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# REPORTS on the MARINE BIOLOGY of the SUDANESE RED SEA.—XIII. REPORT on the SPONGES, collected by Mr. CYRIL CROSSLAND in 1904–5.—Part I. CALCAREA.

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(PLATES 19 & 20.)

[Read 17th June, 1909.]

THE Calcarea collected in the Red Sea by Mr. Crossland consist of 16 species, of which six are new to science. They are distributed among five old and two new genera.

The classification adopted in this report is that of Minchin (12) for the Homocœla and that of Dendy (2) for the Heterocœla, the latter, however, modified by the retention of the family Pharetronidæ and by the addition of a new family, Grantillidæ, for two species of a new genus, *Grantilla.*

A list of the species is as follows :—

*Clathrina coriacea* (Montagu).
*Clathrina primordialis* (Haeckel).
*Clathrina canariensis*, var. *compacta* (Schuffner).
*Clathrina tenuipilosa* (Dendy).
*Sycon coronatum* (Ellis & Solander).
*Sycon raphanus*, O. Schmidt.
*Leucandra primigenia* (Haeckel).
*Leucandra primigenia* var. *microraphis* (Haeckel).
*Leucandra aspera* (O. Schmidt).
*Grantilla hastifera*, n. g. & sp.
*Grantilla quadriradiata*, n. sp.
*Grantessa glabra*, n. sp.
*Leucilla bathybia* (Haeckel).
*Leucilla intermedia*, n. sp.
*Leucilla crosslandi*, n. sp.
*Kebira uteoides*, n. g. & sp.

To these species must be added, in order to complete the Red Sea Calcarea, the following three species not represented in this collection :—

*Clathrina darwinii* (Haeckel) (8).
*Grantessa* (*Sycetta*) *stauridia* (Haeckel) (8).
*Leucandra* (*Leucortis*) *pulvinar* (Haeckel) (8).

The collection is extremely interesting owing to its strikingly intermediate character between the faunas of the Mediterranean and Atlantic on the one hand, and of the Indian Ocean on the other, as is shown by the subjoined table, in which it should be noted that the coasts mentioned always include the islands near them.

| | Atlantic Coasts of America. | Atlantic Coasts of Africa. | Atlantic Coasts of Europe. | Mediterranean. | Red Sea. | East Coast of Africa. | East Indies & Ceylon. | Pacific Coasts of Asia. | Pacific Coasts of America. | Australasia. |
|---|---|---|---|---|---|---|---|---|---|---|
| *Clathrina coriacea* | .. | .. | × | .. | × | .. | .. | .. | .. | .. |
| „ *primordialis* | × | × | .. | × | × | × | × | × | .. | × |
| „ *canariensis* var. *compacta* | .. | × | .. | .. | × | × | .. | .. | .. | .. |
| „ *tenuipilosa* | .. | × | .. | .. | × | .. | × | .. | .. | .. |
| „ *darwinii* | .. | .. | .. | .. | × | × | × | .. | .. | .. |
| *Sycon coronatum* | .. | .. | × | × | × | .. | .. | .. | × | × |
| „ *raphanus* | .. | .. | .. | × | × | .. | × | × | .. | × |
| *Leucandra primigenia* | × | × | .. | × | × | × | × | .. | × | × |
| „ *microraphis* | .. | .. | .. | .. | × | .. | ? | .. | .. | × |
| „ *aspera* | .. | .. | .. | × | × | .. | .. | .. | .. | .. |
| „ *pulvinar* | .. | .. | .. | .. | × | .. | × | .. | .. | × |
| *Grantilla hastifera* | .. | .. | .. | .. | × | .. | .. | .. | .. | .. |
| „ *quadriradiata* | .. | .. | .. | .. | × | .. | .. | .. | .. | .. |
| *Grantessa glabra* | .. | .. | .. | .. | × | .. | .. | .. | .. | .. |
| „ *stauridia* | .. | .. | .. | .. | × | .. | .. | .. | .. | .. |
| *Leucilla bathybia* | .. | .. | .. | .. | × | × | .. | .. | .. | × |
| „ *intermedia* | .. | .. | .. | .. | × | .. | .. | .. | .. | .. |
| „ *crosslandi* | .. | .. | .. | .. | × | .. | .. | .. | .. | .. |
| *Kebira uteoides* | .. | .. | .. | .. | × | .. | .. | .. | .. | .. |

The preservation of the specimens is unfortunately not sufficiently good to render them available for histological study.

Numbers in parentheses refer to the literature quoted at the end of the paper.

I take this opportunity of expressing my gratitude to Professor Dendy, by whose kindness I obtained the collection for examination, and whose suggestions and advice have been invaluable to me throughout the work, which has been carried out in the Zoological Laboratory at King's College (University of London).

## Grade HOMOCŒLA, *Poléjaeff.*

### Family Clathrinidæ, *Minchin.*

Clathrina coriacea (*Montagu*).

Synonymy:—
1818. *Spongia coriacea*, Montagu (**13**).
1842. *Grantia coriacea*, Johnston (**10**).
1864. *Leucosolenia coriacea*, Bowerbank (**1**).
1867. *Leucosolenia coriacea*, Gray (**6**).
1872. *Ascetta coriacea*, Haeckel (**8**).
1905. *Leucosolenia coriacea*, Dendy (**3**).

There were two specimens in the collection, one from Agig Harbour in $4\frac{1}{2}$ fathoms, one from off an Antipatharian growing on mud in 10 fathoms at Khor Ahullarnama.

*Distribution.* Atlantic coasts of Europe; Great Britain; Red Sea.

Clathrina primordialis (*Haeckel*).

Synonymy:—
1871. *Ascetta primordialis*, Haeckel (**8**).

One specimen only, from loose coral at the edge of the leeward reef of Tella Tella Kebira.

*Distribution.* Cosmopolitan.

Clathrina canariensis (*Miklucho*), var. compacta (*Schuffner*).

Synonymy:—
1868. *Nardoa canariensis*, Miklucho (**11**).
1872. *Ascaltis canariensis*, Haeckel (**8**).
1877. *Ascaltis compacta*, Schuffner (**16**).
1908. *Leucosolenia canariensis*, Thacker (**18**).

The specimen is identical with the *C. compacta* described by Schuffner (**16**) from Mauritius, but this species cannot apparently be separated from *C. canariensis*, as all intermediate forms have been described by Thacker (**18**) from the Cape Verde Islands.

Since, however, the variety here dealt with differs so much from the typical *C. canariensis* as described by Haeckel, it seems wise to designate it as a distinct variety. The single specimen in the collection was obtained from the shore at Suez.

*Distribution.* Mauritius, Red Sea, Cape Verde.

Clathrina tenuipilosa (*Dendy*).

Synonymy :—
1905. *Leucosolenia tenuipilosa*, Dendy (3).
1908. *Leucosolenia canariensis*, Thacker (18).

This species is by far the most abundant of the Homocœla in the collection, having been obtained at Suez growing on mud ; from Beacon Island, Khor Dongola, on millepore-reef ; from Agig Harbour, from mud in $4\frac{1}{2}$ fathoms ; and from the coral-reef at Engineer Island, Khor Dongola.

Like the preceding species, it was considered by Thacker (18) to be only a variety of *Clathrina canariensis* on the strength of the similarity of the tri- and quadriradiates ; but it seems to me that the presence of oxea of such unusual and constant form, being very long and extremely slender, should undoubtedly separate it specifically from forms where oxea are entirely absent, even though the number and frequency of the oxea may show very considerable variation as they do in Thacker's specimens.

*Distribution.* Ceylon, Red Sea, Cape Verde.

## Grade HETEROCŒLA, *Poléjaeff.*

### Family Sycettidæ, *Dendy.*

Sycon coronatum (*Ellis & Solander*).

Synonymy :—
1786. *Spongia coronata*, Ellis & Solander (4).
1821. *Scypha coronata*, Gray (7).
1864. *Grantia ciliata*, Bowerbank (1).
1867. *Spongia coronata*, Grant (5)
1872. *Sycandra coronata*, Haeckel (8).
*Sycon ciliatum*, } mult. auct.
*Grantia ciliatum*, }

A single very small specimen measuring only 8 mm. to the top of the oscular fringe, of which length this fringe comprises 4 mm., and with a horizontal oscular collar 4 mm. in diameter, was obtained, from a locality not stated.

*Distribution.* Cosmopolitan.

Sycon raphanus, *O. Schmidt.*

Synonymy :—
1862. *Sycon raphanus*, O. Schmidt (15).
1867. *Grantia raphanus*, Gray (6).
1872. *Sycandra raphanus*, Haeckel (8).

A single small specimen was obtained from the dock-wall at Suez.

*Distribution.* Cosmopolitan.

## Family Grantidæ, *Dendy*.

### Leucandra primigenia (*Haeckel*).

Synonymy :—
1872. *Leucetta primigenia*, Haeckel (8).
1905. *Leucandra primigenia*, Dendy (3).

A single specimen from the mud flats at Suez.

*Distribution*. Cosmopolitan.

### Leucandra primigenia var. microraphis (*Haeckel*).

Synonymy :—
1872. *Leucetta primigenia* v. *microraphis*, Haeckel (8).

Two specimens, one from the coral-reef on Engineer Island, Khor Dongola, the other from a piece of coral near the reef off Cape Elba, Egyptian Sudan frontier, in 10 fathoms of water.

*Distribution*. Red Sea ; Torres Straits, Australia.

### Leucandra aspera (*O. Schmidt*).

Synonymy :—
1852. *Sycon asperum*, O. Schmidt (15).
1866. *Grantia aspera*, O. Schmidt (15).
1867. *Grantia aspera*, Gray (6)
1872. *Leucandra aspera*, Haeckel (8).

A considerable number of fragments, none more than 10 mm. in diameter, occur in the collection from the mud flats and a buoy in Suez Harbour.

*Distribution*. Mediterranean; Red Sea.

## Family Grantillidæ, nov.

A dermal cortex is always present covering over the chamber layer. The skeleton includes subdermal prochiacts *, and may or may not include subdermal sagittal triradiates and subdermal quadriradiates. Subgastral prochiacts may or may not be present. Chambers and skeleton arrangement as in the Grantidæ.

As only a single genus is at present included in the family it is unnecessary to discuss the family characters separately.

* For definition of this term see description of the genus *Grantilla*.

Genus GRANTILLA, n. g.

Grantillidæ with syconoid canal-system, consisting of radially disposed flagellated chambers, supported by an inarticulate tubar skeleton.

The two specimens in the collection, each representing a distinct species, for which this new genus and family have been founded, possess certain distinctive features in their spiculation not hitherto described for any calcareous sponge. The most noteworthy of these is the occurrence of three distinct kinds of subdermal spicules, namely, quadriradiate, sagittal triradiate, and a modified form of triradiate, which from its similarity to the quadriradiates described by Jenkin (9) as chiactines, I have called a "prochiact."

It seems advisable, both for the complete appreciation of the meaning of this spicule, and also in order to avoid confusion as to the nomenclature employed to describe it, first of all to define the terms used in referring to triradiates generally, and then to state the views set forth in this paper on the evolution of this spicule.

The most typical triradiate spicule is one in which all the rays and angles are equal and which lies tangentially in the body-wall of the sponge, all the rays being in the same plane. As a general rule, however, some of the rays are somewhat modified so that it is possible to distinguish two of the rays from the third either by form, or by the inequality of the angles separating them, or by both at once. To describe these "sagittal" spicules the following terms are used. The two rays still equal are called the *paired* or *oral* rays, and the remaining ray is called the *basal* or aboral ray. The angle between the oral rays is called the *oral angle*, whether larger or smaller than the others, which are called the *paired* angles. The primitive plane in which all three rays lie may be called the *facial plane*.

In the primitive Olynthus, the basal ray lies pointing away from the osculum and the paired rays toward it. In the radial chambers of the syconoid canal-system the paired rays point toward the gastral cavity, and the basal away from it. When the chamber is strongly curved the paired rays tend to encircle it.

In describing a *quadriradiate* the three rays in one plane, regarded as the equivalents of the rays of a triradiate, are called the *facial* rays, and the fourth, or extra, ray the *apical*, or gastral ray. Moreover, all the modifications described above as possible in a triradiate are equally possible to the facial rays of a quadriradiate, and the same terms are equally applied to them.

It is considered that the *prochiact* (fig. 1, *b*) has been derived from a tangentially lying cortical triradiate (fig. 1, *a*), by a change in position of the basal ray, which, instead of lying tangentially in the cortex, has been turned until it lies radially, along the side of a flagellated chamber, and at right angles to the facial plane. The oral rays, on the other hand, still lie in the cortex, and, at any rate so far as their distal portions are concerned, in the primitive facial plane. The proximal part of the oral rays is frequently gradually curved between the tangential and radial positions. The oral angle of the prochiact is of course the angle in the primitive facial plane between the paired rays.

