.

Pyura haustor (Stimpson), 1864

Plate 31, figures 3, 4; text figure 223

Cynthia erecta RITTER, 1900, p. 598, pl. 18, fig. 5.

Cynthia haustor STIMPSON, 1864, p. 159; VON DRASCHE, 1884, p. 372, pl. 3, figs. 3–8; TRAUSTEDT, 1885, p. 29; HERDMAN, 1898, p. 257, pl. 14, figs. 1, 2; RITTER, 1900, p. 601, pl. 18, figs. 8–10.

Cynthia macrosiphonus RITTER, 1900, p. 597, pl. 19, fig. 24, pl. 20, fig. 4.

Halocynthia haustor RITTER, 1909, pp. 68, etc., pl. 11, figs. 9, 10; 1913, pp. 446, 447; JOHNSON AND SNOOK, 1927, p. 592; RICKETTS AND CALVIN, 1939, pp. 160, 249, 300, pl. 32, fig. 3.

Halocynthia haustor foliacea RITTER, 1913, p. 447, pl. 33, fig. 7.

? *Halocynthia washingtonia* RITTER, 1913, p. 445, pl. 33, figs. 4–6.

Pyura haustor HARTMEYER, 1909–1911, p. 1340; HUNTSMAN, 1912, pp. 114, 115, 134; 1912a, p. 169, pl. 13, fig. 6, pl. 21, figs. 1, 2; WISMER AND SWANSON, 1935, p. 341.

The following form appears to be no more than a very slightly distinguished geographical race or subspecies (*P. haustor johnsoni*), hardly worthy of recognition:

Halocynthia johnsoni RITTER, 1909, pp. 65–114, pls. 9–14; 1913, p. 447; RITTER AND FORSYTH, 1917, p. 448; JOHNSON AND SNOOK, 1927, p. 592, fig. 689; MACGINITIE, 1935, p. 745; RICKETTS AND CALVIN, 1939, pp. 160, 249, 301.

Body somewhat variable in outline in a lateral view, usually oval with the anteroposterior diameter the longest. Attachment may be by the whole of the ventral surface, which is then much flattened, or by a smaller area of one side or lower surface. The siphons are usually produced into conspicuous tubes; the branchial arising near the anterior end is the larger and longer and is directed obliquely forward or upward; the atrial tube arises a little farther back. In many specimens one or both of the tubes may equal or even exceed in length the transverse body diameter and often be quite crooked; in other specimens they may be very little produced.

The test is tough and rather hard, usually discolored with mud and often completely incrusted, except toward the ends of the siphons, with sand, small stones, debris, or growths of hydroids or other organisms. In fresh specimens it shades into red or reddish orange in color on the tubes.

Besides the long tubular siphons, the surface of the test, if not too much incrusted with foreign matter, may be highly characteristic of the species, as it is often raised into high, sharply defined ridges which meet and cross each other in various directions or may in some cases run roughly parallel. The sharpness and elevation of these ridges, which are raised here and there into irregular tubercles, and the way in which the ridges meet each other often give the body, or parts of it, the appearance of being covered by a network with irregularly polygonal meshes. Toward the ends of the siphons the surface commonly becomes smoother, and under the magnification of a strong hand lens it is seen to be covered near the apertures with minute slender spines, 0.25 to 0.5 mm. in length, which are lacking elsewhere on the body.

The species reaches considerable size. The largest I have examined myself has an anteroposterior body diameter of 50 mm. and a dorsoventral diameter of 35 mm., but this is not a maximum. The tubes in this specimen were both about 22 mm. long, which is proportionately rather short as compared with many examples.

The mantle muscles are fairly thick in large specimens; they are built up of bands crossing at various angles. Prominent among these bands are thick ones which extend down on the sides of the body from the bases of the siphons; these are irregularly crossed by many narrow, more superficial bands. There are strong ring muscles at the base of each siphon. Endocarps are usually little, if at all, developed.

Tentacles in specimens from British Columbia and Puget Sound localities rather few (Huntsman says 15 to 30; Ritter, 1913, gives 21 as the "typical" number), irregular in their sizes and distribution, the larger ones of the compound pinnate type and sometimes extensively branched. Ritter, 1909, found in careful study of 25 adult specimens from southern California south of Point Conception an average of 42 tentacles, compared to 21 in 12 Puget Sound examples. (Chiefly on this and on his observation that the body surface "rarely or never presents positive tubercles" Ritter established the "species" *johnsoni* for the southern form.)

The dorsal tubercle is rather simple, C-shaped or horseshoe shaped, with the open interval directly or obliquely forward and the horns curved inward or outward but not strongly coiled. Dorsal lamina a continuous membrane whose margin is cleft into slender tapering languets.

The branchial sac has six rather wide folds on each side, each bearing a considerable number of quite closely spaced internal longitudinal vessels. It is very difficult to decide how many of these vessels should be counted

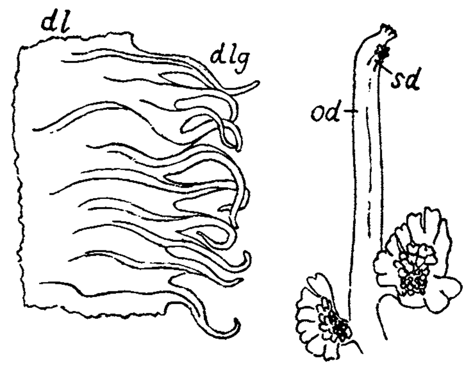


FIG. 223. *Pyura haustor* (Stimpson). Piece of dorsal lamina, and the terminal part of a gonad showing the ending of the ducts and two of the gonad sacs (not much distended). Outline from von Drasche's figure.

as belonging to the folds or to the spaces between them, as the folds do not rise abruptly at their bases. Huntsman gives the following scheme of a specimen of 35 mm. body length:

Right	4 (19) 2 (21) 3 (23) 3 (20) 4 (15) 3 (10) 2
Left	3 (22) 2 (19) 2 (22) 3 (19) 3 (17) 3 (12) 1

The transverse vessels are numerous and of several different sizes, so that the meshes are small; they do not ordinarily have over five to eight stigmata.

The digestive tract forms an elongate, widely open loop. The liver is voluminous and composed of several extensively branched glands arising separately from the stomach. I have not noted any saccular enlargement of the intestine beyond the stomach, which is often found in *P. vittata*, nor do I find mention of it in any of the descriptions.

The gonads are similar to those of *P. vittata*. The individual sacs composing them are irregular in size and shape, and, when numerous, some of them are often crowded out of their normal serial position along the common duct so that they may form more than two rows or appear quite irregularly distributed on the inner surface of the mantle. Large specimens have 50 or more of the sacs on the right side; on the left the number is smaller. Eggs and larvae may often be found in the peribranchial cavity.

DISTRIBUTION: So far as I am aware this species has not previously been reported from farther north than the British Columbia coast, but the United States National Museum has specimens from the Shumagin Islands, Alaska. In the Puget Sound region it is abundant on stones, etc., between tides,

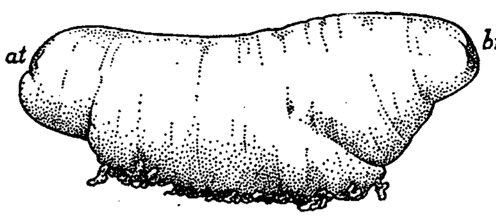


FIG. 224. *Pyura mirabilis* (von Drasche). External (lateral) view, ×1.5. After Ritter.

often growing in groups or masses, and occurs down to 30 fathoms on sandy and gravelly bottoms. Ritter, 1913, also assigns to it doubtfully, but I think correctly, two small and not very typical specimens from a depth of 106 fathoms in the Strait of Juan de Fuca, and in the same article describes as a variety (*foliacea*) some very rough and irregular specimens from off the Oregon coast, "Albatross" Station 3088, 44° 28′ N., 124° 25′ 30″ W., 46 fathoms.

I also include here, as probably only an abnormal specimen of this species, *Halocynthia washingtonia* Ritter, 1913, from "Albatross" Station 3450 in the Strait of Juan de Fuca, 151 fathoms. It is based on a single individual, 2 cm. by 1.5 mm. in measurements, and appears to be within the range of probable individual variations of *P. haustor*, but has the apertures raised only on low prominences, and the atrial aperture with six or seven obscure lobes instead of the usual four. Ritter was much impressed by the last peculiarity, but it seems to me likely that it was nothing more than an individual abnormality. It is not the kind of difference on which we could expect species of this group to be differentiated.

Including as a race or subspecies Ritter's *Halocynthia johnsoni*, the species as a whole ranges southward along the entire California coast and, according to Ritter, is abundant on piles, etc., in San Diego Bay, and was formerly so also in Wilmington (California) Lagoon until that harbor was dredged out, but I am not sure of its occurrence south of the Mexican border.

Pyura mirabilis (von Drasche), 1884

Text figure 224

Cynthia mirabilis VON DRASCHE, 1884, p. 377, pl. 6, figs. 2–7.
Halocynthia mirabilis OKA, 1906, p. 39.
Microcosmus transversus RITTER, 1907, p. 18, pl. 2, figs. 22, 23.

The most striking character of this species is the position of the two siphons at opposite ends of the elongate ovate body; they extend out in prolongation of the axis of the body, or nearly so.

The animal is attached by a large area on the somewhat flattened ventral surface which may have some processes for its more secure fixation. Branchial siphon the most produced, the atrial very little so. Both apertures four-lobed (cross shaped when closed). Body surface transversely wrinkled, especially more strongly so toward the ends, but free from incrusting material. Color dull white, more or less discolored with mud.

Test rather tough, somewhat cartilaginous; the thin outer layer rather soft and easily rubbed off; its interior lining is pearly. Mantle muscles well developed on the dorsal part of the body, consisting of strong longitudinal and transverse bands crossing each other. On the ventral parts the muscles are less strongly developed and form an irregular network.

Tentacles 18 or more (24, according to von Drasche) alternating in size and rather sparingly branched. Dorsal tubercle kidney shaped, the aperture a C-shaped slit with incurved ends, the concavity foward or to the right. Dorsal lamina a row of very slender languets.

Branchial folds seven on each side, the last two small and incomplete. Intestinal loop elongate, its branches virtually parallel and anteroposterior in direction. Stomach elongate and not sharply set off from the intestine; its walls are distinctly longitudinally plicated.

Gonads one on each side, narrowly oblong in outline, nearly straight, having a long central ovary which is divided by clefts into a series of segments and surrounded by the numerous small pyriform testes. The left gonad lies in the intestinal loop.

DISTRIBUTION: Described by von Drasche from a single specimen from Japan, and later redescribed by Oka who recorded it from several Japanese localities but without data as to depth. Ritter, 1907, described it from one specimen from off San Nicolas Island, California, 33 fathoms (type in the United States National Museum) placing it in the genus *Microcosmus* chiefly because he could not discover the dorsal languets, though this was doubtless due to the somewhat poor preservation of the specimen. The American Museum of Natural History has received a fine example about 65 mm. long from G. E. MacGinitie from Brown's Island, Friday Harbor, Washington. These are the only two American occurrences of this peculiarly shaped species that have come to my notice. It is apparently not a deep-water form.

GENUS HERDMANIA LAHILLE, 1887

(Not Ritter, 1903 = *Euherdmania*)

Various members of the family Pyuridae may have small calcareous spicules, usually smooth surfaced and often of branching form, embedded in some of the internal organs or in the test. Their presence or absence does not seem to be of very much taxonomic importance. The peculiar spicules (unique among ascidians) covered with rings of minute appressed spines present in *P. momus* led Lahille (1887, p. 677) to propose a genus *Herdmania* based on this character ("spicules échinés"). Those who have recognized such a group either as a genus or subgenus have almost always employed for it Herdman's (1891) later name *Rhabdocynthia*. He included in it all forms supposed to have rod-like or slightly curved spicules, but it should be restricted to those having spicules similar to those of *momus* and be known by Lahille's name.

Herdmania momus (Savigny), 1816

Text figures 225, 226

Cynthia momus SAVIGNY, 1816, p. 143, pl. 1, fig. 2, pl. 4, fig. 1.

Cynthia pallida HELLER, 1878, p. 96, pl. 3, figs. 17–18; HERDMAN, 1881, p. 60; 1882, p. 143, pl. 17, figs. 17–21; TRAUSTEDT, 1883, pp. 119, 133, pl. 5, fig. 12; 1885, p. 35; HERDMAN, 1886, p. 405.

Halocynthia pallida MICHAELSEN, 1905, p. 83; HARTMEYER, 1905, p. 384.

Pyura momus form *pallida* MICHAELSEN, 1918, p. 10; 1919b, pp. 30–54; 1921, p. 1; 1934, p. 133; VAN NAME, 1921, p. 454, figs. 129–136; 1930, p. 498, figs. 63, 64.

Pyura pallida MICHAELSEN, 1908a, pp. 269, 270.

Rhabdocynthia pallida HERDMAN, 1891, p. 575; SLUITER, 1898, p. 25; 1904, p. 54; 1905, p. 102; 1905a, p. 14; HERDMAN, 1906, p. 308, pl. 2, figs. 36–39.

A number of varieties or "forms" and allied species doubtfully distinct from *momus* have been described from Old World regions but do not come within the scope of this work. See remarks at the end of the following description which was prepared from West Indian specimens.

Usual form of the body rounded or oblong, somewhat compressed laterally, and attached by a small, ventrally or more or less laterally situated area. Apertures on the dorsal side, rather widely separated, often raised on papillae.

Test moderately thick, opaque, rather soft, though tough, in fresh material and remaining soft in formalin, but becoming harder in alcoholic specimens. Surface varying from uneven and wrinkled to rather smooth but occasionally densely overgrown and incrusted with other organisms. Color of external surface and interior of test usually a dull white (sometimes tinged with pink about the apertures) when not stained or incrusted with mud or other substances. Size sometimes very large; but 55 by 45 mm. in longitudinal and dorsoventral diameter is not usually exceeded in the West Indies, though I have seen one measuring 65 mm. in anteroposterior diameter from the Caribbean coast of Panama.

The species is most readily recognized by the characteristic spicules, present chiefly in the mantle and large blood vessels of the branchial sac. These are rod-like or needle-

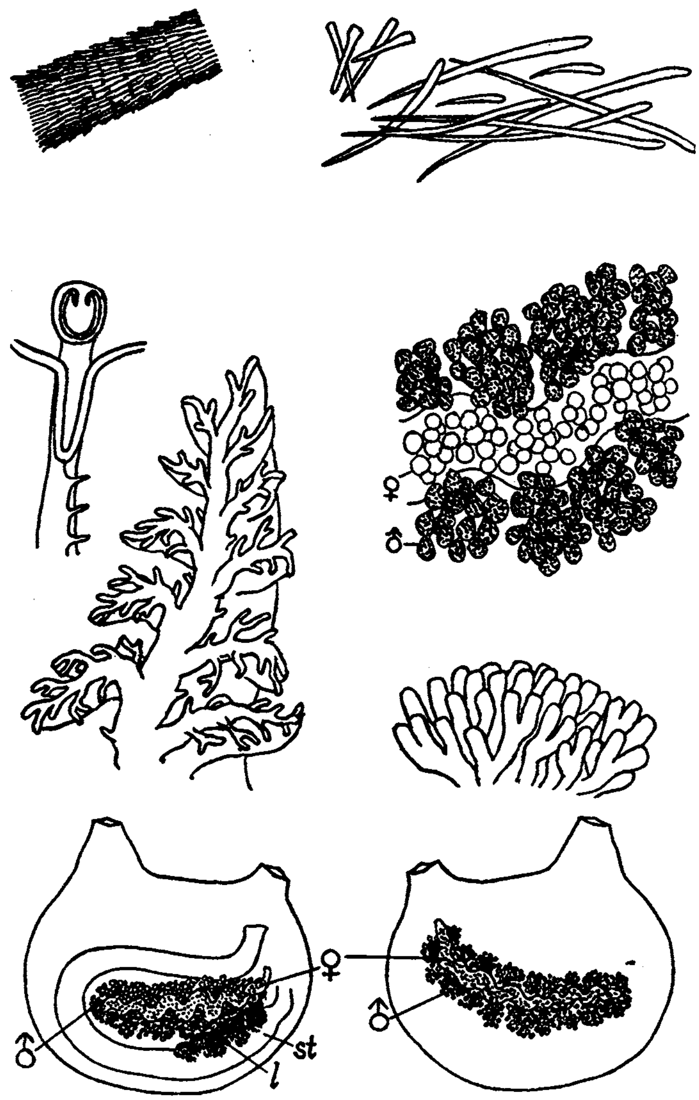


FIG. 225. *Herdmania momus* (Savigny). Upper left figure, a small part of a spicule, ×450, showing the rings of appressed spines. Upper right, spicules, ×35. The large groups are from the mantle and branchial sac, the small group of short spicules from the test. The other figures show enlarged details of dorsal tubercle, tentacle, gonad and liver, enlarged, and left and right sides of body, natural size.

like, very variable in size and proportions, but sometimes 2 mm. or more long in large individuals. They taper toward one or both ends and are usually slightly curved. Under magnification, their surface is seen to be covered with minute appressed points or spines arranged in transverse rings. Somewhat similar spicules are found, though less abundantly, in the test, where they are usually very short, stout, and straight, and often have one end enlarged into a head, the other being either blunt or pointed.

Mantle thin, with rather weak musculature except for some stout bands extending from the bases of the tubes down on the sides. Tentacles irregular in size and arrangement; the larger ones, which are of unequal size and may number from eight to a dozen, are two or three times compound and bear broad membranes. Their branches are not very numerous.

Dorsal tubercle rather small, its aperture U-shaped or horseshoe shaped with the open interval forward (sometimes obliquely to the left), and both horns usually incurved or inrolled. Dorsal lamina a series of languets. Branchial sac with high, sharply defined folds separated by narrow flat intervals. The number of folds is variable; in West Indian specimens usually eight or nine on a side. Transverse vessels of four or five orders, often quite regular in their arrangement, the smallest often crossing the stigmata. There are from six to 10 stigmata in the large meshes on the flat parts of the sac. Internal longitudinal vessels only moderately numerous; they were distributed about as follows in a fully adult and fairly large specimen, though in small individuals they will be found considerably less numerous:

Left 2 (15) 3 (19) 3 (22) 2 (23) 2 (21) 2 (19) 2 (16) 2 (11) 3

Right 4 (16) 3 (20) 2 (22) 2 (23) 2 (22) 3 (18) 2 (14) 2 (10) 1 (5) 0

Digestive tract curved in a simple, broad loop. Stomach elongated, bearing a large and dense mass of short hepatic tubules which are crooked and often slightly branched. Rectum short; margin of its aperture not conspicuously lobed in the specimens studied.

One long, horizontally or obliquely placed gonad on each side, each consisting of an irregularly shaped, sinuously curved ovary bordered or enclosed by the small testes. On the left side the gonad lies in the intestinal loop. Both the ovary and testes discharge by separate, slightly produced ducts at the posterior end of the gonad.

DISTRIBUTION: The species as a whole is of wide range on the coasts of the Red Sea, the Indian Ocean south to the Cape of Good Hope, and the warmer parts of the western Pacific from Japan through the Malay Archipelago to New South Wales and eastward to the Society Islands, as well as in the West Indian and Caribbean regions of America, but is not known from the Mediterranean or the American Pacific coast. Savigny's type locality was the Gulf of Suez. It is a species of shallow or only moderately deep water.

Localities in American waters comprise Cuba (both north and south coasts), Jamaica,

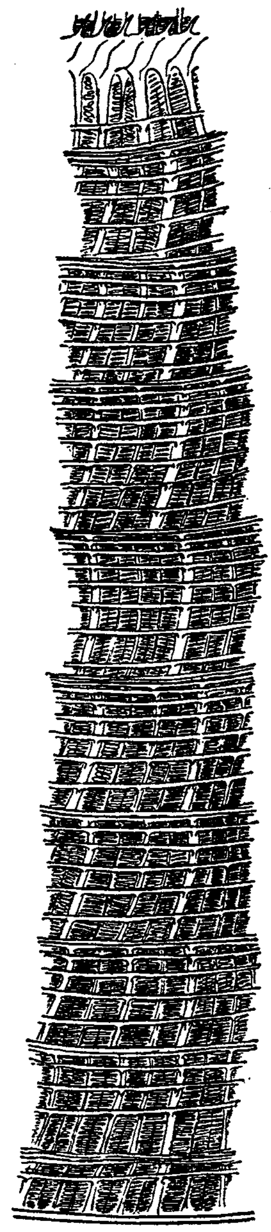


FIG. 226. *Herdmania momus* (Savigny). Part of branchial sac, ×10.

St. Croix, St. Thomas; Cartagena, Colombia; near Colon, Isthmus of Panama; and the Brazilian coast near Rio de Janeiro. It is not known from Bermuda, but is reported by

Traustedt, 1884, from 33° N., 55° W., which is not far east of those islands. Presumably it was picked up attached to some floating object, not from the bottom, in that locality.

Michaelsen (1919b) has published the results of a careful study of specimens of this and certain allied forms from a wide range of localities. As a result, he recognizes a number of subdivisions of the species *momus* which he terms forms (formae), but these are certainly mostly not geographical races or true subspecies, as their wide occurrence and irregular, overlapping distribution show. The best marked of them is in the Australian form *grandis* (= *Cynthia grandis* Heller, 1878, p. 97) which reaches a large size (160 mm. in diameter) and may have as many as 15 branchial folds on one side.

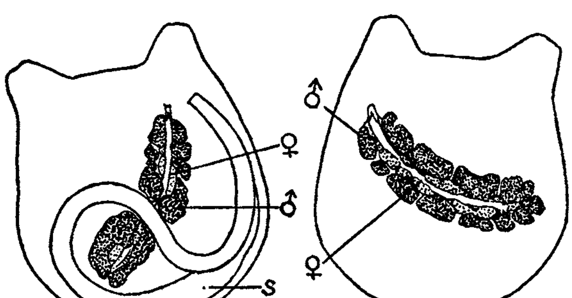


FIG. 227. *Microcosmus glacialis* (Sars). Left and right sides of body, somewhat enlarged.

Michaelsen (1919b) assigns the American representatives of the species to the "forma *pallida*" which is also very widely distributed in Old World waters so that it cannot be considered a geographical race unless we assume that ships have carried it, and which seems to me to differ very little from the typical form of the species (redescribed from specimens from Savigny's original locality, the Gulf of Suez).[1] I am, therefore, using Savigny's name and treating *pallida* simply as a synonym.

[1] The "forma *pallida*" has, according to Michaelsen, eight or nine branchial folds, while the typical form of *momus* from the Gulf of Suez has usually nine and a small or incomplete tenth fold on the right side. The form *pallida* is said to have the anus margin smooth, or nearly so, the typical form to have it lobed; the spicules stouter than in the latter form, which also has the testes in each gonad forming a broad band of serpentine curvature covering the ovary in large part instead of merely bordering it. Such differences might be expected within the limits of individual or age variation.

GENUS **MICROCOSMUS** HELLER, 1878

The chief character distinguishing this genus from *Pyura* is in its having a continuous dorsal lamina with a more or less smooth margin instead of one deeply notched into teeth or languets. In the American species at least, the intestinal loop is narrow, and the left gonad (there is one on each side) lies partly within and partly dorsal to the intestinal loop, crossing the dorsal branch of the loop.

Microcosmus glacialis (Sars), 1859

Plate 1, figure 4; text figures 227–229

Ascidia conchilega SARS, 1851, p. 157. Not O. F. Mueller, 1776.

Glandula glacialis SARS, 1859, p. 65.

Microcosmus glacialis KIAER, 1893, p. 70 (redescription of Sars' type), pl. 3, figs. 31–34; 1896, p. 13; HARTMEYER, 1903, p. 200; REDIKORZEV, 1907, p. 154; 1910, p. 122; 1916, p. 181, fig. 36, pl. 4, figs. 23, 24; HARTMEYER, 1922b, p. 315, figs. 10, 11; 1923, p. 178; ÄRNBÄCK, 1927, p. 79, pl. 3, figs. 69, 70.

Molgula carpenteri HERDMAN, 1886, p. 401, pl. 47, figs. 1, 2.

Molgula wagneri HARTMEYER, 1903, p. 144.

Probably also to be included in this species is *Microcosmus nacreus* VAN NAME, 1912, p. 537, fig. 26, pl. 56, figs. 75–77, pl. 57, fig. 82, pl. 73, fig. 162; HARTMEYER, 1923, p. 182; ÄRNBÄCK, 1928, p. 81.

See Hartmeyer, 1923, p. 178, for other references.

This species has appeared in literature in three different families, eight different genera, and under a still larger number of specific names. Its genus was first correctly determined by Kiaer, 1893, and its synonymy was finally cleared up and listed by Hartmeyer, 1923. I am now including in it the American specimens from off Newfoundland and Nova Scotia which I described as *M. nacreus*, as the distinguishing characters do not appear to be very important, though perhaps worthy of recognition as subspecific if on more investigation they prove to be fairly constant.

This is a densly sand-incrusted species which does not appear to be attached, but to live buried in the sand. In a lateral view the body varies from round to more or less asymmetrically oval, and is somewhat laterally compressed. The dorsal border where the two siphons, which are only slightly prominent, are situated is straight or sometimes slightly concave. In the specimens from Nova Scotia and Newfoundland the body, though wide from side to side in the anterior dorsal part, narrows to a somewhat keel-like edge in the posterior ventral part, its general shape somewhat suggesting some of the bivalve shells of the family Veneridae. This was one of the distinguishing characters of the species *nacreus*, the other being in the branchial sac (see below).

The test is tough and thick, especially ventrally, and densely permeated with sand. It is more or less pearly internally. Diameter of largest specimen, 40 mm. anteroposteriorly, 35 mm. dorsoventrally, and 9 mm. laterally. Mantle musculature well developed, consisting of distinct bands and comprising the sphincters of the apertures, stout bands radiating from the siphons and an overlying layer of circular bands. According to Hartmeyer, 1922, a branchial and an atrial velum are present. There are eight large, two to three times pinnately compound, and smaller ones irregularly distributed. Dorsal tubercle horseshoe or crescent shaped with the horns incurved and the open interval directed forward. Dorsal lamina a membrane with low denticulations along its edge.

The branchial sac has five folds on each side, the ventral ones being the lowest, with moderately numerous internal longitudinal vessels, and transverse vessels of four or five orders (the smallest crossing the stigmata).

There is considerable difference in the distribution of the internal longitudinal vessels. Redikorzev gives the following scheme for an Old World specimen:

Right	1 (9) 7 (9) 5 (10) 5 (9) 5 (7) 3
Left	1 (9) 7 (9) 5 (9) 5 (9) 5 (3) 3

The vessels on the folds are thus comparatively few, and those on the interspaces numerous and separated by only a few, usually three to six, stigmata.

On the other hand, I found the arrangement in a large specimen from off Nova Scotia to be

0 (19) 2 (18) 0 (14) 0 (13) 0 (11) 0

The two vessels in the space between folds I and II were close together near the middle of the space; otherwise the vessels were confined to the folds or so close to their bases that they could be considered as belonging to a fold. Several other smaller examples from the Newfoundland Banks showed a more or less similar distribution of the vessels, and it was also found by Hartmeyer, 1923, in one of the same lot of specimens which he kindly examined for me.

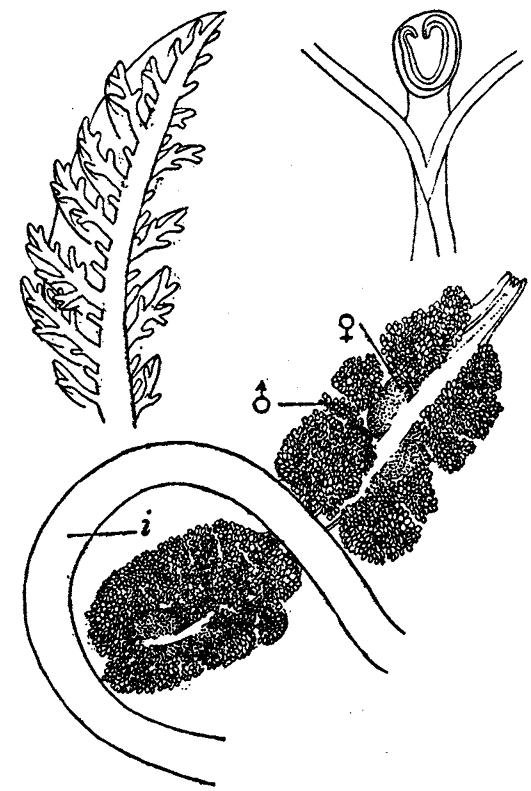


FIG. 228. *Microcosmus glacialis* (Sars). Details: tentacle, dorsal tubercle, intestinal loop, and left gonad, side next to mantle.

The intestine forms a large, considerably bent loop widely open at the reflected end, but its distal branch bends down and lies close along the proximal part of the stomach, which is elongate and tapers gradually into the intestine. The hepatic organ forms a thick plicated area on the wall of its proximal part.

One elongate hermaphroditic gonad is present on each side; a part of the left gonad lies within the loop of the intestine, as usual in this genus. In each gonad the ovary, consisting of an elongate oviduct with masses of eggs along its sides, occupies the axial part, and dense groups of small testes are dis-

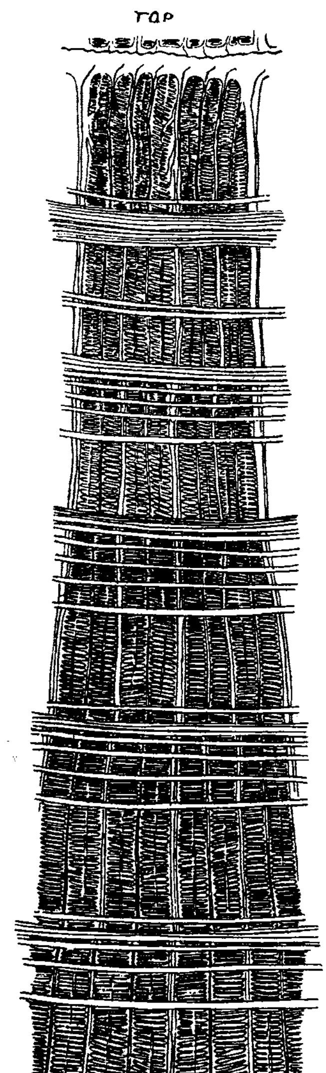


FIG. 229. *Microcosmus glacialis* (Sars). Part of branchial sac from specimen from north of Sable Island, Nova Scotia, ×5.

tributed along both sides of, and more or less overlapping, it. The oviduct extends but little beyond the gonad and ends in an irregularly lobed orifice near the base of the atrial siphon. The common sperm duct, formed by the union of the branches arising from the small masses of testes, accompanies the oviduct and ends close beside, but a little short of, the end of the oviduct.

DISTRIBUTION: The majority of records of this species are from the seas to the north of Europe in latitudes near, or sometimes north of, the Arctic Circle, but not in extreme high latitudes, the depths ranging from 1 to 792 meters. It appears to be a local and in most places an uncommon species. In American waters it is known from Davis Strait, 66° 44′ N., 56° 08′ W., in 315 meters, and from near Sable Island ("Albatross" Station 2501, 44° 27′ N., 60° 20′ 15″ W., 26 fathoms, sand and gravel, one large specimen), also from the Newfoundland Banks ("Albatross" Station 2439, 43° 37′ N., 49° 56′ 30″ W., 36 fathoms, sand) where a number of specimens of different sizes were dredged. The two last localities are much the most southern ones, and the specimens from them present the above-noted differences on which the species *nacreus* Van Name was based. The crediting of *Microcosmus scrotum* (Delle Chiaje), 1841, a Mediterranean species, to Greenland was evidently erroneous (see Michaelsen, 1908a, p. 282).

Microcosmus exasperatus Heller, 1878

Plate 16, figure 3; text figures 230, 231

? *Ascidia cavernosa* LESUEUR, 1823, p. 2, pl. 1, fig. 6; VAN NAME, 1921, p. 482.

? *Ascidia variabilis* LESUEUR, 1823, p. 4, pl. 2, fig. 5; VAN NAME, 1921, p. 483.

? *Microcosmus anchylodeirus* TRAUSTEDT, 1883, pp. 121, 133, pl. 6, fig. 18; HARTMEYER, 1909–1911, p. 1344; MICHAELSEN, 1919b, pp. 58, 62; VAN NAME, 1921, pp. 466, 485; 1930, p. 503.

Microcosmus biconvolutus SLUITER, 1898, p. 26, pl. 2, figs. 36–38; VAN NAME, 1921, p. 485; 1924, p. 24.

Microcosmus claudicans exasperatus HARTMEYER AND MICHAELSEN, 1928, p. 400; VAN NAME, 1930, p. 500, figs. 65–68.

Microcosmus distans HELLER, 1878, p. 100, pl. 3, fig. 20; HERDMAN, 1891, p. 574; SLUITER, 1898, p. 26.

Microcosmus exasperatus HELLER, 1878, p. 99 (this name has page precedence over *variegatus*), pl. 3, fig. 19; SLUITER, 1898, p. 26, pl. 2, fig. 35; MICHAELSEN, 1908a, p. 271, pl. 2, figs. 11–13; 1918, p. 11; VAN NAME, 1918, p. 81, figs. 30, 32, pl. 32, fig. 39; MICHAELSEN, 1919b, p. 63, fig. 9; VAN NAME, 1921, p. 459, figs. 137–144; 1924, p. 31; HUUS, 1927, pp. 168, 169; BERRILL, 1932, p. 78; PLOUGH AND JONES, 1937, p. 101.

Microcosmus miniatus VERRILL, 1900, p. 590, fig. 8; VAN NAME, 1902, p. 396, pl. 56, fig. 79, pl. 57, figs. 91, 95, pl. 62, figs. 129, 130, pl. 69, fig. 148.

Microcosmus variegatus HELLER, 1878, p. 99, pl. 5, fig. 27; TRAUSTEDT, 1883, pp. 122, 134, pl. 5, figs. 10, 11, pl. 6, fig. 17; 1885, p. 42.

? *Pyura cavernosa* HARTMEYER, 1909–1911, p. 1342; Van Name, 1921, p. 487.

? *Pyura variabilis* HARTMEYER, 1909–1911, p. 1342; Van Name, 1921, p. 488.

The references and synonyms of this widely distributed form given in the foregoing list are chiefly those which apply to it as an inhabitant of American waters. The following description was made from West Indian and Bermuda specimens, but it would also apply very well to specimens from the Philippines and Hawaii that I have examined.

Body irregularly elongate ovate, generally attached by considerable area on the ventral or posterior ventral side. Apertures on the dorsal side, widely separated, generally on rather low papillae, which, however, are sometimes produced into tubes of conspicuous length. Size of largest specimen, about 55 mm. by 35 mm. by 27 mm. Body surface very rough and uneven with irregular folds, furrows, and ridges, the latter often with rough angular edges. Though often overgrown to some extent with algae, compound ascidians, or other organisms, it is generally not much incrusted by sand or shell fragments. Color of test in life, some shade of red, red purple, or pink externally and pearly gray or whitish internally. Test fairly thick and tough, often becoming hard and rigid in alcoholic specimens.

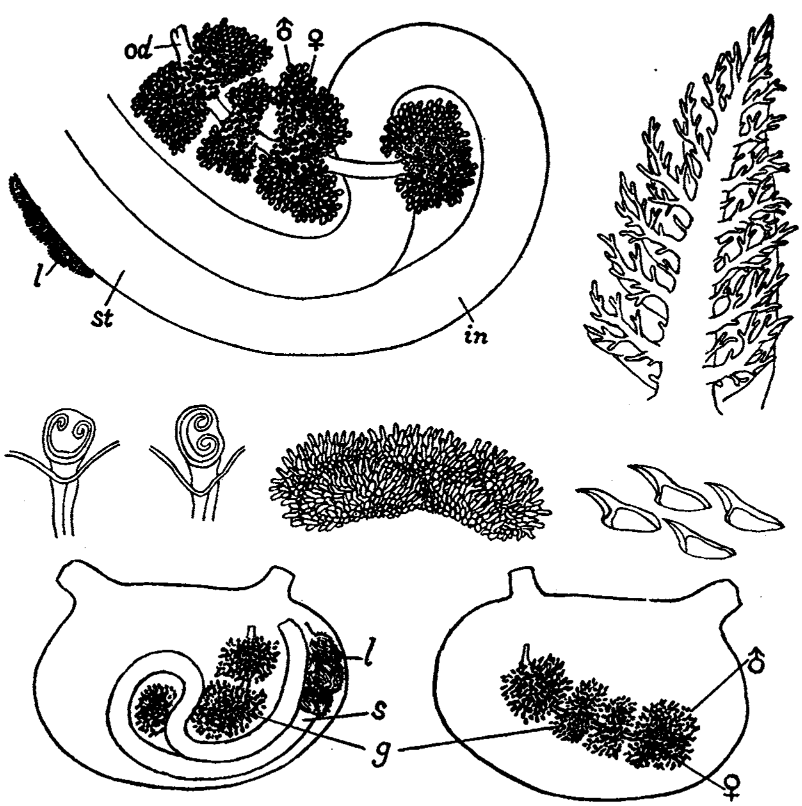


FIG. 230. *Microcosmus exasperatus* Heller. Details: alimentary tract, tentacle, dorsal tubercle, liver, and minute spines (×250), from lining of the distal part of branchial siphon; also, left and right sides of body, somewhat enlarged.

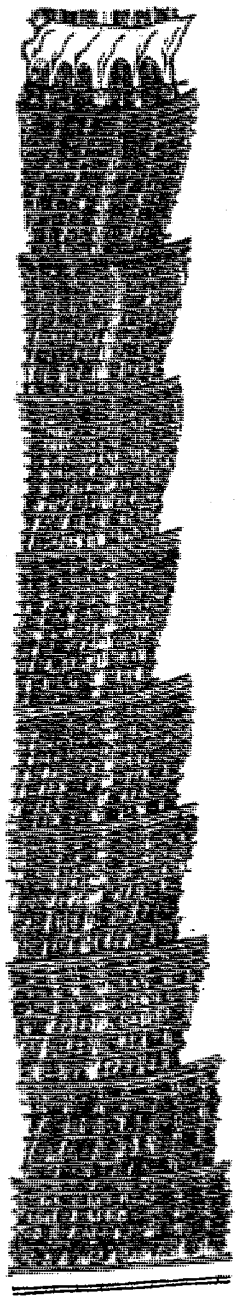


FIG. 231. *Microcosmus exasperatus* Heller. Part of branchial sac, ×5.

Mantle with many very conspicuous muscle bands radiating from the bases of the tubes and extending down onto the sides of the body, where they cross each other nearly at right angles; there are also conspicuous but less regular muscles crossing the ventral region.

Tentacles of tapering form, the larger ones about eight or 10 in number, pinnately branched, and two or three times compound. A variable number of smaller, more or less branched tentacles occupy the intervals between them. Considerable variation was found in the number and length of the primary and secondary branches of the large tentacles in different specimens. In some large specimens from Puerto Rico they were found very numerous, and many third-order branches were present. The tips of the small branches may or may not be slightly enlarged. Dorsal tubercle generally C-shaped with inrolled horns, the open interval directed forward and more or less obliquely to the left.[1] Dorsal lamina rather wide, plain edged.

Branchial sac with about nine (sometimes eight or 10) folds on each side; the folds diminish in height, and in the number of internal longitudinal vessels they bear, fairly regularly from the dorsal to the ventral region, the ninth fold being often much reduced and fading out before the posterior end of the body is reached, or it may be wanting entirely. A small rudiment of a tenth fold is often present on the right side or on both sides, but it extends only a short distance and bears very few vessels. The second fold is often somewhat lower than the third. The folds in this species are ordinarily not very high, and portions of the intervening flat parts of the sac are exposed even when the folds lie flat against the sides. Transverse vessels are quite numerous; at least five orders can be recognized in some parts of the sac, those of the first order being very large. The smallest vessels often cross without interrupting the stigmata. The following scheme shows the distribution of the internal longitudinal vessels in a fairly large and typical example:

[1] A rather large specimen from Hawaii had the dorsal tubercle large and triangular, with several slit-like, variously curved openings, forming no fewer than six small but distinct spirals. A still larger specimen from the same lot had the opening C-shaped with both horns inrolled, as is normal for the species.

Right 4 (25) 4 (22) 5 (24) 4 (20) 3 (19) 4 (16) 3 (12) 3 (9) 2 (6) 1
Right 5 (24) 4 (20) 3 (24) 3 (22) 4 (18) 3 (15) 3 (11) 3 (9) 2 (6) 0 (3) 0

Five to eight stigmata ordinarily intervene between internal longitudinal vessels on the flat parts of the sac between the folds.

Intestinal loop narrow, its branches lying close together except at the anterior end, where it opens out into a small loop and is at the same time strongly bent in a dorsal direction. Stomach long and narrow; its wall bears two large hepatic glands near the oesophageal end. The surface of these glands exhibits convolutions which under low magnification suggest those of the human brain. Under high power they are seen to be composed of compacted masses of blindly ending tubules, whose tips project irregularly above the surface.

One gonad on each side of the body. It consists of several masses or segments arranged along a curved oviduct which passes through them in succession. Generally there are three or four segments in the left, and four or five in the right, gonad. Each mass or segment consists of a central ovary more or less completely surrounded by the male glands, which are of the usual small pyriform type. When highly developed, the masses may become so large as to obliterate the intervals or clefts between them wholly or in part, so that the gonad may appear continuous or nearly so. The anterior end of the left gland lies in the open part of the loop formed by the intestine. The common sperm duct accompanies the oviduct.

As indicated in the synonymy given above, *M. exasperatus* was reduced to the status of a subspecies of the European *M. claudicans* Savigny, 1816, by Hartmeyer and Michaelsen, 1928, on the claim that the condition of the gonads, whether continuous (the usual condition in the adult *claudicans*) or divided into separate masses, as usual in *exasperatus*, is the chief distinction, and that this is subject to variation with age. There is some evidence in support of this course, although I am not following it in the present work as the matter needs more investigation.

DISTRIBUTION: This form ranges widely in warm regions, occurring from the Red Sea and east African coast to the Malay region and eastern coast of Australia and eastward to Hawaii. In America it is found at Bermuda and throughout much of the West Indian region (where it is one of the commonest shallow-water ascidians), including Florida and the coast to and including South Carolina, growing on piles, corals, stones, and mangrove roots as well as in depths down to 23 fathoms or more. I have examined specimens from Cuba, Haiti, Puerto Rico, St. Thomas, Curaçao, Bermuda; Santa Marta and Sabanilla, Colombia; São Francisco, State of Santa Catherina, Brazil; also from Tortugas and Goodland Point, Florida; and one dredged by the Steamer "Albatross" at Station 2617 (33° 37′ 30″ N., 77° 36′ 30″ W.) off the South Carolina coast (the most northern record), as well as from the Philippines and Hawaii.

What *Microcosmus anchylodeirus* Traustedt, 1883, was, based on one specimen from St. Thomas, West Indies, is difficult to determine. It is stated to have only seven folds on each side, and the figure showing a part of the branchial sac indicates that the branchial vessels were somewhat irregular. No specimens referable to it have come to my notice among the large amount of *Microcosmus* material from the West Indies that I have seen, and I am inclined to consider it an abnormal specimen of the present species. I do not accept as at all probable the suggestion of Michaelsen (1919b) that it was a specimen of *M. pupa* (Savigny, 1816, p. 151) described from the Gulf of Suez and entirely unknown in American waters.

Microcosmus helleri Herdman, 1881

Plate 10, figure 5; text figures 232, 233

Microcosmus goanus MICHAELSEN, 1918, p. 12, figs. 1, 2.

Microcosmus helleri HERDMAN, 1881, p. 54; 1882, p. 131, pl. 14, figs. 1–4; TRAUSTEDT, 1885, p. 41; SLUITER, 1895, p. 184, pl. 10, figs. 8, 9; MICHAELSEN, 1918, pp. 18, 19; HARTMEYER, 1919, p. 19, pl. 1, figs. 6–9; VAN NAME, 1921, p. 463, figs. 145–146; 1924, p. 31; 1930, p. 503, figs. 69, 70.

The following description and figures were prepared from specimens dredged off Puerto Rico.

The body is irregularly spheroidal, longer than broad and usually not laterally compressed, though sometimes slightly compressed in a dorsoventral direction. The tubes arise from the dorsal surface at a varying distance apart; they are long, narrow, and diverging in most specimens, and often very crooked. In some specimens, however, they are quite short, perhaps because of contraction. The size of the largest specimen is 45 mm. in length, 32 mm. in dorsoventral, and 29 mm. in lateral, diameter, exclusive of the tubes. These arise more than 10 mm. apart; the branchial tube is about 16 mm. long, the atrial about 11 mm. long.

The surface is rough and raised into small, sharp, irregular ridges and small irregular processes. It is so completely incrusted with sand grains, shell, and coral fragments, etc. (which are embedded in the test, and in the substance of the processes, as well as firmly attached to their surfaces) and so plastered with loosely adherent mud that the surface is generally entirely concealed, and the animal often looks like a ball of mud and debris.

The test is tough but only moderately thick; its lining is slightly nacreous. The test extends into, and forms a thin lining to, the branchial tube; the terminal or posterior margin of this lining is produced into four large, rigid, somewhat spoon-shaped or obtusely pointed lobes that project in a convergent manner into the lumen of the branchial tube anterior to the circle of tentacles. In spite of the most careful search, I was unable to demonstrate any small spines in the lining of either the branchial or atrial tube, such as are present in *M. exasperatus*. Hartmeyer and Michaelsen (1928, p. 398) also report failure to find any.

One specimen had algae growing on it and had evidently been attached in an exposed situation, but most of them had apparently lived buried in the mud, breathing and feeding by means of their long tubes, which are probably extensible when the animal is alive.

The internal structure shows some well-marked differences from *M. exasperatus*. The large tentacles are commonly more extensively branched and often four times pinnate on some of the branches.

The dorsal tentacle is C-shaped, with the open interval forward and the horns inrolled. The branchial sac has only six folds on each side, all complete for the whole length of the body, and rather high, covering or more than covering the flat parts of the sac between them when laid down.

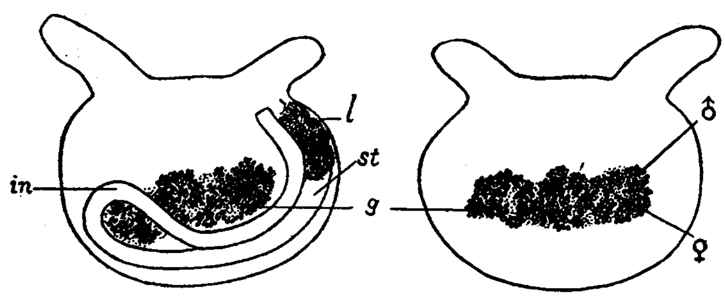


FIG. 232. *Microcosmus helleri* Herdman. Left and right sides of body, ×1.5.

Approximate distribution of the internal longitudinal vessels in a moderately large individual:

Left	3 (24) 2 (19) 2 (25) 4 (22) 3 (16) 3 (13) 1
Right	4 (23) 3 (18) 2 (26) 4 (23) 3 (17) 3 (14) 0

On the flat parts of the sac these vessels are widely spaced, the meshes containing at least nine or 10 or often as many as 12 or 15 stigmata.

The intestinal loop is narrower, with a smaller and narrower open part, and the whole loop is much less bent upwards at the anterior end than in *exasperatus*. The gonads, one on each side, are elongate and usually fairly compact, being only indistinctly divided into segments, if indeed any tendency to such division is noticeable at all.

DISTRIBUTION: This species, though less frequently collected than the last, likewise has a wide geographical range. It is known from the Malay Archipelago (Sluiter, 1895), Cape Jaubert, North Australia (Hartmeyer, 1919), and East Africa (Michaelsen, 1918). Type locality, Torres Strait (Herdman, 1881). Type in the British Museum (Hartmeyer, 1919). In America it is known only from two parts of the West Indies. Many specimens were dredged by the American Museum of Natural History expeditions off the south coast of Puerto Rico in 3 to 18 fathoms on muddy or more or less muddy bottom, and about 15 examples were obtained by Van der Horst at Curaçao in the Spanish Water, hence in a very shallow situation.

GENUS BOLTENIA SAVIGNY, 1816

As now defined, this genus resembles *Pyura* in most respects but is distinguished by the character unique among ascidians that the branchial stigmata are placed in longitudinal rows with the long diameter of the body instead of parallel to that axis. (See description of branchial sac of *B. ovifera* below.)

The type species *B. ovifera* Linnaeus has the body borne on a long stem or stalk. The older authors considered this the chief character distinguishing the genus. Hartmeyer, 1909–1911, recognized that the stalk was an insufficient generic character and united *Boltenia* with *Pyura*. Huntsman, 1912, proposed the retention of *Boltenia* as a genus, but based it not on the presence or absence of a stalk but on the above-mentioned peculiarity of the stigmata. This has met with general approval and acceptance and is followed in this work.

Boltenia ovifera (Linnaeus), 1767

Plate 2, figure 4, plate 5, figure 1;
text figures 234–236

This conspicuous species has appeared in literature under many different synonyms, and no attempt to give a complete list of references and names is made in the present work. The most nearly complete list thus far made is that given by Hartmeyer, 1923 (later references not numerous).

Ascidia pedunculata COUTHOUY, 1838, p. 111.

Boltenia beringia DALL, 1872, p. 157.

Boltenia bolteni PACKARD, 1867, p. 277; VERRILL, 1873–1874, vol. 7, p. 43; 1874, p. 363; VERRILL AND RATHBUN, 1879, p. 231; BAIRD, 1882, pp. 791, 795, etc.; VERRILL, 1885, p. 529; WHITEAVES, 1886, p. 39, text fig.; MCDONALD, 1889, p. 858; PACKARD, 1891, p. 397; KINGSLEY, 1901, p. 183.

Boltenia bolteni +*B. bolteni* var. *rubra* +*B. ciliata* VERRILL, 1879, p. 27.

Boltenia bolteni +*B. ciliata* +*B. elegans* WHITEAVES, 1901, pp. 269, 270.

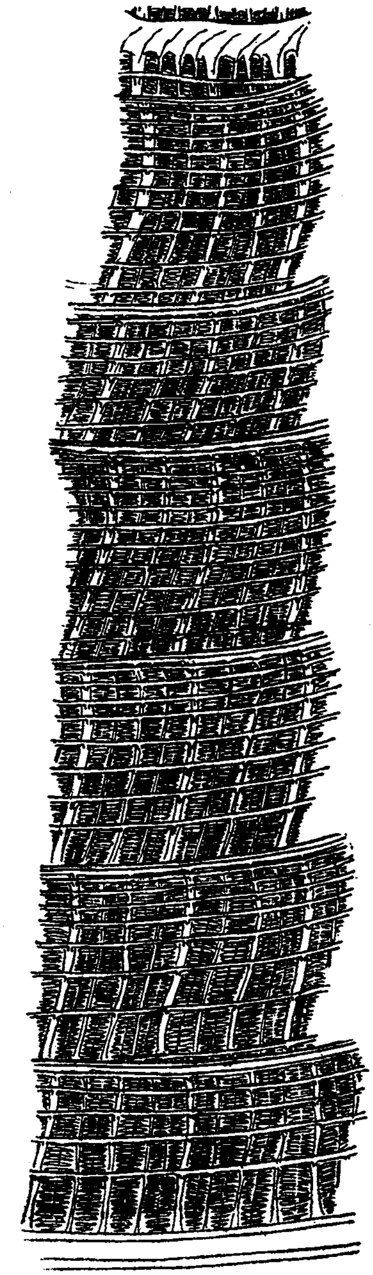


FIG. 233. *Microcosmus helleri* Herdman. Part of branchial sac, ×10.

Boltenia clavata +*B. microcosmus* +*B. rubra* +*B. burkhardti* BINNEY, 1870, pp. 14–16, pl. 23, fig. 325, pl. 24, figs. 327, 337, 338; DALL, 1870, p. 255.

Boltenia elegans HERDMAN, 1881, p. 80; 1882, p. 86, pl. 7, figs. 1–5; RITTER, 1899, p. 518.

Boltenia microcosmus AGASSIZ, 1850, p. 159.

Boltenia ovifera HARTMEYER, 1903, p. 173, figs. 3–5, pl. 4, figs. 11, 12, pl. 10, figs. 1–4; HUNTSMAN, 1912, pp. 112, 133, 147; 1912a, p. 163; RITTER, 1913, p. 456; REDIKORZEV, 1916, p. 143, figs. 27–28, pl. 4, figs. 17–20; HARTMEYER, 1921a, p. 16, figs. 2–4; 1923, p. 138; ÄRNBÄCK, 1928, p. 88; PROCTER, 1933, p. 284.

Boltenia oviformis PACKARD, 1863, p. 412.

Boltenia reniformis GOULD, 1841, p. 319; DEKAY, 1843, p. 260, pl. 34, fig. 324; VERRILL, 1872, pp. 3, 6; METCALF, 1900, p. 512.

Boltenia rubra STIMPSON, 1852, p. 232; HARTMEYER, 1915, p. 313; PRATT, 1916, p. 667, fig. 1011.

Boltenia thompsoni HARTMEYER, 1903, p. 185, pl. 5, fig. 1, pl. 10, figs. 5–9; HUNTSMAN, 1912a, p. 168.

Boltenia sp. VERRILL AND SMITH, 1873, p. 702; SUMNER, OSBURN, AND COLE, 1913, p. 730.

Pyura ovifera HARTMEYER, 1909–1911, p. 1340; 1910a, p. 231; VAN NAME, 1912, p. 527, fig. 24, pl. 55, fig. 66, pl. 56, figs. 68–70, pl. 67, fig. 133, pl. 70, fig. 145; PROCTER, 1933, p. 284; PRATT, 1935, p. 749, fig. 967.

Vorticella bolteni LINNAEUS, 1771, p. 552.

Vorticella ovifera LINNAEUS, 1767, p. 1319.

The body, which is borne on a long, slender, but somewhat stiff stem, is kidney shaped or even spindle shaped, sometimes decidedly compressed laterally, sometimes very little so, if at all. Apertures on widely separated papillae on the dorsal surface, both four-lobed, or the atrial aperture more or less like a transverse cleft. Stem arising from the anterior end or anterior ventral region of the body, generally about two to four times as long as the body; proportionately longer in rather small than in very large individuals. Its basal end is expanded for attachment to the rock or other object on which the animal grows. The test is very variable, sometimes thin, and but little if at all wrinkled on the surface; in other cases it is thick and deeply wrinkled or thrown into irregular elevations. In small and medium-sized specimens the surface both of the body and stem is often thickly covered with small thorn-like tapering processes, which, however, are soft and flexible and not prickly to the touch. They may arise directly from the surface, or each spine from a rounded protuberance on the surface. They may be so numerous and minute as to give the surface a velvety appearance or large enough to be individually conspicuous to the naked eye. As the animal grows older and larger, they disappear more or less completely, though some probably always persist. The species attains a large size: body length, 50 mm. to 80 mm. or often more; stem, often 150 mm. to 200 mm. additional. In alcoholic specimens the color of the body is yellowish white or more or less brownish; in life the body is sometimes deep red, in other cases yellowish, often tinged with red.

Mantle musculature mainly of two layers, the deep layer (deficient on the ventral region) formed by the bands which radiate from the siphons; the superficial layer, of those which encircle the body and the bases of the siphons. Each layer consists of distinct, rather widely separated bands; together they form a network with nearly square meshes.

Branchial tentacles rather few; about a dozen large ones, usually very complex in their branching, which differ much in size among themselves and show some tendency to alternate in size, and a few smaller ones in the intervals.

Dorsal tubercle aperture C-shaped with inrolled horns; open interval to the right. Dorsal lamina cleft into numerous narrow teeth. Branchial sac with nine or 10 folds (the last of which is rudimentary) on each side. The first fold is the highest; the others diminishing in height in quite regular succession except the second, which is lower than its place in the series would indicate. Internal longitudinal vessels very numerous in large speci-

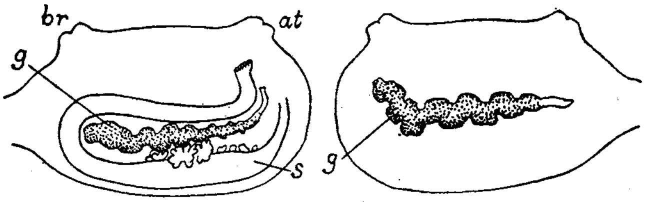


FIG. 234. *Boltenia ovifera* (Linnaeus). Left and right sides of body, about natural size.

mens. In a moderately large one they were distributed as follows:

3 (30) 7 (16) 6 (24) 7 (22) 6 (20) 5 (17) 5 (14) 5 (14)
3 (9) 3 (4) 1

Stigmata placed with their long diameter transverse to the body axis, in longitudinal rows separated by vessels of varying width. In general these rows correspond in number to the internal longitudinal vessels, one of the latter passing over the middle of all the stigmata of a row, except on the upper part of the folds where the vessels are crowded. Transverse vessels of sac numerous and of various sizes, the largest generally separated by 20 to 40 stigmata. The smaller ones occur at varying intervals.

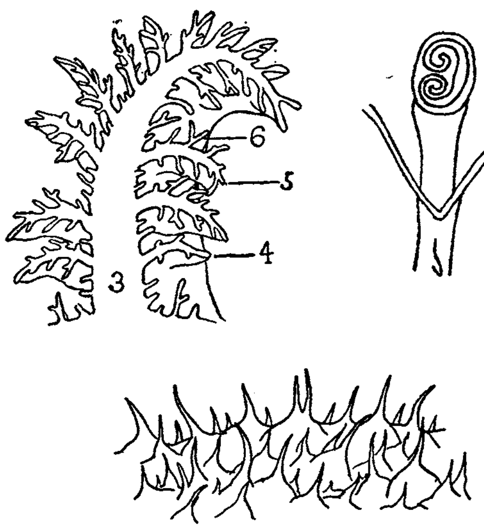


FIG. 235. *Boltenia ovifera* (Linnaeus). One of the third-order branches of a large tentacle, showing fourth-, fifth-, and sixth-order branches; dorsal tubercle, and a small part of the external body surface of a young example to show the minute spines, ×14.

Stomach elongated, tapering, not abruptly distinguished from either the oesophagus or the intestine. It bears a number of lobed hepatic glands. Loop formed by stomach and intestine almost U-shaped, the branches being nearly parallel. Margin of anus with many lobes.

Gonads elongated, somewhat sinuous, with projecting masses or lobes along the sides.

FIG. 236. *Boltenia ovifera* (Linnaeus). Part of branchial sac, ×5.

Ovary central, covered more or less completely by the very numerous small, mostly rounded or pyriform testes, narrowed at the posterior end into a short oviduct which is accompanied by the sperm duct.

The gonad of the left side lies between the branches of the loop formed by the alimentary tract. Egg diameter 0.16 mm., according to Berrill, 1937. (For more details of structure, see Hartmeyer, 1903, 1921a, Ritter, 1913.)

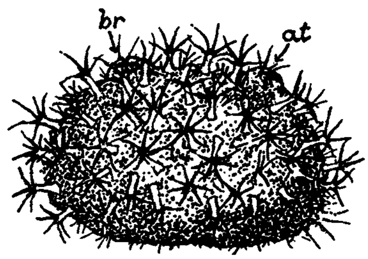


FIG. 237. *Boltenia echinata* (Linnaeus). ×2.2.

DISTRIBUTION: Arctic seas of the Western Hemisphere, including both the east and west coast of Greenland, Bering Sea, Sea of Okhotsk and the vicinity of Wrangel and Herald Islands. On the Atlantic coast of North America it is found much farther south than elsewhere, extending to Cape Cod and Nantucket Shoals. The isolated record of DeKay, 1843, from New York Harbor, and one (an empty test), from the harbor of Providence, Rhode Island, were probably due in some way to human agency. In those latitudes, if it occurred naturally, it would be in the deeper and colder water off the shore, not in harbors. It grows preferably in rocky or other hard bottom, especially in depths from 4 to 50 fathoms (greatest depth recorded, 270 fathoms). Adult specimens are generally found singly, young ones sometimes in small groups. (See especially Hartmeyer, 1923, for details.)

Boltenia echinata (Linnaeus), 1767

Plate 2, figures 2, 3; text figures 237–241

Ascidia echinata LINNAEUS, 1767, p. 1087.

Ascidia hirsuta AGASSIZ, 1850, p. 159.

Boltenia arctica HUNTSMAN, 1912a, p. 163, pl. 13, fig. 5.

Boltenia echinata HUNTSMAN, 1912, p. 133; HARTMEYER, 1915, p. 309; REDIKORZEV, 1916, p. 154, figs. 29–31, pl. 4, fig. 21; HARTMEYER, 1921a, p. 21, figs. 5, 6; 1922a, p. 44; 1923, p. 149, pl. 1, figs. 7, 8; HUNTSMAN, 1922, p. 11; 1922a, p. 13; ÄRNBÄCK, 1928, p. 85, pl. 3, fig. 72; PRATT, 1935, p. 749. Not Ritter, 1907; not Ritter and Forsyth, 1917 = *B. villosa*.

Boltenia hirsuta HUNTSMAN, 1912, p. 147; BERRILL, 1928, p. 162; 1929, pp. 45, 66, etc., fig. 5; 1931, p. 333; 1935, pt. 3, pp. 257, 269.

Cynthia arctica HARTMEYER, 1899a, p. 466, fig. C, pl. 22, fig. 3, pl. 23, figs. 3, 11, 18.

Cynthia echinata STIMPSON, 1854, p. 20; 1860a, p. 2; PACKARD, 1867, p. 277; VERRILL AND SMITH, 1873, pp. 495, 702; PRATT, 1916, p. 667; OKA, 1926a, pp. 559, 561.

Cynthia echinata + *C. hirsuta* BINNEY, 1870, p. 18, pl. 23, fig. 326, pl. 24, fig. 336; DALL, 1870, p. 225.

Halocynthia arctica HARTMEYER, 1903, pp. 190, 373, pl. 11, figs. 10, 11.

Halocynthia echinata VERRILL, 1879, p. 27; WHITEAVES, 1901, p. 268; RITTER, 1913, p. 452; SUMNER, OSBURN, AND COLE, 1913, p. 730.

Microcosmus echinatus TRAUSTEDT, 1883, p. 120.

Pyura arctica HARTMEYER, 1909–1911, p. 1339.

Pyura echinata HARTMEYER, 1910, p. 231, pl. 8; 1910a, p. 233; VAN NAME, 1912, p. 523, fig. 23, pl. 54, figs. 61–65, pl. 70, figs. 143, 144; PROCTER, 1933, p. 283.

See Hartmeyer, 1923, for nearly complete list of references.

Body of elliptical outline when seen from one side, the anteroposterior diameter exceeding the others. Attachment usually by a comparatively small area on the ventral surface; body often slightly compressed in a dorsoventral direction. Apertures four-lobed; in contraction they form small conical papillae on the dorsal surface of the body, rather widely separated. The body surface is rough and also bears numerous and very character-

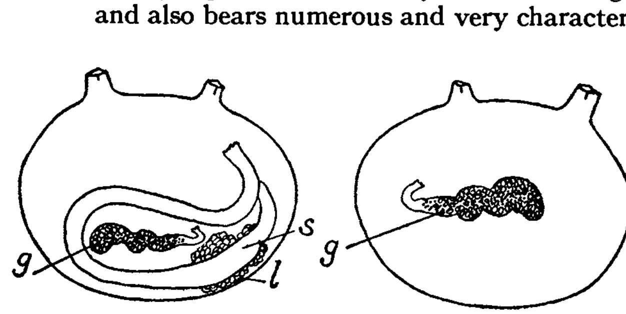


FIG. 238. *Boltenia echinata* (Linnaeus). Left and right sides of body, ×3.

istic large, flexible, spinous processes, giving the animal a cactus-like appearance which at once serves to distinguish the species from all other ascidians of the New England region. Each process has the form of a stout tapering column, at the summit of which an irregular circle of tapering branches, usually four to eight in number, arises. Some of the branches may fork once. One of them may have an axial position, continuing the column, the others extending out radially or obliquely, or all may be radial or oblique. Both the main stem and these branches are studded with slender, hair-like spines of varying length. These spinous processes exceed the siphons in length in the contracted specimens.

Not only does this species attain a much larger size in the Arctic regions, sometimes reaching 35 mm. or even more in greatest diameter, than in the southern parts of its range where 6 mm. to 15 mm. is not usually exceeded, but the spinous processes are better developed in Arctic specimens, and they are more likely to have a stout central or axial branch beyond the point where the lateral branches arise, while in those from southern latitudes the process may be resolved entirely into the laterally or obliquely extending branches. This difference does not, however, always hold good; in fact both kinds may occur on the same individual (see fig. 239).

Color usually deep salmon, often more or less tinged with pink or flesh color, and sometimes of a delicate flesh color throughout. The apertures are red, often bright red with a lighter red ring; the tubes frequently have eight alternate light and deep red longitudinal stripes extending from the edge to the base of the tubes, or four light stripes extending

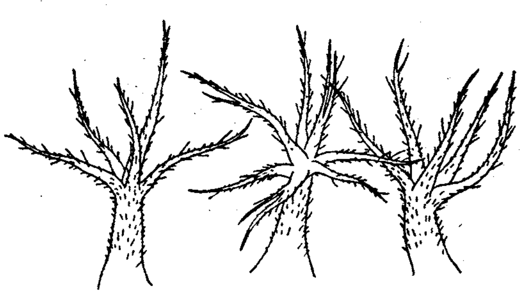


FIG. 239. *Boltenia echinata* (Linnaeus). Spinous processes of body (all from one individual), × about 6.

from the angles of the apertures down their sides.

Test of moderate thickness and very tough. Mantle very thin and generally closely adherent to the test. Musculature not greatly developed. About the origin of the siphons the radial and circular muscles form distinct, though rather narrow bands.

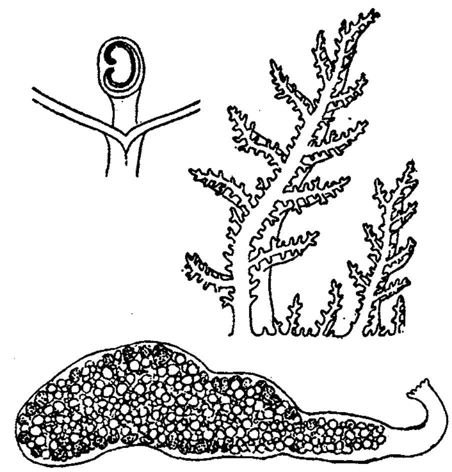


FIG. 240. *Boltenia echinata* (Linnaeus). Enlarged details: dorsal tubercle, tentacles of different sizes or orders, and gonad (seen from side next to mantle).

