

## SIPHONOPHORAE

FROM THE ARCTURUS OCEANOGRAPHIC EXPEDITION.

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(Figs. 185-220 incl.).

	Page
Order CALYCOPHORAE	
Family SPHAERONECTIDAE . . . . .	527
Subfamily NECTOPYRAMINAE	
Genus <i>Nectopyramis</i>	
<i>Nectopyramis diomedea</i> Bigelow . . . . .	528
Subfamily CUBOIDINAE	
Genus <i>Cuboides</i>	
<i>Cuboides vitreus</i> Quoy & Gaimard . . . . .	529
Family PRAYIDAE . . . . .	529
Subfamily AMPHICARYONINAE	
Genus <i>Amphicaryon</i>	
<i>Amphicaryon acaule</i> Chun . . . . .	530
Subfamily PRAYINAE	
Genus <i>Praya</i>	
<i>Praya dubia</i> Quoy & Gaimard . . . . .	531
<i>Praya reticulata</i> Bigelow . . . . .	532
<i>Prayinae</i> sp. ? . . . . .	536
Family HIPPOPODIIDAE . . . . .	536
Genus <i>Hippopodius</i>	
<i>Hippopodius hippopus</i> Forskål . . . . .	536
Genus <i>Vogtia</i>	
<i>Vogtia spinosa</i> Keferstein & Ehlers . . . . .	537
<i>Vogtia serrata</i> Moser . . . . .	538
<i>Vogtia serrata</i> ? . . . . .	538
Family DIPHYIDAE . . . . .	539
Subfamily ABYLINAE	
Genus <i>Abyla</i>	
<i>Abyla leuckartii</i> Huxley . . . . .	543
Genus <i>Abylopsis</i>	
<i>Abylopsis tetragona</i> Otto . . . . .	544
<i>Abylopsis eschscholtzii</i> Huxley . . . . .	546
Genus <i>Bassia</i>	
<i>Bassia bassensis</i> Quoy & Gaimard . . . . .	548

	Page
Subfamily CERATOCYMBINAE	
Genus <i>Ceratocymba</i>	
<i>Ceratocymba sagittata</i> Quoy & Gaimard . . . . .	548
Subfamily GALETTINAE	
Genus <i>Galetta</i>	
<i>Galetta quadrivalvis</i> Blainville . . . . .	549
<i>Galetta quadridentata</i> Quoy & Gaimard . . . . .	556
<i>Galetta monoica</i> Chun . . . . .	558
<i>Galetta australis</i> Quoy & Gaimard . . . . .	559
Subfamily DIPHYINAE	
Genus <i>Diphyes</i>	
<i>Diphyes dispar</i> Chamisso & Eysenhardt . . . . .	564
<i>Diphyes appendiculata</i> Eschscholtz . . . . .	564
<i>Diphyes bojani</i> Eschscholtz . . . . .	565
<i>Diphyes mitra</i> Huxley . . . . .	566
Subfamily CHUNIPHYINAE	
Genus <i>Chuniphyes</i>	
<i>Chuniphyes multidentata</i> Lens & Van Riemsdijk . . . . .	566
Family ? . . . . .	569
Genus <i>Archisoma</i> . . . . .	569
<i>Archisoma natans</i> Bigelow . . . . .	569
Order PHYSOPHORAE	
Family AGALMIDAE . . . . .	575
Genus <i>Agalma</i>	
<i>Agalma okeni</i> Eschscholtz . . . . .	575
Family Agalmidae species ? . . . . .	576
Family FORSKALIIDAE . . . . .	576
Genus <i>Forskalea</i>	
<i>Forskalea</i> species ? . . . . .	576
Family PHYSOPHORIDAE . . . . .	576
Genus <i>Physophora</i>	
<i>Physophora hydrostatica</i> Forskål . . . . .	576
Family ANTHOPHYSIDAE . . . . .	577
Genus <i>Anthophysa</i>	
<i>Anthophysa rosea</i> Brandt . . . . .	577
Genus <i>Athorybia</i>	
<i>Athorybia rosacea</i> Forskål . . . . .	578
Order RHIZOPHYSALIAE	
Family RHIZOPHYSIDAE . . . . .	584
Genus <i>Rhizophysa</i>	
<i>Rhizophysa eysenhardti</i> , Gegenbaur . . . . .	584
<i>Rhizophysa</i> species ? . . . . .	585
Genus <i>Bathyphysa</i>	
<i>Bathyphysa</i> species ? . . . . .	585

	Page
Order CHONDROPHORAE	
Family PORPITIDAE . . . . .	585
Genus <i>Porpita</i>	
<i>Porpita pacifica</i> Lesson . . . . .	585
Family SPHAERONECTIDAE Huxley 1859.	

Moser (1925), in her general discussion of the classification of the Calycopterae, employs Claus' (1873) name Monophyidae for this family rather than Huxley's (1859) older name Sphaeronectidae, because Claus had appreciated, and stated in his definition of the family (based on his genus *Sphaeronectes*) which Huxley did not in writing of his *Sphaeronectes*, that the forms included develop only one definitive nectophore, i. e. that they are monophyid as a group. But the supposed differences between *Sphaeronectes* and *Monophyes*, in the form of the bell, in the precise situation where the subumbrellal canals originate, in the courses of the latter over the subumbrella, and in the outlines of the somatocyst seem to me, as they did to Schneider (1898), too slight to be regarded as anything more than specific.<sup>1</sup> These differences are in fact comparable to those that separate, one from another, the various species *Diphyes*, of *Diphyopsis*, of *Praya*, etc. With the relegation of *Monophyes* to the synonymy of *Sphaeronectes*, the International rules of nomenclature forbid the use of the name "Monophyidae" and demand the substitution of the older designation "Sphaeronectidae" as Schneider (1898) pointed out.

The question which Siphonophores rightly fall in this family of primitive forms will no doubt continue a perplexing one for some time to come, because of the uncertainty whether forms with only one nectophore, but highly organized in other respects, are in fact primitive or whether they are retrogressive, i. e. have lost the second bell. For such presumed degenerate forms Moser (1925, p. 387) has established a new family, Dimophyidae, as a sort of catch-all for offshoots from the Diphyids, from the Prayids, and from the Abylids. But if the classification adopted is to make any pretense at following phylogenetic relationships, such a union of offshoots from three different families is irrational, because to group them together obscures the very wide divergence, in evolution, of which they are

<sup>1</sup> For recent discussions of the status of the various named "species" of *Sphaeronectes* and of *Monophyes* see Bigelow, 1911 a, Moser 1925.

supposed to be the end products. If these reversionary groups are to be set apart from their parent stocks, each should logically be made a distinct family. That is to say, Moser's subfamilies *Dimophiinae*, *Amphicaryoninae*, *Mitrophyinae* and *Cuboidinae* should be raised to family rank.

The present collection contains examples of two genera of Monophyids, *Nectopyramis* and *Cuboides*. The latter Moser considers retrogressive (her *Cuboidinae*). But no direct evidence has yet been brought forward that *Cuboides* is in fact descended from ancestors with two developed bells. Moser's (1925, p. 81) two reasons for so interpreting it are its "ungewöhnlich hohen organisation," and the reduction of the stem to a small disc. But the first of these characters may (unless the contrary be established) be as reasonably regarded as evidence of progressive evolution from a primitive stock as retrogressive from a more specialized, while the second—reduction of the stem—may be independent of the ancestral number of bells. *Cuboides* is therefore included here, as in my earlier papers, under the *Sphaeronectidae*, where it falls on morphological grounds.

*Nectopyramis diomedae* Bigelow.

*Nectopyramis diomedae* Bigelow, 1911 a, p. 191, pl. 1, figs. 1-6; 1912, p. 65; Moser, 1925, p. 116.

Station 59, off Cocos Island, 1090-0 meters, one colony, much distorted and contracted.

One could wish that this specimen were in better condition, for so few examples of the polygastric generation of this species have yet been seen (total of 3) that every additional one is welcome. Fortunately the gelatinous substance of the bell of this *Arcturus* specimen, with its canals, is well enough preserved to make its specific identity certain, though the branching of the somatic canals is somewhat more complex than it was in the type specimen. Thus the canal which runs to the dorso-basal angle of the nectophore has five short transverse branches, contrasted with only two in the type specimen (Bigelow, 1911 a, pl. 1, fig. 1); the ventro-apical trunk has five very short side branches, whereas in the type it was unbranched. The dorso-apical trunk has one additional branch, and the canal that extends from the ventral subumbral canal to the ventro-basal angle of the nectophore has three small cross-branches instead of only one. But the two canals that ramify over the left and right faces of the hydroecium agree essentially with those of the type.

These slight differences are of a sort that may reasonably be credited to a slightly more advanced stage in growth.

Unfortunately the specimen is much distorted. However, it shows that the relative locations of hydroecium and nectosac are as in the original specimen, and that the conformation of the nectophore (39 mm. long) was essentially the

same. The subumbrella surface of the nectosac being destroyed, nothing can be said as to the subumbral canals, nor does any trace of the stem remain.

Previous captures of this species have been off the coast of Peru to the southwest of the Galapagos, and midway between that group and the Paumotos. The locality of capture of the *Arcturus* example corroborates this evidence of its wide occurrence in the Eastern Tropical Pacific. It has not yet been found in the Atlantic, though a closely allied species (*N. thetis*) has been described from the Bay of Biscay (Bigelow 1911).

*Cuboides vitreus* Quoy & Gaimard.

*Cuboides vitreus* [Eudoxid]; Quoy & Gaimard, 1827, p. 19, pl. 2 c, figs. 1-3. For synonymy see Bigelow, 1911 a, p. 190; Moser, 1925, p. 404; Browne, 1926, p. 60.

Station 74, 636-0 meters, complete Eudoxid, 2 loose bracts and one loose gonophore.

These specimens add nothing to the excellent description and figures that Chun (1892, pl. 11, 12) has given of the Polygastric generation (as "*Halopyramis adamantina*") and of the Eudoxids set free therefrom (as "*Cuboides adamantina*").

*C. vitreus* had already been found widespread in the Galapagos-Panama region, and off the coast of Peru by the *Albatross* in 1904-1905. Hence it was somewhat surprising that it was found at only one of the *Arcturus* stations, i. e. near Cocos Island.<sup>2</sup>

#### Family PRAYIDAE Kölliker, 1853.

This family, as here limited, includes two subfamilies, Prayinae and Amphicaryoninae. Moser (1925) has transferred the latter to her new family Dimophyidae. But as pointed out above, this grouping together of genera the phylogenetic relationships of which are believed to be diverse seems to me unnatural. And since it seems certain that *Amphicaryon* is closely allied to the more typical Prayids, from which it differs chiefly in the fact that one of its bells is degenerate, Chun's (1888) and my location of it as a subfamily of the Prayidae seems the more natural arrangement. Browne (1926, p. 60) also refers it to this family.

Both subfamilies are represented in the collection, Amphicaryoninae by *Amphicaryon* (its only known representative), Prayinae by its type-genus, *Praya*.

The history of the latter is a striking illustration of the nomenclatorial difficulties that face the student of Siphonophores. The genus was founded by Blainville, in 1834, for a species, *P. dubia*, described and pictured almost simultaneously by Quoy & Gaimard (1834) as *Diphyes dubia*. And as Blainville's illustration was based on their specimen, there is, in this case, no doubt of the identification.

<sup>2</sup> For the locations and depth data of the *Arcturus* stations see Beebe (1926).