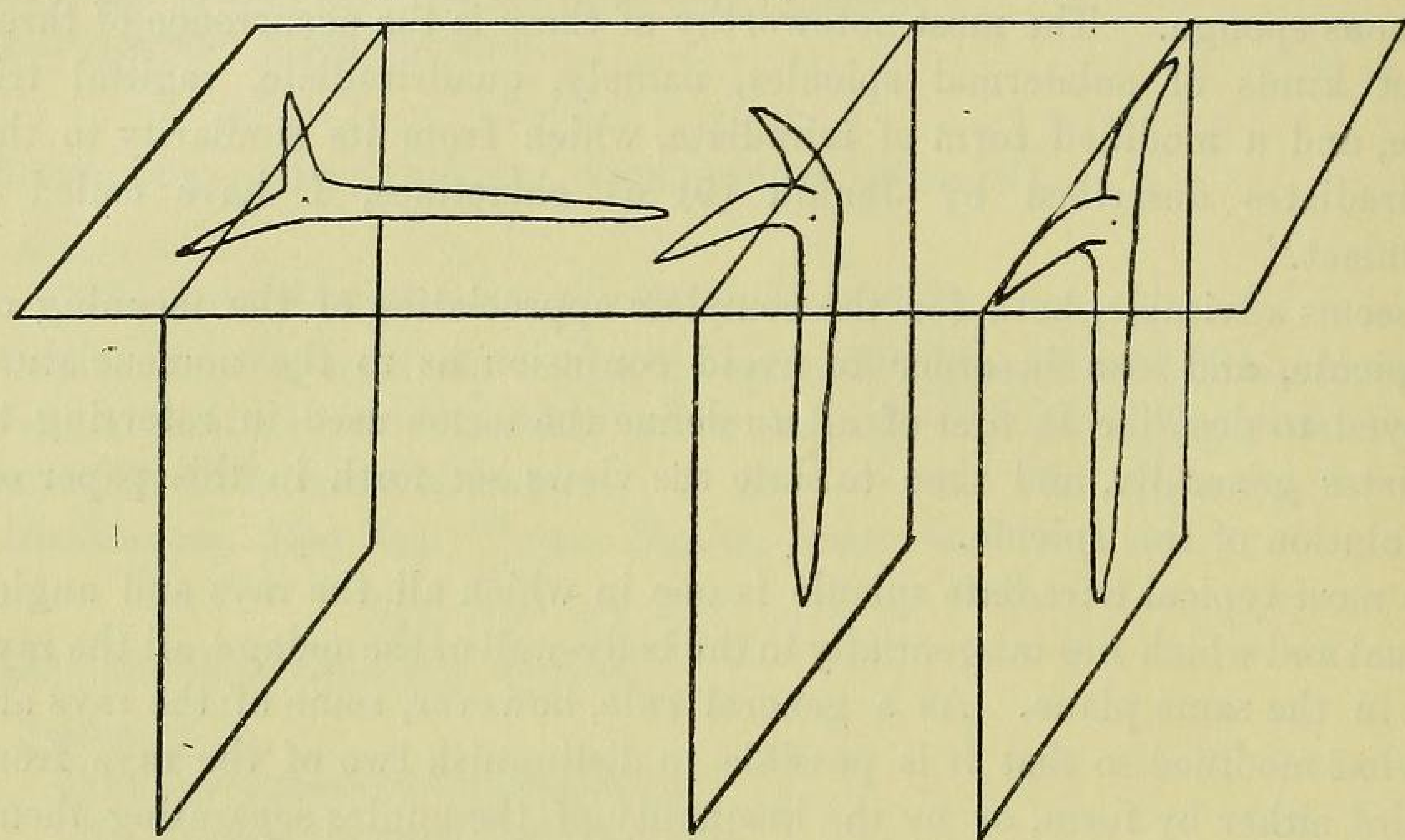



Fig. 1.—Diagram of the evolution of secondary sagittal triradiate (*c*) through a prochiact (*b*) from an ordinary sagittal triradiate (*a*).

A further development of this spicule, however, to form what we may term a *secondary* * sagittal triradiate, takes place by the gradual widening of the primitive oral angle until it becomes 180°, *i. e.* until the paired rays come to lie exactly opposite each other, and once more in one plane with the basal ray (fig. 1, *c*). In this way a new or *secondary* oral angle is developed, quite distinct from the primitive oral angle of the primitive facial plane, since it is bounded by different regions of the rays, the regions bounding the primitive oral angle now forming the sides of the rays. There is also established a secondary facial plane at right angles to the original one, by this alignment of the paired rays. The spicule thus formed is in shape a typical sagittal triradiate, and I believe that such spicules form the characteristic subdermal sagittal triradiates of the family Heteropidæ. In practice it must often be impossible to distinguish between secondary and primary sagittals.

A discussion of this view as to the nature and origin of the prochiacts, and also the evidence which has led to its adoption, will be given later on, when dealing with the evolution of the family Heteropidæ.

* The term *secondary* is here used only in a general sense, and it must be understood that the secondary sagittal spicules referred to in this paper are not of necessity equivalent to secondary sagittal spicules described by other authors.

Jenkin's chiactines, save that they possess an apical ray, are very similar to prochiacts. The basal ray lies in the wall of the chamber, "viewed along the axis of the basal ray, the paired rays are seen to be folded to one side" (Jenkin). The apical ray of a quadradiate is, so far as we know from other cases, both developmentally and phylogenetically a structure of much later origin than the facial rays. Jenkin, moreover, states that in *Streptoconus*, whose canal-system is the most primitive of all the chiact-bearing sponges at present described, some of the chiactines lack the apical ray. (They are therefore prochiacts.)

The extreme similarity between the chiactine and the prochiact above described is thus evident, the only difference, save as regards the apical ray, being that the oral angle of the chiactine, to judge by Jenkin's figures, is greater than that of the prochiact. The presence of a complete series in *Grantilla*, however, in which spicules are found whose original oral angle may be widened out to anything between 90° (in some prochiacts) and 180° (in the secondary sagittal triradiate), is evidence that this difference is of very slight significance; and if, as I shall hope to demonstrate hereinafter, the prochiact is primitive, and the others, in which the primitive oral angle is larger, are more modified, then the width of the primitive oral angle of the chiactine would be clearly accounted for as a similar development of the primitive type towards a uniplanar spicule. The chiactine may therefore be looked upon as a direct development of the prochiact by the addition of an apical ray.

Both the species of *Grantilla* possess prochiacts both in the subdermal and subgastral layers, and these spicules form a very large proportion of the tubar skeleton in each case. There are present, however, subgastral and subdermal sagittal triradiates, and, as above stated, intermediate forms are common. Further, in one of the species here described, *Grantilla quadriradiata*, there also occur subdermal quadriradiates, with the apical ray pointing gastralwards.

Thus these sponges unite in themselves the characteristic features of the spiculation of three groups, the Amphoriscidæ, the Heteropidæ, and the two chiactine-bearing families, the Chiphoridæ and the Staurorrhaphidæ.

The most primitive sponge in which chiactine (and prochiact) spicules occur is *Streptoconus*, which, save for the presence of these spicules, would be placed in the genus *Sycetta*, the canal-systems of the two sponges being absolutely similar. The occurrence in so primitive a type of sponge of this spicule indicates its very great phyletic antiquity, showing in fact that the prochiact must have originated previous to the development of a dermal cortex. It is at this point that I differentiate the Grantillid line of descent from that of the Sycettidæ–Grantidæ, including in the former line all those families which either still possess, or presumably have had in the history of their evolution, prochiact spicules. (See phylogenetic tree on p. 192.)

Of these, the two families of chiactine-bearing sponges, the Chiphoridæ and the Staurorrhaphidæ, form an extremely compact and definite group, exactly comparable to that formed by the two families Sycettidæ and Grantidæ. The Staurorrhaphidæ are immediately derivable from the Chiphoridæ by the development of a dermal cortex.

These two families would thus form a branch diverging from the main Grantillid stem almost immediately after the appearance of the primitive prochiact, the point of divergence being marked by the development of the apical ray, transforming the prochiact into the chiactine.

It is possible to derive the genus *Grantilla* in two entirely different ways. According to one view there is no connection whatever between the Chiphoridæ and Staurorrhaphidæ on the one hand and this genus on the other. *Grantilla* would then be a direct development from the typical Heteropid form, by the bending of the paired rays of some of the sagittal triradiates. Against this view there are however several, to my mind, very serious objections. It implies that two spicules of peculiar and extremely similar shape and occupying similar positions in the sponge-wall, namely, the subgastral prochiact and the chiactine, should have been developed independently at two different times in the phyletic history of the Heterocœla. It necessitates, further, our belief that these two spicules should have developed by entirely different methods from spicules of entirely different type; for Jenkin (**9**) is of the opinion that the chiactines are developed from the gastral quadriradiates. Another objection to this view is the presence of subdermal quadriradiates in *Grantilla quadriradiata*; so that if the Grantillidæ are to be derived from the Heteropidæ, it must be assumed that the spiculation of all these sponges is extremely liable to variation. This interpretation of these sponges would be in direct opposition to the principles of classification suggested by Dendy (**2**), who lays very great stress upon the stability of the composition and arrangement of the skeletal elements in the different families of the Heterocœla. It is, however, possible, as Professor Dendy has suggested to me, to give to the Grantillidæ an interpretation in which none of these difficulties appear, namely, that they are a primitive group, derived from the same ancestors as the Chiphoridæ and the Staurorrhaphidæ, and representatives of the original line of descent from which the Heteropidæ and the Amphoriscidæ have been derived by specialization of their respective characters.

The Grantillidæ would thus be immediately derived from the primitive prochiact-bearing stock by the appearance of a dermal cortex. That a dermal cortex has originated more than once in the history of the Heterocœla is made evident by a consideration of the two families Grantidæ and Staurorrhaphidæ. To derive the Staurorrhaphidæ from the Grantidæ would necessitate the diphyletic origin of chiactines ; to derive them from the Chiphoridæ necessitates a similar diphyletic origin for the dermal cortex. Of these two alternatives the latter is by far the most simple; the direct continuity of the line Chiphoridæ–Staurorrhaphidæ, the peculiarly restricted distribution of these two families, and the obvious identity of their chiactines, all indicating that the Staurorrhaphidæ are directly derived from the Chiphoridæ.

It must thus, in any case, be assumed that a dermal cortex has appeared independently in two different groups; and the occurrence of a third independent appearance of this structure, as shown above, for the Grantillidæ, presents no serious difficulty. This, doubtless, took place very early indeed in the history of the Grantillidæ, very soon after the first appearance of the subgastral prochiact, and while the skeletogenous cells were still plastic and easily influenced by varying conditions. Previously to the appearance of the dermal cortex, the only support for the chamber-layer consisted in a system of small spicules in the walls of the chamber, completely separate from the skeleton of the adjacent chambers, to which its only skeletal union was through the mediation of the gastral cortex. Immediately upon the appearance of a dermal cortex, however, many new opportunities arise for strengthening the skeletal framework.

In many cases this strengthening consists in the development of the cortex to enormous proportions, with a special skeleton consisting of either large oxea or triradiates tangentially arranged, as in *Ute* in the Grantidæ and *Grantiopsis* in the Staurorrhaphidæ. Among the Grantillidæ the same result has been obtained in an entirely different way, namely, by the development of subdermal spicules with one ray pointing gastralwards. Two entirely different types of spicule have thus appeared simultaneously, the prochiact and the quadriradiate. The presence of a complete series of stages between the prochiact and the secondary sagittal triradiate seems to me to be conclusive proof that these two forms are not separate developments, but that one of them is directly derived from the other.

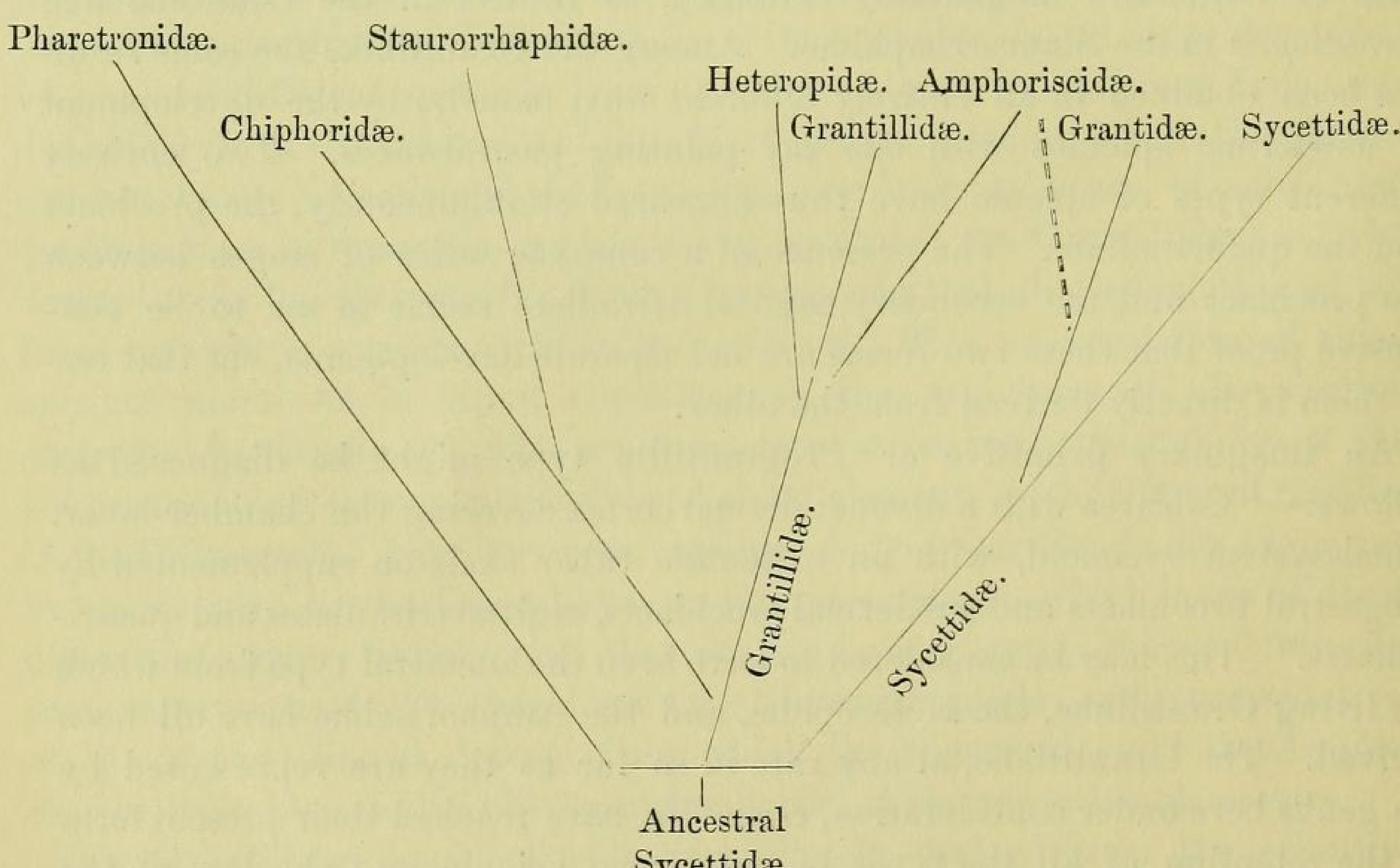
An imaginary primitive or Prograntillid type might be diagnosed as follows:—"Calcarea with a distinct dermal cortex covering the chamber-layer. Canal-system syconoid, with an articulate tubar skeleton supplemented by subgastral prochiacts and subdermal prochiacts, sagittal triradiates and quadriradiates." This may be considered to have been the ancestral type from which the living Grantillidæ, the Heteropidæ, and the Amphoriscidæ have all been derived. The Grantillidæ, at any rate in so far as they are represented by the genus here under consideration, *Grantilla*, have reached their present form by the retention of all the types of subdermal spicule, and the loss of the primitive articulate tubar skeléton. The Heteropidæ, on the other hand, have specialized in the subdermal sagittal triradiates, and no longer possess either subdermal prochiacts or quadriradiates; while the Amphoriscidæ have lost the whole of the prochiact–sagittal triradiate series, and have retained the subdermal quadriradiates only.