Tentacles of four or five orders, arranged with some degree of regularity; the largest (usually about six in number) extensively branched in an irregularly pinnate manner. Smallest tentacles merely small simple papillae. Dorsal lamina broken up into a series of long, narrow, tapering languets. Dorsal tubercle aperture C-shaped with irregularly incurved horns; open interval to the right.

Branchial sac with six to eight folds on each side, two of them, the second and the last, often rudimentary and represented chiefly by a few closely grouped internal longitudinal vessels. Transverse vessels few, of different sizes, but not regularly arranged. Stigmata placed (except as noted below) with their long diameter transverse to the body axis, forming regular longitudinal rows separated by longitudinal vessels not to be confounded with the internal longitudinal vessels which are also present. On the flat parts of the sac the stigmata are moderately long and narrow; they become shorter and the longitudinal rows of them closer together as the summit of a fold is approached. On most of the intervals between folds, one of the longitudinal vessels separating rows of stigmata is wider than the others and is pierced by a few longitudinally placed stigmata.

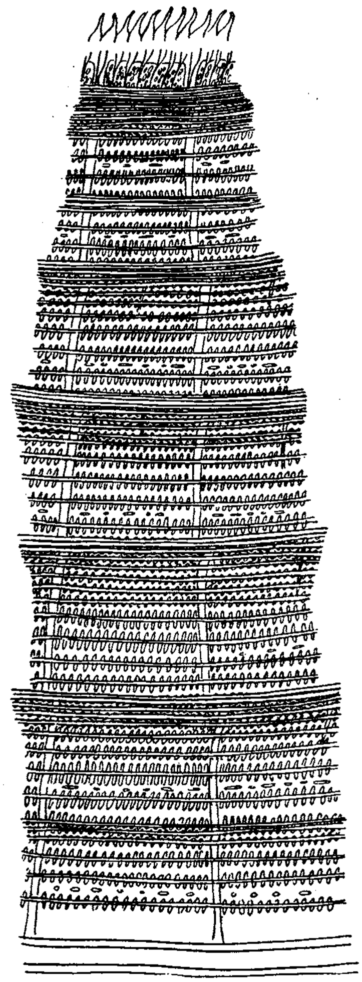


FIG. 241. *Boltenia echinata* (Linnaeus). Part of branchial sac, ×12.

Internal longitudinal vessels generally corresponding in number to the longitudinal rows of stigmata; one vessel crossing all the stigmata of a given row. At the summit of the folds, however, the vessels become more numerous than the rows of stigmata. Their distribution in several moderately large specimens was about as follows:

1 (18) 2 (5) 4 (14) 5 (16) 5 (16) 5 (10) 2 (3) 3

Digestive tract forming a widely open loop. Stomach elongated, thin walled, but having on the side toward the branchial sac a large hepatic gland composed of many small, short, blunt-ended caeca. Margin of anus lobed.

One elongate, sinuous, irregularly lobed, longitudinally placed gonad on each side of the body, that of the left side lying entirely within the intestinal loop. The posterior end of each gonad is produced into a short recurved oviduct ending in a somewhat enlarged aperture with a lobed margin and accompanied by the sperm duct. Egg diameter 0.18 mm., according to Berrill, 1937. In most specimens the peribranchial cavities contain numerous tailed larvae.

DISTRIBUTION: A circumpolar species, widely distributed and common, which reaches its largest size in the Arctic regions, but ranges south to Denmark and the Irish Sea in Europe and to Georges Bank, Martha's Vineyard, Massachusetts, and Block Island, Rhode Island, on the New England coast, though rare south of Cape Cod. On the American Pacific coast the most southern record is Departure Bay, British Columbia (Huntsman, 1912a); on the Asiatic side it reaches northern Japan. It is found in rather shallow water attached to stones or other solid objects, the majority of the records being between low-water mark and 50 fathoms. The greatest reported depth is 162 fathoms. See Hartmeyer (1923, p. 160) for further details.

Though different generic names were used, this species has most often appeared in literature under the Linnaean specific name *echinata*, one that its appearance naturally suggests. Owing to errors in certain published descriptions leading to a belief that there were two species, an Arctic and a boreal one, Hartmeyer (1903) gave the name *arctica* to the supposed northern form. In 1910, Hartmeyer showed that this was incorrect and restored *echinata* as the name for the whole species. Because of the structure of its branchial sac it is now placed in the genus *Boltenia*. I cannot follow Huntsman, 1912, and Berrill in recognizing the eastern American form as distinct under the name *B. hirsuta* Agassiz.

Boltenia villosa (Stimpson), 1864

Text figure 242

Boltenia echinata (not Linnaeus, 1767) RITTER, 1907, p. 14, pl. 2, figs. 17–19; RITTER AND FORSYTH, 1917, p. 440.

Boltenia villosa HUNTSMAN, 1912, pp. 114, 115, 134; 1912a, p. 166, pl. 13, figs. 2–4, pl. 20, figs. 4–6; ÄRNBÄCK, 1928, p. 88; PRATT, 1935, p. 750; WISMER AND SWANSON, 1935, p. 341.

Cynthia castaneiformis VON DRASCHE, 1884, p. 373, pl. 3, figs. 9, 10; TRAUSTEDT, 1885, p. 31; RITTER, 1900, p. 599, pl. 18, figs. 6, 7, pl. 19, fig. 25; PRATT, 1916, p. 666.

Cynthia villosa STIMPSON, 1864, p. 160; HERDMAN, 1898, p. 258, pl. 12, figs. 7–11; ? RITTER, 1901, p. 238; OKA, 1926a, p. 561.

Halocynthia castaneiformis RITTER, 1913, p. 455.

Halocynthia villosa RITTER, 1907, pp. 12, 13; 1913, p. 454.

Pyura aculeata + *P. castaneiformis* + *P. echinata* (in part) + *P. villosa* HARTMEYER, 1909–1911, pp. 1339, 1342.

"External Features: Rounded or oblong. Apertures on dorsal surface, distant from each other, Siphons short, conical; atrial straight, projecting upwards and slightly backwards, oral curved so that aperture is directed forward. Attachment by a stalk, which varies from extremely short to three or four times the length of the body. It arises either from the middle of the ventral surface, from the anterior end of ventral surface, or from intermediate points. Individuals with long stalks usually have the stalk parallel to a line joining apertures and arising from the anterior end. In this case the relations of the parts are the same as in the type of the genus *B. ovifera*.

"Surface covered with spines which extend over the stalk. Each spine arises from a more or less distinct tubercle of the test. The spines may be few or many, coarse or fine, simple or with small lateral branches. In a few specimens they are reduced so much that only the tubercles appear on a hasty examination.

"Colour reddish orange, most distinct near apertures, which may be rayed with deep red. On the body the colour is often masked by foreign material" (Huntsman, 1912a, p. 166).

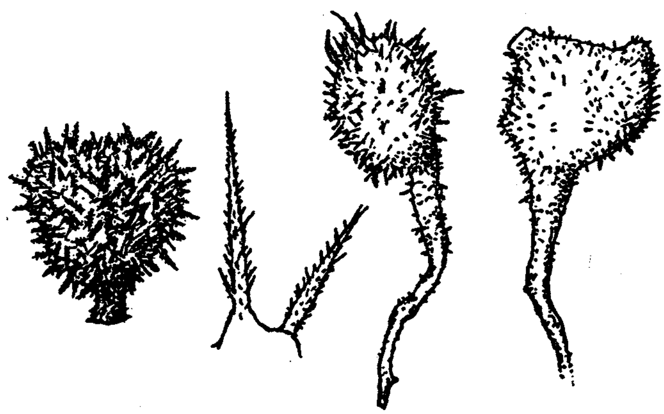


FIG. 242. *Boltenia villosa* (Stimpson). Three individuals, all somewhat enlarged, the two right-hand examples after Huntsman. Also, two large spinous processes of the body surface, ×5.

Five specimens ranged from 12 mm. to 30 mm. in greatest (anteroposterior) body diameter; the stalk from 15 mm. to 40 mm., longest in the smallest specimens.

The internal structure corresponds closely to that of *B. echinata*. Huntsman gives the tentacles as 20 to 35, of several sizes, simple to slightly tripinnate. The folds of the branchial sac number from six to eight, depending on the size of the individual. There may be a ninth fold, according to Ritter.

"*B. villosa* always possesses a stalk, although it may be very short. The siphons are tubular and the oral is bent forward. The spines are never very long nor have they long lateral branches. The anus is not lobed, or only imperfectly. *B. arctica* [=*B. echinata* of this work], on the other hand, is without a stalk, its siphons are square, very short and straight; the spines are always long and with long branches; the colour is not as bright as in *B. villosa* and the anus is distinctly lobed. . . . The number of folds cannot be used to distinguish them from each other" (Huntsman, 1912a, pp. 167–168).

DISTRIBUTION: This is a species of the

American Pacific coast which appears to replace *B. echinata* south of the Puget Sound region. It ranges from near San Diego northward, overlapping the range of *B. echinata* on the British Columbia coast where, according to Huntsman, it is common or abundant. Most northerly reliable record, Prince Rupert, British Columbia. The record from Yakutat Bay, Alaska, given by Ritter, 1901, though accepted without comment by Huntsman, 1912a, might apply to *B. echinata*. Recorded from low-water mark to 48 fathoms.

GENUS **HARTMEYERIA** RITTER, 1913

This is a small genus related to *Microcosmus*, from which it differs in having the wall of the branchial sac raised into conical elevations or "infundibula" separated by the transverse vessels of the sac as in the Molgulidae. The summits of the infundibula, with the internal longitudinal vessels which cross them, form the ridge or free edge of the folds. The stigmata, which are straight or only slightly curved on most parts of the sac, become spirally arranged on the summits of the infundibula as in that family.

Hartmeyeria triangularis Ritter, 1913

Hartmeyeria triangularis RITTER, 1913, p. 461, pl. 33, figs. 8–12; HARTMEYER, 1922b, pp. 310, 313; 1923, p. 184; ÄRNBÄCK, 1928, p. 89; OKA, 1929, p. 351.

Microcosmus triangularis MICHAELSEN, 1919b, p. 55.

"Superficial Characteristics: Body inclined to a triangular form, the two orifices marking the basal angles, and the peduncle the third angle; somewhat compressed laterally; the whole surface, excepting the siphons, covered with a layer of black, closely adhering sand grains. Test on the rather prominent siphons usually presenting a series of regular, parallel, closely set ridges or folds, these with the light color of the test in this region as opposed to the covering of the black sand, setting the siphons off conspicuously from the rest of the body. Greatest diameter of largest specimen, 14 mm. Length of the longest peduncle seen, 35 mm. Thickness of peduncle uniform and scarcely more than 1 mm. in the thickest part, possessing a well-defined coating of test to which the sand adheres as it does on the body" (Ritter, 1913, p. 461).

Mantle musculature composed of thin, regularly spaced radial and circular bands forming a network. Both apertures four-lobed.

Oral tentacles branched, 20 to 35 in number, of different sizes irregularly arranged. There are also atrial tentacles, 16 in number, slender and unbranched, forming a circle within the atrial orifice. Dorsal lamina a plain narrow ridge.

The branchial sac has six folds, on each side of which the second and sometimes the last are reduced, and may bear but a single internal longitudinal vessel. These vessels are confined to the folds. The larger transverse vessels separate the series of stigmata, which are crossed by narrow transverse (parastigmatic) vessels.

The description of the branchial sac given by Ritter is not altogether satisfactory as he makes no mention of the infundibula, though they are indicated in his figure 10. Hartmeyer, 1921b, also examined a specimen of this species in connection with his study of another species of the genus (*H. monarchica* from the Gulf of Aden) and gives the arrangement of the vessels as follows:

0 (7) 0 (1) 0 (7) 0 (5) 0 (3) 0

According to Hartmeyer, a large infundibulum is situated on each fold between each pair of large transverse vessels. The infundibula divide near the top into two smaller ones separated by a smaller (or second order) transverse vessel. This structure of the sac is like that usual in the genus *Molgula*. Stigmata nearly straight on the flat parts of the sac between folds, becoming curved and spirally arranged on the infundibula.

The alimentary tract forms a longitudinal loop whose branches are not in contact. The stomach is elongate pear shaped and tapers off into the intestine. It bears many finger-like hepatic tubes.

One compact oval or elongate hermaphroditic gonad on each side of the body, that on the left side lying partly within (between the branches of) the intestinal loop and crossing the dorsal branch of it as usual in *Microcosmus*. Each gonad consists of a central ovary surrounded or bordered by the numerous small, pear-shaped, or lobed testes.

LOCALITY: Known only from about two dozen specimens taken by W. H. Dall in 9 to 12 fathoms at Kiska Harbor, Aleutian Islands, Alaska. Type, U.S.N.M. No. 5679 (Ritter, 1913, p. 463).

Hartmeyeria orientalis Oka, 1929, from the south part of Sakhalin Island seems to be close to this species and may have to be united with it.

GENUS **HALOCYNTHIA** VERRILL, 1879
(*Nomen conservandum* for *Tethyum* Bohadsch, 1761)

This name was proposed by Verrill, 1879, as a substitute for *Cynthia*, then in common use, which was preoccupied by a genus of Lepidoptera. It is now used in a restricted sense for a small group of species which differ from the typical *Pyura* in the arrangement of the gonads. There are ordinarily several small tubular gonads on each side placed anteroposteriorly parallel to each other, those on the left side only partly within the intestinal loop, their distal ends lying across the intestine (see fig. 243). The body surface is covered with spine-bearing papillae, though the spines may be so minute as merely to give the surface a velvety appearance. Its species are also peculiar in that the hepatic gland of the stomach wall is composed of longitudinal plications on the proximal part of the stomach near the entrance of the oesophagus, but of a mass of short round-ended secreting tubules on the main part of the stomach. The gland is mainly confined to the aspect of the stomach toward the branchial sac. Dorsal lamina represented by a row of languets; one or two incomplete rows of small languets commonly present to the right of the principal row in the posterior part of the body.

Halocynthia pyriformis (Rathke), 1806
"SEA PEACH"

Plate 5, figure 2; text figures 243–245

Ascidia pyriformis RATHKE, *in* Mueller, 1806, vol. 4, p. 41, pl. 156, figs. 1, 2.

Cynthia papillosa (in part) TRAUSTEDT, 1880, p. 407. Not Gunnerus, 1675.

Cynthia pyriformis STIMPSON, 1854, p. 20; 1860a, p. 1; PACKARD, 1863, p. 412; BINNEY, 1870, p. 17, pl. 23, figs. 320, 321; DALL, 1870, p. 255; MORSE, 1871, p. 352; DALL, 1872, p. 157; METCALF, 1900, p. 510; HARTMEYER, 1915, p. 313.

Halocynthia aurantium (in part) HARTMEYER, 1903, p. 195; MICHAELSEN, 1919b, p. 11, fig. 2a–2c; HARANT, 1929, p. 66.

Halocynthia pyriformis VERRILL, 1879, p. 27; WHITEAVES, 1901, p. 268; MICHAELSEN, 1919b, p. 11, fig. 2; HARTMEYER, 1920, p. 127; 1921a, p. 30; 1923, p. 163; ÄRNBÄCK, 1927, p. 33; PRATT, 1935, p. 748.

Pyura aurantium (in part) HARTMEYER, 1909–1911, p. 1339; VAN NAME, 1912, p. 532, fig. 25, pl. 55, fig. 67, pl. 56, figs. 71–84, pl. 67, fig. 134.

Pyura pectinicola MICHAELSEN, 1908, p. 262, pl. 2, figs. 16–19; HARTMEYER, 1909–1911, p. 1341.

Pyura pyriformis PROCTER, 1933, p. 284.

Tethyum aurantium (in part) REDIKORZEV, 1916, p. 169, figs. 32–35, pl. 4, fig. 22.

Tethyum microspinosum VAN NAME, 1921, p. 443, figs. 107–111.

Tethyum pyriforme HARTMEYER, 1914b, p. 1103; BERRILL, 1935, pt. 3, p. 257.

Tethyum pyriforme americanum HUNTSMAN, 1912, pp. 112, 148; BERRILL, 1929, pp. 46, 48, fig. 6; 1935, pt. 3, p. 269.

See also under *H. aurantium* below.

This is closely related to the next species, *H. aurantium* (Pallas), 1787, and has been treated as identical with it in many works, though not in most of the more recent ones. If the two forms are considered as constituting one species, or if *pyriformis* is reduced to the status of a subspecies, the species name must be *aurantium* on account of priority.

Body stout and generally of rather regular more or less egg-shaped, barrel-shaped, or pear-shaped form, attached by the smaller end. Siphons generally short and stout, like

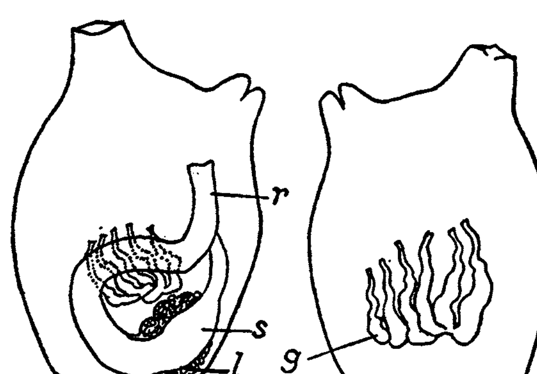


FIG. 243. *Halocynthia pyriformis* (Rathke). Left and right sides of the body, ×2.4.

large papillae, the branchial (the larger) being almost terminal in position, the atrial on the dorsal surface, more or less oblique in direction, and removed a varying distance from the branchial siphon. Elongated clavate specimens attached by a narrow base also occasionally occur. Both apertures generally four-lobed, but in the case of the atrial, two pairs of these lobes are often almost fused,

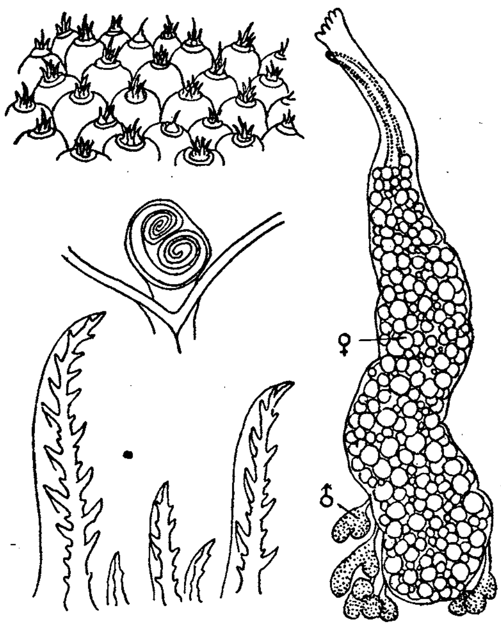


FIG. 244. *Halocynthia pyriformis* (Rathke). Small part of the body surface, showing the minute spines, dorsal tubercle, tentacles, and gonad, ×20.

so that the aperture has the form of a transverse cleft. One specimen with a five-lobed branchial aperture was found. Test thin but tough and leathery. External surface of the body usually smooth and even, often nearly free from wrinkles even in preserved specimens, sometimes slightly wrinkled with shallow circularly disposed furrows. It has, however, a granular appearance and feeling, like fine sandpaper, due to very minute short stiff spines abundantly distributed over the surface, singly or in small groups of from two to six or even more, each single spine or each group being raised on a small rounded elevation. On some specimens single spines, on others groups predominate. About the orifices the spines are longer but rarely sufficiently so as to be very conspicuous. The spines do not branch but (especially in the case of the larger ones) there may be slightly projecting points along the sides or at the base.

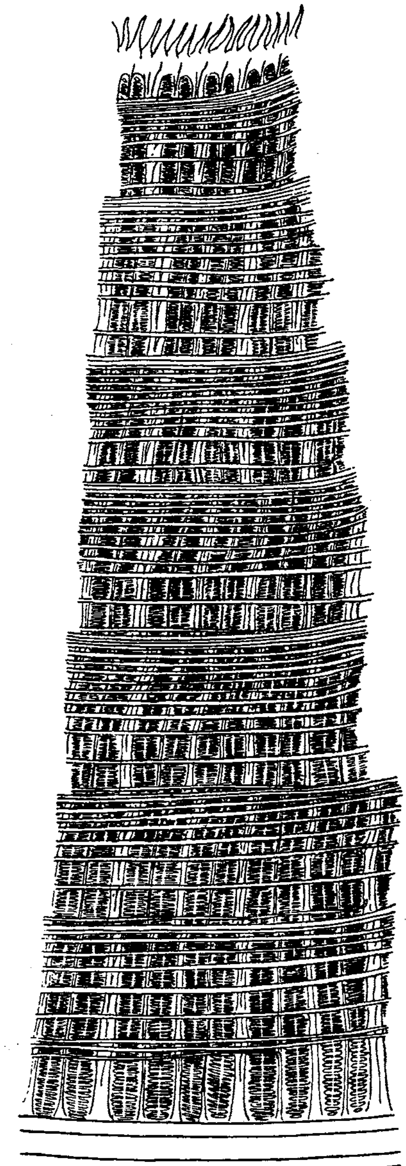


FIG. 245. *Halocynthia pyriformis* (Rathke). Part of branchial sac, ×8.

"Color generally yellowish white, more or less tinged on the upper part and one side with peach-red; frequently yellowish white throughout, or merely tinged with orange in certain parts, especially between the tubes. Not unfrequently the color is deep orange-red or peach-red over most of the surface, except the lower part of the sides, which are flesh-color or salmon-color, and a band of light orange bordered with darker orange-red, which passes from each tube down the sides to the base; a similar band or spot generally exists between the bases of the tubes. The apertures are salmon-color inside, often surrounded by a delicate circle of red, or in the darker specimens with a pale orange circle" (Verrill, 1871, pp. 97–98).

It reaches a large size. Hartmeyer reports one from Davis Strait 130 mm. in anteroposterior length, but half that length is the usual maximum, and in many places 30 mm. to 40 mm. appears to be seldom exceeded. Mantle usually easily separable from the test in preserved specimens, the muscles forming virtually continuous sheets over the whole body.

Oral tentacles about 20 to 30, of several sizes, even the largest usually only about twice pinnate. Dorsal tubercle aperture C-shaped, the open interval forward or obliquely directed, the horns often spirally inrolled.

Branchial sac with eight or nine folds on each side, mostly quite high, with rather numerous internal longitudinal vessels, arranged as follows in a specimen of about 35 mm. in height:

2 (16) 3 (18) 4 (22) 4 (24) 4 (22) 4 (14) 3 (10) 2 (3) 1

Eight to 12 stigmata usually intervene between these vessels on the flat parts of the sac.

Stomach rather short and wide, its wall with longitudinal glandular folds on the proximal part near the entrance of the oesophagus, but with a large hepatic gland of short tubular or rounded diverticula on the main part of the stomach, chiefly on the aspect toward the branchial sac; intestinal loop short and rather wide.

Gonads elongate, flask-shaped, or tubular, more or less sinuously curved, ending in a short oviduct at the anterior end. They vary in number, generally four to seven on a side, the right side usually having more than the left. In contracted preserved specimens they often appear to be more or less fused together at the blind (ventral) end, sometimes apparently forming a single branching mass, but an oviduct can be distinguished at the free end of most, if not all, of the branches, so that it seems questionable if much actual fusion takes place. On the left side the intestine passes between the oviducts and the mantle. In the specimens examined the ovaries were very well developed and occupied most of the gonad, the testes being few and visible only at the posterior end of the ovary where they spread out irregularly beyond the border of the latter. Their ducts, however, appeared to unite, and running along the ovary, to open on a papilla at one side of the oviduct, as in many other ascidians. Egg diameter 0.26 mm., according to Berrill, 1937. For more details of the anatomy, see Ritter, 1913 (pp. 448–452).

Distribution: Ellesmere Land (one record), Davis Strait, and southward to Massachusetts Bay though not common along the coast south of eastern Maine. A specimen washed up on the beach at Duxbury, Massachusetts, is the most southern record I have. In the Eastern Hemisphere it is known from Barents Sea, the Murman coast, and Spitzbergen, southern Iceland, etc., the Faeroe Islands and Bergen, Norway (one record), being the southern limits. It is not a characteristic species of high latitudes nor is it, as yet at least, known to be circumpolar, but it has a closely related, if really distinct, Pacific representative (*H. aurantium*).

It prefers hard bottoms and is most commonly found in depths of 4 to 50 fathoms, though occasionally found from low-water mark to over 100 fathoms.

Tethyum microspinosum Van Name (1921, p. 443, figs. 107–111) was described from a single specimen in the American Museum of Natural History (A.M.N.H. No. 305) supposed to be from Andros Island, Bahamas. Its most important character distinguishing it from others of the present genus is in lacking gonads entirely on the right side, though there are five well-developed ones situated as usual on the left side. No such species has since been found anywhere in the West Indian region, and I now believe that the specimen is an abnormal one of *H. pyriformis* which had been placed with the Bahaman material by mistake. In this connection it may be mentioned that Michaelsen (1919B, p. 20) records a specimen of the nearly related Red Sea species *H. spinosa* which also lacked the gonads normally present on the right side.

Halocynthia aurantium (Pallas), 1787

Plate 31, figure 1

Ascidia aurantium PALLAS, 1787, p. 240, pl. 7, fig. 38.

Cynthia pyriformis TRAUSTEDT, 1885 (in part), p. 34.

Cynthia superba PRATT, 1916, p. 667.

Cynthia superba + *C. deani* RITTER, 1900, p. 590, pl. 18, fig. 1, pl. 19, figs. 16–18, pl. 20, fig. 19, p. 592, pl. 18, figs. 2, 3, pl. 19, figs. 21–23.

Halocynthia aurantium RITTER, 1913, p. 448; HARTMEYER, 1921a, pp. 30, 33; 1923, p. 171; ÄRNBÄCK, 1927, p. 84; PRATT, 1935, p. 748.

Halocynthia aurantium (in part) + *H. a.* form *koreana* HARTMEYER, 1903, pp. 195, 200.

Halocynthia aurantium + *H. superba* MICHAELSEN, 1919b, p. 11, figs. 1a–1d, 3a–3c.

Halocynthia superba OKA, 1906, p. 41.

Halocynthia superba + *H. deani* HARTMEYER, 1903, p. 200.

Tethyum aurantium HUNTSMAN, 1912, pp. 114, 115, 136; 1912a, p. 173, pl. 13, fig. 8, pl. 21, fig. 3; REDIKORZEV, 1916 (in part), p. 169, figs. 32–35, pl. 4, fig. 22.

This is the Pacific representative of *H. pyriformis*.

Huntsman, 1912, 1912a, and Ritter, 1913, who had numerous examples of both forms for study, treated this form as distinct from the Atlantic *H. pyriformis*. *H. aurantium* is said to differ in having, first, a smaller number of gonads, only three in each side according to Huntsman (total number, six) or a total of four to eight, according to Ritter, as compared to a total of about 12 or often more in *H. pyriformis;* second, a greater tendency of the minute spines of the body surface to be arranged in small circular groups instead of singly; and, third, the body in *H. aurantium* averaging longer in proportion to its breadth. For detailed comparison, see Ritter, 1913. The Pacific form also reaches somewhat greater dimensions, Ritter reporting one (under the name *superba*) 150 mm. long from Puget Sound. The constancy and definiteness of the distinctions between the two species are certainly not so convincing as might be desired.

DISTRIBUTION: In the Arctic Ocean it is known only from points comparatively near Bering Strait. It inhabits Bering Sea, ranging south on the American side to Puget Sound and on the Asiatic side to northern Japan and Korea. Its usual range in depth is from about 5 to 50 fathoms. Type locality, the Kurile Islands.

Halocynthia igaboja Oka, 1906

? *Cynthia hilgendorfi* TRAUSTEDT, 1885, p. 36, pl. 4, figs. 30–33; OKA, 1935, p. 436, fig. 6.

Halocynthia igaboja OKA, 1906, p. 45.

Halocynthia okai RITTER, 1907, p. 11, pl. 1, figs. 9–16; RITTER AND FORSYTH, 1917, p. 441.

? *Halocynthia owstoni* OKA, 1906, p. 42.

? *Halocynthia ritteri* OKA, 1906, p. 43 (syn. of *hilgendorfi*, according to Oka, 1935).

Pyura okai HARTMEYER, 1909–1911, p. 134.

Tethyum igaboja HUNTSMAN, 1912, pp. 114, 115, 136; 1921a, p. 177, pl. 13, fig. 7, pl. 21, figs. 4–6.

This is one of the largest of the American simple ascidians, and the apparent size of its body is increased by its covering of long spines. The body is of oval or elliptical outline directly attached by the posterior end, which is usually the smaller end, without any pedicel. Large specimens reach 80 to 100 mm. in anteroposterior, and 45 to 60 mm. in transverse, diameter. Branchial aperture terminal, the atrial on the dorsal side sometimes as much as one-third or one-half the length of the body back. In contracted preserved specimens the apertures are often hard to find among the spines covering the body but can doubtless be more or less protruded on papillae or tubes in living specimens.

The body surface is commonly almost completely covered with straight, tapering, thorn-like spines, some of them 10 or even 12 mm. long with short, usually recurved branches arising from their sides and usually also a circle of small radiating or obliquely extending straight sharp branches at their tip. Between them there are many short, minute, more or less branched spines on the body surface.

Color red, reddish, or orange about the apertures during life. On other parts of the body the color is more or less obscured by the brownish spines and the mud and other foreign material that adhere to them.

The internal structure conforms quite closely to the type of *H. pyriformis*. The mantle is rather thin and semi-transparent. Though no part is free from slender transverse or oblique muscle bands, by far the most conspicuous feature of its musculature is the large number of strong bands extending nearly the whole length of the body from the bases of the siphons and crossing each other obliquely on sides in a network with oblique meshes.

The tentacles vary in size and number and are irregular in arrangement. The number has been stated as from 12 to 50; the latter figure given by Huntsman, 1913a, applied to a very large individual and evidently included small and medium-sized tentacles as well as the larger ones. The latter are usually tripinnate.

The dorsal tubercle is horseshoe shaped and very prominent, its opening directly or obliquely forward, and has its horns strongly inrolled in large specimens.

The branchial sac usually has nine to 10 folds on each side and sometimes a poorly developed eleventh fold on one or both sides. In the dorsal part of the sac the folds may bear 20 or more internal longitudinal vessels. Usually only one vessel on each interval between folds. The following is a typical example:

0 (16) 1 (18) 1 (22) 1 (19) 1 (18) 1 (18) 1 (14) 1 (11) 1 (7) 1 (3) 0 (1) 0

The alimentary tract resembles that of *H. pyriformis*. The gonads are likewise similar, and on the left side of the body their anterior ends lie across the internal aspect of the intestinal loop as in that species. Their number is very variable; Huntsman gives two to 16 on the right side and five to 14 on the left side (usually more on the left). They consist of a curved tubular ovary, overlapped and bordered by the numerous single testes which also spread out considerably over the surface of the testes and inner aspect of the mantle in the vicinity of the ovary of the gonad of which they are a part.

DISTRIBUTION: Described by Oka from Otaru, Hokkaido Island, Japan. On the American coast it has been reported from Prince Rupert, Ucluelet, and Departure Bay, British Columbia (Huntsman); Puget Sound (Ritter); off Point Pinos Light, Monterey Bay, California (Ritter), and seems to be fairly common in the waters about Santa Catalina Island, California, in depths of about 10 to 40 fathoms or more. In this region it usually has specimens of a brachiopod growing upon it, attached among the spines by their pedicel.

Its usual range in depth is given as 10 to 30 fathoms on shelly or gravelly bottoms. The United States National Museum has a specimen from off Newport, Oregon, in 90 fathoms.

As indicated in the list of synonyms given above, there have been three other specimens of *Halocynthia* described from Japanese waters much like *H. igaboja* in their large size, their internal structure, and in bearing spines similar in character, at least on some parts of the body. All three of these names have priority or page precedence over *H. igaboja*. *Cynthia hilgendorfi* Traustedt, the earliest, was based on several specimens, the largest 40 mm. long, from "Hakodadi" (doubtless Hakodata on Hokkaido Island, the same island from which *H. igaboja* and *owstoni* were described by Oka). Oka comments on the close relationship of *owstoni* and *ritteri* to Traustedt's *hilgendorfi*, and we can hardly doubt the identity of those three. The question is whether *igaboja* must likewise be united with *hilgendorfi*. The specimens (at least two in number or perhaps more) that were the basis of Traustedt's description had long, crooked siphons upon which most of the longer spines were borne. Therefore, their external appearance was quite different from the American specimens in which the body is usually completely spinous and the siphons do not project at all (at least in the contracted preserved specimens), yet Oka's *owstoni* amd *ritteri*, having short tubes, bridge over this difference, and it seems possible that *hilgendorfi* may eventually have to be accepted as the name for all these forms.

GENUS CULEOLUS HERDMAN, 1881

Body more or less egg shaped or pyramidal and attached by a very long slender stalk, much more slender and flexible that that of *Boltenia ovifera*, arising from the smaller anterior end. Apertures large, rounded, or cleft-like, both dorsally situated. Branchial sac reduced to a framework of transverse and internal longitudinal vessels, the resulting meshes not divided into stigmata by interstigmatic vessels. Dorsal lamina reduced to a series of languets. Reproductive organs consisting of one or more hermaphroditic gonads on each side of the body.

Minute calcareous or more or less siliceous spicules of irregular branching form, with

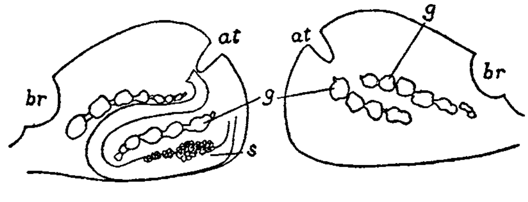


FIG. 246. *Culeolus suhmi* Herdman. Left and right sides of body of a large specimen, about one-half natural size.

points suggestive of those of stag's antlers, are generally present in the tissues of the tentacles, branchial vessels, and endostyle.

This is a deep-sea genus of wide distribution which has, however, been found in water

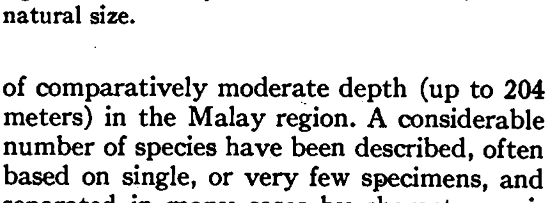


FIG. 247. *Culeolus suhmi* Herdman. Left and right sides of body of a small individual, about natural size.

of comparatively moderate depth (up to 204 meters) in the Malay region. A considerable number of species have been described, often based on single, or very few specimens, and separated in many cases by characters evidently well within the limits of individual variation. Deep-sea animals are often of extremely wide geographical range, and we can hardly doubt that many of the supposed species will eventually have to be united, several of them probably under the name of Herdman's type species *Culeolus murrayi* obtained by the "Challenger" expedition east of Japan (35°41′N., 157°42′E. in 2300 fathoms, red clay). With the insufficient information now available, it seems premature to take such a step with regard to any of the three species reported from near the American coasts.

Culeolus suhmi Herdman, 1881

Text figures 246–250

Culeolus perlatus HERDMAN, 1882, p. 115, pl. 11, figs. 8, 9, pl. 13, figs. 1, 2; MICHAELSEN, 1904a, p. 183.

Culeolus suhmi HERDMAN, 1881, p. 86; VAN NAME, 1912, p. 540, figs. 27–28, pl. 56, figs. 78–81, pl. 57, fig. 83; HARTMEYER, 1912b, pp. 374, 378; ÄRNBÄCK, 1928, p. 93.

Culeolus tanneri VERRILL, 1885, p. 529, pl. 31, figs. 144, 145; 1885a, p. 447.

The body is between ovate and pyramidal in form, narrowing anteriorly into the very long, narrow cylindrical, flexible stalk, whose distal end breaks up into a tuft of rootlets. The body is more or less distinctly and abruptly truncate behind. The rounded or somewhat triangular oral aperture is near the origin of the stalk. The atrial aperture, situated on the posterior dorsal part of the body, has the form of a transverse slit. Usually neither aperature is prominent above the surface.

Test thin, tough, and somewhat translucent, probably even and without folds or wrinkles during life. Its surface is thickly covered with small, low, rounded tubercles, each bearing a minute nipple-like papilla which gives the surface a velvety character. On certain parts, especially about the apertures and along a curved line which arises dorsally at or near the atrial aperture and encircles the more or less truncated rear end of the body, there are pointed papillae with slight lateral projections reaching 1 mm. or more in height. Color in preservation yellowish brown, the stalk and the tips of the papillae darker brown.

Dimensions of three specimens having the stalk complete: (1) body 60 mm. long, 37 mm. deep; stem 165 mm. long and about 1.5 mm. thick; apertures 45 mm. apart; (2) body 24 mm. long, 18 mm. deep; stem 100 mm. long and 0.7 mm. thick; (3) immature, 14 mm. long, 11.5 mm. deep, stem 82 mm. long.

Except for the peculiarity of the branchial sac mentioned above under the genus, the internal structure resembles that of a *Pyura*. The mantle muscles consist of bands forming

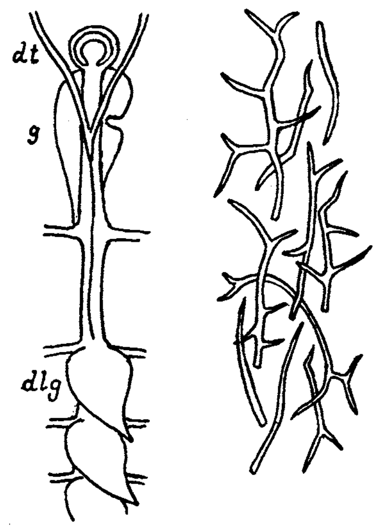


FIG. 248. *Culeolus suhmi* Herdman. Dorsal tubercle with part of dorsal lamina and spicules from the mantle (near the endostyle).

rather open meshes. The branchial sac is extremely delicate, being composed only of rather large transverse vessels and the internal longitudinal vessels, which together form large square or oblong meshes. In adult specimens there are usually six folds on each

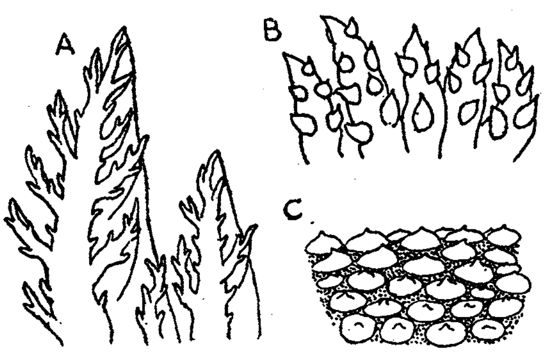


FIG. 249. *Culeolus suhmi* Herdman. A. Tentacles of different sizes, ×8. B. Spinose papillae from the test bordering the branchial aperture, ×10. C. Part of body surface, ×12.

side. The ventral one (in young specimens more than one) may be more or less rudimentary.

In a specimen of 24 mm. body length the internal longitudinal vessels are distributed about as follows:

2 (9) 3 (8) 2 (10) 3 (8) 3 (6) 2 (4) 1

In another one, somewhat larger (42 mm. body length):

Left	3 (9) 3 (8) 4 (11) 2 (6) 1 (3) 1
Right	2 (11) 2 (10) 3 (7) 2 (5) 0 (2) 0

Tentacles numbering about 20 to 30, more orsse lirregular in size and distribution. One

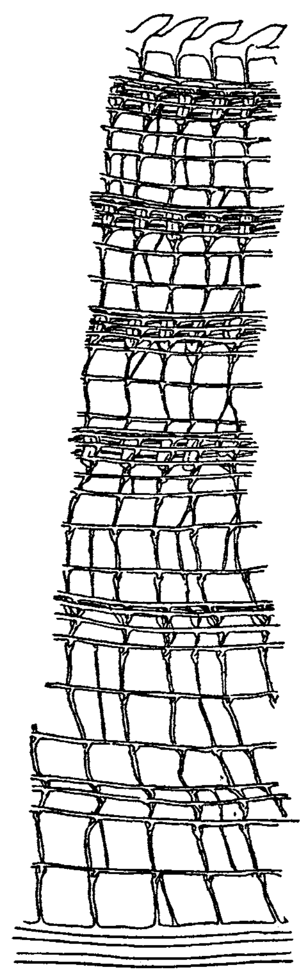


FIG. 250. *Culeolus suhmi* Herdman. Part of branchial sac, × about 7.

or more may be relatively very large. Even the largest are only twice compound and with few branches.

The dorsal tubercle had a simple pit-like aperture in one case; in another it was plainly C-shaped, the open interval to the rear. Dorsal languets large, leaf-like. Spicules in internal organs few.

Stomach elongate, tapering gradually into the intestine which forms a long but open horizontal loop with the short rectum abruptly bent dorsally. The stomach bears groups of short, yellowish, hepatic tubercles. Anal margin lobed or sinuate.

There are two gonads on each side of the body. On the left side one of them lies within the space surrounded by the intestinal loop, the other dorsal to the intestine. In the largest individual the gonads were all greatly elongated and constricted at intervals so as to form a chain of rounded masses, at least six in number, connected like a string of beads. In two other individuals the gonads were only moderately elongated and exhibited but little tendency to constriction into segments, though this is perhaps largely due to their being greatly distended with the sexual products. The ovary occupies the whole length of the organ on the side attached to the mantle, including the constricted portions; the small, usually two- or three-lobed testes are chiefly found in the superficial parts of the enlarged segments.

This location of one of the gonads of the left side dorsal to the intestine was found in three specimens dissected (a fourth specimen was immature and did not have the gonads developed), but its constancy and importance as a specific character need further confirmation, as there is considerable individual variation in the form, number, and location of the gonads in this genus.

LOCALITIES: Specimens were dredged by the United States Fish Commission Steamer "Albatross," at several stations in very deep water (1608 to 2919 fathoms) off the coast of New Jersey and Maryland located between 37° to 40° N. and 68° to 72° W. Verrill's type of *C. tanneri* was from Station 2041, 39° 22′ 50″ N., 68° 25′ W., 1608 fathoms, globigerina ooze. There do not, however, seem to be any sufficient characters separating these specimens from Herdman's *C. suhmi* obtained by the "Challenger" expedition in the same vicinity (37°25′N., 71°40′W., 1700 fathoms). The American Museum has a single specimen from a group of about 25 found on a telegraph cable taken up from 47° 26′ N., 07° 53′ W., 2147 fathoms, near the Spanish coast. Two specimens of this lot which were examined internally corresponded closely with the above description.

Culeolus pyramidalis Ritter, 1907

Text figure 251

Culeolus pyramidalis RITTER, 1907, p. 16, pl. 2, figs. 20, 21; HARTMEYER, 1912b, pp. 374–378.

This form was described by Ritter from three specimens dredged at stations only a few miles apart. He was not sure that the two smaller ones belonged to the same species as the large one on which his description and figures are based.

Externally there seems to be little to differentiate them from *C. suhmi* of the North Atlantic. Body dimensions of type and largest specimen: 25 by 20 by 15 mm., stalk 190 mm. long.

A few branching spicules were found in the vessels of the gill sac and in the tentacles. These, Ritter claims, were not calcareous as they were not affected by acids.

The internal condition of the specimen was evidently in a very damaged condition, making in the case of the branchial sac, "the true structure impossible of determination." The gonads also were "not determined."

Ritter's statement (p. 17) regarding the course of the intestinal loop, that the rectal limb lies ventral to the stomach and runs nearly parallel and close to the endostyle for some distance, would differentiate it not only from other members of the genus but from all the rest of the family also, and is probably to be explained by the intestine's having been torn loose and displaced in relation to the other organs.

LOCALITIES: "Albatross" Stations 4394 (32° 54′ N., 121° 15′ W., 2259 fathoms, soft gray mud) and 4396 (33° 01′ N., 121° 32′ W., 2228 fathoms, red mud) both at the foot of the continental slope west of San Diego, California.

Culeolus sluiteri Ritter, 1913

Culeolus sluiteri RITTER, 1913, p. 463, pl. 34, figs. 14–17; ÄRNBÄCK, 1928, p. 93.

Based on a single specimen of large size, 65 mm. body length, with a stalk 110 mm. long, though broken off at the lower end. The body is truncated behind and is described as "covered with low broad mounds each of which

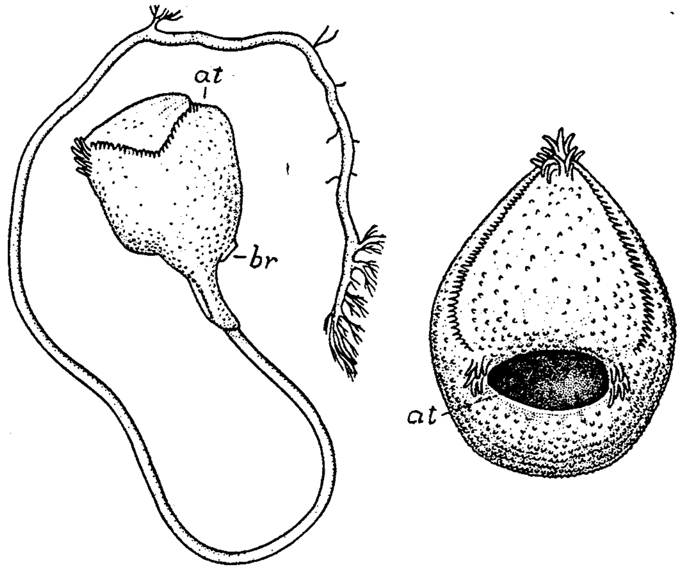


FIG. 251. *Culeolus pyramidalis* Ritter. Entire animal, ×1.5; also dorsal surface of body showing atrial aperture, ×3. After Ritter.

bears at its summit a wartlike brownish knob."

The tentacles number 33, varying in size from "almost minute with a few small branches to large with many branches bearing numerous secondary branches."

Dorsal tubercle not described. Branchial sac with five prominent folds on each side, with the internal longitudinal vessels arranged as follows:

1 (13) 2 (9) 1 (14) 1 (8) 1 (8) 1
1 (10) 1 (5) 1 (15) 1 (11) 2 (5) 1

No spicules were found in any of the branchial structures. Alimentary system unsatisfactorily preserved.

Ritter's characterization of the gonads is, as he himself admits, puzzling. Gonads of the usual type in the form of connected series of lobulated masses containing both eggs and testes are present on both sides. All those of each side are said to have a sperm duct in common; those of the left side are located within the intestinal loop.

In addition, however, to these gonads of the usual type he describes a long sinuous cylindrical or tubular "ovary" lying close to them on each side of the body attached to the inner surface of the mantle. "The exact relation of these to the gonad lobes cannot be made out owing to rupture and disarrangement of the parts. From what can be observed the cylinders would seem to be receptacles which receive the ova from the ovaries while still immature and in which they ripen" (Ritter, 1913, pp. 464–465). It is difficult to believe that fundamental differences in the structure of the reproductive organ exist within this apparently homogeneous genus.

LOCALITY: The only specimen, "Albatross" Station 3480, 52° 06′ N., 171° 45′ W., just south of the Aleutian Islands, 283 fathoms. Type in the United States National Museum (U.S.N.M. No. 5688).

GENUS **FUNGULUS** HERDMAN, 1882

An abyssal genus related to *Culeolus*, known from only two specimens: the type, *F. cinereus* Herdman, 1882, from west of Kerguelen Island, and the following:

Fungulus antarcticus Herdman, 1912

Text figure 252

Fungulus antarcticus HERDMAN, 1912, p. 90, pl. 4, figs. 15–18; HARTMEYER, 1912b, pp. 374, 378.

Body of the only specimen rounded, about 1.5 cm. in diameter, borne on short, stout peduncle 1.5 cm. long and 4 to 6 mm. thick arising from the anterior end. Surface nearly smooth, color yellowish gray. Test thin but tough.

Mantle thin but muscular. No spicules found in the tissues. Tentacles few, not much branched. Branchial sac similar to that of *Culeolus* with a few folds and large square meshes. Herdman's figure (here reproduced) shows the stomach ovate and longitudinally plicated, the intestinal loop small and an elongate sinuous gonad on each side ending near the atrial aperture, characters suggestive of the genus *Styela*.

LOCALITY: South of the South Orkney Islands, 64° 48′ S., 44° 26′ W., in 2485 fathoms.

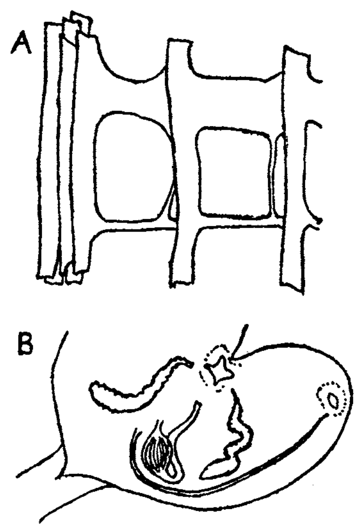


FIG. 252. *Fungulus antarcticus* Herdman. A. Part of branchial sac. B. Alimentary tract and gonads. After Herdman.

GENUS **BATHYPERA** MICHAELSEN, 1904
(Syn. *Halomolgula* Ritter, 1907)

A deep-sea and Antarctic genus whose most conspicuous character is having the body surface covered by minute papillae arranged in a regular pattern and filled with small, pointed, calcareous spicules. In its internal structure it appears to be somewhat intermediate between the Molgulidae and the Pyuridae; though placed in the former group by Hartmeyer, the large renal sac characteristic of the Molgulidae has apparently not been demonstrated in it, and the genus seems more in place in the Pyuridae. See under the type species, *B. splendens*, for its principal characters.

Bathypera splendens Michaelsen, 1904

Bathypera splendens MICHAELSEN, 1904a, p. 192, pl. 10, fig. 9, pl. 11, figs. 15–19; HARTMEYER, 1911b, p. 426, pl. 45, fig. 3, pl. 48, fig. 8, pl. 49, figs. 1–9; 1912b, pp. 374, 376; HERDMAN, 1923, p. 11, pl. 9, figs. 1–17.

Pyura liouvillia SLUITER, 1912, p. 453; 1914, p. 12, pl. 1, figs. 9, 13, pl. 4, fig. 41.

The body varies in shape from spherical, sometimes attached by a very short pedicel, to dome shaped, attached by a broad base. Apertures slit-like (bilabiate), well apart, generally only slightly prominent, sometimes nearly even with the surface. Maximum diameter of the largest specimens, 3 to 3.5 cm.

Body surface, or at least the upper part, smooth but covered with minute, hard, pointed papillae arranged in intersecting curved lines which converge toward the two apertures and extend onto the part of the test which invaginates to line the interior of the siphons. These papillae contain minute, pointed, calcareous spicules, which give them their hard character and cause them to appear as white dots on the surface of the grayish test.

Mantle musclature moderately strong, consisting of definite bands forming an open network.

Larger tentacles branched, alternating in size about 12 to 14 in number, in addition to a varying, but in large specimens considerable number of small tentacles in the intervals. Dorsal tubercle cordate, the open interval forward and the horns incurved. Dorsal lamina a continuous membrane whose margin in the anterior part is produced into long pointed languets, sometimes forked.

Branchial sac with 6 folds on each side with (in large individuals) 12 to 20 internal longitudinal vessels on a fold and 5 or 6 on the intervals between folds. The transverse vessels, especially the small ones, are very irregular, and the stigmata which are short, often curved, and occasionally form small spirals or incipient infundibula, are very irregular in arrangement also.

Alimentary loop located in the posterior part of the body forming an open but rather narrow transverse loop.

One elongate gonad on each side, the left one in the intestinal loop. The gonads consist of an elongate ovary ending in a very short oviduct bordered and overlapped by the numerous testes which are much branched.

DISTRIBUTION: This Antarctic species has been collected off Enderby Land, 2534 fathoms (type locality), Kaiser Wilhelm II Land, 191 to 1592 fathoms, and off Adelie Land and Wilkes Land, 120 to 358 fathoms. Its occurrence in the part of the Antarctic covered by the present work is based on Sluiter's 1912, 1914, record of a species which he described as *Pyura liouvillia* obtained at two stations in West Antarctica, depths 230 meters and 75 meters. Sluiter's description agrees well with *B. splendens* except that he failed to find the calcareous spicules in the papillae, though the latter were present in their usual arrangement, and there seems to be very little question of the identity of his species with the present one, as the spicules might easily have been dissolved out or lost their characteristic shape.

Bathypera ovoida (Ritter), 1907

Text figure 253

Bathypera ovoida HERDMAN, 1923, p. 14.

Bathypera splendens (in part) HERDMAN, 1923, p. 11.

Halomolgula ovoida RITTER, 1907, p. 3, pl. 1, figs. 1–6; HARTMEYER, 1909–1911, p. 1329; 1912b, pp. 374, 378.

Halomolgula ovoidia RITTER, 1907, pp. 1, etc.[1]

"Superficial Characters: Form varying from almost perfectly spherical to strongly depressed biscuit-shape with elliptical base. Outline in general very regular and even; surface, except on area of attachment, wholly free from foreign substances. Siphons projecting scarcely at all above the general surface. Attached usually by posterior end, the area of attachment being usually broad and often extended by a flange, more or less regular, of test. Color light grey; in some regions, especially about the anterior end, approaching white. Size, longest diameter of largest specimens, 4 cm.; short diameter of same specimen, 3.5 cm.; more usual size, longer

[1] This evidently unintentional misspelling occurs throughout Ritter's 1907 article, except in the main heading of the description. Actually the name *ovoidia*, occurring in the list of species on page 1, has page precedence, but as it is not accompanied there by any descriptive matter, we must consider it a ***nomen nudum***, thus validating the name *ovoida* appearing on page 3. Hartmeyer, 1909–1911 and 1912b, took this view.

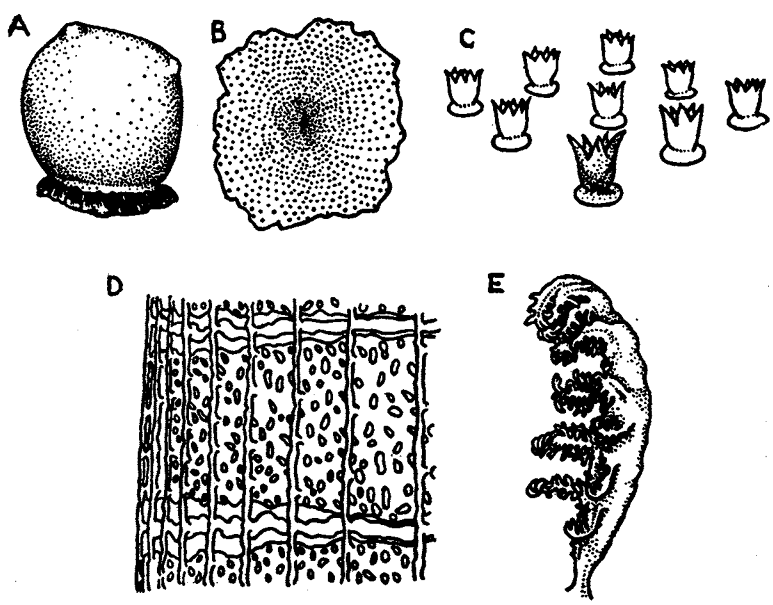


FIG. 253. *Bathypera ovoida* (Ritter). A. Whole animal (rather large specimen), natural size. B. Surface surrounding one of the apertures showing the arrangement of the papillae. C. Some of the papillae enlarged. D. Part of the folds of the branchial sac. (Some of the stigmata are more elongate and curved than those in the figure.) E. Tentacles of the first (largest) order. After Ritter.

diameter about 2 cm., shorter about 1.5 cm. Test thin and papery, entire surface beset with minute stellate tubercles, each of which contains several short, rod-like calcareous spicules. Except for presence of the opaque white tubercles just mentioned, test quite transparent.

"Mantle: Delicate, easily separating from the test, its muscle bands delicate though numerous, especially in the anterior half of the animal, where they are disposed both meridianally and circularly, with also some fibres running obliquely.

"Branchial Apparatus: Siphons very short or wholly absent. Branchial orifice appearing on the surface usually as a longitudinal slit. Branchial orifice probably with six lobes. Branchial tentacles from twelve to fourteen, compound, rather large, with several intervening ones much smaller. Hypophysis mouth simple, elliptical, situated slightly to the right side and far removed from the tentacular circlet. Peripharyngeal groove distant from the tentacular circlet and pursuing a meandering course by bending in between the anterior ends of the branchial folds.

"Ganglion: Extremely long and narrow, extending from in front of the hypophysis backward behind it to a distance three or four times the length of the latter. Dorsal lamina broad, heavy, crenulated membrane beset with numerous conical processes. Branchial sac, with nine folds on each side, eight of which are large, the one on each side of the endostyle being small. Internal longitudinal vessels on each side of each fold varying from six on the smaller folds to nine or ten on the larger. Infundibula large, quadrilateral, frequently notched at their inner borders, i.e., the borders toward the inner margins of the folds. Stigmata small and irregularly distributed, usually short elliptical, but in some regions somewhat curved. Those of the infundibula generally smaller than those between the folds. Transverse vessels limited to the folds, and to the intervals between the infundibula.

"Intestinal Tract: Wide, simple, open loop situated across the posterior dorsal side of the animal, somewhat to the left. Stomach not large, sharply set off from the esophagus but not from the intestine, the wall irregularly folded. Anus bordered by five or six petaloid lobes. Renal organs in the form of two or three distinct patches on the inner surface of the mantle in the vicinity of the gonads, the largest patch being lateral to the right gonad. Gonads one on each side of the body, the left in the intestinal loop, each long and sausage-shaped" (Ritter, 1907, pp. 3–5).

It would seem possible that the structures considered renal organs by Ritter may have been endocarps.

To this description Ritter adds some further particulars for which I must refer the reader to the original work, though it needs to be quoted here that in the gonads the ovary occupies the axis for its entire length, the small bean-shaped testes being "disposed on both sides."

LOCALITY: Station 4425, 21.8 miles south, 07° east, of San Nicolas Island off southern California, 1000 to 1100 fathoms, green mud and fine sand, April 13, 1904, 150 specimens.

GENUS **HETEROSTIGMA** ÄRNBÄCK, 1924

A genus established by Ärnbäck for an Old World Arctic species, *H. separ*. Ärnbäck later (1928) pointed out that a species I had previously described (Van Name, 1912) from the New England coast as *Caesira singularis* agreed in many respects with her new genus and concluded also that the genus, which is in some respects intermediate between the Molgulidae and Pyuridae, fitted better in the latter family. I am following her course in the present work, though inclined to believe that a separate family might be justified.

The peculiarities include simple unbranched oral tentacles, spirally arranged stigmata on at least a part of the branchial sac (on the whole of it in *H. singulare*), the reduction of the folds of the sac to the point of virtually complete flattening (their positions being indicated by the internal longitudinal vessels), a single hermaphroditic gonad on one or both sides, and an elongate stomach with a liver, but no renal organ.

Heterostigma singulare (Van Name), 1912
Text figures 254–256

Caesira singularis VAN NAME, 1912, p. 518, figs. 21, 22, pl. 54, figs. 58–60, pl. 73, fig. 166.

Heterostigma singularis ÄRNBÄCK, 1928, p. 79.

? *Molgula producta* (in part) VERRILL AND

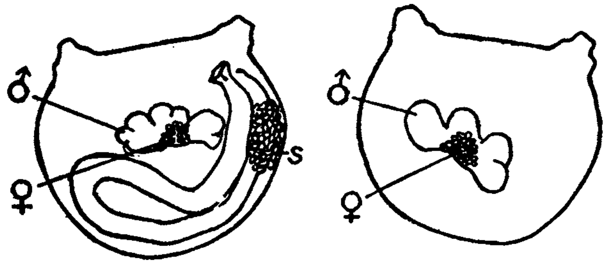


FIG. 254. *Heterostigma singulare* (Van Name). Left and right sides of body, ×4.

SMITH, 1873, pp. 502, 510, 699; SUMNER, OSBURN, AND COLE, 1913, p. 729. Not Stimpson, 1852.

Molgula singularis ÄRNBÄCK, 1924a, p. 7; HARANT, 1929, p. 64.

Molgula sp. HARANT, 1925, pp. 2, 5.

Molgulina singularis HARTMEYER, 1914, p. 7.

Body round or elliptical in outline, not much compressed laterally and completely

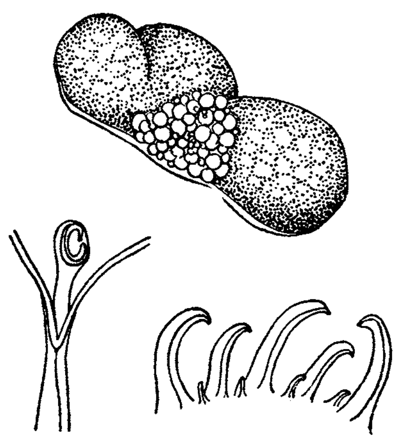


FIG. 255. *Heterostigma singulare* (Van Name). Right gonad (side next to mantle), × about 18; dorsal tubercle and part of the circle of tentacles.

covered with sand in which it lives buried. Apertures both on the dorsal aspect, widely separated, not prominent in contraction but probably extensible as tubes during life, showing no well-defined lobes in the contracted state. Test thin, firm, somewhat pearly within. Largest specimen, 11.5 mm. long, 9 mm. dorsoventrally, and 7 mm. from side to side.

Mantle very thin, with a network of nearly rectangular meshes covering almost the entire body, formed of bands radiating from the apertures crossed at right angles by other bands. Oral tentacles unbranched; of three sizes quite regularly arranged, about eight of the largest and six of the second order. Dorsal tubercle small, simply C-shaped; open interval to the left in two examples, to the right in a third example. Endostyle very narrow.

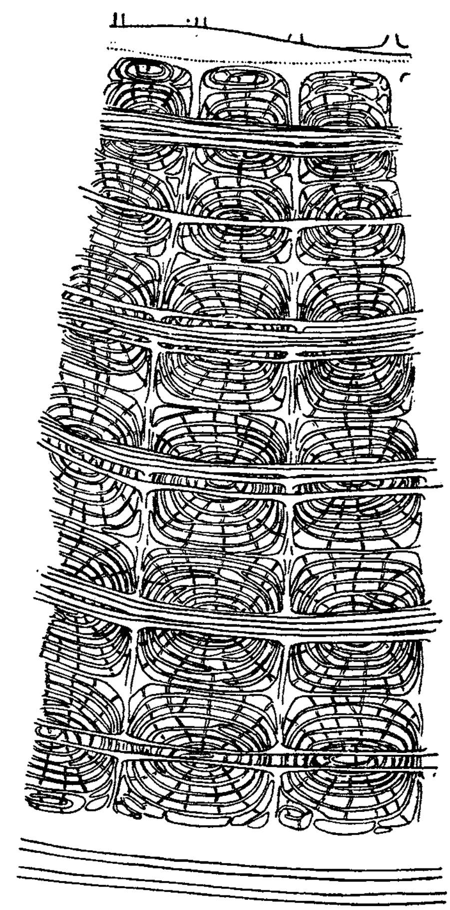


FIG. 256. *Heterostigma singulare* (Van Name). Part of branchial sac, ×14.

"The branchial sac is of very delicate structure, and has no true folds, though six folds on each side are indicated by six longitudinal rows, each of eight large flattened infundibula, bridged over by one or more longitudinal vessels. The infundibula show little if any of the tendency to divide into two apices that is common in this family. On the basal or outer portion of the infundibula the stigmata are concentric; toward the center or apex they form a single, occasionally interrupted spiral, and are crossed and supported by some slender radial vessels. The surface of the sac is crossed by seven transverse vessels situated between the vertical rows of infundibula. Small imperfect or rudimentary infundibula occur along the dorsal and ventral edges of the sac next to the median dorsal vessel and the endostyle. The bars or vessels separating adjacent stigmata are slender and usually narrower than the stigmata, giving the infundibula an appearance suggesting a spider's web.

"Stomach provided with a great number of small papilla-like caeca; the intestinal loop narrow and comparatively little bent; anus with a square or somewhat two-lipped opening.

"A kidney is apparently wanting.

"The gonads have the positions usual in the genus *Molgula*. They are hermaphroditic and each consists of three or more large rounded testes arranged in a longitudinal row and apparently more or less fused together by their ventral portions but separated by clefts above (dorsally). The ovary appears to consist of a mass of small eggs grouped together at the lower (ventral) middle part of the gonad" (Van Name, 1912, pp. 519–520).

Localities of specimens I have examined:

"Station 333 (off S. end of Stellwagen's Bank, Race Point Light S. 18° E., 5½ miles, 27 fathoms, fine yellow sand).

"Station 281 (on Stellwagen's Bank, Race Point Light S. 12° E., 8½ miles, 14 fathoms, fine yellow sand and broken shells).

"Station 828 (north of Block Island, 15 fathoms, sand). Long Island Sound (no further particulars on label)" (Van Name, 1910, p. 520).

The above localities are all in shallow water from a limited region. Race Point is near the north end of Cape Cod, Massachusetts; the Long Island Sound locality was probably in the eastern part.

It seems possible that certain specimens from off Buzzards Bay, Massachusetts, and 15 miles east of Block Island off the Rhode Island coast, 29 fathoms, referred to Stimpson's (1852) *Molgula producta* (see under *M. complanata*) by Verrill and Smith (1873, pp. 502, 510, and 699) may really belong to this species instead of to Stimpson's. Their external appearance in life is thus described by Verrill and Smith:

"The *Molgula producta* was dredged in some numbers on a bottom of fine sand, with some mud. The integument is thin, translucent, closely covered with a layer of fine sand; the tubes are transparent, whitish or flesh-color, sometimes pink at the ends; anal tube with four, and branchial with six, flake-white, longitudinal stripes and often with a circle of flake-white spots at the base outside, and other spots within. The anal orifice is square, but the branchial is either subcircular or squarish, in expansion, and destitute of distinct lobes or papillae, in this respect differing from all the other species of the genus. The branchial tube is generally a little the longest, and both of them are somewhat tapered, with a swollen base."

Unfortunately, Verrill and Smith say nothing of the internal structure, and as I have not seen living specimens of *H. singulare*, the assignment of their specimens to this species must remain doubtful.

Harant (1929, p. 64) assigns to this species specimens from very deep water collected by the Prince of Monaco at two stations near the Azores: Station 650, 36° 54′ N., 20° 46′ 15″ W., 4400 meters, and Station 749, 38° 54′ N., 21° 06′ 45″ W., 5005 meters. He claims that they correspond so closely with the American species that there is no reason to call them even a distinct variety.

FAMILY MOLGULIDAE LACAZE-DUTHIERS, 1877

(= Caesiridae auct. mult.)

A family of simple ascidians, some of them of large size, related to the Pyuridae, with which they are connected by a few more or less intermediate genera, and from which they have probably evolved. The Molgulidae may be regarded as the most specialized or highly developed family of ascidians.

The body is usually rounded or elliptical in form, frequently not permanently attached, the animal living buried in the sand or mud of the sea bottom.

