ON ADAPTATIONS IN STRUCTURE AND HABITS OF SOME MARINE ANIMALS OF TORTUGAS, FLORIDA.

By J. F. McClendon.

In June, 1908, at the laboratory of the Carnegie Institution of Washington, at Tortugas, Florida, I began the study of the habits of some reef animals with a view to some comparative studies of behavior. The results were written up in the Zoological Laboratory of the University of Missouri.

It was found that many of these animals were thigmotatic and remained in glass tubes rather than in the open. They also learned to find the tubes when removed from them. Such was the case with five species of the Alpheidæ, one of the Pontoniidæ, *Typton tortugæ* Rathbun, and *Gonodactylus ærstedii*. All the anemones were thigmotactic on their bases. These same animals were heliotropic. The Crustaceans were negatively heliotropic and the anemones kept their bases from the light, while *Cradactis variabilis* Hargitt hid all but the tips of the fronds and tentacles from the light. In removing its base from the light, *Stoichactis helianthus*, which lives on coral heads, makes snail-like movements similar to *Metridium*,[1] while *Cradactis*, which lives in holes in decayed coral heads, crawls on its tentacles.

ON ADAPTATIONS OF SYNALPHEUS BROOKSI AND TYPTON TORTUGÆ.

In lagoons between the reefs is found the loggerhead sponge, *Hircinia acuta*, which grows to 3 feet or more in diameter, but is of no commercial value. The passages in this sponge are thickly populated by *Synalpheus brooksi* Coutière. These Alpheids are thigmotactic and negatively heliotropic and seldom come outside the sponge, which they do only at night and then rarely leave its surface. The only other animals seen in the interior of the sponge were a small species of Amphipod and a Pontoniid. The Alpheids were several hundred times as numerous as the Amphipods or Pontoniids. Near or at the surface crabs and worms were sometimes found.

Both Alpheid and the Pontoniid, *Typton tortugæ*, have the fourth and fifth pairs of thoracic appendages pincer-like (plate 1, figs. 1 and 3). In the Alpheid the fourth and in the Pontoniid the fifth pair are asymmetrically hypertrophied. In the Alpheid the asymmetry is very great, and the large chela can be snapped with such vigor as to produce a loud, clicking sound. When this claw is removed its mate grows to replace

[1] McClendon, 1906, On the Locomotion of a Sea Anemone, Biol. Bull. 10.

it and the asymmetry is reversed, as first shown by Przibram. It is not known on which side the large claw develops first. I interpret Herrick's records as demonstrating that the large claw develops first on the left side in *Synalpheus minus* (*Alpheus saulcyi*).[1] It was found in my specimens about as frequently on the right as left side in both large and small individuals. Of 50 taken at random, 22 had the large claw on the left and 28 on the right. In another species Przibram found 40 individuals with the large claw on the left and 47 on the right.

The Pontoniid *Typton tortugæ*, as was stated above, has the pincer-like appendages of the fifth thoracic segment well developed. One of these claws is much larger than the other, but the asymmetry is not as great as in the Alpheids. Both of these claws are snapped with a sharp, clicking sound. When the large claw is removed the small one grows to take its place, as in the Alpheids.

The two animals do not perhaps resemble one another as much in general coloration as in general form, though the color varies so much in both animals that these differences are not at first noticeable. The color darkens with age. The Alpheid varies from the color shown in plate 1, fig. 1, to a light brown. Specimens with a claw like fig. 2 may be a dull cream or light brown in general color. The nerve cord and some other organs may be surrounded by red pigment cells. Yellowish, brownish, or reddish glands in thorax or abdomen may show through.

The Pontoniid *Typton tortugæ* varies from the color shown in fig. 3 to an almost colorless condition, or to a light red or a pale bluish. The large claw of the pale specimens is often paler than the small claw in fig. 3. After the large claw has been removed the small one grows to take its place, but for some time retains more or less its general form and color. Often yellow, brown, or green glands show through in the thorax and abdomen.

As these animals pass their entire adult existence in the dark or dim light, it is improbable that their color is of much significance in their struggle for existence; hence it would not be fixed by natural selection. The fact that their eyes are not degenerate might indicate that they sometimes come near the mouths of the passages in the sponge. Perhaps they are forced out when the sponge becomes overcrowded, but I doubt that many of the larger ones would find another sponge before they were eaten by fish. Neither form was found in any other habitat, though Herrick records the Alpheid from reef rocks as well as loggerhead sponges in the Bahamas.