Since arriving, in conjunction with Professor Dendy, at the above conclusions with regard to the phylogeny of the Heterocœla, I have seen a paper by Geoffrey Smith, on the Anaspidacea (**17**), in which he develops the same view of evolution by specialization on one of many characters all found in the primitive type. His remarks have such a close connection with the above interpretation, that I think it well to quote them somewhat fully. He says:— " . . . . the primitive ancestors of the specialized groups are not distinguished from their modern representatives so much by simplicity of structure, but rather by combining in themselves the heterogeneous elements which have been segregated out in the course of evolution and separated into the different streams of descent that have given rise to the modern groups."

It was the habit of morphologists, and perhaps still is, "to imagine that a primitive ancestral form must have been simpler and have exhibited less complication of structure than its modern representatives. . . . ."

The conclusions of this author form a very striking confirmation of the views of the evolution of the Heterocœla brought forward in this paper, and form an exceedingly strong argument on behalf of the position assigned to the Grantillidæ herein.

The above view of the evolution of the Heterocœla is shown below by means of a phylogenetic table :—




The Amphoriscidæ are characterized by the presence of conspicuous subdermal quadriradiates, with their apical rays directed gastralwards. These quadriradiates have undoubtedly been produced by the addition of an apical ray to ordinary (regular or sagittal) tangentially placed dermal triradiates.

It seems to me extremely doubtful whether the family is monophyletic in origin, and although I have not broken it up in the present instance, I am of the opinion that it will be found necessary to do so in the near future.

The series *Leucandra–Leucilla* is an eminently natural one, species like *Leucandra verdensis,* Thacker (18) and *Leucilla intermedia,* n. sp., described below, being directly intermediate between the typical Leucandras, which have no subdermal quadriradiates,and the typical Leucillas, in which they are extremely large. *L. verdensis*, although possessing subdermal quadriradiates, is placed in the genus *Leucandra* by Thacker on account of the "inconspicuousness" of these spicules (*cf.* diagnosis of the family Amphoriscidæ in Dendy (2)), in comparison with the dermal tangentially lying triradiates ; while my new species *L. intermedia*, in which the quadriradiates are but little larger, has been placed in the genus *Leucilla* since the dermal triradiates are by no means so large as the quadriradiates, which are therefore "conspicuous." In both these species the apical rays are small in comparison with the facial rays. On the other hand, it is obviously impossible to derive such genera as *Syculmis* and *Amphoriscus,* in which the canal-system is syconoid or sylleibid, from any form which has, like *Leucandra*, a typically leuconoid canal-system. It is therefore suggested that the "Amphoriscidæ Sycones" are derived from the Grantillidæ, and the "Amphoriscidæ Leucones" from the leuconoid Grantidæ.

The Heteropidæ, which like the Amphoriscidæ are descended from primitive Grantillid ancestors, possess features far more difficult of explanation than do the Amphoriscidæ. Chief amongst these is the occurrence of subdermal sagittal triradiates and prochiacts.

It is impossible to derive these spicules from any tangential dermal spicules merely by the addition of a ray, as in the case of the quadriradiates, and they must therefore have been developed either as a completely new structure, or by a change of position of one or more of the rays of an existing spicule.

On behalf of the second of these two views, that these spicules are developed from dermal triradiates by a bending of the basal ray, there is strong presumptive evidence to be obtained from the study of the development of the chiactines of the Chiphoridæ and the Staurorrhaphidæ.

In six species out of nine Jenkin states that the chiactines, which do not extend right up to the osculum, are replaced in that region by ordinary gastral quadriradiates, whose facial rays lie in the primitive facial plane and whose apical rays point into the gastral cavity. Between the areas in which these two types occur, there is an intermediate region in which quadriradiates are found "in all intermediate positions between tangential and centrifugal," *i. e.*, with the basal ray directed in all intermediate positions between aborally, as in the gastral quadriradiate, and dermalwards, as in the typical chiact. This change of position, he suggests, is caused by the appearance of the flagellated chambers, which continually appear in that region as the sponge elongates, so that "the spicules formed in the oscular collar may be supposed to be turned round by the development of flagellated chambers under their basal rays. A very similar tipping of dermal triradiates, due to the growth under them of the flagellated chambers, occurs at the base of the collar in *Tenthrenodes antarcticus.*" (Jenkin, 9.)

We thus have a description of the formation of chiacts direct from gastral quadriradiates by a direct change of position. The result of the "tipping" in *Tenthrenodes* is less clear, as there never occur any *sub*dermal spicules in this genus, *i. e.* spicules with a ray pointing gastralwards.

As regards the two species of *Grantilla*, I have been unable to make any investigations on *G. quadriradiata,* as the single specimen obtained by Mr. Crossland consists of a fragment from which the oscular portion has been lost. In *G. hastifera* I found that neither subgastral nor subdermal triradiates or prochiacts extend quite to the oscular rim, but that there is, as in the Chiphorid and Staurorrhaphid species, a small area in which they are not arranged absolutely radially, but are slightly inclined on both surfaces. This inclination does not seem to be always in the same direction, but may be either oral- or aboralwards. The spicules in this region of the sponge are considerably smaller than the full-grown ones, being not much larger than the triradiates of the dermal and gastral cortices. Above the region of irregularly placed prochiacts and triradiates it was found impossible to distinguish them from the cortical spicules. Owing to the preservation of the specimens not being sufficiently good, I found it impossible to obtain any histological details of their development.

It is therefore impossible to be absolutely certain that these subdermal and subgastral spicules are derived directly from the dermal and gastral cortical triradiates by a change of position, though the facts given above and the great similarity of the spicules in the different genera are very strongly in favour of such a derivation; and it seems undoubtedly easier to so derive them, especially as it is possible to do so in entire harmony with the known facts, rather than to consider them an entirely new structure with an origin entirely independent of any existing spicule.

The retention of the paired rays of the prochiact in the primitive facial plane can also be explained very easily in accordance with this view. The change of position of the spicule must undoubtedly commence while it is quite small, and must be a gradual process, as it presumably depends upon the growth of the flagellated chambers under it for its accomplishment, at any rate in the case of the subgastral spicules.

Since the gastral and dermal cortices are separated by the growth of the flagellated chambers, there will be no obstruction in the way of the basal ray as it gradually assumes the radial position ; but to the movement of the paired rays, which it must be remembered are growing during the whole of this period, a very serious obstruction is opposed by the presence of a cortex.

Were the additional calcite secreted by the calcoblasts deposited along the line of the axis of the ray, the ray as it elongated would have to force its way through the cortex as the spicule turned, whereas this difficulty would be entirely obviated if the further growth of the paired rays continued along the original lines occupied by the spicule, *i. e.* in the primitive facial plane, each portion of calcite secreted being thus a little more out of line with the basal ray than the last. This would fully explain the peculiar curvature of the paired rays of the prochiact, and since the dermal and gastral cortical triradiates in *Grantilla* are very nearly regular, the oral angle between the rays of the original cortical triradiate is very similar to the oral angle of a prochiact.

It is, however, more difficult to understand how the growth of the flagellated chambers can cause the change of position in the case of the subdermal triradiates and prochiacts, though the evidence in favour of a similar origin to that of the subgastral spicules is very strong. Like the similar subgastral spicules, they lie in the region of the oscular rim in *Grantilla hastifera* in intermediate positions between tangential and radial, while, as quoted above, Jenkin (**9**) states that in *Tenthrenodes* such a "tipping" is actually caused by the growth of the chambers.

These arguments imply that the prochiact is more primitive than the subdermal sagittal triradiate, which will then be derived from it by the widening of the oral angle by the turning of the paired rays until they lie in one plane with the axis of the basal ray (fig. 1, p. 188); and the immediate derivation of one from the other is rendered certain by the absolutely complete series of intermediate forms which occur in *Grantilla*. This series is as complete on the subgastral surface as on the subdermal, and leads to the conclusion that the subgastral sagittal triradiates of *Grantilla* are derived, like the subdermal, *viâ* prochiacts from the cortical triradiates. It is, of course, not suggested that spicules once formed change from prochiacts to sagittal triradiates, but that this change has occurred during the evolution of the group.

It also leads to the conclusion that the subgastral sagittal triradiate of such a form as *Grantilla*, and probably also of the Heteropidæ, is entirely different from the sagittal triradiate of the first joint of the ordinary articulate tubar skeleton, being secondary in origin, and therefore that the inarticulate tubar skeleton is an entirely new structure, supplanting and replacing the articulate, instead of being derived from it.

In dealing with the question of these secondarily formed sagittal triradiates, the researches of von Ebner (**19**) into the physical characters of spicules are of very great importance.

Von Ebner (**19**) studied this question in a large number (14) of species, including members both of the Homocœla and the Heterocœla, and deduced, from the behaviour of their spicules when examined under polarized light, the occurrence of "secondary" sagittal triradiates differing markedly in their optical orientation from the primitive sagittal triradiates.

In examining a typical regular triradiate by polarized light, it is found that the whole spicule behaves as a single crystal, with its optic axis lying perpendicularly to its facial plane. Similarly, the optic axis of a quadriradiate lies perpendicular to its facial plane, and therefore corresponds with the morphological axis of its apical ray. It should, however, be noted, as von Ebner points out, that, owing to the curvature of the surface of the sponge and of the chambers in those species possessing a syconoid canal-system, the facial rays of a spicule rarely lie in one plane, but are usually in the form of an extremely low and widespread tripod. References to the facial plane must therefore be taken to refer to the plane containing the apices of the three rays, whether or not this should also contain the other portions of the rays. There must therefore also be distinguished the true oral angle from the angle seen between the paired rays when the spicule is viewed as though projected in the facial plane, as is the case in ordinary microscopic examination. The true oral angle is the angle between the paired rays *measured in the plane containing those rays.*

When examining sagittal triradiates, spicules are very frequently found whose true oral angle is 170° and whose oral rays lie in a plane perpendicular to the optic axis. The basal ray of these spicules is usually somewhat inclined to the optic axis, usually from 10°–50°.

Among the sagittal triradiates whose true oral angle is greater than 120°, von Ebner found that in a large number of cases, when the spicule was viewed as a projection in a plane at right angles to the optic axis, that the angle then seen between the oral rays was one of 120°. In many cases, however, he found that the projection of the oral angle in such a plane produced an angle greater than 120°, usually from 150° to 180°.

He therefore divided all sagittal triradiates into two classes distinguished by the size of the " Projections Oralwinkel " in a plane at right angles to the optic axis : (*a*) those in which the angle was 120° ; (*b*) those in which it was greater.

The very close similarity of this optical series of modifications with the morphological modifications here described in *Grantilla* can at once be seen. Viewing the tubar triradiates of *Grantilla* in the primitive facial plane, they can be divided into those in which the primitive oral angle is less than, equal to, or greater than 120°. The first two of these divisions includes the prochiacts, while all the secondary triradiates will be placed in the other.

It must, however, be observed that the two cases are not equivalent, since in one case the spicule is orientated with regard to its optic axis, and in the other case with regard to its morphological axis.

If the theory put forward in this paper is accepted, the prochiacts and secondary sagittal triradiates of *Grantilla* are derived directly from an already formed spicule by an actual change in the morphological orientation of the spicule during its growth. Such a change, whether of the whole spicule or of one ray, must obviously cause a similar change in the position of the optic axis of the spicule or ray, as it is impossible to imagine that the crystal components of an already formed spicule should change their position in the spicule as it turned, so as to retain the primitive orientation in the sponge of their optic axis.

Thus the morphological movement of the spicule would not affect its orientation with regard to the optic axis, though it is very possible that the morphological movement might tend to influence the physical orientation of the calcite, which quite possibly might continue to be laid down in its primitive orientation with regard to the sponge rather than with regard to the spicule.

From a polariscopic examination of the actual prochiacts and secondary triradiates, it appears that the orientation of the spicule about its optic axis varies very greatly, but whether these variations are related in any manner to the morphological characters of the spicule, or to the amount of the widening of the primitive oral angle, I am unable to say.

In connection with the morphologically secondary sagittal triradiates of *Grantilla* and the entire replacement in this genus of the primitive articulate tubar skeleton by such spicules or by prochiacts, it is noteworthy that, leaving out of account *Megapogon*, which has a leuconoid canal-system and an irregular spicule arrangement, there are but two genera in the families Chiphoridæ and Staurorrhaphidæ which retain their articulate tubar skeleton. In *Streptoconus* the chiactines form the gastral joint of the articulate tubar skeleton, the upper joints being composed of typical sagittal triradiates. In *Grantiopsis* the tubar skeleton, save in so far as the chiactines are concerned, is composed of triradiates which have undergone a considerable modification, the paired rays of the spicule having almost disappeared, and being only represented by minute projections at the gastral end of the spicule. In all the other genera of these two families the tubar skeleton is entirely composed of the chiactines, with in some species the very occasional addition of a triradiate, presumably from its position a remnant of the articulate tubar skeleton.