Tentacles almost always branched, branchial sac generally with well-developed folds, usually six or seven on each side, bearing internal longitudinal vessels. Stigmata, especially those on the folds, usually curved and arranged in spirals, straight stigmata being exceptional in the family. Alimentary tract on the left side, gonads usually hermaphroditic, one on each side of the body attached to the inside of the body wall.

The best character for recognizing members of the family is the presence of a large, sac-like (usually oblong or sausage-shaped) renal organ or kidney attached to the inside of the body wall on the right side of the body. It is a closed sac; the excreted matter forms one or more solid concretions which remain in it throughout the life of the individual. It occurs in all the Molgulidae and in no others. The nearest approach to it is the presence in the Ascidiidae of great numbers of very minute (mostly microscopic) renal sacs of a similar character lying on or in the immediate vicinity of the intestinal tract, on the left side of the body.

One peculiarity of the Molgulidae requires notice here. Two American species of the genus *Molgula* (*M. retortiformis* and *M. robusta*), also *Bostrichobranchus pilularis* and *Eugyra arenosa* as well as a few Old World Molgulidae, are known to develop directly from the egg to the adult stage without the intervention of a free-swimming tailed larval (tadpole) stage. Possibly *M. provisionalis* may do so also. This is not known in any other members of the class Ascidiacea, though of course there are many whose development has not yet been studied. (See Berrill, 1931, for a study of this subject.)

GENERA OF MOLGULIDAE

A_1. Branchial sac with folds (usually six or seven on each side), each bearing several or many internal longitudinal vessels.

- B_1. Stigmata more or less curved or spiral in their arrangement, especially on the summits of the folds, which are formed by or bear a row of conical infundibula.
  - C_1. Gonads one on each side, the left gonad dorsal or anterior to the primary intestinal loop (in the secondary loop) . . . . typical species of *Molgula*
  - C_2. Gonads one on each side, the left gonad in the primary intestinal loop . . . Subgenus *Molguloides*
  - C_3. Gonads one on each side but the male and female parts of each gonad separated . . . . Subgenus *Meristocarpus*
  - C_4. Similar to *Molgula*, stigmata said not to form spirals even on the folds . . . . *Ascopera*
- B_2. Stigmata in connected double spirals on infundibula on the folds and also on the flat parts of the sac. A pair of adhesive secreting glands near the endostyle. No right gonad . . . . . . *Rhizomolgula*

A_2. Branchial sac without folds but with one wide internal longitudinal vessel of flat cross section in the place of each fold.

- B_1. Body axis much curved (very convex ventrally), stigmata short, mostly curved, forming small, irregularly distributed infundibula. A gonad on each side; left gonad in the secondary intestinal loop . . . . *Paramolgula*
- B_2. Stigmata spiral, on large infundibula bridged over by the internal longitudinal vessels, additional (accessory) infundibula present in some species.
  - C_1. Spirals formed by the stigmata interrupted at intervals, accessory infundibula present; gonads present on both sides. . . *Pareugyrioides*
  - C_2. Stigmata in connected chains of very perfect double spirals usually interrupted only at the summits of the infundibula or centers of the spirals . . . . *Eugyra*
  - C_3. Arrangement of stigmata similar to *Eugyra* in young individuals, but the infundibula become greatly multiplied and irregularly distributed in old individuals . . . . *Bostrichobranchus*

A_3. Imperfectly known abyssal genera (see pp. 428, 442) . . *Anomopera* and *Hexacrobylus*

GENUS MOLGULA FORBES AND HANLEY, 1848
Nomen Conservandum
(= *Caesira* Fleming, 1822, and many recent authors)

The principal genus of the Molgulidae, found in most parts of the world but less well represented in the tropical regions than elsewhere. Type of the genus: *M. oculata* Forbes and Hanley, 1848, a European species.

In *Molgula* the branchial sac has folds (usually six or seven on each side), each bearing several or many internal longitudinal vessels; the summit of the fold is usually formed by a row of conical infundibula upon which the stigmata are arranged in spirals, though the spirals are more or less imperfect and interrupted. Even on the flat intervals between folds, the stigmata are mostly more or less curved, and may develop small accessory spirals in some species.

The stomach, which has a hepatic organ on its proximal part, is elongate and tapers off into the intestine, the intestinal loop narrow with its two parts in close or approximate contact except near the reflected end; the whole tract is generally more or less bent with the concavity dorsal so as to form a secondary loop.

In all typical *Molgulas* the left gonad is situated dorsal to the intestine, often more or less enclosed by the secondary loop formed by the intestine, the right gonad is more or less dorsal to the kidney or somewhat curved around it.

Though its members differ considerably in details, such as the degree of development of the spirals and infundibula of the branchial sac, and the shape of the gonads, the genus forms a fairly compact group that seems to stand in very little need of splitting up into genera or even subgenera, though it has been subject to such subdivision in much detail by Huntsman, 1922b, to whose work the reader is referred.

Among the American species the only ones whose deviation from the typical *Molgula* type seems to merit possible separation are *M. retortiformis* (type of *Meristocarpus* Pizon, 1899), due to its complete separation of the male and female parts of each gonad; *M. immunda* (subgenus *Molguloides* Huntsman, 1922), due to having the left gonad in the primary intestinal loop instead of dorsal to it; and possibly *M. complanata* (type of *Lithonephrya* Giard, 1872, syn. *Ctenicella* Lacaze-Duthiers, 1877), on account of its inverted U-shaped gonads with the opening anterior and ventral, instead of dorsally directed as usual. In the present work I am not giving these generic rating.

The genus cannot well be divided on the basis of whether the young pass through a tailed larval (tadpole) stage or have direct development, unless we entirely ignore the adult characters, although a genus (*Anurella*) was established by Lacaze-Duthiers, 1870, based upon that character. We are, therefore, forced to conclude that the loss of the tailed larval stage has occurred independently in the species in which it is found. (See remarks under family Molgulidae, also Berrill, 1931, for a study of direct development in ascidians.)

Molgula griffithsii (MacLeay), 1825

Text figures 257–260

Caesira crystallina HARTMEYER, 1909–1911, p. 1323; 1912a, p. 14; VAN NAME, 1912, p. 494, figs. 12, 13, pl. 48, figs. 31–33.

Caesira intumescens VAN NAME, 1912, p. 482, fig. 8, pl. 46, figs. 17–20; HARTMEYER, 1921a, p. 7; BERRILL, 1931, p. 312.

Clavelina chrystallina MOELLER, 1842, p. 95.

Cystingia griffithsii MACLEAY, 1825, p. 541, pl. 19; HUNTSMAN, 1922, p. 7; 1922a, p. 7; 1922b, p. 228.

Molgula chrystallina TRAUSTEDT, 1880, p. 421; 1883, p. 110; 1885, p. 18, pl. 1, figs. 4, 5; 1886, p. 427, pl. 37, figs. 12, 13, pl. 39, fig. 31; KIAER, 1893, p. 73; HARTMEYER, 1914b, p. 1098; 1921a, p. 6; 1923, p. 45.

Molgula crystallina HARTMEYER, 1903, p. 134; BJERKAN, 1905, p. 4; 1908a, pp. 56, 114; REDIKORZEV, 1908a, p. 11, pl. 1, figs. 1, 2 (describes var. *tuberculata*, p. 13, fig. 2a, 2b, pl. 1, fig. 3); RITTER, 1913, p. 439; OKA, 1914, p. 444, figs. 1, 2; REDIKORZEV, 1916, p. 58, fig. 9, pl. 1, fig. 6, pl. 4, fig. 5 (var. *tuberculata*, p. 64, pl. 4, fig. 6); BERRILL, 1931, p. 312.

Molgula griffithsii ÄRNBÄCK, 1928, p. 47, figs. 5, 6, pl. 1, figs. 1–6; 1938, p. 13 (*griffithsi*).

Pera crystallina VERRILL, 1872a, pp. 213, 290, pl. 8, fig. 9; 1879, p. 27; HARTMEYER, 1899a, p. 455, fig. A, pl. 22, fig. 1, pl. 23, figs. 1, 16; WHITEAVES, 1901, p. 271.

Pera pellucida STIMPSON, 1852, p. 232; 1860a, p. 2; BINNEY, 1870, p. 17. Not *Molgula pellucida* Verrill, 1872.

For other names and references, see Hartmeyer, 1923, pp. 45, 46.

Body generally ovoid, tapering or more or less abruptly narrowed at the smaller end into a stalk or pedicel by which it is quite firmly attached. The pedicel sometimes exceeds the body itself in length but is usually much shorter than the body and occasionally is a mere protuberance or is lacking entirely. The four-lobed atrial orifice is at the opposite end from the pedicel; the branchial orifice, which is only obscurely lobed, is on the dorsal side, far removed from the atrial orifice. Neither opening is usually prominent in preserved specimens.

The test is fairly thick and firm, but quite transparent, and usually free from adhering material. In the majority of examples it appears quite smooth, though under magnification minute rounded tubercles may be seen, which in some examples are large enough to be very conspicuous. Redikorzev, 1908a, described a variety *tuberculata* based on an extreme development of this character, but it seems to be merely a matter of individual variation.

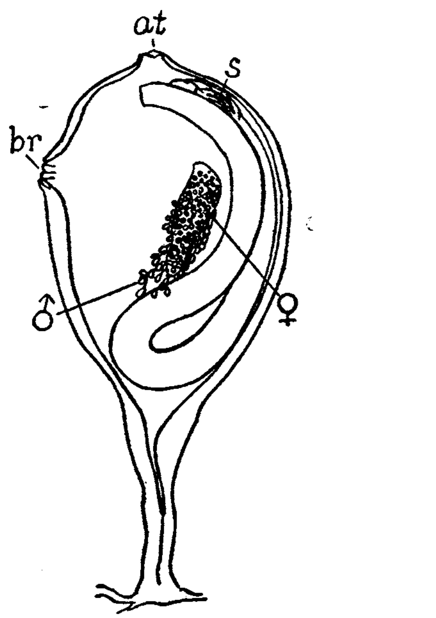


FIG. 257. *Molgula griffithsii* (MacLeay). Left side of body, including test, ×6.

The usual body length, exclusive of the pedicel, is 10 to 20 mm., only rarely attaining 25 mm. or more, the maximum transverse diameter being considerably less.

Its external appearance is, therefore, quite distinctive, only in case of more or less abnormally distorted or mutilated specimens, in which the pedicel is lacking or has been torn off, is its recognition likely to be difficult. Its internal anatomy is peculiar only in a few respects, but notably in having only five branchial folds on each side.

The mantle musculature is rather slight, composed of slender bands forming a network with more or less rectangular meshes on parts of the body. Tentacles numerous; they are of four or five orders, even the largest somewhat sparingly branched (usually only twice pinnate). Dorsal tubercle simply C-shaped or horseshoe shaped, open interval directly or obliquely toward the right. Dorsal lamina smooth edged.

The five folds of the branchial sac each bear only a few internal longitudinal vessels, usually three or four (seldom as many as five on some of the folds). The stigmata are long and narrow, spirally arranged on the well-developed infundibula; one or (in the ventral parts of the sac) two of the latter between each pair of primary transverse vessels. There are some additional smaller spirals in the spaces dorsal to the first and ventral to the last fold.

The alimentary loop is very narrow, little opened out at the reflected end, and usually little bent dorsally at that end. The stomach has a few irregular glandular plications. The kidney is wide and short.

The ovaries are moderately elongate, usually nearly straight except for being a little bent dorsally at the end, which is not produced into an oviduct. The small male glands,

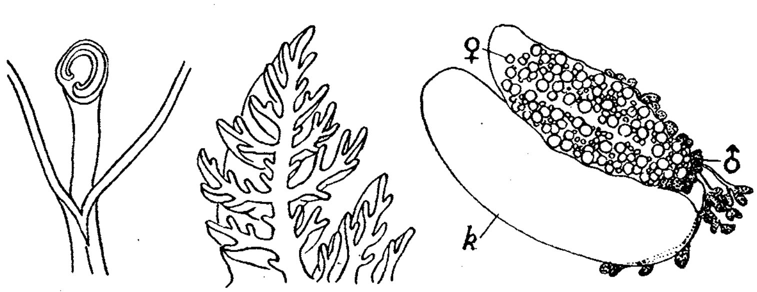


FIG. 258. *Molgula griffithsii* (MacLeay). Details of dorsal tubercle, tentacles, and right gonad.

though overlapping the anterior part of the ovary, extend out away from it to an extent unusual in this genus. They may or may not all discharge by a single sperm duct. On the left side some of them may sometimes be visible in the narrow opening formed by the end

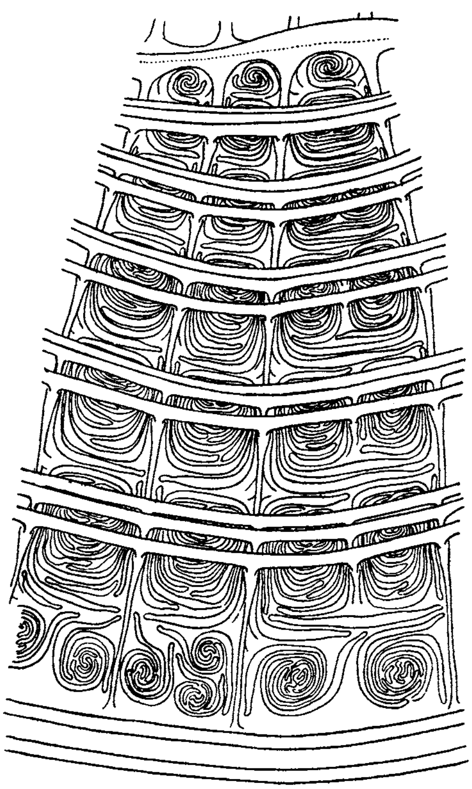


FIG. 259. *Molgula griffithsii* (MacLeay). Part of the branchial sac of a rather young example, ×16.

of the intestinal loop; on the right side some of them often extend around the anterior end of the kidney. Even in extreme cases the condition is not comparable to the complete separation of the male and female components that is found in *M. retortiformis* and is merely an exaggeration of the extension of the testes beyond the margin of the ovary that is found in most *Molgulas*.

DISTRIBUTION: Circumpolar in the Arctic region and fairly common in some parts of it. On the American side records south of Greenland are very few, though Stimpson obtained one at the eastern edge of Georges Bank off the Massachusetts coast in 30 fathoms. I have not seen examples myself from south of the Gulf of St. Lawrence and the Newfoundland Banks. In the north Pacific region it

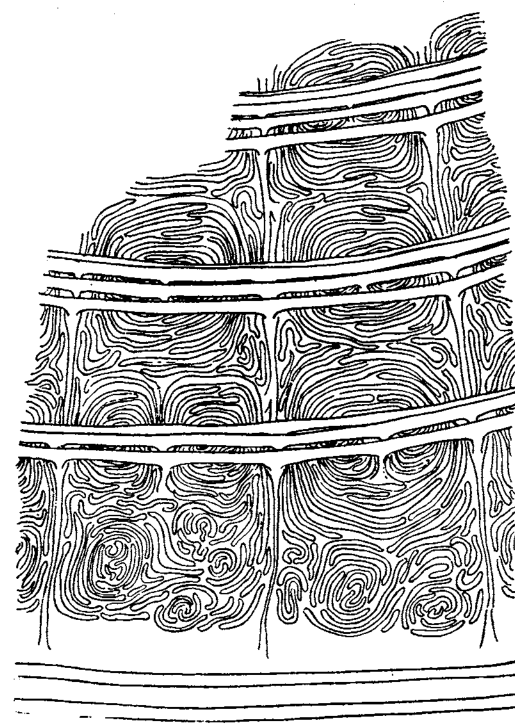


FIG. 260. *Molgula griffithsii* (MacLeay). Part of branchial sac of an old and large example, ×20.

ranges south to the Aleutian Islands and Korea and is common in Bering Strait. The American Museum collection contains a cluster of over a dozen fair-sized individuals from Bering Strait attached to a worm tube. In European waters it is chiefly Arctic in range.

Though not recorded from low-water mark, it is chiefly a species of shallow and very moderate depths. One record of 408 meters given by Hartmeyer is the extreme. Most of them are in less than 40 fathoms.

It is only with much reluctance that I have followed Huntsman in replacing the familiar name *Molgula chrystallina* (Moeller) by which this has long been known. *Cystingia griffithsii* was described by MacLeay, 1825, in such a poor and confusing manner that nobody could make much out of it. Huntsman (1922a) and Hartmeyer (1923) came (apparently independently) to the conclusion that MacLeay's species was the present one. Huntsman adopted MacLeay's name. Hartmeyer declined to do so. I believe that Hartmeyer was entirely correct in rejecting it, as I think that a description so insufficient and misleading that it was nearly a century before anybody figured out even what family it belonged to falls very far short of being a justifiable basis for upsetting not only a long-used specific name but, by antedating *Molgula*, also the name of that large and important genus and of the family Molgulidae. Unfortunately in the 20 years that have elapsed, others have followed Huntsman's abandonment of *chrystallina*, and I do not think it worth while to go back to it at this late date. The replacement of *Molgula* would logically follow, but fortunately the fact that that name has long been established as a ***nomen conservandum*** sufficiently protects it (see also Ärnbäck, 1928).

Molgula siphonalis Sars, 1859

Plate 1, figure 2, plate 6, figure 3;
text figures 261–264

Ascidia conchilega H. P. C. MOELLER, 1842, p. 95. Not O. F. Mueller, 1776.

Caesira pannosa VAN NAME, 1912, p. 484, fig. 9, pl. 47, figs. 21–24, pl. 48, fig. 25, pl. 71, fig. 148; HARTMEYER, 1912a, p. 17; HUNTSMAN, 1912, pp. 113, 142.

Caesira septentrionalis HARTMEYER, 1910, p. 229; VAN NAME, 1912, p. 478, figs. 6, 7, pl. 46, figs. 14–16, pl. 73, fig. 160; HARTMEYER, 1912, p. 439; 1912a, p. 17; 1912c, p. 264.

Caesira siphonalis HARTMEYER, 1912a, p. 18.

Cynthia conchilega RINK, 1857, p. 104; LÜTKEN, 1875, p. 138.

Molgula boreas TRAUSTEDT, 1883, p. 112.

Molgula pannosa VERRILL, 1871, p. 55, fig. 2; 1872a, p. 211; 1873–1874, vol. 7, pp. 39, 43, 46, 413; 1874a, pp. 352, 355, 363, 368; WHITEAVES, 1874, p. 12; 1874a, p. 214; VERRILL, 1879, p. 27; KINGSLEY, 1901, p. 182; WHITEAVES, 1901, p. 270; HARTMEYER, 1914, p. 7; PROCTER, 1933, p. 283 (perhaps only in part). Not *M. pannosa* Sumner, Osburn, and Cole, 1913, p. 729.

Molgula septentrionalis TRAUSTEDT, 1883, p. 111; HARTMEYER, 1903, p. 152, pl. 4, figs. 7, 8, pl. 7, figs. 12–16, pl. 8, fig. 1; 1914, p. 7; 1914b, p. 1099; REDIKORZEV, 1916, p. 94, fig. 16, pl. 3, fig. 4, pl. 4, fig. 11; HARTMEYER, 1922a, p. 7; HUNTSMAN, 1922, p. 4; 1922a, p. 7b.

Molgula siphonalis SARS, 1859, p. 65; KIAER, 1893, p. 65; 1896, p. 15; HARTMEYER, 1903, p. 157; RITTER, 1913, p. 440; HARTMEYER, 1914, p. 7; 1914b, p. 1099; REDIKORZEV, 1916, p. 92; ÄRNBÄCK, 1928, p. 28, fig. 2, pl. 1, figs. 13–16. Not Hartmeyer, 1899a, p. 462 (= *M. retortiformis*).

Body ovate, the anteroposterior diameter usually the greatest, the siphons both on the dorsal surface, the branchial near the anterior end, the atrial not far behind it in most specimens. Body surface usually covered with short, irregular, hair-like processes to which a thick coating of sand, shell fragments, and other debris adheres, though there is often a dorsal bare area in which the siphons are situated. Attachment by a small ventral or ventrolateral area, usually not very firm, in many cases largely by means of the hair-like processes of the test. The siphons, especially the atrial, which is larger, are capable of considerable extension but also of complete retraction. The atrial aperture is square, the branchial has six small, pointed lobes or papillae. The largest specimen I have examined myself was 24 mm. in anteroposterior diameter, 16 mm. dorsoventrally, and still less transversely; the usual dimensions are not over one-half to two-thirds as great as this.

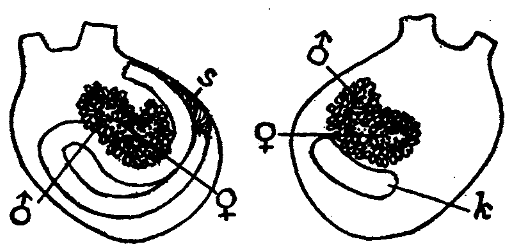


FIG. 261. *Molgula siphonalis* Sars. Left and right sides of body, ×3.

Mantle musculature well developed on the siphons, from which radiating bands extend a short distance on the side, but is slight on most parts except for one or more rows of short, stout parallel bands along each side of the endostyle, placed more or less at right angles to that organ; they do not cross the mid-ventral line. These are much more conspicuous in some specimens than in others

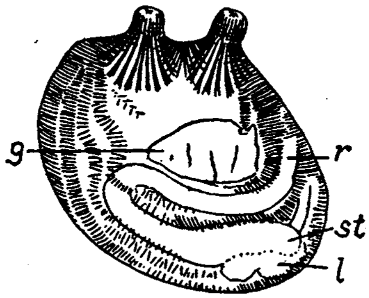


FIG. 262. *Molgula siphonalis* Sars. Left side of mantle showing the characteristic arrangement of the small muscle bands, though in most specimens they are not so conspicuous, ×2. Based on figure of Ärnbäck, 1924.

and may escape notice when weakly developed.

Dorsal tubercle simply C-shaped or horseshoe shaped; the direction of the open interval varies but is apparently oftenest toward the left rear. Dorsal lamina rather wide, its margin smooth. Tentacles numerous, of at least four orders in some individuals; the large ones few, two or three times pinnate, the smallest often simple or nearly so.

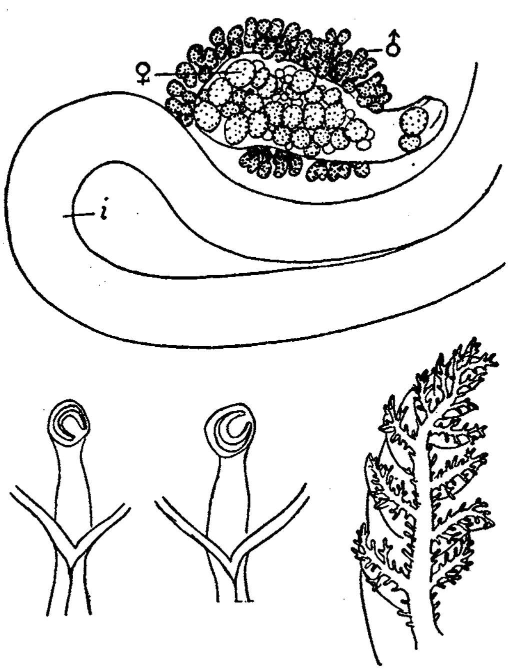


FIG. 263. *Molgula siphonalis* Sars. Details: gonad and part of intestinal loop, dorsal tubercles of two individuals, and one of the large tentacles.

Branchial sac with seven well-developed folds on each side, which are composed largely of a series of infundibula that divide at the summit. The internal longitudinal vessels in a fairly large adult were arranged as follows:

Left	0 (5) 0 (6) 0 (7) 0 (6) 0 (5) 0 (4) 0 (4) 0
Right	0 (6) 0 (5) 0 (6) 0 (6) 0 (5) 0 (5) 0 (4) 0

Large individuals have 11 or 12 vessels on the higher folds. Often one vessel is slightly

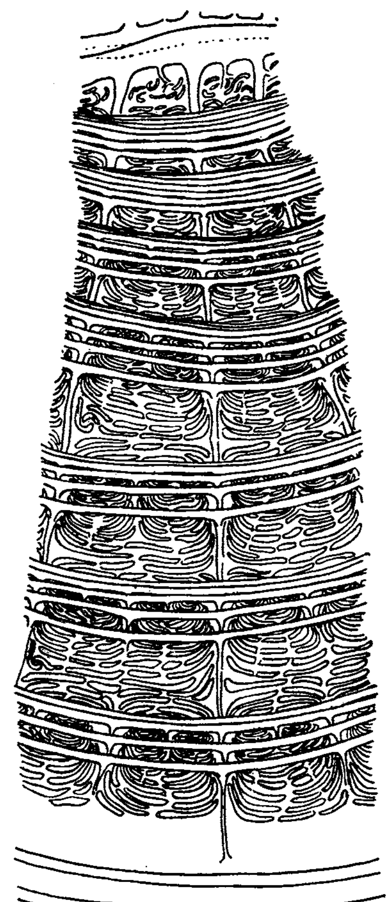


FIG. 264. *Molgula siphonalis* Sars. Part of branchial sac, ×15.

removed from the base of the fold and actually on the adjacent flat interval, but clearly belongs to the group on the fold.

The stomach has a thick glandular wall in the proximal part, causing irregular folds and convolutions on the surface. The intestinal loop is open a little way at the anterior reflected end, but elsewhere the parts are close or overlapping. There is considerable individual variation in respect to the extent to which the reflected end is bent up dorsally.

The gonads are not greatly elongated; they lie dorsal to, and close to, the intestinal loop and kidney, respectively. The ovaries are somewhat curved, rather wide, flask-shaped sacs contracting into a neck at the posterior end which turns up dorsally to a varying extent; they are bordered and overlapped on the mesial aspect by the pyriform or somewhat lobed testes. The eggs become quite large while in the ovary. I failed to find eggs or larvae in the peribranchial cavity in the specimens examined, and I know of no observations on the breeding of this species. The sperm ducts open at several points on the mesial surface of the gonad.

The kidney is sausage shaped, quite large and long and considerably curved.

DISTRIBUTION: Mainly an Arctic species known from Spitzbergen, the Murman coast, the White Sea, Barents and Kara seas, etc., and both east and west coasts of Greenland, also Fox Basin, but ranging south on the American coast to the vicinity of the Bay of Fundy and eastern part of the Maine coast as far as Casco Bay. There is one off-shore record considerably farther south ("Albatross" Station 2525, 41° 49′ N., 65° 49′ 30″ W., 72 fathoms) at the eastern edge of Georges Bank. It ranges from quite shallow water, 10 fathoms near Eastport, Maine, 2 fathoms in Casco Bay, down to 80 fathoms, according to Verrill. Hartmeyer records one from 292 meters in Barents Sea, but such a depth appears to be unusual. Generally it occurs on hard, gravelly, sandy, or more or less muddy bottoms, but Procter, 1933, reports it "on piles just about low water mark abundant" at Mount Desert, Maine. I have not seen any of Procter's specimens and do not know of any other report of its growing on piles. Perhaps his specimens were the new species, *M. provisionalis*.

In Old World waters it does not appear to be common, specimens usually being obtained singly, but Verrill collected it in some quantity near Eastport, Maine, describing it as *M. pannosa*. Huntsman, 1912, reported it from many points in that vicinity but never in quantity. The claim that it is completely circumpolar is unsatisfactory, resting only on the report by Ritter, 1913, of a single small specimen from "Albatross" Station 3560 near St. Paul Island of the Pribilof group, in 43 fathoms.

Molgula citrina Alder and Hancock, 1848

Text figures 265–267

Caesira citrina HARTMEYER, 1909–1911, p. 1323; 1912, p. 440; VAN NAME, 1912, p. 488, figs. 10, 11, pl. 48, figs. 26–30, pl. 73, fig. 163.

Caesira littoralis HUNTSMAN, 1912, pp. 112, 142.

Molgula arctica KIAER, 1896, p. 14, pl. 5, figs. 3–7; BJERKAN, 1908a, p. 57; REDIKORZEV, 1916, p. 103, fig. 18, pl. 3, fig. 3.

? *Molgula birulai* REDIKORZEV, 1907a, p. 522; 1916, p. 106, fig. 20, pl. 2, fig. 3, pl. 4, fig. 13.

Molgula citrina ALDER AND HANCOCK, 1848, p. 198; 1907, p. 62, figs. 46, 47, pl. 26, figs. 5–9, pl. 27, figs. 6–8, pl. 28, figs. 3–5, pl. 40, fig. 4, pl. 48, fig. 3; SUMNER, OSBURN, AND COLE, 1913, p. 729; HARTMEYER, 1915, p. 323; REDIKORZEV, 1916, p. 98, fig. 17, pl. 2, fig. 4, pl. 4, fig. 12; HARTMEYER, 1923, p. 97; GRAVE, 1926, pp. 453, etc., pls. 1, 2; ÄRNBÄCK, 1928, p. 34, pl. 1, figs. 17–22; BERRILL, 1928, pp. 164–166; 1929, p. 52; 1931, pp. 291, 312, 333, fig. 2; PROCTER, 1933, p. 283; GRAVE, 1937, p. 564.

Molgula echinosiphonica LACAZE-DUTHIERS, 1877, p. 569, pl. 19; GRAVE, 1926, p. 455.

Molgula littoralis VERRILL, 1871, p. 56, fig. 4a; 1872a, p. 211; WHITEAVES, 1874, p. 12; VERRILL, 1879, p. 27; WHITEAVES, 1901, p. 270.

Molgula nana KUPFFER, 1873, Ber. Kommand d. Meere, vol. 1, p. 136; 1875, p. 226; TRAUSTEDT, 1880, p. 426; 1883, p. 111; KAIER, 1893, p. 76, pl. 4, figs. 43, 44; 1896, p. 14; HARTMEYER, 1903, pp. 156, 373; GRAVE, 1926, p. 455.

See Hartmeyer, 1923, p. 97, for full list of references to that date.

Specimens of this small species vary greatly in their external appearance and shape, some being attached by a broad area of the ventral region and considerably flattened; others are more nearly round. Some are very smooth externally, others quite rough and with much adhering sand and foreign matter.

The siphons arise from the dorsal surface a little way apart, the branchial near the anterior end, the atrial near or behind the middle. The former, which is often of larger diameter, has the aperture surrounded by six narrow acute lobes; the atrial siphon is usually longer, at least when extended, and has a square aperture. On their external surface near the end, the siphons often, but not al-

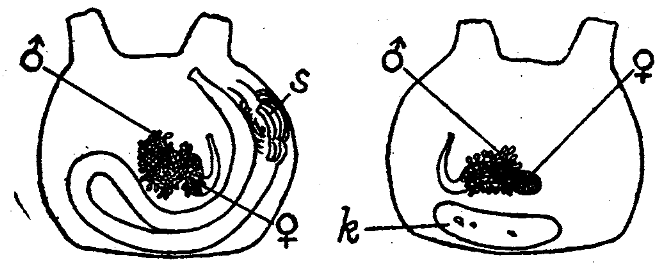


FIG. 265. *Molgula citrina* Alder and Hancock. Left and right sides of body, ×5.

ways, bear a few small, short, lateral, pointed processes, which explain one of the specific names (*echinosiphonica*) of this animal.

Of its color when alive Verrill says:

"When living the color of the body is translucent dull greenish or olive, between the tubes usually more or less ferruginous brown or russet; on the sides the viscera show through as dull orange-colored and darker blotches" (Verrill, 1871, p. 56).

It usually remains quite small; in some localities it does not often exceed 6 to 8 mm. in greatest diameter. The largest specimen that I have examined was 16 mm. long, 13 mm. dorsoventrally, and 11 mm. wide. Generally it grows quite firmly attached, and often several individuals grow together in a group adhering together more or less firmly. The test is tough and rather firm; the body surface may be quite smooth and clean, or roughened by a few granule-like papillae or small wrinkles. In other cases these, though present, are concealed by adherent sand or debris.

Musculature of mantle weak and on most parts of the body diffuse, consisting of fibers more or less isolated or grouped into only very narrow bands, which cross each other in various directions. Radiating and circular muscles about the bases of the siphons not strongly developed, the radiating bands being of loose structure and not very stout, and tapering off quite abruptly at some distance from the origin of the siphons. Along each side of the endostyle there are some distinct though narrow bands disposed in oblique and transverse directions to the course of the endostyle.

Tentacles moderately numerous and of at least four or five sizes and degrees of complexity as regards their branching, which in the

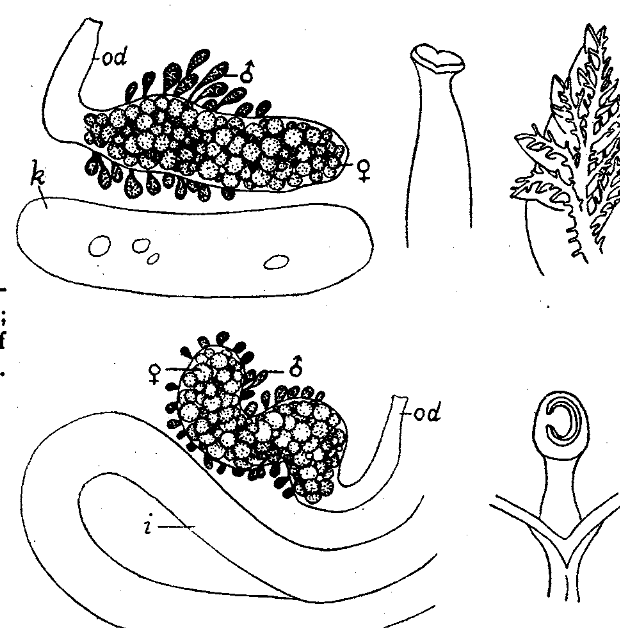


FIG. 266. *Molgula citrina* Alder and Hancock. Details: Right gonad and kidney, ×12; left gonad and intestinal loop, ×12; end of rectum, large tentacle, and dorsal tubercle.

large tentacles is of the bipinnate type (though a few branches may bear incipient branchlets of a third order), while the smallest are entirely simple, often mere papillae. Large tentacles comparatively few (about six or eight). Dorsal tubercle large; its orifice C-shaped with the open interval to the right; horns not strongly incurved or inrolled, sometimes almost meeting to form a circle. Dorsal lamina a broad thick membrane, its border sometimes slightly sinuous.

Branchial sac with seven rather narrow but sharply defined folds on each side, which are rendered conspicuous by the groups of stout, internal, longitudinal vessels which run along them and by the series of infundibula along their summits. These vessels numbered in a rather small specimen as follows:

Left	0 (5) 0 (5) 0 (4) 0 (4) 0 (4) 0 (2) 0 (2) 0
Right	0 (5) 0 (5) 0 (5) 0 (4) 0 (4) 0 (3) 0 (2) 0

In large individuals they are more numerous, eight or nine occurring on some of the folds.

On the folds the branchial sac is raised into large infundibula which generally divide into two at the summit. The stigmata are mostly quite long and wide. Between the folds their direction is mainly longitudinal but seldom quite straight, and on the infundibula they are curved and their arrangement becomes more and more spiral. Ventral to the last fold the stigmata may form irregular curves and rudimentary spirals.

The cardiac portion of the stomach has deep glandular folds in its walls. The intestinal loop is rather narrow with the reflected end somewhat turned up. Kidney large, sausage shaped, little curved.

It is, however, not by any of the foregoing internal characters that the species is most easily positively recognized but by the gonads, especially by the unusually long slender oviducts. The left gonad is dorsal to the horizontal part of the intestinal loop; the right gonad just dorsal to the kidney. They differ in form, the left having the ovary, which is elongated, bent in an S-shaped curve, the right having the ovary much straighter. In each case the ovary is prolonged at the posterior end into a long, slender, tubular oviduct, which bends dorsally rather abruptly shortly after leaving the gonad. Its walls are very delicate.

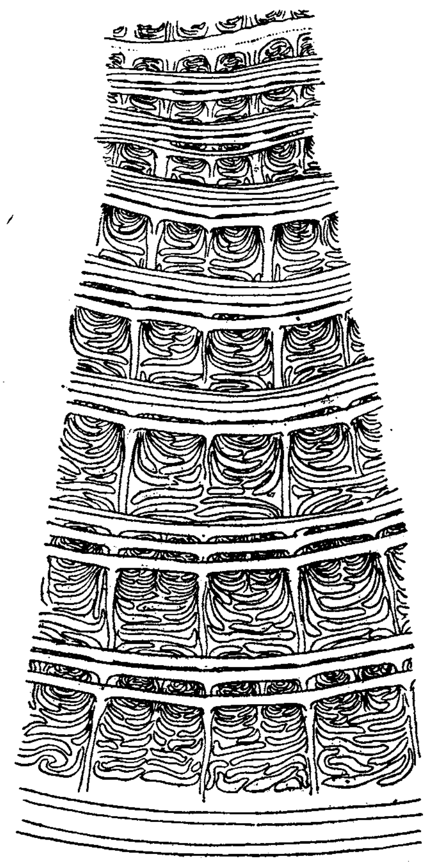


FIG. 267. *Molgula citrina* Alder and Hancock. Part of branchial sac, ×15.

The testes are small pyriform or two-lobed glands lying in groups or masses against the free surface of the ovary and against the inner surface of the mantle about the border of, but not always very close to, the ovary. The sperm ducts are short and do not accompany the oviduct, according to Huntsman (1912, p. 142).

This species is viviparous, development taking place in the body of the parent. In the specimens studied (all collected during the summer months), there was generally a group of embryos and tailed larvae in various stages in the peribranchial cavity anterior to the gonad on each side.

According to Grave (1926, p. 455), the measurements of the eggs and larvae of this species are as follows: diameter of egg exclusive of the follicle, 0.2 to 0.21 mm.; body of larva, 0.32 by 0.19 mm.; tail of larva, 1.08 mm.; entire length of larva, 1.4 mm.

DISTRIBUTION: *M. citrina* was described by Alder and Hancock (1848) from the British coast but is widely distributed in the waters of northern Europe extending into the Arctic regions in that part of the world. It is not, however, known from Greenland. On the American side it has been found from the St. Lawrence estuary and gulf, south to off Martha's Vineyard Island, Massachusetts, with one record from Narragansett Bay, Rhode Island. At many places on the New England coast it is a common species, being found on bottom of various kinds provided that some firm objects for attachment are present, and occurring on the under side of stones near low-water mark, on piles, etc. The records are mostly in water less than 20 fathoms in depth, though off Nova Scotia it was collected by the "Albatross" in 126 fathoms (the deepest record).

The development of the larva of this species has been studied by Kingsley, 1882 (who supposed he was dealing with *Molgula manhattensis*), by Grave, 1926, 1937, and Berrill, 1931. Grave considered the American and European forms distinct on account of a difference in the stage of development of the larva at the time of hatching. Berrill (1931, p. 293) denies that the difference is constant. He regards *citrina* and the European *nana* or *echinosiphonica* as one species.

Molgula complanata Alder and Hancock, 1870

Text figures 268–270

This species, an inhabitant of the northern waters of both Europe and America, has been dealt with under many different generic and specific names, some of which, however, apply to it entirely or chiefly as an Old World species. The following are names used by American authors or others dealing with it as a species of American waters:

Caesira canadensis HUNTSMAN, 1912, pp. 112, 140; BERRILL, 1928, p. 52.

Caesira papillosa HARTMEYER, 1909–1911, p. 1324; 1912, p. 440; VAN NAME, 1912, p. 497, fig. 14, pl. 49, figs. 34–38, pl. 73, fig. 167. Not Huntsman, 1912 (= *Molgula provisionalis* of this work).

? *Caesira producta* VAN NAME, 1912, pp. 520, 521, in part only; SUMNER, OSBURN, AND COLE, 1913, p. 729, in part only.

Lithonephrya canadensis + *L. tenax* HUNTSMAN, 1922, pp. 5, 6.

Lithonephrya complanata GIARD, 1872, Arch. Zool. Exp. Gen., vol. 1, p. 404; HUNTSMAN, 1922, p. 5; ÄRNBÄCK, 1931, pp. 1, 5, pl. 1, figs. 6–8.

Molgula complanata ALDER AND HANCOCK, 1870, p. 366; 1907, vol. 2, p. 45, fig. 37, pl. 24, figs. 1–6; HARTMEYER, 1923, pp. 76, 77; ÄRNBÄCK, 1928, p. 44, pl. 1, fig. 10; BERRILL, 1928, p. 166; 1931, p. 295, fig. 4 (eggs and larvae).

Molgula papillosa VERRILL, 1871, p. 57, fig. 4b; 1871a, p. 362; 1872a, p. 211, pl. 8, fig. 4; 1873–1874, vol. 7, p. 43; VERRILL AND SMITH, 1873, pp. 495, 699; VERRILL, 1874, p. 363; WHITEAVES, 1874, p. 12; 1874a, p. 217; SUMNER, OSBURN, AND COLE, 1913, p. 729; HARTMEYER, 1915, p. 322; PRATT, 1916, p. 665.

? *Molgula producta* STIMPSON, 1852, p. 229; 1860, p. 2; BINNEY, 1870, p. 21, but perhaps not figs. 315, 316 on pl. 22; DALL, 1870, p. 255; VERRILL AND SMITH, 1873, p. 699, in part, but perhaps not references on pp. 502, 510 (see under *Heterostigma singulare*). Not Whiteaves, 1874, p. 12; 1901, p. 271 (= *B. pilularis*).

Molgula tenax TRAUSTEDT, 1883, p. 110; HERDMAN, 1891, p. 567 (in part); HARTMEYER, 1903, p. 137, pl. 4, fig. 3, pl. 7, figs. 4–9.

Molgulina papillosa HARTMEYER, 1914, p. 7.

Of the various additional names listed by Hartmeyer, 1923, and Ärnbäck, 1928, as synonyms of *M. complanata*, the following are perhaps the most important:

Ctenicella lanceplaini LACAZE-DUTHIERS, 1877, p. 604, pl. 23.

Ctenicella morgatae LACAZE-DUTHIERS, 1877, p. 662, pl. 24.

Lithonephria eugyranda GIARD, 1881, Compt. Rend. Acad. Sci. Paris, vol. 92, p. 1350.

Lithonephrya dicipiens GIARD, 1872, p. 404.

Molgula eugyroides HERDMAN, 1893, Ann. Mag. Nat. Hist., ser. 6, vol. 12, p. 443. Not Traustedt, 1883.

See Hartmeyer, 1923, pp. 76, 77, for other synonyms and references.

The usual form of the body in this species is more or less spherical, slightly compressed laterally. The siphons, which may equal the body diameter or length, when extended, arise rather near together on the dorsal side, sometimes from a common base or elevation of the surface. They are not entirely retractile, and even in the most contracted state of the body usually project as short tubes or conspicuous papillae. The body surface is thickly incrusted with sand and shell fragments. It is granular when cleaned off, especially on the siphons, and bears slender fibrous processes by means of which it is usually rather lightly attached to some firm object, adhering by the ventral or lateral part of the body.

It may be asked why a species of such a shape should have received the name *complanata* which it would not seem to deserve. Reference to Alder and Hancock's original description disclosed that they had but one specimen, which happened to be of low depressed form attached by the ventral side. Specimens of such a vertically or obliquely flattened form do, however, often occur and may be attached by a wide area on the ventral or ventrolateral region. To them such a specific name would apply, but usually the area of attachment is small and affects the rounded contour of the body very little.

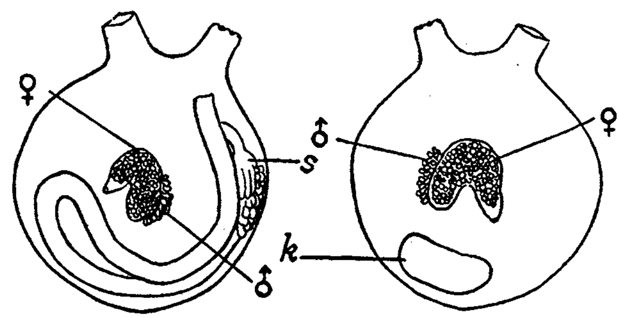


FIG. 268. *Molgula complanata* Alder and Hancock. Left and right sides of body, ×4.

It is a small species, often only 3 to 6 mm. in greatest diameter though adult; the largest example that I have examined myself measured 14.5 by 9 mm. and 7 mm. transversely, but such a size is not frequent.

The mantle is thin, semi-transparent, and with weak, more or less diffuse musculature, including bands radiating from the bases of the siphons and with very slender transverse bands in the regions each side of the endostyle.

The tentacles are subject to much individual variation in number and arrangement. The larger ones are bipinnate and usually few in number; the smallest are often entirely unbranched. Dorsal tubercle oval with a longitudinally elongate, slit-like, usually only slightly curved orifice. Dorsal lamina narrow, smooth edged anteriorly but with small teeth in the posterior part.

Either six or seven branchial folds on each side, or sometimes six on one side and seven on the other. The first fold and the last fold may be much reduced and may bear, or be represented by, only one or two internal longitudinal vessels.

The folds are all low and are separated by comparatively wide flat intervals; in fact it might better describe the condition to speak of them as rows of large low infundibula rather than folds. Each infundibulum divides in two at the summit, where the stigmata become spiral in their arrangement. Elsewhere the stigmata are rather long and wide, some nearly straight but becoming more and more curved toward the upper part of the infundibulum on which they are situated.

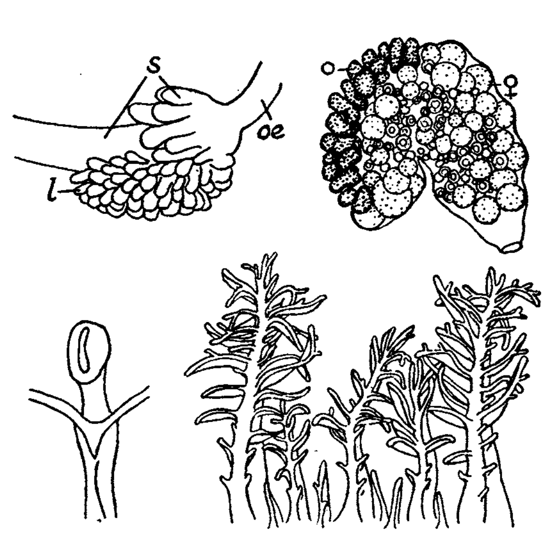


FIG. 269. *Molgula complanata* Alder and Hancock. Details: stomach showing glandular folds and hepatic tubules, gonad side next to mantle, dorsal tubercle, and group of tentacles.

The maximum number of internal longitudinal vessels on any of the folds is in many individuals only three.

Stomach with few irregular longitudinal folds in its cardiac portion, the pyloric portion being smooth walled and tapering off gradually into the intestine. Over a considerable portion of its surface, however, especially on the posterior side, there is a thick glandular mass of small rounded or short fold-like caeca opening into the stomach and constituting a hepatic organ of greater bulk than is usually present in this genus. The in-

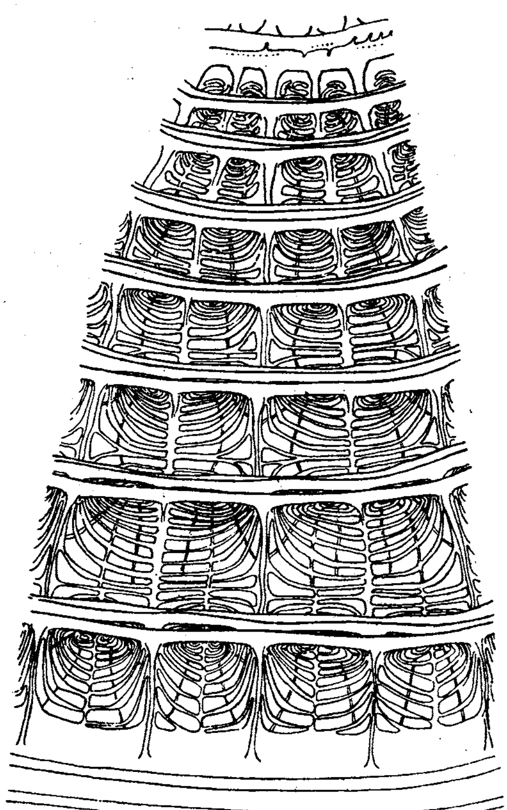


FIG. 270. *Molgula complanata* Alder and Hancock. Part of branchial sac, ×18.

testinal loop is narrow and has the reflected end bent up dorsally to a varying extent.

Kidney sausage shaped, rather wide for its length, and situated against the right posterior part of the body wall. It usually contains a few small concretions.

One gonad on each side; they are peculiar in their shape and direction, as the ovary in each is more or less bent in an inverted U-shaped curve, and the narrow, distal end where the aperture is situated (it can hardly be described as an oviduct) is directed anteroventrally, thus directly away from the base of the atrial siphon. A series of small pyriform or lobed testes borders the posterior margin of the ovary, overlapping or covering it in part. (See also remarks on p. 374 above.)

Development viviparous. In the specimens dissected (all collected during the summer months) the ovaries were greatly developed and distended with eggs of various sizes, while the testes were comparatively small, in respect to both the number and the size of the pyriform or lobed glands which composed them. The eggs, when ready to be laid, are rather large, 0.26 mm. or more in diameter. They develop into tailed larvae in the peribranchial cavity. A group of these tailed larvae was usually present in the peribranchial cavity on each side of the body near the gonad. The larvae in these groups generally measured about 0.36 mm. long exclusive of the tail, but larger, more advanced ones were also sometimes present, generally in other parts of the cavity.

DISTRIBUTION: Assuming that all the above-listed forms are specifically identical, the known range of *M. complanata* includes parts of the Arctic regions lying north of Europe (Spitzbergen, Bear Island, the White Sea, etc.) and the west coast of Greenland. On the European side it ranges south through the whole length of the English Channel; on the American side it is known to occur from the St. Lawrence estuary (specimen in the American Museum of Natural History) to off Martha's Vineyard Island, Massachusetts. It is recorded from low-water mark (at Eastport, Maine, under stones, Verrill, 1871) to a depth of over 270 fathoms off Norway (Hartmeyer), but its usual range in depth is from 10 to 20 fathoms. It lives on stony, shelly, or hard sandy bottoms and is a rather uncommon and local species. Specimens are usually found singly, though sometimes growing on or with other species of ascidians. Herdman, 1891, credited "*M. tenax*" to the West Indies by mistake.

In the present work the view of Hartmeyer, 1923, and Ärnbäck, 1928, that the various forms in the above lists represent one species only is accepted. Berrill (1931, p. 297) apparently accepts the identity of the American form with *complanata* but would treat *M.*

lanceplaini and *M. morgatae* (both European forms) as distinct because of small differences in the larvae. The consideration of the European forms is, however, somewhat beyond the scope of this work except in the case of *complanata*, which has priority over Verrill's name *papillosa*.

Stimpson's (1852) name *producta*, based on specimens from near Boston, Massachusetts, has priority over all others but has always been rejected as insufficiently described. It is only in consequence of what we have since learned of the breeding of the *Molgulas* of the New England region that his statement regarding the larvae indicates to us that he was dealing with the present species. I am unwilling to replace a name long in general use and based on a careful description and figures by one which is based on what we conjecture Stimpson's specimens "must have been."

Stimpson's (1852) description of *Molgula producta* is as follows:

"This is usually perfectly globular, while the apertures are on tubes often equal in length to the diameter of the body, which originate close together and diverge. The test is rather thin, pellucid, usually of a pale rose tint, and covered, the tubes included, with a thin coating of sand. The branchial aperture is rounded, with six short cirri within, the anal is square. Diameter half an inch.

"It occurred on a sandy bottom, in six fathoms in Boston Bay; and also at low water on Bird Island. The tadpole-like young were ejected in August, and were of a bright vermilion color, which continued for a long time after their final detachment."

"Localities, Boston Bay, sandy bottom, 6 fathoms, and at low water on Bird Island also near Boston."

I cannot question that Verrill's (1871) *papillosa* is the present species, as when I was preparing my 1912 article he himself handed me for examination the container of the types of *papillosa*. There were several specimens, no particular one especially designated, but all of this species. Huntsman, 1912, having nothing but Verrill's description covering only external features to judge by, applied the name *papillosa* to the form called *provisionalis* in this work and made a new species, *canadensis*, of the true *papillosa*. This in no way reflects either on Verrill's description or on the excellent character of Huntsman's work, for it is often impossible in the case of ascidians that cover themselves thickly with sand and debris to write a description of the external appearance that will not apply equally well (or in individual cases even better) to some specimen of another species. Indeed in the case of such ascidians, even with specimens actually in hand, we must often cut them open before we can say even what family they belong to. I do not believe Verrill ever found *M. provisionalis* at all (see below under that species).

Molgula manhattensis (DeKay), 1843

Plate 10, figures 2, 4, plate 11, figures 3, 4;
text figures 271–273

Ascidea manhattensis + *A. rustica* DEKAY, 1843, p. 259.

Ascidia amphora AGASSIZ, 1850, p. 159; STIMPSON, 1860a, p. 2; BINNEY, 1870, p. 23, pl. 24, fig. 333; DALL, 1870, p. 255.

Ascidia rustica COUTHOUY, 1838, p. 111 (not Linnaeus, 1767); GOULD, 1841, p. 319.

Ascidia manhattensis STIMPSON, 1860a, p. 2; PERKINS, 1869, p. 160; BINNEY, 1870, p. 25; TELLKAMPF, 1874, pp. 83, 84, etc.

Caesira manhattensis HARTMEYER, 1909–1911, p. 1323; 1912a, p. 14; VAN NAME, 1912, p. 471, figs. 4, 5, pl. 45, figs. 11–15, pl. 71, figs. 151, 152.

Caesira sordida VAN NAME, 1912, p. 520.

Gymnocystis manhattensis HUNTSMAN, 1922b, p. 228.

Molgula manhattensis VERRILL, 1871, p. 54, fig. 1; 1871a, p. 359; PERKINS, 1871, p. 160; VERRILL, 1872a, p. 213; VERRILL AND SMITH, 1873, pp. 699, 311, 445, etc., pl. 32, fig. 250; VERRILL, 1879, p. 27; VERRILL AND RATHBUN, 1879, p. 231; Not Kingsley, 1882, see note below; MCDONALD, 1889, p. 858; METCALF, 1900, pp. 519, 584, etc., 4 figs.; WILSON, 1900, p. 354; SUMNER, OSBURN, AND COLE, 1913, pp. 155, 729, etc.; MINER, 1913, p. 91, fig. 1; HARTMEYER, 1914, p. 7; 1915, p. 313; PRATT, 1916, p. 665, fig. 1007; VAN NAME, 1921, p. 471, figs. 153, 154; HARTMEYER (in part only), 1923, p. 56; GRAVE, 1926, pp. 454, 463, etc., pl. 1, figs. 2, 4; LUCAS, 1927, p. 243; HARANT (in part only), 1927, p. 240; 1927a, p. 3; ÄRNBÄCK, 1928, p. 20, pl. 2, figs. 31–34; BERRILL, 1928, pp. 162, 163, fig. 1a–1c; 1929, pp. 46, 52, etc., fig. 18a; 1931, pp. 288, 312, etc., fig. 1a–1f; HARANT (in part only), 1931, p. 322; HARANT AND VERNIÈRES (in part only), 1933, p. 21; PRATT, 1935, p. 750, fig. 968; RICHARDS, 1938, p. 252, fig. 44.

Molgula platei ÄRNBÄCK, 1928 (not Hartmeyer, 1914), pp. 21, 22, pl. 2, figs. 31, 34; BERRILL, 1931, pp. 298, 312, fig. 6a–6c (see remarks under *M. platei* below, p. 413).

Molgula sordida STIMPSON, 1852, p. 229; VERRILL, 1879, p. 27; VAN NAME, 1912, p. 520; 1921, p. 486. Not Sluiter, 1904.

Not *Bostrichobranchus manhattensis* Traustedt, 1883 (= *B. pilularis*).

Not *M. manhattensis* Kingsley, 1882, pp. 441–451 (= *M. citrina*). Probably not *M. manhattensis* from Casco Bay, Maine, Verrill and Smith, 1873, p. 669 (see Van Name, 1912, p. 476); probably not Kingsley, 1901, p. 182.

M. manhattensis Hartmeyer, 1921a, p. 9, 1923, p. 67, as far as it refers to *Caesira papillosa* Huntsman, 1912 (not *M. papillosa* Verrill, 1871), is not *manhattensis* but a new species (*M. provisionalis*, see below).

Body normally nearly globular except for some degree of lateral compression. Siphons diverging and usually more or less curved, originating from the dorsal surface, usually a little way apart. The atrial siphon is tapering and may equal half the body diameter in length; it has a square aperture. The branchial siphon is shorter, stouter, and more truncate, and has a six-lobed aperture. Attachment of body most frequently by an area on the left ventral region, but many individuals often grow together in large clusters or masses, and the extent and position of the area of attachment are very variable.

Test firm, tough, and moderately thick, with a finely but irregularly roughened surface. This roughness commonly develops on or near the bases of the siphons into more or less noticeable papillae, and on various parts of the body into an irregular coat of short, uneven, hair-like processes, which often catch and attach sand grains, shell fragments, bits of eel-grass, etc., sometimes in such abundance as completely to disguise the form and appearance of the animal. Occasionally specimens have a fairly smooth even coating of sand grains. In living specimens the test has a pale greenish yellow or olive color. "The branchial orifice is sometimes surrounded within by a ring of dull reddish brown, the 6 lobes have each a spot of dark brown with smaller ones between. The anal orifice is greenish yellow" (Verrill, 1871a, p. 55). The mantle, when the test is removed, is greenish, the intestine and gonads showing through it.

Large specimens measure 20 mm. to 25 mm. in their anteroposterior and dorsoventral diameters, the lateral diameter being somewhat less. The largest specimen I have seen was from Providence, Rhode Island. It measured 35 by 35 mm. in diameter when distended with water and even more when collapsed. Such size is very unusual.

Mantle musculature rather weak. Muscle bands radiating from siphons not very numerous. Over most of the body the musculature consists of rather weak and not very closely placed bands of different sizes. They cross each other in various directions, the greater number having a transverse or somewhat oblique direction.

Branched tentacles of about four orders are present in addition to a variable, but often considerable, number of minute simple or rudimentary ones. The larger tentacles are arranged with some approximation to regularity and numbered, in several specimens studied, about four of the first, four of the second, and eight of the third order, but there is much individual variation. Largest tentacles three times compound; ultimate

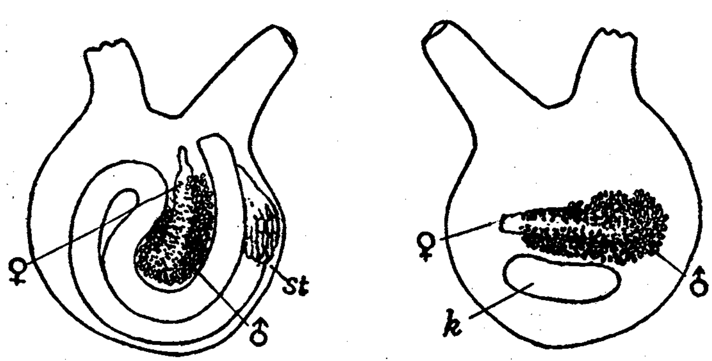


FIG. 271. *Molgula manhattensis* (DeKay). Left and right sides of body, × about 1.5.

branchlets borne numerously on the trunk and larger branches as well as on the smaller ones; their tips not at all swollen.

Dorsal tubercle aperture C-shaped or horseshoe shaped, open interval to the right or rear; horns usually strongly incurved. Dorsal lamina plain, or slightly irregularly toothed near the posterior end.

Branchial sac with six folds on each side, which are not very prominent but are conspicuous on account of the internal longitudinal vessels they bear, these being confined to the folds.

In very young individuals each fold is constituted by a row of large infundibula, one between each principal transverse vessel, and accessory infundibula are wanting or very little developed. As the age and size of the animal increase, the primary infundibula begin to divide at their summits, and numerous accessory infundibula are formed, eventually obscuring the prominence of the primary infundibula and producing in old and large individuals a somewhat complex arrangement of the stigmata.

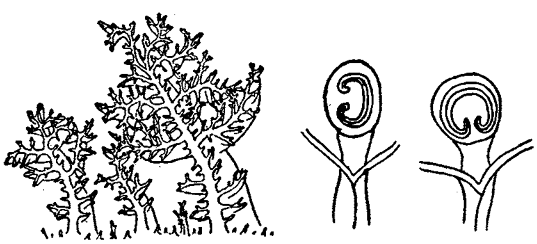


FIG. 272. *Molgula manhattensis* (DeKay). Group of tentacles and dorsal tubercles of two individuals.

The number of internal longitudinal vessels on a fold is small, ranging in adults from four to six (less often seven) on the more dorsal folds down to three, two, or even one on the ventrally situated folds. There are five principal transverse vessels, in the intervals of which there are several orders of smaller ones which are for the most part confined to the folds, though in the ventral part of the sac some of those of the second order become thicker and extend across the flat spaces and assume the role of vessels of the first order. The summit of each fold is occupied by a series of small infundibula formed by the division of the primary ones; upon these the stigmata are narrow and form single or double spirals of many turns. They are

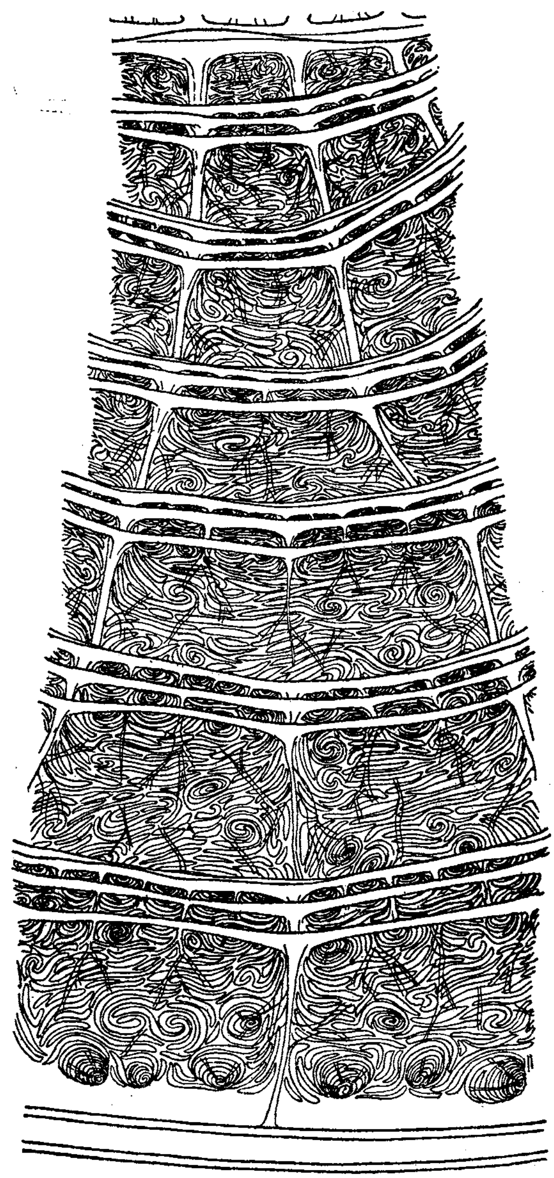


FIG. 273. *Molgula manhattensis* (DeKay). Part of branchial sac, ×15.

bridged over by the internal longitudinal vessels borne on the summit of the fold. Along the sides of the folds are less regular rows of small infundibula. On the intervals between folds the stigmata are wider but still mostly very long and narrow. Though a majority are longitudinal in direction, many of them are curved or hooked at one end, and here and there they assume a spiral arrangement, a more or less perfect infundibulum being formed. Along each side of the endostyle there is a somewhat irregular row of larger infundibula.

Digestive tract forming a narrow loop whose branches are in close contact for most of their length. The whole loop is bent in a curve of about three-fourths to four-fifths of a circle. Although there is some individual variation in the curvature, the usually very regularly circular course of the loop is an aid in recognizing this species. Wall of the proximal part of the stomach plicated with irregular convolutions. Posterior part smooth walled, tapering gradually off into the intestine. Kidney of moderate size with a slightly elongated bean-shaped outline.

The ovary, forming the central part of each gonad, has an elongated narrowly flask-shaped outline; its walls have transverse plications which do not usually constrict the interior cavity very deeply. The eggs are small and are mostly embedded in, or attached to, the thick glandular walls of the ovary. That part of the wall lying against the mantle is, however, thin and bears few or no eggs. The testis, bordering and more or less overlapping the ovary, consists of dense masses of small, distinct, mostly two- or three-lobed glands.

The ovary of the left gonad is curved, its ventral (closed) end often more or less bent up anteriorly, partly conforming to the curve of the intestinal loop; this curve with the testes bordering it makes the gonad wide at the lower or ventral end. The long axis of the left gonad is nearly vertical. The right gonad is narrower and longer than the left and is nearly anteroposterior in direction; the male glands extend along the ventral margin of its ovary (between the latter and the kidney) but reach also around its anterior (closed) end and at least a part of the dorsal margin. The difference in the direction of the long axis of the gonads on the right and left sides is very conspicuous and often furnishes the easiest means of recognizing the species, as it can be seen through the mantle (in some specimens even through the test) if they are held up to a strong light.

DISTRIBUTION: On the American Atlantic coast, *M. manhattensis* is known to range from the harbor of Portland, Maine (records from farther north and east are probably *M. provisionalis*), to Louisiana (Shell Island, Mussel Bayou, Drum Bay, etc.), and northeastern Texas, but its distribution appears to be interrupted by the Florida peninsula, as I have no records from southern Florida.

M. manhattensis is much the commonest and most conspicuous simple ascidian on the Atlantic coast from Massachusetts southward to Chesapeake Bay or beyond. It will live in highly polluted water and is still found on the shores of the island from which DeKay named it. It is also one of the few ascidians that will live in water of somewhat diminished salinity.

It may occur in European waters also, *Molgula tubifera* Oersted, 1844, syn. *Molgula ampulloides* Van Beneden, 1846, a common species on the coasts of northern Europe reported from the White Sea to Spain and Portugal, being evidently very closely allied, but I do not consider its identity with the American form as reliably established. Hartmeyer, 1923, united this and a number of other related European species of *Molgula* under the name *manhattensis*, which has priority, but in this he went altogether too far. For a discussion of this matter, see Ärnbäck, 1928.

M. manhattensis inhabits the shallowest water, often growing in abundance on the piles of wharves, the bottoms of anchored boats or floats, on which it frequently forms large groups or masses, and on eel grass (*Zostera*). The deepest reliable records that I know of are 16 fathoms in Chesapeake Bay, but such depths are apparently rather unusual.

This species has been the subject of a number of anatomical and embryological studies, which have for the most part been omitted from the above list of references and from the bibliography at the end of this work. Tellkampff's (1874) observations should, however, be mentioned as largely incorrect, and Kingsley's (1882) studies were evidently really based on another species (*M. citrina*, see Grave, 1926). The investigations of Grave, 1926, and Berrill, 1928, 1929, 1931, are most important. They show that *M. manhattensis* has very small eggs produced in large numbers and a small tadpole larva whose development ("invariably" according to Berrill) takes place outside the body. It is, therefore, rare to find even a single larva in the parent individual. The process is much the same, and the free-swimming larval stage lasts about the same length of time (1 to 10 hours) as in the European *M. tubifera*, according to Berrill (1931, p. 288), which tends to confirm the close relationship of *tubifera* and *manhattensis* alluded to above.