The Alpheid has large eggs, few in number, attached to the swimmerets of the female. The metamorphosis is abbreviated, and in some cases omitted. The young remain attached for a time to the mother, but perhaps always leave the sponge and live a short pelagic life before finding another sponge. The female Pontoniid deposits numerous small eggs on the swimmerets. These hatch into small larvæ which lead a comparatively long pelagic life before acquiring the form and habits of the adult.

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[1] Brooks and Herrick: The Embryology and Metamorphosis of the Macroura. Mem. Nat'l Acad. Sci., 5, 1891.

I studied the habits of these animals as well as I could in dim light in the cavities of pieces cut from the sponge. They appeared to behave normally, whereas in glass tubes in brighter light they remained motionless. Both animals explore the cavities of the sponge with cautious movements unless disturbed, in which case they snap their claws. The Alpheid advances, using its large claw as an antenna and protector. Its antennæ can be extended about as far forward as the large claw. When meeting an Alpheid or a Pontoniid it may try to squeeze past or it may snap its claw. When placed in glass dishes Alpheids cut one another to pieces, but this is seldom if ever done in the narrow passages of the sponge.

The Pontoniid *Typton tortugæ* advances, using both claws as antennæ, the antennæ being very much shorter than the smaller claw. It spreads the claws apart and waves them about, thus exploring the cavity in front of it. On meeting another it behaves as the Alpheid, except that it may snap either or both claws. Both animals try to squeeze through small openings. The chelæ of *Typton* sometimes show what appear to be claw marks. As their claws are more slender, hence more easily grasped and less powerful than those of the Alpheids, it is to be expected that they would show claw marks first in case both species snapped with equal frequency.

Both animals appeared to eat from the walls of the cavities in the sponge, but I did not determine whether they ate the sponge itself or a sediment deposited on it. I did not determine whether they ate one another in the sponge, but they were so numerous that it seems strange that they received sufficient oxygen. The Alpheids are sometimes infested with a parasitic isopod, *Bopyrus*, in the gill cavity.

I do not intend to discuss here the origin of the form or habits of these animals, but it seems to me that we have here a convergence both in form and habit. It is probable that similarity in form and habits made both animals better suited to living in the same habitat, *i.e.*, the sponge, and that accidentally finding the sponge they remained there. However, this does not explain why the young at the end of pelagic life always (or at least usually) select the loggerhead sponge. There are numerous Alpheids living in holes in the reef rocks, and certainly they are more closely related in form and general habits to *Synalpheus brooksi* than is *Typton*.

This *Synalpheus* and the *Typton* select the sponge not because it has holes in it in which they can hide, but on account of some more specific quality, such as taste (smell), color, or outward form. Or when some individuals of these species have established themselves in a sponge the others may be attracted to it by a social instinct (which may not be disproved by the fact that they destroy one another when placed under unnatural conditions). The isolation of these animals in the loggerhead sponge is an example of what Gulick calls habitudinal segregation and may have been a factor in the evolution of the species.

Since the Alpheids occur in far greater numbers than *Typton* we might suppose the former to be much better adapted to living in the sponge than the latter. However, although *Typton* produces more

eggs, it has a much longer pelagic life than the Alpheid and is much more likely to be eaten or swept out to sea by the tides, where it can not find a sponge when the proper time comes.

The smallest loggerhead sponges I found would not live in a large aquarium with running sea-water more than 2 days before the water began to get foul within the passages in the sponge and the Alpheids and *Typton* began to die. Field observations were very limited. These and other difficulties restricted the investigation to its present limits.

ON ADAPTATIONS OF THE REEF ANEMONE, CRADACTIS VARIABILIS.

Cradactis variabilis Hargitt is an anemone about an inch or two in length when expanded, living in holes in old coral heads or reef rocks. Besides the tentacles, which are few in number and arranged as in *Sagartia*, long outgrowths called fronds extend from the region bearing the tentacles (plate 1, figs. 4, 5; plate 2, figs. 8, 9, 10). The animals may be a moss-green or brown in general color, but the tentacles are always paler and often colorless and transparent at their tips. The fronds may or may not be branched, and may end simply or in pale knobs, as in plate 1, fig. 4, or in curious "eyes," as in fig. 5.