A similar replacement occurs in the Heteropidæ by means of subdermal and subgastral secondary sagittal triradiates. Very frequently in this family again the loss of the primitive tubar spiculation is complete, in which case there is formed an inarticulate tubar skeleton. As typical examples of this may be mentioned *Grantessa stauridea* and *Grantessa simplex*.

Among the syconoid Amphoriscidæ the replacement of the tubar skeleton is characteristically by large quadriradiates and triradiates. In *Amphoriscus* and *Syculmis*, for example, there are present subdermal and subgastral quadriradiates whose apical rays point respectively gastral- and dermalwards, while in *Heteropegma* the former alone are present. In all these forms the spicules of the articulate tubar skeleton are very considerably reduced, the reduction in size being very especially noticeable in some species of *Heteropegma*.

The remarkable consistency with which, throughout these families, the primitive tubar spiculation is replaced by spicules which, though of various kinds, are in every case derived from cortical triradiates, seems to me to be very strong evidence in support of the true phylogenetic unity of the group.

This view of the evolution of the more highly organized families of the Heterocœle Calcarea differs from that suggested by Dendy (2) only in the derivation of the Heteropidæ and Amphoriscidæ, not directly from the Grantidæ, but as an entirely separate line from Sycettid (*i. e.* non-corticate) ancestors. This modification has been rendered necessary by the undoubtedly primitive character of the prochiact, and the important part which it is considered to have played in the evolution of the group.

GRANTILLA QUADRIRADIATA, sp. n. (Pl. **19**. figs. 1, 2.)

The sponge is represented by a fragment only (Pl. **19**. fig. 1), of a single sycon person, possessing neither osculum nor attachment, so that a full description of its external form is impossible. The specimen is cylindrical in form, and measures 12 mm. in length and 26 mm. in diameter at the widest part.

The canal-system is typically syconoid, and the chambers do not appear to be at all branched (Pl. **19**. fig. 2).

The skeleton arrangement of the chamber layer is of the inarticulate tubar type, composed of sagittal triradiates and prochiacts on both surfaces, and also of subdermal quadriradiates, and a few oxea.

Dermal and gastral cortices are present, each containing tangentially arranged triradiates.

*Skeleton arrangement.* (Pl. **19**. fig. 2.)

A. Dermal cortex.

The spiculation of the dermal cortex, which is fairly thick, consists entirely of triradiates (text-fig. 2, *e*). These are fairly large, typically quite regular, with their rays of equal length, though many of them show a slight differentiation of their angles into oral (the largest) and paired, in which case the basal ray is usually very slightly longer than the oral. All the rays are equal in thickness. They are arranged over the surface of the sponge entirely without regard to orientation, except that they are placed tangentially.

B. Tubar skeleton (Text-fig. 2, *a*, *b*, *c*, *d*).

(i.) Quadriradiates (Text-fig. 2, *c*).—These are the only quadriradiates present in the sponge, and are large subdermal quadriradiates, whose facial rays are decidedly sagittal, the two oral rays being usually nearly in a straight line and the oral angle almost 180°. The apical ray is considerably the longest, frequently being nearly three times as long as the facial rays. It is quite straight and of the same diameter for most of its length, the diminution in thickness being confined to the distal third of its length.

All the three facial rays are of approximately the same length and diameter, the basal being sometimes slightly longer than the two oral. All the facial rays are slightly curved ; they taper slowly for the most part of their length, and are usually somewhat abruptly pointed.

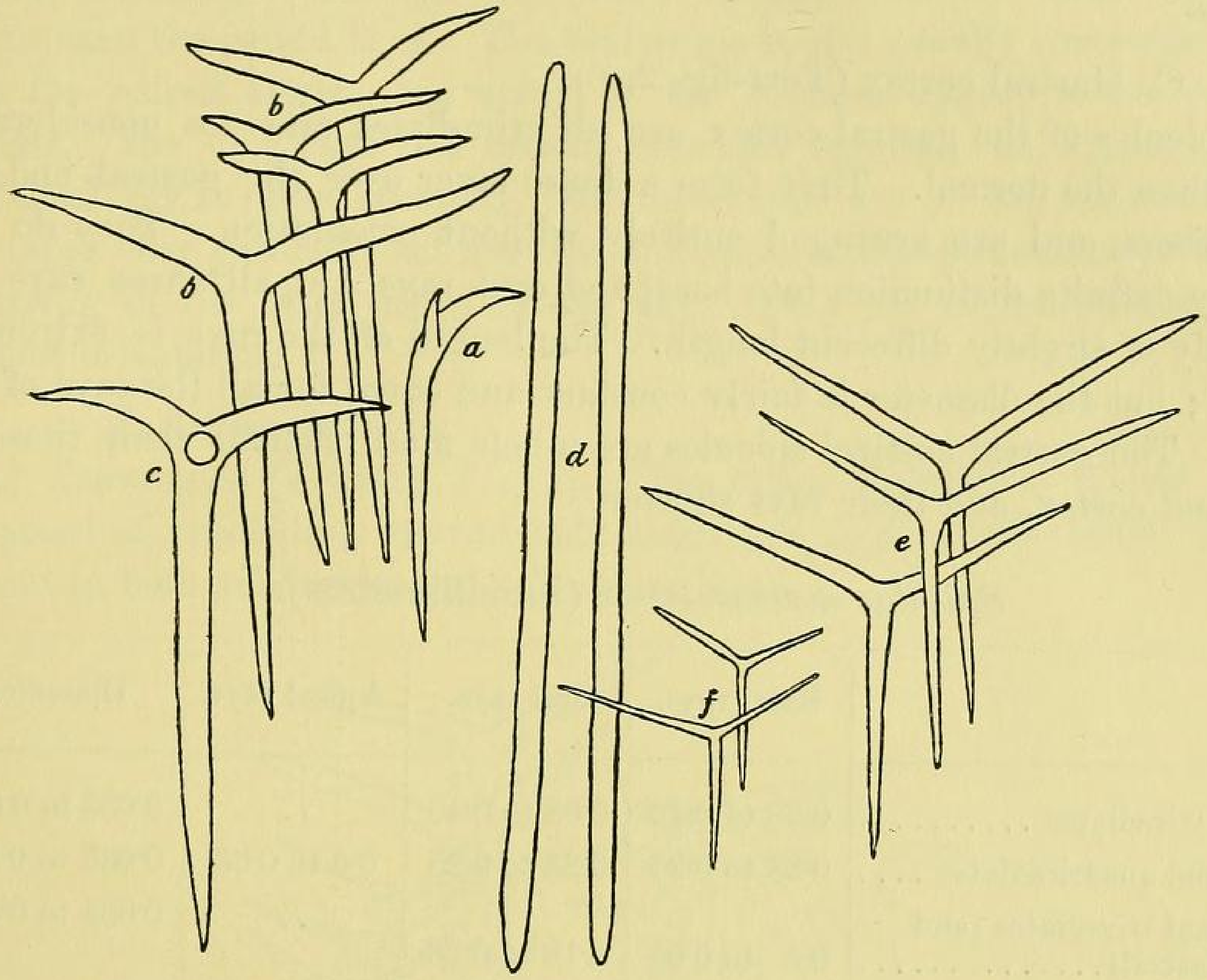



Fig. 2.—Spicules of *Grantilla quadriradiata*, all ×60.

(ii.) Triradiates (Text-fig. 2, *a*, *b*).—The subgastral elements of the inarticulate tubar skeleton are very largely prochiacts (text-fig. 2, *a*) of typical form, with a few intermediate forms, and true sagittal triradiates with them (text-fig. 2, *b*). The subdermal skeleton also contains a very considerable number of prochiacts, though here the number of sagittal triradiates is proportionately very much larger, forming about one-half of the total number of subdermal spicules. Intermediate forms also occur fairly numerously, so that the prochiacts do not on that side amount to more than one-third of the total number of subdermal triradiates.

The paired rays of both prochiacts and sagittal triradiates are usually curved, and frequently are not quite equal, either in length, or inclination to the basal ray. This is much more marked in the triradiates than in the prochiacts. The rays in each case taper gradually for the greater part of their length, and rapidly for the distal fourth of their length.

The basal ray is very much the longest, reaching to as much as three times the length of the oral rays, and is quite straight. It tapers gradually for its whole length, but somewhat more rapidly in the distal portions. All three rays are of the same diameter.

(iii.) Oxea (text-fig. 2, *a*).—A very few oxea occur, radially arranged, and traversing the sponge-wall from cortex to cortex, though they do not project from the surface. They are of almost the same diameter throughout their length, and their ends are bluntly pointed. They are quite straight or nearly so.

C. Gastral cortex (Text-fig. 2, *f*).

The spicules of the gastral cortex are all triradiates and are considerably smaller than the dermal. They form a dense layer over the gastral ends of the chambers, and are arranged entirely without orientation. They do not show any definite distinction into basal and oral rays, but all three rays are frequently of slightly different length. The length of the rays is extremely variable ; but the diameter is fairly constant and equal for all the rays of one spicule. The gastral cortical spicules are much more slender than those of the dermal cortex, and their rays shorter.

*Spicular measurements* (in millimetres).

| | Basal rays. | Oral rays. | Apical rays. | Diameter. |
|---|---|---|---|---|
| Dermal triradiates .......... | 0·38 to 0·42 | 0·33 to 0·40 | .. | 0·035 to 0·04 |
| Subdermal quadriradiates .... | 0·23 to 0·26 | 0·23 to 0·25 | 0·5 to 0·65 | 0·035 to 0·345 |
| Subdermal triradiates (and subgastral).............. | 0·5 to 0·65 | 0·18 to 0·23 | .. | 0·034 to 0·042 |
| Gastral triradiates .......... | 0·17 to 0·28 | | .. | 0·02 |
| Oxea...................... | 1·2 to 1·3 | .. | .. | 0·03 |

The single specimen in the collection was obtained from the Harbour at Suez.

*Distribution.* Red Sea.

GRANTILLA HASTIFERA, sp. n. (Pl. 19. figs. 3, 4.)

The specimen (fig. 3) consists of a cylindrical syconoid person with a single apical osculum. The aboscular end is broken, and close to the osculum the proximal portion of a second sycon person joins on to the first ; the second tube, however, is only a fragment.

The specimen measures 22 mm. long by 9 mm. diameter at the widest part.

The tubar skeleton is inarticulate, and is composed chiefly of prochiacts and sagittal triradiates, the oral rays of the latter being of unequal length. A number of radially disposed oxea also occur, whose outer ends project considerably from the sponge, and are " semi-hastate," *i. e.* barbed on one side only.

The canal-system is typically syconoid, the chambers being protected by a fairly well-developed dermal cortex, containing a dense layer of triradiates.

*Skeleton arrangement.* (Pl. 19. fig. 4.)

A. Dermal cortex.

The spiculation of the dermal cortex consists entirely of regular to sub-regular triradiates (text-fig. 3, *c*), which usually have the basal ray slightly longer than the paired rays. The oral angle is also usually somewhat greater than the paired angles, but many of the spicules appear to be absolutely regular. The oral rays are usually straight, but may be slightly curved. The basal ray is quite straight. All three rays are of the same thickness, and taper very gradually till near the end, most of the diminution of thickness occurring in the distal third of the ray. They lie in the cortex entirely without orientation.

B. Tubar skeleton.

(i.) Triradiates (Text-fig. 3, *a*, *b*).—The tubar skeleton is almost entirely composed of prochiacts, intermediate forms and sagittal triradiates, all being present in both subdermal and subgastral layers.

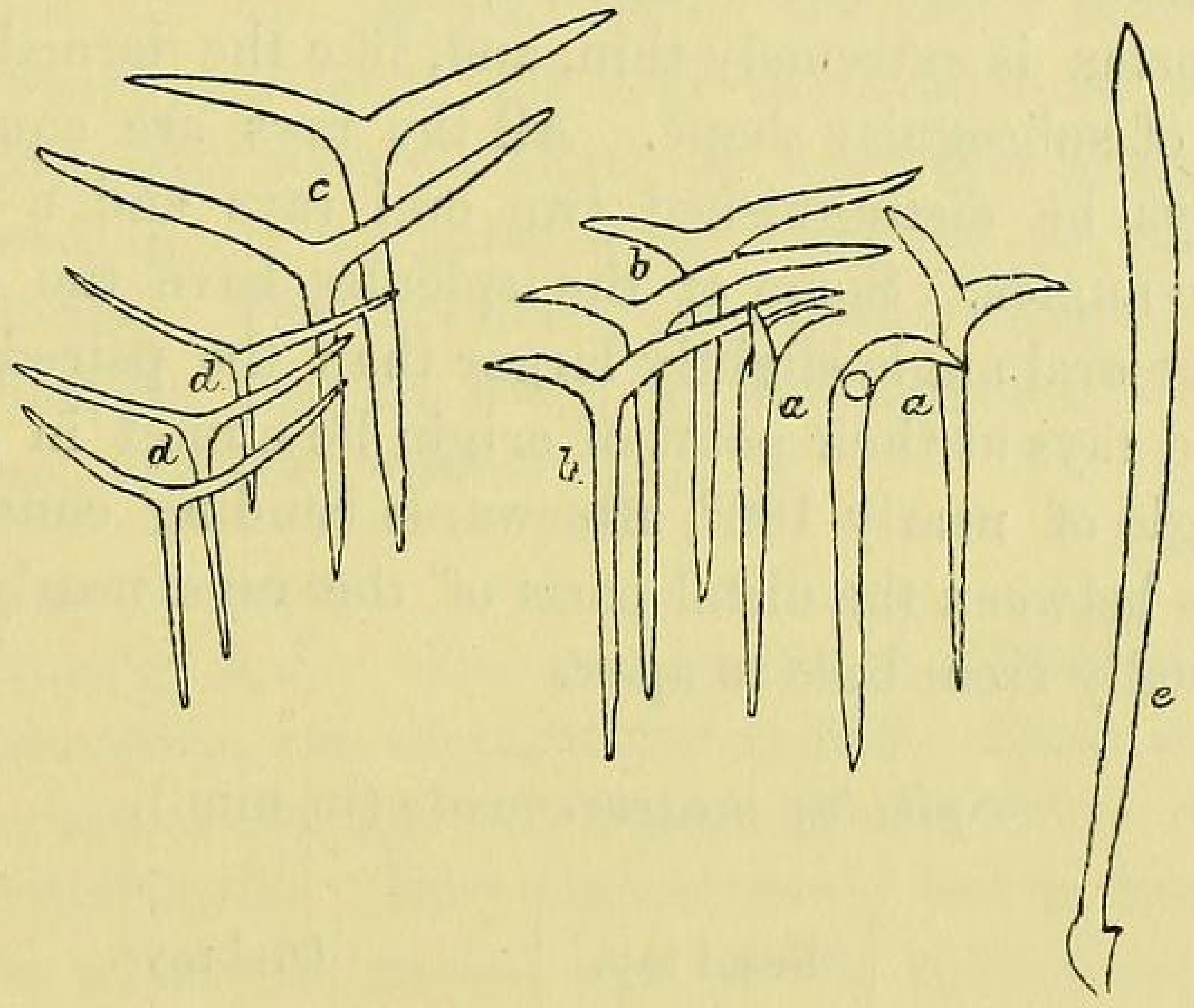



Fig. 3.—Spicules of *Grantilla hastifera*, all ×60.