It was many years, however, before any Siphonophore agreeing with Quoy & Gaimard's excellent illustrations of *dubia* was again seen. Meanwhile the name *Praya* came into general use for another species (or group of species) closely allied to *dubia* but differing from it in the canalization of the nectophore. And when, after a lapse of more than three quarters of a century, the *Albatross* collected specimens of Quoy & Gaimard's old species, this difference proved so sharp as to demand generic separation. In my account the *Albatross* series (1911 a.) I therefore proposed the new genus *Nectodroma* for *dubia* Quoy & Gaimard and for a new species, *reticulata*. The former was also represented in the *Gauss* collection; and Moser (1925) agrees that it is generically distinct from the species that have usually been named *Praya*. But she points out (what I had overlooked) that, to accord with the nomenclatural principle of priority, that generic name must be given to *dubia*, because this was the only species referred to *Praya* by Blainville (1834) in his original description of the genus. This would entail the substitution of some other name for the form (or forms) that have commonly passed as *Praya*, and because of the confusion that might result, Moser considered a departure from the rules justified in this instance. But the case is so clear, *Praya* having been originally described as a monotypic genus for Quoy & Gaimard's *Diphyes dubia*, and there being no doubt as to the identity with the latter of the specimens of *dubia* recently taken, that the cause of eventual stability will better be served by adherence to priority. This entails acceptance of *dubia* as the type of *Praya*; and this course is followed here. Selection of a name for the Prayids that differ sufficiently from the latter in canalization for generic separation (typified by *Physalia cymbiformis* of Delle Chiaje, which has usually been known as *Praya cymbiformis*) may be left to the student who next has opportunity to study representatives of that group.

*Amphicaryon acaule* Chun.

*Amphicaryon acaule* Chun, 1888, p. 1162; Bigelow 1911 a, pl. 4, figs. 1-8;

Moser 1925, p. 399.

*Diplodoxia acaulis* (Eudoxid) Chun 1888, p. 1163.

Station 51, 500-0 meters, one specimen.

Station 105, 1274-0 meters, one specimen.

The condition of these two specimens is so poor that they add nothing to our knowledge of the morphology of this interesting Siphonophore. In one of them (Station 105) the larger nectophore is about 7 mm. high. The other specimen is larger (10 mm. in diameter) but so crushed in its polar axis that

its height cannot be estimated. It is interesting that the 7 mm. specimen shows much the same mutual relationship between the two bells (the small being flat, scale-like, and not at all enclosed by the larger) that characterized a 3 mm. specimen in the *Albatross* collection (Bigelow 1911 a, *pl. 4, fig. 8*). In the larger *Arcturus* example the larger bell encloses most of the smaller, the nectosac of which is well preserved.

Neither specimen adds to our knowledge of the appendages:—the stem of the smaller has been entirely lost; in the larger, only the bases of a few siphons (4, perhaps more) are still to be seen.

The three authors who have actually examined specimens of *Amphicaryon* of late (Bigelow 1911 a, Moser 1925, Browne 1926) differ as to whether its small degenerate bell is the upper (older) or primary one of the pair, or the lower (younger). Evidence for the first view, held by me and by Browne, is that in very young specimens this small bell is relatively much larger than it is in adults, and that it at first overlaps the nectophore that later comes to surround it. Moser who has confirmed these observations on material collected by the *Gauss*, reaches the opposite conclusion, chiefly on the theoretic ground that the degenerate bell is "von Anfang an functionsfähig und verkümmert" (Moser 1925, *p. 400*). This question must wait its positive answer, one way or the other, until some student has the opportunity to follow the development of *Amphicaryon* from a stage so young that it will be possible to trace the history of the two definitive bells from their earliest formation, and so to learn whether it is the first formed or the second that later degenerates.

As this Siphonophore has already been found in West Indian waters, among the Canaries, and at five *Gauss* stations in the Atlantic between L. 20° N. and 32° S., likewise widespread in the Eastern Tropical Pacific, there is nothing surprising in its representation in the *Arcturus* series. The considerable depth of these hauls, like those of the *Gauss* and *Albatross* that yielded it, indicate that *Amphicaryon* is more often bathypelagic than epiplanktonic.

*Praya dubia* Quoy & Gaimard.

*Diphyes dubia*, Quoy & Gaimard, 1834, *p. 104, pl. 5, figs. 34-36*.  
*Nectrodroma dubia*, Bigelow, 1911 a, *p. 204*; Moser, 1925, *p. 381*.

Station 54, surface, 2 loose nectophores.

Station 74, 909-0 meters; 1 very fragmentary nectophore.

The nectophores from Station 54 apparently belong to a single colony, the one being somewhat larger than the other. But unfortunately the length cannot be stated for either, because the gelatinous extension below the level of the ventral face of the opening of the nectosac has been destroyed. The length of the larger bell from this point to apex is now 52 mm. that of the smaller 43 mm. The type of canalization of this Prayid, combining a large number of dichotomously branched radial canals on the nectosac, with branched somatic canals, is so characteristic that there is no danger of confusing its bells with those of any other siphonophore yet described. The *Arcturus* examples correspond so closely in this respect to those collected by the *Albatross* (Bigelow 1911 a, *pl. 3, figs. 8, 9*), by the *Gauss* (Moser 1925, *p. 382*), and a century ago by Quoy & Gaimard (1834) that only the minor points of difference need be noted.

In the larger of the two bells the pedicular canal divides into six subumbrals on joining the nectosac; these again subdivide dichotomously but irregularly until about fifty reach the margin of the bell.<sup>3</sup> The branching of the pedicular canal could not be traced in the *Albatross* specimens because of their condition, but there were at least fifty-five canals at the margin of the bell. Moser makes no statement as to this point, for the *Gauss* specimens, nor did Quoy & Gaimard.

In both the *Arcturus* bells the ascending trunk of the somatic system is unbranched, just as it was in the *Albatross* specimens. Quoy & Gaimard's examples, and the *Gauss* specimen show a more advanced stage of development with this trunk giving off several short transverse branches. The two main descending trunks into which the primary somatic trunk divides near the apex of the bell correspond, in the simplicity of their branching, to the *Albatross* material.

Moser (1925) and I have already argued that the presence of deep hydroecial furrows indicates a biserial rather than a coronal arrangement of the bells. The *Arcturus* capture of two nectophores, taken in the same haul though no longer connected, tends to support this conclusion.

Previous records for *Praya dubia* have been from the eastern side of the Pacific and from Australian waters. The *Arcturus* specimens are from the same general region as those taken by the *Albatross*, between the Galapagos and the American coast. The presence of this species off Valparaiso (Moser) and off South Australia (Quoy & Gaimard) shows that it is not confined to high temperatures.

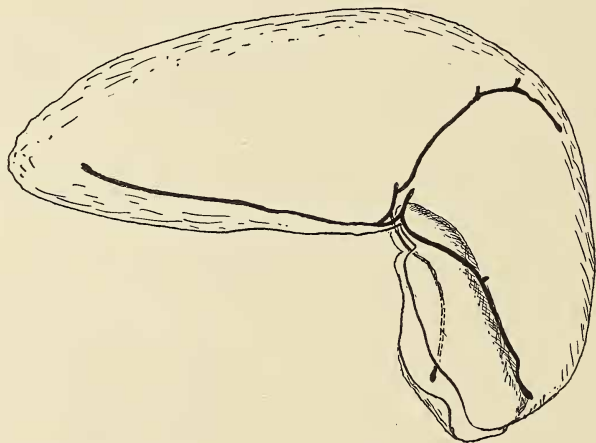


Fig. 185. *Praya reticulata*; bract,  $\times 3$ ; from offing of Monterey Bay, California.

*Praya reticulata* Bigelow.

*Nectodroma reticulata*, Bigelow, 1911 a, p. 206, pl. 1, figs. 7-8, pl. 3, figs. 1-7; Moser, 1925, p. 383.

<sup>3</sup> The margin is damaged so that the precise number of canals cannot be determined within one or two.



Station 26, 600-0 meters, two nectophores.

Station 39, surface, two nectophores.

Station 87, 1090-0 meters, one nectophore.

These bells are fragmentary, but show enough of the characteristic somatic-canal system to locate them in this species, rather than in *dubia*. In every case the subumbrella has been entirely destroyed, consequently they add nothing to previous knowledge as to the subumbral canals, the netlike arrangement of which is the most characteristic feature of this species.

As no account of the stem-groups has yet appeared, it will be appropriate here to describe detached stems taken off Monterey, California, in July 1928 (Bigelow and Leslie 1930) which are referable to these species because their bracts agree in all essential respects with those that were taken side by side with the nectophores of *P. reticulata* by the *Albatross* (Bigelow 1911 a, 1913).

The most characteristic feature of the bract is a curious asymmetry of the canal system, with the right hydroecial trunk giving off a long branch that runs directly dorsad, to the margin of the bract (Fig. 185), whereas only a very short corresponding branch arises from the left hydroecial trunk. No variant from this basic type was found among the many bracts examined from the Monterey collection, which agrees with the *Albatross* series in this respect. But there is some variation, even in bracts of equal sizes, in the relative lengths of the chief trunks, and in the degree to which these give off short lateral spurs. Thus bracts were noted in which the dorsal trunk sends out one, two or no such spurs; the apical trunk one or none; the left hydroecial trunk one or none in its course over the face of the hydroecium. The length of the dorsal trunk is also variable; in some bracts it runs merely to the dorsal margin, there to terminate; in most cases, however, it then bends to continue inferiorly for a short distance (Fig. 185). In none of the Monterey bracts does it extend as far in that direction as was the case in the example figured from the *Albatross* series (Bigelow, 1911 a, *pl.* 3, *fig.* 6), nor does the right hydroecial trunk recurve. But in view of the variability so commonly seen among siphonophores in this respect, such a difference is not incompatible with reference of the Monterey and Tropical Pacific bracts to the one species.

Another interesting instance of variation is to be seen in the fact that while the right hydroecial wall is considerably the wider in most bracts, a few specimens were found in which the reverse was true, a difference probably associated with the conditions of crowding during the growth of the individual bracts.

The most interesting feature of the groups of the appendages is that search of several segments of stem, and of the mass of damaged gonophores, bracts etc. in the several tows that yielded this form off Monterey, failed to reveal any special swimming bells. Consequently it is safe to conclude that this species lacks such structures, and differs correspondingly from *Stephanophyes*, where they are prominent features of the colony (Chun 1892).

The largest number of gonophores counted in any one stem-group (identified as such by having only one bract and one siphon) was nine, four of these female, five male. Among the material are many detached gonophores of both sexes in various stages of growth. Both the male and the female sex bells are medusi-

form, with well developed radial- and ring-canals. But the subumbral musculature is much more strongly developed in female bells than in male. Furthermore, every female gonophore examined showed a slight asymmetry of the sort

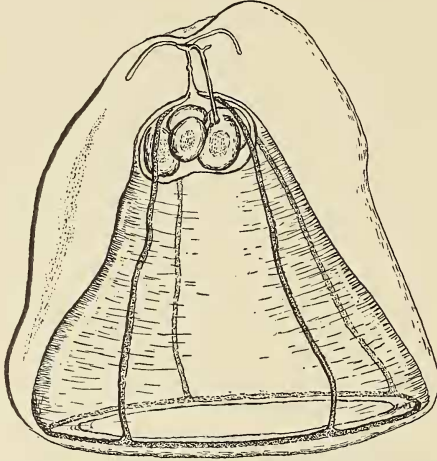


Fig. 186. *Praya reticulata*; female gonophore,  $\times 4.7$ ; from offspring of Monterey Bay, California.

illustrated (Fig. 186). Female gonophores grow to a much larger size than males, the largest of the former measuring about 13 mm., in bell height largest male only about 7 mm. (Fig. 187.)