These anemones are usually found in cavities in old coral heads that communicate with the exterior by a number of passages about half an inch or more in diameter. The anemones are attached near enough to these passages to extend the tips of the fronds to the exterior (plate 2, fig. 7). This extension is caused by heliotropism of the fronds. One mistakes them at first for sea-weed, although they do not resemble any particular kind of sea-weed that I have found growing on the reefs. The tentacles are extended about as far as and sometimes a little farther than the fronds, but the fronds tend to conceal the tentacles. At night the fronds are contracted and the tentacles remain extended; therefore it is probable that the fronds are not necessary as breathing organs.

If a bit of crab meat is held near the passage through which the *Cradactis* is extended no response is obtained. But if one of the fronds is touched with the meat the tentacles are extended toward it, while the frond touched may contract slightly. In order to observe the food-taking more minutely, some of the anemones were taken from the rock and allowed to attach themselves to the bottom of an opaque dish filled with sea-water. When a bit of crab meat is placed on the end of a tentacle it adheres and the tentacle and one or more adjacent ones are bent down and the food placed on the mouth and pressed there. Immediately many or all of the tentacles are pressed on the food, hiding it from view until it is swallowed. The fronds may contract more or less during the process. *Cradactis* sometimes swallows filter paper placed firmly on the mid-region of a tentacle or on the disk, but not when placed on the end of a tentacle. This may be a question of degree or extent of stimulation. It disgorges the paper within 10 minutes. It rejects bits of shell, etc., placed on the disk or tentacles.

India ink placed in the water near the anemone showed ciliary currents running towards the tips of the tentacles and fronds, and on

the disk running towards the mouth. A secretion sticks the particles together. These currents are useful on both fronds and tentacles in the rejection of particles, and on the tentacles in the placing of food in the mouth, the food being carried to the tip of the tentacle before it is placed in the mouth.

When disturbed by light falling on the base, it sometimes moves with snail-like motion (like *Metridium*) a short distance, but the tentacles catch hold of the substratum on all sides. The tentacles and column sometimes perform writhing movements. More often the animal bends over to one side and catches hold of the substratum with the tentacles, with or without previously elongating the column, the fronds contracting slowly all the while. It then loosens the base, walks on its tentacles to a new place (plate 2, figs. 11, 12), bends over and attaches the base, and lets go its hold with the tentacles. This method of locomotion is much more rapid than that of *Metridium*, but could not be used if the *Cradactis* did not live in holes, as it might otherwise be washed away by the currents that constantly sweep over the reefs.

The resemblance of the fronds to sea-weed leads one to suppose that they act as lures or in hiding the *Cradactis* from its prey (anemones being unpalatable are usually not in need of protection). The fact that the fronds are heliotropic and contracted completely at night is in harmony with this view. I did not cut them off to see whether the anemone would live and reproduce as well without them. The cavities containing the *Cradactis* are inhabited by other animals, especially a small black crab, and one might suppose that the fronds protected the tentacles of the anemone from the legs of the crabs that crawled over it. The crabs are active at night in the least light in which they can be seen (their black color making them hard to see in the holes in the rock). In case they are normally active at night the fronds would serve as a protection from the crabs only half of the time. The anemones sometimes grasp the crabs and hold them until they wrench themselves loose, which they invariably do in a short time. Perhaps the anemone gets part of its food as particles dropped from the crabs' mouths.

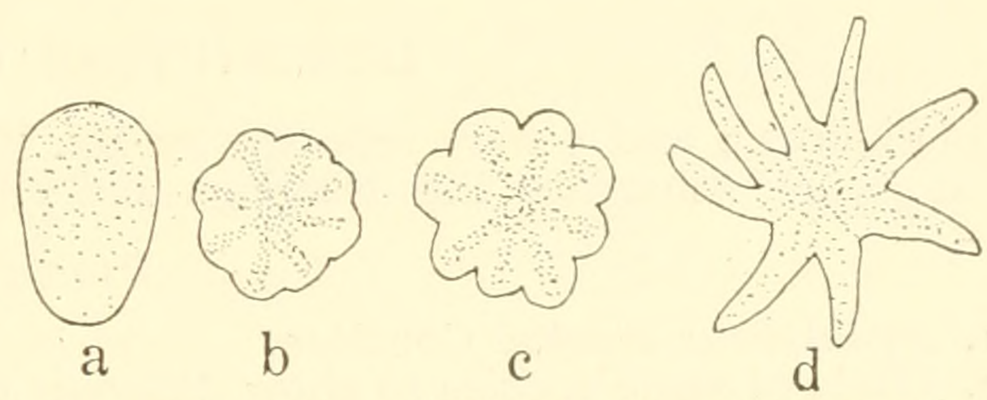


FIG. 1.—*Cradactis variabilis*. *a*, Planula just escaped from cœlentric cavity of mother, oral (pigmented) side uppermost. *b*, The same, second day, seen from oral side; pigment arranged radially. *c*, The same, third day. *d*, The same, fourth day; tentacles elongating and septa becoming distinct. The mouth should be elongated in the plane of symmetry.