Grave (1926, p. 455) gives the following measurements of the mature egg and larva of *manhattensis:* diameter of egg exclusive of the follicle, 0.11 to 0.115 mm.; body of larva, 0.175 by 0.09 mm.; tail of larva, 0.555 mm.; entire length of larva, 0.73 mm.

Molgula provisionalis, new species

Text figures, 274, 275

Caesira papillosa HUNTSMAN, 1912, pp. 112, 139. Not *Molgula papillosa* Verrill, 1871; Verrill and Smith, 1873; and most authors. Not *Caesira papillosa* Hartmeyer, 1909; Van Name, 1912.

Molgula manhattensis (in part) HARTMEYER, 1923, p. 59.

? *Molgula simplex* KUPFFER, 1872, p. 363. Not *M. simplex* Alder and Hancock, 1870, and most authors.

Molgula sp. BERRILL, 1931, p. 290.

Body usually only lightly attached, obliquely ovate or elliptical, approaching a sphere in many cases, but usually the anteroposterior diameter is noticeably greater than the dorsoventral, while the width from side to side is less than either, even when well distended with water. The siphons are well developed and can be only partially retracted; even in contracted preserved specimens they almost always form large papillae or in some cases tubes, which may equal in length the body diameter. Usually they are unequal in size, the atrial commonly the larger and longer. The branchial orifice is surrounded by six slender, pointed lobes; the atrial is four-lobed or square. The tubes arise a considerable distance apart and the dorsal body outline between them is usually straight.

The body surface is fairly even but bears rather thinly scattered, irregular, crooked, hair-like processes to which more or less sand

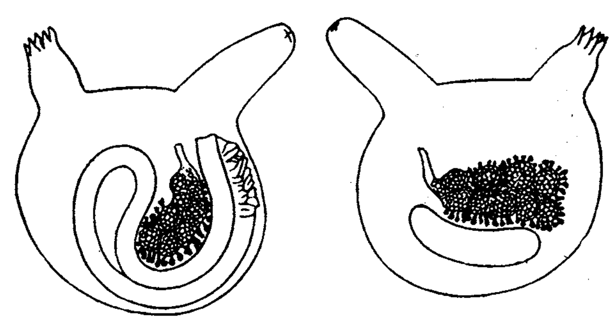


FIG. 274. *Molgula provisionalis*, new species. Left and right sides of body, ×3.

and debris usually adhere. The test is tough, yet rather thin and semi-transparent, so that the more conspicuous internal organs are often visible through it. Its external appearance is thus such as in *Molgula manhattensis*, but it is smaller and is not found in dense clusters or large masses as that species often is. Size of largest specimens examined: about 13 mm. anteroposteriorly, 11 mm. dorsoventrally, and 9 or 10 mm. transversely. In an alcoholic specimen of about that size the atrial and branchial tubes were 5 mm. and 2 mm. long, respectively, but are often longer.

In internal structure it also much resem-

This appears to be closely allied to *Molgula macrosiphonica* Kupffer, 1872, reported from the Baltic Sea and the North Sea near Ostende, although with the descriptions now available it does not seem safe to assume that they are identical. References to Kupffer's species are:

Anurella macrosiphonica PRUVOT, 1897, Arch. Zool. Exp., ser. 3, vol. 5, p. 618.

Molgula macrosiphonica KUPFFER, 1872, p. 362, pl. 17, figs. 1–8; 1875, p. 224, pl. 5, fig. 12; LACAZE-DUTHIERS, 1877, p. 530; DAMAS, 1905, p. 177, fig. 6; MICHAELSEN, 1908, p. 126, pl. 3, fig. 14; ÄRNBÄCK, 1928, p. 22, pl. 2, figs. 35–37; HARANT, 1931, p. 324; BERRILL, 1931, pp. 307, 312, etc.

Molgula manhattensis (in part) HARTMEYER, 1921, p. 9; 1923, p. 56.

bles *Molgula manhattensis*. The mantle muscles, tentacles, and dorsal tubercle are as in examples of *manhattensis* of similar size; the dorsal tubercle has its open interval to the rear or obliquely, or even directly, to the right.

The dorsal lamina usually has a few coarse teeth, especially posteriorly.

IV

V

VI

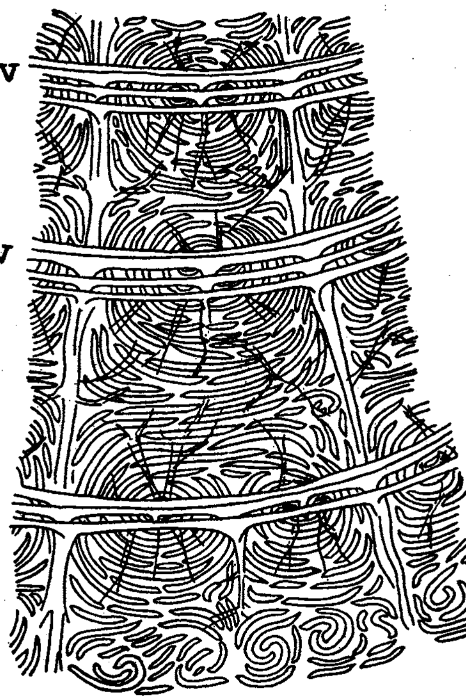


FIG. 275. *Molgula provisionalis*, new species. Part of branchial sac, ×28.

The branchial sac has six low folds separated by wide flat intervals; the internal longitudinal vessels are confined to the folds, and in the specimens studied number not over five or six (Huntsman says up to eight) on the more dorsal folds, decreasing to three or even two on the sixth fold.

The principal infundibula, though low and flat because of the low folds, are better developed and more regular than in *manhattensis* and are so large that those of adjacent folds come close together. As a result there is not much space between them for the development of the small supplementary infundibula and spirals which are conspicuous on the flat intervals in *manhattensis;* these occur in the present species chiefly dorsal to the first fold and ventral to the sixth (along the endostyle).

The large infundibula divide into two only at the extreme summit (along the ridge of the fold). In the case of the sixth fold there are two well-formed infundibula between adjacent primary transverse vessels instead of only one. In the European *M. macrosiphonica* Kupffer, the stigmata are short and quite irregularly arranged and the infundibula scarcely at all developed, so that the sac has a very different appearance, according to Michaelsen's (1908) figure 14, which is from a photograph.

The alimentary canal in *M. provisionalis* has the blind end of the loop more opened out than it is in *manhattensis*, and the whole loop is usually less bent. The kidney is curved and rather elongate; the gonads are as in *manhattensis* though with longer oviducts and with one very conspicuous difference. The walls of the ovary are produced into a series of rounded pouches, very easily seen through the mantle, while in *manhattensis* the ovary is much more simple in outline. The testes are in groups along the margin of the ovary or somewhat overlapping it, as in *manhattensis*. Their ducts are very slender and difficult to trace. Huntsman (1912) says: "From 1 to 4 vasa deferentia on each side (usually 2) opening not far from the inner side of the ovary. The free part of each vas deferens is extremely short and can be seen only with difficulty."

The eggs are conspicuously larger in the present species, attaining a diameter of 0.18 or 0.19 mm. as compared with 0.11 or 0.115 mm. in *manhattensis* (measurements from preserved material).

In the allied European *Molgula macrosiphonica* the development is direct without forming a tailed larva, and the development of the egg takes place outside the body of the parent. So far as I am aware, direct development has not yet been demonstrated in the American form, though no evidence to the contrary has been recorded. Berrill was not successful in fertilizing the eggs of *M. provisionalis* (see Berrill, 1931, p. 290).

Huntsman was actually the discoverer of this species, but he mistakenly identified it with Verrill's *M. papillosa*.

DISTRIBUTION: This species is as yet known only from a very limited region, extending from the vicinity of St. Andrews, New Brunswick, and the waters about Grand Manan Island, at the mouth of the Bay of Fundy, to Mount Desert Island on the Maine coast. Though *Molgula manhattensis*, a close ally of this species, occurs on the western part of the Maine coast (vicinity of Portland and perhaps Casco Bay), there is a considerable interval along the coast from which neither species has been recorded, so far as I am aware. It seems strange that, although Huntsman found this species (which he mistakenly identified with *Molgula papillosa* Verrill, 1871) to be the most abundant and generally distributed *Molgula* near St. Andrews, New Brunswick, such careful and diligent collectors as Stimpson and Verrill failed to find it at all in the extensive collecting they did in that region in the last century. That it was not present there or at least only as a rare or very local species in Verrill's time (about 1870) is confirmed by the fact that I examined the larger part of his material, most of which is still preserved, and did not find a single specimen of it. This is a striking example of the differences in the marine invertebrate fauna of the same place at different periods. (*Ciona "tenella"* Stimpson, affords another but opposite instance—the almost complete disappearance of a species that Stimpson and Verrill found common in that region.)

This is a shallow-water species. Huntsman collected it among the roots of eel grass and under stones at low water and also dredged it off Grand Manan Island, probably at no great depth. Type, A.M.N.H. No. 1459, from Bar Harbor, Maine. There would seem to be a possibility that Procter's "*M. pannosa* Verrill" which he reports (1933, p. 283) as abundant on piles just about low-water mark at Mount Desert Island was this species, though I have not seen specimens from piles.

Molgula robusta (Van Name), 1912

Plate 1, figure 3; text figures 276–278

Caesira robusta VAN NAME, 1912, p. 505, figs. 16, 17, pl. 51, figs. 43–47, pl. 73, fig. 161; HUNTSMAN, 1922b, p. 228.

Molgula koreni SUMNER, OSBURN, AND COLE, 1913, p. 729. Not Traustedt, 1880.

Molgula robusta HARTMEYER, 1914, p. 7; 1923, pp. 73, 94; LUCAS, 1927, pp. 243–246; ÄRNBÄCK, 1928, p. 24, pl. 2, fig. 38; BERRILL, 1928, p. 163; 1929, p. 52; 1931, pp. 305, 312, 333, fig. 11.

The validity of this species as distinct from *M. manhattensis* (DeKay) was questioned by Hartmeyer, 1923, but aside from the existence of noticeable differences in the adults as mentioned below, Lucas, 1927, found that while *manhattensis* has a free-swimming larva provided with a statolith, *robusta* does not pass through any free-swimming stage, and no statolith is formed. The adult of *robusta* presents the following characters distinguishing it from *manhattensis*.

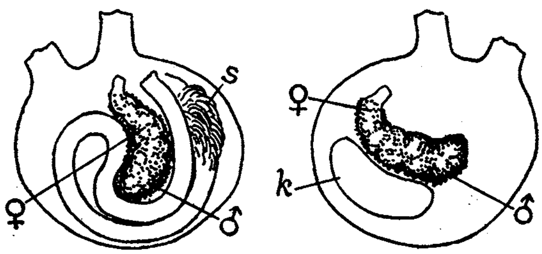


FIG. 276. *Molgula robusta* (Van Name). Left and right sides of body, ×1.8.

It averages larger and has a thicker and more opaque test; the type specimen measures 38 mm. long, 23 mm. high, though only about 7 mm. from side to side; and the body is unattached. It is found lying on its side (usually the left according to Lucas) on the sea bottom which causes it to be more or less asymmetrical, the tubes bending toward the upper side. The tubes are usually quite short and rise near together.

The body is unattached and thickly coated with coarse sand with occasionally small pebbles embedded in the surface of the test. The dorsal tubercle was C-shaped with incurved horns and open interval toward the right in the specimens examined, as in *manhattensis*, but the dorsal lamina differs in having rather long pointed teeth on the margin of the posterior part. The posterior ends of the internal longitudinal vessels often have a few similar teeth.

The branchial sac has a larger average number of internal longitudinal vessels, and the stigmata are shorter and more numerous, and they form comparatively few secondary spirals on the flat part of the sac. Distribution of the above vessels in an individual 26 mm. in greatest diameter:

0 (11) 0 (10) 0 (10) 0 (8) 0 (7) 0 (5) 0

The intestinal loop is usually more opened out at its reflected end which, moreover, does not usually approach the rectal end so closely, the whole loop being a little less bent. Although the gonads are much like those of *manhattensis*, the walls of the ovaries exhibit more marked transverse plications. The small male glands surround almost the entire border of the ovaries. Diameter of the egg exclusive of the follicle, 0.11 mm. (Berrill, 1931, p. 312).

According to Lucas the eggs (and previous to laying, also the ovaries) are reddish purple, while in *manhattensis* they are colorless.

The following observations on the breeding of *M. robusta* made at Woods Hole, Massachusetts, are quoted from Lucas (1927, pp. 243, 244):

"The eggs of *M. robusta* are usually shed at night, probably toward morning. With the eggs and surrounding them is a mucous mass, very viscous, which tends to hold them together in strings. When these strings of eggs and mucus are stirred in the sea water, considerable time is required for the mass to settle to the bottom, a condition not true for the eggs when free from the mucus. It may be that in nature the current, carrying the strings of mucus, is a means of disseminating the eggs. Eggs isolated from the mucus are not adhesive.

"The eggs in their development during the first two days show very obvious changes for

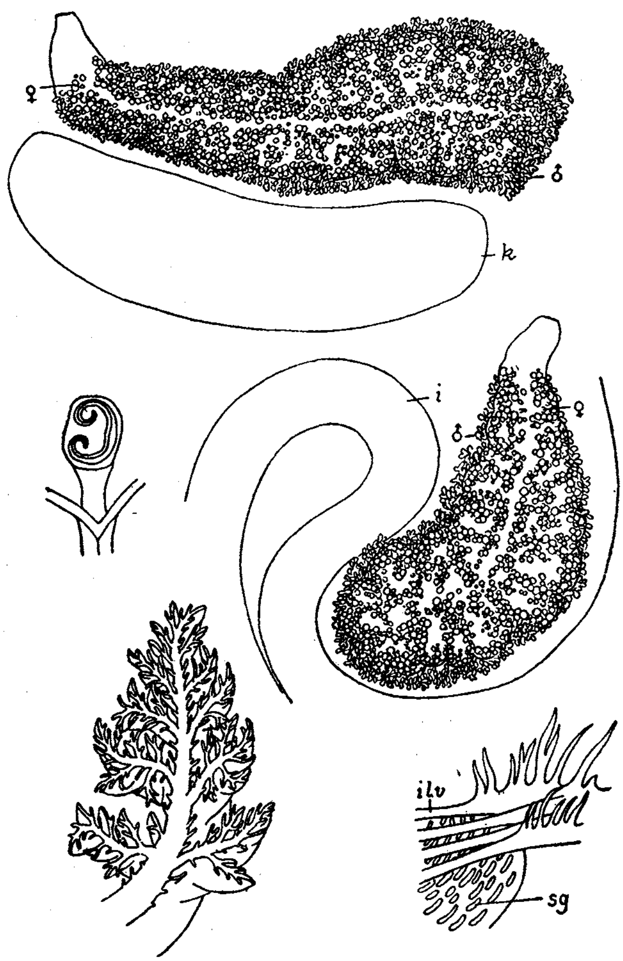


FIG. 277. *Molgula robusta* (Van Name). Details of gonads, dorsal tubercle, tentacle, and posterior end of internal longitudinal vessels showing the pointed, tooth-like processes.

the reason that the deep reddish-purple pigment renders them opaque. In two and a half days the epidermal tubes, five in number, push out from the body, but as yet they do not cause an evagination of the tunic. A day later, one of these tubes projects beyond the tunic, and by means of this epidermal tube the embryo becomes attached to the object upon which it is resting, provided attachment has not already been effected by the mucus. The embryos were observed from day to day in their development, and at no time was either a free-swimming larval stage or a statolith or similar organ noted.

"At least one statolith is always present in the tadpole of *M. manhattensis*, and this large, black, spherical body persists long after the animal becomes attached."

DISTRIBUTION: *Molgula robusta* has been found only at Woods Hole and in neighboring parts of Vineyard Sound, Massachusetts, on sandy or somewhat muddy bottoms, where there are tidal currents, in depths from about 50 to 80 feet. Even in that region its distribution is very local.

Molgula arenata Stimpson, 1852

Plate 10, figure 1; text figures 279–282

Ascidia psammophora AGASSIZ, 1850, p. 159 (description insufficient); BINNEY, 1870, p. 24, pl. 24, figs. 330, 331; DALL, 1870, p. 255.

Caesira arenata HARTMEYER, 1909–1911, p. 1324; 1912a, p. 15; VAN NAME, 1912, p. 501, fig. 15, pl. 50, figs. 39–42, pl. 52, figs. 48, 49, pl. 71, fig. 150.

Caesira psammophora HARTMEYER, 1909–1911, p. 1324.

Eugyra arenata HERDMAN, 1891, p. 569.

Euritteria (subg. *Comita*) *arenata* HUNTSMAN, 1922b, p. 226.

Molgula arenata STIMPSON, 1852, p. 230; PERKINS, 1869, p. 160; BINNEY, 1870, p. 21; DALL, 1870, p. 255; VERRILL, 1870, p. 424; 1871a, p. 362; VERRILL AND SMITH, 1873, pp. 419, 669, etc.; MCDONALD, 1889, p. 858; SUMNER, OSBURN, AND COLE, 1913, p. 729, chart 190; PRATT, 1916, p. 665; HARTMEYER, 1923, p. 74; ALLEE, 1923, p. 213 (*arenaria*); ÄRNBÄCK, 1928, pp. 12, 26, pl. 1, fig. 7, pl. 2, fig. 39; BERRILL, 1929, p. 46; 1931, pp. 303, 333, figs. 9, 10; PRATT, 1935, p. 750; RICHARDS, 1938, p. 253, pl. 28, fig. 3.

Molgula psammophora VERRILL, 1872a, p. 213, pl. 8, fig. 5.

Externally this species is commonly of very regular and symmetrical form, having an approximately circular outline when seen from one side, except that between the apertures the outline is nearly straight, and the body is considerably flattened from side to side, often

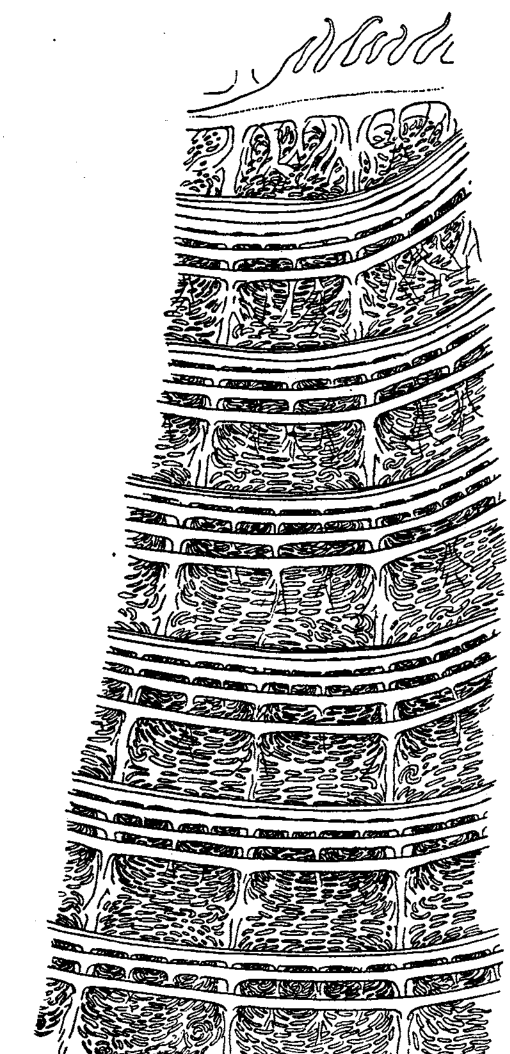


FIG. 278. *Molgula robusta* (Van Name). Part of branchial sac, ×20.

to such an extent as to be disk-like. The apertures are widely separated, their distance apart usually about equaling one-fifth of the circumference of the body, and in the contracted alcoholic specimens they often project but little, sometimes scarcely at all, beyond the general outline of the body, though capable of some extension during life. Generally the body is smooth and evenly covered with a close coat of sand grains, which extends to the lobes surrounding the apertures. The largest specimens measure 18.5 mm. to 20 mm. in length and scarcely less in depth, but often not more than 7 mm. in transverse diameter.

Test transparent or translucent, grayish or brownish in alcoholic specimens when the sand is removed, and moderately thick and tough in large specimens. When removed from the test, the body, owing to the widely separated and very short siphons, has a somewhat triangular outline with the apertures at two of the angles. The mantle is quite transparent, allowing the viscera to be clearly seen. On the sides of the body the musculature of the mantle is for the most part diffuse and very slight. The bands which radiate from the siphons are few in number and extend but a little way on the sides, though farther on the dorsal region of the body between the siphons and along the mid-ventral region. Slenderer and less regular circular bands cross the radiating bands, and between the siphons and along the ventral region near the endostyle slender, more or less irregular transverse bands are numerous and quite closely placed.

At least five orders of oral tentacles are present, the largest of which are extensively branched in an irregular tripinnate manner and usually number six, while those of the second and third orders are also much branched.

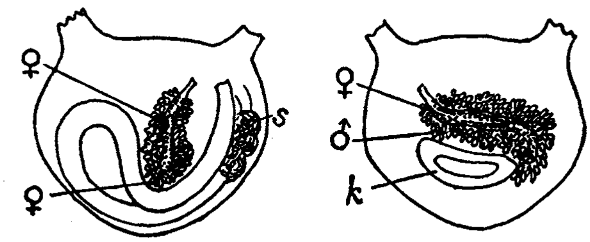


FIG. 279. *Molgula arenata* Stimpson. Left and right sides of body, ×3.

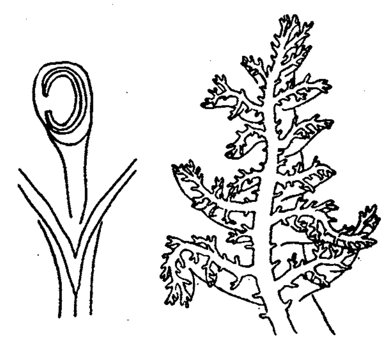


FIG. 280. *Molgula arenata* Stimpson. Large tentacle and dorsal tubercle.

Dorsal tubercle generally with a plain C-shaped opening; the horns not spirally rolled. They usually turn to the right.

Dorsal lamina plain for much of its length.

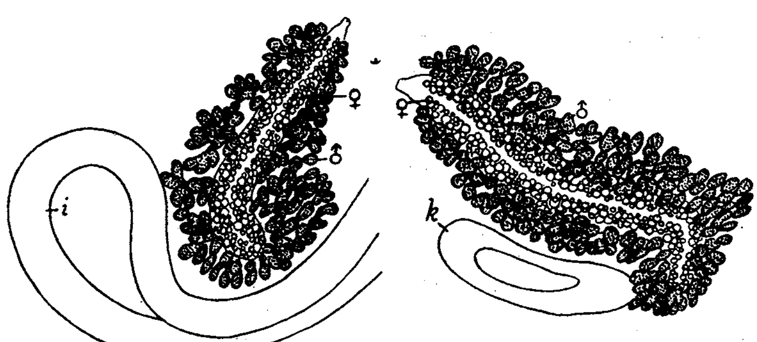


FIG. 281. *Molgula arenata* Stimpson. Left and right gonads, ×9.

Posteriorly it becomes very broad and bears small triangular teeth. Similar but longer and narrower teeth (only four or five in number) occur on the extreme posterior end of some of the internal longitudinal vessels.

Branchial sac of delicate structure with six folds on each side. These folds are but slightly prominent, and each might perhaps be better described as a row of infundibula bridged over longitudinally by a group of internal longitudinal vessels. These vessels are usually confined to the folds or lie close to the bases of the folds. They numbered on the right side of two fairly large individuals about as follows:

0 (7) 0 (6) 0 (6) 0 (5) 0 (4) 0 (4) 0
0 (7) 0 (8) 0 (7) 0 (6) 0 (5) 0 (3) 0

Between each two large vessels (first or second order) there is a single large infundibulum on each fold. It divides more or less completely into anterior and posterior cones separated by a vessel of the third order. Stigmata between and on the basal portion of the infundibula long and often exceeding in width the vessels separating them; this makes the sac very delicate. Dorsal to the first fold, and ventral to the last fold, the stigmata are irregularly arranged and curved.

Stomach wall with a few shallow, widely separated folds in addition to numerous small convoluted glandular folds which completely occupy most of the surface of its cardiac portion and form a fairly extensive secreting organ of a green color. The intestine forms a loop whose branches are rather widely separated for some distance from the reflected end, which, owing to the bending of the whole loop, is considerably turned upward (dorsally). The margin of the anus is apparently plain, or nearly so.

Kidney large, somewhat narrowed toward the ends, and very slightly curved with the concavity dorsal. It lies against the body wall in the right ventral region and generally contains one very large concretion.

Gonads in the usual position in the concavity dorsal to the intestinal loop and dorsal to the kidney. Each consists of an elongated tubular ovary (constricted at the end which is directed toward the atrial siphon, but not greatly produced), bordered nearly all around by the small pyriform, or two- or three-lobed testes. The left ovary has a nearly dorsoventral direction and is often somewhat bent

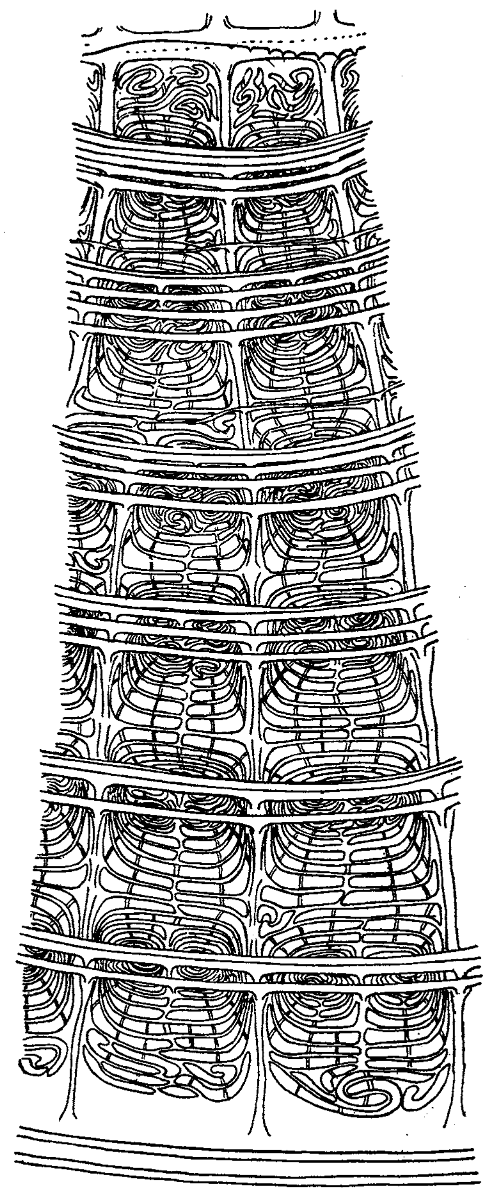


FIG. 282. *Molgula arenata* Stimpson. Part of branchial sac, ×15.

posteriorly at the ventral end; the right ovary lies more nearly horizontal and its closed end bends abruptly down around the anterior end of the kidney, but does not enclose that end of the kidney as it does in *M. occidentalis*.

Reproduction and development: oviparous; no tadpole larva is formed; eggs 0.11 mm. in diameter exclusive of the follicle. (See Berrill, 1931, pp. 303, 304, 333, figs. 9, 10.)

DISTRIBUTION: South shore of Cape Cod to off Cape May, New Jersey, on sandy bottoms in shallow water, the recorded depths ranging from 3 to 25 fathoms. The majority of the records are in the region of Woods Hole and Martha's Vineyard, Massachusetts. It lives buried in the sand, usually without attachment to any solid object, and I do not believe the reports of this species by Visscher, 1927, as one of those that fouls ships' bottoms.

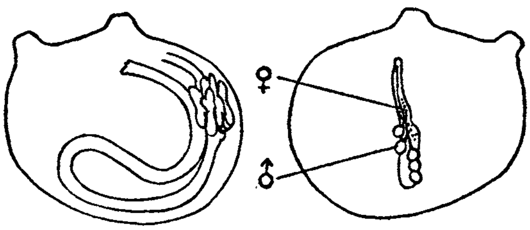


FIG. 283. *Molgula verrilli* (Van Name). Left and right sides of body, ×4. (No left gonad or kidney was found, perhaps due to mutilation of only specimen.)

Molgula verrilli (Van Name), 1912

Text figures 283–285

Caesira verrilli VAN NAME, 1912, p. 516, fig. 20, pl. 53, figs. 53–57; HARTMEYER, 1912b, pp. 374, 378.

Molgula verrilli HARTMEYER, 1923, p. 75; ÄRNBÄCK, 1928, p. 57.

Molgulina verrilli HARTMEYER, 1914, p. 7.

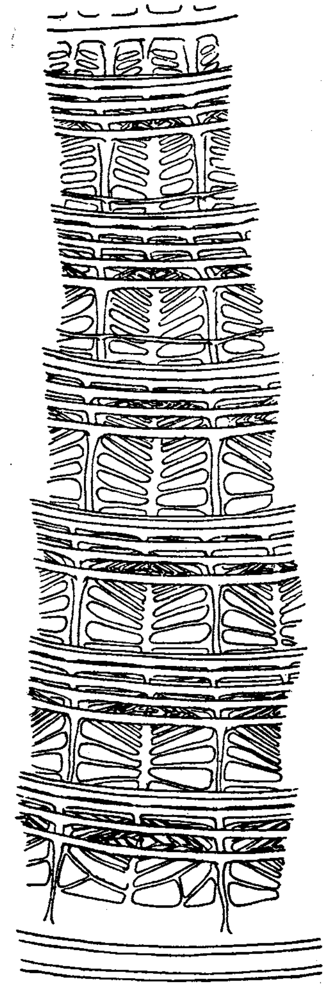


FIG. 285. *Molgula verrilli* (Van Name). Part of branchial sac, ×18.

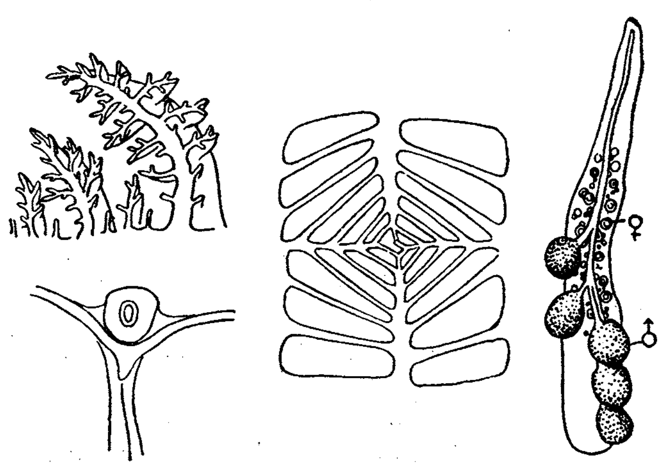


FIG. 284. *Molgula verrilli* (Van Name). Details: group of tentacles, dorsal tubercle, arrangement of stigmata on the infundibula, and right gonad.

Only one badly mutilated specimen of this small deep-sea species was obtained. The following is somewhat condensed from the original description.

The only specimen is of rather regular form, measuring about 9 mm. long, 7 mm. deep, and 5.5 mm. transversely across the body. The siphons, which are drawn in almost even with the surface of the body, arise rather near together on the anterior part of the dorsal surface. The atrial siphon has the orifice distinctly four-lobed; the lobes of the branchial siphon cannot readily be counted in its strongly contracted condition. Test of moderate and even thickness; it would be somewhat transparent were it not quite thickly and evenly covered with Foraminifera, sand grains, etc.

Musculature of the mantle rather weak and composed entirely of very slender fibers.

Tentacles of at least four orders rather regularly arranged, the largest, which are bipinnate, numbering about eight. Dorsal tubercle with an oval orifice. Dorsal lamina narrow, plain edged.

Branchial sac with six folds on each side. They do not represent much plication of the wall of the sac, but are conspicuous from the groups of internal longitudinal vessels which are almost entirely confined to the folds and are raised on high supporting papillae.

The stigmata are rather few, broad and short, and between the folds are longitudinal or only slightly oblique in direction. As the summit of a fold is approached they become more oblique until they lie at an angle of about 45 degrees to the transverse vessels, becoming at the same time smaller and shorter, and assuming an arrangement in spirals whose centers lie at the summit of the folds midway between the transverse vessels. The spiral is, however, an angular one, made up of straight stigmata successively shorter as the center is approached, and each placed at right angles to the preceding one of the series; the stigmata do not in this species exhibit the tendency to curve that is usual in the genus *Molgula*. These spirals are raised into low pyramidal infundibula having a square base.

Stomach wall with a number of longitudinal plications forming capacious caeca. Intestinal loop quite widely open at the reflected end, the whole bent into a curve widely open dorsally.

No kidney and no left gonad were demonstrated in the mutilated specimen, but the writer is not inclined to believe that they were wanting, nor to question that this species is a true *Molgula*.

The gonad on the right side contains an elongated tapering tubular ovary with a few eggs in various stages of development. Its smaller end, where the orifice is situated, is directed dorsally toward the base of the atrial siphon. The male part of the organ consists of only five large rounded glands lying beside the ventral part of the ovary. Their efferent ducts unite to form a common sperm duct running beside the ovary and apparently reaching nearly to the dorsal end of that organ.

LOCALITY: The only specimen was dredged in the deep water off the eastern edge of Georges Bank at Station 2572 (40° 29′ N., 66° 04′ W., 1769 fathoms, gray ooze).

Molgula lutulenta (Van Name), 1912

Text figures 286–288

Caesira lutulenta VAN NAME, 1912, p. 468, figs. 2, 3, pl. 45, figs. 7–10, pl. 73, fig. 168.

Molgula lutulenta HARTMEYER, 1914, p. 7; VAN NAME, 1921, p. 474, fig. 155; HARTMEYER, 1923, p. 73; ÄRNBÄCK, 1928, p. 26. Not *Molgula lutulenta* Herdman, 1923.

This is a small species of elliptical outline with the apertures on low papillae near together on the dorsal side, projecting very little in the contracted preserved specimens. The greatest body diameter (anteroposterior) does not actually exceed about 15 mm., but its surface is densely covered with long, moss-like, fibrous processes to which fine sand and mud adhere, making it appear larger and giving it the appearance of a ball of mud.

Test thin, though tough, the mantle very delicate with poorly developed muscles.

Tentacles chiefly of three sizes or orders, quite regularly arranged, those of the first two orders apparently usually numbering six each and those of the third order 12. A few tentacles of the fourth and fifth orders (the last merely small unbranched papillae) occur in the spaces between the larger ones. Dorsal tubercle clearly seen in one specimen only. In this it had an elongated, very slightly curved, slit-like orifice placed almost transversely. Dorsal lamina plain edged anteriorly,

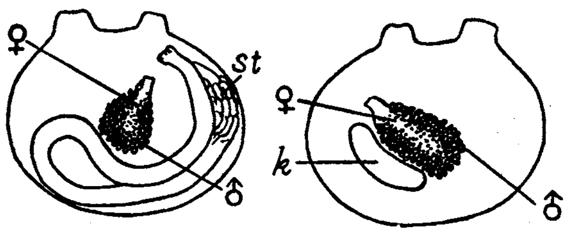


FIG. 286. *Molgula lutulenta* (Van Name). Left and right sides of body, ×3.

but the margin of its posterior portion is, in some individuals at least, obscurely denticulate.

Branchial sac of very delicate structure with six folds on each side. Each fold virtually consists of a single row of six large infundibula which are separated by the five large first-order transverse vessels and bear seven or eight internal longitudinal vessels on the folds in the dorsal part of the sac. Their arrangement in a fairly large individual is as follows:

0 (7) 0 (8) 0 (7) 0 (6) 0 (5) 0 (4) 0

Each infundibulum divides into two at the summit. No secondary infundibula were ob-

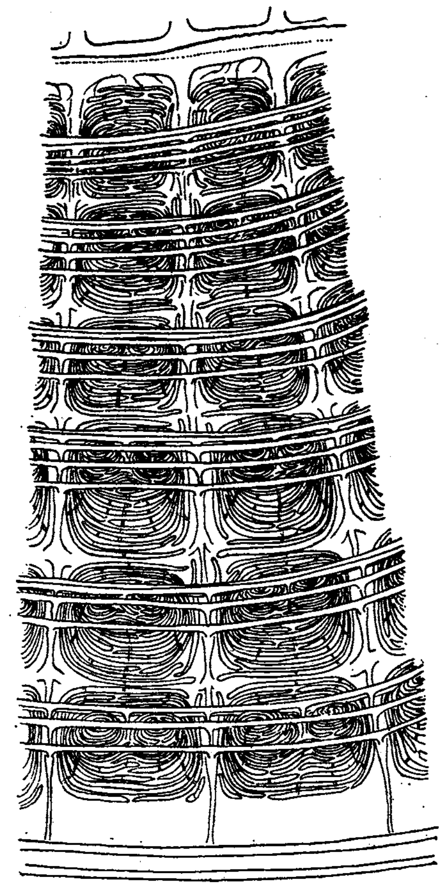


FIG. 288. *Molgula lutulenta* (Van Name). Part of branchial sac, ×12.

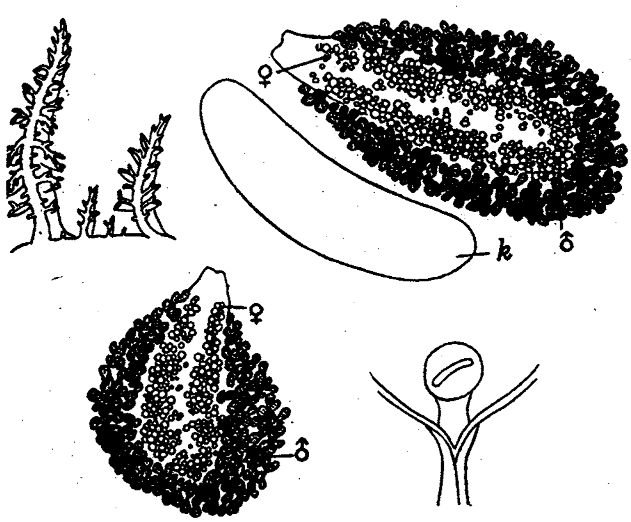


FIG. 287. *Molgula lutulenta* (Van Name). Details: group of tentacles, right and left gonads, ×10, and dorsal tubercle.

served. The stigmata (almost confined to the infundibula) are very long and narrow and regularly spiral in their arrangement, though not continuous from base to summit of the infundibula. The free ends of the spirals generally terminate at the odd-numbered transverse vessels.

Intestinal loop fairly widely open for some distance from its reflected end. The whole loop is much less bent than in many of the other species of this genus, the reflected part being only slightly turned up toward the dorsal side of the body. Stomach wall with rather numerous irregular glandular folds.

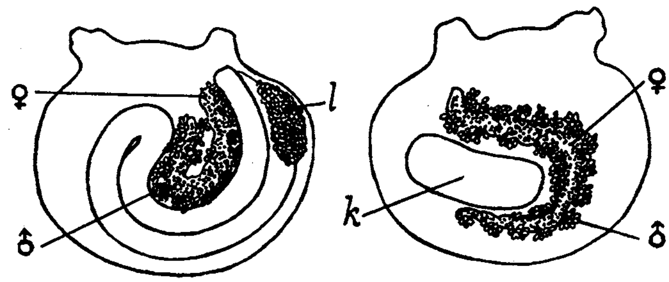


FIG. 289. *Molgula occidentalis* Traustedt. Left and right sides of body, ×15.

Kidney rather small, sausage shaped, and only moderately wide. It has an oblique position against the body wall in the right posterior ventral part of the body.

The gonads, which have the usual positions dorsal to the intestinal loop and the kidney, respectively, are unusually wide and short. Each consists of a central flask-shaped ovary (containing in all the specimens studied very numerous small eggs) bordered, except at and near the small open end, with the numerous small-lobed or pyriform testes.

This species, readily distinguished by the fine, moss-like processes on the outer surface and by the long, spirally arranged stigmata and the short, broad gonads, is found in moderately deep water. Most of the specimens which I know of were dredged by the United States Fish Commission in a small area off the eastern coast bounded by north latitude 39° 48′ and 40° 07′ 48″, and by west longitude 69° 56′ and 71° 48′ 48″, in from 67 to 142½ fathoms. However, four specimens obtained by the steamer "Albatross" at Station 2338, off Havana, Cuba, in 189 fathoms, are apparently also referable to this species. It lives buried in mud or fine sand.

Molgula occidentalis Traustedt, 1883

Plate 19, figure 5; text figures 289, 290

Caesira occidentalis HARTMEYER, 1909–1911, pp. 1323, 1629.

Euritteria occidentalis HUNTSMAN, 1922b, p. 226.

Molgula occidentalis TRAUSTEDT, 1883, pp. 113, 129, pl. 5, figs. 4, 5, pl. 6, fig. 14; HARTMEYER, 1914, p. 7; VAN NAME, 1921, p. 467, figs. 147–152; 1924, p. 32; ÄRNBÄCK, 1928, p. 27; VAN NAME, 1930, p. 506, figs. 71–73; PEARSE AND WHARTON, 1938, p. 645.

Molgula sp. STIMPSON, 1860, p. 443.

Body of rounded or oval outline; the depth may or may not exceed the length. It is not much compressed laterally. Apertures on the dorsal side, usually situated not far apart, sometimes sunk in the depressions between rounded prominences of the test that are present on that part of the body, in other cases raised on low papillae. Examples may often be found growing attached to mangrove roots, dead coral, etc., but usually not very firmly. Whether they sometimes live unattached buried in the sand of the sea bottom I do not know. The species reaches a considerable size; one from Lemon Bay, Florida, in the United States National Museum measured 65 mm. in length, 62 mm. dorsoventrally, and 38 mm. transversely, but such a size is unusual, and a specimen over 38 or 40 mm. in greatest diameter is a large one.

Test rather thin, though tough, on most parts of the body; on the dorsal region it often becomes quite abruptly very rough, thick, and hard. The surface is sometimes roughened by rather fine wrinkles and much incrusted with mud, sand, shell fragments, etc., these materials being in part embedded in the test and in part adherent to short fibrous processes with which parts of the surface are provided, but some specimens have much of the body bare of foreign matter and fairly smooth. The color is usually that of the incrusting sand or mud; where the surface is exposed it is of a dingy yellowish or gray

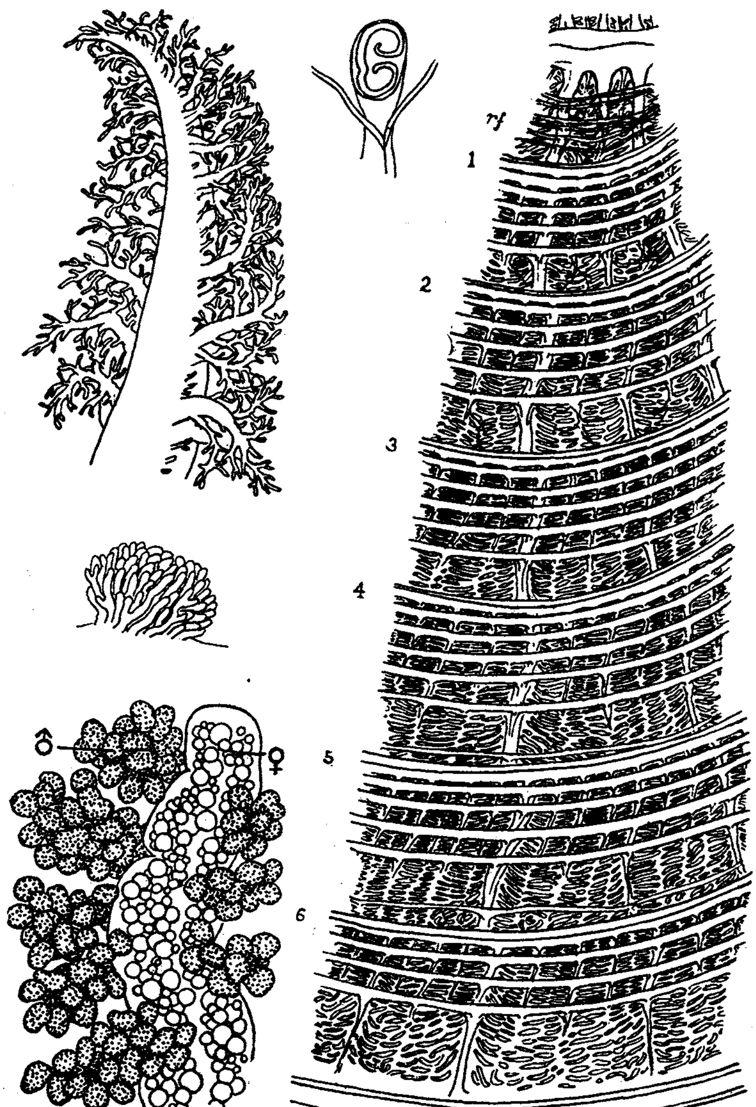


FIG. 290. *Molgula occidentalis* Traustedt. Details: large tentacle, dorsal tubercle, part of branchial sac, ×12, hepatic tubules, and closed end of left gonad, ×15.

color, about the apertures sometimes deep red.

Mantle thin and semi-transparent, sometimes dark colored. There are a few stout muscle bands radiating from the tubes and extending part way down the sides, and, as shown in Traustedt's figures, there are rows of short transverse bands on many parts of the sides and ventral region, and well-developed circular muscles about the apertures.

About a dozen large, three times compound tentacles are present in the largest specimens, beside some additional smaller tentacles. Dorsal tubercle aperture C-shaped; open interval more or less directly to the left in all of a number of specimens in which this character was examined; horns inrolled. Dorsal lamina plain edged.

Branchial sac with six well-developed folds on each side, though an additional incomplete dorsal one may be present; they are broad and sharply defined and bear many internal longitudinal vessels in large specimens.

Distribution of the internal longitudinal vessels in a medium-sized individual:

Left	0 [5] 1 (11) 0 (12) 0 (11) 0 (10) 1 (9) 1 (7) 0
Right	0 [6] 0 (12) 0 (12) 1 (10) 1 (10) 0 (8) 0 (6) 0

In a larger example, 39 mm. long, which was without any trace of the extra fold, the vessels were distributed as follows:

Left	8 (15) 1 (17) 1 (16) 2 (14) 1 (11) 1 (9) 0
Right	7 (17) 1 (16) 1 (14) 2 (12) 2 (10) 1 (7) 1

Four (in the ventral parts of the sac often five) orders of transverse vessels are recognizable on the folds, where they are quite regularly arranged. On the flat spaces between folds the smaller ones become irregular and often disappear. In young and small individuals the general arrangement of the stigmata is much as in *M. manhattensis*. There are well-formed infundibula with spiral stigmata along the summits of the folds; on the flat parts of the sac the stigmata are narrow, mainly longitudinal and usually not much curved, though a few incipient secondary spirals may be formed, especially in the ventral region.

In old and large specimens the infundibula become less conspicuous and the above-described arrangement of the stigmata, though not entirely lost, is less easily noticed, except on the folds, which are often very high and compressed to almost knife-like sharpness. The stigmata on the flat areas and on the lower parts of the folds may acquire an arrangement in dorsoventral columns by the development of more transverse vessels of the smaller orders so that in extreme cases the branchial sac may have an appearance suggesting to a careless observer that of one of the Pyuridae rather than of a member of the present family.

Intestinal loop very narrow (its branches in contact for most of the length). It is bent into about three-quarters of a circle. Stomach with a large, greenish hepatic gland consisting of an immense number of very minute, short, sparingly branched tubules. Kidney large and broad, elongate oblong in shape; usually not much curved.

A large gonad is present on each side of the body. Each gonad consists of an elongate, curved, tubular ovary bordered along its sides with clusters of small oval or more or less lobed or branched male glands. Right gonad very long and narrow and bent around the kidney so as to surround all except the posterior part of it. The dorsal end of the ovary, where the aperture for the discharge of the eggs is situated, is bent dorsally toward the base of the atrial tube. Left gonad also elongated, situated in the curve formed by the dorsal side of the digestive tract. In large specimens, but not in young or poorly developed ones, the ovary is bent into a U-shaped curve; the small groups of male glands lie, in the specimens studied, chiefly along the outside of the curve (hence between the ovary and intestine), often somewhat overlapping the ovary, but some are in the bend of the loop formed by the ovary. When well developed the left ovary and testes form a compact group, broad below and narrow above (that is, in the dorsal part), the bend of the intestinal loop being completely filled. The sperm ducts from the individual glands lie on the surface of the ovary next to the branchial sac, but I could not demonstrate that they unite to form a single common duct for the whole gonad. The egg diameter in this species is 0.11 mm., according to Berrill, 1937.

The gonads furnish the best means of recognizing this species, as they are usually easily seen through the mantle as soon as the animal is removed from the test.

DISTRIBUTION: This species ranges from North Carolina (Fort Macon, near Beaufort, and the mouth of the Cape Fear River) to the West Indies (Puerto Rico, off Guanica Playa, 18 fathoms; Guanica and San Juan harbors; and Curaçao,) but is especially common on the Florida coasts, where it is the principal representative of the family. It ranges in depth from low-water mark, often growing on mangrove roots, to 21 fathoms (off the west coast of Florida). Traustedt's type was from the West Indies (probably from the former Danish possessions). It has not been reported from Bermuda.

Although it has not been reported from the American Pacific coast, a few small, sand-incrusted specimens from Lower California represent it, or a form so very closely allied to it that I cannot distinguish it specifically.

The two largest of the specimens are only about 13 or 14 mm. in anteroposterior and a little less in dorsoventral diameter, and are somewhat compressed from side to side. The external characters are as in *occidentalis*. In the position of the siphons, the thin, dark-colored mantle and its musculature, the dorsal tubercle, dorsal lamina, alimentary loop, and kidney, no differences from *occidentalis* were noted. The tentacles (likewise profusely branched) and the internal longitudinal vessels of the branchial sac were apparently somewhat fewer which, however, would be expected in such small specimens. The infundibula of the branchial sac were well formed and conspicuous; the stigmata conformed to the description given of young specimens of *occidentalis* as given under that species. The shape of the gonads corresponded to those of that species, especially in the bending down of the right gonad around the anterior end of the kidney.

West coast localities: One specimen was collected by the "Albatross" expedition of 1911 at San Bartolomé on the west coast of Lower California, no depth given. Four other specimens, one about the size mentioned above, and three smaller ones, were dredged by F. E. Lewis near Espiritu Santo in the Gulf of California in 15 fathoms.

Molgula habanensis, new species

Text figures 291, 292

This species shows relationship to *M. regularis* and *M. malvinensis* in the form of its gonads but resembles *M. lutulenta* in its external characters and branchial sac.

The body is of ellipsoidal form, the anteroposterior diameter the greatest; the apertures (six- and four-lobed, respectively) both on the dorsal aspect and not prominent, at least in the alcoholic specimens; the test soft and flexible and densely covered with rather short crinkled hairs, very numerous and so fine that only minute sand grains adhere to them. The largest examples I have seen do not much exceed 10 mm. in greatest diameter; they had evidently lived buried in fine sand on the sea bottom.

In alcoholic specimens the animal is readily removed entire from the test; the mantle is tough but thin and transparent, allowing the gonads, which are conspicuously yellow in color, and other internal structures to be distinctly seen. The mantle musculature comprises a rather small number of narrow, sharply defined bands radiating from the apertures and extending well down on the sides; those of the two apertures do not cross much. There are more superficial circular muscles about each of the two apertures; on most parts of the body the musculature is slight and diffuse and does not interfere with the transparency of the mantle.

The development of the tentacles varies much in different individuals; large, profusely branched ones, evidently to be considered as of the first order, commonly number from six to 10; several orders of smaller ones are present but seldom show regularity of arrangement throughout more than a part of the circle, and are often poorly developed or sometimes lacking in other parts.

The dorsal tubercle has a longitudinally elongate aperture in the form of an ellipse which is uninterrupted or nearly so. Dorsal lamina smooth edged.

The branchial sac has six sharply defined folds on each side, the last, however, much lower than any of the others; on the higher ones there may be as many as 10 or 11 internal longitudinal vessels, counting those present on both aspects, some of which end in an upturned tooth at the posterior end. None of these vessels occur on the flat intervals. There are seven principal transverse vessels, the odd-numbered ones the stoutest. On the first five folds there is a large, somewhat pyramidal infundibulum in each of the spaces marked off by these vessels (eight on each fold). These infundibula show only a slight tendency to divide at the summit. The stig-

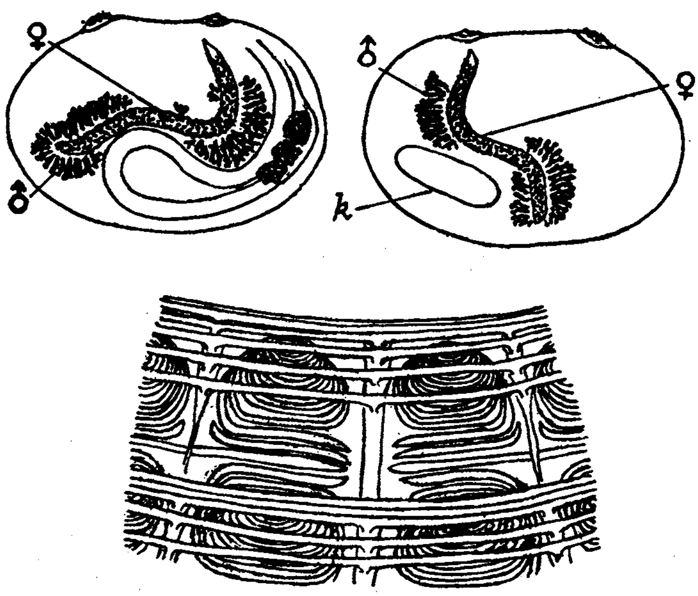


FIG. 291. *Molgula habanensis*, new species. Left and right sides of body. ×6, and piece of branchial sac.

mata on them are spiral, long, and narrow, with only few interruptions. On the flat parts of the sac there are a few long, nearly straight stigmata. In the fifth (ventral-most) fold there are sometimes two infundibula between primary transverse vessels; in most respects the structure of the branchial sac approaches that of *Molgula lutulenta*, but the stigmata are not so narrow, nor do they make so many turns on the infundibula.

The stomach has a hepatic organ on its dorsal and exterior aspect composed of several compact lobes of small, short, secreting tubules. The intestinal loop is rather narrow, though fairly well opened out at the anterior end, which is a little upturned dorsally.

The gonads of each side have a very long, somewhat sinuously curved tubular ovary closely adherent to the mantle. The testes are not very numerous and vary in shape from pyriform through clavate forms usually branched at the closed end, to considerably ramified shapes suggesting those in many *Styela* (*S. partita*, for instance). They are attached to the mantle on either side of the ovary, but either a little removed from it or just touching it, not ordinarily overlapping it. They are not, however, arranged uniformly along the ovary but in more or less definite groups usually located approximately as shown in figure 291. Apparently each gonad may have a common sperm duct, but this was not demonstrated with certainty. The ovary on the left side lies dorsal to the intestinal loop; the anterior part, however, extends far in front of the reflected end of the loop. The right side gonad lies dorsal to the rather elongate, oblong kidney, bending down also around its anterior side. The distal parts of both gonads bend up abruptly dorsally to end near the atrial aperture.

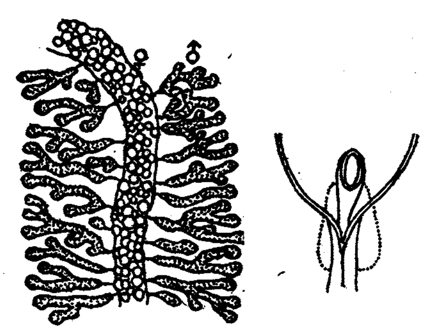


FIG. 292. *Molgula habanensis*, new species. Part of a gonad, and dorsal tubercle.

LOCALITY: About a dozen specimens were dredged by the steamer "Albatross" at Station 2338, off Havana, Cuba, in 189 fathoms, January 19, 1885. The bottom was evidently fine sand. Type in the American Museum of Natural History (A.M.N.H. No. 1864).

Molgula contorta Sluiter, 1898

Text figure 293

Molgula contorta SLUITER, 1898, p. 28, pl. 2, figs. 39, 40; VAN NAME, 1921, p. 486.

Molgulina contorta HARTMEYER, 1914, p. 7; VAN NAME, 1921, p. 486.

Body spherical, 9 mm. in diameter, nearly completely covered with sand grains which adhere to filaments of the test. Apertures square on short siphons situated near together. Test thin, gelatinous, with numerous filaments.

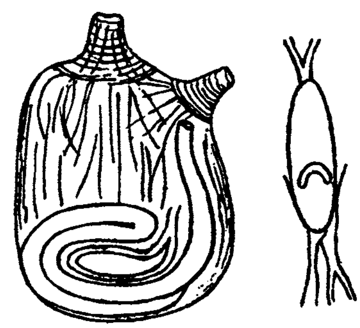


FIG. 293. *Molgula contorta* Sluiter. Left side of body and dorsal tubercle. Outlines from figures of Sluiter.

Mantle thin and delicate, with weak muscle bands. Tentacles all branched, eight large and eight small alternating. Dorsal tubercle elongate oval, the aperture horseshoe shaped, the open interval to the rear. Nerve ganglion immediately over the dorsal tubercle. Dorsal lamina narrow and smooth margined.

Branchial sac with seven folds on each side, only four internal longitudinal vessels on each fold. Stigmata arranged as in the genus *Eugyra* and in *Molgula eugyroides* Traustedt, the infundibula corresponding in position with the folds and dividing in two at the summit, but the spirals not very perfect, their turns more or less irregular.

The alimentary tract is only very briefly described and the gonads not at all. Yet the peculiar course of the intestine forming a completely closed primary loop and a very narrow transverse secondary loop in which the gonad of the left side lies is clearly shown in the figure here reproduced from Sluiter's work. The gonad conforms in shape to the secondary loop of the intestine.

LOCALITY: Sluiter described this species, which as far as I know has not yet been found again, from two specimens from Rio Hacha, Goajira, Colombia, depth 6 to 7 meters.

Molgula eugyroides Traustedt, 1883

Text figure 294

Molgula eugyroides TRAUSTEDT, 1833, pp. 110, 112, pl. 5, figs. 1–3; VAN NAME, 1921, p. 486. Not Herdman, 1893; not Hartmeyer, 1912c (see Ärnbäck, 1931, pp. 11, 12).

Molgulina eugyroides HARTMEYER, 1914, p. 7.

Body unattached, elongate ellipsoidal, thickly covered with sand. Greatest diameter, 10 mm. Test thin, membranous, transparent.

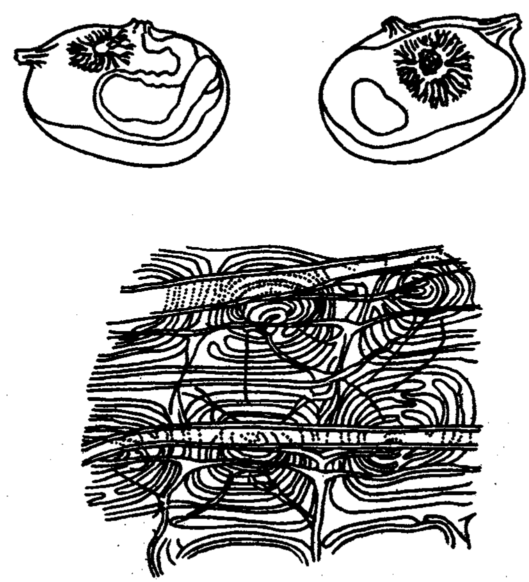


FIG. 294. *Molgula eugyroides* Traustedt. Left and right sides of body and piece of branchial sac. Outlines from figures of Traustedt.

Mantle musculature very weakly developed, reduced to some transversely running, very short fibers between the apertures. Branchial opening on the fore part of the back and directed forward; atrial opening about the middle of the back, both on short, fully retractile siphons well furnished with muscles. Large tentacles about 12 in number. Dorsal tubercle rather large, aperture linear with a very slight curvature, concavity to the right side. Ganglion elongate, lying close behind the dorsal tubercle.

Branchial sac strikingly reminiscent of the genus *Eugyra* except that there are actual folds. There are six strongly dorsally curved folds on each side; the internal longitudinal vessels in the vicinity of the gullet project out in rather long, irregular papillae. There are three to four of these vessels on each fold; stigmata as in the genus *Eugyra;* one infundibulum in each field. Dorsal lamina long and high, margin with a few but prominent projections.

Intestine forming an open loop which extends far forward. The stomach is inconspicuous and goes over gradually into the intestine, which becomes narrow in the middle part and widens again toward the anus.

Gonads, as in other species of the genus, one on each side, placed well up toward the back and of stellate form.

LOCALITY: Harbor of Bahia, Brazil. Reported Norwegian localities are incorrect (see Ärnbäck, 1931).

I am not aware that this peculiar species has been found again since Traustedt's description and figures were published. Hartmeyer, 1914, made this the type of a genus *Molgulina* chiefly on the ground of its *Eugyra*-like branchial sac.

The "stellate" form of the gonads of this species is due to the grouping of the elongate testes in a radial manner about the rounded, centrally situated ovary.

Molgula platana, new species
Text figure 295

The very small size and contracted condition of the specimens make a detailed study very difficult, but they so closely resemble *M. siphonalis* of the northern seas that they seem to furnish a good instance of bipolarity, if that term may be used in the case of a species from as far north as the mouth of the La Plata River.

In a lateral view the body is rounded or ovate and somewhat compressed from side to side; the apertures are not externally prominent but were probably capable of considerable extension during life; the branchial is well forward and the atrial considerably removed from it on the dorsal aspect.

The body appears to have been only lightly attached or, in some cases, perhaps merely anchored in coarse sand; one specimen has a small, stalk-like process from the lower surface, but this is apparently not a pedicel but a process to aid in attaching the body to some slender object, perhaps a hydroid stem. The largest specimens are only 7 to 8 mm. in diameter.

The test is thin but tough; it is transparent and bears scattered minute papillae and, especially on the lower parts, a few slender crooked hairs. The specimens were more or less covered with very coarse sand grains, which were, however, so slightly attached that most of them soon came off.

The mantle is thin and has slender, more or less separated muscle bands which do not much interfere with its transparency. On the siphons there are well-developed sphincters, and bands extend a little way down on the

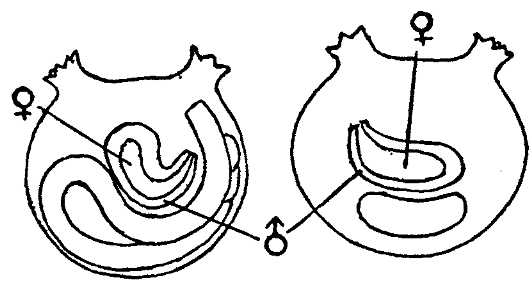


FIG. 295. *Molgula platana*, new species. Left and right sides of body, ×12.

sides from the siphons and from the area between them. The region of the endostyle throughout most of its length is crossed by transverse bands which end after extending a little way up on the sides. There are also areas or rows of short bands placed side by side on the sides of the body but these do not form networks, and they leave the central area of the sides of the body (where the gonads are located) almost free from muscles.

Owing to the contracted condition of the anterior region I could not count the tentacles; in the only specimen in which I demonstrated the form of the dorsal tubercle the aperture was C-shaped with incurved horns and the open interval to the left and somewhat toward the rear. The body axis is much curved in the species; the endostyle is, in consequence, very long and the dorsal lamina very short. The latter is wide and smooth margined.

The branchial sac much resembles that of

M. siphonalis. It has seven sharply defined folds, the higher ones usually with five or six stout, internal, longitudinal vessels on the ventral leaf of the fold (counting in one that may be a little way off the base on the adjacent interval) and two or three slender, less well-developed ones on the dorsal leaf of the fold.

The folds are composed mostly of a row of well-developed infundibula on which the spirals formed by the stigmata are quite regular and not much interrupted. On the intervals between folds the stigmata are elongate and mostly straight. I did not observe any accessory infundibula.

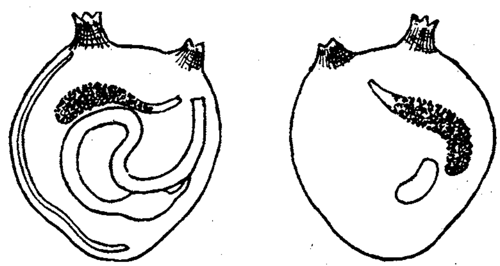


FIG. 296. *Molgula pyriformis* Herdman. Left and right sides of body. After figure of Hartmeyer, 1922b, drawn from Herdman's type.

The intestinal loop is fairly well opened out at the reflected end, and the whole tract so bent as to form a fairly deep secondary loop, in the concavity of which the left gonad is placed, conforming in shape more or less to its curvature; the right gonad is dorsal to the rather large and somewhat curved kidney.

Both gonads are of irregularly ovate form and quite broad; the elongate ovary occupies the axial part and, in the case of the left gonad, is considerably curved. The open ends of the ovaries bend up dorsally, but I could not demonstrate that they are produced into even a short oviduct. The ovary is covered on its mesial aspect and broadly bordered and overlapped on all sides by the very numerous testes which are pyriform or elongate and somewhat branched; I could not demonstrate the sperm ducts. In all the specimens the gonads are very large relative to the body size, giving the appearance of adult condition, but the eggs in the ovaries are very small.

LOCALITY: "Albatross" Station 2764, near the mouth of the La Plata River, 36° 42′ S., 56° 23′ W., 11½ fathoms. Type in the American Museum of Natural History (A.M.N.H. No. 1858).

The possibility of the identity of this species with *M. pyriformis* (see below) is not excluded, but differences in the form and position of the gonads and the fact that that species is from deep water make it seem best to treat them as distinct for the present.

Molgula pyriformis Herdman, 1881

Text figure 296

Caesira pyriformis HARTMEYER, 1912b (in part), pp. 373, 374, 378.

Molgula pyriformis HERDMAN, 1881, p. 236; 1882, p. 79, pl. 6, figs. 1–3; HARTMEYER, 1922b, p. 316, figs. 12, 13.

Not *M. pyriformis* Michaelsen, 1900, 1907; not *Caesira pyriformis* Hartmeyer, 1909–1911, 1911b, 1912b, except in so far as these names refer to Herdman's type.

The body in the only specimen obtained is inverted conical and laterally compressed, with the apertures (not prominent) widely apart on the truncated upper end; height, 20 mm., greatest width at top, 15 mm.