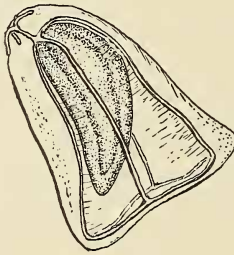


Fig. 187. *Praya reticulata*; male gonophore,  $\times 4.7$ ; from offspring of Monterey Bay, California.

A distinctive feature in gonophores of both sexes is a trifold branching of the pedicular canal at its point of junction, with the three branches extending outward centrifugally over the apex of the bell. No other Prayid, of which the gonophores have been described, shows this arrangement.

In the female bells the manubrium is entirely filled with 4-6 large eggs (fig. 186). The number of these egg-masses that were found detached, as well as of empty bells that had lost all but the base of the manubrium, suggests

that the clusters of eggs are normally shed *en masse*. In the male bells the manubrium is of the usual form (Fig. 187), a sexual difference common among siphonophores.

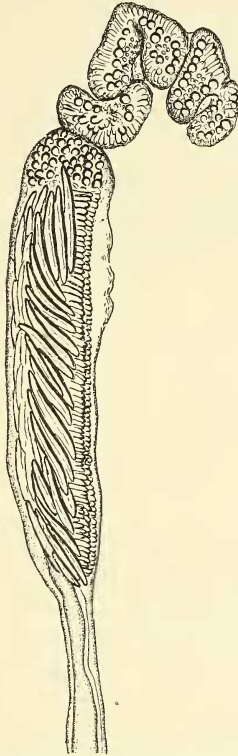


Fig. 188. *Praya reticulata*; young tentillum,  $\times 72$ ; from offing of Monterey Bay, California.

Sketches are given of a young and of an adult tentillum (Figs. 188, 189) from the same tentacle because those of *Praya*<sup>4</sup> have not previously been illustrated. I may note in passing that the curious mouthless siphons and tentacles that are characteristic of *Stephanophyes* do not occur in *Praya*.

Previous records of the nectophores of this species are Eastern Tropical Pacific off Peru (2 stations), and south of Japan (1 station), by the *Albatross*. Bracts and stems have also been taken off Monterey, California, as just stated, and in Puget Sound (in collection of Museum of Comparative Zoology). The *Arcturus* records are all from the Galapagos-Panama region. Thus, if my identification of the loose stems and bracts is correct, this species is generally distributed over the warm temperate Pacific.

<sup>4</sup> For accounts of those of allied *Prayids* see Haeckel 1888 a, Chun 1892, Schneider 1899.

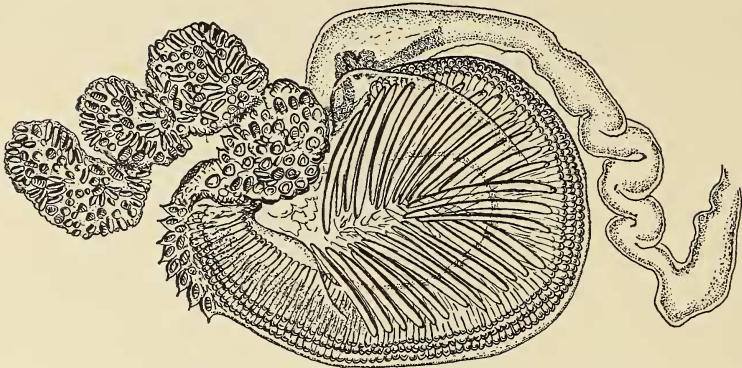


Fig. 189. *Praya reticulata*; adult tentillum,  $\times 72$ ; from same tentacle that bore the young tentillum illustrated in Figure 188.

*Prayinae* (species ?).

Seven nectophores, apparently referable this family, but too fragmentary for generic or specific determination, were taken at Station 11, surface, Station 29, 250–0 meters; Station 50, 727–0 meters; Station 59, 1090–0 meters, and Station 97, 820–0 meters.

Family HIPPOPODIIDAE K lliker (1853).

Moser (1925) prefers the name Polyphyidae Chun (1882) for this family. But as Haeckel's genus Polyphyes is doubtless a synonym of Hippopodius (Moser herself so classes it) the international rules of zoological nomenclature forbids the use of a family designation derived from it.

According to the latest general classification, this family is monotypic, for Moser (1925) unequivocally unites *Hippopodius* and *Vogtia* (genera that had long been treated as distinct) on the ground that the character on which generic separation has usually been based (form of the nectophore) is a specific one. But this union obscures the fact that *Hippopodius* and *Vogtia* are separated by a much more significant character, i. e. the tentilla (Bigelow 1918, p. 403). The two genera are therefore considered here as distinct though this course entails uncertainty when it is a question of relegating loose nectophores to the one genus or to the other.

*Hippopodius hippopus* (Forsk l).

*Gleba hippopus* Forsk l, 1775, p. 14, 1776, pl. 43, fig. E.

For synonymy, see Bigelow, 1911 b, p. 208, and Moser, 1925, p. 409 (" *Hippopodius luteus*").

Moser (1925), like Lens & Van Riemsdijk (1908), uses the specific name

*luteus* Quoy & Gaimard for this well known Siphonophore. But there seems no doubt that the animal described by these French zoologists was identical with the detached bell that Forskål had described and pictured in 1775-76 as *Gleba hippopus*. The ordinary rules of nomenclature therefore require that *hippopus* be employed as the specific name, as pointed out by Schneider (1898) and by me (1911 a). Recent authors, generally, have accepted Chun's (1897) and Schneider's (1898) view that *Hippopodius* Quoy & Gaimard should be used as the generic designation, rather than *Gleba* Forskål, of checkered history. And no good purpose would be served by re-opening the question at this late date.

Variouly fragmented colonies, and loose bells of this species were taken at the following stations: 11, surface; 18 depth ?; 29, 250-0 meters; 41, surface; 45, 363-0 meters; 49, 365-0 meters; 84, 1274-0 meters; 86, 909-0 meters; 87, 1090-0 meters; 96, 2181-0 meters; 98 depth ? 102, surface; 107, 1454-0 meters; 113, 1636-0 meters.

The general morphology of *Hippopodius* is now so well known that nothing is added by this material, for the bells alone remain, whether loose, or still connected. Fortunately, however, for the zoogeographer, these are so firm, and so characteristic in outline, that they are among the most readily recognized of siphonophore-units.

The localities of capture are generally dispersed over the whole route of the *Arcturus*, e. g. between Cuba, Bermuda and the continental edge off Cape Hatteras; likewise the Sargasso Sea to the southeast of Bermuda in the Atlantic; and the Galapagos-Cocos Island-Panama region in the Pacific.

These records provide cumulative evidence that *Hippopodius hippopus* is cosmopolitan in the warmer belts of the high seas, and thence northward and southward in their current-extensions. Like most siphonophores, however, it is highly sporadic in its appearance, and has failed to appear in some collections from regions where it might have been expected.

So far as known it is not at home in any of the extensions, equatorward, of sub-arctic or sub-antarctic waters, or in coast water subject to extreme winter chilling; hence its absence from the continental shelf off the eastern United States, and from the North Sea region.

The comparative scarcity of *H. hippopus* in *Arcturus* surface hauls, contrasted with its strong representation in deep tows with open nets, is in line with the captures by the *Albatross* (Bigelow 1911 a), *Gauss* (Moser 1925), and *Bache* (Bigelow 1918). Moser (1925) has already remarked on its considerable vertical range, and on its comparative tolerance to varying temperature that this implies.

*Vogtia spinosa*, Keferstein & Ehlers.

*Vogtia spinosus*, Keferstein & Ehlers, 1861, p. 24, pl. 5, figs. 16, 17, Chun, 1897, p. 103; Bigelow, 1911 a, p. 210, pl. 15, figs. 5-12, 1913, p. 68, fig. 1.  
*Vogtia köllikeri*, Haeckel, 1888 a, p. 182, pl. 29, fig. 9-14.  
*Hippopodius spinosus*, Moser, 1925, p. 419.

Detached bells, showing the characteristic spination of this species on the facets as well as on the ridges, were taken at stations 29, 250-0 meters; 33, 1274-0 meters; 38, 545-0 meters; and 59, 272-0 meters.

These nectophores agree closely with the more extensive material collected

by the *Albatross* in the same general part of the Pacific in 1904-1905. Moser (1923, p. 43) states that she has found that *V. spinosa* is identical with *V. pentacantha* Kölliker (1853). In that case the former name becomes (by the rule of priority), a synonym of the latter. On this point I can express no opinion, having seen no intermediate specimens. And since Moser (1925) retains both species in her account of the *Gauss* collection, the same course is followed provisionally here.

*Vogtia serrata* Moser.

*Hippopodius serratus* Moser, 1925, p. 420, pl. 27, figs. 6-8, pl. 28, figs. 4-9.  
 [*Vogtia serrata* Moser, 1913, p. 149, no description of figures.]  
*Vogtia pentacantha*, Moser, 1912, p. 329; Bigelow 1913, p. 66, pl. 5, figs. 7-9, pl. 6, fig. 6.  
 [non *V. pentacantha* Kölliker.]

Station 33, 1274-0 meters; one adult nectophore.

This bell, sufficiently preserved to show its characteristic shape, agrees so closely with the *Vogtia* described by me (1913) from the Northwestern Pacific as *V. pentacantha*, but which, as Moser (1925) points out, was almost certainly her *V. serrata*, that I have no hesitation in identifying it as such.

The only respect in which it differs from Moser's (1925) account is in the fact that its angles—at least in its present flabby state—are smooth, not denticulate. But in view of its poor condition, and of the variability of denticulation among Calycophorae in general, this does not warrant separating it, or the specimens from the Northwestern Pacific (these likewise were smooth) from *serrata*.

? *Vogtia serrata*, Moser.

Five loose nectophores, from station 61, 1090-0 meters, are provisionally referred to this species, because they entirely lack the large conical gelatinous spines so characteristic of *V. spinosa* and of *V. pentacantha*. Furthermore, one of these bells shows slight traces of denticulation in places along the angles separating the facets, agreeing in this with Moser's (1925) account and illustrations, though for the most part the angles are smooth; wholly so in the best-preserved example (fig. 190). Further evidence that their closest affinity is with *serrata* is afforded by the form of the ventral sinus, for in the only one in which this can now be traced, it is narrow-linear, (cf. fig. with Bigelow, 1918, pl. 5, figs. 7-9), without the lateral expansion characteristic of *V. spinosa* and of *V. pentacantha*.

The only reason for hesitation in referring these bells to *serrata* is their peculiarly elongate outline, with pyramidal apex (fig. 190) much more prominent than in any *Vogtia* previously described.

This feature, however, must be classed as of little systematic significance, unless some discontinuity can be shown between bells of this form, and those of the same general character but less elongate in outline.

If the identification of these bells be correct, the records are interesting, geographically, as extending to the Eastern Tropical Pacific the known range of the species (mid-Atlantic; Tropical Indian Ocean; Subantarctic; Northwest Pacific; Bering Sea; Sea of Okhotsk; Japanese and Chinese waters), corroborat-

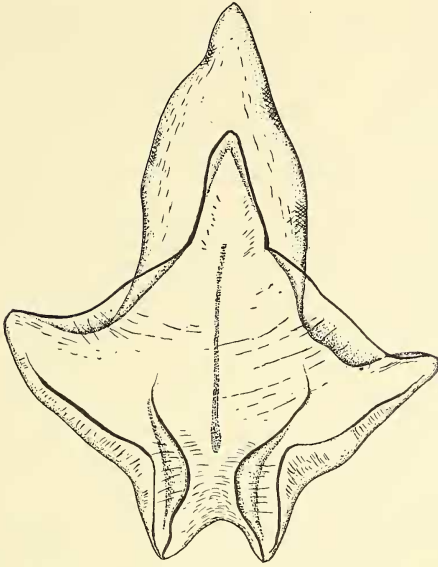


Fig. 190. *Vogtia serrata*?; nectophore in ventral view,  $\times 3.3$ ; from Arcturus Sta. 61.

ing Moser's (1925, p. 421) classification of it as "Kosmopolit im weitesten Sinne des Wortes."