The prochiacts (text-fig. 3, *a*) are much more numerous in the subgastral than in the subdermal layer, where they but occasionally appear. The paired rays are equal in length and as a rule about one-third of the length of the basal ray ; they are curved very considerably, and taper throughout their whole length. The basal ray is quite straight, and likewise tapers through its whole length. All the rays are of equal thickness.

The intermediate forms between prochiact and sagittal triradiate spicules also have approximately equal oral rays, and the measurements given below for the prochiacts apply equally to them.

The sagittal triradiates (text-fig. 3, *b*), however, show a peculiar modification of their paired rays, which are of unequal length, one of them being very nearly twice as long as the other in a typical specimen, while sometimes it may even reach to two and a half times as long. These elongated rays do not lie in any special direction, but point towards any part of the sponge indiscriminately, two adjacent spicules frequently having their elongated rays pointing in opposite directions. The shorter of the two paired rays is of about the same length as the paired rays of the prochiacts. Both the paired rays are strongly curved, and are somewhat abruptly pointed. The basal ray is quite straight and tapers almost uniformly from base to apex, the tapering being slightly more rapid towards the point.

(ii.) Oxea (Text-fig. 3, *e*).—There are present radially arranged oxea, extending completely through the sponge-wall and with the distal third of their length projecting from the surface of the sponge. They are slightly curved, and thickest about one-third of their length from the inner (gastral) end, which is abruptly pointed. The distal end, towards which the spicule gradually tapers, is swollen into a head, whose proximal part is barbed on one side and rounded on the other. The distal end of the head is pointed.

C. Gastral cortex (Text-fig. 3, *a*).

The gastral cortex is extremely thin, and, like the dermal cortex, contains triradiates only of subregular shape. All the rays are equal in length, but there can always be distinguished two oral rays and a basal ray by the inequality of the angles. Some of the spicules have the paired rays quite straight, with the oral angle slightly larger than the paired angles, while in others the paired rays at their point of origin lie almost in one straight line, with an oral angle of nearly 180°, afterwards bending considerably so as to make the angles between the distal parts of the rays nearly equal. All the rays taper gradually from base to apex.

*Spicular measurements* (in mm.).

| | Basal ray. | Oral rays. | Diameter. |
|---|---|---|---|
| Dermal triradiates | 0·27 to | 0·30 | 0·03 to 0·035 |
| Subdermal and subgastral do. | 0·32 to 0·35 | (*a*) 0·2 to 0·3 (*b*) 0·1 to 0·12 | 0·03 |
| Prochiacts | 0·4 to 0·45 | 0·1 to 0·12 | 0·025 to 0·03 |
| Gastral cortical triradiates | 0·18 to | 0·24 | 0·015 to 0·018 |
| Oxea | 1·0 to 1·1 | | 0·03 to 0·04 |

A single specimen of this species was obtained at Suez.

*Distribution.* Red Sea.

This species has been placed in the genus *Grantilla* with the previous species owing to the striking similarity between their tubar skeletons, although no quadriradiates occur in this species.

### Family Heteropidæ, *Dendy*.

Grantessa glabra, sp. n. (Pl. 19. figs. 5, 6.)

The specimen (fig. 5) consists of an irregular syconoid individual with a slight division into two persons indicated at one end. Each of these persons has a distal osculum, one of them being closed.

In the aboscular portion of the sponge is a large rent, so that it is impossible to say definitely that the sponge is not colonial in form. The specimen measures 20 mm. in length and 9 mm. in breadth.

The canal-system (Pl. 19. fig. 6) is typically syconoid, with fairly thick dermal and gastral cortices, and is supported by an inarticulate tubar skeleton, composed of large, typically sagittal triradiates, and a few oxea (fig. 6).

*Skeleton arrangement.* (Pl. 19. fig. 6.)

A. Dermal cortex.

The spiculation of the dermal cortex consists entirely of triradiates (text-fig. 4, *b*), which are large and vary in shape from regular to slightly sagittal, very frequently with the basal ray somewhat longer than the others. They are disposed in an irregular layer over the dermal surface, without regard to orientation. The rays are all of equal thickness, but some spicules are found in which the rays are much thicker than in others. The rays taper from base to apex, and are quite straight.

B. Tubar skeleton.

(i.) Oxea (Text-fig. 4, *d*).—The oxea, many of which have the form of the stylotes of *Monaxonida*, are straight and radially placed on the sides of the flagellated chambers amid the triradiates of the tubar skeleton with their pointed ends dermalwards. They are extremely few in number. A few oxea are also found in which the gastral end of the spicule is considerably more sharply pointed than in the typical example. They are thickest about the middle, whence they taper slightly towards the rounded gastral end, and more rapidly towards the dermal end.

(ii.) Triradiates (Text-fig. 4, *a*).—Large sagittal triradiates forming an inarticulate tubar skeleton in which, however, many of the triradiates, both in the subgastral and subdermal layers, have their paired rays placed considerably more deeply than have others. The basal ray is by far the longest of the rays, being very frequently almost twice as long as the paired rays, which are sometimes slightly unequal in length. The basal ray is quite straight. The angles between the rays are all equal at first, but the paired rays almost immediate curve outwards to form a typical sagittal spicule.

All the rays taper from base to apex.

C. Gastral cortex.

The spiculation of the gastral cortex is entirely made up, like that of the dermal cortex, of a layer of triradiates (text-fig. 4, *c*). They are equiangular,

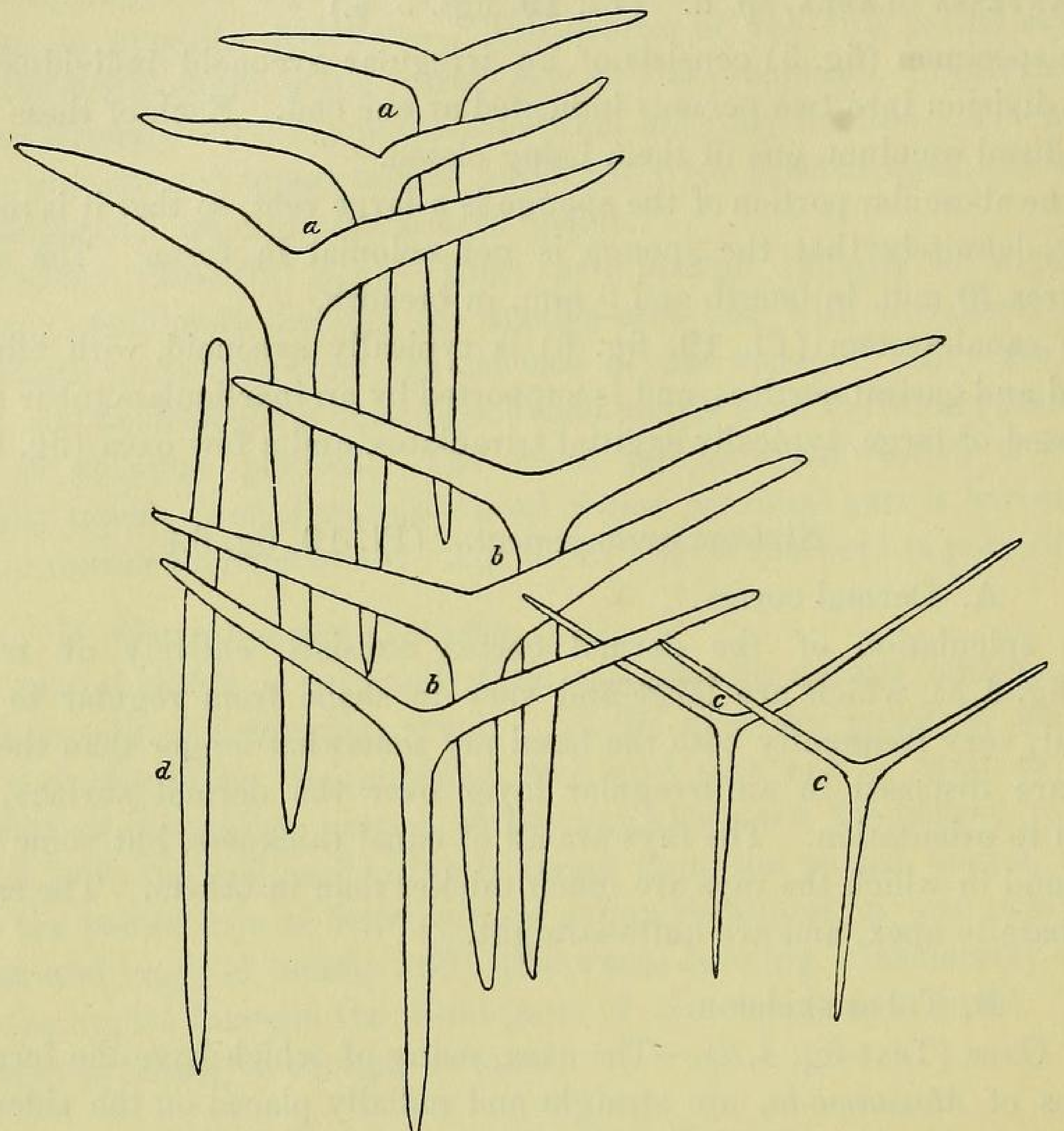



Fig. 4.—Spicules of *Grantessa glabra*, all ×60.

and their rays are somewhat less in length than those of the dermal triradiates. They are also very much more slender, being not more than a fourth of that of the larger dermal triradiates. Their rays often show a slight variation in length, and are quite straight. They taper from the base to the apex.

*Spicular measurements* (in mm.).

| | Basal ray. | Oral rays. | Diameter. |
|---|---|---|---|
| Dermal triradiates | 0·5 to 0·7 | 0·5 to 0·65 | 0·04 to 0·065 |
| Gastral triradiates | 0·4 to 0·5 | | 0·015 |
| Tubar triradiates | 0·75 to 0·8 | 0·4 to 0·5 | 0·07 to 0·09 |
| Oxea | 1·0 to 1·1 | | 0·05 to 0·06 |

A single specimen of this species was obtained at Suez.

*Distribution.* Red Sea.

Family AMPHORISCIDÆ, *Dendy.*

LEUCILLA BATHYBIA (*Haeckel*).

Synonymy ;

1872. *Leucaltis bathybia*, Hæckel (**8**).

1877. *Leucaltis bathybia*, Schuffner (**16**).

Three specimens were obtained from a buoy in Suez Harbour.

*Distribution.* Red Sea; Amirante Is., Australia.

LEUCILLA INTERMEDIA, sp. n. (Pl. **20**. fig. 7.)

The specimens in the collection are small, irregularly massive, and usually with a single osculum at the top; there are no specimens present in which two oscula occur. They vary in diameter, the largest being 8 mm. at its widest part, which is close to the base.

The canal-system is sylleibid, with slightly elongated flagellated chambers arranged in groups round wide exhalant canals (Pl. **19**. fig. 7).

The spiculation of the chamber-layer is irregular.

*Skeleton arrangement.* (Pl. **19**. fig. 7.)

A. Dermal cortex.

(i.) Quadradiates (Text-fig. 5, *a*).—Large slender quadriradiates usually with the basal ray slightly longer than the paired rays, but spicules occur with the basal ray much the shortest. All the facial rays are straight and equal in diameter. They are also of the same diameter throughout nearly the whole of their length, the ends being somewhat abruptly pointed in most cases. In the case of those spicules which have a short basal ray, however, the basal ray tapers gradually throughout its length. The facial rays are not orientated in any special direction. The apical ray, which is directed gastralwards, is small and slender.

(ii.) Triradiates (Text-fig. 5, *d*).—A thin irregular layer of regular, tangentially placed triradiates occurs interspersed among the quadriradiates. The rays are straight, equal in length, and taper gradually from base to point. The spicules are scattered over the surface of the sponge without regard to orientation.

B. Gastral Cortex.

The spiculation of the gastral cortex consists entirely of small sagittal quadriradiates with extremely short apical rays (text-fig. 5, *b*). They form a dense but thin layer over the gastral surface of the sponge. The facial rays are all equal in length, and of the same diameter. They taper gradually throughout their whole length. The basal ray is quite straight, but the paired rays are usually curved. The apical ray is much shorter and of less diameter than the facial rays. There is no orientation of the facial rays.