Test thin, sand covered, and opaque. Mantle thin, with muscle bands radiating from the apertures. "Over the rest of the mantle the commonest form of muscle band is a short, thick fusiform clump of fibers."

Tentacles numerous, branched, "of many sizes arranged indefinitely." Dorsal tubercle with a simple funnel-like aperture.

Branchial sac delicate, with seven folds on the right and six on the left, folds composed of large infundibula with the stigmata in interrupted spirals. On the flat intervals the stigmata are mostly straight. There are eight internal longitudinal vessels on the larger folds (six on folds near the endostyle), according to Hartmeyer (see below).

The intestinal loop is widely open at the reflected end, which part is strongly bent dorsally, forming a deep secondary loop.

Herdman's description and figures gave no information regarding the gonads. Due to this omission, Michaelsen and Hartmeyer incorrectly identified the species dealt with in this work as *M. pulchra* with Herdman's *pyriformis*.

Later, Hartmeyer reëxamined Herdman's type (see Hartmeyer, 1922b), correcting that and other errors and describing and figuring the gonads of the true *pyriformis*. They are elongate and of the usual *Molgula* type, somewhat curved; the left gonad is dorsal to the reflected end of the intestinal loop; the right gonad is obliquely placed dorsal to the middle of the right side (see figure). Both gonads are produced into very short oviducts.

LOCALITY: The only specimen of this deep-water species was dredged by the "Challenger" at Station 320, off Buenos Aires, 37° 17′ S., 53° 52′ W., 600 fathoms. See also remarks under *M. platana*.

Molgula malvinensis Ärnbäck, 1938

Text figure 297

Molgula malvinensis ÄRNBÄCK, 1938, p. 5, fig. 1, pl. 1, figs. 1–3.

A species sharply distinguished by the unusual form of its gonads. It otherwise closely resembles *Molgula occidentalis* in most of its characters, external and internal, though not known to reach such a large size (maximum diameter, 23 to 27 mm. in the largest examples); the apertures are near together on the dorsal side, and the body surface is thickly incrusted with sand and small debris, in part embedded and in part adhering to short, hair-like, or somewhat branched processes of the test.

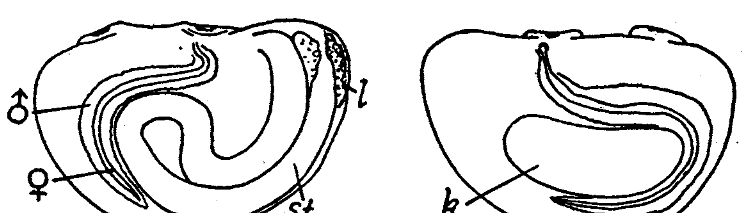


FIG. 297. *Molgula malvinensis* Ärnbäck. Left and right sides of body, ×2.5. Outlines from Ärnbäck's figures.

The description of *M. occidentalis* applies to this species in most characters as far as concerns the tentacles, dorsal tubercle, dorsal lamina (whose margin I found nearly smooth in the two specimens I examined), and the vessels and stigmata of the branchial sac whose folds may number either six or seven on a side, the stomach and the intestinal loop, though the latter is less abruptly bent back at the reflected end, leaving a considerably longer open space between the branches, and if we may judge from the few specimens available, the whole loop is less bent (see figure).

The kidney is large and bean shaped, somewhat curved, with its dorsal margin concave. The ovaries are very long, narrow tubes, tapering to extreme narrowness at the closed or ventral end. That of the right side resembles in its position and course that of *M. occidentalis*, curving around the kidney on its anterior side, but that of the left side has a very different position, lying anterior and dorsal to the reflected anterior part of the intestine and conforming closely to the outside of the curve which the latter forms, much in the manner that the right gonad conforms to the margin of the kidney. Both gonads bend abruptly dorsally to end near the atrial aperture.

The gonads did not appear to be in an active functional condition in the specimens I examined, and judging from Ärnbäck's figures they were not so in her specimens either. The ovaries contained only small eggs. The very small and numerous testes which border the ovaries along both their sides for virtually all their length, except a short oviducal part at the distal (dorsal) end, are elongate, pyriform, or clavate, often branched glands.

DISTRIBUTION: Falkland Islands, known from a few specimens obtained at Port Louis, Greenpatch, the type locality, at a depth of a few meters (Ärnbäck), and from Port William where it was dredged in 8 to 10 fathoms by Waldo L. Schmitt of the United States National Museum.

Molgula kophameli Michaelsen, 1900

Molgula kophameli MICHAELSEN, 1900, p. 125; 1907, p. 80; 1915, p. 367 (in part), pl. 16, fig. 7. Not Michaelsen, 1923, p. 56 (specimens from Brazil and West Africa).

See also remarks on *Molgula setigera*, which seems to be very closely allied.

Michaelsen's original description was based chiefly on a single specimen from the Strait of Magellan and was not accompanied by any illustration.

It was of ellipsoidal form 26 mm. long, 22 mm. high, and 20 mm. wide. Both apertures on the dorsal side, about 11 mm. apart, not raised above the surface. Body covered with coarse sand and in part overgrown with thread-like algae, but scattered, fine hairs between this adherent material appear to belong to the test ("scheinen dem Cellulosemantel des Thieres anzugehören"). The test is thin and soft but tough.

Mantle musculature strong, especially the bands radiating from the apertures. Larger tentacles 16, mostly alternating in size, three or slightly four times compound, smaller, less branched tentacles also present. Dorsal lamina long, rather narrow and smooth-margined. Dorsal tubercle with the aperture forming an irregular circle, the ends nearly in contact, the interval toward the right.

Branchial sac with seven folds with internal longitudinal vessels distributed as follows:

0 (9) 0 (9) 0 (8) 0 (8) 0 (8) 0 (7) 0 (4) 0

It is clear from the discription that well-formed infundibula with spirally arranged stigmata extend into the folds, but it is difficult to get any definite idea regarding the arrangement of the stigmata elsewhere. They are said to be mostly long and narrow (though some of them shorter), some straight, some more or less curved, though only near the endostyle is a spiral arrangement clearly apparent.

The intestinal loop is long and narrow, horizontally directed, situated near the ventral median line and bent in a gentle curve. Its branches are in close contact and are almost at right angles to the dorsoventrally extending stomach and rectum.

The gonads are described as broadly band shaped ("breit bandförmig"). The left is situated on the dorsal side of the horizontal part of the intestinal loop; it is about 13 mm. long and 2.5 mm. wide in the type. The ovary occupies the central part of the gonad, surrounded by the numerous small, pyriform testes often confluent at their narrow basal ends. A long oviduct, 6 mm. long in the type, arising from the posterior end of the gonad, bends dorsally and extends to near the atrial aperture. Michaelsen makes no mention of, and evidently did not find, a common sperm duct (see remarks under *Molgula setigera* regarding the gonads).

The right gonad lies dorsal to the kidney, extending beyond its ends both in front and behind. Kidney narrowly bean shaped, somewhat curved; its length in the type specimen, about 8 mm.

Distribution: Magellanic region. I cannot accept as reliable reports from warm or tropical latitudes. Type locality, Gente Grande, Strait of Magellan, 2 to 3 fathoms (one specimen). Michaelsen also reported specimens from off the Argentine coast in 43° 06′ S., 60° 00′ W. (56 fathoms) and 48° S., 61° W. *Molgula setigera* Ärnbäck, from the Falkland Islands, is very possibly identical with this species.

I question the identity of several small "very much softened" specimens from off Praio do Furado, Brazil (22° 30′ S., 40° 55′ W., 30 fathoms) referred to this species by Michaelsen (1923) and disagree with his view that *Molgula africana* Sluiter, 1915, from near Cape Blanco on the northwestern African coast, is also referable to this species. Neither Sluiter's description nor his figure indicates the existence in *M. africana* of the long tubular oviduct, which is one of the chief characteristics of *M. kophameli*.

Molgula setigera Ärnbäck, 1938

Plate 23, figure 5; text figure 298

Molgula setigera Ärnbäck, 1938, p. 7, fig. 2, pl. 1, figs. 4–8.

"This species is easily recognized by its peculiar external aspect, the surface of the test being more or less densely provided with long bristle-like hairs. In the largest specimen in the collection these processes form something like a bristly coating which covers the whole body, except the basal side; in the others they are more sparsely arranged on the sides of the body but around the siphons they form long tufts. Besides these bristles, the test bears an abundant growth of short hair-like processes to which sand and shell fragments adhere" (Ärnbäck, 1938).

The body is almost globular or ovate, somewhat flattened on the basal side; the siphons are very short and rather widely separated. Attachment apparently to loose gravel and shells by the basal side. The two largest specimens measured 20 by 15 mm. and 18 by 13 mm., respectively.

In internal structure it corresponds so closely to *M. kophameli* Michaelsen from the Strait of Magellan that I shall not take the space to discuss it here save in regard to the gonads. In them the resemblance is close in the two forms, the long dorsally directed tubular oviduct also occurring in *setigera*, but Ärnbäck describes the common sperm duct or vas deferens which Michaelsen apparently failed to demonstrate, probably on account of its shortness. It ends, according to Ärnbäck, close to the end of the gonad, near the base of the long oviduct.

LOCALITIES: Falkland Islands, Port Louis, Greenpatch, and Stanley Harbor, greatest depth, 10 meters; five specimens available.

Though I have resisted in the present work the temptation to unite this species with Michaelsen's *kophameli*, I consider their identity as not unlikely. The peculiar bristle-like test processes of *setigera* stand in the way of doing so, but are perhaps present in *kophameli* also, even if less numerous and less conspicuously developed in the specimens available. They may be represented by the scattered fine hairs between the adherent material referred to in Michaelsen's description.

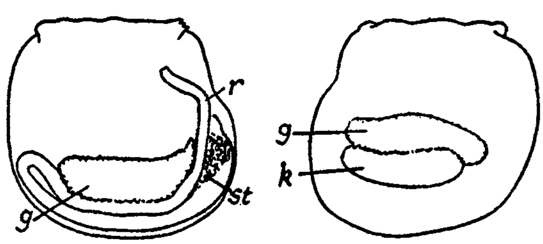


FIG. 298. *Molgula setigera* Ärnbäck. Left and right sides of body, ×2.2. Outlines from figures of Ärnbäck.

Molgula pulchra Michaelsen, 1900

Text figure 299

Caesira enodis SLUITER, 1912, p. 452; 1914, p. 4, pl. 1, figs. 3–7.

Caesira georgiana HARTMEYER, 1909–1911, p. 1323.

Caesira pulchra HARTMEYER, 1909–1911, p. 1324.

? *Caesira pyriformis* var. *kerguelenensis* HARTMEYER, 1919b, p. 519, pl. 55, figs. 10–12.

Molgula georgiana MICHAELSEN, 1900, p. 132; SLUITER, 1932, p. 2.

Molgula pulchra MICHAELSEN, 1900, p. 128, pl. 3, figs. 17, 18; 1907, p. 81; SLUITER, 1932, p. 1.

Molgula pyriformis (in part, not Herdman, 1881) MICHAELSEN, 1900, p. 131, pl. 3, fig. 16; 1907, p. 81.

The probability is that all the above references apply to the same species.

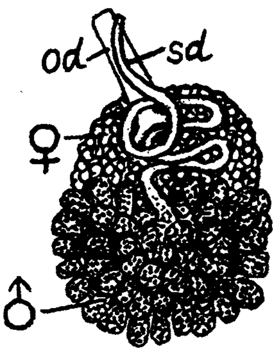


FIG. 299. *Molgula pulchra* Michaelsen. Gonad seen from the side next to the branchial sac, × about 10.

Seen from the side, the body is slightly elongate, oval or nearly round and usually somewhat laterally compressed and often partly covered with sand or debris attached to crooked, hair-like processes of the test. The apertures are on papillae or more or less prominent tubes or short siphons which arise from the dorsal surface a varying distance apart in different individuals. They have the usual six and four lobes, respectively, but these are not usually evident externally in contracted specimens where small, pointed processes on the terminal part of the siphons may be more conspicuous than the true lobes. Sluiter, 1932, records a specimen 25 mm. in diameter; a diameter of 12 to 15 mm. is the usual size.

The test is firm but thin; it would be transparent were it not for the covering of sand. The mantle is rather thin with a light but diffuse musculature, though there are distinct bands that extend down the sides from the bases of the siphons. The intestinal tract and gonads are usually clearly visible through the mantle.

Branchial tentacles of several sizes and quite numerous; including very small ones, the total number may be about 60. They are only sparingly (sometimes very sparingly) branched; the small ones not at all. Dorsal tubercle small, inverted conical, with a small, pit-like aperture, or a curved slit. Dorsal lamina plain; owing to the great curvature of the body axis, it is very short, while the endostyle is very long and much curved.

Branchial sac with seven or sometimes only six folds on each side; they are only slightly elevated and are rendered conspicuous chiefly by their internal longitudinal vessels. There are usually only two or three, rarely four, vessels on each fold except the last, which is rudimentary and has but one or two vessels; none are present on the intervals between folds. The transverse vessels are very slender; the stigmata form a row of large, often imperfect, spirals or slightly raised infundibula on each fold. On the flat parts of the sac the stigmata are rather short and mainly straight and longitudinal, though here and there accessory spirals are present. The infundibula are strengthened by a few radial vessels on the inner surface of the sac.

The stomach is rather elongate and bears a hepatic organ composed of compactly massed, very short glandular tubules. The intestinal loop is very narrow, its proximal and distal branches close together for most of their length. The whole tract is bent in a curve approximating to a semicircle, or the bend may be somewhat abrupt in the region of the stomach and the anteriorly extending part comparatively straight.

The left gonad is situated dorsal to the intestine in the widely open secondary loop of the latter; the right gonad is close to the small, slightly curved, bean-shaped kidney, either in the concavity of the latter or more anterior to it. Each gonad consists of an ovary of more or less rounded or oval outline; a tubular oviduct of moderate length arises abruptly from its dorsal margin. The testis covers in part the unattached surface of the ovary, extending beyond the border of the ovary around part of its circumference (though not on the dorsal part of the border). The testis is composed of small clavate glands somewhat radially arranged in the marginal part of the organ. The long common sperm duct is characteristic, as it lies upon the free surface of the ovary and makes several tortuous loops upon it before straightening out into a terminal part which accompanies (always?) the oviduct. This is a viviparous species.

DISTRIBUTION: Type locality, South Georgia (Michaelsen, "*M. pulchra*"; Sluiter, 1932) in 10 meters depth. It has been collected at various points in the Subantarctic and Antarctic parts of the Western Hemisphere in shallow water (7 to 70 fathoms where depths are recorded); in the region of the Strait of Magellan (Punta Arenas, "*M. pyriformis*"; "Albatross" Station 2773, 52° 23′ S., 68° 11′ W., 10 fathoms); Tierra del Fuego, Haburton Harbor (Michaelsen, 1900, "*M. pyriformis*"); Palmer Archipelago (Sluiter, 1914, "*C. enodis*"). See also remarks under *Molgula confluxa* (Sluiter), 1912, below.

Caesira pyriformis var. *kerguelensis* Hartmeyer (1911b, p. 519, pl. 55, figs. 10–12) from Kerguelen Island, may also be this species.

Molgula pedunculata Herdman, 1881

Text figure 300

Caesira concomitans HARTMEYER, 1909–1911, p. 1739.

Caesira hodgsoni HARTMEYER, 1909–1911, p. 1739.

Caesira maxima HARTMEYER, 1911b, p. 417, pl. 45, fig. 2, pl. 48, figs. 1–4.

Caesira pedunculata HARTMEYER, 1909–1911, p. 1739; SLUITER, 1914, p. 3, pl. 1, figs. 1–2.

? *Molgula angulata* ÄRNBÄCK, 1938, p. 9, fig. 3, pl. 1, figs. 9, 10.

Molgula concomitans HERDMAN, 1910, p. 15, pl. 5, figs. 1 (part), 2–7.

Molgula hodgsoni HERDMAN, 1910, p. 11, pl. 3, figs. 7–13.

Molgula maxima SLUITER, 1905b, p. 472; 1906, p. 47, pl. 3, figs. 44, 45, pl. 5, fig. 59.

Molgula pedunculata HERDMAN, 1881, p. 234; 1882, p. 74, pl. 5, figs. 1–3; SLUITER, 1906, p. 48; ÄRNBÄCK, 1938, p. 11.

In uniting the above species, I am following Sluiter, 1914, and more or less strongly expressed opinions of Hartmeyer, 1911b, and Ärnbäck, 1938.

This is a large species, probably the largest member of the genus. Apparently specimens up to 4 cm. in diameter are not unusual, and Sluiter reports examples 18 cm. long and 8 to 10 cm. wide.

I have not had an opportunity to examine specimens myself, but from the various descriptions it can be gathered that the body is generally somewhat rounded or pyriform, with some lateral compression, and generally attached by an area on the anterior part of the ventral aspect which may sometimes be produced (as in Herdman's type) into a short, wide peduncle, though not to an extent to make the specific name *pedunculata* a well chosen or, for most specimens, a descriptive one. The apertures are a little way apart on more or less prominent siphons; the position of the attached area makes the atrial the more prominent of the two. The body surface is generally free from much incrustation and rather smooth, except for a roughening due to minute, short outgrowths most numerous near the siphons. These have been described by Herdman as small "tag-like excrescences." The test is grayish in color, of firm, tough consistency and more or less translucent.

The mantle musculature consists of transverse and longitudinal bands and is moderately developed, especially on the siphons. The tentacles are of various sizes; eight or more of them are large and much branched, alternating in size; there are also smaller ones in varying numbers. Dorsal tubercle large and prominent, its aperture U- or C-shaped with incurved or more or less inrolled horns, the open interval usually to the rear and somewhat to the left. The body axis in this species is much curved, making the endostyle and the ventral folds very long and forming a large arc of a circle, and the dorsal lamina, which is wide and smooth margined, very short.

The branchial sac is characteristic and affords one of the strongest reasons for uniting the species here considered as synonymous. It normally has seven well-developed folds, the last one or last two lower than the others, with a fairly large number of internal longitudinal vessels on the folds, and several, sometimes as many as six or eight (an unusual number in a *Molgula*), on the intervals between folds. The stigmata are more or less irregular, mostly short and straight or somewhat curved and, according to the descriptions, rarely form spirals or infundibula (never, according to some statements, which would be hard to believe in a *Molgula*).

Sluiter, who had the best series of specimens, described the intestinal loop as narrow, but it is evidently subject to much variation, from the statements and figures of the different authors. The whole intestinal tract is usually bent to form a deep secondary loop.

The gonads are situated as usual in the genus and are sausage shaped (more or less curved, according to Hartmeyer's figures) or "half moon-shaped," according to Sluiter. The ovary terminates in a short oviduct directed toward the atrial siphon, according to Herdman, 1910, and to Sluiter's figure.

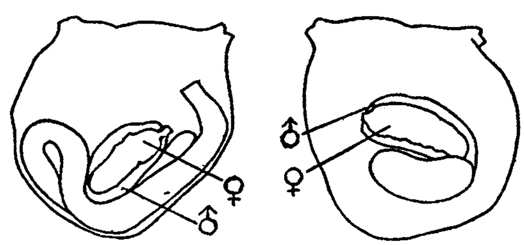


FIG. 300. Outlines from figure of "*Molgula angulata*" Ärnbäck, ×2.5, which is very close to, if not identical with, *Molgula pedunculata* Herdman.

DISTRIBUTION: If we are correct in uniting these various supposed species, this is apparently a circumpolar Antarctic and, to some extent, Subantarctic form. Herdman's type of *pedunculata* was from south of Kerguelen Island in 150 fathoms. Sluiter's *M. maxima* was obtained near Booth Wandel and Antwerp Islands, and *M. angulata* Ärnbäck at Paulet Island, in the western Antarctic region.

Molgula bacca Herdman, 1910

Text figure 301

Caesira bacca HARTMEYER, 1909–1911, p. 1739; 1911b, p. 414, pl. 45, fig. 1.

Molgula bacca HERDMAN, 1910, p. 13, pl. 4, figs. 1–5; ÄRNBÄCK, 1938, p. 12, fig. 4.

This Antarctic species is a stalked form so much like *M. griffithsii* of the Arctic and northern regions that it will suffice to mention the differences. It attains about the same size. In one case the stalk or pedicel nearly equaled the body in length; in the others it was much shorter.

In the available specimens the open interval of the dorsal tubercle was directed to the

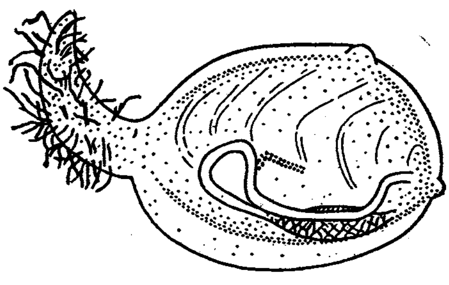


FIG. 301. *Molgula bacca* Herdman. Left side of body, ×1.5. After Ärnbäck.

left (in *griffithsii*, usually at least, toward the right).

The branchial sac has seven folds on each side instead of only five as in *griffithsii*, and the internal longitudinal vessels are more numerous, reaching in the largest example about 14 on most of the folds, on the last fold only eight or nine.

LOCALITIES: Known from only three specimens, only one of which was obtained in the western Antarctic (southeast of Seymour Island, 64° 20′ S., 56° 38′ W., 150 meters). The other localities are McMurdo Bay (type locality, Herdman) and off Kaiser Wilhelm II Land, 385 meters, Hartmeyer.

This species and *M. griffithsii* are a striking instance of bipolarity of related species.

Molgula confluxa (Sluiter), 1912

Text figure 302

Caesira confluxa SLUITER, 1914, p. 6, pl. 1, figs. 14–18.

Microcosmus confluxus SLUITER, 1912, p. 454.

Described from a single specimen measuring 17 by 12 by 10 mm. The two siphons are short but rather wide, and only 6 mm. apart. Apertures rather indistinctly lobed, the branchial with six, the atrial with four lobes.

Body surface weakly wrinkled, without foreign matter and of a soiled gray color. Test thin but coriaceous and pearly on its inner surface.

Mantle weakly muscular; tentacles about 30 in number, comprising two sizes, sparingly branched. Dorsal tubercle with an aperture of reversed S-shape. Dorsal lamina narrow and smooth margined. The branchial sac has six narrow folds; the first and sixth folds have three or four internal longitudinal vessels, the others six. None on the intervals between folds. Stigmata short, mostly straight or little curved.

At the rear end of the sac the internal longitudinal vessels of each fold join to form a single one; on the right side the collective vessels of all the folds join to form a single one before entering the median dorsal vessel; on the left side most of them join the dorsal vessel separately, but those of the second and third folds join together before doing so. Only four large transverse vessels on each side of the sac; the smaller transverse vessels very irregular, forming an irregular network in which there are stigmata of various lengths, some of them a little curved, but no infundibula are formed.

The digestive canal forms a narrow loop with the branches of the intestine nearly in contact and the stomach indistinctly demarcated. The left gonad is dorsal to the intestinal loop, "arrangement of ovary and testes as usual" in the genus. A renal sac is present on the right side.

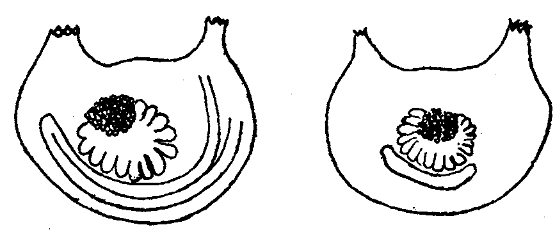


FIG. 302. *Molgula confluxa* (Sluiter). Left and right sides of body. Outlines from figure of Sluiter.

Sluiter's illustration, which is far from satisfactory, shows the left gonad to be of slightly ovate outline, the ventral part evidently composed of the testes, the dorsal part the ovary. Some features of this species are suggestive of *M. pulchra*. Perhaps the peculiarities of the branchial vessels were individual abnormalities.

LOCALITY: Antarctic, King George Island, South Shetlands, depth 75 meters.

Molgula platei Hartmeyer, 1914

Text figure 303

Molgula platei HARTMEYER, 1914, p. 8, figs. 2, 3.

Not *Molgula platei* Ärnbäck, 1928, pp. 21, 22, pl. 2, figs. 31–34 (= *M. manhattensis*); not Berrill, 1931, pp. 298, 312, fig. 6a–6c (= *M. manhattensis*).

A species known only from one specimen from Calbuco, Chile, which in most of its characters agrees so closely with *Molgula manhattensis* that it is impossible even by Hartmeyer's careful description and figure of the single specimen to determine definite differences separating the two species. Hartmeyer remarks that it is the first species of that section of the genus *Molgula* known from the Pacific.

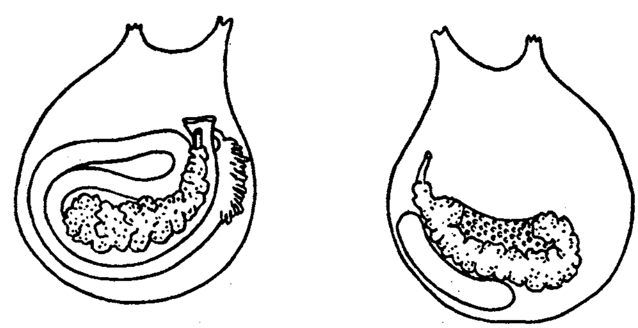


FIG. 303. *Molgula platei* Hartmeyer. Left and right sides of body. After Hartmeyer's figure of the type.

He fails to give the measurements of the specimen, but judging from his statement that the kidney was 12 mm. long, his figure indicates an exterior body diameter of well over 20 mm. The external surface is described as in part quite smooth, with a few inconspicuous processes for attachment, mostly on the basal part.

The figure reproduced from Hartmeyer's article shows the general form of the body, intestinal loop, kidney, and gonads. The tentacles number 32 (8+8+16) plus some additional minute ones; the dorsal tubercle is C-shaped, the interval toward the right and a little toward the rear. The branchial sac has six folds, which are not very high, and have but few vessels: 0 (4) 0 (3) 0 (3) 0 (3) 0 (2) 0 (2) 0. There are well-developed infundibula that divide once or sometimes twice in the folds. The description of the stigmata on the flat parts of the sac indicates a close resemblance to that described and figured in the present work for *M. manhattensis*.

As the gonads are seen through the mantle, the ovary is largely or quite concealed by the testes. Hartmeyer says nothing about finding eggs or larvae in the peribranchial cavity, and makes no suggestion that the species is viviparous.

Ärnbäck (1928, p. 21) makes the surprising and, in the opinion of the present writer, entirely incorrect statement that *M. platei* is found on the east coast of North America. Her belief to that effect was based on the fact that among a lot of specimens of *M. manhattensis* from the coast of New Jersey which I sent her in response to a request for specimens of that common American species, she found two individuals in which there were tailed larvae (very small, according to her statement) in the peribranchial cavity. On learning of her discovery I dissected many remaining specimens of the same lot and found no larvae whatever; they were all undoubtedly specimens of *M. manhattensis*. Neither have I found larvae in any of the very numerous specimens of *M. manhattensis* from other localities which I have studied. It is, however, quite possible that in rare instances some obstruction might occasion the retention of some larvae in the body. Moreover, it is entirely unexplained on what Ärnbäck based her assertion, made on page 22 of her 1928 article, that "*M. platei* produces tadpole larvae which develop in the body of the parent animal," as she nowhere makes any statement of having examined the type and only known specimen of *platei*, or of having obtained any other specimens of that South American species.

I wish to make it perfectly clear that I do not believe that *Molgula platei* occurs on the east coast of North America.

Molgula verrucifera Ritter and Forsyth, 1917

Plate 31, figure 2; text figure 304

Molgula verrucifera RITTER AND FORSYTH, 1917, p. 446, pl. 38, fig. 5, pl. 40, figs. 15–20; BERRILL, 1931, pp. 298, 333, fig. 6d–6f; 1937, p. 566.

The following description is based upon the excellent one of Ritter and Forsyth, 1917, with some condensation and certain additions.

Body usually somewhat depressed spherical, with a heavy coating of sand, usually quite firmly attached by a larger or smaller part of the ventral region. Siphons rather short and far apart, likewise covered with sand; not wholly retractile. Largest specimen, 10 by 8 by 7.5 mm. Test thin but firm with sandy covering adhering to numerous fine processes.

Mantle thin; the longitudinal muscle bands radiate from the siphons and spread out on the sides of the body so as to be separated by considerable spaces, extending to about the middle of each side. Finer circular muscle bands are confined to the siphonal regions.

Branchial System: When removed from the test, the two siphons are of about equal length though the atrial is often more slender. Branchial orifice six-lobed with tentacle-like processes inserted around its edge. Of these processes six long ones are arranged symmetrically and alternating with them are two smaller processes. Atrial orifice four-lobed, also with tentacle-like processes inserted on its edge. Branchial tentacles 16 to 20, usually of two sizes alternating; bipinnate, the tips of the branches often swollen. Dorsal tubercle with a longitudinal slit-like aperture slightly curved to one side or the other. Dorsal lamina plain, with a thickened edge.

Seven branchial folds on each side, those next to the dorsal lamina very short. Distribution of the internal longitudinal vessels in a moderately large individual:

Right	0 (3) 0 (6) 0 (6) 0 (6) 0 (6) 0 (6) 0 (4)
Left	0 (3) 0 (5) 0 (6) 0 (6) 0 (6) 0 (5) 0 (3)

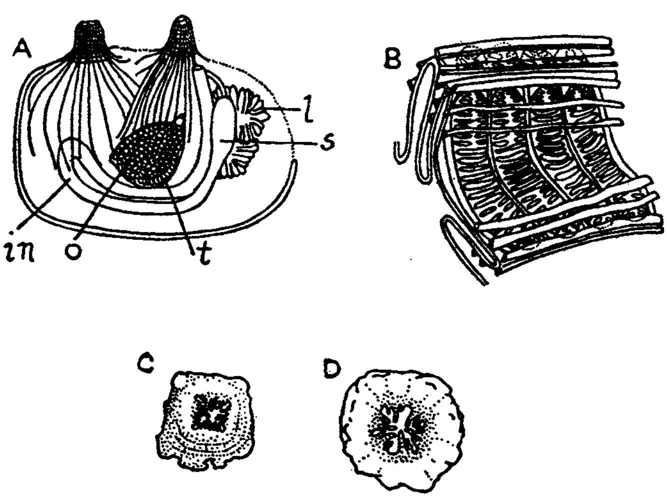


FIG. 304. *Molgula verrucifera* Ritter and Forsyth. A. Left side of body, ×4.5. B. Part of branchial sac. C. Atrial aperture showing processes. D. Branchial aperture showing processes. After Ritter and Forsyth.

The internal longitudinal vessels are distributed on both sides of the folds, usually the same number on each side, but those on convex sides always stronger. Five primary transverse vessels occur, intercepting two rather small infundibula on each fold. Secondary transverse vessels present, one between each of the two infundibula thus intercepted. Finally tertiary vessels are often found on the faces of the infundibula, where they divide the stigmata of the faces and separate the two short spirals which, in such cases, often occur at the apices of the infundibula, though usually the stigmata at the apex of an infundibulum form a single short spiral. On the flat parts of the sac between folds there are rows of short, entirely straight stigmata, and in some parts often some quite irregular ones.

Digestive System: Situated on left side of the body, forming a long, almost closed loop which in turn forms a regular curve on posterior dorsal portion of that side and is sometimes bent up at the closed anterior end also. Stomach thin walled, smooth, over twice as long as wide, and of not much greater diameter than intestine. On inner surface of oesophagus and stomach and extending beyond them is a voluminous, rosette-shaped, reddish brown liver, made up of two distinct portions, each consisting of numerous radiating elongated caeca. Anus plain edged, situated in peribranchial cavity near the emergence of oesophagus and near atrial siphon. Kidney bean shaped, located on right ventral portion of the body.

Two hermaphroditic gonads, one on each side of the body. Ovaries large, rounded, or oval, somewhat flattened bodies, that on left side situated dorsal to the intestinal loop. A short oviduct arises from anterior edge of ovary and opens into the peribranchial cavity where the larvae develop. Specimens taken in July and in October had numerous tadpoles in that cavity. Testicular lobes comparatively few; not much branched, situated on posterior border of ovary.

Development studied by Berrill, 1931, from specimens received from Ritter. Diameter of egg 0.13 mm., according to Berrill, 1937.

"Development takes place within the atrial cavity of the parent and it can be seen from fig. 6, D, E, F, that there is relatively an enormous increase in size before hatching, and also that the ectodermal ampullae appear before metamorphosis" (Berrill, 1931, p. 298).

DISTRIBUTION: Type locality, on the exposed surfaces of rocks usually, but sometimes on the under surfaces, in the littoral zone, La Jolla, California (Ritter and Forsyth). I have obtained it myself among the roots of sea weeds on surf-beaten rocks on the ocean shore at Corona Del Mar, California, as well as attached to other ascidians dredged a short distance off shore in that locality.

Molgula regularis Ritter, 1907

Text figure 305

Caesira regularis HARTMEYER, 1909–1911, p. 1324.

Euritteria regularis HUNTSMAN, 1922b, p. 226.

Molgula regularis RITTER, 1907, p. 8, pl. 1, figs. 7, 8; HUNTSMAN, 1912a, pp. 135, 136.

See also *Molgula cooperi.*

Described as follows by Ritter:

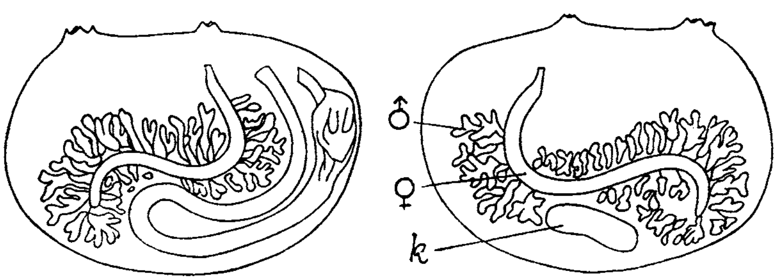


FIG. 305. *Molgula regularis* Ritter. Left and right sides of body, ×5.

"Superficial Characters: Ellipsoid, very regular in outline, surface entirely covered with foraminiferous shells and sand particles, which cling closely to the great number of filiform processes of the test. No definite area of attachment, though a thin membrane-like substance loosely adhering to one side of some of the specimens may mark the place of contact with the substratum on which the body rests. No siphon nor orifices visible without removing the covering of foreign particles. Length of longest specimen, 4 cm.; thickness of same, 2.3 cm. Other specimens of the collection but little smaller.

"Test: Thin and leathery after adhering particles are removed; semi-transparent. Filamentous processes very numerous and slender, but little branched, foreign particles clinging to them throughout their length.

"Mantle: No definite muscle bands excepting around the orifices. Here large and strong bands regularly disposed radially around the orifices, uniform in length and terminating abruptly at their distal ends; also a narrow zone of circular fibres around each orifice. The rest of the mantle containing an open meshwork of fine fibres.

"Branchial Apparatus: Siphons entirely wanting. Orifices not far apart, the branchial being well forward, the atrial near the middle of the length of the body. On removal from the test the orifices found to be slightly but unequivocally six-lobed (branchial), and four-lobed (atrial). Branchial tentacles about ten, of several sizes, the largest large and copiously branched. Hypophysis-mouth a narrow ellipse directed somewhat obliquely to the long axis of the animal. Peripharyngeal band running close to the anterior ends of the branchial folds. Ganglion a little more than twice as long as broad, less than its length behind the hypophyseal mouth. Dorsal lamina a plain-edged rather broad membrane. Branchial sac with six prominent folds. Longitudinal vessels of the folds delicate and rather irregular in number and course; about five on each side of each fold, nearly equally spaced from one another. Infundibula large, extending full size to the edge of the folds and leaving little space between them along the transverse vessels. Stigmata large everywhere; little curved except as they extend around the infundibula.

"Intestinal Tract: Situated on the left side at the extreme posterior end of the animal; loop a close one. Stomach not large, nearly twice as long as broad, smooth-walled. Intestine very long and thin, of uniform diameter throughout; rectal half forming a wide semi-circle; anus without lobes. Renal organ consisting of a large, brown, regular elongate central portion, surrounded by a still larger clear part; situated on the right side of the body, close to the posterior end of the endostyle. Gonads, one on each side of the body, that on the left in front of the intestinal loop" (Ritter, 1907, pp. 8–10).

The most striking character is the greatly elongated form of the gonads, or more strictly speaking, of the ovaries, which are long, sinuously curved tubes of rather small diameter that extend along dorsal to, and bending down in front of, the intestinal loop on the left side and the kidney on the right. Their posterior or oviducal ends bend up dorsally, ending near the atrial aperture. The testes are lobed or branched bodies suggesting in their form and arrangement about the closed end and along the sides of the ovaries those of some species of *Styela*, as *S. partita* (see fig. 305). Ritter's figure 7 appears to have been drawn from a specimen with rather poorly developed gonads and gives little idea of the voluminous development that they may attain, especially in the male portion.

LOCALITIES: "Albatross" Station 4309, off Point Loma Light, southern California, 67 to 73 fathoms, fine sand and shells, March 3, 1904, half a dozen specimens.

I assign here a few small specimens (none reaching 15 mm. in greatest diameter) from Corona Del Mar, California, dredged outside the harbor in a few fathoms, the others from Santa Cruz Island of the Santa Barbara group, collected by Willis G. Hewatt in depths of 20 fathoms. These specimens agree fairly well with Ritter's description, though they indicate that it should be added to his description that there are additional smaller and simpler tentacles between the large ones, that the infundibula of the branchial sac commonly divide near the summit as usual in this genus, and that the stomach bears the usual dark-colored hepatic organ on its proximal part and has a few slight folds in its wall.

These specimens are well covered with sand or fine debris on most parts of the body, though a bare area indicates that they were attached. I failed to find eggs or larvae in the peribranchial cavities or other indication of being viviparous. See remarks under *M. cooperi*. *M. habanensis* (p. 402) is an allied form.

Molgula cooperi (Huntsman), 1912

Caesira cooperi HUNTSMAN, 1912, pp. 114, 127; 1912a, p. 134, pl. 11, fig. 7, pl. 18, figs. 2–4.

Euritteria cooperi HUNTSMAN, 1922b, p. 226 (made type of new genus *Euritteria*).

Molgula cooperi BERRILL, 1931, pp. 297, 333, fig. 6g–6i (eggs and larvae).

? *Molgula regularis* RITTER, 1907, p. 8, pl. 1, figs. 7, 8.

In describing this species Huntsman, 1912a, himself expresses doubt as to its distinctness from Ritter's *M. regularis*, but mentions the following characters distinguishing *cooperi*:

"(1) The presence of siphons (not invariably). (2) The larger number of tentacles (about 10 in *M. regularis*). (3) The curvature of the aperture of the dorsal tubercle. (4) The smaller diameter of the stomach as compared with that of the intestine and the presence of gastric folds. (5) The position of the left gonad in close relation to the intestinal loop."

The specimens of *cooperi* average smaller, the largest being only 15 mm. in greatest (anteroposterior) diameter. Huntsman found a single common sperm duct (vas deferens) for each gonad that opened near the end of the oviduct. (No observation by Ritter regarding this in *regularis*.)

Development: Viviparous (Huntsman, 1912, p. 116). Eggs and tailed larvae from original specimens of Huntsman studied by Berrill, 1931. Eggs large (about 0.19 without the follicle cells). Ectodermal ampullae visible in the tadpoles previous to hatching.

LOCALITY: Departure Bay, British Columbia, 5 to 15 fathoms on sandy or gravelly bottoms. Fifteen specimens (Huntsman, 1912).

I would not be inclined to put great weight on the above differences of structure or on the more northern locality of *cooperi*, in view of the fact that both forms have the very long, sinuously curved gonads extending in front of the intestinal loop on the left side and the kidney on the right side, which constitutes an unusual feature, but the viviparous character of *cooperi*, if it is a fact, seems to be one that we cannot disregard. Ritter makes no mention of it in *regularis*, neither have I found any eggs or developing larvae in the peribranchial cavities of any specimens which I identify with Ritter's *regularis* that I have examined. For the present at least, I think we should follow Huntsman in treating the two forms as distinct, and I assign to the present species rather than to *M. regularis* a specimen from off Newport, Oregon, in 96 fathoms which is in the United States National Museum collection, as I found several eggs in its peribranchial cavity.

Molgula pugetiensis Herdman, 1898
Text figure 306

Caesira apoploa HUNTSMAN, 1912, pp. 114, 115, 124; 1912a, p. 129, pl. 11, fig. 5, pl. 16, fig. 8, pl. 17, figs. 1, 4.

? *Caesira hecateia* HUNTSMAN, 1912, p. 125; 1912a, p. 130, pl. 11, fig. 6, pl. 17, figs. 2, 3.

Caesira pugetiensis HUNTSMAN, 1912, p. 126; 1912a, p. 132.

? *Caesira* sp. HUNTSMAN, 1912, p. 126; 1912a, p. 132, pl. 17, fig. 5.

Molgula pugetiensis HERDMAN, 1898, p. 265, pl. 16, figs. 3–7.

Although Huntsman treated the above three forms as distinct species, I do not think he gave sufficient weight to the very strong probability that his *apoploa* was identical with Herdman's *pugetiensis*. In regard to the distinctness of *hecateia* from *apoploa*, Huntsman himself expressed doubt. (See below.)

The body is usually nearly spherical or slightly ellipsoidal, more or less entirely covered with fine short hairs to which a coating of sand adheres, some of it rather loosely. On the ventral surface the hairs are often longer and aid in attaching the animal, though in some cases it appears to live free in the sand. The siphons, which are capable of considerable extension as well as complete retraction flush with the surface, are rather near together on the dorsal surface; their bases are often surrounded by a bare area of varying size. The branchial aperture has six pointed lobes which are often conspicuous externally and are always so when the body is removed from the test; the atrial aperture is square. The specimens I have seen are all small (10 mm. or less in maximum diameter), but Herdman's type of *pugetiensis* measured 22 mm. anteroposteriorly, 14 mm. dorsoventrally, and 8 mm. transversely, while Huntsman, 1912a, records 32 mm. as the maximum diameter of a specimen of his *M. hecateia*. The test is fairly thick but soft and flexible and, where not incrusted, rather transparent.

The mantle is rather thin and transparent. There are sharply defined muscle bands radiating from the siphons extending down some distance on the sides; they are overlaid by closely placed transverse or circular fibers. Lower on the sides the musculature is slight and diffuse, composed of fibers crossing in various directions. There are also rows of very short, stouter bundles of fibers each side of, and transverse to, the median line which, however, they do not reach or cross; but the musculature does not obscure a distinct view of the gonads and intestinal tract.

The tentacles are quite numerous and of various sizes; there may be 25 or more large and medium-sized branched ones as well as

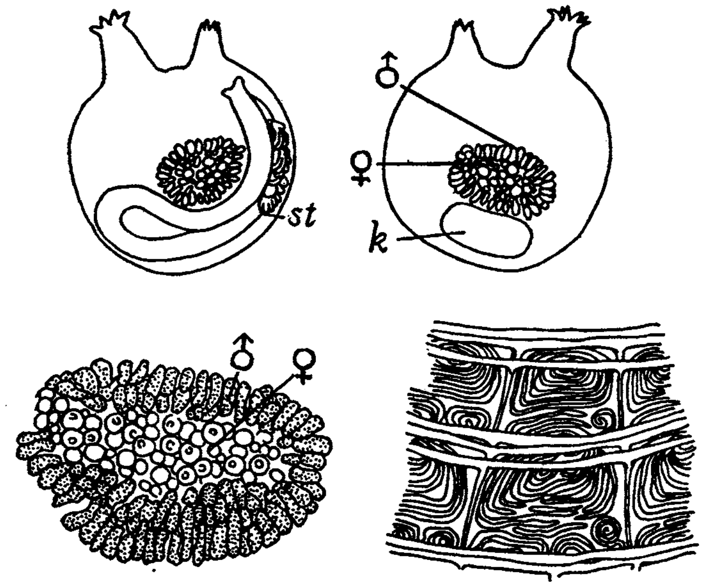


FIG. 306. *Molgula pugetiensis* Herdman. Left and right sides of body, ×4.5; gonad (side next to mantle), ×15; and piece of branchial sac.

many smaller and more simple ones. The largest are usually only twice, sometimes slightly three times, pinnate. Dorsal tubercle small but prominent, its aperture of simple form, described as horseshoe shaped, the open interval usually to the rear or more or less to the right, but in some small specimens from Departure Bay, British Columbia, Huntman's type locality of his *M. apoploa*, I could find no open interval, the margin of the aperture being of continuous longitudinally elongate oval or bean-shaped outline.

The dorsal lamina is rather narrow and smooth margined anteriorly; farther back it is wider, and the margin may be uneven. It extends back past the oesophageal opening.

Branchial sac with seven folds on each side, the stigmata on most parts of the sac long, narrow, and not very frequently interrupted. In the folds there are large, prominent infundibula on which the stigmata make many turns; usually two infundibula between the primary transverse vessels or less often one large one which divides. The infundibula are pyramidal in their lower part rather than conical, having a somewhat square base. On the flat parts of the sac, the stigmata are mainly parallel and longitudinal, but spirals and accessory infundibula are formed here and there, more numerously in large specimens.

The internal longitudinal vessels are stout and few and, as observed by Huntsman, usually confined to the ventral leaf of the folds. If any are present on the dorsal leaf, they are more or less vestigial. The usual number of internal longitudinal vessels on a fold is three, in larger individuals four (see also remarks on *M. hecateia* at the end of this description).

The intestinal loop, though opened out a little way at the reflected end, is narrow, the two branches often in close contact. The whole tract is bent in nearly a semicircle, forming a well-marked secondary loop; the reflected end may be still more sharply bent up, though individuals vary much in the degree of curvature. The stomach has a voluminous, dark-colored hepatic organ.

The gonads form a compact mass, usually oblong or short elliptical in outline (often quite regularly so), that of the left side in the secondary loop dorsal to, and usually close to, the intestine; that of the right side just dorsal to the rather short, bean-shaped kidney. The ovary occupies the central or axial part of the gonad and is enclosed all around its margin by the small, closely placed testes which also overlap the marginal parts of the ovary on both the mesial and exterior aspects, though leaving its central part uncovered. I could not find that the ovary was at all produced into an oviduct in the specimens I have examined, nor could I find a common sperm duct for the whole gonad. According to Huntsman, there are several (up to six to eight) vasa deferentia opening on the mesial aspect of the ovary. The eggs in the ovary become rather large (0.16 to 0.17 mm. in diameter), but in no case did I find eggs or larvae in the peribranchial cavity or any indication that the species is viviparous.

DISTRIBUTION: Whole coast of British Columbia including northern part of Puget Sound, in shallow water (from 5 to 20 fathoms).

Type and only locality of Herdman's *pugetiensis*, Puget Sound off Victoria, British Columbia, based on only one specimen; of Huntsman's *apoploa*, Departure Bay, east coast of Vancouver Island, but reported also from Ucluelet on the west coast and from Alert Bay and Hecate Strait.

Huntsman described his *M. hecateia*, which he considered somewhat doubtfully distinct from his *apoploa*, on the basis of a single lot of six specimens from Hecate Strait, where *apoploa* also occurs. This small number of specimens appears to me to diminish the importance of the differences (all minor ones) on which he based the species; the most striking difference was the greater number of internal longitudinal vessels on a fold (usually five or six) though confined to the ventral leaf of the fold. The specimens of *hecateia* were, however, very large ones for this species (two of them measured 32 by 30 by 15 mm. and 23 by 14 by 13 mm., respectively), so that a larger number of the vessels would naturally be expected. Oka (1930, Proc. Imp. Acad. Japan, vol. 6, no. 4, p. 168) states that specimens from the Bay of Mutu, Japan, appear to be *M. pugetiensis*.

It is possible that its southward range on the American coast is very much greater than stated above, as there are two small specimens in the American Museum collection from San Nicolas Island, off southern California, taken in 5 and 20 fathoms, respectively, by W. G. Hewatt. They differ from the above description in certain minor particulars, such as freedom from much incrusting sand, more regular parallel arrangement of the stigmata on flat parts of the sac, no accessory infundibula being formed, larger dorsal tubercle, intestinal loop more opened out at the reflected end, the kidney more elongate, which taken together might indicate difference of species should they prove constant, but the limited material available does not make it justifiable to separate them specifically at present.

Molgula pacifica (Huntsman), 1912

Caesira pacifica HUNTSMAN, 1912, pp. 115, 126; 1912a, p. 132, pl. 17, figs. 6–8, pl. 18, fig. 1.

Described by Huntsman from a single specimen 15 by 13 by 10 mm. in its diameters. The surface has small root-like filaments and is somewhat overgrown with other organisms. Color in life yellowish gray with reddish orange siphons. The latter are short (the atrial the longer) and near together.

Besides the siphonal musculature there are irregularly scattered fine, short fibers over the surface of the mantle; these are more numerous in front and behind than on the sides and below.

About 40 tentacles, the largest slightly tripinnate, the smallest simple. Dorsal tubercle horseshoe shaped, the ends approximated; open interval toward the right. Dorsal lamina short and narrow, not reaching far beyond the oesophageal aperture, its margin smooth and undulated. Seven branchial folds on each side, the last two incomplete. Arrangement of internal longitudinal vessels (which are present on both dorsal and ventral aspects of the folds):

Right 0 (6) 0 (10) 0 (11) 0 (11) 0 (11) 0 (11) 0 (9) 0

Left 0 (7) 0 (10) 0 (11) 0 (11) 0 (11) 0 (10) 0 (7) 0

The folds are chiefly formed by the larger infundibula which are square at the base and on which the long, narrow stigmata are mostly situated, there being few stigmata that do not take part in the infundibular spirals. The spirals are interrupted, each stigma extending not more than a quarter or halfway around an infundibulum. No accessory infundibula.

Intestinal loop rather narrow, the whole loop bent up in a semicircular curve.

One wide, short ovate gonad on each side, the left gonad dorsal to the intestine, filling the secondary intestinal loop, the ovary visible through the mantle as a narrow anteroposterior strip among the numerous testes. Ducts short, directed dorsally from the posterodorsal part of gonad. Kidney wide, shorter than the right gonad, not much curved.

LOCALITY: Ucluelet, British Columbia, attached to rock on exposed shore between tides.

Molgula oregonia Ritter, 1913

Text figure 307

Molgula oregonia RITTER, 1913, p. 435; HARTMEYER, 1914, p. 7; ÄRNBÄCK, 1928, p. 57; BERRILL, 1931, p. 312.

Most of Ritter's careful description of this species is quoted here. It was not accompanied with any illustration.

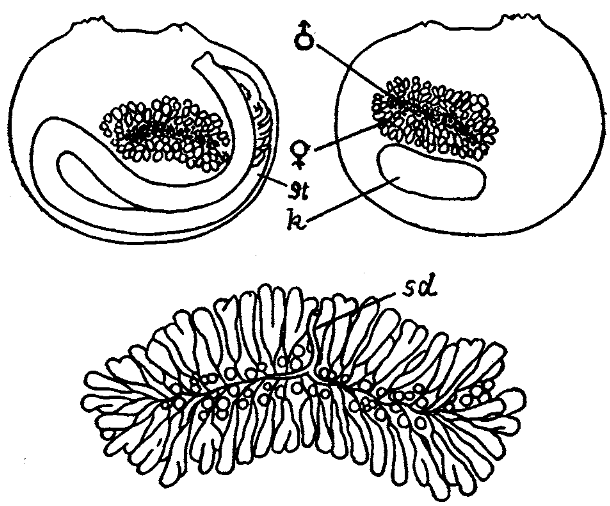


FIG. 307. *Molgula oregonia* Ritter. Left and right sides of body, ×3.5; gonad as seen from side next to the branchial sac, ×10.

"Superficial Characteristics: Ovate, the long axis transverse, stiff and hard in general consistency, this due partly to the rigidity of the test and partly to the incrustation of sand which forms a nearly uniform layer over the whole surface in most specimens, the sand grains being embedded in the test itself rather than adherent to the coarse filiform test processes which are restricted to a few patches or tufts. Excepting for irregularities apparently due to post-mortem changes, general outline rather regular though test somewhat wrinkled in some specimens; a few individuals having worm tubes, and other smaller ascidian species clinging to them. Siphons entirely absent so far as can be determined; orifices very small, discoverable only by the most careful scrutiny; nearly equally distant from the two ends, the branchial being somewhat nearer the anterior than the atrial is to the posterior; distance apart slightly greater than the distance of the atrial from the posterior end. Dimensions of one of the largest specimens, 22 by 15 by 13 mm.; of a second specimen, 18 by 13 by 10; of a third, 18 by 14 by 15. Test less than 1 mm. thick, dense, thick, and not at all transparent. Mantle rather thick, yellowish opaque over the anterior third, thin and semitransparent elsewhere except for the voluminous gonads; muscle bands of the mantle radiating from the orifice, entirely hidden in the vicinity of the openings by the thickened yellowish epithelial mantle tissue, reaching back to about the middle of the body all around; lobing of the orifices (six, branchial; four, atrial) obscure, even when test is removed.

"Respiratory System: Branchial tentacles about 15, possibly a few more minute ones, 8 or 10 of larger size, some of these large and thick and copiously branched, the branching being secondary as well as primary. Dorsal tubercle small, the hypophysis mouth a simple, narrow horseshoe in shape. Branchial sac with six folds on each side, none of the folds with less than 6 longitudinal vessels, and some with 12 or 13, never more than one vessel between the folds, more frequently none at all, the individual vessels on the folds broad and strong and usually close together;

transverse vessels very few, entirely absent for long stretches in the spaces between the folds; infundibula reaching deep into the prominent folds, but not easily seen on surface views of the inside of the sac on account of the crowded condition of the longitudinal vessels of the folds; stigmata long, rather regular, and usually straight and directed lengthwise in the spaces between the folds. Dorsal lamina with plain edge throughout its course" (Ritter, 1913).

Internal longitudinal vessels in a typical specimen, according to Ritter:

Right 0 (10) 0 (11) 1 (11) 1 (11) 1 (10) 1 (7) 0

Left 0 (8) 0 (11) 1 (10) 1 (10) 1 (9) 0 (7) 0

"Alimentary System: The narrow intestinal loop situated on the left side, but far back and extending across the entire body; the two limbs of the loop almost in contact with each other except at the closed end, this end again bent sharply forward making a short second double-tubed loop. Stomach but little greater in diameter than the gut; the wall presenting a number of low, rather inconspicuous irregular lobes. Anus situated very close to the atrial orifice, the rim nearly or quite plain. Renal organ an elongate, bean-shaped body situated far back on the right side, somewhat concave on its anterior edge and convex on its posterior edge to correspond with the rounded outline of the body, length nearly equaling one-half the longest diameter of the body removed from the test.

"Reproductive System: Voluminous on both sides of the body, that of the left lying above and close along the intestinal loop; that of the right above and close along the renal organ, reaching down somewhat on the anterior end of the latter. Ovary and testes intimately commingled, the cylindric ovary occupying the middle and entirely surrounded by the testes; the mass of the left side as long as the intestinal loop and in addition extending into and quite filling the concavity of the secondary loop" (Ritter, 1913, p. 436).

LOCALITIES: "Albatross" Station 3088 (type locality), 44° 28′ N., 124° 25′ 30″ W., off Oregon, 46 fathoms, c. p., September 3, 1889, 16 specimens.

"Albatross" Station 3213, 54° 10′ N., 162° 57′ 30″ W., south Alaska Peninsula, 41 fathoms, bk. s., May 21, 1890, a single specimen.

The United States National Museum also has a few specimens, several of them of good size, taken at or near low-water level at St. George Island, Pribilof Islands, by G. D. Hanna in September and October, 1913, which give additional information regarding the character of the species.

It is not identical with *M. arenata* of the east coast, as suggested by Ärnbäck, 1928, though it is a near ally of it. It inhabits much colder waters, its range is widely separated geographically, and the body in contraction does not ordinarily assume the strongly laterally compressed form characteristic of *arenata*. Though the internal characters are similar, the internal longitudinal vessels on the dorsal leaf of the folds are very slender, the intestinal loop is narrower and less bent, and there are differences in the gonads. These are rather stout and wide, and the left gonad is more horizontally directed. The right gonad sometimes bends down anterior to the kidney as in *arenata*, but often does not do so at all.

The ovary is rather elongate and somewhat sinuously curved, the clavate testes lie on its mesial aspect, their ends, considerably cleft and branched into rounded lobes, extend beyond the margins of the ovary and form a wide border around the latter as it is seen through the mantle. At least in some individuals there is a single sperm duct for the whole gonad. A long branch of the duct arises at each end of the ovary lying on its mesial aspect and receiving the small ducts from the individual testes. About the middle of the length of the ovary the two branches unite to form a dorsally directed terminal branch.

It is a viviparous species; the specimens have large eggs (0.31 mm. in diameter exclusive of the thin inconspicuous follicle) in the peribranchial cavity. In no case did I observe any tendency toward forming tailed larvae.

SUBGENUS OR GENUS **MERISTOCARPUS** PIZON, 1899

The complete separation of the male and female components of the gonads in the following species has not been overlooked by those favoring the multiplication of genera, and Pizon (1899, Bull. Mus. Hist. Nat. Paris, vol. 5, p. 43) established the genus *Meristocarpus* on the basis of that character. The group is certainly valid, at least as a section or subgenus of *Molgula;* and, if it is desired to give it recognition, Pizon's name should be adopted rather than placing it in *Cystingia* MacLeay with *Molgula griffithsii*, a species with which it has little in common, as was done by Huntsman (1922).

Molgula retortiformis Verrill, 1871

Plate 3, figures 5, 6; text figures 308–310

Caesira retortiformis HARTMEYER, 1909–1911, p. 1324; 1910, p. 229; 1912, p. 18; VAN NAME, 1912, p. 509, figs. 18, 19, pl. 52, figs. 50–52, pl. 69, figs. 139, 140.

Cystingia retortiformis HUNTSMAN, 1922, p. 7; 1922b, p. 228.

Molgula graphica RITTER, 1901, p. 320, pl. 27, figs. 6–9.

Molgula groenlandica TRAUSTEDT, 1880, p. 425; 1883, p. 112.

Molgula retortiformis VERRILL, 1871, p. 56, fig. 3; 1872a, p. 211; 1874, pp. 352, 363; 1879, p. 27; VERRILL AND RATHBUN, 1879, p. 231; MCDONALD, 1889, p. 858; KINGSLEY, 1901, p. 182; WHITEAVES, 1901, p. 270; HARTMEYER, 1903, pp. 145, 373, figs. 1, 2, pl. 4, figs. 4–6, pl. 7, figs. 10, 11; HUNTSMAN, 1912, pp. 112, 143; RITTER, 1913, p. 437; REDIKORZEV, 1916, p. 85, fig. 15, pl. 2, fig. 5, pl. 4, fig. 10; HARTMEYER, 1921a, p. 7; 1923, p. 114; ÄRNBÄCK, 1928, p. 54, pl. 1, figs. 11, 12; BERRILL, 1931, pp. 299, 312, 333, fig. 7.

Molgula siphonalis HARTMEYER, 1899a (not Sars, 1859), p. 462, fig. B, pl. 22, fig. 2, pl. 23, figs. 2, 13.

Other synonyms: *Molgula longicollis* Wagner, *Pera longicollis* (Herdman), *Meristocarpus fuscus* Pizon. See Hartmeyer, 1923, p. 114.

This is one of the largest ascidians of the Arctic and Subarctic regions. It reaches 75 mm. in greatest diameter off Newfoundland (Hartmeyer), and 100 mm. in Bering Sea (Ritter). In most regions 30 to 40 mm. in greatest diameter is not usually exceeded.

For a description of the external features of this species Verrill's original description is here quoted. It should be emphasized, however, that in preserved material the long extensile siphons will usually be found more or less completely drawn in. The test is thick and often of somewhat cartilaginous character in alcoholic specimens.

"Body subglobular or more or less oval, generally higher than broad and a little compressed laterally, destitute of a disk, though generally adhering. The integument is thick and firm, but translucent, usually covered, together with the tubes, by various zoöphytes, ascidians, fragments of shells, etc., which form a coarse, rough, and rather loosely adherent coating but this is usually incomplete or thin and the surface more or less exposed. When cleaned the surface is roughened by small, scattered, granule-like papillae, and irregular rough processes, while in large specimens it is more or less rudely wrinkled. The large tubes arise from the upper part, a short distance apart, and are widely divergent and very unequal. The anal tube is much the longest, usually equaling in length the diameter of the body, very large and swollen at the base, curving outward and tapering to the end, which is blunt with a small square aperture, its surface is often roughened with irregular processes and in partial contraction is often sulcated. The branchial tube is usually about one-fourth as long, much smaller at the base, curved outward, the aperture surrounded with six short, conical, acute papillae or tentacular lobes, its surface below often

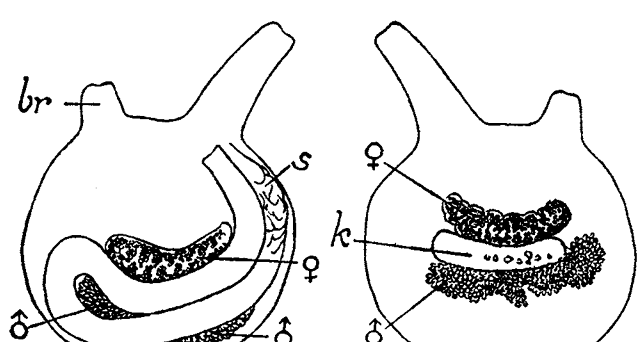


FIG. 308. *Molgula retortiformis* Verrill. Left and right sides of body, ×1.5.

rough with irregular verrucae. In contraction the tubes form large, low and rough verrucae, or may be wholly retracted and invaginated, together with a portion of the integument of the body around their bases.

"When living the color is uniform light olive or grayish green.

"The young have essentially the same characters as the adults, but are smoother" (Verrill, 1871a, p. 56).

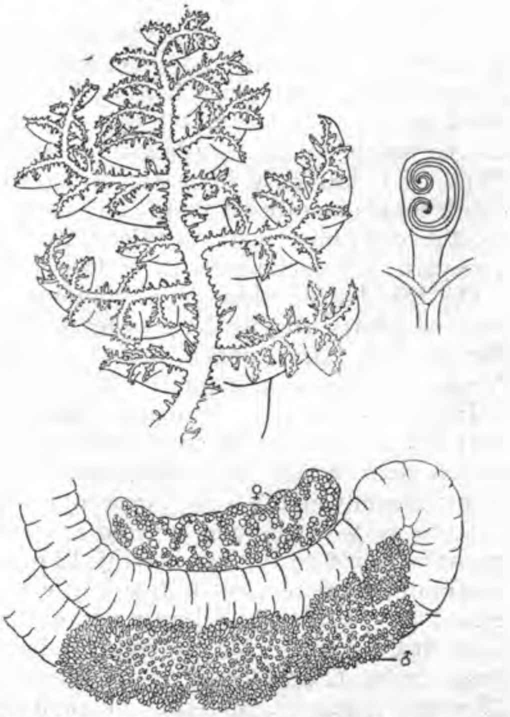


FIG. 309. *Molgula retortiformis* Verrill. Left gonad (male and female parts), ×4.5; large tentacle, and dorsal tubercle.

Mantle musculature well developed, siphons very muscular. Strong bands radiating from the siphons extend for a distance on the sides of the body. A rather close network of slender muscle bands crossing each other in various directions (though transverse bands predominate) covers most of the body.

Oral tentacles of four or five orders, the larger ones very few and complex in their branching. Dorsal tubercle large, C-shaped, with the open interval toward the right and the horns spirally incurved. Dorsal lamina plain edged.

Branchial sac with seven well-developed folds on each side. It is difficult to say whether the internal longitudinal vessels should be regarded as confined to these folds or whether the two vessels at the base of each fold should

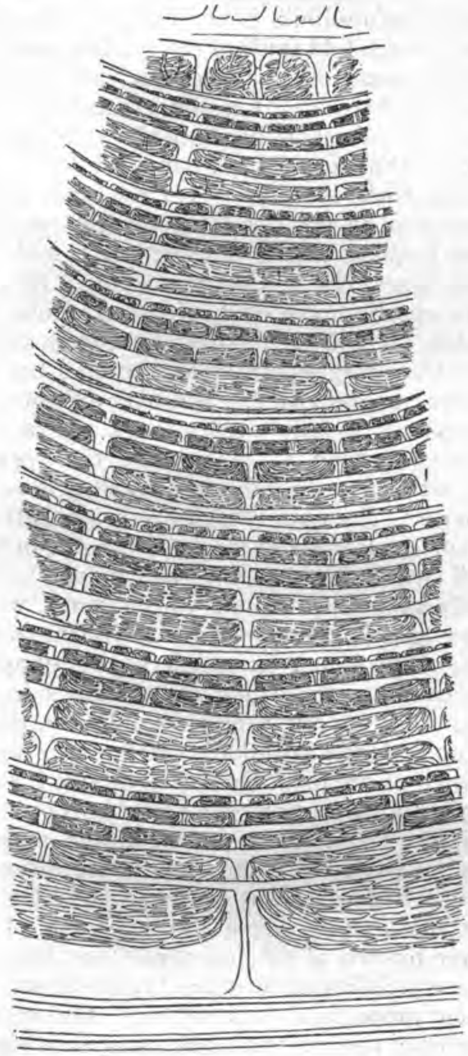


FIG. 310. *Molgula retortiformis* Verrill. Part of branchial sac, ×12.

be reckoned as belonging to the interspaces dorsal and ventral to it, since they usually lie a little removed from the fold, though clearly belonging to the group borne on the fold. The largest folds bear about 12 vessels including outlying ones; the vessels on the dorsal leaf of a fold are slenderer than those on the ventral leaf. Transverse vessels of sac of four or five orders, seven of them of the first order.

Except in young individuals, the development of a spiral arrangement of the stigmata and of infundibula is confined to the upper part of each fold (indeed the whole upper portion of each fold may be described as composed of a row of infundibula); elsewhere the stigmata are straight or moderately curved and for the most part rather short.

Intestinal loop very narrow and nearly horizontal in position, the stomach and rectum forming nearly a right angle with the other part. Kidney sausage shaped, its long axis nearly horizontal, situated about the middle of the right side. An ovary and a testis, entirely separated from each other, are present on each side. Each ovary is an elongated sac usually somewhat larger at the blind end than at that where the opening (sometimes produced into a small oviduct) is situated. The eggs, which are comparatively large, are formed in its walls (except in that wall which lies against the mantle). The walls have deep transverse plications, which often cause the eggs to look as if arranged in irregular columns extending part way across the cavity of the ovary. On the left side, the ovary lies outside the intestinal loop, dorsal to and along the middle part of the upper branch of the loop. On the right side it has a similar position along the dorsal border of the kidney. The testis is an elongated mass of minute pyriform glands which are often incompletely two-cleft, or three-cleft. On the left side it lies against the inner side of the lower branch of the intestinal loop (on that side which lies against the branchial sac). It often projects a little beyond the ventral border of the intestine, and likewise is visible in the small open portion of the loop. On the right side the testis lies ventral to the kidney, overlapping it and extending also somewhat around its anterior end. This complete separation of the male and female glands furnishes an easy means of identifying the species. There are a number of distinct, very short sperm ducts for each gonad.