Family DIPHYIDAE, Quoy & Gaimard 1827.

In earlier papers (1911 a, 1913, 1918) I credited this family to Eschscholtz (1829). But as Huxley (1859), and recently Moser (1925, p. 125) point out, it was in fact set up by Quoy & Gaimard in 1827, in their preliminary report on the Medusae and Siphonophores, collected by the *Astrolabe* in the Straits of Gibraltar. For an interesting account of the history of the family, see Moser (1925, p. 127).

The *Arcturus* collection contains representatives of five sub-families of this family—Abylinae, Ceratocymbinae, Galettinae (Galeolarinae, auct.), Diphyinae and Chuniphyinae. The first two of these groups call for no special discussion. The third has usually been named Galeolarinae. But Stechow (1921) has pointed out that this name can not be used for Siphonophores because the generic name *Galeolaria* was preoccupied by Lamarck (1818) for a worm. As substitutes, for the Siphonophores in question, he has proposed *Galetta* and Galettinae.

Most students agree in recognizing Galettinae as one of the major subdivisions of the Diphyidae; but different diagnoses, by Moser (1925) and by me, result in different allocations of certain of the species concerned. As is so usually the case, successive studies progressively clarify the situation.

In earlier papers (following Chun) I considered permanent attachment of the stem-groups as one of the alternative characters separating Galettinae from Diphyinae. To this Moser (1925) objects that Lochmann's (1914) observations on the development of *Galetta quadrivalvis* show that even in this typical *Galetta* the stem-groups do become detached, to live independent for a period of 8-14 hours during the final ripening of the sex products.

Thus no sharp line can be drawn between the typical Diphyinae, in which the stem-groups carry on a protracted independent existence after breaking free, with their bracts undergoing a progressive development, producing meantime a succession of gonophores, and the opposite extreme (if such does indeed characterize any actual *Galetta*) in which the stem-groups remain permanently attached to the stem.

But the contrast between the states illustrated in this respect by *Galetta quadrivalvis* on the one hand, and by *Diphyses* on the other, is more significant than a mere difference in the duration of the period of free existence for the stem-groups would be. Furthermore, no sharper line can be drawn in any other respect between Galettinae and Diphyinae. Thus while the bells of the more typical members of the former are rounded, contrasting with the strongly pyramidal bells with well marked angles of the latter, several species, e. g. *truncata*, bridge the gap between these two categories, for their rounded bells show slightly marked angles. Such species have been referred sometimes to the one genus, sometimes to the other. Similarly, no definite distinction can be drawn between species in which the bells are firmly connected and those in which they are loosely attached one to the other. Neither is the presence or absence of an hydroecium any more precise as an alternative character, because in some species it is represented by a shallow furrow or indentation of the base of the superior nectophore; thus Moser (1925) mentions a shallow hydroecium as characteristic of her "Formenkreis III" of *Galetta*, though in general she considers the absence of an hydroecium as diagnostic of the genus.



We face here one of those cases (the bane of the systematist) where two groups of species, though differing so widely in several morphological respects that they are separable at a glance, are connected by intermediate forms. And when, of necessity, we deal with characters that are not strictly alternative (unless new diagnostic features be found that have so far been overlooked) no definitions can be drawn so definite but what it may always be an open question to which group certain of the intermediate species are best referred. In the present case the form of the inferior nectophore (with simple groove-like hydroecium in Galettinae which is more or less completely bridged in Diphyinae) may prove more diagnostic than that of the superior nectophore.

Recent authors differ as to whether the known species of the subfamily Diphyinae represent one genus, *Diphyes*, or two, *Diphyes* and *Diphyopsis*: final decision will govern the choice of name for the subfamily. Most students, since Huxley (1859) have recognized the two genera, believing that the presence or absence of special swimming bells in the stem-groups is a proper generic character rather than a specific one.

Schneider (1898), however, and latterly Moser (1925) recognize only the one genus, *Diphyes*. This course is certainly the more convenient in practice, because specimens (as taken) have usually lost the stem, hence could not be referred to the one category or to the other by a character shown only by the stem-groups. And it has repeatedly happened in the past that a new Diphyid has been described that could only provisionally be given a generic name for this reason.

A recent survey of the history of this group also shows that to recognize two genera, one with, the other without special nectophores in the stem-groups, would require the resurrection of a long forgotten name for some of the best known of all siphonophores; there seems no escape if the ordinarily accepted rules of nomenclature, embodied in the International Code, are to be followed.

The first Diphyid to appear in zoological literature was the "*Biphore bipartie*, *Salpa* (*bipartita*) *lanceolata bipartita*" of Bory de St. Vincent (1804), for which Cuvier 1817, *p.* 61) set up the genus *Diphyes*. As Bory's name was not binomial, the type species of *Diphyes* must always remain the *Diphyes dispar* of Chamisso & Eysenhardt (1821). Haeckel (1888 a), however, when he split

*Diphyes* into two genera (the one with, the other without the special nectophores) did not give the new name to the category that differs from *dispar* in this respect, but placed *dispar* itself in his new genus *Diphyopsis* together with two supposedly new species (*canpanulifera* and *compressa*) that are now known to be synonyms of it. The generic name *Diphyopsis* is therefore a synonym of *Diphyes*, and all species that agree with *dispar* must be referred to *Diphyes*.<sup>5</sup>

Therefore if two genera are to be distinguished, those which differ from *dispar*, in lacking special nectophores, must be removed from *Diphyes*, not those that agree with *dispar*, and a name must be found for them.

On running through the synonymy of the several species in question, we find that the only available generic name (*Diphyes*, *Eudoxia* and *Cucullus* having been proposed first for the nectophores or for the eudoxids of *Diphyes*, proper) is *Eudoxoides*, given by Huxley (1859) to a loose bract so characteristic in outline that Moser (1925) has been able to identify it as belonging to *Diphyes mitra*, which, as she has proved on extensive material, has no swimming bells in its stem-groups.<sup>6</sup>

But revival of this name for the category of species so characterized (*Diphyopsis* must be abandoned in any case), entails the removal, to it, of all the species that most recent authors have called *Diphyes*, and the relegation to *Diphyes* of all the species of the defunct genus *Diphyopsis*.

In short, we come to this:—continued recognition of two genera in this subfamily will cause increased nomenclatural confusion in a group where such confusion has too long been rife; in actual practice great inconvenience will result. On the other hand, to recognize only one genus will conceal the fact that the species concerned fall into two major categories, the members of each of which differ among themselves by other characters.

In reaching a decision in such a case weight may fairly be given to the essential difference between the ideas that we mean to express by the names species and genus. To the taxonomist the species is the nearest known approach to a basic unit or integer; a genus on the contrary is, in essence, a subjective concept, for it will always be

<sup>5</sup> I had overlooked this situation in my earlier discussions of the subfamily.

<sup>6</sup> The bud interpreted as such by Lens & Van Riemsdijk (1908) was in reality that of a gonophore.

a matter of opinion how species should be grouped, with changes in viewpoints as to the relative importance of given characters often leading to rapid generic realignments. While in the present case it might seem that the presence or absence of special swimming bells is more significant than the conformation of the bell, or the arrangement of the ridges etc., we have no assurance that within a few years the opposite view may not prevail. On the whole it seems that in the case in question systematic presentation of the Siphonophores will be best served by regarding all these characters as specific, i. e. by including the two categories in question within the one genus, *Diphyes*.

The discontinuity and anatomical precision of the structural features that separate species within this genus make them easy of identification. Keys for that purpose are given by Moser (1925, p. 169) and in my account of the *Albatross* Siphonophores (1911 a, p. 246).

*Abyla leuckartii* Huxley.

*Abyla leuckartii* Huxley, 1859, p. 49, pl. 3, fig. 2.

For synonymy and description of the polygastric generation, see Bigelow, 1911 a, p. 216, pl. 13, figs. 5-8; Moser, 1925, p. 288, pl. 17, figs. 4-6.

Station 11, surface, five superior nectophores and one fragmentary gonophore.

? Station 29, depth? one bract.

The bract listed above is referred to *A. leuckartii* because it conforms to the other bracts, bearing gonophores of the *leuckartii* type, that I have previously seen (p. 549, 1918); i. e. the asymmetrical ridge joins the apical ridge, while the apical facet is hardly convex. But the bracts of this species so closely resemble those of *Ceratocymba sagittata* that a loose example of this type can never be identified positively.

The eudoxid of *A. leuckartii* seems first to have been described in 1908, but without knowledge of its parentage by Lens & Van Riemsdijk, who recorded, under the specific name *asymetrica*, a new eudoxid with bract of the *Ceratocymba* type, in which the baso-ventral teeth of the gonophore were about equal in length, while the baso-dorsal teeth projected but little beyond the dorsal outline of the bell. This combination of characters positively identifies this eudoxid as belonging to *A. leuckartii*, for it is now known that this basal conformation is not only characteristic of the latter, but very sharply marks it off from the eudoxid of *Ceratocymba sagittata*, where one of the ventro-basal teeth is greatly elongate, while the dorso-basal tooth projects (p. 548).

Moser (1925, p. 269), it is true, relegates the *C. asymetrica* of Lens & Van Riemsdijk to the synonymy of *Ceratocymba sagittata*. But the outlines of the gonophore are so distinctive in this case, that Lens & Van Riemsdijk's illustration of it (1909, pl. 1, fig. 5) is quite sufficient to demonstrate its identity as *leuckartii*, the eudoxid of which is now well known.

All other *Ceratocymbas* that have been described, belong to *Ceratocymba sagittata* (p. 548). This includes the *Ceratocymba sagittata* of Bedot (1904) as Moser (1925) has pointed out, for while Browne (1926, p. 66) objects that the bract in Bedot's figures is symmetrical, I have myself seen specimens in which the asymmetrical ridge might easily be overlooked.

The structure of the very characteristic nectophores of *A. leuckartii* has been described and figured in such detail by previous writers that the few examples in the *Arcturus* series could not be expected to add to our knowledge of the morphology of the species, especially since all of them have lost all but the basal part of the stem.

Moser (1925) considers it likely that the gonophores of the two sexes are mirror pictures one of the other, as is the case in *Ceratocymba sagittata*. But determination of this point must await examination of male gonophores, the female bell of *leuckartii* alone having been studied so far (Bigelow, 1918, Pl. 6, fig. 4).

The *Arcturus* captures are from general regions (mid-Atlantic; and between Panama and the Galapagos) where *A. leuckartii* had already been reported. While this species is one of the less frequent Abylids, its reported captures show it to be general in the warmer belts. Thus it has been taken in the eastern tropical Pacific, in Australian, Malaysian and Philippine waters, in the tropical Indian Ocean; also among the West Indies, and at widely separated localities in the North and South Atlantic.

*Abylopsis tetragona*, Otto.

*Pyramis tetragona*, Otto, 1823, p. 306, pl. 42, figs. 2 a-2 e.

For synonymy, see Bigelow, 1911 a, p. 224; Browne, 1926, p. 63; ('*Abylopsis pentagona*'); Moser, 1925, p. 320.