Cradactis develops to the planula stage in the cœlenteron of the mother. On being released, the planula swims around for a few hours (text fig. 1, *a*) and attaches itself (*b*) by the smaller end. It gradually develops a mouth and tentacles (*b-d*). When first liberated, the planula has 8 mesenteries, and 8 tentacles develop soon after. Individuals were seen with 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28 and more tentacles. From this one might conclude that the tentacles (and mesenteries) appear in pairs, but they were often observed to appear in sets of four, symmetrical in relation to the oral plane. The first pair of fronds appear

in the 20-tentacle stage as outgrowths of the body-wall just beneath the tentacles and with their axis perpendicular to the oral plane. The second pair of fronds appear in the 28-tentacle stage or later.

SUMMARY.

(1) Convergence in structure and habitat is the cause of commensalism between an Alpheid and a Pontoniid living in the loggerhead sponge.

(2) Abbreviation of its pelagic life accounts for the numerical supersedence of the Alpheid.

(3) The weed-like outgrowths or fronds of a reef anemone, *Cradactis*, probably hide it from its prey.

(4) *Cradactis* is kept just within the mouths of cavities in reef rocks by the combined action of negative heliotropism of its base and positive heliotropism of the fronds. The fronds are entirely contracted in the absence of light.

(5) The fronds possess the sense of taste but do not carry food to the mouth.

(6) *Cradactis* moves from place to place by walking on its tentacles, a phenomenon sometimes seen in *Hydra*.

DESCRIPTION OF PLATES.

(Figures 4 and 5 were redrawn by Mr. Kline, fig. 6, from life, by K. Morita, otherwise the drawings and photographs are the author's.)

Plate 1.

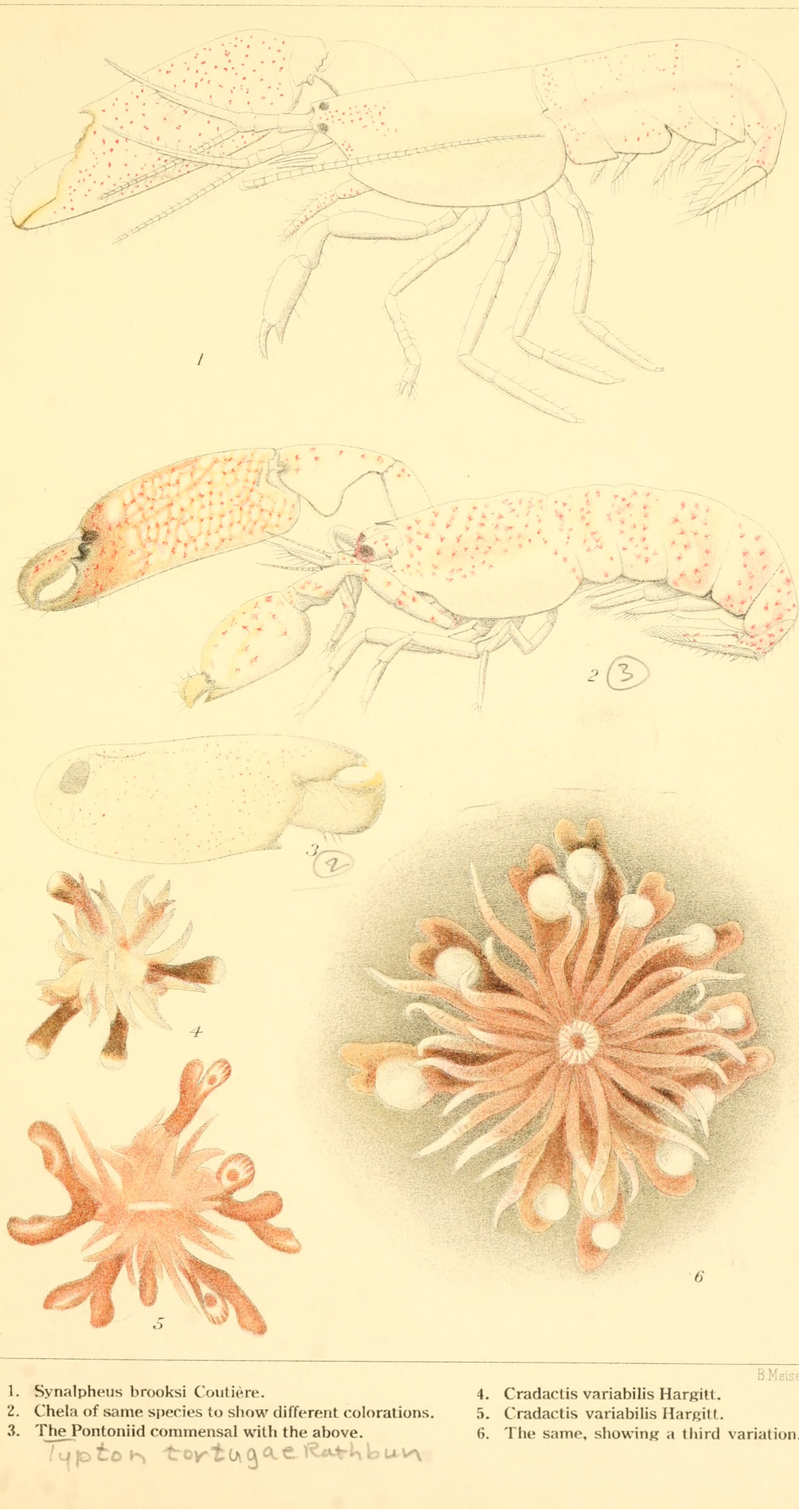
1. *Synalpheus brooksi* Coutière.
2. Chela of same species to show different coloration.
3. *Typton tortugæ* Rathbun commensal with the above.
4. *Cradactis variabilis* Hargitt.
5. The same, showing another variety in color and shape of fronds.
6. *Cradactis variabilis* Hargitt, × 2.