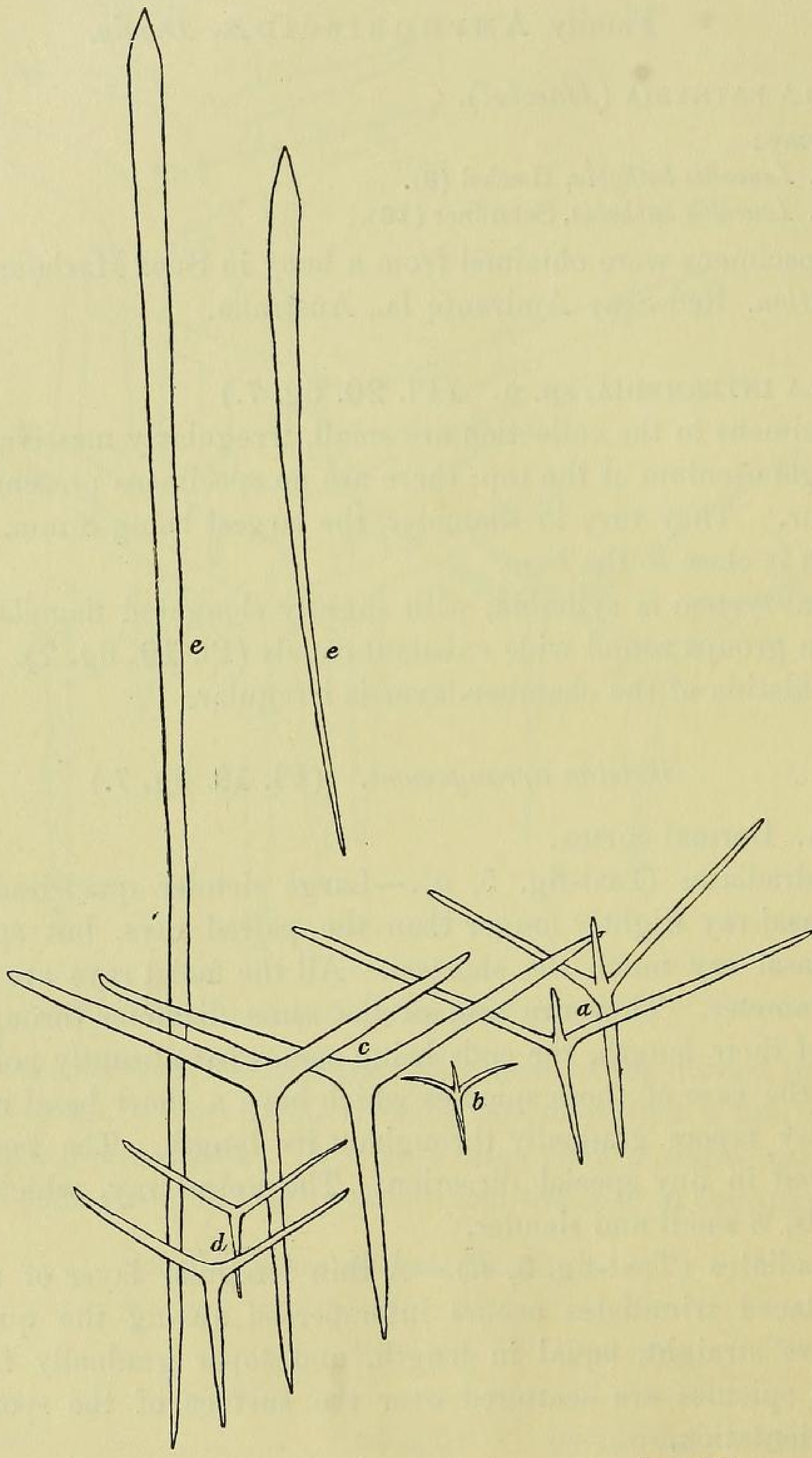



Fig. 5.—Spicules of *Leucilla intermedia*, all ×60.

C. Skeleton of the chamber-layer.

(i.) Oxea (Text-fig. 5, *e*).—The oxea are extremely long, and lie amidst the triradiates. They are arranged radially, with their distal ends projecting some way from the surface of the sponge. They are of somewhat peculiar shape, their greatest diameter occurring near the inner (gastral) end, which is abruptly pointed. The spicules taper gradually and uniformly to the distal end, which is very elongated and slender.

(ii.) Triradiates (Text-fig. 5, *c*).—The main portion of the skeleton of the chamber-layer is composed of irregularly scattered triradiates of rather large size, all the rays being of equal length and thickness. The inequality of the angles separating the rays, however, renders it always possible to distinguish the basal ray from the paired rays. The rays are all straight and somewhat abruptly pointed.

*Spicular measurements* (in mm.).

| | Basal ray. | Paired rays. | Apical ray. | Diameter. Facial rays. | Diameter. Apical ray. |
|---|---|---|---|---|---|
| Subdermal quadriradiates | 0·17 to 0·5 | 0·4 to 0·5 | 0·12 | 0·015 to 0·017 | 0·015 to 0·016 |
| Gastral quadriradiates | 0·1 to 0·11 | 0·1 to 0·11 | 0·07 to 0·08 | 0·008 | 0·007 |
| | All rays. | | | Diameter. | |
| Dermal triradiates | 0·23 to 0·26 | | — | 0·015 to 0·017 | |
| Triradiates of the chamber-layer | 0·37 to 0·5 | | — | 0·03 to 0·035 | |
| Oxea | 1·0 to 3·0 | | — | 0·05 to 0·06 | |

A considerable number of specimens of this sponge were obtained at Suez.

*Distribution.* Red Sea.

LEUCILLA CROSSLANDI, sp. n.

The specimen in the collection is but a fragment, without osculum or place of attachment. It apparently belongs to a fairly simple sponge form. It is 8 mm. long by 5 mm. broad at its widest part.

The canal-system is typically leuconoid, with small spherical chambers irregularly scattered through the sponge-wall.

The spicules are quadriradiates and triradiates.

*Skeleton arrangement.*

A. Dermal cortex.

(i.) Subdermal quadriradiates, of which there are two kinds:—

(α) (Text-fig. 6, *a*). Very large sagittal quadriradiates, lying immediately below the dermal surface. Of the facial rays there is usually a short basal ray and longer paired rays, all three rays tapering uniformly to a sharp point from base to apex, and all being quite straight. The gastrally directed apical ray is frequently as long as the basal ray,

(β) (Text-fig. 6, *b*, *c*). Quadriradiates, not quite so large as the previous and with the paired rays slightly curved, are also present. This slight curving tends to bring the axes of the paired rays to lie nearly in a straight line. Instead of tapering uniformly and ending in a sharp point,

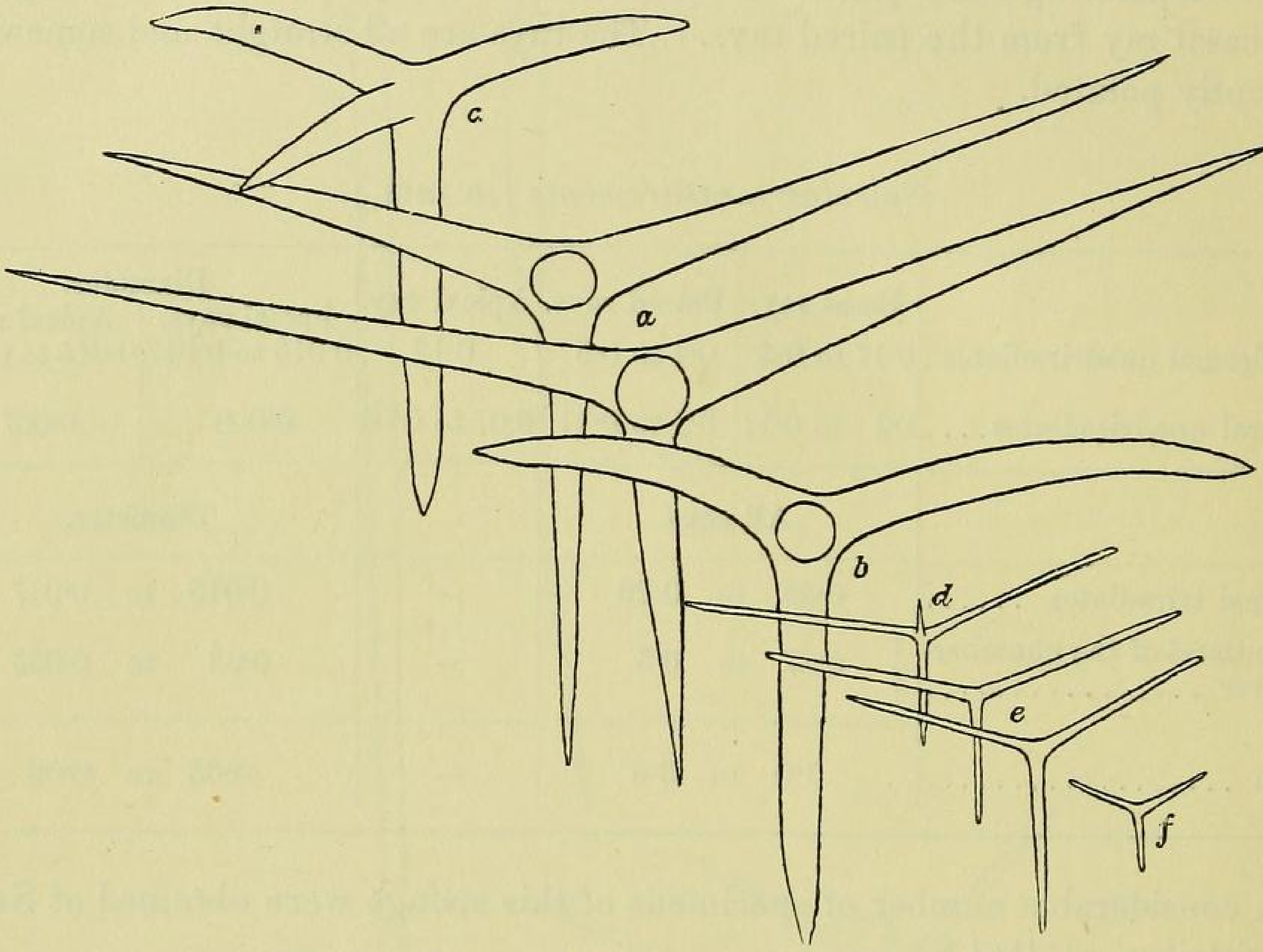



Fig. 6.—Spicules of *Leucilla crosslandi*, all ×60.

the ends are obtusely pointed, and the rays are of very nearly the same diameter for two-thirds their length. The apical ray is frequently the longest of the rays. The facial rays may be equal in length.

*Measurements of subdermal quadriradiates* (in mm.).

| | Basal ray. | Paired rays. | Apical ray. | Diameter of rays. |
|---|---|---|---|---|
| α { .............. | 0·61 | 0·92 | 0·55 | 0·1 |
| ............... | 0·7 | 0·89 | 0·57 | 0·09 |
| β { .............. | 0·6 | 0·6 | 0·58 | 0·09 |
| ............... | 0·55 | 0·55 | 0·6 | 0·075 |

(ii.) Triradiates (Text-fig. 6, *e*).—Exactly similar triradiates were found in the dermal and gastral cortices and in the chamber-layer. They are described under the skeleton of the chamber-layer. The dermal cortex is composed of a thin but very dense layer of these, filling up the interstices between the subdermal quadriradiates.

B. Gastral cortex.

(i.) Quadriradiates (Text-fig. 6, *d*). — Very slender quadriradiates with an extremely small apical ray projecting into the gastral cavity. They are sagittal, with the paired rays much longer than the basal and a very wide oral angle. All the rays are straight and the facial are all equal in diameter. The apical ray is considerably more slender than the facial rays, and tapers nearly uniformly from base to apex. The facial rays are of the same diameter for the greater part of their length and have rounded ends. The paired rays vary from 0·25 to 0·28 mm. in length, the basal from 0·18 to 0·2 mm., all three facial rays having a diameter of 0·014 mm. ; the apical rays are about 0·05 mm. long, and 0·01 mm. in diameter.

(ii.) Triradiates (Text-fig. 6, *e*).—Exactly similar to those of the chamber-layer, forming a thin but dense layer among the quadriradiates.

C. Skeleton of the chamber-layer (Text-fig. 6, *e*, *f*).

This part of the skeleton consists of a great mass of sagittal triradiates scattered throughout the chamber-layer of the sponge, without orientation. There is easily distinguishable, in most spicules, a basal and two paired rays, by the great width of the oral angle. The basal ray is also usually not quite so long as the paired rays, but it may be equal to them in length or even longer than they are. All the rays are quite straight and of equal diameter almost up to the tip, which is somewhat rounded.

There are also present in the chamber-layer, though not in the dermal or gastral cortex, a quantity of very small triradiates, which may very possibly be the incompletely developed specimens of the preceding. They are sagittal and have the paired rays always slightly longer than the basal. The thickness and form of the rays are the same as in the larger triradiates.

*Measurements of triradiates* (in mm.).

| | Basal ray. | Oral rays. | Diameter. |
|---|---|---|---|
| Large triradiates ............ | 0·2 to 0·28 | 0·25 to 0·30 | 0·014 |
| Small triradiates ............ | 0·14 to 0·18 | 0·16 to 0·2 | 0·014 |

A fragment of a single specimen was obtained at Suez.

*Distribution*. Red Sea.

### Family PHARETRONIDÆ, *Zittel.*

### Subfamily DIALYTINÆ, *Rauff.*

### Genus KEBIRA,* n. g.

Sponge composed of a single person with an apical osculum. The chamber-layer is covered over with a thick dermal cortex, in which occur numerous large oxea, longitudinally arranged. The spicular fibres are composed of triradiates, the paired rays of which are vestigial. The fibres lie radially disposed, or inclined but little to the radial direction, in the chamber-layer. The canal-system is leuconoid, with large subdermal cavities, inhalant and exhalant canals.

This genus is of unusual interest not only as a living member of the family Pharetronidæ, an almost wholly fossil group, but also on account of the presence of triradiates of very peculiar type.

In the only other known living genus belonging to the subfamily Dialytinæ, *Lelapia* (2 *a*), there also occur fibres of modified triradiates, in this case tuning-fork spicules, the paired rays being bent towards each other so that they come to lie parallel and close together, and almost in line with the basal ray. Thus the spicular fibre comes to be composed of spicules simulating oxea.