This well known species was taken at Stations 15, 29, 33, 38, 39, 45, 49, 53, 74 and 84, in 18 different tows, from depths ranging between 250-0 and 1274-0 meters; all in open nets. The material consists of upwards of 35 colonies, 25 inferior nectophores, and a single loose gonophore. The collection contains no complete eudoxids, and no loose superior nectophores: probably these were overlooked in the sorting of the plankton on shipboard.

Most of the specimens are more or less fragmentary—many of them extremely so. There is, however, no danger of confusing the inferior nectophores of this large Abylid with those of any other species. Its superior nectophore (figs. 191-192) closely resembles that of *A. eschscholtzii*: so closely in fact that Moser (1925) considers them indistinguishable. They can, however, be separated by minor characters, at least in most cases, as I have previously suggested (1911 a), and as Browne (1926, p. 64) has recently shown. For discussion of this point, see page 546, under *A. eschscholtzii*.

*A. tetragona* has so often been described and figured, and it is in general so well known morphologically, that the present series could not be expected to add materially to the earlier accounts, except by way of confirmation.

Although this is no doubt the most familiar member of its family, opinion is not yet unanimous as to the correct specific name for it. Hence it seems necessary to restate my reasons for following Schneider (1898) in reviving Otto's name *tetragona*.

Admittedly Otto's (1823) description and illustrations are so inaccurate that, of themselves, they would not suffice to identify them with any actual Siphonophore. But they do satisfy the requirements of Article 25, of the International Code of Zoological Nomenclature, that a name be "published and accompanied by an indication, or a definition, or a description." Consequently, *tetragona* can not be regarded as a nomen nudem, to be relegated to oblivion.

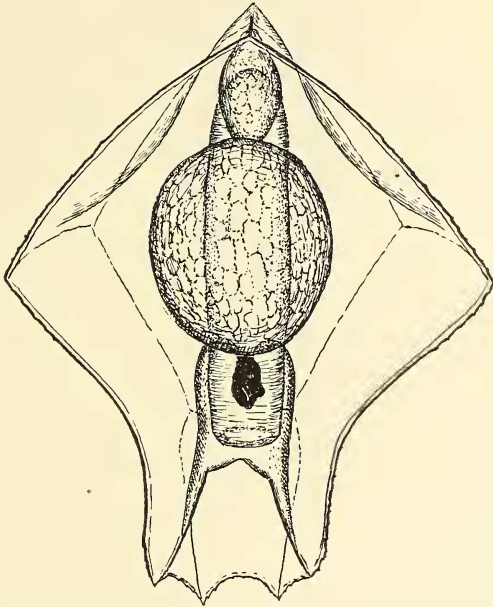


Fig. 191. *Abylopsis tetragona*; superior nectophore, ventral view,  $\times 10$ ; from *Arcturus* Sta. 49.

In 1897 Chun pointed out that Otto's specimens were still preserved in good condition in the Breslau Museum, and by personal examination he was able to establish that they belonged to the species that authors had called *pentagona*, following Quoy & Gaimard (1827) and Eschscholtz (1829). Chun, however, did not revise Otto's (the oldest) name, quoting in justification, section 6 of the code of nomenclature of the German Zoological Society, which provided that a name in general use was not to be superseded by an older one not referable to a definite systematic unit. But as Schneider (1898, p. 89) showed, *tetragona* was removed from this unidentifiable category by Chun's own identification of its type specimen. Consequently modern zoological usage demands the substitution of *tetragona* Otto for *pentagona* Quoy & Gaimard, no matter how misleading the original account of *tetragona* may have been.

The *Arcturus* records are from general regions where *A. tetragona* was already known to be widespread; probably as regularly occurrent as is any.

siphonophore. It is interesting, however, and hard to explain, that none of the specimens came from surface tows. Nor can it be supposed that it was represented in the latter, but overlooked in the sorting of the catches, being

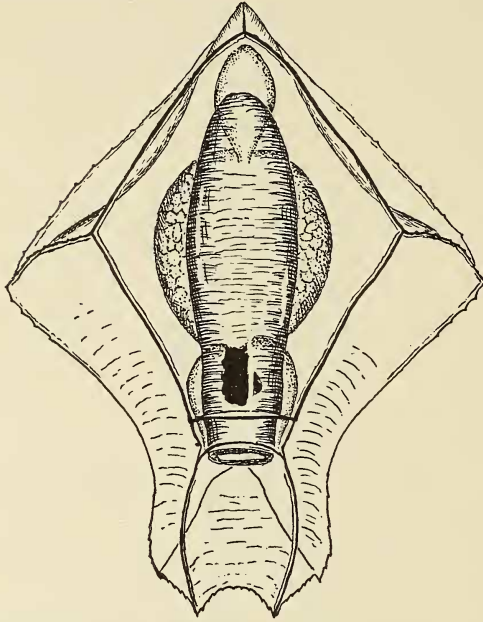


Fig. 192. *Abylopsis tetragona*; superior nectophore, dorsal view of specimen illustrated in Figure 191.

far too conspicuous an object. *Tetragona* was also taken most regularly in deep hauls in the Eastern Tropical Pacific on the *Albatross*, only occasionally at the surface. But the *Bache*, in the northwest Atlantic had it more frequently at the surface; likewise the *Gauss*, and earlier collections. One must then be cautious in referring a species to the bathyplankton on the basis of a single collection.

*Abylopsis eschscholtzii*, Huxley.

*Aglaismoides eschscholtzii*, Huxley, 1859, p. 60, pl. 4, fig. 2.

For synonymy, description, and general discussion, see Bigelow, 1911 a, p. 226; Moser, 1925, p. 334; Browne, 1926, p. 65.

Station 84, surface, one pair of nectophores united, also 9 loose superior and 29 inferior nectophores.

Station 87, 1090-0 meters, 2 superior, 9 inferior nectophores.

Station 98, 1500-0 meters, one inferior nectophore.

There is no danger of confusing the inferior nectophores of *A. eschscholtzii* with those of any other species. According to Moser (1925, p. 338), the superior nectophore resembles in all respects that of *A. tetragona*, and so far as general form, shapes of the facets, etc. is concerned, this is certainly the case. In most instances, however, it is possible to relegate a given nectophore to one or to the

other species, by minor characters. I have already suggested that the course of the subumbral canals (highly arched in *tetragona*) would prove diagnostic, and Browne's (1926) subsequent studies, with my own, have proved that this type is usually characteristic of that species, but apparently never occurs in *A. eschscholtzii*.

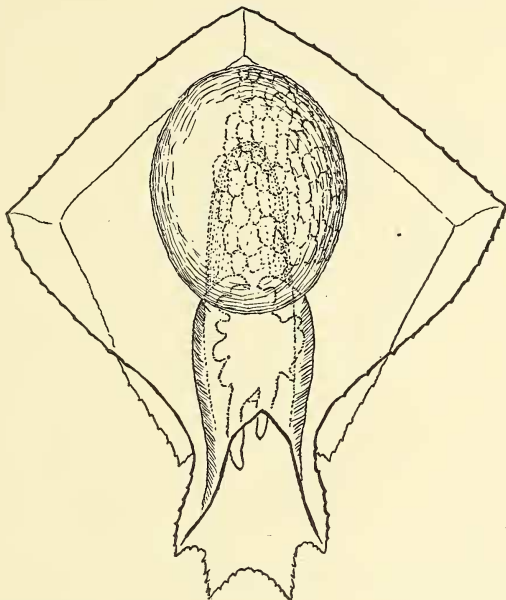


Fig. 193. *Abylopsis eschscholtzii*; superior nectophore, ventral view,  $\times 15$ ; from *Arcturus* Sta. 84.

Some examples, however, as he found, show a state intermediate between the extremes figured by me (1911 a, *pl.* 14, *figs.* 1, 6), and therefore could not be placed on this basis alone, if separated from their very diagnostic lower nectophores. But he has pointed out that another difference may be depended upon, in all but an occasional example, for the apex of the nectosac extends apically beyond the main body of the somatocyst in *tetragona*, but falls short of it in *eschscholtzii*.

Fresh examination of specimens of each, in which both nectophores are still connected, making their identity certain (Figs. 191-194), confirms his conclusions. And it is by this criterion that the loose superior nectophores listed above from the *Arcturus* series are referred to this species. Rarely, a loose nectophore may be found so nearly intermediate in all respects that its identity, as the one species or the other, cannot be determined.

The inferior nectophores listed above agree, even to minute details, with the earlier accounts.

The *Arcturus* localities are near the Galapagos, and in the Atlantic near

Bermuda; regions where this species has already been taken by the *Albatross*, and by the *Bache*. This is one of the commoner species of its group, widespread in warm oceans. It has not been recorded as yet from the Mediterranean, but

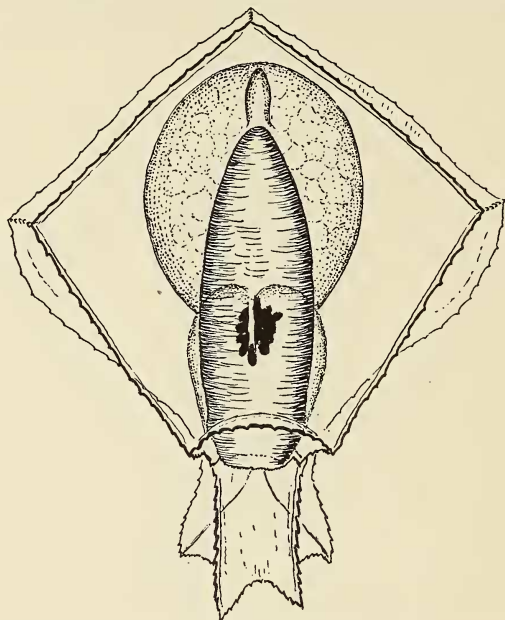


Fig. 194. *Abylopsis eschscholtzii*; superior nectophore,  $\times 15$ ; dorsal view of specimen illustrated in Figure 193.

in view of Moser's (1925) recent capture there, of several siphonophores previously known only from the open oceans, it is not safe to assume that *A. eschscholtzii* will not equally be found within the Mediterranean, when the siphonophore-fauna of the latter has been examined more intensively.

*Bassia bassensis*, Quoy & Gaimard.

*Diphyes bassensis*, Quoy & Gaimard, 1834,<sup>7</sup> p. 91, pl. 7, figs. 18-21.  
For synonymy, see Bigelow, 1911 a, p. 220; Moser, 1925, p. 347.

Station 45, 7 eudoxids all much crumpled.

Station 97, 1000-0 meters, two superior nectophores, all much crumpled.

This scattering representation of this well known form calls for no special comment, as it is generally distributed and often reported in the warmer belts of all the oceans.

*Ceratocymba sagittata*, Quoy & Gaimard.

*Cymba sagittata*, Quoy & Gaimard, 1827, pl. 16, pl. 2 C; figs. 1-9.  
For synonymy, see Bigelow, 1918, p. 411, 412; Moser, 1925, p. 269.

<sup>7</sup> This paper, with the accompanying plates, is dated "1833." But according to Sherborn & Woodward (1901) it did not appear until 1834. And this date is accepted in the catalogue of the British Museum.



This species was taken at stations 17, 29, 38, 96, 98 and 108, in hauls varying in depth from the surface to 2181-0 meters. The material consists of seven superior nectophores, 9-26 mm. long, one inferior nectophore 39 mm. long, two bracts 16 and 20 mm. long, and one male gonophore, 25 mm. long.