Plate 2.

7. A portion of an old coral head showing the fronds (f) of *Cradactis* protruding from the cavities.

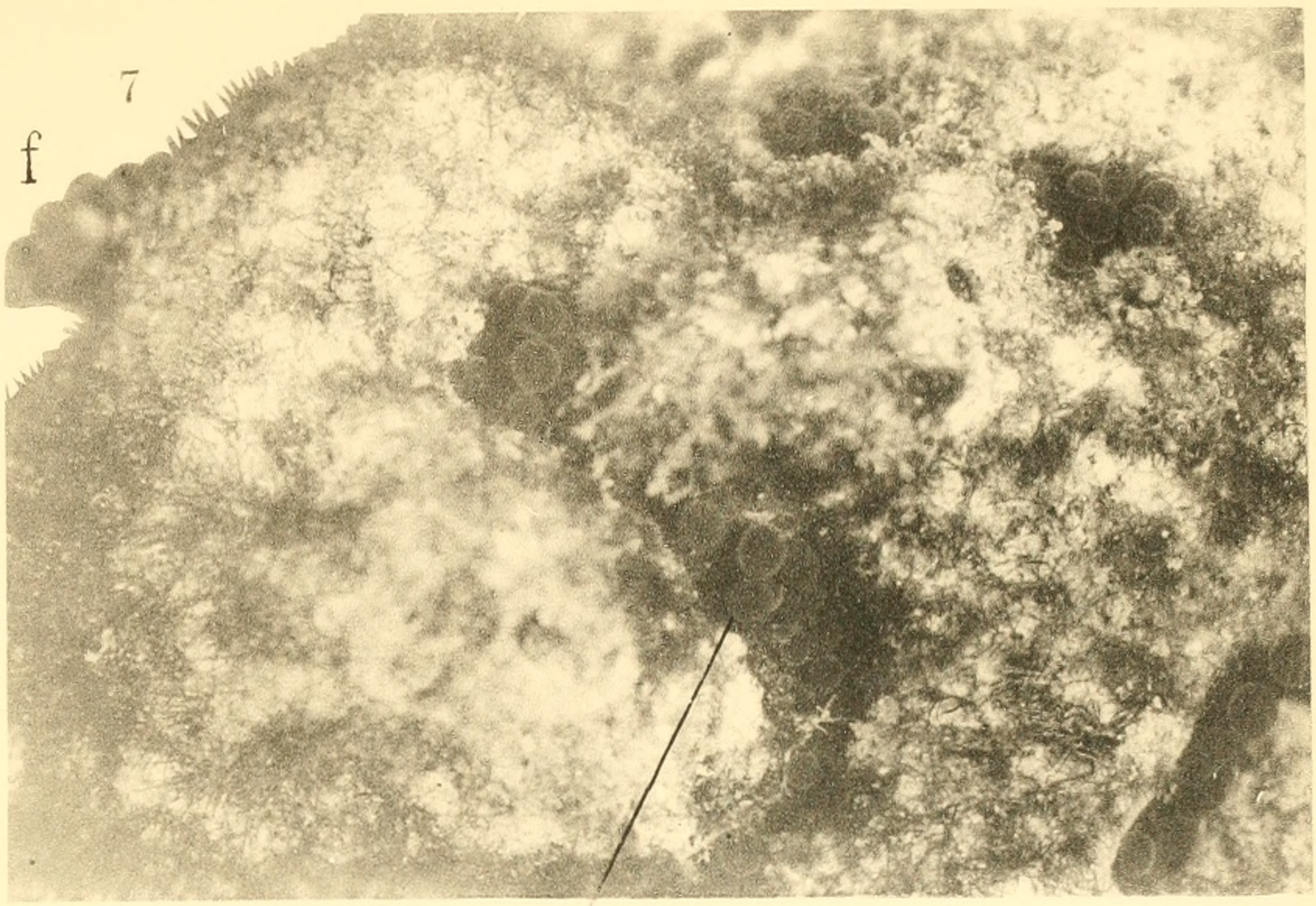
8–10. *Cradactis variabilis*, showing varieties in shape of fronds.