Reproduction is ordinarily oviparous but is apparently not always so (see below), and the development is direct without the formation of tadpole larvae. The eggs are fairly large, 0.18 mm. in diameter exclusive of the follicle. (See Berrill, 1931, p. 300.)

DISTRIBUTION: *M. retortiformis* is widely distributed in the Arctic waters of Europe, Asia, and America, having been recorded from Spitzbergen, the White Sea, etc., the Siberian Arctic Ocean, the North Pacific, Bering Sea, Iceland, Greenland, and Hudson Bay.

On the American Atlantic coast it is fairly common in the Eastport, Maine, and Bay of Fundy region, occurring there at low-water mark and on the banks off the coast, and ranges south to the southeastern angle of Cape Cod, but only in water of moderate depth some distance off shore. The southernmost record I have is off Gay Head, Martha's Vineyard, Massachusetts, in 35 fathoms.

On the Pacific side, it is common and reaches a large size in the southeast part of Bering Sea, and ranges south to Sitka, Alaska, and Kamchatka on the Asiatic coast.

In depth it ranges from near low tide to over 100 fathoms, but is commoner in depths of less than 40 fathoms, and grows best on stony, gravelly, or other hard types of bottom.

Some very small sand-covered specimens (mostly from 6 to 10, occasionally 12 mm. in maximum diameter) but fully adult, were received from Waldo L. Schmitt who obtained them at Canoe Bay, Alaska, from the back of large crabs (*Paralithodes camtschatica* and *Chionocetes bairdi*). In spite of their very small size they conform closely to *M. retortiformis* in structure, but most of them contain eggs (which likewise conform in size to those of that species) in the peribranchial cavity, though this is not in accordance with the reputed oviparous character of the species. However, it seems necessary to refer them to it unless we assume the existence in Alaska of a small viviparous species resembling *retortiformis* in all other respects, which does not seem very probable.

It seems possible that the rather large eggs of this species are discharged with difficulty through the siphons of individuals that become sexually mature while still very small, resulting in their occasional retention beyond the usual time.

SUBGENUS **MOLGULOIDES** HUNTSMAN, 1922

Differs in having the left gonad in the primary intestinal loop instead of dorsal to it (in the secondary loop).

Molgula (Molguloides) immunda
(Hartmeyer), 1909
Text figure 311

Caesira immunda HARTMEYER, 1909–1911, p. 1324; 1912b, pp. 245, 374, 378.
Molgula sordida SLUITER, 1904, p. 118, pl. 14, figs. 11–16. Not *Molgula sordida* Stimpson, 1852, which probably equals *M. manhattensis.*

This small abyssal species has the body rounded or ellipsoidal, the apertures on small, widely separated papillae which are nearly at opposite ends of the dorsal aspect of the body. In the contracted preserved specimens the lobes of the apertures are not apparent externally.

The test is thin, though fairly tough; it would be transparent were it not for a dense covering of short, crooked hairs to which more or less mud or fine sand grains adhere. Maximum diameter, 17 mm. (Sluiter).

Mantle with muscle bands forming an open network. Prebranchial zone extensive, the peripharyngeal bands being far back from the branchial aperture. Branchial tentacles of several sizes and quite numerous; the larger ones, about 16 to 20 in number, are two or three times compound; the very small ones may be nearly or quite simple. Dorsal tubercle (also its aperture) longitudinally elongated. Dorsal lamina plain.

The branchial sac has seven folds on each side, the higher ones bearing eight to 10 internal longitudinal vessels. Nevertheless it bears a superficial resemblance to that of *Eugyra,* as each fold bridges over a row of large infundibula with spirally arranged stigmata, one infundibulum in each of the spaces which the transverse vessels mark off. The infundibula are rather low and usually do not extend very far up into the folds, which are narrow. The stigmata on them often form very perfect double spirals as in *Eugyra,* but are interrupted occasionally as is characteristic of *Molgula.*

The intestinal tract forms a small, partly open loop in the left ventral part of the body. The stomach is rather short, its wall with longitudinal glandular plications. The kidney is bean shaped, situated on the ventral part of the right side.

The left gonad is in the primary intestinal loop, but overlaps the adjacent parts of the intestine when well developed. Right gonad in about the center of the right side of the body. Each gonad consists of a centrally situated ovary of rounded outline, and of individual male glands, which are not very numerous but are usually cleft into two to six or more lobes and are arranged radially around most of the circumference of the

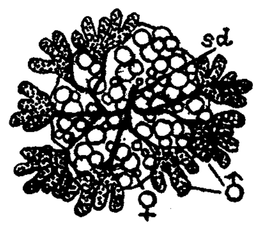


FIG. 311. *Molgula immunda* (Hartmeyer). Gonad (side next to branchial sac), ×16.

ovary. The ovarian aperture was not demonstrated. The whole gonad forms a compact, circular mass, quite thick when well developed. The individual sperm ducts lie upon the free surface of the ovary, converging toward its center where they unite (or at least most of them do) and discharge by a single orifice for the gonad. Largest eggs found in the ovary, about 0.17 mm. in diameter.

DISTRIBUTION: This species was described by Sluiter from specimens obtained by the Siboga expedition in 05° 46′ S., 134° 00′ E., in 1788 meters. Sluiter described it as *M. sordida;* the name was changed by Hartmeyer on account of preoccupation. Two specimens, one of which was in fair condition for study, were dredged by the "Albatross" at Station D4700 (off northern Chile, 20° 29′ S., 103° 26′ W., in 2200 fathoms) and agree so well with Sluiter's description that there seems to be no doubt of their identity. *M. bathybia* (Hartmeyer), 1912b, from north of Enderby Land in the eastern Antarctic, is a nearly allied, if distinct, species.

GENUS **ASCOPERA** HERDMAN, 1881

This group was based by Herdman on two very large specimens dredged by the "Challenger" at a station south of Kerguelen Island in 150 fathoms. The body is borne on a thick peduncle of varying length; its surface is smooth or has fine papillae. The stigmata of the branchial sac are described as not forming spirals or infundibula, even on the folds of the sac. This seems to be the chief ground for keeping the genus separate from *Molgula*, but I have not had the opportunity to examine material of it myself.

I fully agree with the doubts of both Hartmeyer, 1909–1911, and Ärnbäck, 1938, regarding the distinctness of the two species, differing chiefly in the relative length of the peduncle, and unite them under the name having page priority in Herdman's work.

The test is rather thin, tough, and leathery, gray or brownish in color in preservation, translucent or somewhat opaque; its surface is fairly even but covered with fine granulations or minute, short papillae.

Herdman called this the largest ascidian with which he was acquainted. His type of the species *gigantea* had the body 20 cm. long, 15 cm. wide at the top, 12 cm. wide at the middle, and a peduncle 10 cm. long. The type of this species *pedunculata* had the body 7 cm. long and 7 cm. wide, with a peduncle 17 mm. long.

The mantle is thin with feebly developed musculature. Twenty-eight branchial tentacles comprising three sizes were counted by

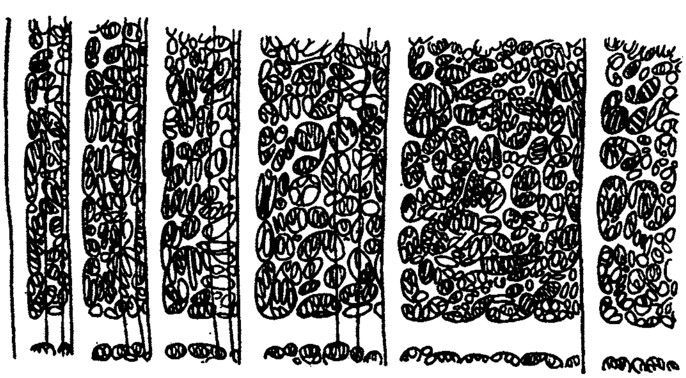


FIG. 312. *Ascopera gigantea* Herdman. Part of one fold of the branchial sac. After Herdman, 1882.

Ascopera gigantea Herdman, 1881
Text figure 312

Ascopera gigantea HERDMAN, 1881, p. 238; 1882, p. 62, pl. 1, pl. 2, figs. 1–4, pl. 3, figs. 3–5; HARTMEYER, 1909–1911, p. 1328; 1911b, p. 421, pl. 45, fig. 4, pl. 48, figs. 5–7; ÄRNBÄCK, 1938, p. 19, pl. 3, fig. 30.

Ascopera pedunculata HERDMAN, 1881, p. 239; 1882, p. 65, pl. 2, fig. 5, pl. 3, figs. 1, 2; HARTMEYER, 1909–1911, p. 1328; ÄRNBÄCK, 1938, p. 20. (Also misprinted *pudunculata*.)

Body pear shaped, borne on a peduncle arising from the smaller ventral end. The apertures, which are produced as short, tubular siphons, are far apart at the wider end, the atrial siphons terminal, the branchial more or less anteriorly placed and curved downward toward the peduncle.

The latter is rather stout; it varies from shorter than the body to several times the length of the latter; it becomes much enlarged at the farther end, forming a base for attaching or anchoring the body.

Ärnbäck in an individual of 38-mm. body length with a stalk 80 mm. long, and the dorsal tubercle was horseshoe shaped, with incurved horns, the open interval to the left; the dorsal lamina was short with a plain margin.

The branchial sac has seven folds which each bear a moderate number of internal longitudinal vessels; such vessels are also present on the flat parts of the sac between the folds. As in *Paramolgula*, the transverse vessels give off a system of irregular branches ramifying upon the inner surface of the sac, often passing over and partly concealing the stigmata. The latter are numerous, short, and somewhat irregular, mostly straight or nearly so, and longitudinal in direction.

The stomach is elongate with a large hepatic organ; the intestinal loop is elongate anteroposteriorly and quite abruptly reflected, forming only a very small open primary loop, its distal part running back in contact with the proximal part of the intestine and the stomach.

The gonads are elongated bodies having the posterior end produced into a short oviduct. According to Ärnbäck, there are several sperm ducts opening on the mesial aspect of each gonad. The gonad of the left side is dorsal to the intestine, that of the right side dorsal to the large, elongate, and somewhat curved kidney.

DISTRIBUTION: A species of the Antarctic and Subantarctic regions apparently circumpolar but not often obtained. Reported (as *A. gigantea*) by Ärnbäck from South Georgia, two specimens, and (as *A. pedunculata*) from Paulet Island, 63° 36′ S., 55° 48′ W., 17 specimens.

GENUS **RHIZOMOLGULA** RITTER, 1901

A genus related to *Eugyra* or perhaps still more closely to *Bostrichobranchus* in the arrangement of the stigmata but connecting these genera with *Molgula* through having six branchial folds on each side of the sac, each with internal longitudinal vessels. There is but one gonad, the left, situated in the primary intestinal loop, also a pair of glands near the endostyle which produce an adhesive secretion. (See Huntsman, 1912a, p. 136.)

For more details, see description below of *R. globularis* which appears to be the only species.

Rhizomolgula globularis (Pallas), 1776

Text figure 313

Ascidia globularis PALLAS, 1776, p. 709; 1787, p. 241.

Rhizomolgula arenaria RITTER, 1901, p. 231, pl. 28, figs. 10–19; MICHAELSEN, 1908, p. 147.

Rhizomolgula gigantea REDIKORZEV, 1907a, p. 523; 1908a, p. 19, figs. 4–6, pl. 1, figs. 4, 5, 8, 21–24, pl. 2, fig. 25.

Rhizomolgula globularis HUNTSMAN, 1912, p. 127; 1912a, p. 137, pl. 11, fig. 8, pl. 18, figs. 5, 6; REDIKORZEV, 1916, p. 128, fig. 26, pl. 3, fig. 5, pl. 4, fig. 16; HUNTSMAN, 1922, p. 8; 1922a, p. 9; HARTMEYER, 1923, p. 124; ÄRNBÄCK, 1928, p. 58, figs. 7–12, pl. 3, figs. 47–51.

Rhizomolgula (? n. sp.) *intermedia* MICHAELSEN, 1908, p. 147, pl. 2, fig. 12.

Rhizomolgula ritteri HARTMEYER, 1903, p. 168, pl. 6, fig. 1, pl. 9, figs. 5–9; 1910, p. 230; RITTER, 1913, p. 444; HARTMEYER, 1914, p. 1098; PRATT, 1916, p. 665.

For other synonyms and references, see Hartmeyer, 1923.

Body sometimes ovate or rounded but more often pear shaped, somewhat flattened at the anterior end where the two apertures (usually not prominent) are situated, and bearing at the end opposite to it a small root-like branched peduncle (or sometimes more than one) for attachment. The peduncle contains the ducts of two glands situated near the posterior end of the endostyle which produce an adhesive secretion. In the vicinity of these glands the mantle adheres firmly to the test. The body surface may be fairly clean or more or less completely incrusted with sand. The size is usually small, not much over 12 to 16 mm. in greatest diameter, but it occasionally becomes larger; Redikorzev mentions one 26 by 31 by 22 mm. in measurements, but a maximum diameter of over 20 mm. seems to be unusual.

The branchial aperture usually has six, the atrial four, lobes. Though probably capable of some extension, they are usually not prominent in preserved material. The larger tentacles number about 20, evidently representing three orders; there may be a nearly equal number of smaller, simple, or slightly branched ones in the intervals. Dorsal tubercle usually simply horseshoe shaped, with the open interval forward. Dorsal lamina plain. Mantle musculature well developed, consisting of a network of longitudinal and transverse bands covering most parts of the body.

Branchial sac with six folds (composed chiefly of the rows of primary infundibula) on each side of the body. The folds each bear several (a maximum of six or seven) internal longitudinal vessels; none between the folds.

The stigmata are arranged on the same principle as described under *Bostrichobranchus*. The development of the secondary spirals is, however, not carried to such an extent as in that genus, and though often forming numerous and well-developed infundibula they do not equal or obscure the prominence of the large primary ones. Neither are the spirals as perfect as in that genus, the stigmata being subject to occasional interruptions.

The stomach has longitudinal glandular folds; the intestinal loop is horizontally directed; the ovary has a long slender oviduct and is situated in the small open part of the primary intestinal loop, bordered or overlapped by the pyriform or lobed testes; the sperm ducts open on several short necks on the mesial surface of the gonad. The kidney is elongate and lies far back; it is displaced more or less toward the left so as to be near to, or in contact with, the stomach.

DISTRIBUTION: A northern species of circumpolar distribution which has appeared in literature under many different names. Its range is mainly in or near the Arctic Circle, and fails to extend far southward along the eastern American coast, Hamilton Inlet on the Labrador coast being the most southern record that I am aware of (see Huntsman, 1922a). On the Pacific side, however, it is common in the southeast corner of Bering Sea and ranges south to Prince William Sound (Ritter, 1901).

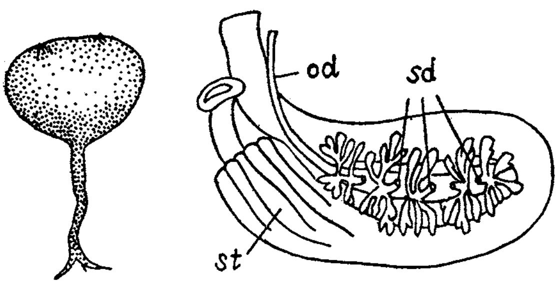


FIG. 313. *Rhizomolgula globularis* (Pallas). Entire animal, about twice the usual size. Intestine and gonad (side toward the branchial sac). Outline from figure of Redikorzev, 1916.

It is a shallow-water form, maximum depth recorded 72 meters, according to Ärnbäck, 1928; most records are much less.

GENUS **ANOMOPERA** HARTMEYER, 1923

Established for the following deep-sea species which does not appear to differ very greatly from *Molgula*.

Anomopera ingolfiana Hartmeyer, 1923

Anomopera ingolfiana HARTMEYER, 1923, p. 130, pl. 1, figs. 2–4; ÄRNBÄCK, 1928, p. 63.

Based on a single small specimen of ovate form, somewhat laterally compressed, apertures near together near one end, not externally prominent. Body surface with many long, thread-like processes to which sand grains adhere. Measurements: 8 by 10 by 5 mm.

Mantle with well-developed longitudinal and transverse muscle bands. Tentacles moderately branched, of various sizes representing three or, in some places, four orders, those of the first three orders numbering about 16. Dorsal tubercle small, its characters not clearly made out. Dorsal lamina smooth margined.

Branchial sac with only four folds on each side, the first and second with 18 and 20 internal longitudinal vessels, respectively, the other two with less. The stigmata are spiral in arrangement and form infundibula on the folds, but show no tendency to form spirals on the flat parts of the sac, where they are long and are longitudinal or oblique in direction.

Alimentary loop rather small, in the posterior ventral part of the body; stomach oval, its walls with a number of thick glandular folds; at the beginning of the intestine there are a pair of caecal enlargements similar to those in the intestines of some Synoicidae.

A gonad was found only on the right side. It is of irregular form and consists of a number of rounded lobes, which are apparently male glands only. No ovary demonstrated. Kidney small, in contact with the anterior part of the gonad.

LOCALITY: In the entrance to Denmark Strait between Iceland and Greenland, 61° 44′ N., 30° 29′ W., in 1135 fathoms.

GENUS **PARAMOLGULA** TRAUSTEDT, 1885

Differs from *Molgula* chiefly in the complete suppression of the folds of the branchial sac; in the place of each fold there is a single wide internal longitudinal vessel of flat cross section, curved to correspond with the much curved body axis. The transverse vessels of the sac, especially the smaller ones, are very irregular; the stigmata are small, short, and mostly curved, forming many small, irregularly distributed infundibula.

Paramolgula gregaria (Lesson), 1830

Plate 25, figure 4, plate 26, figures 1–4;
text figures 314–316

Caesira glomerata HARTMEYER, 1909–1911, pp. 1323, 1660.

Cynthia gigantea CUNNINGHAM, 1871, p. 125; 1871a, p. 489.

Cynthia gregaria LESSON, 1830, p. 157, pl. 52, fig. 3; 1830a, p. 435.

Cynthia magellanica CUNNINGHAM, 1871, p. 488, pl. 58, fig. 2 (see Hartmeyer, 1922b, p. 371).

Ctenicella lebruni PIZON, 1898, p. 364, pl. 13, fig. 5, pl. 15, fig. 3; 1898a, p. 1817; 1898b, p. 274.

Ctenicella rugosa PIZON, 1898, p. 372, pl. 13, fig. 4, pl. 15, figs. 1, 2; 1898a, p. 1817; 1898b, p. 275.

Molgula gigantea HERDMAN, 1881, p. 234; 1882, p. 69, pl. 4, figs. 1–4.

Molgula glomerata PIZON, 1898, p. 354, pl. 14, figs. 1, 2; 1898a, p. 1817; 1898b, p. 274.

Molgula gregaria HERDMAN, 1881, p. 234; 1882, p. 73, pl. 4, figs. 5–8.

Molgula horrida HERDMAN, 1881, p. 235; 1882, p. 76, pl. 5, figs. 4–7; MICHAELSEN, 1900, p. 142.

Paramolgula chilensis HARTMEYER, 1914, p. 18, figs. 7, 8.

Paramolgula gigantea MICHAELSEN, 1900, p. 138; 1907, p. 81; HARTMEYER, 1922b, p. 321; ÄRNBÄCK, 1938, p. 15, pl. 3, figs. 24–28, +*P. g.* forma *capax*, p. 16, figs. 5, 6, pl. 3, fig. 29.

Paramolgula gregaria HARTMEYER, 1909–1911, p. 1326; HERDMAN, 1912, p. 88, pl. 4, fig. 9.

Paramolgula horrida HERDMAN, 1912, p. 89, pl. 4, figs. 10, 11.

Paramolgula patagonica MICHAELSEN, 1900, p. 141, pl. 2, fig. 10, pl. 3, fig. 13; 1907, p. 81.

Paramolgula schulzei TRAUSTEDT, 1885, p. 20, pl. 1, figs. 8, 9, pl. 2, fig. 17, pl. 4, fig. 39; MICHAELSEN, 1900, p. 141; 1907, p. 81.

Paramolgula villosa MICHAELSEN, 1912, p. 176.

Stomatropa villosa PIZON, 1898, p. 379, pl. 14, figs. 3–6; 1898a, p. 1817; 1898b, p. 273.

Body sac-like, rounded, oval, or somewhat oblong in outline in a lateral view; the dorsoventral diameter commonly exceeding the anteroposterior diameter. Unless distended with water, the body usually collapses and becomes narrow from side to side. Attachment generally by a small area in the ventral or left ventral region; this may be developed into a more or less distinct but very short peduncle.

Apertures near together on the dorsal aspect, the branchial normally six-lobed, the atrial four-lobed; in preserved specimens the siphons usually form only low, often more or less tuberculated elevations on the surface, but are occasionally more produced and variously bent or curved and in life are probably capable of considerable extension. Test tough and leathery; very variable in thickness in different individuals but, as far as I have observed, usually relatively thicker in young than in old and large ones.

The body surface may be fairly smooth and even or much wrinkled with irregular grooves which, however, are usually shallow; in some cases these suggest in appearance the convolutions of the human brain. In young examples and occasionally in larger ones the test in preserved specimens is pale gray, yellowish, or nearly white, but more often (in very large

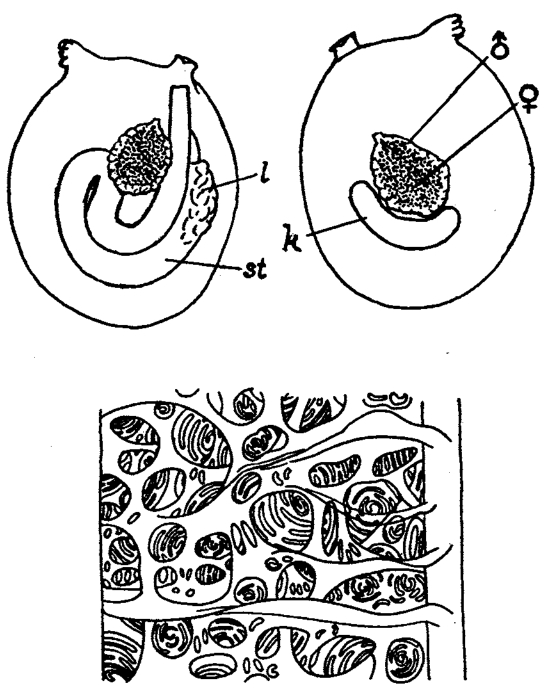


FIG. 314. *Paramolgula gregaria* (Lesson). Left and right sides of body, somewhat reduced. Piece of the branchial sac of a large individual, seen from the inside. After Herdman, 1882.

specimens almost always) it is of some dark shade, due to discoloration with mud, and its surface is granulated or rough and covered with sand grains, debris, algae, bryozoa, etc. It is very frequently the case that an individual exhibits both the smooth and rough types of surface on different parts of its body, the transition from the smooth to the rough part (which is more often on the ventral region) being abrupt.

This is one of the largest known simple ascidians. Herdman, 1882, gives the measurements of 30 specimens; the smallest was 5.5 cm., and the largest 33 cm., in maximum diameter.

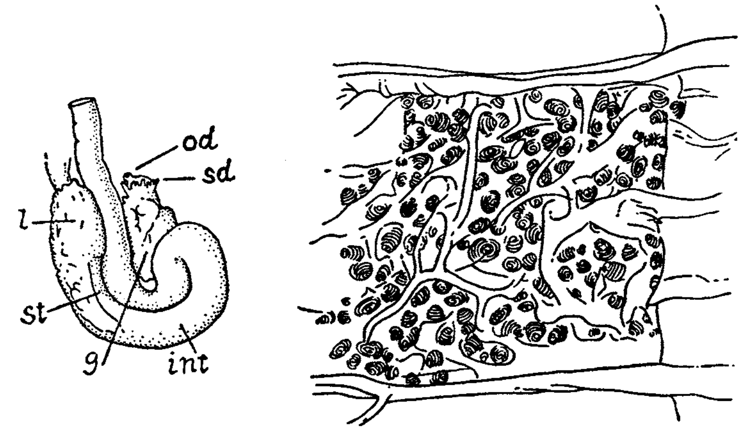


FIG. 315. *Paramolgula gregaria* (Lesson). Mesial side of alimentary tract and gonad of left side, and piece of branchial sac seen from inside. After Ärnbäck's (1938) figures of "*P. gigantea* form *capax*," ×10.

The mantle musculature is developed to a varying extent in different individuals. There are the usual bands, longitudinal and circular, on and about the bases of the siphons. On most parts of the body a dense network of

FIG. 316. *Paramolgula gregaria* (Lesson). Piece of branchial sac seen from inside, from Herdman's (1882) figure of "*Molgula horrida*."

small, variously directed bundles is present and often renders the mantle somewhat thick and opaque.

The branchial tentacles are commonly not over 12 to 16 in number; they are much branched and show a tendency to alternate in size; the dorsal tubercle was C-shaped, with inrolled horns and the open interval to the right in the specimens in which I examined it. The dorsal lamina, which is smooth margined or nearly so, is very short, the dorsal region of the body being greatly contracted longitudinally; the endostyle is very long, and much curved, the internal longitudinal vessels becoming longer and curved in a longer arc of a circle as that organ is approached.

The branchial sac is entirely without folds, the place of each fold being taken by a single, wide, internal longitudinal vessel of flattened cross section, seven in number on each side. The transverse vessels converge toward the short dorsal lamina; they give off numerous, irregular, anastomosing branches on the inner surface of the sac, forming a network which becomes very complex, and composed of stout vessels in old and large specimens, more or less concealing the stigmata over which they pass. In some individuals these branching vessels are less developed. The stigmata are small, short, and mostly curved in old individuals, more or less irregularly arranged and forming numerous irregularly distributed, small, low infundibula on which they have a well-developed spiral arrangement. In young individuals, seven rows of larger and better formed infundibula, evidently primary ones, located as in the genus *Eugyra*, can be distinguished.

The alimentary tract is much curved and more compact in its arrangement than in most members of the Molgulidae. The stomach is elongate, tapering off into the intestine and bearing (chiefly on its posterior and mesial aspects) a large hepatic organ composed of small, short, compactly crowded caeca. The intestine forms a deep secondary loop by the dorsal bending of the anterior reflected part, but there is little or no open primary loop, as it doubles back so abruptly that the proximal and distal branches are in contact for nearly their whole length.

The gonads of each side are thick, cushion-like, compact bodies of somewhat irregularly rounded, oval, or slightly elongate outline, in which the ovary occupies the layer adjacent to the mantle, being covered and enclosed on the unattached or mesial aspect by the male part of the organ, which is a compact layer of dense clusters of small, pyriform, or clavate testes. The testes may extend beyond and form a border about the margin of the ovary as seen through the mantle. The ovary opens by an oviduct of insignificant size and length at its distal end. There are usually several (sometimes, according to Ärnbäck, as many as 12) small sperm ducts to each gonad, which open on small papillae on the mesial surface of the gonad near the base of the oviduct.

The gonad of the left side is dorsal to, and partly in, the secondary loop of the intestine; that of the right side is dorsal to the kidney. The latter is large, sausage shaped, unusually long and narrow and very much curved.

DISTRIBUTION: This very large and conspicuous species is found in the region of the Strait of Magellan and north on the Argentine coast to the mouth of the La Plata, about Tierra del Fuego, and in the Falkland Islands. It is a common, and evidently in some places an actually abundant, species in shallow waters. The greatest depth that I find recorded is 55 fathoms, the least, 1 meter. Lesson described this species from the Falkland Islands, where it is commonly found in large groups or clusters, sometimes of as many as 40 individuals. Its abundance and large size have resulted in its being obtained by most collecting expeditions in the above regions. From the Chilean side of the continent it does not appear to have been reported often, but a small specimen in the United States National Museum from "Albatross" Station 2787 (46° 47′ S., 75° 15′ W., 61 fathoms) seems to be referable to this species, and *P. chilensis* Hartmeyer, 1914, from Calbuco, Chile, appears also to be based on young examples of it.

This is a difficult species to deal with from a taxonomic point of view on account of its variability, both in internal and external characters, which is so great that it is hard to believe that several species do not exist. Perhaps they do, but after examining a great many specimens, large and small, young and old, I have given up in despair the attempt to find a basis for separating them and have lumped everything. I hope that anyone who believes he can do better will try, and he will have my best wishes for his success.

GENUS **PAREUGYRIOIDES** HARTMEYER, 1914

Related to *Eugyra* and *Bostrichobranchus* and resembling them in having the branchial sac without folds and with stout internal longitudinal vessels on each side in their places, but the stigmata, though situated on conical infundibula, are interrupted at intervals instead of forming continuous spirals from the base to the summit as in those genera. Gonads present on both sides of the body.

Pareugyrioides dalli (Ritter), 1913
Text figure 317

Eugyrioides dalli RITTER, 1913, p. 44, pl. 33, figs. 1–3.

Pareugyrioides dalli HARTMEYER, 1914, p. 22; REDIKORZEV, 1916, pp. 46, 51; ÄRNBÄCK, 1928, p. 64; HUUS, 1937, p. 678.

The following description is based on a medium-sized specimen in the American Museum of Natural History. It is of elliptical outline in a lateral view, about 17 by 15 by 11 mm. in measurements, and is densely covered all over with coarse sand which adheres to the surface and to short hair-like processes of the test. In the present specimen the tubes are entirely retracted, and the apertures are difficult to find. Ritter's specimens were, mostly at least, much less densely coated with sand, the test in many cases being somewhat transparent, and their branchial and atrial apertures (six- and four-lobed, respectively) were at the tips of short, opaque, white papillae.

The mantle is thin and somewhat transparent and largely free from muscles, except the sphincters of the apertures and stout

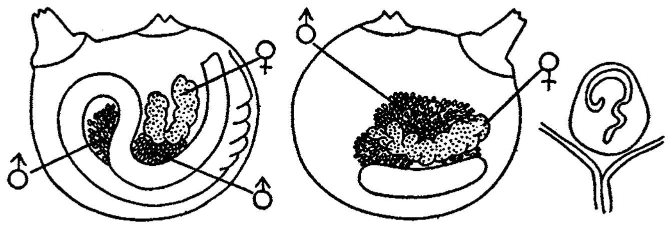


FIG. 317. *Pareugyrioides dalli* (Ritter). Left and right sides of body, ×2.5, and dorsal tubercle. From specimen from Teller, Alaska.

bands radiating from them which end abruptly without extending far from the apertures.

The tentacles vary in size; there are about 12 or 15 of the larger ones and additional smaller ones. They bear a wide membrane, but even the largest are rather sparsely branched; the small branches are short and end bluntly. The dorsal tubercle is rather large; its opening is an irregularly curved cleft with its chief concavity to the right. (According to Ritter it is horseshoe shaped, the open interval to the right.)

The main characters of the branchial sac are given under the genus. The transverse, and especially the seven internal longitudinal vessels are very stout and prominent. The infundibula are of two orders. The primary infundibula, which are the largest, form longitudinal rows bridged over by the internal longitudinal vessels. There is usually one between each pair of transverse vessels, but two in the ventral region.

The secondary or smaller infundibula are irregularly distributed chiefly in the spaces between the longitudinal rows of primary infundibula, and become more numerous in the ventral part of the sac.

Though the stigmata mostly form spirals (occasionally interrupted as in the genus *Molgula*) on the walls of high conical infundibula, some short, straight, or slightly curved stigmata occur on the intervening flat parts of the sac.

The stomach is elongated and tapers gradually into the intestine. In the proximal part its walls are raised into slightly prominent glandular convolutions. The branches of the intestinal loop are parallel and in contact except for a small open part where it doubles back, and the whole loop is bent into about a semicircle with the concavity dorsal.

A large gonad of irregular outline is present on each side of the body. They are easily visible through the thin transparent mantle. The gonads consist of both male and female parts, which are not very intimately united.

On the left side the ovary is U-shaped and occupies the concavity formed by the dorsal side of the intestinal loop. The male part of the gonad, consisting of numerous small pyriform testes, is visible through the mantle ventral to the ovary (between it and the dorsal branch of the intestine) and a part of it also in the lumen or open space between the branches at the anterior end of the loop.

On the right side the ovary is elongated and has its somewhat narrowed posterior end turned up dorsally. The testes are visible as a large mass on the dorsal border of the ovary and to a lesser extent along the ventral border except along the middle part of its length; they extend also on a part of the side of the ovary which is toward the branchial sac.

In two larger specimens from Kiska Harbor, Alaska (the type locality), about 25 and 28 mm. in largest diameter, respectively, having very well-developed reproductive organs, the mass of testes of the right gonad extends to some extent down around the anterior end of the renal sac, though the ovary does not do so.

The renal sac is elongate, slightly curved, and lies just ventral to the right gonad, about equaling the latter in length.

DISTRIBUTION: This species was first collected by W. H. Dall and is known only from Alaska in shallow water. Ritter records it from Chichagoff Harbor, Attu, 5 to 7 fathoms; Kiska Harbor, Aleutian Islands (type locality), 7 to 12 fathoms, and "Albatross" Station 3637, 57° 06′ 30″ N., 170° 28′ W., 32 fathoms, coarse gravel. The type is in the United States National Museum (U.S.N.M. No. 5678). The specimen in the American Museum of Natural History here described is from the Bering Strait region: Teller, Alaska, 65° 15′ N., 166° 25′ W., 5 fathoms, sand and some rocks, much the most northern locality.

An allied, if distinct, species, *P. japonica*, from Japan was described by Hartmeyer, 1914.

GENUS **EUGYRA** ALDER AND HANCOCK, 1870

Branchial sac without folds. Five to seven large, widely spaced, internal longitudinal vessels on each side crossed by five transverse vessels. The first-named vessels bridge over regular rows of large conical infundibula which project into the cavity of the branchial sac. Two very long narrow stigmata form a perfect double spiral of many turns on each infundibulum, one stigma winding from the base to the summit where it ends, the other descending from the summit to the base between the turns of the other spiral. In young individuals the infundibula start as flat spirals; as the number of turns increases the raised infundibula provide the additional surface necessary.

There is a single gonad (on the left side), or one on each side, the left one in, or mostly within, the primary intestinal loop. Each gonad consists of a rounded or flask-shaped ovary surrounded by, and partially overlapped on, its mesial aspect by the numerous small pyriform or lobed testes.

I am following Michaelsen (1915) and Hartmeyer (1923) in including in this genus *Eugyrioides* Seeliger, which has a gonad on both sides of the body. That cannot be made a generic distinction in this group. Indeed, it it is not altogether certain how reliable it is even as a specific distinction, though it appears to obtain in the case of the two common northern forms.

In this genus (and in the closely allied *Bostrichobranchus*) the development of a spiral arrangement of the stigmata attains its highest development in the entire class Ascidiacea. The well-distinguished species seem to be few but widely distributed.

Eugyra arenosa and *Bostrichobranchus pilularis* are known to have direct development without a tailed larval stage.

Eugyra glutinans (Moeller), 1842

Text figure 318

Cynthia glutinans MOELLER, 1842, p. 94.

? *Eugyra arctoa* ÄRNBÄCK, 1928, p. 67, pl. 3, figs. 57–59.

Eugyra glutinans VERRILL, 1872a, pp. 213, 289; TRAUSTEDT, 1880 (in part), p. 428; KIAER, 1893 (in part), p. 79; 1896 (in part), p. 18; ? WHITEAVES, 1901, p. 271; HARTMEYER, 1903 (in part), p. 126; REDIKORZEV, 1916, p. 35, fig. 5, pl. 1, fig. 3; HARTMEYER, 1923, p. 22.

Eugyrioides arctica REDIKORZEV, 1916, p. 40, fig. 6.

Eugyrioides glutinans HARTMEYER, 1914, p. 25; 1914b, p. 1097; REDIKORZEV, 1916, p. 35, pl. 1, fig. 3; ÄRNBÄCK, 1928, p. 64, pl. 3, figs. 52–56.

Eugyrioides rara RITTER, 1913, p. 443.

Eugyrioides schmidti REDIKORZEV, 1911, p. 215, fig. 1; 1916, p. 42, fig. 7, pl. 1, fig. 4, pl. 4, fig. 3.

Glandula glutinans STIMPSON, 1860a (in part), p. 1; ? PACKARD, 1867, p. 277; ? 1891, p. 396.

Paramolgula arctica BONNEVIE, 1896, p. 9, pl. 4, figs. 30, 31, 37.

Paramolgula rara KIAER, 1896, p. 17, pl. 5, figs. 16–19; REDIKORZEV, 1907, pp. 128, 152.

Not *Eugyra glutinans* Sumner, Osburn, and Cole, 1913, pp. 159, 729, chart 190 (= *Bostrichobranchus pilularis*).

For other references and synonyms, see Hartmeyer, 1923, pp. 22, 23.

The body is of elliptical outline and almost entirely covered with sand or small shell fragments except the tubes, and often also a bare area of varying size on the ventral region. Some specimens have a few elongate hairs or hair-like processes from the lower part of the body, serving to attach them lightly or anchor them in the sand, but I have not observed what could really be called a peduncle, nor any well-developed dorsal furrow for the protection of the tubes, though the latter are very retractile.

The largest specimen I have seen was little over 9 mm. in its longest (anteroposterior) diameter; the majority were not over 6 to 7 mm. The tubes are near together, the branchial quite close to the anterior end. The test is tough but transparent where not covered with sand, and ordinarily quite colorless, but in a living specimen from Corona Del Mar the tubes had a strong reddish tinge.

Internally the correspondence with *E. arenosa* is quite close, except for the additional gonad.

The mantle musculature comprises, besides narrow fibers, radiating and circular, forming a very open meshwork on and near the bases of the tubes, also numerous slender

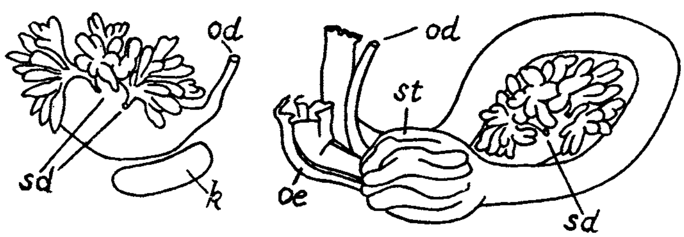


FIG. 318. *Eugyra glutinans* (Moeller). Right gonad and alimentary tract with left gonad (side next to the branchial sac). After Redikorzev's (1916) figure of "*Eugyrioides schmidti.*"

transverse fibers which extend across the ventral region and spread thinly over most of the lateral surface of the body on each side.

The dorsal tubercle was very small, with a simple pit-like or slit-like aperture in the specimens in which I examined it.

The tentacles, branchial sac, alimentary tract, etc., are much the same as in *arenosa;* the sac often has but five internal longitudinal vessels, and the doubling of the number of infundibula in the ventral row usual in *E. arenosa* is said to be less frequent and often confined to a few of the meshes. The intestine forms a loop rather widely open at the reflected end, which is strongly bent dorsally to form also a deep secondary loop.

The left gonad lies in the primary intestinal loop. Its ovary is elongate and tapers gradually into a long and wide oviduct in which the eggs appear to be retained for some time. This extends upward to near the base of the atrial tube, accompanying the rectum, but not very closely. The right gonad, very large and well developed in the specimens examined, lies dorsal and anterior to the kidney, which is bean shaped, quite small, and located far back on the right side of the body. Its oviduct passes dorsal to the kidney, bending sharply dorsally toward the base of the atrial tube. The small testes, which are elongate and somewhat branched, form groups surrounding more or less of the circumference of the ovary. There is no common sperm duct for the whole gonad, though the individual ducts of groups of testes unite to form a common duct for the group.

DISTRIBUTION: While I have much hesitation in including in a species which is chiefly an inhabitant of the Arctic and near-Arctic regions of the world, specimens not only from California but also from Lower California, I have not succeeded in finding characters to justify separating them.

Most of the records of this species are within or near the Arctic Circle and extend from the Murman coast westward, including northern Norway, Jan Mayan, Iceland, and southwestern Greenland (Baffin Bay). That it ranges southward along the Labrador Coast (as reported by Packard, 1867, 1891; Whiteaves, 1901) is not improbable but not certain, owing to its resemblance to, and possible confusion with, *Bostrichobranchus pilularis* which occurs in the Gulf of St. Lawrence and possibly farther north.

It seems probable that *E. glutinans* is a true circumpolar species, as there are two records from the Japanese Sea (Redikorzev, 1911, 1916), and from Kiska Harbor, Aleutian Islands (Ritter, 1913), where Dall collected numerous specimens in 9 to 12 fathoms, but it apparently occurs far south on the American Pacific coast.

Two specimens were dredged by G. E. MacGinitie off the California coast in the vicinity of Newport Bay (off Balboa, December 31, 1932, 9 to 10 fathoms, and July 5, 1939), and 12 were sent me by the United States National Museum from Magdalena Bay, west coast of Lower California, where they were dredged in 10 to 15 fathoms on sandy, weedy bottom "inside the northern point of entrance to the Bay," July 18, 1937.

It appears to have a great range in depth, 9 to 1805 meters, according to Hartmeyer, 1923, but most of the records are in less than 100 meters.

The synonymy of this species has been complicated not only by the various different generic and specific names under which it has appeared in literature, but also by confusion with *Eugyra arenosa* Alder and Hancock, 1848, due largely to Traustedt's (1880) uniting these two forms. (See Hartmeyer, 1914, 1923.)

E. arctoa was described by Ärnbäck from a single specimen 3.5 mm. in height and about 4.5 mm. in breadth, dredged in Baffin Bay in 408 meters. It is of elliptical outline covered with slender short filaments to which some mud and sand grains adhere. It is without a stalk and resembles *E. glutinans* both internally and externally but has only one gonad and has only five internal longitudinal vessels on each side. The spirals are flat and make only a few turns. Secondary spirals are wanting. In spite of the single gonad, which is entirely in the primary intestinal loop, I think its peculiarities may very likely be attributed to immaturity and abnormality and that its recognition as a distinct species should be postponed until more specimens give it justification.

Eugyra pedunculata Traustedt, 1886

Eugyra pedunculata TRAUSTEDT, 1886, p. 427, pl. 37, figs. 14, 15, pl. 38, fig. 25, pl. 39, fig. 32; HARTMEYER, 1903, p. 129; REDIKORZEV, 1907, pp. 128, 153; 1908a, p. 9, fig. 1a, 1b, pl. 1, fig. 1; 1916, p. 16, fig. 1, pl. 1, fig. 1, pl. 4, fig. 1; HARTMEYER, 1923, p. 40; ÄRNBÄCK, 1928, p. 66, pl. 3, fig. 60.

As this species barely comes within the part of the world this work covers, it will be dealt with very briefly.

It is similar in size and most characters to *E. arenosa* but differs in having the body externally smooth and usually free from foreign matter, and raised on a rather narrow stalk or pedicel which may equal or occasionally somewhat exceed in length the body diameter. The stalk arises from the ventral region and ends in a tuft of root-like processes by which the animal is anchored in the mud.

Internally the most striking difference is in its having only six internal longitudinal vessels; the first two, instead of only the first of the eight longitudinal rows of infundibula, are not crossed by such a vessel. Other characters are a simple, cup-shaped dorsal tubercle, tentacles with comparatively few branches, and the weakly developed mantle musculature.

DISTRIBUTION: This is a species of high northern latitudes known until recent years only from Spitzbergen and points farther eastward on or near the coasts of Europe and Siberia but has been reported by Ärnbäck from two eastern Greenland localities in 74° 52′ N., 17° 16′ W., 350 meters, clay with sand and stones, and from Scoresby Sound, 70 meters, mud.

Eugyra kerguelenensis Herdman, 1881

Text figures 319, 320

? *Eugyra guttula* MICHAELSEN, 1915, pp. 350–354 (also misprinted *guttala*), pl. 18, fig. 33.

Eugyra kerguelenensis HERDMAN, 1881, p. 237; 1882, p. 81, pl. 6, figs. 4–9; HARTMEYER, 1922b, p. 319.

Eugyrioides antarctica HARTMEYER, 1909–1911, p. 1321 (*nomen nudum*); 1912b, p. 231, pl. 40, figs. 4–11.

? *Eugyrioides guttula* HARTMEYER, 1909–1911, p. 1321; 1912b, pp. 236, 239.

? *Paramolgula guttula* MICHAELSEN, 1900, p. 135, pl. 3, figs. 14, 15; 1907, p. 81.

The body is of rounded, ovate, or elliptical form; the siphons, which in the retracted condition form only low papillae, are near together on the anterior dorsal aspect on a flattened or depressed area, which may have a raised margin; the body surface has a rather thin covering of very fine, crooked hairs to which mud adheres. Maximum diameter of Hartmeyer's specimens, 11 mm.

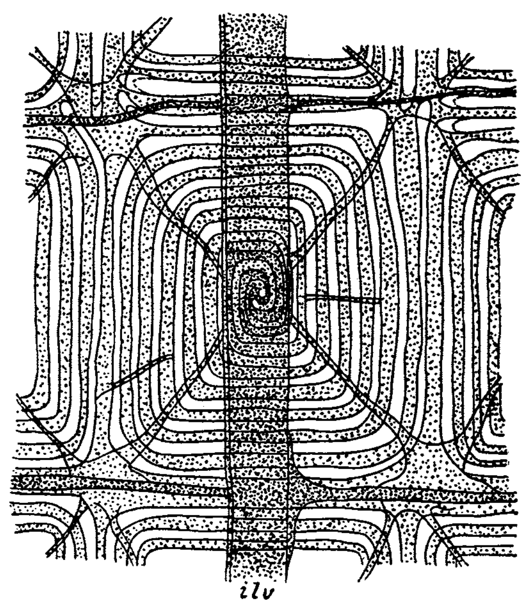


FIG. 319. *Eugyra kerguelenensis* Herdman. Piece of branchial sac. After Hartmeyer, 1912b.

Test thin but tough, transparent when clean. Mantle very thin, virtually without muscles except the radial and circular bands in the regions of the apertures, and a row of very short, wide, parallel bands along and near the endostyle on each side (the direction of the individual bands at right angles to the endostyle).

Tentacles rather numerous, of different sizes, even the largest not very profusely

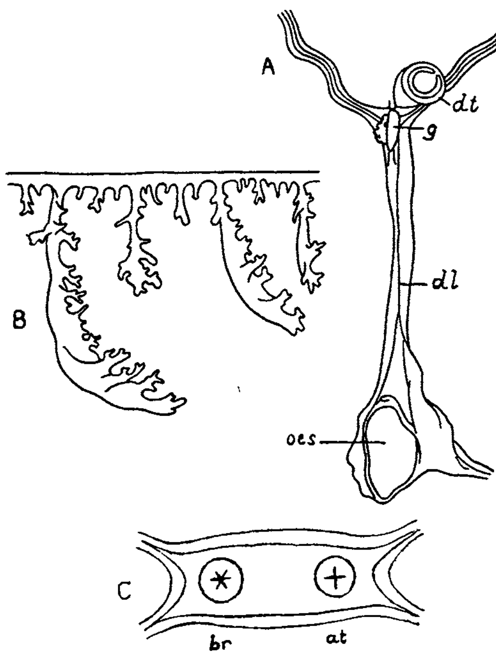


FIG. 320. *Eugyra kerguelenensis* Herdman. A. Part of circle of tentacles. B. Dorsal lamina (entire length) and adjacent structures. After Hartmeyer, 1912b. C. Outline of depressed area on the dorsal surface of the body, enclosing the apertures (in specimens from Argentine coast).

branched. In one specimen Hartmeyer found a total of about 30 at least slightly branched, in addition to rudimentary unbranched ones.

Dorsal tubercle with an almost completely closed ring-like opening. Dorsal lamina smooth, extending beyond the oesophageal aperture on the left of the latter. Hartmeyer describes the dorsal lamina as "double in the Kerguelen specimens," there being a second but narrower lamina on the right of the other, extending only to the oesophageal aperture. (It would seem, however, that the wider left lamella is the true dorsal lamina.)

Branchial sac without folds; with eight very regular longitudinal rows of large infundibula on each side, six in each of the rows except the ventral-most, which has 12. A single, wide, flat, internal longitudinal vessel bridges over each row except the most dorsal one. A pair of long, uninterrupted spiral stigmata of many turns occupies each infundibulum. Herdman's figure shows seven turns inward to the center and seven out. No other stigmata; no accessory spirals.

Intestinal loop somewhat open; stomach rather short and wide, its wall with longitudinal glandular plications. Each gonad consists of an elongate, more or less curved ovary and numerous small, often considerably lobed or branched testes which lie upon its unattached surface, extending a little beyond its borders. Left gonad in the primary intestinal loop and more or less covered by the dorsal branch of the loop; the right gonad is dorsal and anterior to the small, bean-shaped kidney, which is situated rather far back on the right side of the body.

DISTRIBUTION: Obtained at Kerguelen Island in 10 to 100 fathoms by the "Challenger" expedition (see Herdman, 1882), also in the same region by the Gazelle and Valdivia expeditions (see Hartmeyer, 1912b, 1922b).

I am referring to it provisionally a lot of about 50 specimens dredged by the "Albatross" at Station 2769 off the coast of Argentina (45° 22′ S., 64° 20′ W.) in 51 fathoms.

Some of these are larger than Hartmeyer's specimens, the largest being 17 mm. in its greatest diameter. Although the condition of the specimens for study is not very good, I have been able to demonstrate correspondence with Hartmeyer's Kerguelen specimens in most characters. Apparently a supplementary lamella is present along the dorsal lamina in the anterior part, but how far back that condition extends I did not succeed in determining. The double spirals on the infundibula have a large number of turns, sometimes at least a dozen. The depressed siphonal area on the body surface is oblong with parallel sides, and diverging furrows extend out from each of its four corners (see fig. 320c). These furrows are quite conspicuous, and Hartmeyer could hardly have failed to mention them if they were equally so on his specimens. But the Argentina specimens are evidently in a rather more strongly contracted condition than Hartmeyer's; in a more relaxed condition the furrows might be less noticeable.

We are probably also justified in referring to this species *Paramolgula guttula* Michaelsen, 1900, based on a single, very small, and very immature specimen, only 5 mm. in diameter, from the same region off the Argentine coast and at almost the same depth (43° 06′ S., 60° 00′ W., 56 fathoms). Hartmeyer recognized its relationship to *Eugyra*, and in a later article (1915) Michaelsen himself agreed to such a disposition of it. The poor development of the spirals of its branchial stigmata is only what might be expected in an individual so young.

Eugyra arenosa californica, new subspecies

This may not be even subspecifically distinct from the northern European species *E. arenosa* Alder and Hancock, 1848. Important references to the latter are:

Eugyra arenosa ALDER AND HANCOCK, 1848, p. 197; LACAZE-DUTHIERS, 1877, p. 648, pl. 27; HARTMEYER, 1914, p. 25; REDIKORZEV, 1916, p. 27, figs. 3, 4; HARTMEYER, 1923, p. 30; ÄRNBÄCK, 1928, p. 69, pl. 3, figs. 61, 62.

See Hartmeyer, 1923, for other references and synonyms.

This is one of numerous ascidians which, in the condition they are usually found, resemble a ball of mud. The body is of elliptical outline with a more or less noticeable longitudinal furrow on the dorsal aspect. Except for usually having a nearly bare area on the ventral or ventrolateral aspect, it is covered with a moss-like coating of extremely fine crooked hairs to which the mud and fine sand adhere.

The test is more or less transparent and colorless where not covered with sand. Not only the siphons, but also a longitudinally elongate area of thinner, softer test about their bases can be retracted, and in the contracted condition this area together with the siphons is drawn in so that the borders of the firmer test each side of it close together and completely conceal and protect them, forming the above-mentioned furrow on the dorsal aspect. In the fully extended condition this area of the test may be distended as a dome-shaped elevation from which the siphons arise. It has only a light or incomplete covering of sand in most individuals. The greatest (anteroposterior) body diameter rarely exceeds about 15 mm. and is oftener only from 6 to 10 mm. The mantle is thin and transparent, with narrow but sharply defined circular and radiating bands on and near the bases of the tubes and a series of short spindle-shaped muscle bands along each side of the endostyle transverse in direction to that organ, also a similar series in the vicinity of the rectum on each side.

The normal number of large compound tentacles appears to be 16 (4+4+8) comprising three orders, the largest two to three times compound; small tentacles in the intervals are usually few. The dorsal tubercle is usually small and more or less irregularly C-shaped with the open interval to the left. The branchial sac is beautifully regular in its structure. It has eight longitudinal rows of large infundibula, each formed of many (in large individuals up to a dozen or more) spiral turns of two long, narrow, uninterrupted stigmata, one winding to the summit or center where it ends, the other descending to the base between the coils of the first one. The infundibulum, which may be virtually flat or more or less conically raised in the central part or wholly conical, is supported on its external (peribranchial) surface by several radial vessels which merely cross but do not interrupt the long spiral stigmata.

Of the eight longitudinal rows of infundibula, all but the most dorsal are bridged over by one of the internal longitudinal vessels. They form six dorsoventral rows separated by the five transverse vessels, except that in the most ventral longitudinal series there are usually two infundibula (separated by a narrow second-order transverse vessel) between each of the five main transverse vessels. Additional ("secondary") infundibula are of more or less rare occurrence, but occasionally a small one may be found in the ventral part of the sac in a corner of one of the square fields marked off by the vessels.

The intestinal tract forms a loop considerably opened at the reflected end, and the whole is bent up dorsally to an extent varying much in different individuals. A part of the proximal portion of the stomach wall is developed into a hepatic organ composed of a few thick glandular folds longitudinal to the axis of the stomach in their direction. The rectum is rather long, its aperture commonly more or less lobed.

The kidney is of moderate size, elliptical in outline, and is situated quite far back on the right side.

The one gonad is on the left side and visible in the opening of the primary loop of the intestine, consisting of a more or less pear-shaped or elongated ovary which tapers into the long oviduct accompanying the rectum to near its end. The oviduct is usually full of eggs. The testes form small groups of lobate or branching glands which surround more or less the border of the ovary, overlapping its marginal portion to a varying extent. The ducts of several adjacent small glands commonly unite on the inner aspect of the ovary to discharge by a common opening, but I have not observed their all uniting to discharge by one common sperm duct.

As seen from the aspect toward the mantle, the gonad is visible in the opening of the primary loop of the intestine and does not, ordinarily at least, show at all dorsal to the intestine in the secondary loop of the latter as is described and figured in the European *Eugyra arenosa*. This may indicate a difference in the shape or position of the gonad in the two forms.

LOCALITIES: This is a common species on the muddy or more or less sandy bottom of the ocean in the vicinity of Corona del Mar at the entrance to Newport Bay, California, in depths varying from a few feet to 20 fathoms. The type, from this locality, is A.M.N.H. No. 1586. I have also received specimens from Santa Cruz Island of the Santa Barbara group, collected by Willis G. Hewatt. It apparently lives buried in the sand or mud and not firmly fixed to any solid object, though two or more individuals may be lightly attached together.

As stated above, it is hard to distinguish this form from *Eugyra arenosa* Alder and Hancock, 1848, of northern Europe (coasts of the North Sea, the British Channel, etc., the Faeroe Islands being its northwestern limit), but there is no record from any intermediate point such as Bering Sea or British Columbia to connect the southern California form geographically with the European one, and possible colonization of a species of such habits by accidental transportation on ships' bottoms seems to be excluded. I, therefore, hesitate to identify the two and am treating the California form as a subspecies.

GENUS OR SUBGENUS BOSTRICHOBRANCHUS TRAUSTEDT, 1883

Characters the same as for *Eugyra* except that in addition to the large primary infundibula that are bridged over by the internal longitudinal vessels as in *Eugyra*, numerous additional small infundibula begin to develop even in quite young individuals, and increase in size and number as the animal becomes older. In old and large specimens the infundibula become so tall and narrow as often to be almost finger-like, and the accessory or secondary ones so large and numerous in all parts of the sac as to obscure the prominence of the primary ones. Normally a gonad is present on the left side only (in the primary intestinal loop).

This group was reduced to a subgenus by Huntsman, 1912, and simply united with *Eugyra* by Ärnbäck, 1928. It is so close to the latter that Huntsman's course has much to recommend it, but nevertheless the remarkable development of the accessory infundibula in the present group represents a distinct advance step in the evolution and specialization of the branchial sac beyond that characteristic of *Eugyra* which seems worthy of recognition in classification. The type and only species is *B. pilularis*. It has direct development, no tailed larva being formed (Berrill, 1931).

Bostrichobranchus pilularis (Verrill), 1871

Plate 3, figures 1, 2; text figures 321–325

Bostrichobranchus manhattensis TRAUSTEDT, 1883, pp. 109, 128; 1885, pp. 22, 53, pl. 1, figs. 10–12; SEELIGER, 1907, p. 1192, fig. 218.

Bostrichobranchus molguloides METCALF, 1900, pp. 583–587, pl. 36, figs. 33, 37; SUMNER, OSBURN, AND COLE, 1913, p. 729; PRATT, 1916, p. 665.

Bostrichobranchus pilularis VAN NAME, 1912, p. 458, fig. 1, pl. 43, figs. 1–4, pl. 44, figs. 5, 6, pl. 69, fig. 137; 1921, p. 475, figs. 156–159; HARTMEYER, 1923, p. 15; PRATT, 1925, p. 751, fig. 969; BERRILL, 1928, p. 52.

Caesira pellucida HARTMEYER, 1909–1911, p. 1324.

Eugyra glutinans Sumner, Osburn, and Cole, 1913, p. 729, chart 190. Not Moeller, 1842.

Eugyra pilularis Verrill, 1872a, p. 211, pl. 8, fig. 3; 1873, p. 440; Verrill and Smith, 1873, pp. 509, 700, pl. 33, fig. 243; Verrill, 1874, pp. 348, 352, 368; Whiteaves, 1874, p. 7; Verrill, 1879, p. 27; Sumner, Osburn, and Cole, 1913, pp. 729, etc., chart 190; Pratt, 1916, p. 665, fig. 1008; Ärnbäck, 1928, p. 72, pl. 2, fig. 40, pl. 3, figs. 67–68; Berrill, 1931, pp. 306, 333, fig. 12e–12i; 1937, p. 566.

Eugyriopsis manhattensis Pizon, 1898, p. 319; 1898b, p. 273.

Herdmania bostrichobranchus Metcalf, 1900, pp. 520, 521, pl. 36, figs. 36, 37 (made type of a new genus *Herdmania*, but this is antedated by *Herdmania* Lahille, 1887).

Molgula pellucida Verrill, 1872a, pp. 211, 289, pl. 8, fig. 2; Verrill and Smith, 1873, pp. 699, 426, 429; Coues and Yarrow, 1878, p. 303; Howard, 1883, p. 304; Herdman, 1891, p. 569; Van Name, 1912, p. 459; Sumner, Osburn, and Cole, 1913, p. 729; Pratt, 1916, p. 665.

Molgula pilularis Verrill, 1871, p. 58, fig. 4c; 1871a, p. 361.

Molgula producta Whiteaves, 1874, p. 12; 1874a, pp. 216–218; 1901, p. 271. Not Stimpson, 1852.

Not *Molgula pellucida* MacDonald, 1859, from Australia.

The very unsatisfactory illustrations labeled *Molgula producta* in Binney, 1870, pl. 22, figs. 315, 316, may perhaps be intended to represent *B. pilularis*, but the description in the text does not refer to *pilularis*. See under *Molgula complanata*.

See also under *Eugyra glutinans* (remarks on distribution).

The external appearance of living examples of this species is thus described by Verrill (1871, p. 58):

"Body unattached, globular, covered with a thin layer of mud, and, when the tubes are retracted, looking like a small soft ball of mud. Integument of the body, when cleaned, very thin, soft, nearly transparent, thickly covered with minute granules, and minutely fibrous, usually concealed by the adhering particles of mud and fine sand, but this can be easily removed. The tubes are naked, nearly transparent, subconical, slender, as long as the diameter of the body, originating close together and but slightly divergent, both of them nearly straight; they can be wholly retracted and their bases are surrounded and connected by a narrow, naked, oval, or oblong band, which is usually conspicuous when the tubes are withdrawn; in partial contraction the tubes are conical, subpellucid, reticulated with white lines. The branchial tube is a little shorter than the anal, the aperture surrounded by six acute, conical papillae, and twelve small dark brownish spots. Anal tube a little smaller, slightly longer, a little tapering, with a small

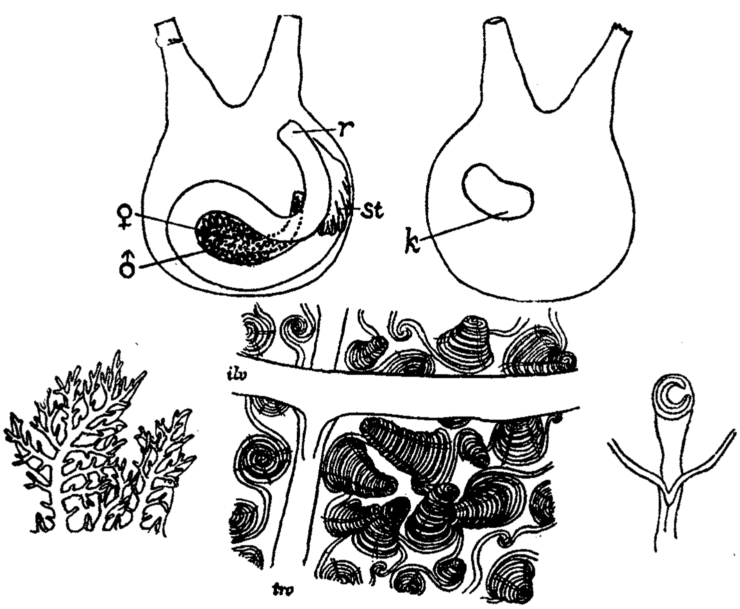


Fig. 321. *Bostrichobranchus pilularis* (Verrill). Left and right sides of body, siphons extended, ×13; group of tentacles, dorsal tubercle, and small piece of branchial sac of an old individual, ×32.

square aperture, surrounded by four small lobes and four small, reddish brown eye-spots.

"In life the body when cleaned is transparent grayish, the dark intestine showing through very distinctly; tubes greenish at base.

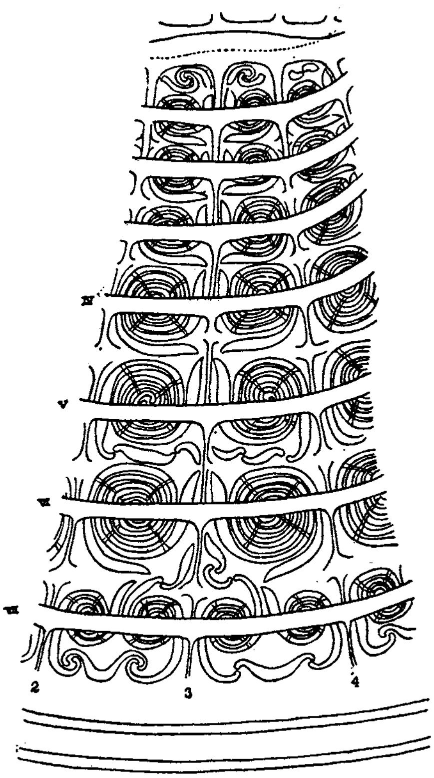


FIG. 322. *Bostrichobranchus pilularis* (Verrill). Part of branchial sac of very young individual, showing structure similar to that of *Eugyra* with beginnings of accessory spirals, ×36.

"Diameter usually about 5 mm., seldom more than 6 mm. or 8 mm."

The species is a variable one and appears to be considerably affected by the environment in which it happens to grow. Individuals from certain localities may be nearly free from sand or mud and have a fairly smooth, sometimes quite transparent test. The size attained is also apparently much influenced by the locality. In some places it does not exceed the dimensions given by Verrill, although, as the reproductive organs show, the animals are adult. In exceptionally favorable places it becomes 28 mm. to 35 mm. long, and 24 mm. or 25 mm. in dorsoventral diameter. The species can generally be recognized by the area mentioned in Verrill's description quoted above on the surface of the body, usually free from sand or mud, which surrounds the base of the siphons and is bordered by a definite line. Probably this area forms a convex protrusion when the body is much distended with water.

Transverse muscle fibers prevail in the mantle and are for the most part gathered into very slender bands which are not at all conspicuous on most parts of the body. But in the vicinity of the siphons strong bands spread out in a radial manner over the body surface, becoming abruptly slender after a certain distance, and near each side of the midventral line (though not extending across that line) there are many stout transverse muscle bands. The circular muscles about the bases of the siphons are also well developed.

The tentacles are numerous and of about four different sizes or orders, arranged with some regularity, the largest numbering about eight. The largest tentacles are irregularly bipinnately or to some extent tripinnately branched. The orifice of the dorsal tubercle is C-shaped or horseshoe shaped, with the open interval directed toward the left. In large specimens the horns are generally more or less irregularly incurved or bent. The dorsal lamina is plain edged.

The branchial sac is entirely without folds, their place being taken by seven stout internal longitudinal vessels, which are crossed by five transverse vessels. In young individuals the sac resembles that of *Eugyra* with regular rows of large infundibula, on which a long narrow stigma winds from the base to the summit, where it ends. At the summit another stigma begins and winds down between the coils of the other to the base (see fig. 323). But even while the animal is still very small, other ("secondary") spirals begin to appear, developing into conical infundibula and becoming more numerous as the individual grows older, until in old and large specimens some of them equal the primary infundibula in size and height, and are so many that the primary ones can no longer be recognized, and the fields marked off by the vessels become filled with infundibula irregularly and closely distributed. All but the smallest ones of a very few turns are raised into inwardly projecting cones, many of them so tall and narrow as to be finger-like in form. The branchial sac and its development are described in much more detail in Van Name, 1912 (pp. 461–464).