In *Kebira*, however, the same result is obtained by a totally different method. Here, at first sight, the spicules of the fibres appear to be true oxea, but on more careful observation it is found that there is present on the inner (gastral) end of each, a small triangular head or swelling representing the two paired rays (text-fig. 8, *e*). Although typically almost absent, yet there occasionally appear considerable rudiments of these paired rays, especially at the gastral end of the spicular fibre, where there are no surrounding spicules. All the paired rays are turned gastralwards, and the fibres run either radially, or very slightly inclined to the radial direction (Pl. 20. fig. 9).

It must be noted that where sufficient vestiges of the oral rays are present for their true shape and position to be made out, they are seen to be typically sagittal and to show no signs of turning inwards to form a tuning-fork spicule, so that it is not possible to derive them from tuning-fork spicules by the loss of the paired rays.

KEBIRA UTEOIDES, sp. n. (Pl. 20. figs. 8, 9.)

Sponge of well defined flask-shape (Pl. 20. fig. 8) with a thick dermal cortex containing large longitudinally placed oxea. Dermal surface covered by a

* The name is taken from the locality where it was obtained—Tella Tella Kebira.

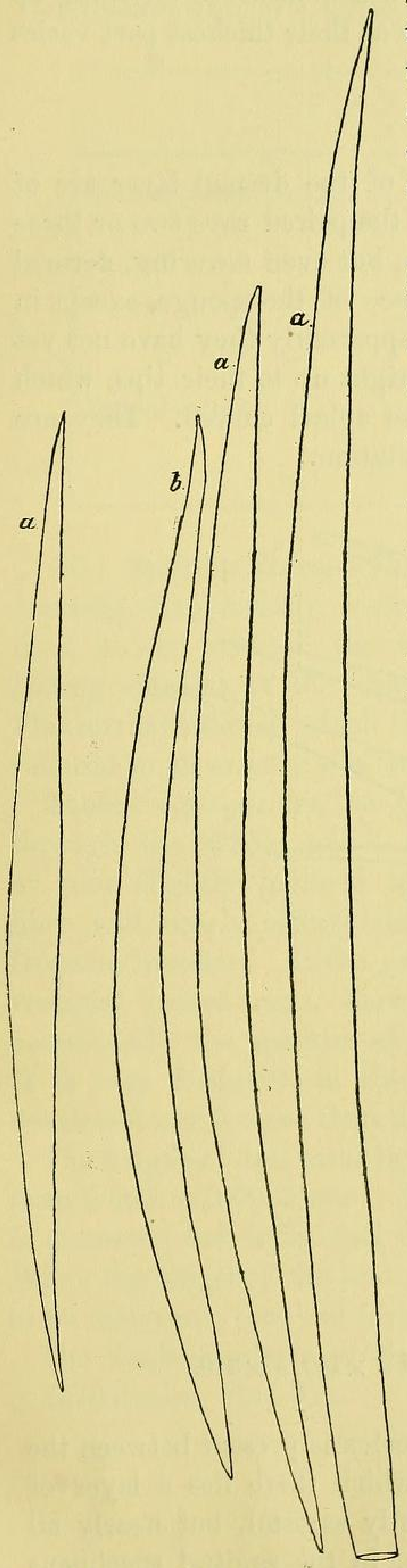



Fig. 7.—Oxea of *Kebira uteoides*, ×60.

sparse layer of sagittal triradiates arranged tangentially. Gastral surface covered with a thin layer of subregular triradiates. Surface of the sponge smooth and not marked by ridges or depressions. There is a single osculum at the upper end—not guarded by any fringe or collar.

The canal-system is typically leuconoid and possesses a series of shallow, but somewhat broad, subdermal cavities, from which inhalant canals lead to the chambers. From the chambers wide exhalant canals lead to the gastral cavity (Pl. **20**. fig. 9).

I have been unable to distinguish the openings from the exterior to the subdermal spaces, but the arrangement of skeleton of the dermal cortex leads me to think that probably they are in the form of very numerous minute pores irregularly scattered over the surface of the sponge. No special pore areas were observed on the surface.

The arrangement of the skeleton is shown in Pl. **20**. fig. 9.

The spicules are of two kinds, oxea and triradiates.

(*a*) Oxea (Text-fig. 7).

The oxea are extremely large, and occur in great quantities in the very thick dermal cortex covering the sponge. They are thickest in the middle, and gradually taper towards the ends. Their shape is more or less curved, according to the part of the body in which they occur, and the contour of which they follow, so that at the oscular end of the body, those of them which project into the oscular rim (fig. 7 *b*), which is very low, and not definitely marked off from the rest of the body, have their ends slightly bent in the reverse direction to the general curve of the spicule.

They vary very greatly in length, being found in all stages of growth, so that the smallest observed specimen measures scarcely ·2 mm. long, while all intermediate stages are found between this and the largest specimens which measure anything up to 4 mm. The diameter of the largest specimens at their thickest part varies from ·15 to ·18 mm.

(*b*) Triradiates.

(i.) Dermal (Text-fig. 8, *c*).—The triradiates of the dermal layer are of small dimensions and all markedly sagittal, with the paired rays two or three times as long as the basal. They form a sparse, but even covering, dermad to the oxea, over the whole of the external surface of the sponge, except in the immediate region of the oscular rim, where apparently they have not yet developed. The rays are all equal in diameter right up to their tips, which are rounded. The basal rays are straight, the apical curved. They are scattered over the surface without regard to orientation.

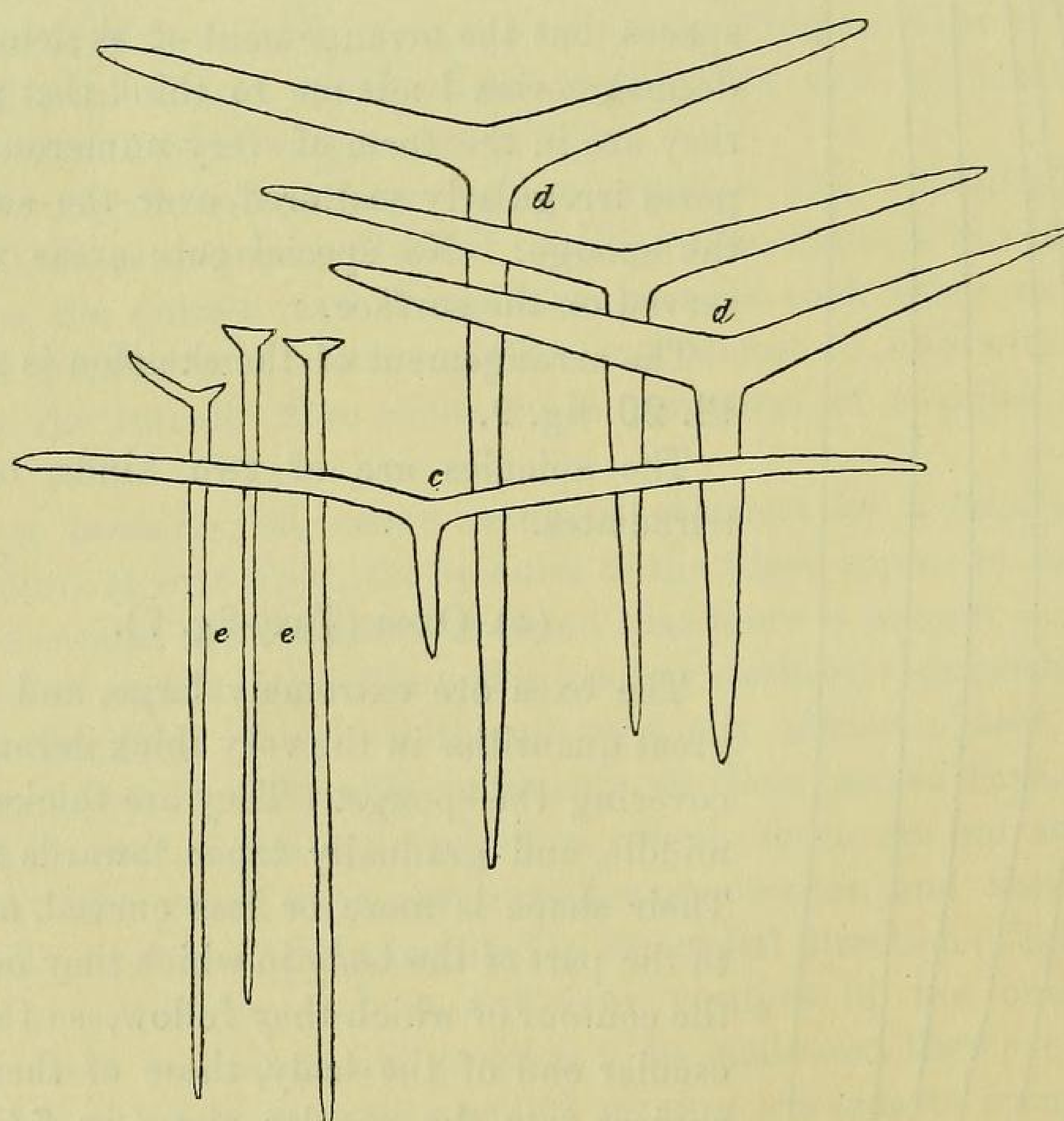



Fig. 8.—Triradiates of *Kebira uteoides*, *c* and *d* ×160, *e* ×310.

(ii.) Gastral (Text-fig. 8, *d*).—A thin gastral cortex is present between the flagellated chambers and the gastral cavity, in which there lies a layer of triradiates. These spicules are regular or slightly sagittal, but nearly all have the basal ray longer than the paired rays, in the sagittal specimens considerably so. All the rays are straight and of the same diameter. The ends are rounded.

Measurements of a series of triradiates is given below (in mm.) :—

| | Paired rays. | Basal ray. | Diam. at base. |
|---|---|---|---|
| Gastral cortex .............. | 0·19 | 0·4 | 0·023 |
| " | 0·195 | 0·21 | 0·03 |
| " | 0·2 | 0·23 | 0·016 |
| " | 0·13 | 0·15 | 0·023 |
| Dermal cortex .............. | 0·24 | 0·076 | 0·015 |
| " | 0·22 | 0·091 | 0·015 |

(iii.) Spicular fibres.—The fibres are composed of remarkable triradiates (text-fig. 8, *e*), usually having their oral rays reduced to a small triangular head at the end of the basal ray. The only other calcareous sponge having spicules of this shape is *Grantiopsis cylindrica*, Dendy, one of the Staurorrhaphidæ, in which the spicules of the articulate tubar skeleton are reduced to an exactly similar form.

These "*nail-spicules*," as I propose to call them, form long fibres extending through the whole width of the chamber layer, and arranged radially or very slightly inclined to the radial direction. A cross section of a fibre will nearly always show from 3 to 5 spicules, four being the most frequent number. At the gastral ends of the fibres the "nail-heads," *i. e.* the vestigial paired rays, show a tendency to increase their size, and also occasionally the spicules at the sides of the fibre have enlarged "heads." It is very frequent, in this case, to find that one of the paired rays is developed much more than the other.

The length of the basal ray varies from 0·18 to 0·22 mm., and its diameter from 0·003 to 0·0035 mm. The head typically measures 0·008 to 0·01 mm. in diameter, but individual oral rays have been noticed as long as 0·02 mm. When the length of the oral rays is sufficiently great to enable their diameter to be measured, they are found to be equal in width to the basal ray.

The single specimen in the collection was obtained at Tella Tella Kebira.

*Distribution.* Red Sea.

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## EXPLANATION OF THE PLATES.

### PLATE 19.

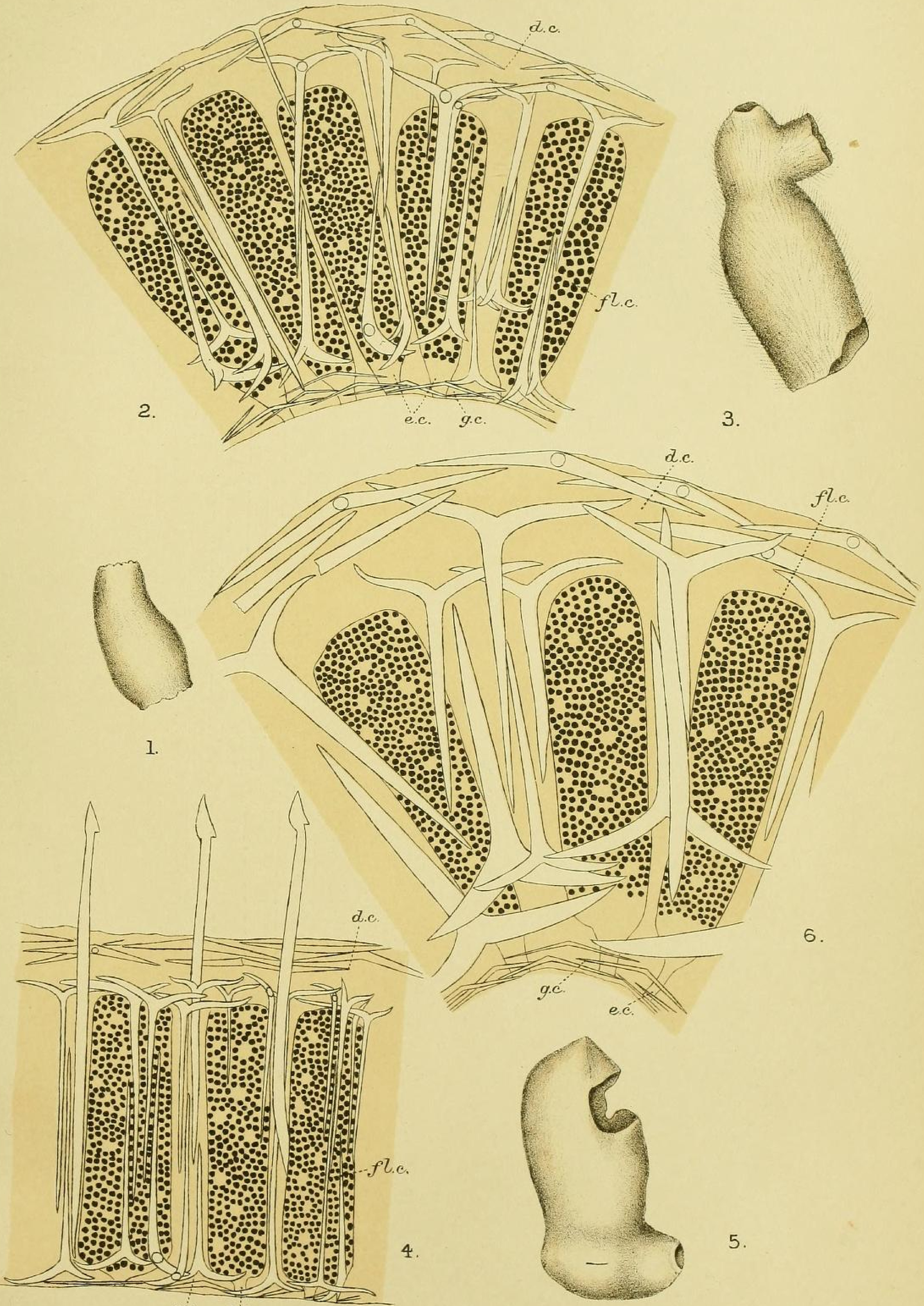
Fig. 1. *Grantilla quadriradiata.* External form. ×2.
2. „ „ Transverse section through sponge-wall. ×60.
3. „ *hastifera.* External form. ×2.
4. „ „ Transverse section through sponge-wall. ×60.
5. *Grantessa glabra.* External form. ×2.
6. „ „ Transverse section through sponge-wall. ×60.