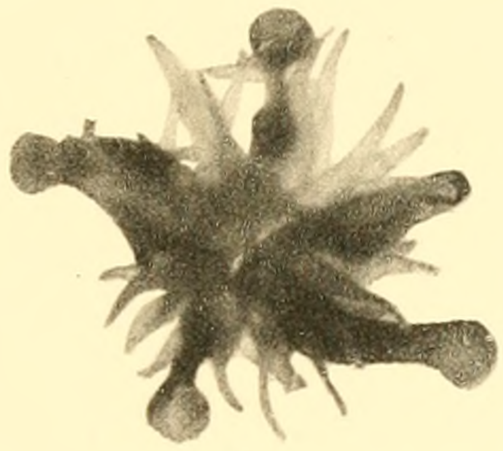
11, 12. *Cradactis variabilis*, walking on its tentacles, with detached base toward the observer.



B. Meisel lith.

1. Synalpheus brooksi Coutière.
2. Chela of same species to show different colorations.
3. The Pontoniid commensal with the above.
   Typton tortugae Rathbun
4. Cradactis variabilis Hargitt.
5. Cradactis variabilis Hargitt.
6. The same, showing a third variation.

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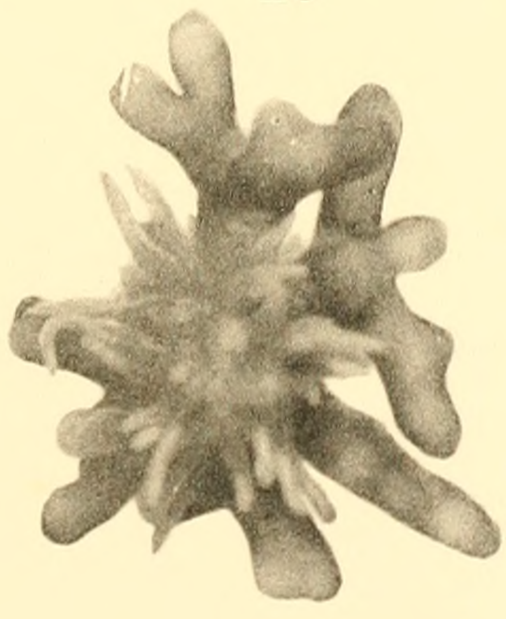
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Fig. 7. A portion of an old coral head showing fronds (f) of Cradactis protruding from the cavities.
Figs. 8-10. Cradactis variabilis showing varieties in shape of fronds.
Figs. 11-12. Cradactis variabilis walking on its tentacles with detached base toward the observer.