The reproductive organs are situated only on the left side of the body. However, I once found a specimen (from off St. George Sound, Florida) that had a well-developed gonad on the right side also. The ovary is flask shaped and lies in the loop of the intestine. Its posterior end extends into a tubular, dorsally curving oviduct of varying length. The numerous

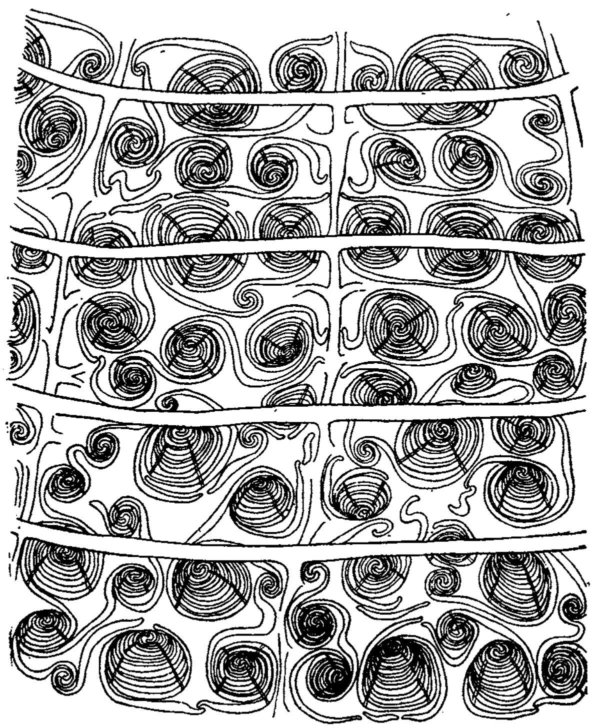


FIG. 323. *Bostrichobranchus pilularis* (Verrill). Part of branchial sac of an adult individual with well-developed accessory infundibula, but in which the primary ones are still recognizable, ×36.

testes are cleft into two to six or more lobes and lie in the mesial aspect of the ovary, overlapping its borders. They open by several very short ducts. No tailed larvae are formed. The eggs, according to Berrill (1931), are 0.11 mm. in diameter exclusive of the follicle.

The alimentary canal forms a small but moderately wide open loop. The stomach walls have longitudinal folds. These are usually few in number (often only about eight or 10) near the oesophageal end, but most of them fork, or incomplete folds arise between them, so that at the pyloric end they are more numerous and more irregular. The gland surrounding the intestine is well developed and covers the outer surface of the intestine for some distance on the inside of the bend of the loop.

The kidney is a rather small, transparent, bean-shaped sac in the right posterior part of the body, attached to the mantle. It generally contains two or three large dark-colored concretions.

DISTRIBUTION: It is known to range from the St. Lawrence estuary and Banks of Newfoundland to Florida and is locally common from the Bay of Fundy region to southern New England, but specimens from most localities are small (8 to 10 mm. in diameter) and it seems to attain its greatest abundance and maximum size (28 to 35 mm.) in the vicinity of Cape Cod, especially at Race Point at the extremity of the Cape, and in Vineyard Sound and Buzzards Bay. Often in these lo-

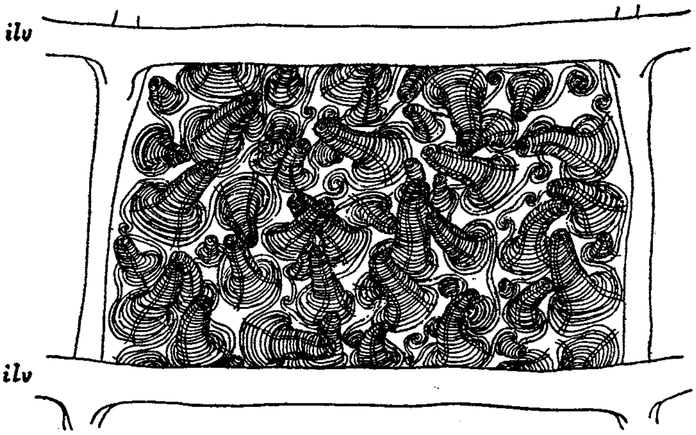


FIG. 324. *Bostrichobranchus pilularis* (Verrill). Small piece of the branchial sac of a very old individual, showing great increase in number and elongation of the infundibula, so that the primary infundibula are no longer recognizable, ×23.

calities several specimens will be found lightly attached together by the fibrous processes of the test.

South of New York the records are fewer and the specimens of smaller size. It was collected at Bird Island Shoals near Beaufort, North Carolina (Coues and Yarrow), and the United States National Museum has examples from off Savannah, Georgia, the east coast of Florida in 32° 00′ N., 80° 25′ W., and the west coast of that state in 28° 56′ N., 83° 00′ W. and off St. George Sound. The range in depth recorded is from ½ to 120 fathoms. It lives upon, or more or less buried in, the mud or sand of the sea bottom and can usually be obtained only by dredging.

A number of causes have contributed to complicate the synonymy of this common and widely distributed species, among them the fact that it has been confused with *Molgula manhattensis* by certain authors. It has appeared in the same book under three different generic names and under several specific names. (See Van Name, 1912; Hartmeyer, 1923.)

In explanation of my inclusion of "*Molgula pellucida*" among the synonyms of this species, I would like to say that I examined specimens from Huntington Bay, Long Island, New York, collected by T. A. Tellkampf, which were labeled "*pellucida*" by Verrill, and found them to be *B. pilularis*. Though not designated as types, it seems not unlikely they were Verrill's types of his *Molgula pellucida*. They had much less than the usual coating of sand or mud, as was also the case with the North Carolina specimens collected by Coues and Yarrow, which were designated *M. pellucida* by Verrill and which I also examined. In the latter specimens the tubes were not retracted. I do not now believe that *pellucida* can be regarded as deserving of recognition as a variety of *pilularis*, as I suggested in my 1912 article.

GENUS **HEXACROBYLUS** SLUITER, 1905

A peculiar genus of deep-sea ascidians (see Sluiter, 1905, Tijds. Nederlandsch Indie Dierk. Ver., ser. 2, vol. 9, p. 326) included in the Molgulidae in recent classifications. It is especially distinguished by having the branchial sac in a greatly reduced condition and having the branchial aperture surrounded by a high collar-like circular fold, extended into six large lobes, branched somewhat after the fashion of the compound tentacles of many other members of the family, though they evidently do not represent tentacles. The lobes are ordinarily found curled inward over the aperture.

The other two known species are from the Malay region and Indian Ocean.

Hexacrobylus arcticus Hartmeyer, 1923

Hexacrobylus arcticus HARTMEYER, 1923, p. 133, pl. 1, figs. 5, 6; ÄRNBÄCK, 1928, p. 76.

The body is ovate or sometimes pyriform; both apertures circular, without lobes, on protrusible siphons; the branchial terminal, surrounded by the lobed collar (see under the genus), the atrial on the dorsal aspect of the body. The test bears scattered hair-like processes; these form a tuft at the near end for anchoring the body in the mud. It is of very small size, the largest of a number of specimens being only 10 by 5 mm. in diameter.

Much remains to be learned about its internal structure, and as it has not been taken at any point actually within the region this work attempts to cover, I refer the reader to Hartmeyer's article for further particulars.

DISTRIBUTION: Reported as yet only from two deep-sea stations, one near the Faeroe Islands, the other north of Iceland (67° 40′ N., 15° 40′ W., 495 fathoms), and, therefore, not very far from the Greenland coast.

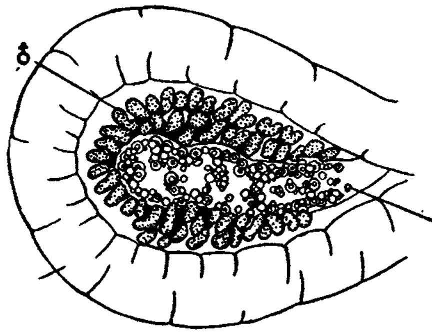


FIG. 325. *Bostrichobranchus pilularis* (Verrill). Part of intestinal loop and gonad (side attached to the mantle), ×7.

ASCIDIANS TOO INCOMPLETELY DESCRIBED FOR CLASSIFICATION

Ascidia albeola Lesueur, 1823

Ascidia albeola LESUEUR, 1823, p. 8, pl. 2, fig. 1; VAN NAME, 1921, p. 482.

Ecteinascidia albeola HARTMEYER, 1909–1911, pp. 1412, 1630.

"Body sub-pyriform, more inflated above, terminating in two apertures, that of the branchia more elevated; base destitute of a peduncle but spreading a little outwards to increase the surface of attachment; color white, diaphanous, exhibiting an interior globular red point. . . ."

Apparently an *Ecteinascidia* (immature), perhaps *E. conklini*.

LOCALITY: Guadeloupe.

Acidia lobifera Lesueur, 1823

Ascidia lobifera LESUEUR, 1823, p. 7; HARTMEYER, 1909–1911, p. 1406; VAN NAME, 1921, p. 482.

"Body sessile, sub-globular, with approximate unequal apertures concealed in the midst of irregular, fleshy lobes. . . . The color in its present state is shell-black and the surface is wrinkled."

Except for the color (it may have become accidentally stained), the description suggests *Styela plicata*. No locality given, but presumably it is eastern American.

Ascidia ovalis Lesueur, 1823

Ascidia ovalis LESUEUR, 1823, p. 6, pl. 3, fig. a; VAN NAME, 1921, p. 482.

Phallusia ovalis HARTMEYER, 1909–1911, p. 1405.

"Body sessile, resembling the preceding species (*plicata*) but smaller, less rugged, being destitute of large inflated folds, with some slight, irregular wrinkles on the surface; apertures large, distinct, placed at the extremity of two short tubes; the skin which margins the apertures is very thin and apparently divided into many small obsolete angles; one of these apertures is placed lower than the other and lateral; colonies in the alcohol, white, nearly the size of *plicata*." (*Styela plicata* is referred to.)

From the bottom of a vessel at Philadelphia.

Ascidia monstrans Gould, 1852

Ascidia monstrans GOULD, 1852, p. 496, pl. 52, fig. 611.

Phallusia monstrans HARTMEYER, 1909–1911, p. 1405; VAN NAME, 1921, p. 486.

Text figure 326

"Animal small subglobose at base and produced toward the respiratory orifice into a long, tapering tube; the excretory orifice is very small, seated far below the other on a slight mamillation. The tunic is thin, smooth, coriaceous, passing from olive green at base, through deep orange to vermilion at the orifices; lips of the orifices simple, furnished with long delicate ciliae continually in motion.

"Height sometimes one inch, diameter about two-thirds the height."

LOCALITY: Near entrance to harbor, Rio de Janeiro, Brazil, in 3 fathoms of water, attached to old shells, etc.

Ascidia multiformis Lesueur, 1823

Ascidia multiformis LESUEUR, 1823, p. 3, pl. 2, fig. 2 (var. A, pl. 2, fig. 4); VAN NAME, 1921, p. 482.

Caesira multiformis HARTMEYER, 1909–1911, p. 1324.

Molgula multiformis VAN NAME, 1921, p. 486.

"Body variable in form, sometimes depressed or orbicular, sometimes elongated and projecting two large unequal tubes which, as in the other species, are distinct when collapsed and divergent when projected, the opening of one of these is furnished with four,

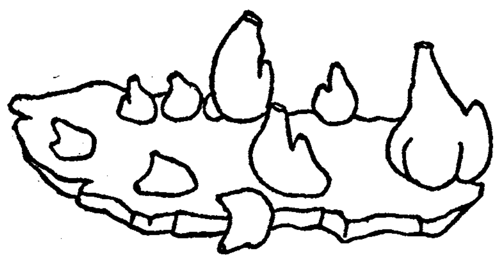


FIG. 326. *Ascidia monstrans* Gould. Outline of Gould's figure, somewhat less than natural size.

the other with five triangular flaps, base sessile, discoidal, forming on attaching surface wider than the body, substance soft, diaphanous, and tinted with red, length about 5 lines, breadth 2 lines. Many specimens are much smaller. . . . They are gregarious, attaching themselves to rocks on the shore of the island of Guadeloupe.

"Var. *a* differs in being much longer, more solid and more opaque, the apertures are entire, the interior of the opening is black and the general exterior color gray; the almost smooth surface is interrupted by a few wrinkles. . . . It is a native of the coast of Guadeloupe."

Ascidia proboscidea Lesueur, 1823

Ascidia proboscidea LESUEUR, 1823, p. 6, pl. 1, figs. 4, 5.

Probably not an ascidian.

Cynthia amphora Gould, 1852

Text figure 327

Cynthia amphora GOULD, 1852, p. 495, pl. 52, fig. 609; VAN NAME, 1921, p. 483.

Pyura amphora HARTMEYER, 1909–1911, p. 1342; VAN NAME, 1921, p. 487.

"Animal subglobose, color ochraceous, tinted orange, tunic thin, and rendered rough by short wrinkles running in all directions, surface also divided into segments by longitudinal furrows. Orifices approximate, large, remarkable for the eversion and thickening of their lip. The superior orifice is much larger, and they both open at the end of short, thick, constricted tubes.

"Height an inch and a half, circumference three or four inches."

LOCALITY: Rio de Janeiro, Brazil, abreast of Fort Santa Cruz, 4 to 5 fathoms.

Cynthia subcaerulea Stimpson, 1852

Cynthia subcaerulea STIMPSON, 1852, p. 231; VAN NAME, 1921, pp. 419, 484.

Pyura subcaerulea HARTMEYER, 1909–1911, p. 1342.

"Body firm, hemispheric, adhering by the base. Test thin but tough, smooth, translucent, with a pale bluish tinge. Orifices small, sessile, not far removed from each other. Diameter one-fourth of an inch."

LOCALITY: Oak Island Beach, North Carolina, attached to corallines thrown ashore.

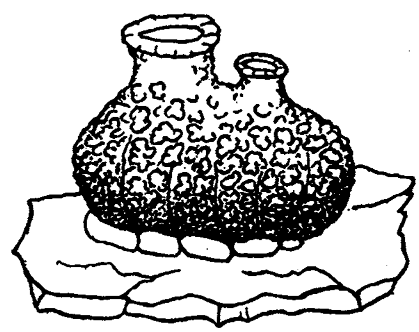


FIG. 327. *Cynthia amphora* Gould. Outline of Gould's figure, three-quarters natural size.

Didemnum (?) inerme Herdman, 1886

Didemnopsis inerme HARTMEYER, 1909–1911, p. 1447.

Didemnum (?) *inerme* HERDMAN, 1886, p. 265, pl. 34, figs. 6, 7; VAN NAME, 1902, p. 326; 1921, p. 484.

Colony a rounded mass attached by the greater part of its lower half; 1.2 by 1.5 by 1.3 cm.; color dull gray, semi-transparent; no spicules found, bladder cells present.

Nothing could be made out about the zooids. Placed in *Didemnum* by Herdman "simply from the general appearance."

LOCALITY: Off Bermuda in shallow water, collected by the "Challenger" expedition.

Aplidium crassum Herdman, 1886

Aplidium crassum HERDMAN, 1886, p. 207, pl. 25, figs. 15, 16.

Described from a single specimen of irregularly conical form attached by a wide and spreading base. Color opaque, whitish gray, becoming slightly hyaline toward the point of attachment. Surface uneven but moderately smooth. Colony 2 cm. long, greatest width (above the base) 1.5 cm. Large bladder cells present in the outer part of the test. Zooids in the deeper part of the colony.

Zooids about 7 mm. long by 1.5 mm. wide, their bodies not divided into regions. Mantle with very heavy musculature on the branchial region. Tentacles about 12, all of the same size. Branchial sac with a good many rows of stigmata separated by transverse vessels bearing wide membranes. Dorsal lamina represented by rather short and broad languets with blunt points, their edges continuous with the membranes on the transverse vessels. Alimentary canal wide but not very long. No information regarding the stomach.

Reproductive organs in the intestinal loop, extending beyond it for a short distance, forming a small post-abdomen. Ova large, bright yellow in color. Testes very numerous, small, and pyriform.

LOCALITY: Off Bahia, Brazil, in shallow water.

It seems very doubtful whether this is an *Aplidium* or even a member of the Synoicidae; more probably it is a *Clavelina*. (See remarks on this species at the end of the description of *Clavelina picta*.)

Psammaplidium flavum Herdman, 1886

Psammaplidium flavum HERDMAN, 1886, p. 249, pl. 32, figs. 11–13.

Psammaplidium is a genus of Synoicidae established by Herdman, 1886, to contain a number of specimens of that family having little in common except that the test is densely crowded with embedded sand grains. In it he placed no fewer than nine supposed species collected by the "Challenger," and the genus was for many years used as a convenient receptacle for the disposal of obscure specimens of compound ascidians if a fair amount of embedded sand could be found in them. Hartmeyer, 1909–1911, lists no fewer than 31 species which various authors put in it, though of course no genus based on such a character would be recognized at the present time.

In the case of most of the American species placed in it, it has been possible to find out or to make a probable guess as to what genus they really belong in, and they have been dealt with accordingly. In the case of the present species, Hartmeyer did not venture on any conjecture, and I cannot do so either.

The only specimen forms an irregularly hemispherical mass from 1 to 1.5 cm. in diameter and opaque yellowish brown in color, with an even but finely roughened surface. Zooids about 3 mm. long, not visible until the colony is cut open.

Mantle musculature of zooids very strong with mainly longitudinal bands. Branchial sac long and narrow, stigmata small and inconspicuous. Alimentary canal relatively small and forming a short loop.

"The most remarkable point however in the test is the presence in the outer layer of a great number of closely placed masses of large granular cells. . . . A careful examination of the test showed that no vessels were present and that the cavities in the test matrix in which the masses of cells were placed had no tubes leaving from them, but were closed upon all sides" (Herdman, 1886, p. 250).

LOCALITY: "Challenger" Station 320 off the mouth of the La Plata River, 37° 17′ S., 53° 52′ W., in 600 fathoms.

Psammaplidium pedunculatum Ritter, 1901

Psammaplidium pedunculatum (?) RITTER, 1901, p. 254. Apparently not Herdman, 1891, p. 620; 1899, p. 88, pl. 6, figs. 7–9.

Ritter, 1901, briefly described a specimen consisting of two small club-shaped lobes containing embedded sand attached together at their narrow basal parts.

"Color: Cherry red in life, this however disappearing in preserved condition except for a slight tinge particularly noticeable around the siphons.

"Zooids: Arranged in very distinct systems of about a dozen each; one or two systems to each lobe. Common cloacal opening large and distinct. Zooids much contracted and very opaque. A distinct though not long single-pointed atrial languet. About twelve series of branchial stigmata. Stomach rather large, though not clearly set off from the intestine which is also large. A single narrow longitudinal fold on the left side of the stomach, triangular in form with very narrow base directed toward the posterior end of the stomach, the apex reaching nearly though not quite to the anterior end.

"Post-abdomen very dense and opaque; gonads not recognized."

LOCALITY: Sitka, Alaska, in about 10 fathoms.

Ritter identified this doubtfully with *P. pedunculatum* Herdman, 1899, supposed to have come from Port Jackson, Australia. I can see no adequate reason for believing the Alaska specimen, whatever it was, identical with the Australian form, nor am I able to assign it definitely to any accepted genus without more information than Ritter gives.

SYNOICIDAE FROM THE FALKLAND ISLANDS

Herdman, 1912 (pp. 99, 100), reports specimens of Synoicidae from the Falkland Islands which he doubtfully assigns to *Polyclinum complanatum* Herdman, 1899, and *Amaroucium distomoides* Herdman, 1899, both described from Port Jackson, Australia, also some small specimens which he simply reports as *Amaroucium* sp. It is not possible to make a guess what these specimens are from the few statements made regarding them. Their assignment to the Australian species (whose generic position seems doubtful in both cases) does not appear to me to have any adequate justification.

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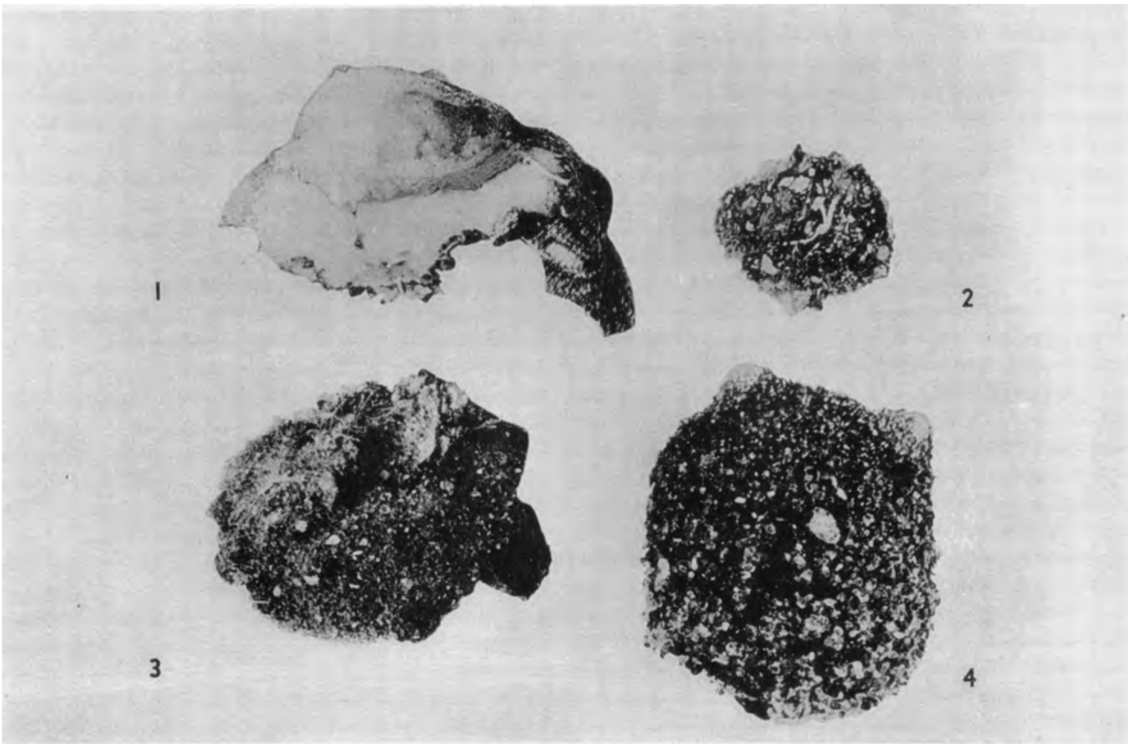
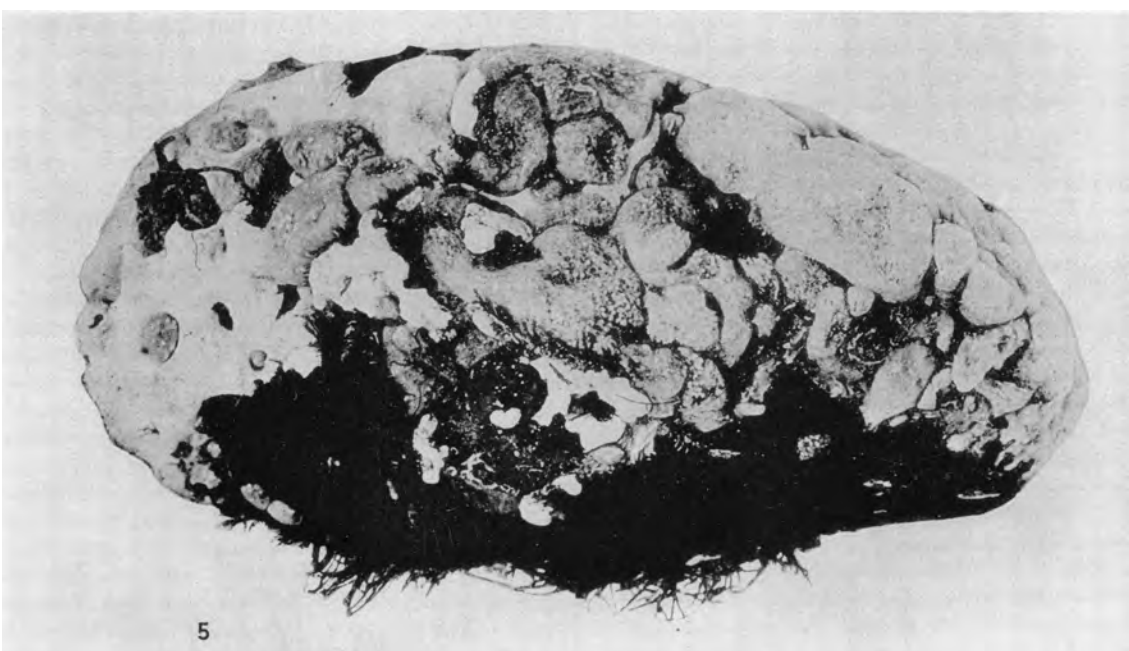
Names used in this work as the valid and correct ones are entered in italics in the index; those regarded as synonyms or probable synonyms, in roman type.

In the case of synonyms, the page reference given is to the name used in this work as the valid one.

PLATES 1–31

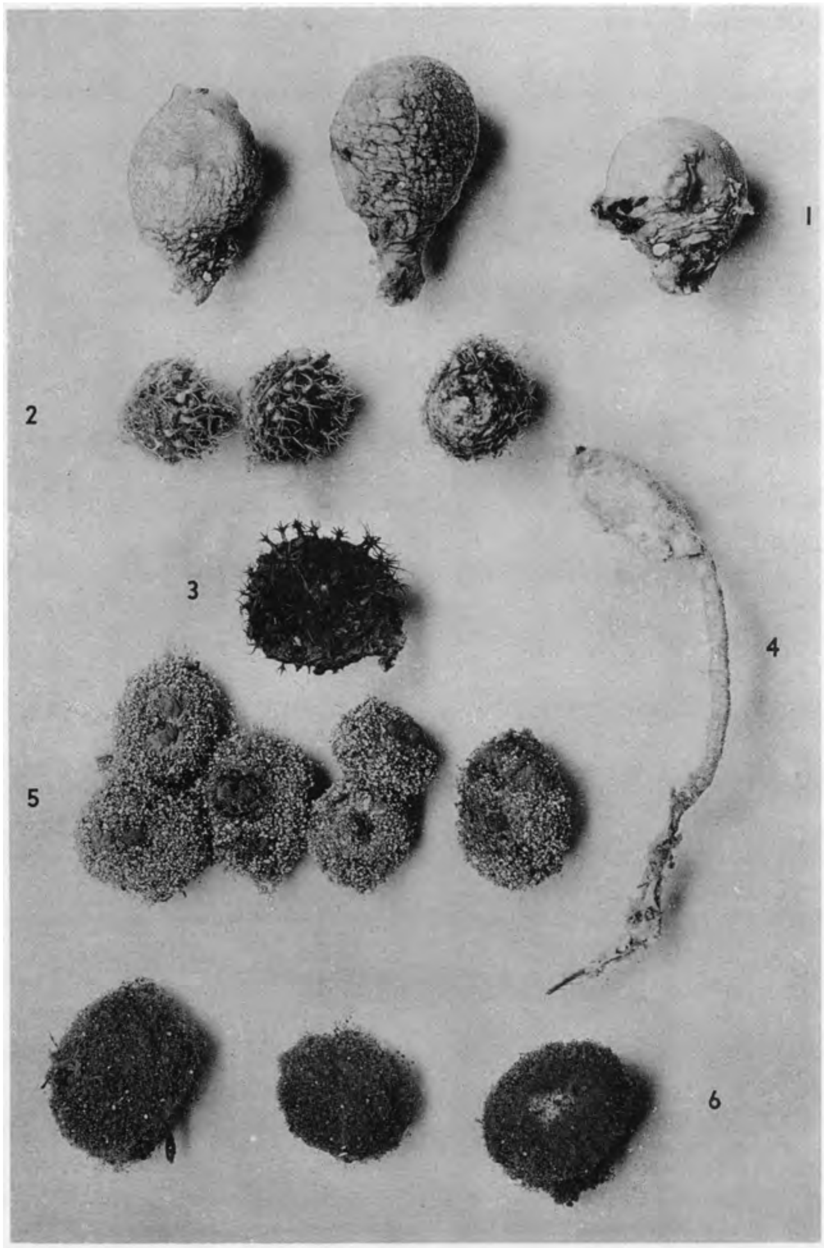




SPECIES OF NORTHEASTERN UNITED STATES AND CANADA

1. *Cnemidocarpa finmarkiensis* (Kiaer), attached to a piece of a shell. "Albatross" Station 2466 (south of Newfoundland).
2. *Molgula siphonalis* Sars. Banks of Newfoundland.
3. *Molgula robusta* (Van Name). Woods Hole, Massachusetts. Type.
4. *Microcosmus glacialis* (Sars). Off Nova Scotia.
5. Mussel shell bearing white incrusting colonies of *Didemnum albidum* (Verrill) and more prominent, darker colored colonies of *Amaroucium glabrum* Verrill. Off Massachusetts coast, 41° 17′ N., 68° 21′ W., 32 fathoms.

All natural size.



SPECIES OF NORTHEASTERN UNITED STATES AND CANADA

1. *Dendrodoa pulchella* (Verrill). Three individuals from the Grand Banks.

2. *Boltenia echinata* (Linnaeus). Three individuals from Eastport, Maine.

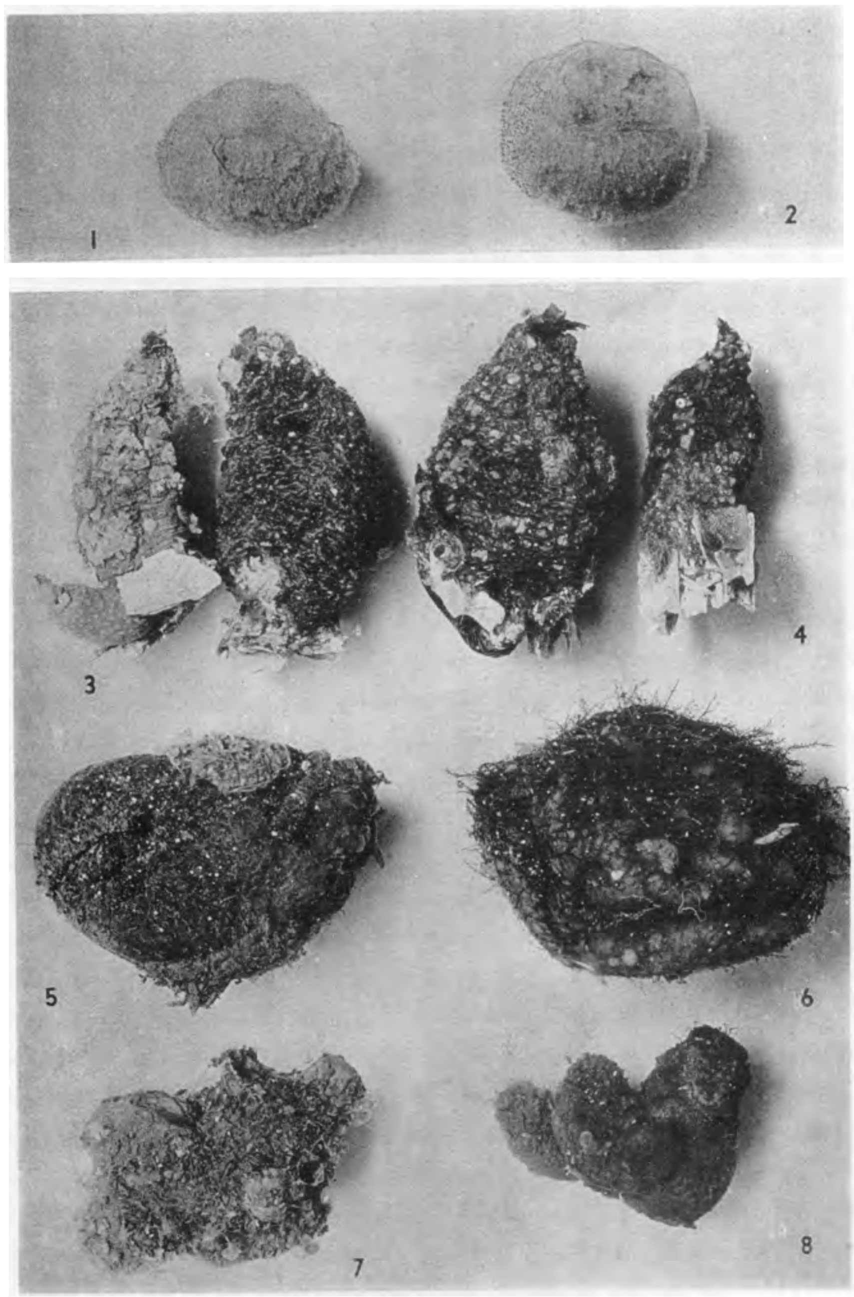
3. *Boltenia echinata* (Linnaeus). Labrador.

4. *Boltenia ovifera* (Linnaeus). Young individual. Grand Banks.

5. *Polycarpa albatrossi* (Van Name). "Albatross" Station 2714, 38° 22′ N., 70° 17′ 30″ W., 1825 fathoms.

6. *Polycarpa fibrosa* (Stimpson). "Albatross" Station 2056, 42° 01′ 30″ N., 68° 01′ W., 97 fathoms.

All natural size.



SPECIES OF NORTHEASTERN UNITED STATES AND CANADA

1, 2. *Bostrichobranchus pilularis* (Verrill). Large specimens free from incrusting sand and mud. Vineyard Sound, Massachusetts.

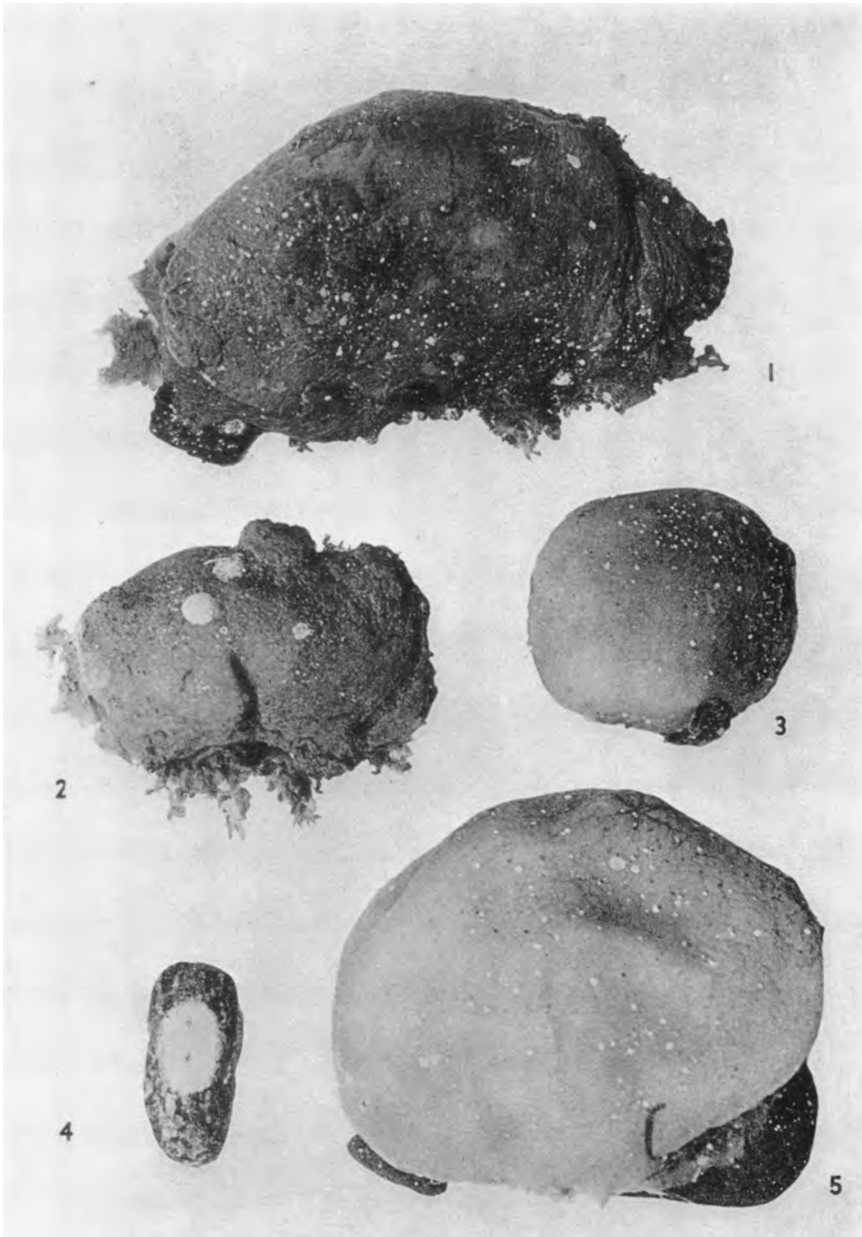
3, 4. *Styela rustica* (Linnaeus). Grand Banks.

5. *Molgula retortiformis* Verrill. Siphons entirely retracted. "Albatross" Station 2699, 45° 04′ N., 55° 23′ W., 72 fathoms.

6. *Molgula retortiformis* Verrill. Siphons entirely retracted. Eastport, Maine.

7, 8. *Styela partita* (Stimpson). Two groups of individuals. Newport, Rhode Island.

All natural size.



SPECIES OF NORTHEASTERN UNITED STATES AND CANADA

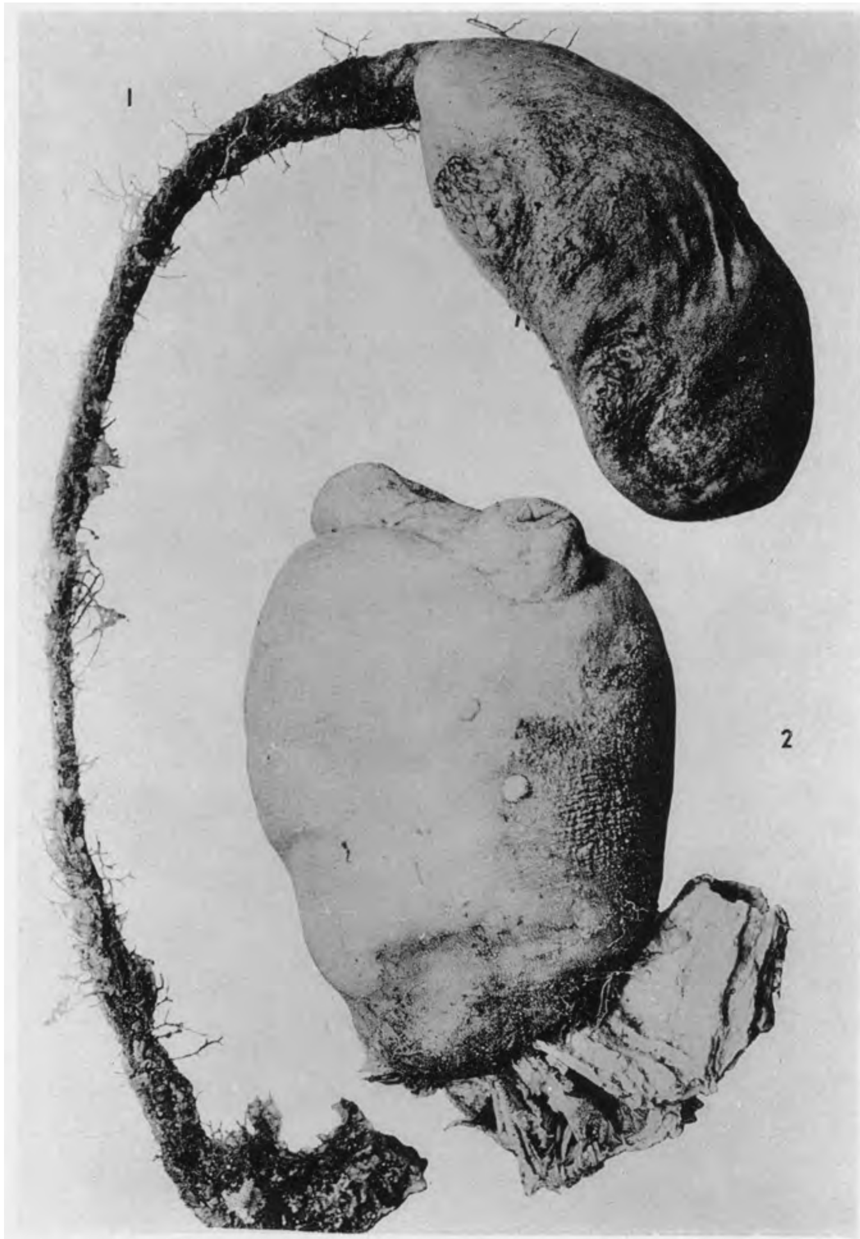
1, 2. *Ascidia obliqua* Alder. Off Chatham, Massachusetts. 34½ fathoms.

3. *Ascidia prunum* O. F. Mueller. "Albatross" Station 2490, 45° 27′ 30″ N., 58° 27′ 45″ W., 50 fathoms.

4. *Dendrodoa (Styelopsis) carnea* (Agassiz), attached to a pebble. Long Island Sound. Color in life red.

5. *Ascidia callosa* Stimpson. Eastport, Maine.

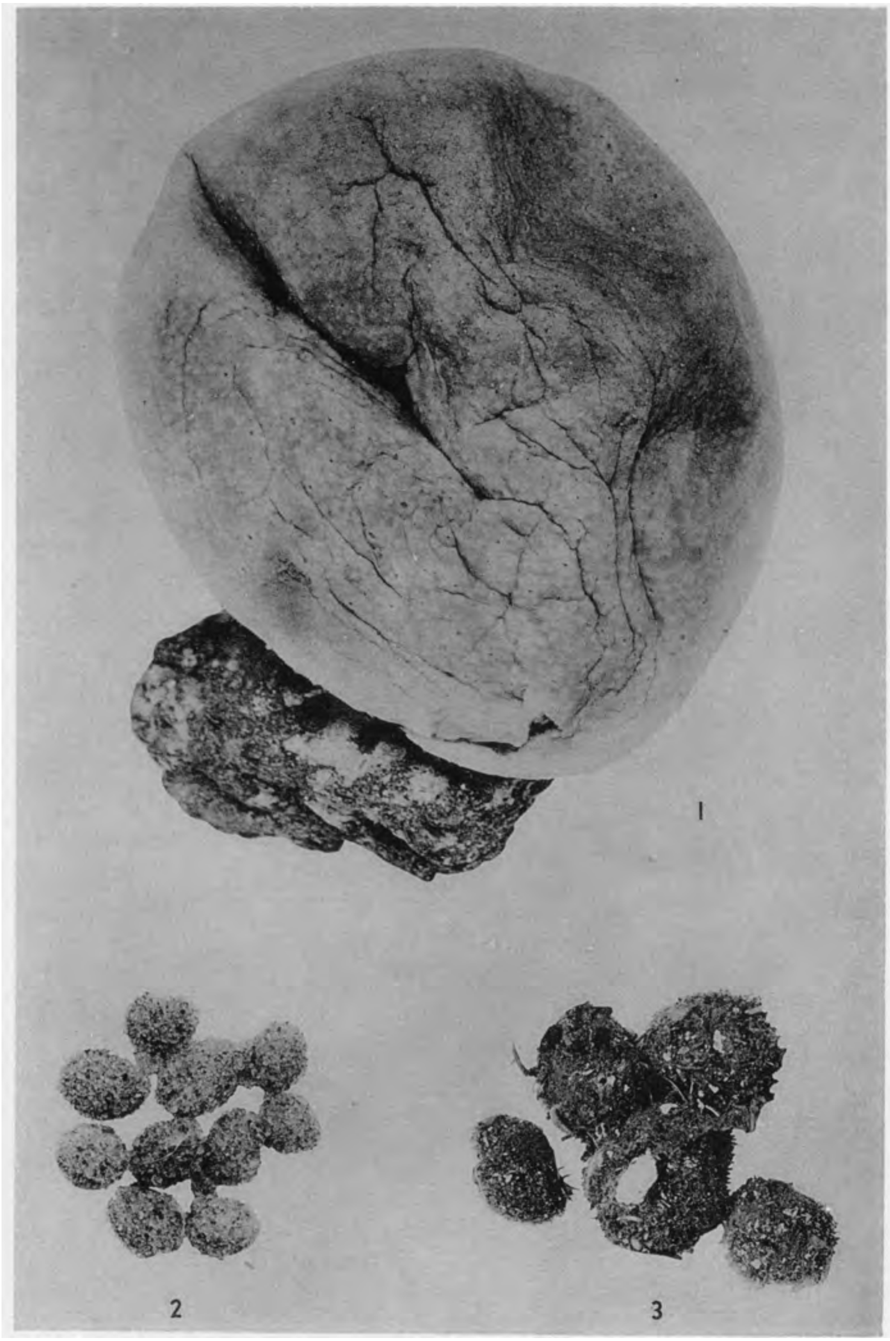
All natural size.



SPECIES OF NORTHEASTERN UNITED STATES AND CANADA

1. *Boltenia ovifera* (Linnaeus). Georges Bank, 41 fathoms.
2. *Halocynthia pyriformis* (Rathke). Labrador.

Both natural size.

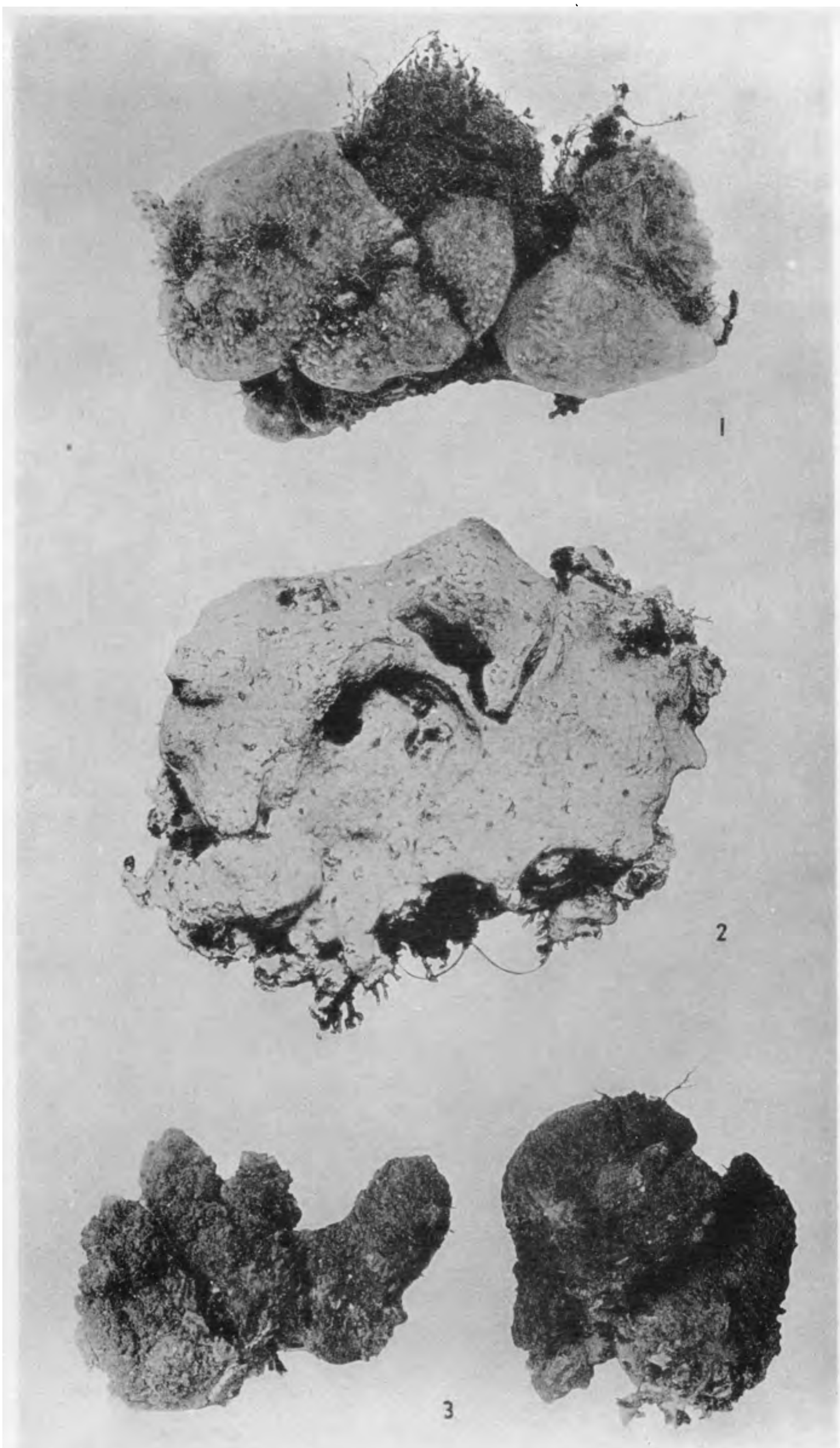


SPECIES OF NORTHEASTERN UNITED STATES AND CANADA

1. *Synoicum pulmonaria* (Ellis and Solander). Banks of Newfoundland.
2. *Cnemidocarpa mollis* (Stimpson). Vineyard Sound, Massachusetts.
3. *Molgula siphonalis* Sars. Bay of Fundy.

All natural size.

Amaroucium stellatum Verrill. Woods Hole, Massachusetts. Natural size.



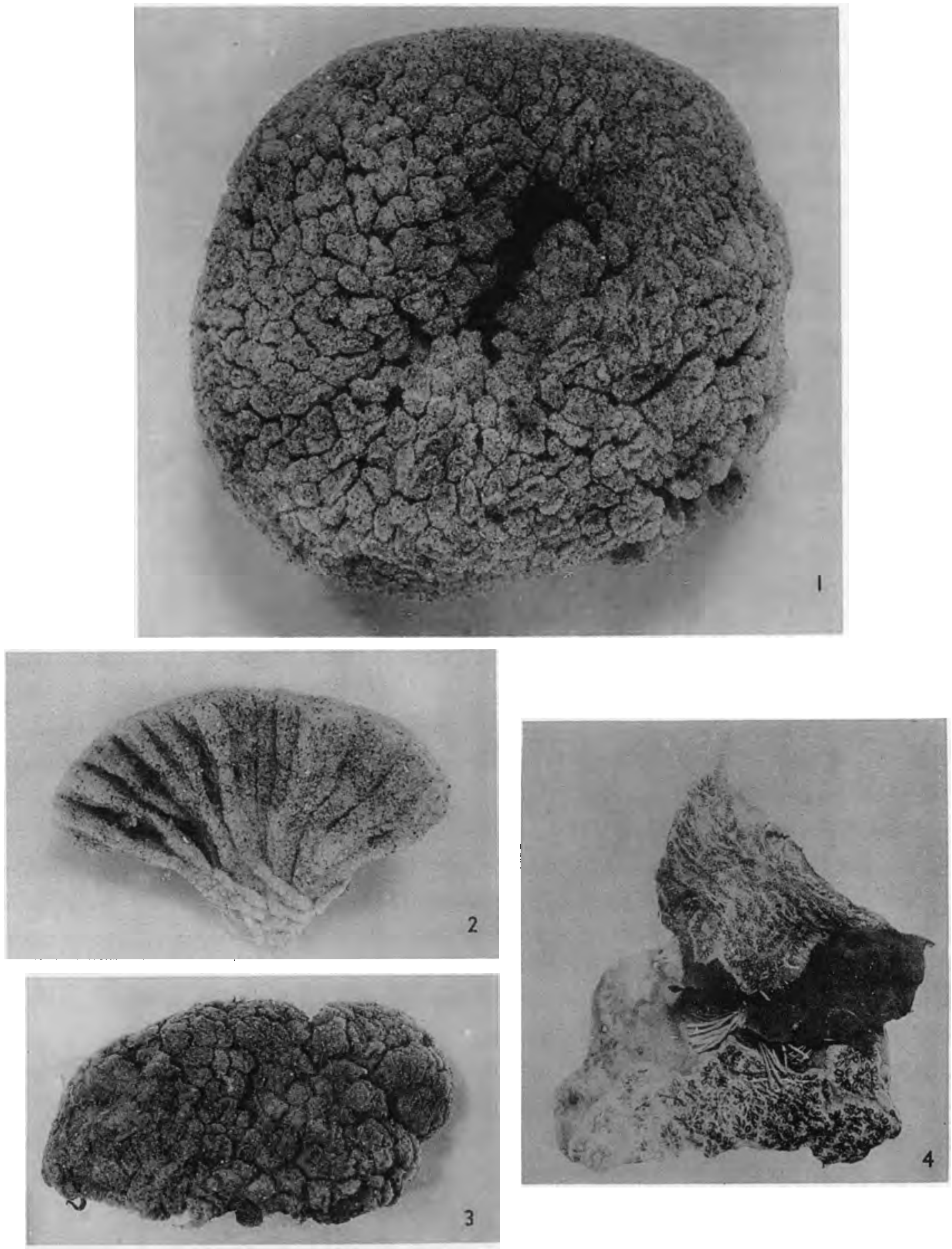
SPECIES FROM SOUTHERN NEW ENGLAND AND SOUTHWARD

1. *Amaroucium constellatum* Verrill. Piles of wharf, Vineyard Haven, Massachusetts.

2. *Didemnum candidum lutarium* Van Name. Woods Hole, Massachusetts.

3. *Styela atlantica* (Van Name). Two groups from United States Fish Commission Station 940, 39° 54′ N., 69° 51′ 30″ W., 134 fathoms.

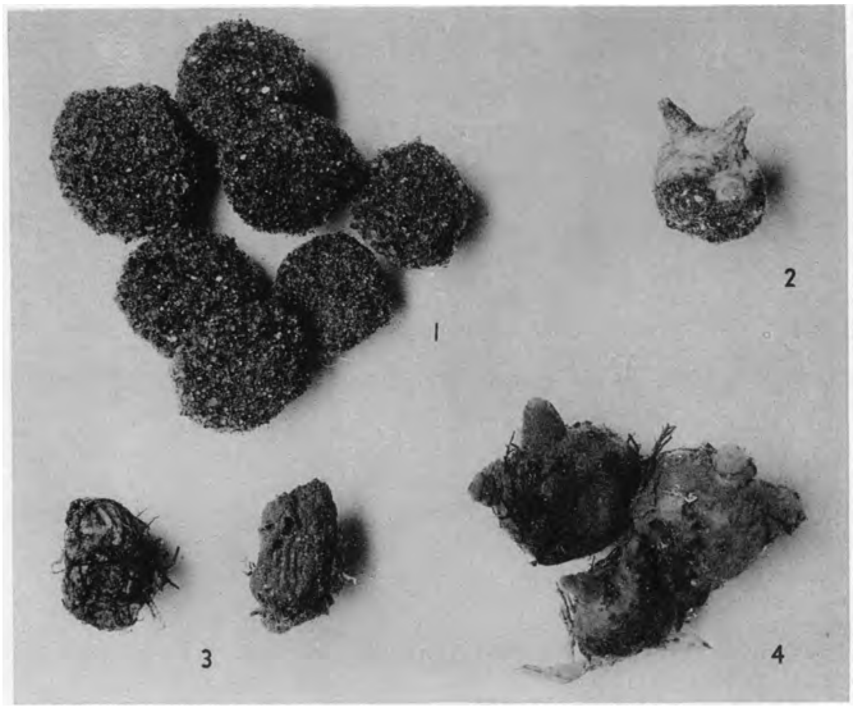
All natural size.

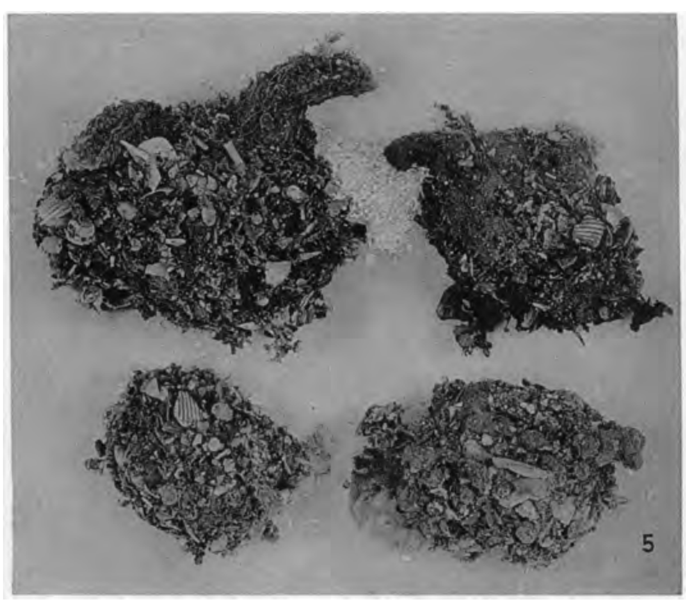


SPECIES FROM SOUTHERN NEW ENGLAND AND SOUTHWARD

1. *Amaroucium pellucidum* (Leidy). Colony seen from above. Vineyard Sound, Massachusetts.
2. *Amaroucium pellucidum* (Leidy). Piece of a colony seen from one side. Vineyard Sound, Massachusetts.
3. *Amaroucium pellucidum* (Leidy). Irregularly shaped colony. Woods Hole, Massachusetts.
4. *Botryllus schlosseri* (Pallas). Colony attached to a piece of rock. Woods Hole, Massachusetts.

All natural size.

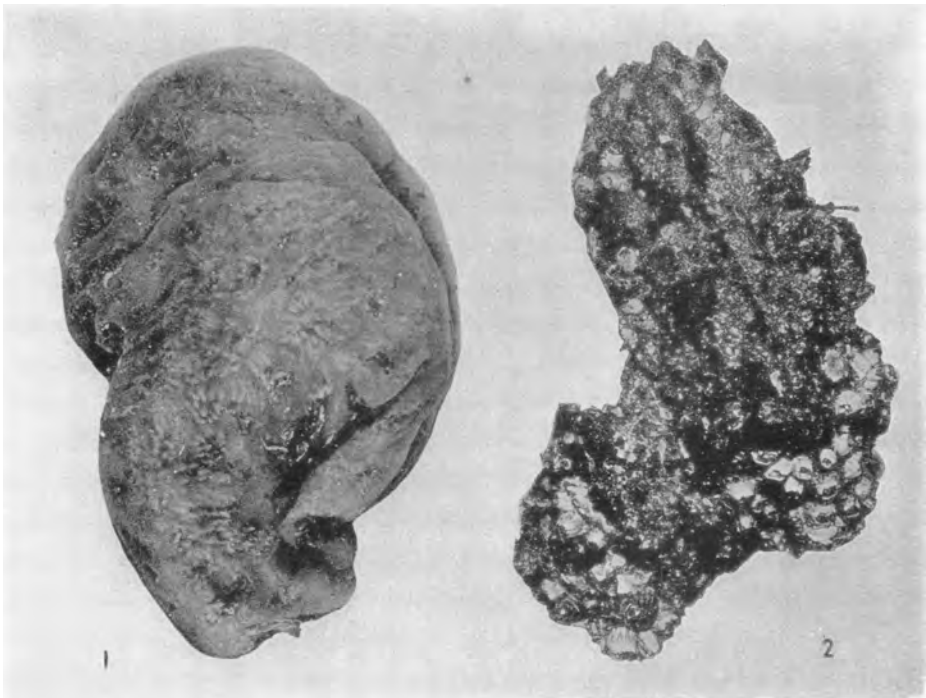


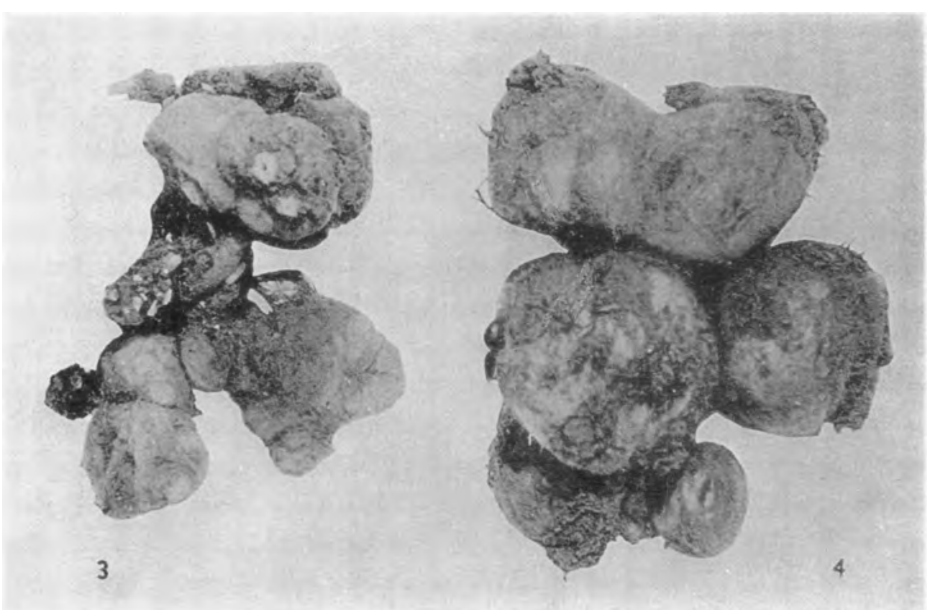


SPECIES FROM ATLANTIC COAST OF THE UNITED STATES AND WEST INDIES

1. *Molgula arenata* Stimpson. Seven individuals, strongly contracted. Near New Haven, Connecticut.
2. *Molgula manhattensis* (DeKay). Individual with siphons considerably extended. Vineyard Sound, Massachusetts.
3. *Styela partita* (Stimpson). Two individuals. Vineyard Sound, Massachusetts.
4. *Molgula manhattensis* (DeKay). Group of three specimens. Vineyard Sound, Massachusetts.
5. *Microcosmus helleri* Herdman. Four individuals. Puerto Rico.

All natural size.



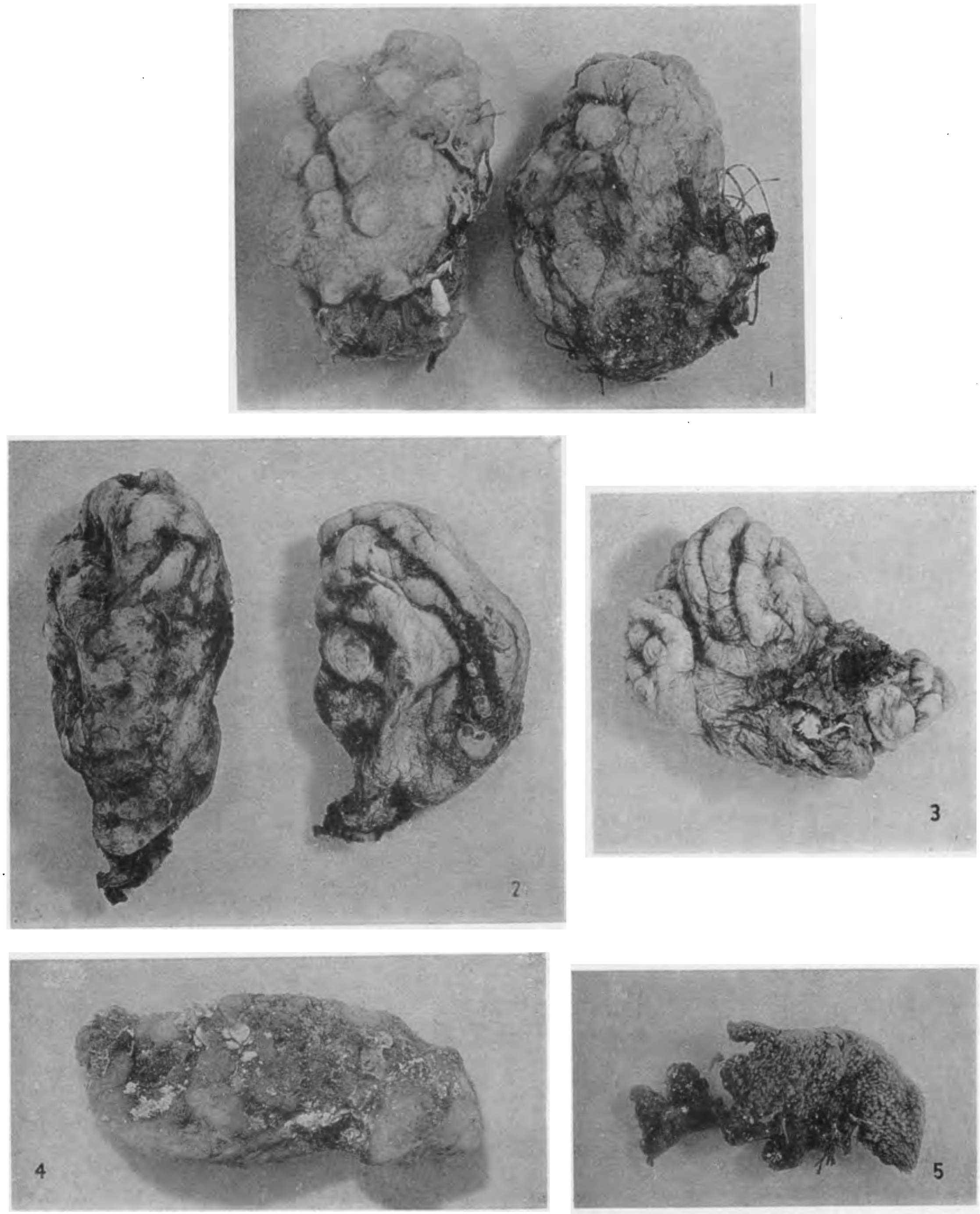


SPECIES FROM THE SOUTHEASTERN UNITED STATES

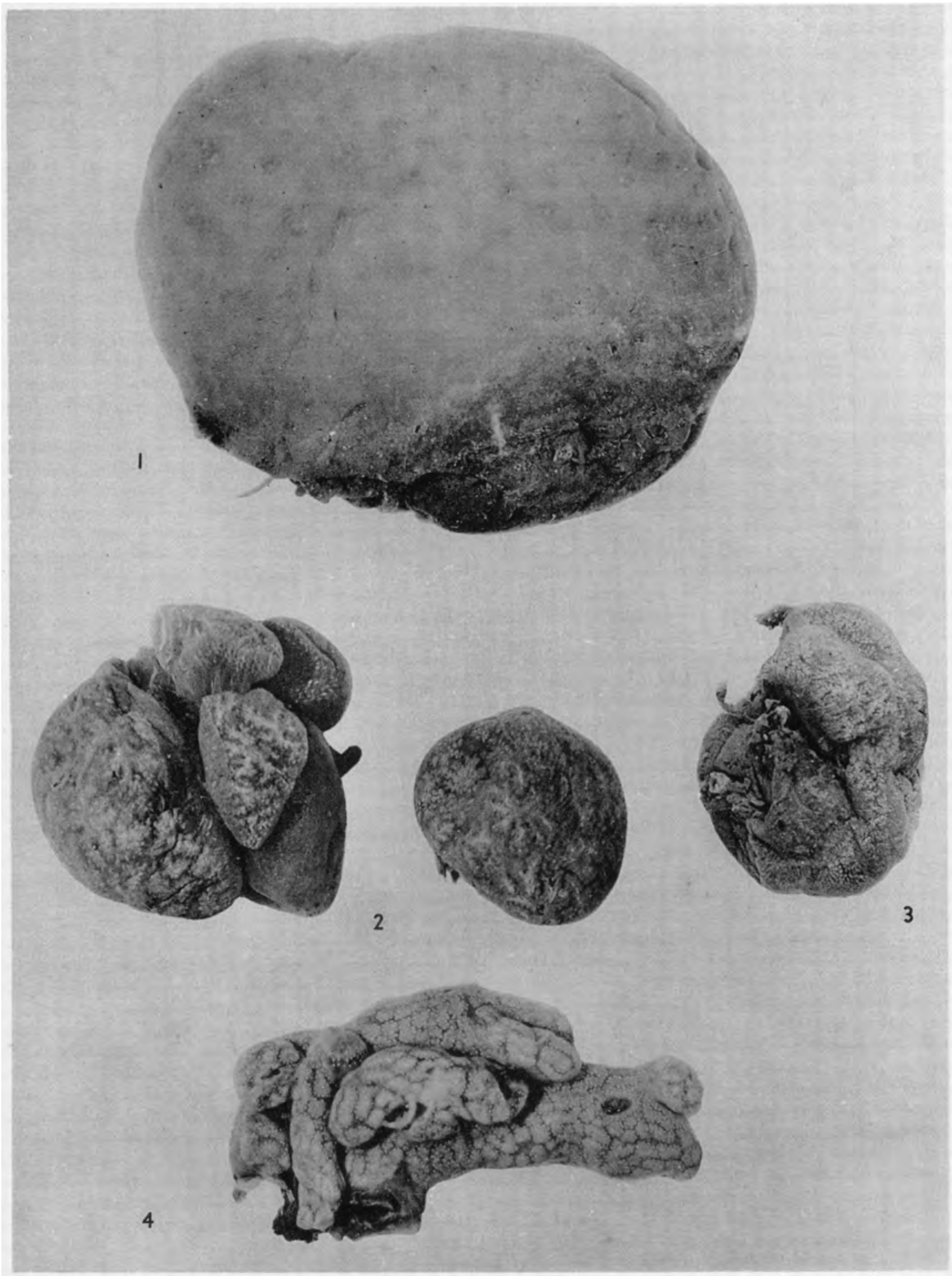
1. *Amaroucium bermudae* Van Name. Florida.
2. *Polycarpa circumarata* (Sluiter). Side view of large specimen incrusted with small barnacles. Color red when alive. Near Sanibel Island, Florida.