### PLATE 20.

Fig. 7. *Leucilla intermedia.* Transverse section through sponge-wall. ×60.
8. *Kebira uteoides.* External form. ×6.
9. „ „ Longitudinal section through sponge-wall. ×60.

### LETTERING OF FIGS. 2, 4, 6, 7, 9.

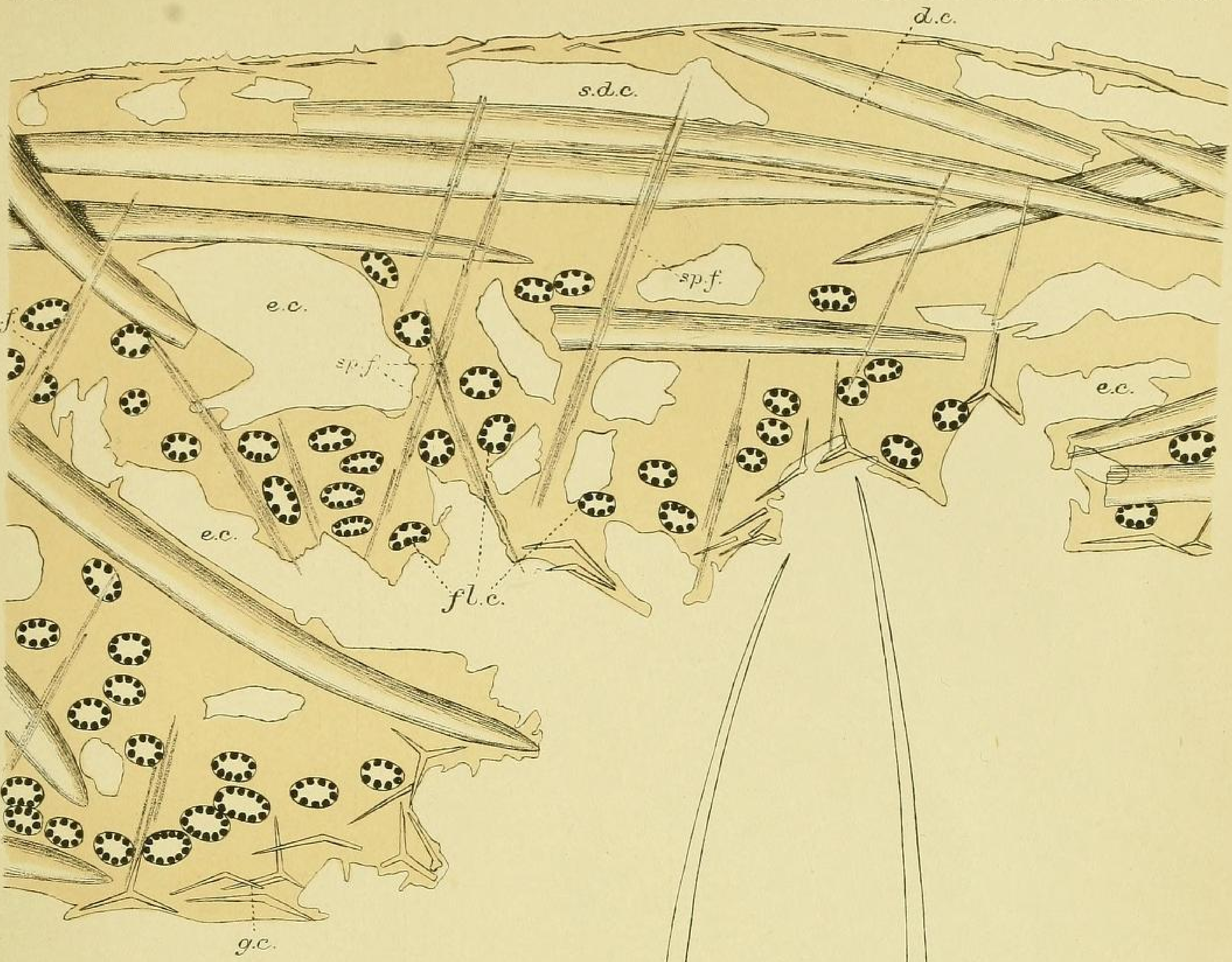
*d.c.*, dermal cortex. *g.c.*, gastral cortex.
*e.c.*, exhalant canal. *i.c.*, inhalant canal.
*fl.c.*, flagellated chamber. *s.d.c.*, sub-dermal cavity.
*sp.f.*, spicular fibres (composed of "nail-spicules").




R.W.H.Row del.

Huth lith. et imp.

RED SEA SPONGES.

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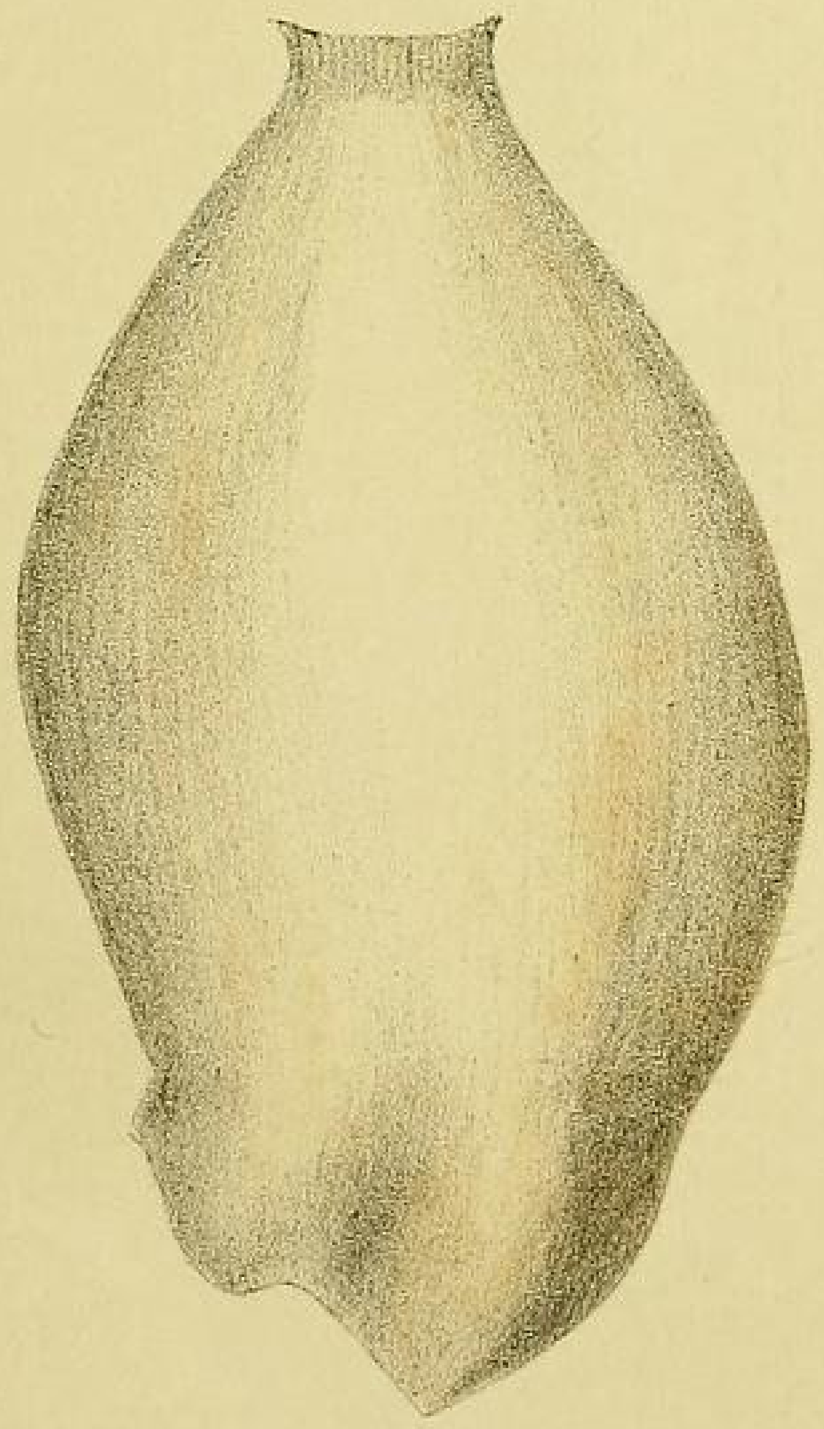

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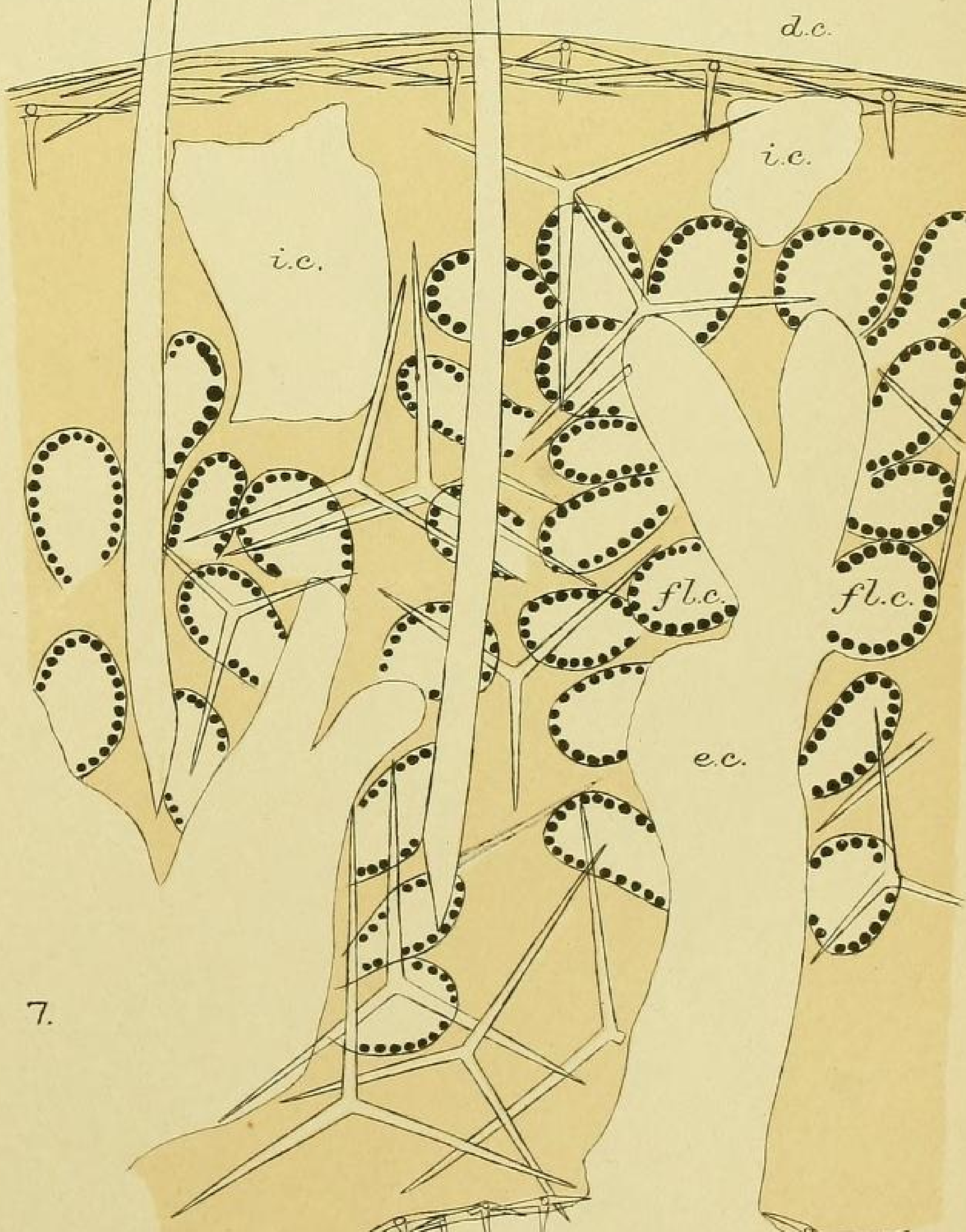


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RED SEA SPONGES.