The superior nectophore of this species, though among the most easily recognized of all Calycophorae, was not seen until 1908 (Lens & Van Riemsdijk, as "*Diphyabylla hubrechii*"). But both the inferior and the superior bells have been described so fully since then, at different stages in growth, and pictured in such detail (Bigelow 1911 a "*Diphyabylla hubrechii*," p. 231, pl. 12, fig. 7; 1918, p. 7, fig. 1; Moser, 1912 a, fig. 23; 1925, p. 274, pl. 15) that no additional account is needed here. The *Arcturus* specimens agree with those of corresponding sizes of which accounts have already appeared.

The bracts of the free eudoxid of *Ceratocymba* so closely resemble those of *Abyla leuckartii* that Moser (1912 a, 1925) describes them as indistinguishable, though the gonophores are easily distinguishable, their basal teeth being symmetrical in *A. leuckartii* but strongly asymmetrical in *Ceratocymba* (Bigelow 1918, pl. 6, figs. 3-4, pl. 7, figs. 2-3; Moser, 1925, Pl. 16, figs. 2-5, Totton, 1925). In the eudoxids that I have seen with gonophores of the *Ceratocymba* type, the asymmetrical (left lateral) ridge of the bract fails to reach the apical ridge, and the apical facet is strongly concave. On the other hand, in the only eudoxid of *leuckartii* that I have examined (identity established by its gonophore), the asymmetrical ridge joins the apical ridge of the bract, while the apical facet of the latter is nearly flat. This difference is described in greater detail elsewhere (Bigelow, 1918, p. 414).

Here the matter must rest until someone has an opportunity to examine a large series of eudoxids (with gonophores) of the two species.

Meantime, bracts that show the characters just stated are listed here as *Ceratocymba*. The male gonophore listed above, characterized by its asymmetry and by the fact that it is a mirror-picture of the female sex bell in this respect, agrees with the previous accounts and figures.

*Ceratocymba sagittata* was to be expected in the *Arcturus* collection for it had already been reported from the same general regions. The localities of record for it cover widely separated localities in the Indian Ocean, the Malaysian region, the Eastern Tropical Pacific and in the North and South Atlantic where the *Gauss* (Moser, 1925) and the *Bache* (Bigelow, 1918) gathered considerable series.

*Galetta*<sup>8</sup> *quadriavalvis*, Blainville.

*Sulculeolaria quadriavalvis*, Blainville, 1830, p. 126; 1834, p. 138, pl. 6, fig. 6 (Lesueur, mss.).

The synonymies given earlier by Moser (1925, p. 139) also include all references published prior to 1918 to the form recorded by me (1911 a, p. 237) here (p. 556) as *Galetta quadridentata*, Quoy & Gaimard.

Opinions still differ as to whether *quadriavalvis* in which the base of the superior nectophore is bidentate, and *quadridentata*, in which it has four teeth, represent two separate species or whether they are merely the extremes of one varietal range. Solution of this question is, however, needed because almost

<sup>8</sup> *Galeolaria* auct., see p. 539.

all our knowledge of the general organization and development of this group of siphonophores has been drawn from the one or the other of the two.

No difference has yet been found to separate the inferior nectophores of these two forms: both show the two circular constrictions of the nectosac, the four basal teeth, the divided ventro-basal wing, and the complex canal system that has often been described for *Galetta quadrivalvis*. My own examination of the stem-groups of the two, as described below, has equally failed to bring out any points of difference. The superior nectophores also agree in their general form and in the arrangement of their canals; they differ only in the sculpture of the base. But in this respect the two forms differ so widely (considering the reliability of this character in general among Diphyids) that in previous discussion I had no hesitation in referring them to separate species.

A search of the literature shows that both these forms were early recorded, though with no more than passing mention. Blainville's (1830, 1834, p. 138, pl. 6, fig. 6) description and figures of *Galetta* ("*Sulculeolaria*") *quadrivalvis* were based on the inferior nectophore; hence it will never be possible to determine whether it was of the bidentate or quadridentate type. But, simultaneously, Quoy & Gaimard (1834) described and pictured as *Galeolaria quadridentata* a superior nectophore of the quadridentate form; hence my (1918) choice of that name for the latter. Since that time, though one feature or another of this group has been the subject of many discussions, the particular feature in question has been ignored for the most part. The quadridentate form was reported by Keferstein & Ehlers (1861, as "*Diphyes quadrivalvis*"), who describe the superior nectophore as having six points ("*Zipfel*"), two upper, two lower, and one on each side, which clearly refers to the four circumoral teeth and to the two ventro-basal wings. According to Moser (1925, as "*Galeolaria quadrivalvis*") the mouth of the nectosac is surrounded by four teeth (two dorsal and two lateral) with divided ventro-basal wing. And this same conformation has been described and figured by me (1918) under the name *Galeolaria quadridentata* Quoy & Gaimard.

A bidentate contour was first definitely recorded by Leuckart (1854, p. 280 as "*Galeolaria filiformis*"), who described the "*Klappen des vordern Schwimmstückes*" as "*ein innere und ein ausseres Paare*"; and (p. 284) "*die Klappen am ausseren und innern Rande der vordern Schwimmglocke*" as "*in der medianlinie gespalten, also paarig . . .*" This evidently refers to paired dorsal teeth, and to divided baso-ventral lamella.

It is also certain that the superior nectophore figures by Lens & Van Riemsdijk (1908, pl. 9, fig. 74) had only dorsal, and no lateral teeth. This was also true of the *Albatross* specimens from the Eastern Tropical Pacific, (Bigelow 1911 a).<sup>9</sup>

My own earlier studies on the *Albatross* and *Bache* material of the two types, show that the extremes are far apart. Moser (1925) however, in the latest pronouncement on the subject, definitely unites them in the synonymy of

<sup>9</sup> Gegenbaur's (1853) description of his *Diphyes quadrivalvis* was apparently based on the bidentate form also, for his account and figure of two pointed projections above and below the bell-opening is not compatible with the presence of lateral teeth. Vogt (1854) seems also to have seen only ventro-basal lamella and the dorsal tooth (or teeth).

the one species *quadriavalvis*, remarking that the dentition is variable, but with no statement as to what range of variability she has actually observed, nor any more direct reference to the bidentate form.

It is certain that further discussion of the earlier accounts can never settle the question whether these two forms, so widely different in one very obvious character, but inseparable (so far as yet known) in all others, are different species, are dimorphic forms of one species, or are merely varieties of the one. The answer can only come by determination (from examination of large series), whether the two types are actually discontinuous, or whether they are connected by intermediate states with lateral teeth varying from well developed to none.

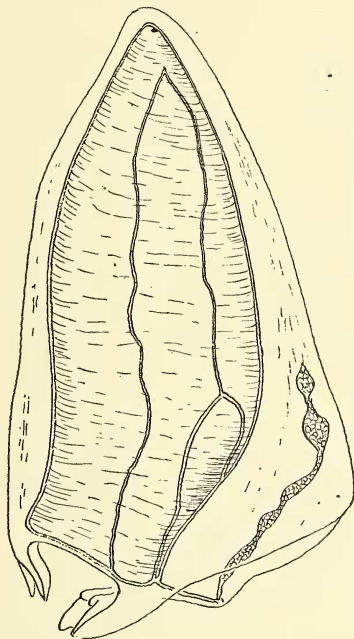


Fig. 195. *Galetta quadriavalvis*; lateral view of superior nectophore,  $\times 4$ ; from *Arcturus* Sta. 87.

Meantime, it is necessary to refer to the two forms in question, either by one specific name, or by two names. In a case of this sort, it is important to emphasize the facts (a) that a difference does exist between two forms; and (b) that reduction of this difference to terms of nomenclature requires investigations of a sort or extent not yet undertaken. In the present report of progress, the two forms are referred to different species, though with the express reservation that this reference is no more than provisional. Browne (1926) also follows this course. Fortunately there is no question of a new name in this case, whatever be the decision, for *quadridentata* Quoy & Gaimard (1834), almost

certainly was based on the quadridentate form in question; while *quadrivalvis* Blainville can be applied to the bidentate.

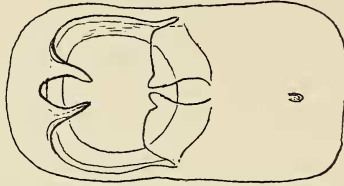


Fig. 196. *Galetta quadrivalvis*; basal view of superior nectophore,  $\times 4$ ; from Arcturus Sta. 87

Thirty-four superior nectophores of the bidentate type, with two prominent baso-dorsal teeth (figs. 195, 196), and deeply divided ventro-basal lamella or wing were taken at station 87, 1000-0 meters.

Examination of 32 of them gave the following result, with regard to variation:—in 25 the outline of the margin of the bell-rims was uninterrupted from base of dorsal tooth to base of ventral lamella (Figs. 195, 196), with no trace of any baso-lateral tooth or even projecting angle on either side: seven specimens, however, show slight indication of such a tooth opposite each lateral, exumbrel ridge (Fig. 197). But even in the specimen in which this is most pronounced, it is a very minute structure, as contrasted with the lateral teeth of *Galetta quadridenta* (p. 556; Bigelow, 1918, pl. 8, fig. 1, 2). Thus a wide gap remains between the most convergent examples of the two types that have yet been actually recorded: a gap that future investigation may, or may not bridge.

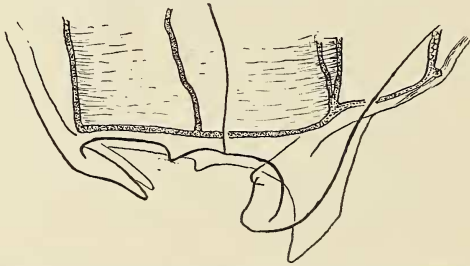


Fig. 197. Lateral view of base of superior nectophore of specimen showing lateral marginal angles,  $\times 6$ ; from Arcturus Sta. 87.

Moser (1925) has already, and justly, made use of the courses of the sub-umbrellar canals and of their anastomoses as specific characters within this genus. So far as I can learn, none of the earlier illustrations show those of *Galetta quadrivalvis* in an altogether satisfactory way, Fewkes' (1879 pl. 3, fig. 4) picture being the most illustrative. An illustration of one of the present series is therefore given in figure 195. As Moser points out, the superior nectophore of *quadrivalvis* agrees essentially in this respect with that of *Galetta australis*, and of *Galetta monoica*, all of them being characterized by the presence

of a commissure connecting the ascending branch of the looped lateral canal with the ventral canal (c/f Fig. 195 with Bigelow 1911 a, *pl.* 6, *figs.* 1, 2, 5, 8). The chief difference is that while in *G. quadrivalvis* and in *G. monoica* the ascending lateral trunk arises close to the union of pedicular canal with subumbrellar system, in *G. australis* it arises from the ring-canal at some distance from this point.

Forty-two inferior nectophores taken in the same haul, need no special comment: they agree in every respect with the earlier accounts. Had they been taken alone, they might equally have been referred to *Galetta quadridentata*. But since they were gathered side by side with superior nectophores of the bidentate type, in a haul which yielded none of the quadridentate type, their connection with the former seems assured.

Unfortunately all but the base of the stem has been lost in every case, consequently the present series adds nothing to previous knowledge of the cormidia. But as Moser (1925) has recently emphasized the interest that attaches to the reserve-bells that various authors have described in this species, it is worth remarking that one of the *Albatross* specimens shows two such buds—both at an early stage in development (Fig. 198). Each bud, furthermore, is attached to the base of the stem by a structure corresponding to the larger pedicular attachment which bore the two large nectophores.<sup>10</sup> By their location and relation to the large bells, these young bells, with those described below (*p.* 556) for *Galetta quadridentata* answer Moser's (1925, *p.* 141) question "wie und wo die Ersatzglocken entstehen und sich entwickeln."