3, 4. Clusters of *Molgula manhattensis* (DeKay). Siphons almost completely retracted. New Jersey.

All natural size.



SPECIES FROM THE SOUTHEASTERN UNITED STATES AND WEST INDIES
1–3. *Styela plicata* (Lesueur). West coast of Florida.
4. *Ascidia interrupta* Heller. A rough, incrusted specimen. Bahamas.
5. *Diplosoma macdonaldi* Herdman. Puerto Rico.
All natural size.



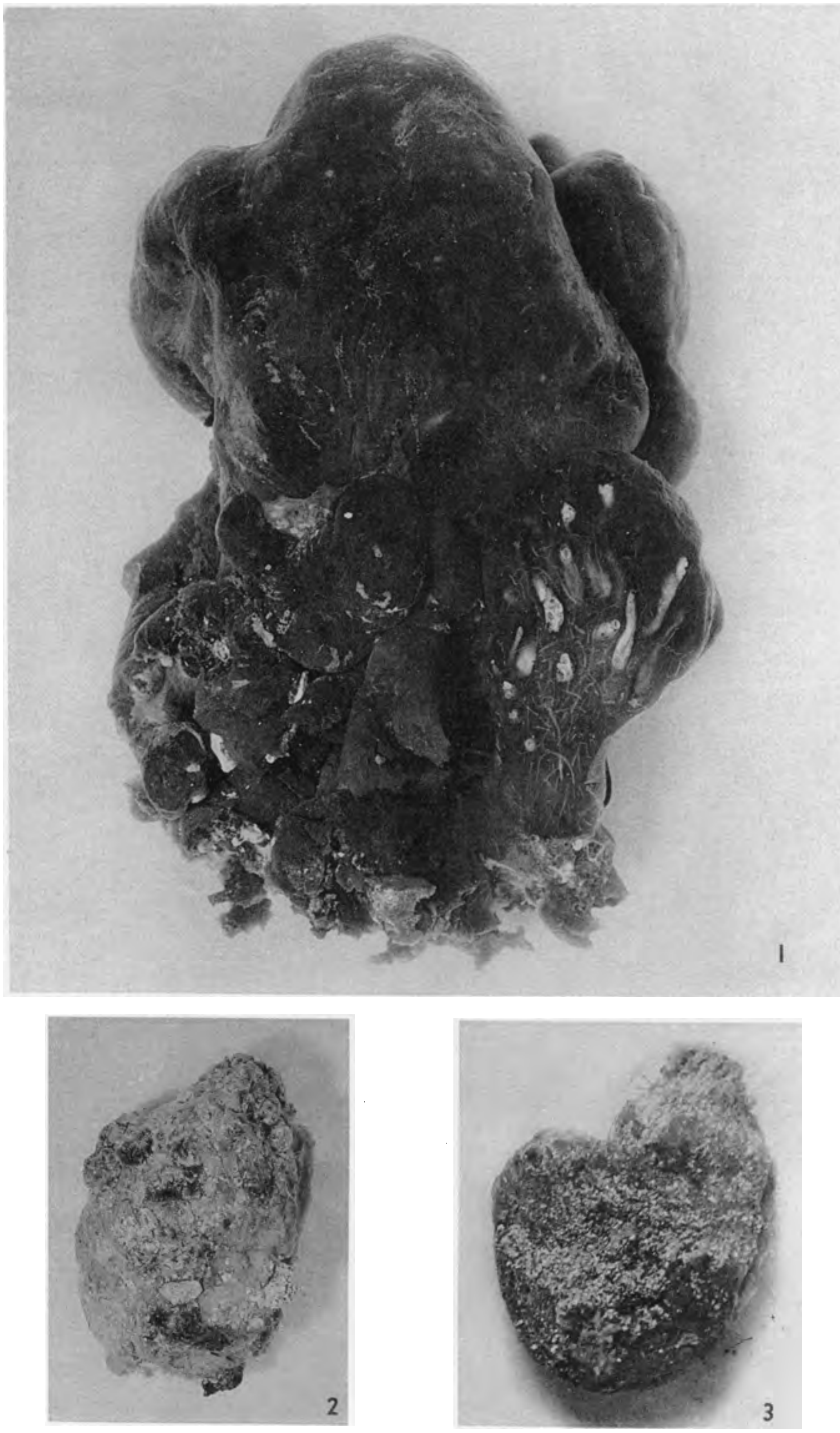
SPECIES FROM THE SOUTHEASTERN UNITED STATES AND WEST INDIES

1. *Amaroucium stellatum* Verrill. Plate-like colony from the Gulf coast of Florida.

2, 3. *Polyclinum constellatum* Savigny. Puerto Rico.

4. *Didemnum candidum* Savigny. Colony showing the arrangement of the zooids in systems and several of the common cloacal apertures with unusual distinctness. Louisiana coast.

All natural size.



SPECIES FROM FLORIDA AND THE WEST INDIES

1. *Clavelina gigantea* Van Name. Colony with one of its lobes sectioned to show the zooids. Color black in life (long retained in preservation). Near Tarpon Springs, Florida.

2, 3. *Polycarpa obtecta* Traustedt. Puerto Rico.

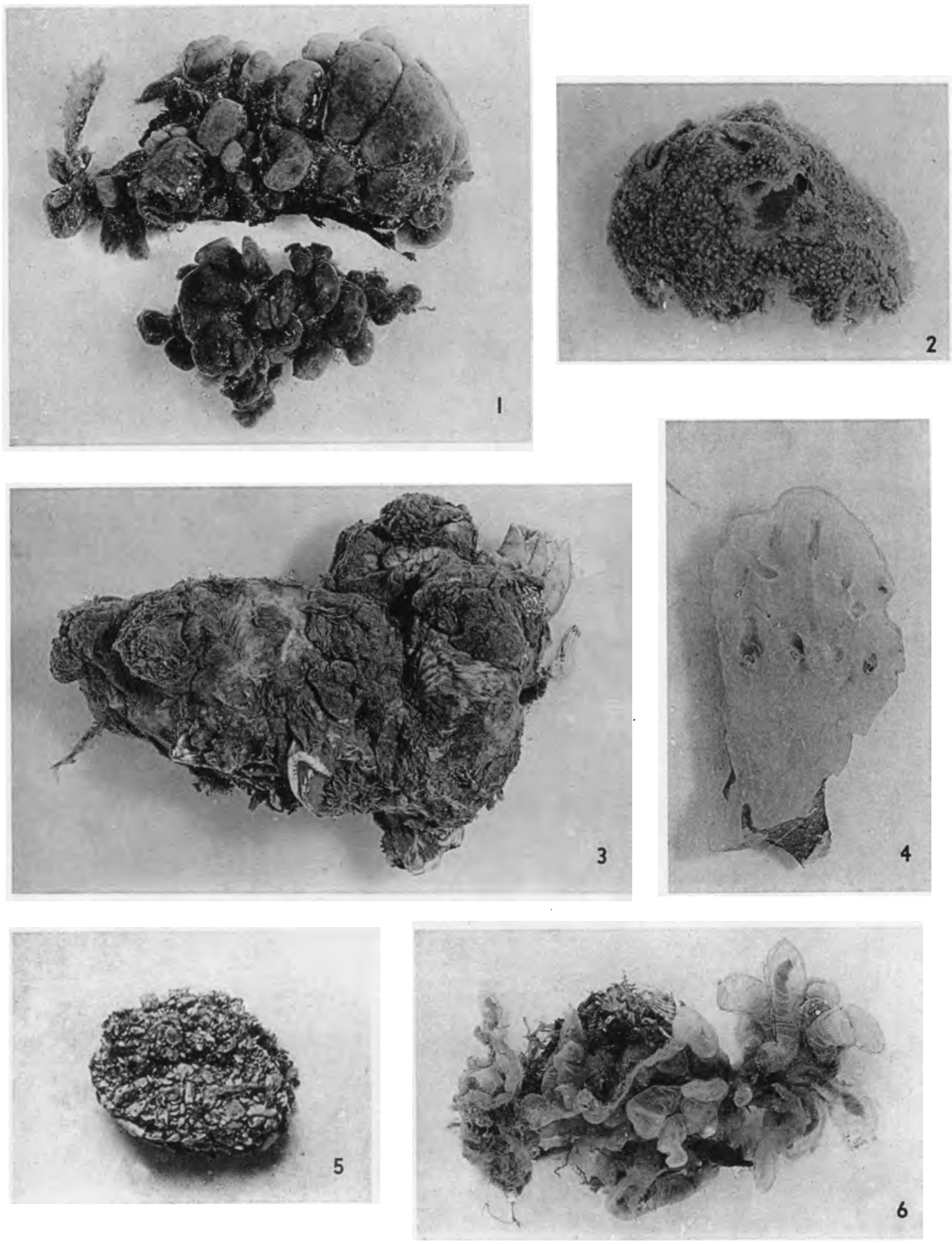
All natural size.

SPECIES FROM FLORIDA AND THE WEST INDIES

1, 2. *Ascidia nigra* (Savigny). Color bluish black, permanent in alcohol. Curaçao.

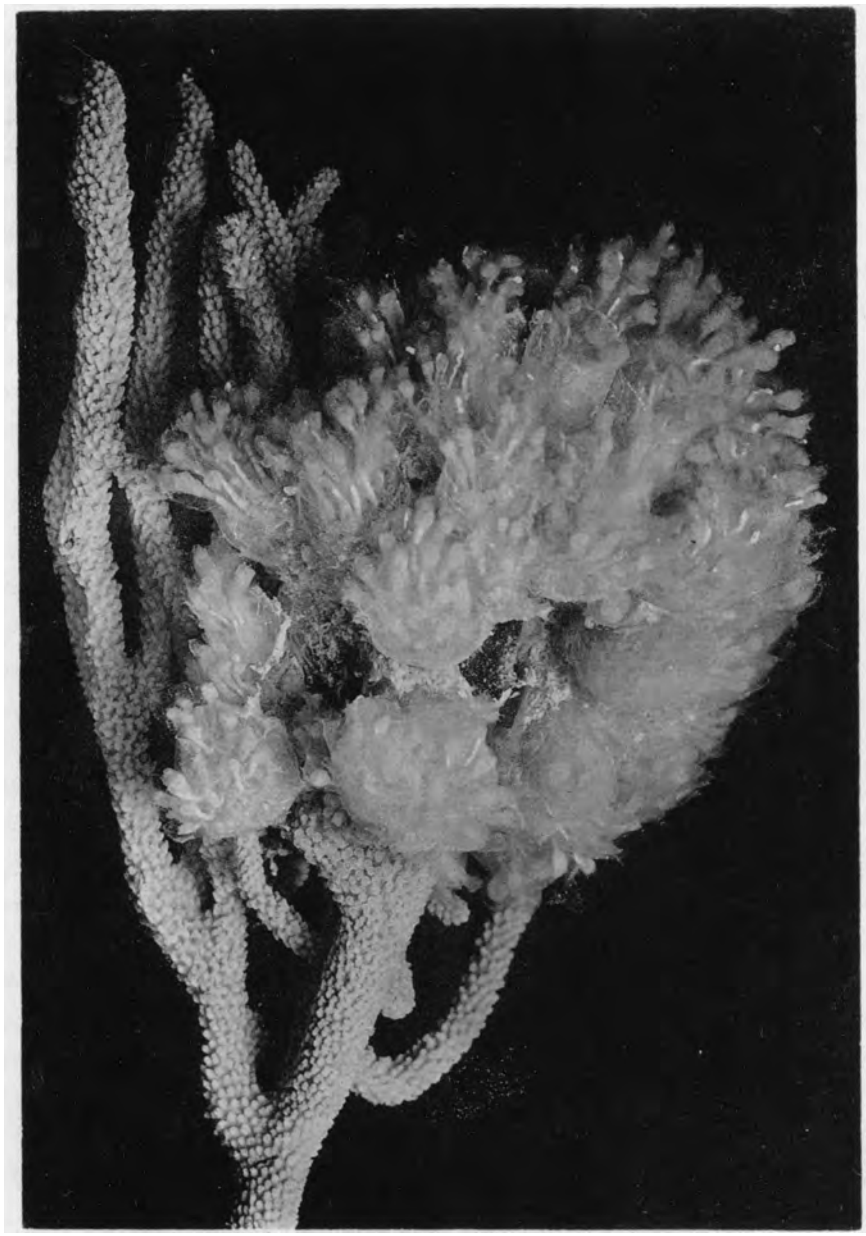
3. *Eudistoma hepaticum* (Van Name). Color in alcohol deep purple. Virgin Islands.

All natural size.

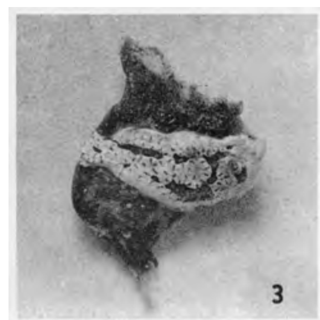


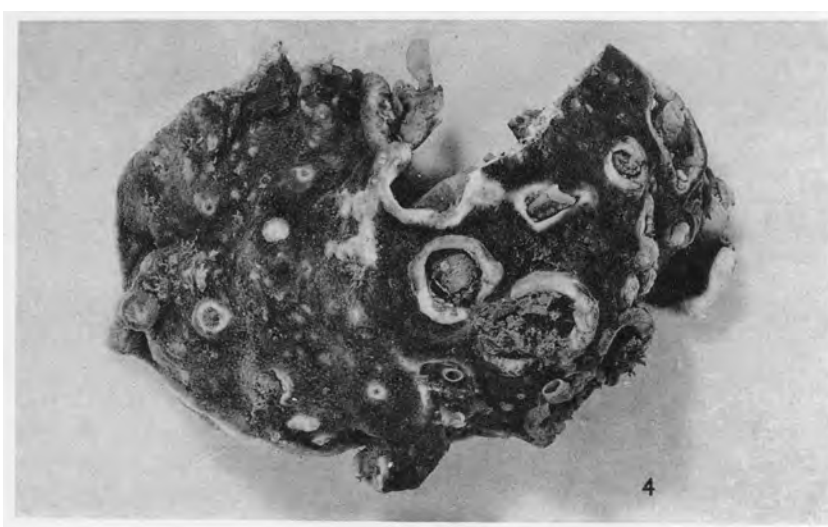
SPECIES FROM THE WEST INDIAN REGION, INCLUDING FLORIDA

1. *Eudistoma olivaceum* (Van Name). Two colonies. Natural size. Puerto Rico.
2. *Distaplia bermudensis* Van Name. Colony. Natural size. Puerto Rico.
3. *Microcosmus exasperatus* Heller. Large individual with a barnacle and other objects attached, × 1.5. Puerto Rico.
4. *Clavelina gigantea* Van Name. Small, light-colored colony (sectioned). Natural size. West coast of Florida.
5. *Pyura vittata* (Stimpson). Small individual, much incrusted with shell fragments. Natural size. Bermuda.
6. *Clavelina oblonga* Herdman. Colony slightly enlarged. Natural size. Florida.



Clavelina picta (Verrill). Type, × 1 ⅓. Bermuda.





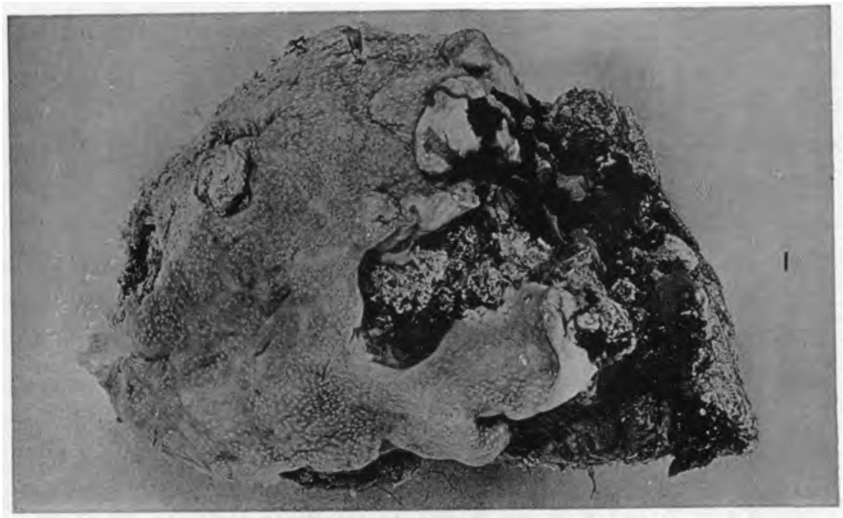
SPECIES FROM THE WEST INDIAN REGION, INCLUDING FLORIDA

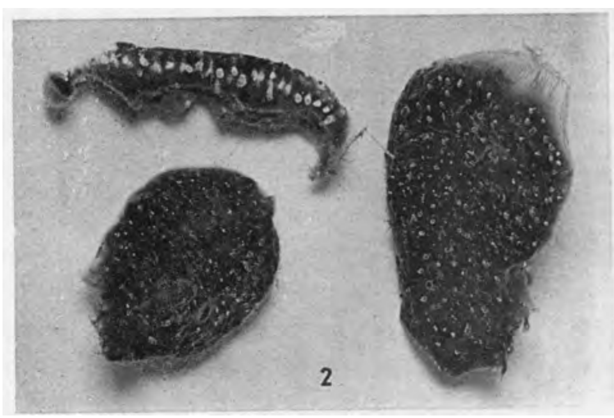
1. *Polyandrocarpa* (*Eusynstyela*) *gravei* Van Name. Type colony, attached to a piece of slate, × 1.4. Dry Tortugas, Florida.

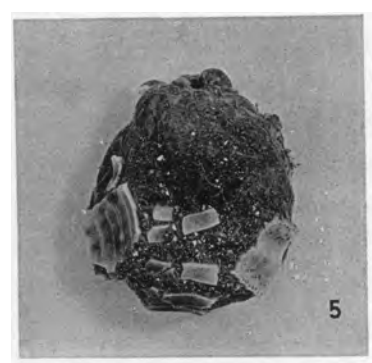
2. *Symplegma viride* Herdman. Colony attached to a piece of coral rock. Natural size. Bermuda.

3. *Didemnum* (*Polysyncraton*) *amethysteum* (Van Name), attached to a sponge. Natural size. Bermuda.

4. *Trididemnum savignii* (Herdman). Natural size. Puerto Rico.







SPECIES FROM THE WEST INDIAN REGION, INCLUDING FLORIDA

1. *Trididemnum solidum* (Van Name). Colony attached to a piece of coral rock. Puerto Rico.

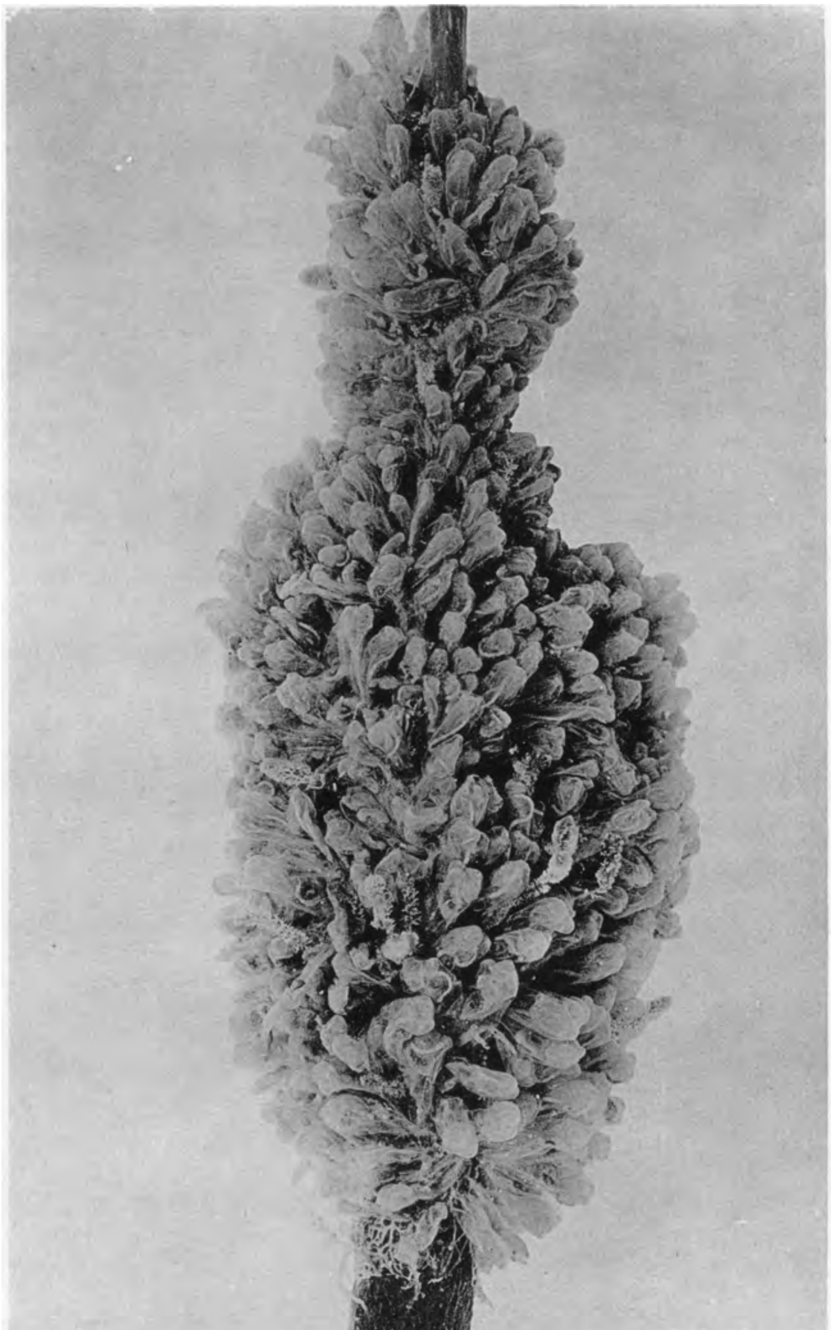
2. *Cystodytes dellechiajei* (Della Valle). One colony sectioned to show the white calcareous capsules surrounding the basal part of each zooid. Bermuda.

3. *Polycarpa spongiabilis* Traustedt. Puerto Rico.

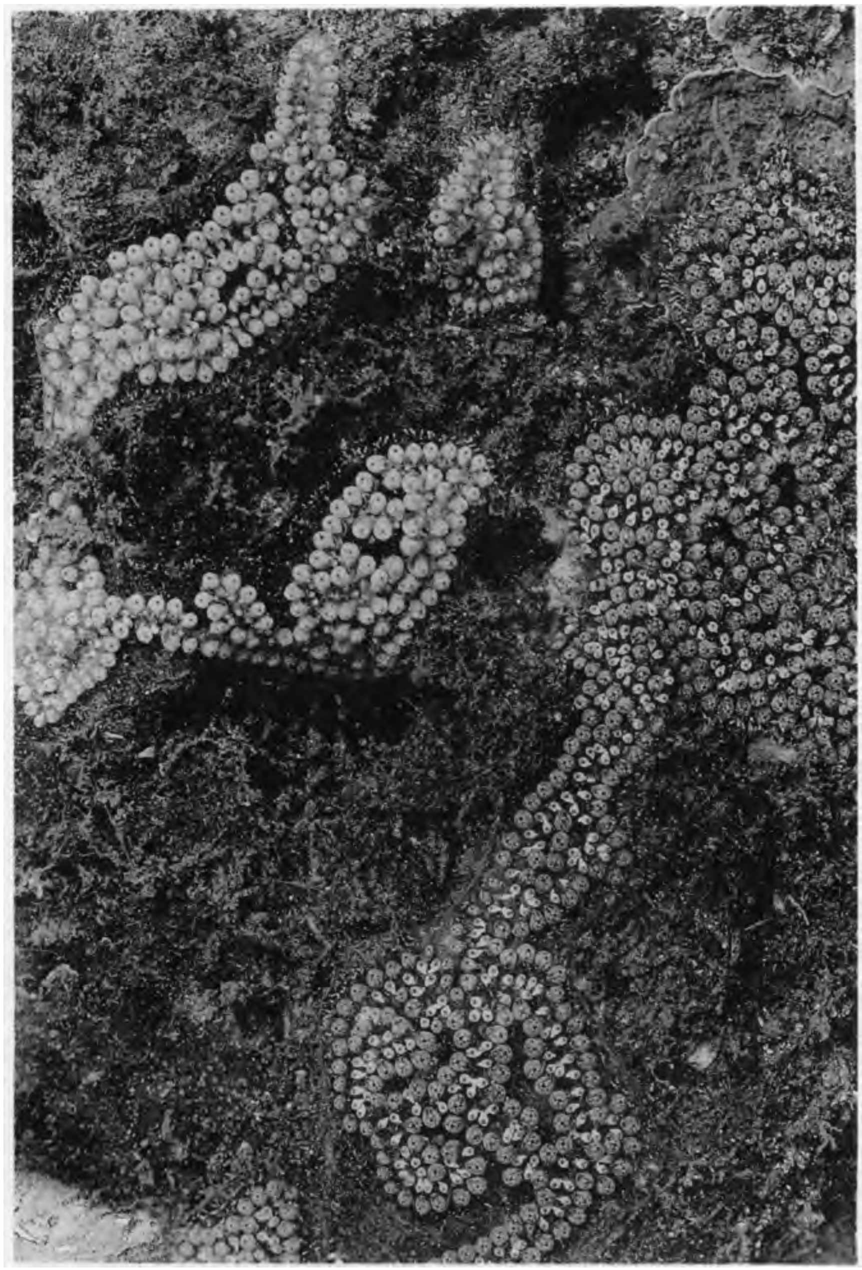
4. Three small colonies of *Amaroucium bermudae* Van Name from Bermuda. The widest specimen is the type.

5. *Molgula occidentalis* Traustedt. Florida.

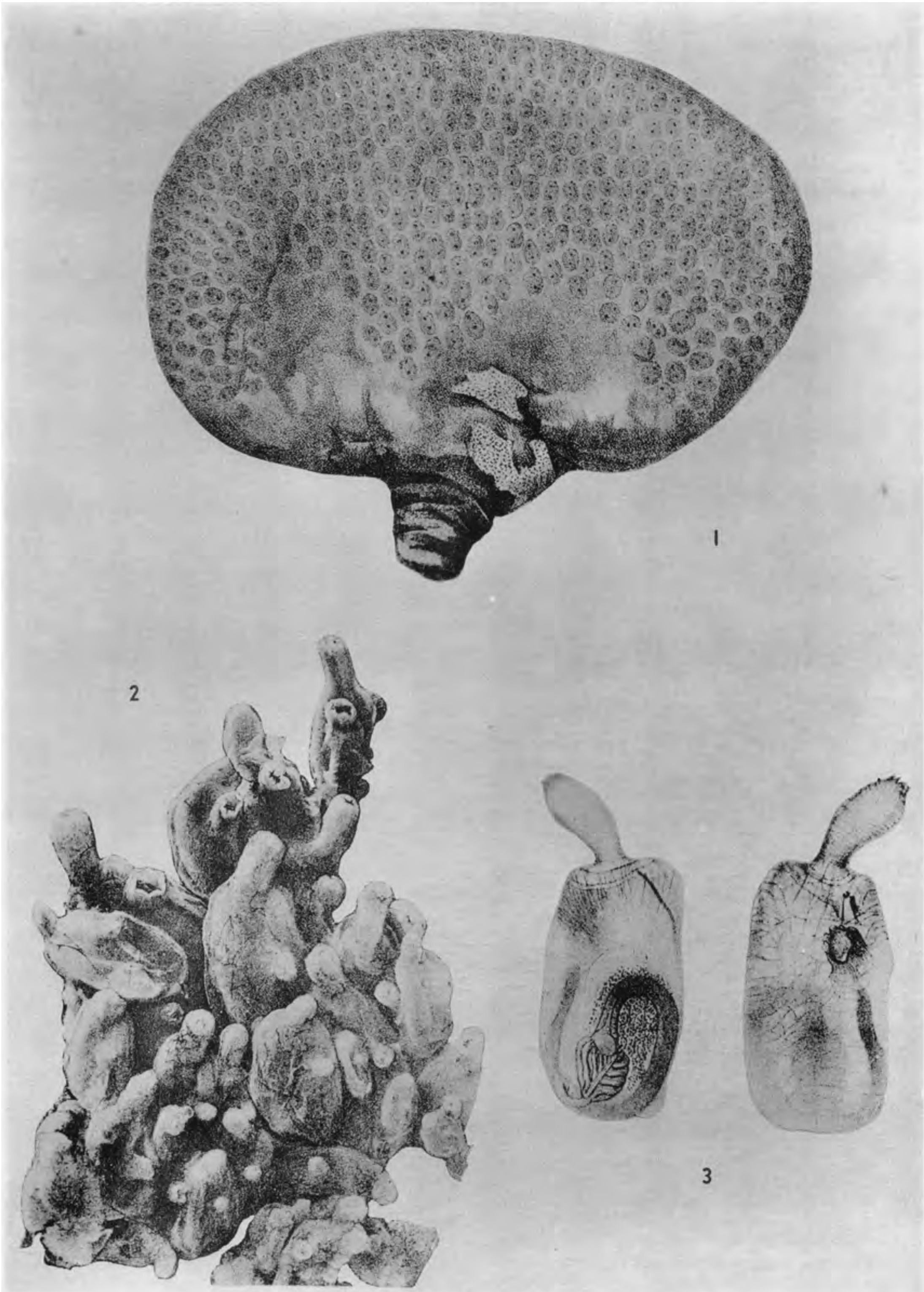
All natural size.



Ecteinascidia turbinata Herdman. Colony growing on mangrove root. Natural size. Bahamas.



Botryllus planus (Van Name). Two colonies (differently colored) attached to a stone, × about 2.5. Photograph of living specimens by H. H. Verrill. Bermuda.

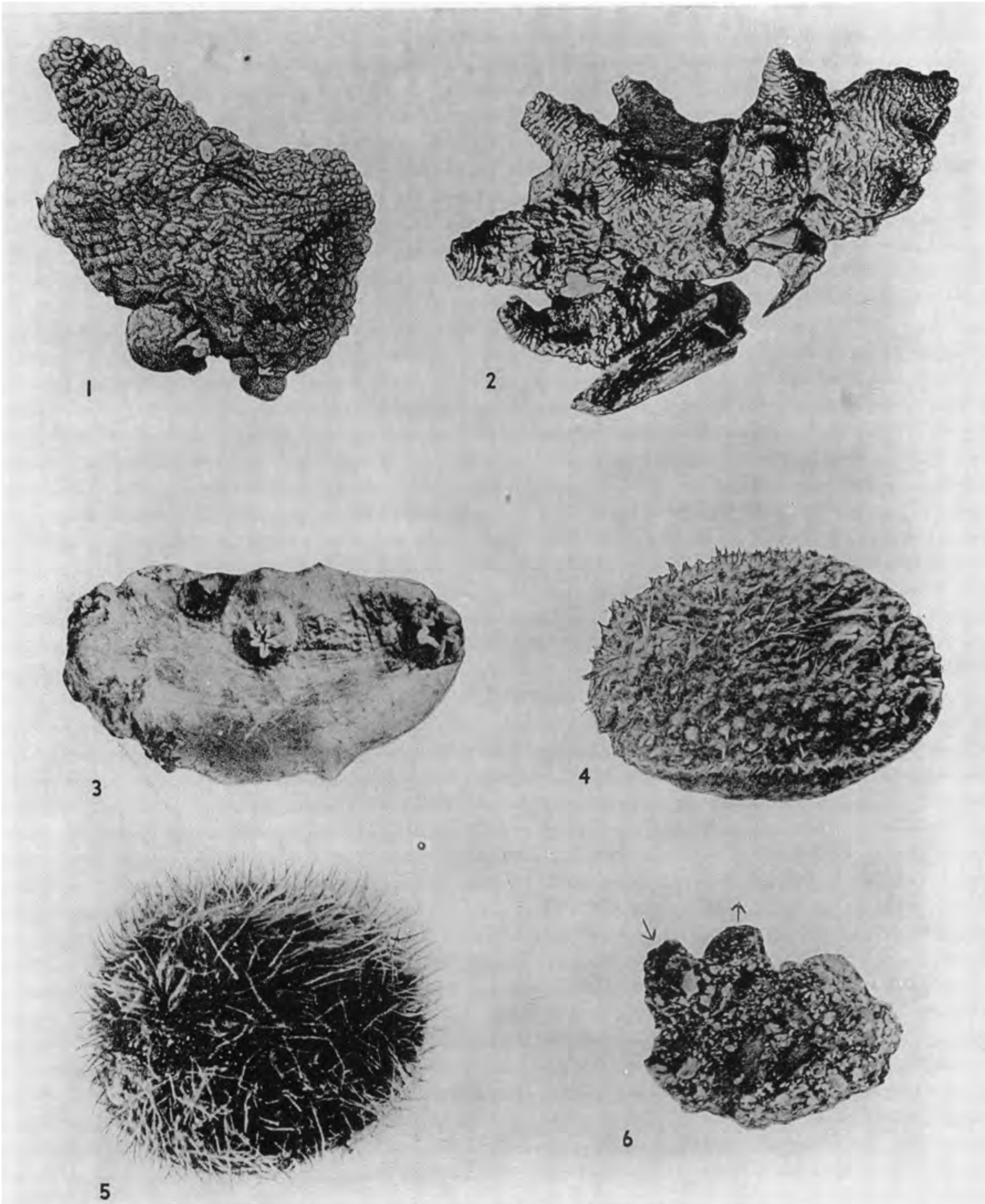


SPECIES OF THE MAGELLANIC REGION

1. *Gynandrocarpa placenta* (Herdman). Slightly reduced, after Herdman's (1886) figure of *Goodsiria placenta* var. *fusca*. Cape of Good Hope.

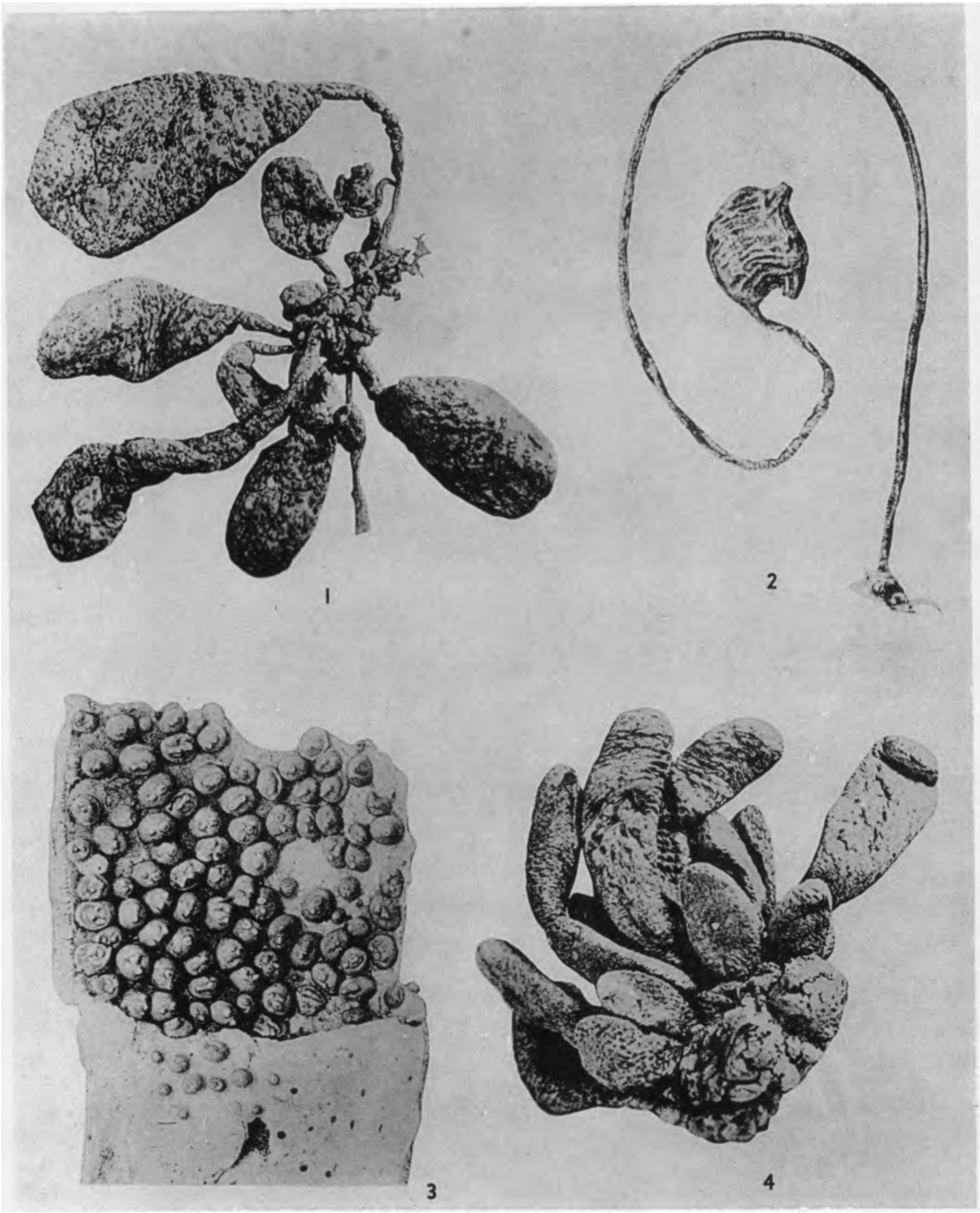
2. *Corella eumyota* Traustedt. Cluster of individuals, × 1 1/3. After Ärnbäck, 1929. Chile.

3. *Corella eumyota* Traustedt. Right and left sides of a specimen removed from the test, × 2.5. After Ärnbäck, 1929. Chile.



SPECIES OF THE MAGELLANIC REGION

1. *Pyura discoveryi* (Herdman). Type, × 2. After Herdman, 1910. South Victoria Land.
2. *Pyura discoveryi* (Herdman). Cluster of individuals, nearly natural size. After Ärnbäck, 1938. South Georgia.
3. *Ascidia translucida* Herdman. Natural size. After Ärnbäck, 1938. South Georgia.
4. *Pyura stubenrauchi* (Michaelsen). × 2.6. After Ärnbäck's (1938) figure of "*Pyura echinops*."
5. *Molgula setigera* Ärnbäck. × 3. After Ärnbäck, 1938. Falkland Islands.
6. *Pyura paessleri* (Michaelsen). × 1.75. After Ärnbäck's (1938) figure of "*Paracynthia distincta*." Falkland Islands.



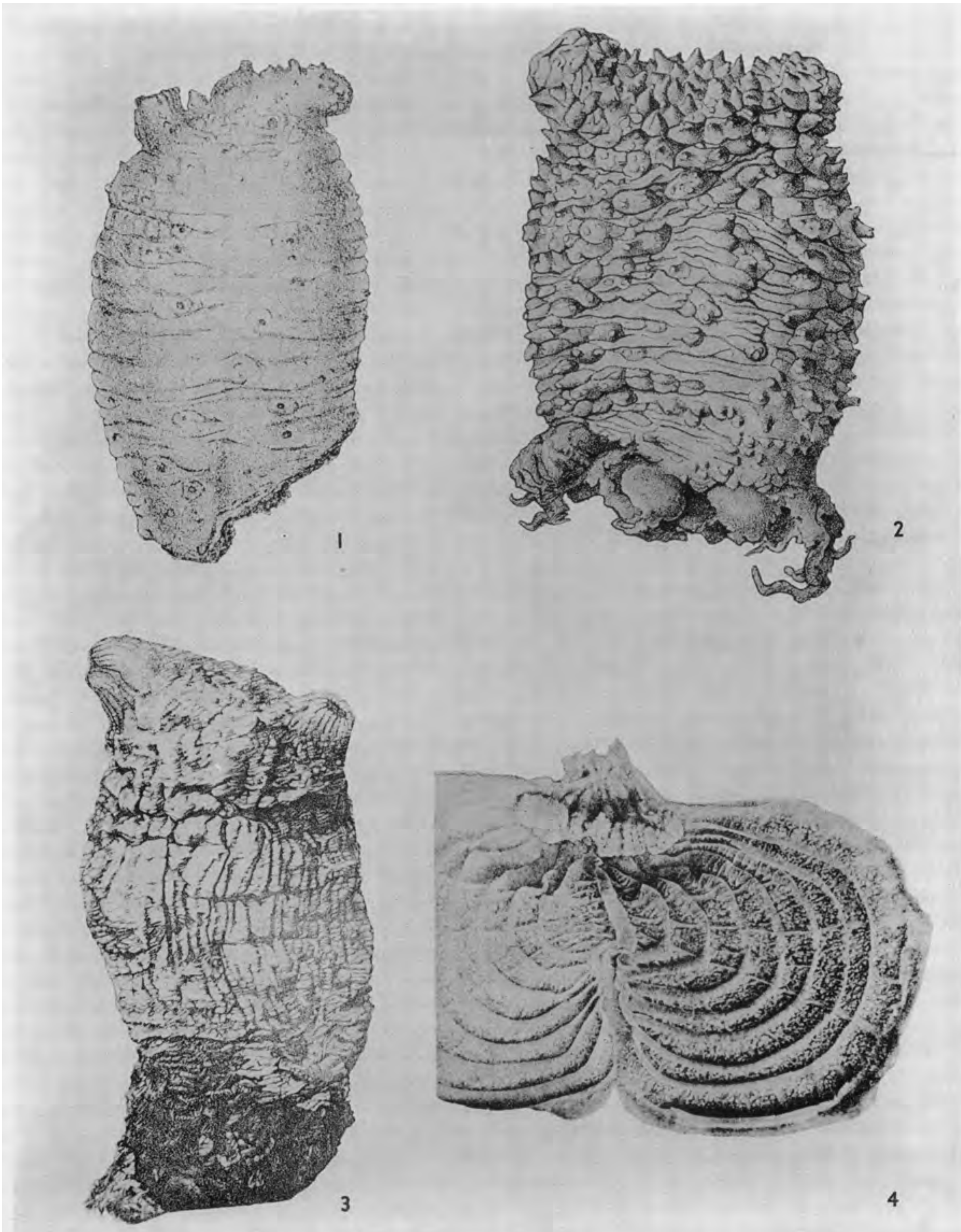
SPECIES OF THE MAGELLANIC REGION

1. *Polyzoa opuntia* Lesson. About one-third natural size. After Michaelsen's (1900) illustration of "*P. pictonis* var. *georgiana.*" South Georgia.

2. *Pyura turqueti* (Sluiter). Natural size. After Ärnbäck, 1938. Western Antarctic.

3. *Alloeocarpa bacca* Ärnbäck. × 1.5. After Ärnbäck, 1929. South Chile.

4. *Polyzoa opuntia* Lesson. About two-fifths natural size. After Michaelsen's (1900) illustration of "*P. pictonis* var. *waerni.*" Tierra del Fuego.



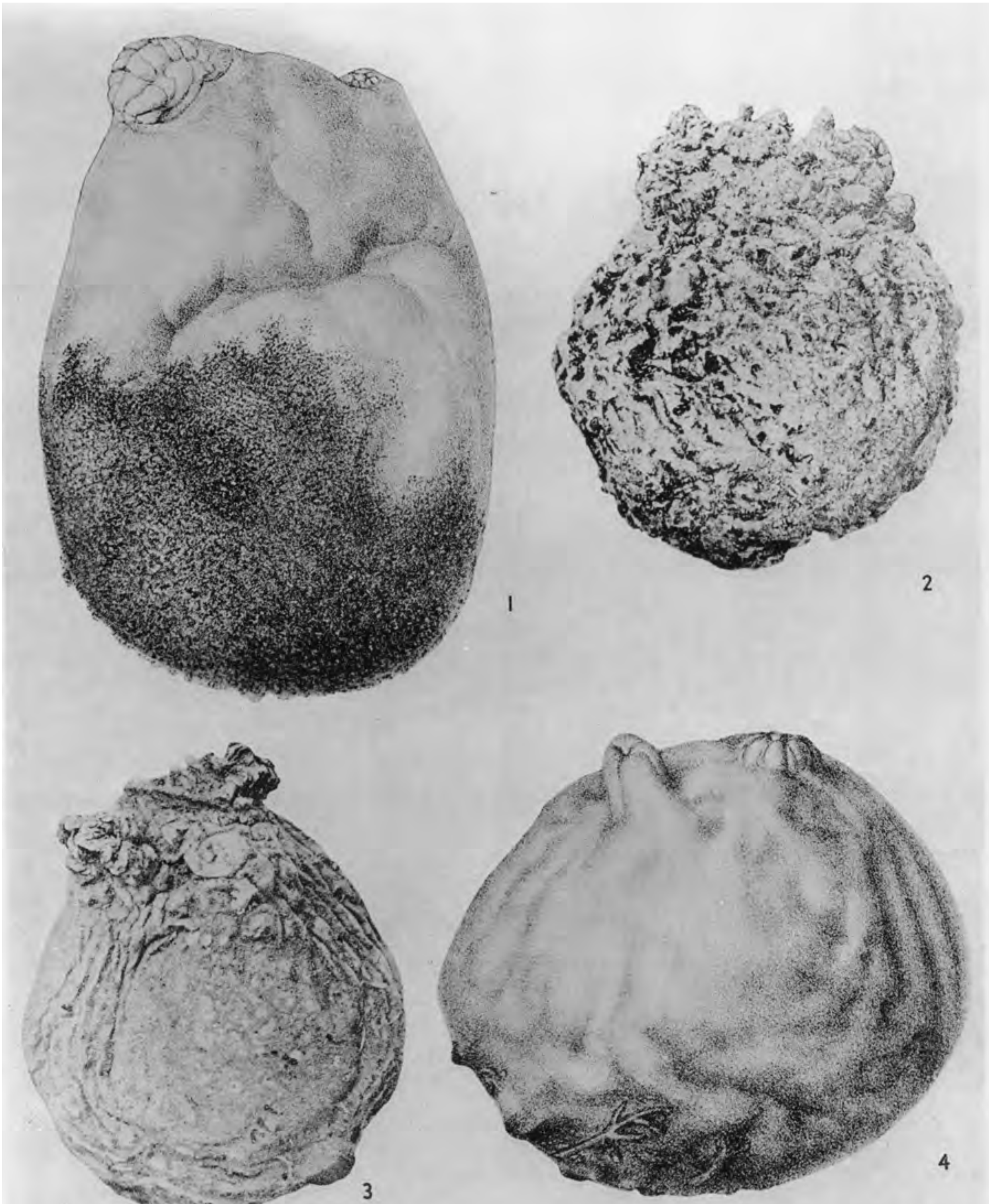
SPECIES OF THE MAGELLANIC REGION

1. *Cnemidocarpa verrucosa* (Lesson). Natural size. After Herdman's (1912) illustration of "*Styela lactea.*" Falkland Islands.

2. *Cnemidocarpa verrucosa* (Lesson). Natural size. After Sluiter's (1906) illustration of "*Styela flexibilis.*" Booth Wandel Island, Antarctic.

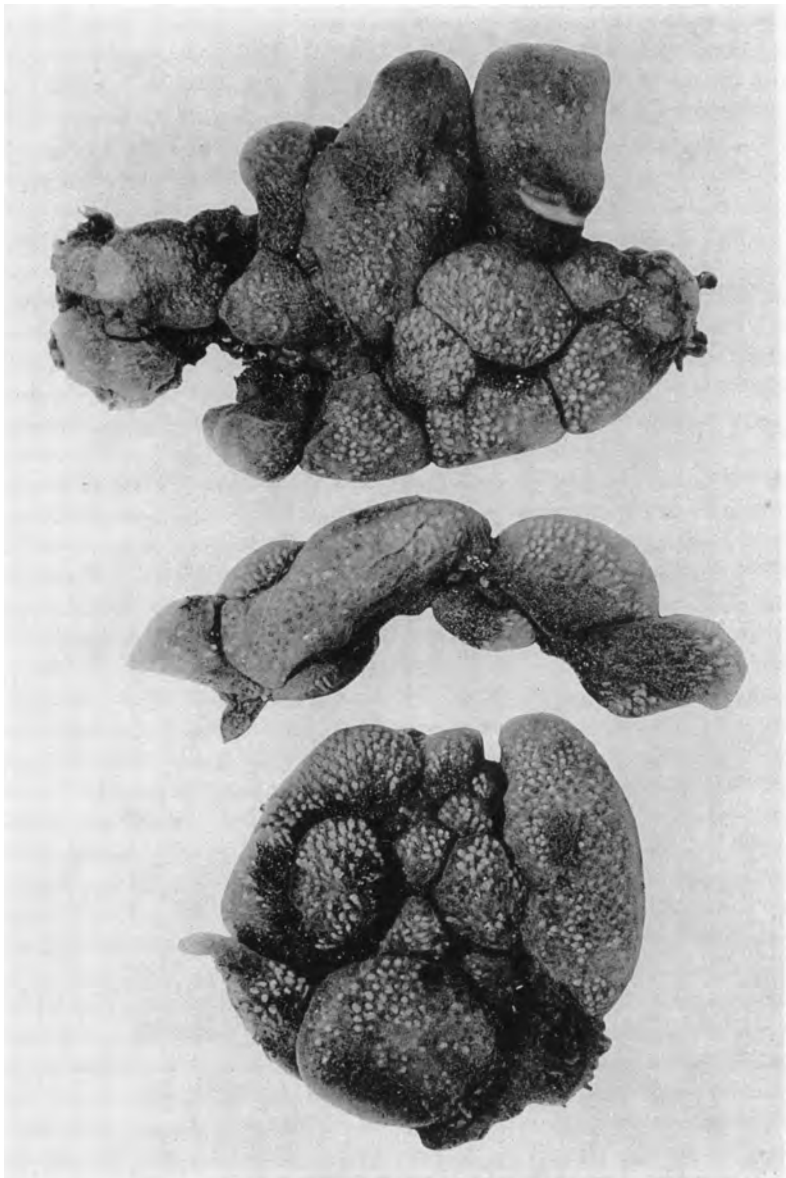
3. *Cnemidocarpa verrucosa* (Lesson). One-half natural size. After Herdman's (1910) illustration of "*Styela spectabilis.*" South Victoria Land.

4. *Paramolgula gregaria* (Lesson). Interior of branchial sac opened by ventral incision. After Ärnbäck's (1938) illustration of "*P. gigantea.*" Falkland Islands.

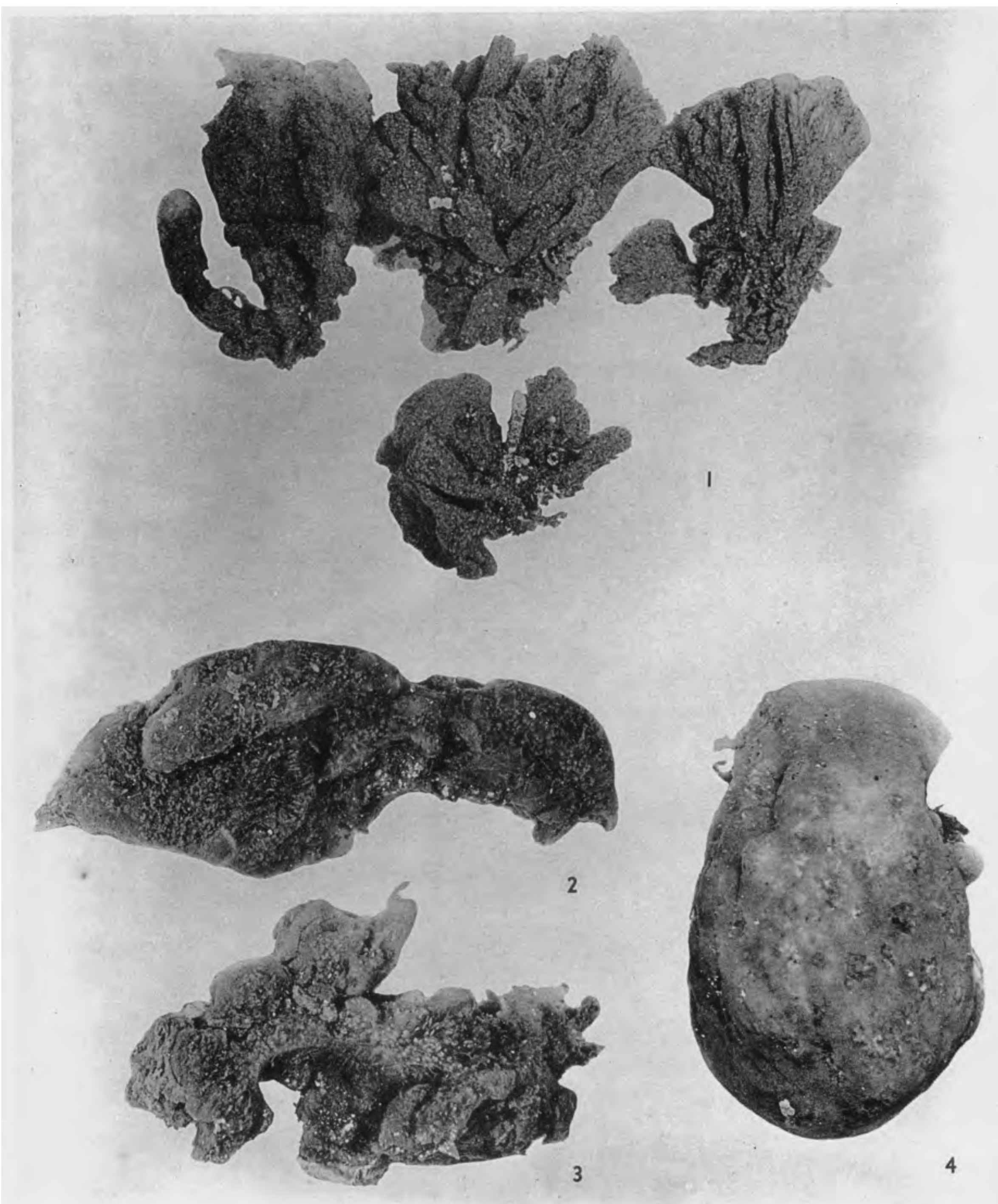


Paramolgula gregaria (LESSON) OF THE MAGELLANIC REGION

1. After Herdman's (1882) illustration of "*Molgula gigantea*," "a small specimen natural size." Strait of Magellan.
2. After Ärnbäck's (1938) illustration of "*Paramolgula gigantea*," from the Falkland Islands. Natural size.
3. After Ärnbäck's (1938) illustration of the same species from Tierra del Fuego. One-half natural size.
4. After Herdman's (1882) illustration of "*Molgula gregaria*," from the Falkland Islands. Natural size.



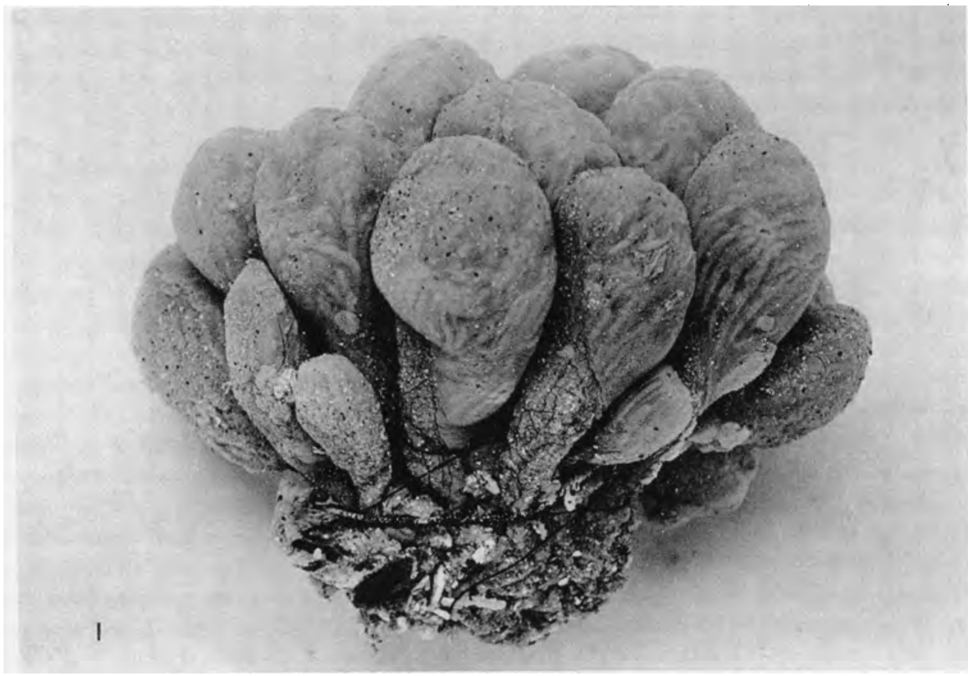
Eudistoma ritteri, new species, cotypes. Pescadero Point, near Pacific Grove, California. Colonies natural size.



SPECIES OF THE PACIFIC COAST

1. *Sigillinaria aequali-siphonis* (Ritter and Forsyth). Dillon Beach, California.
2. *Amaroucium californicum* Ritter and Forsyth. Near Pacific Grove, California.
3. *Amaroucium californicum* Ritter and Forsyth. Very irregular colony. Near Pacific Grove, California.
4. *Amaroucium solidum* Ritter and Forsyth. Near Hopkins Marine Station, Pacific Grove, California.

All natural size.



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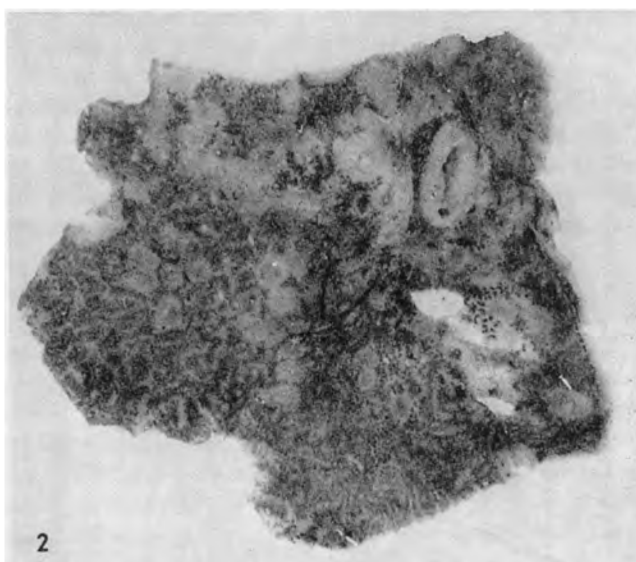


2

3

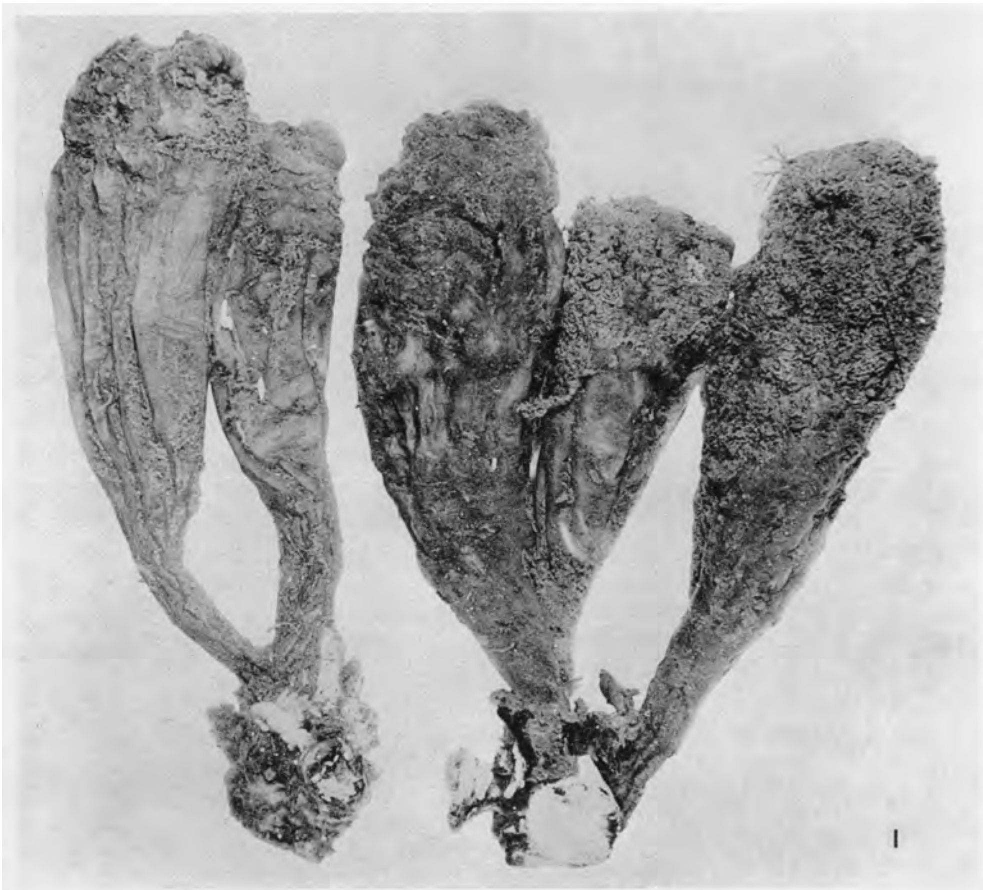
SPECIES OF THE PACIFIC COAST

1. *Synocium par-fustis* (Ritter and Forsyth). Group of unusually large heads. Near Pacific Grove, California. Test red in life; zooids deeper red.

2. *Botrylloides diegense* Ritter and Forsyth. Incrusting a flat stone. Newport Bay, California. Zooids of this specimen with much orange pigment about the apertures.

3. *Sigillinaria pulchra* (Ritter). Four colonies, natural size. Pescadero Point, near Pacific Grove, California. Test colorless, transparent; zooids bright red.

All natural size.



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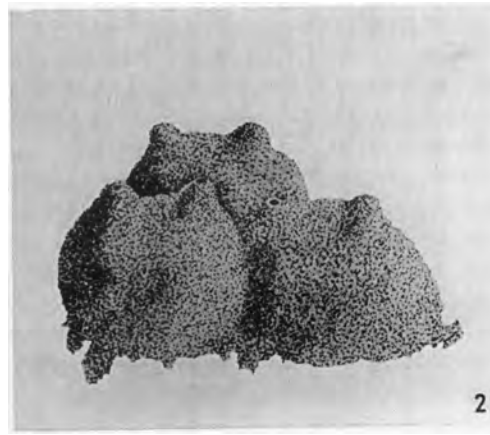
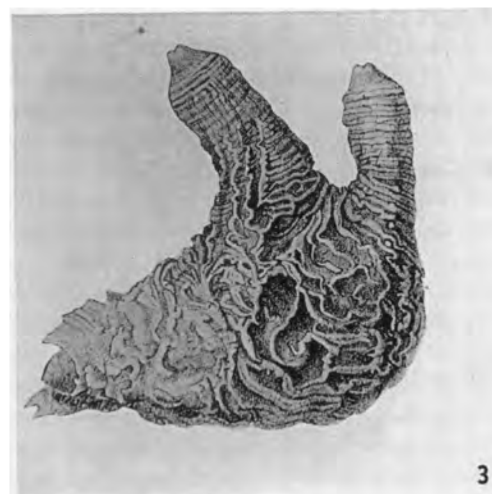
2

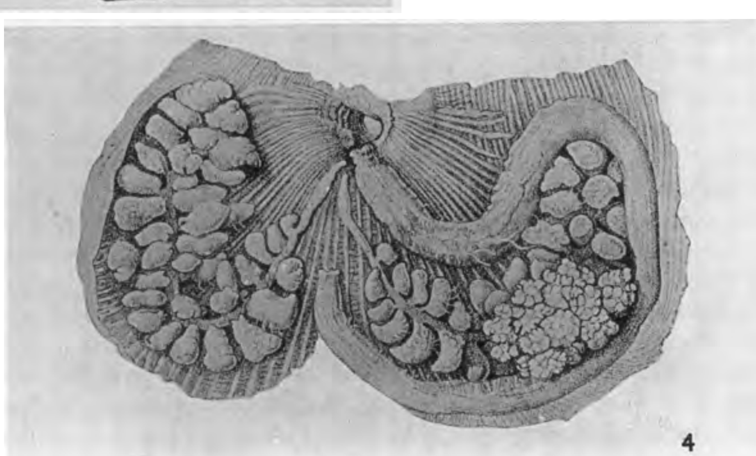
SPECIES OF THE PACIFIC COAST

1. *Styela barnharti* Ritter and Forsyth. Five moderately large adult individuals, from the bottom of a float. Natural size. Corona del Mar, Newport Bay, California.

2. *Clavelina huntsmani* Van Name. Clusters of large zooids. Natural size. Pacific Grove, California.







SPECIES OF THE PACIFIC COAST

1. *Halocynthia aurantium* (Pallas). Natural size. After Redikorzev, 1916.
2. *Molgula verrucifera* Ritter and Forsyth. Group of three individuals. A little over twice natural size. After Ritter and Forsyth, 1917.
3. *Pyura haustor* (Stimpson). About natural size. After von Drasche (1884).
4. *Pyura haustor* (Stimpson). Inner surface of mantle showing intestinal tract, liver, and gonads of each side. Slightly enlarged. After von Drasche, 1884.