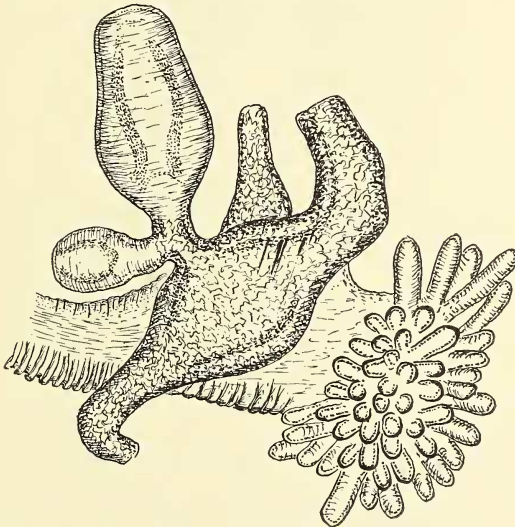


Fig. 198. *Galetta quadrivalvis*; basal part of stem of specimen showing two reserve buds,  $\times 40$ ; from Arcturus Sta. 87.

<sup>10</sup> These were joined together, when the specimen was taken.

The presence of a fourth pedicle (Fig. 198), intermediate in size, suggests that in life the colony had borne still another and larger reserve bud, though this had become detached before the preserved material was examined. Owing to the contracted condition it is not possible to determine how far the pedicles which bore the two large nectophores extended to either side of the axial canals; the present state, as shown in the sketch (Fig. 198), may therefore be misleading in this respect. We have still to learn whether the successive detachment of large bells, and their replacement by small, described by Gegenbaur (1854), and by Korotneff (1884) who observed the event in specimens living in aquaria, is the normal process, as it seems to be in some Prayids, or whether the reserve-bells play that role only when one or other of the chief bells has been accidentally lost. Gegenbaur's (1853) observation that while most of the reserve-bells show the incipient characters of inferior nectophores, occasionally (when four such buds were present), one showed the characters of a superior nectophore, seems to support the first alternative.

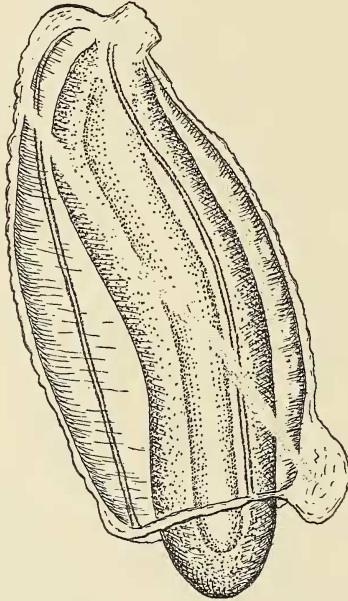


Fig. 199. *Galetta quadrivalvis*; male gonophore,  $\times 70$ .

For accounts of the stem-groups of *Galetta quadrivalvis* (this, with *quadridentata* is the only member of the genus, the cormidia of which have been adequately described), we must turn back to Vogt (1854), Leuckart (1854), Gegenbaur (1853), and Schneider (1896, 1898). These descriptions are in essential agreement as to the simplicity of the bracts; the general structure of the tentilla; the fact that each stem-group bears but a single gonophore; and as to the disparity in size and appearance between the male and female sex bells.

Moser (1925, p. 144) points out certain slight disagreements among the early accounts as to form and canalization of the bracts, and as to external sculpture of the gonophores. The bracts of the *Albatross* specimens, though much crumpled after twenty-five years preservation, still show the conical bases described and figured by Vogt (1854) and by Gegenbaur (1853). But in their present state it is impossible to determine whether, or not, they had the very stout canals that Leuckart (1853, *pl. 2, figs. 8, 9*; 1854, *p. 285, pl. 11, fig. 17*) described and illustrated.

The sex bells are essentially of the form shown by Vogt (1854, *pl. 19, figs. 1, 6*), made characteristically asymmetrical by the presence of one marginal wing-like expansion of the jelly, at the bell opening (Figs. 199, 200). None of the many examples, of both sexes, that I have examined among the *Albatross* material, now show the two longitudinal ribs described by Gegenbaur (1853). But in all of them the surface of the exumbrella has been more or less wrinkled by the preservation.

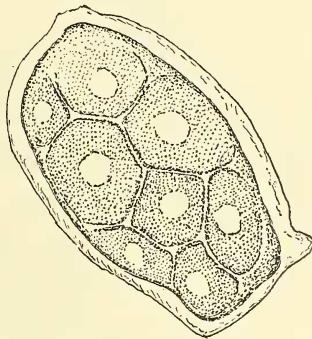


Fig. 200. *Galetta quadrivalvis*; female gonophore,  $\times 70$ .

Gegenbaur (1853), Vogt (1854) and Leuckart (1854) all describe the individual colonies (stems) as bearing gonophores of one sex only, and this is the view generally accepted. Neppi (1921), however, has reported an example in which the most distal gonophore was a male, the others female, suggesting that in reality this species is monoecious, and protandrous. I can throw no light on this point, for the segments of stem that I have been able to examine (in every case unisexual) were from an *Albatross* lot containing more than one example.

The gonophores bud off the pedicles of the siphons as Vogt (1854), Gegenbaur (1853), Leuckart (1853, 1854), and Schneider (1896) all found. Schneider's figure (1896, *pl. 45, fig. 37*) shows their relationship to the bract attachment and siphon, as well as the form of the latter so clearly that no further illustration is needed here. Vogt (1854, *pl. 19, fig. 3*) and more recently Schneider (1898, *pl. 12, fig. 31*) have already given satisfactory figures of the tentilla, which are of the ordinary Diphyid type.

*Galetta quadrivalvis* is widespread in the Eastern Tropical Pacific. The present locality-record is near Narborough Island of the Galapagos group. For

a summary of its known distribution in the Atlantic, Indo-Pacific and Mediterranean, see Moser, 1925, p. 141.

*Galetta quadridentata*, Quoy & Gaimard.

*Galeolaria quadridentata*, Quoy & Gaimard, 1834, p. 34, pl. 5, figs. 32, 33; Bigelow, 1918, p. 417, pl. 8, figs. 1, 2. (On synonymy, see p. 549 under *Galetta quadrivalvis*).

Station 29, 250-0 meters, two superior nectophores and ten inferior nectophores; fragmentary.

The superior nectophores listed above are identified by their basal sculpture; the loose inferiors, however, being identical in appearance with those of *Galetta*

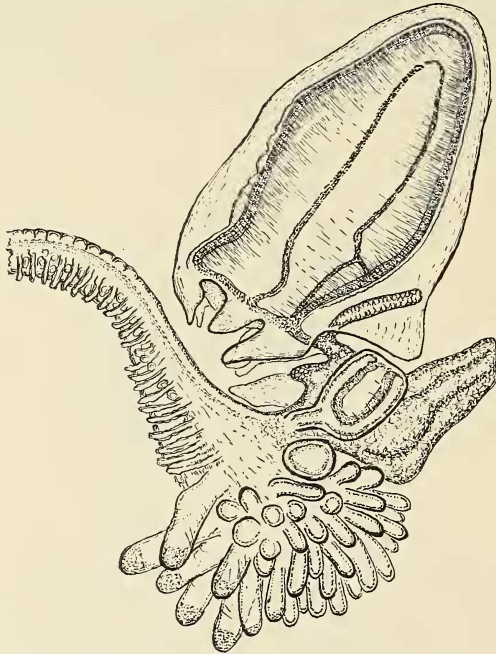


Fig. 201. *Galetta quadridentata*; base of stem, found attached to inferior nectophore, with reserve-buds,  $\times 20$ ; from Arcturus Sta. 28.

*quadrivalvis*, might equally belong to that species. They are referred to *quadridentata* because taken in hauls which also yielded superior nectophores of that species, but none of *quadrivalvis*.

These nectophores are all more or less fragmentary: but the four basal teeth surrounding the oral opening of the superiors are conspicuous. And so far as can be seen in their present condition, they agree so closely with the *quadridentata* bells from the *Bache* collection (Bigelow 1918), that no further account is needed here.

The most interesting feature of the series is the fact that one of the inferior bells still had, attached, the basal part of the stem, and that the latter bore a



reserve bell well advanced in development, as well as the very young bud for a second (fig. 201). The larger of these buds already shows all essential features of a superior nectophore, including the four circumoral basal teeth, the divided ventro-basal lamella, and the characteristic lateral subumbral canals. The latter follow the same course as in *Galettia quadrivalvis* (c/f Fig. 195), and are similarly connected with the ventral canal by a transverse commissure. The smaller bud is still too young to show its future identity, whether as superior or as inferior nectophore. The situation of these reserve-bells relative to the stem in general, relative to the zone of proliferation for siphons, and relative

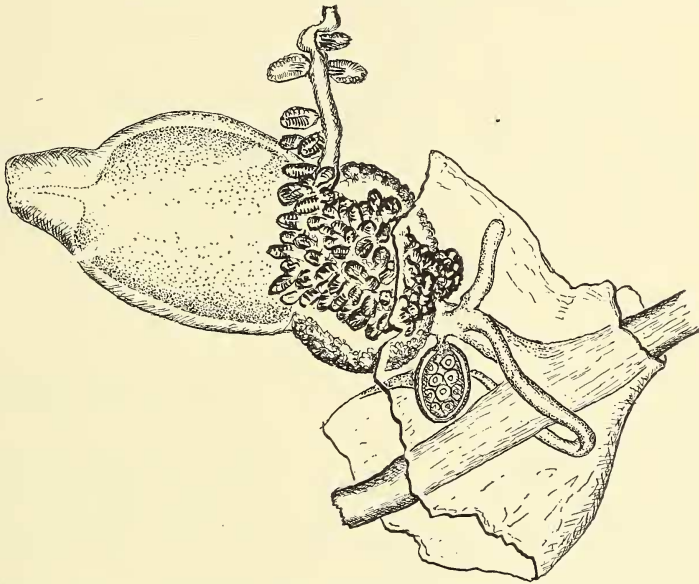


Fig. 202. *Galettia quadridentata*; portion of stem, with siphon, gonophore, and basal part of bract,  $\times 43$ ; from a specimen from Naples in the collection of the Museum of Comparative Zoology.

to the pedicles that bear the preexisting bells, is precisely the same as in *Galettia quadrivalvis* (Fig. 198).

*Galettia quadridentata* is apparently dioecious, for the present example bears only female gonophores as does another, better preserved, from Naples, in the collection of the Museum of Comparative Zoology. The arrangement of organs within each stem-group is likewise the same as in *G. quadrivalvis*, i. e. with the gonophores borne on the pedicles of the siphons, not on the stem proper (see Schneider 1896, pl. 45, fig. 37).

In the *Arcturus* specimens all the bracts have been lost. But in one from Naples, just mentioned (now in alcohol), these structures are intact on a considerable length of stem. And while they are so crumpled that it is not possible to reconstruct their natural outlines (further than that they are generally conical),

several clearly show the very stout canals (Fig. 202) mentioned by Leuckart (1854) and such as Schneider (1896, *pl.* 45, *fig.* 31) figured either for *G. quadridentata* or for *G. quadrivalvis* (p. 549). Occasional bracts are still in good enough condition to show that the attachment is by a muscular lamella, attached longitudinally along the pedicular attachment of the siphon (Fig. 203) proving that

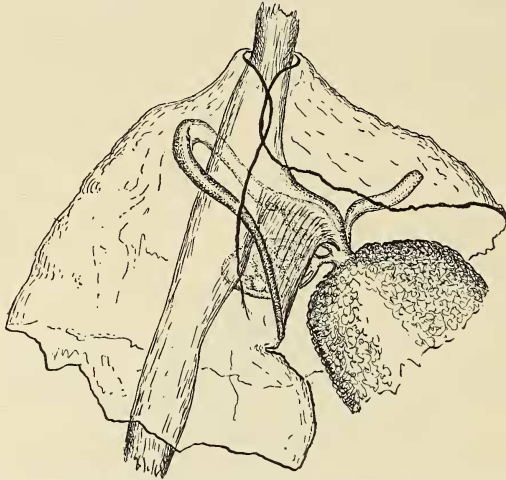


Fig. 203. *Galetta quadridentata*; another view of bract shown in Figure 202, to show its muscular attachment,  $\times 43$ .

this pedicle is morphologically a portion of the stem, as Leuckart (1854) long ago interpreted it, not of the siphon. The gonophore (this specimen is female) is attached just distal to the bracteal lamella (Fig. 202). One of the branches of the bracteal canal surrounds the stem, the other runs out roughly at right angles to the extension of the latter that bears gonophore and siphon (Figs. 202, 203).

This quadridentate form (whether distinct species or variety of *Galetta quadrivalvis*) has already been reported from the eastern side of the Pacific by Moser (1925, p. 140, Valparaiso, as "*Galeolaria quadrivalvis*"). Specimens of this type have also been definitely reported from the Mediterranean (Keferstein & Ehlers 1861, Bigelow 1918), and from the Indian Ocean (Quoy & Gaimard 1834). It seems that most of Moser's (1925) records for *G. quadrivalvis* also belong to *G. quadridentata*, hence the latter is evidently as wide-ranging (in fact cosmopolitan in warm seas) as is its bidentate relative.

*Galetta monoica*, Chun.

*Epibulia monoica*, Chun, 1888, p. 765 (1157).

For synonymy and descriptions, see Lens & Van Riemsdijk, 1908, p. 60, *pl.* 9, *figs.* 76, 77; Bigelow, 1911 a, p. 239, *pl.* 6, *figs.* 4-9; Moser, 1925, p. 144; Browne, 1926, p. 69.

Station 45, surface, two superior and one inferior nectophore.

Station 87, 1090-0 meters, one superior nectophore.

Station 94, surface, one inferior nectophore.

Although these bells are in a very fragmentary state, they all show the basal dentition so clearly that their specific identity is assured.

Moser (1925, p. 145) considers this form a "belanglose Varietät" of *G. quadrivalvis*. But as no intermediates, with regard to basal dentition, have been reported, though the typical *monoica* has been represented in several gatherings of siphonophores (most recently in Professor J. Stanley Gardiner's collection from the Indian Ocean described by Browne, 1926, and in the Madeiran collection reported upon by Candeis, 1929), it is more rational to regard it as a good species: as well-defined, indeed, as is any species of *Galetta*, and by alternative characters as precise.

The differences between *monoica*, *quadrivalvis* and *quadridentata*, may be summarized as follows:—

1. Superior nectophore: (A) with one dorsal and two dorso-lateral teeth; one lateral projecting lappet on each side, and divided basal-wing, *monoica*:—(B) with two dorsal teeth and divided wing, *quadrivalvis*:—(C) with four basal teeth (two dorsal, two lateral) and divided basal wing, *quadridentata*.

2. Inferior nectophore: (A) with three dorsal teeth, one lateral projecting angle on each side, and undivided baso-ventral wing, *monoica*:—(B) with four teeth (two dorsal, one lateral on each side), and with divided baso-ventral wing; *quadrivalvis* and *quadridentata*.

3. Outlines of inferior nectosac: simple in *monoica*; with anular contractions in *quadrivalvis* and *quadridentata*.

The superior bells of *monoica* so far examined also agree in a much shorter somatocyst than is usual either in *quadrivalvis* or *quadridentata*.

The present specimens are all so battered that they add nothing to the previous accounts. Additional information as to the stem-groups is especially to be desired.

Locality-records for *Galetta monoica* include the region of the Canaries (type locality), the general vicinity of the Cape Verdes and the triangle between Bermuda, the Bahamas and the coast of the United States in the Atlantic; the Eastern Tropical Pacific; Japanese waters; the Philippine and Malaysian regions; and the Tropical Indian Ocean. Evidently it is so widespread that it can be described as cosmopolitan in the warm belts of the oceans. It seems not to have been recorded as yet in the Mediterranean, but is to be expected there. The depths of capture prove it chiefly epiplanktonic.

*Galetta australis*, Quoy & Gaimard.

*Galeolaria australis*, Quoy & Gaimard, 1834, p. 42, pl. 5, figs. 29–31.

For synonymy, recent descriptions and discussions, see Bigelow, 1911 a, p. 238, pl. 5, figs. 8, 9 (omitting *G. chuni* from this synonymy); Moser, 1925, p. 145, pl. 4, figs. 1, 2; Browne, 1926, p. 57; Candeis, 1929.

Stations 94, 97, 98, 100, 102; hauls between surface and 300–0 meters; nine superior and eleven inferior nectophores.

The successive studies listed above have made this (next to *quadrivalvas*) the best-known *Galetta* so far as the conformation of the bases of the nectophores is concerned; the upper has a divided baso-ventral wing but no basal teeth; the lower also lacks basal teeth, and has an undivided ventro-basal wing.<sup>11</sup>

<sup>11</sup> Moser (1925, p. 148) states that I have shown the basal wing of the inferior nectophore as divided. Actually, as the legend states, the figure to which she refers (Bigelow, 1911 a, pl. 6, fig. 2), was of the superior nectophore, not the inferior.

In my earlier discussion I referred *Galetta chuni* Lens & Van Riemsdijk provisionally to the synonymy of *Galetta australis*. But Moser (1925) and Browne (1926) who have examined specimens of the *chuni* type, both consider it distinct, though on somewhat different grounds. According to the former the canal system is the most important distinction between the two (see her synopsis, p. 139), while differences in the length of the somatocyst are nothing more than variations. Browne, however, has reached the opposite conclusion from his observation that large specimens of this general group, whether with short somatocysts—(his “*australis*”)—or long (his “*chuni*”) invariably show the complex type of canalization, whereas small ones vary in this respect, indicating that the oblique commissures connecting the ventral canal with the laterals are usually formed late in development. And my own observations tend to corroborate this, four of the superior nectophores in the *Arcturus* series clearly showing this oblique commissure-canal, whereas one small one (about 7 mm. high) as clearly lacks it. Similarly, 35 specimens more than 10 mm. long from the Eastern Tropical Pacific all show the commissure; also 10 examples (v 10 mm. long) from the Western Atlantic (*Bache*), 10 from Japanese waters (*Albatross*) and 20 taken among the Philippines.

I must point out that my earlier illustration (1911 a, *pl. 6, fig. 3*) does not correctly show the canalization of the inferior nectophore, the connection of the lateral canal with the pedicular having been omitted. This is correctly shown by Moser (1925, *pl. 3, fig. 2*) as looped, just as it is in *Galetta quadrivalvis* and in *Galetta monoica*.

Final decision as to whether the length of the somatocyst is any more significant as a specific character, as between *australis* and *chuni*, can only come from cumulative evidence. In the eight superior nectophores of the present series, the somatocyst falls considerably short of the mid-level of the nectosac i. e. is of small *australis* type; this also applies to the series collected by the *Albatross* in Philippine waters (Bigelow, 1919, p. 337). Ten *Albatross* specimens from Japan likewise all have very short somatocysts; so, too, 35 from the Eastern Tropical Pacific; and 10 collected by the *Bach* in the Western Atlantic. This, then, seems a comparatively constant character. And when given specimens can almost always be referred definitely to the one group or to the other, such groups can fairly be dignified with the name of “species,” in the sense in which this term is necessarily employed among siphonophores, even should an occasional intermediate be found.

Candeis' (1929) discovery of superior nectophores resembling those of the well-known *Galetta australis* in the conformation of the base, but with extremely minute somatocyst, raises, afresh, the question of the relationship to *australis* of the form described by Gegenbaur (1854, “*Diphye turgida*”) as lacking that organ. Here the *Arcturus* series gives no help.

The inferior nectophore of *Galetta australis* (the identity established by the fact that the Eastern Pacific collection of the *Albatross* contained several pairs, still connected)<sup>12</sup> bears a very long undivided baso-ventral wing, but (like the

<sup>12</sup> Moser (1925, p. 148) seems to have overlooked this observation, for she states that such inferior bells “muss anderswohin gehören, da auch ihre Lateralkanten sehr kurz statt lang sind.”

superior nectophore) lacks basal teeth. Moser points out that the lateral ridges of the inferior nectophores in the *Gauss* series that were taken with superior nectophores of *australis* (but not actually connected), extend down to the level of the bell opening, instead of ending an appreciable distance above the latter as they are shown in a photograph of one of the *Albatross* specimens (Bigelow, 1911 a, pl. 5, fig. 9) and as they appear in another from that same series, with two bells still connected, now in the collection of the Museum of Comparative Zoölogy. But as Browne (1926, p. 69) has remarked, "to see clearly these ridges it is necessary to have very good specimens."

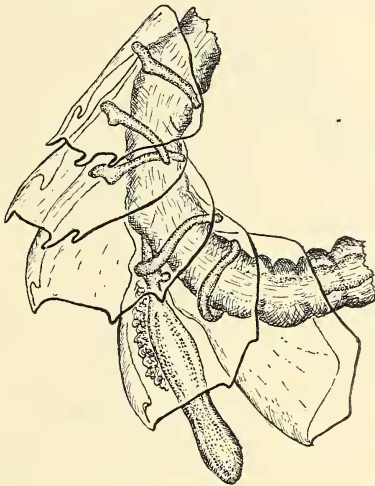


Fig. 204. *Galetta australis*; portion of stem, to show bracts,  $\times 27$ ; from a specimen from Albatross Sta. 4661.

The early accounts of the stem-groups (Sars, 1846, "*Diphyes biloba*"; Gegenbaur 1860, "*Diphyes sarsii*"), show that they closely resemble those of *G. quadrivalvis* in the conical shape of the bracts, in the small size of the gonophores, and in the lack of special swimming bells. According to Gegenbaur, the bract has one prominent marginal tooth or angle; whereas Sars credits it with four. But portions of stems, with the bracts still attached, from the *Albatross* Eastern Pacific series, suggest that this difference is chiefly one of the stage of development and state of preservation, for younger bracts show four strong marginal teeth, which are represented only by angles in older bracts. One segment of stem, in particular, shows this succession very clearly (Fig. 204).

The very stout bracteal canals recall those of *Galetta quadrivalvis*, by their prominence. And the gonophores, siphons and tentacles are similarly borne on tubular, cylindrical diverticula from the stem, which at the same time form pedicles for the siphons (Fig. 205). Here (as in *quadrivalvis*) one gonophore per stem-group seems to be the invariable rule.

In each of the specimens collected by the *Albatross* in the Eastern Tropical and in the Northwestern Pacific, with base of stem intact, a bud is to be seen

for a future nectophore (Figs. 206-207).<sup>13</sup> In most cases it may be assumed that this, bud is fated to develop into an inferior nectophore, because it is a large superior nectophore that still bears the stem. But in one case it is a large inferior nectophore, that bears the base of the stem, and here one of the two reserve buds (Fig. 207) evidently represents a future superior bell, just as is the case with one of *Galetta quadridentata* shown in figure 201 (see also p. 557). This

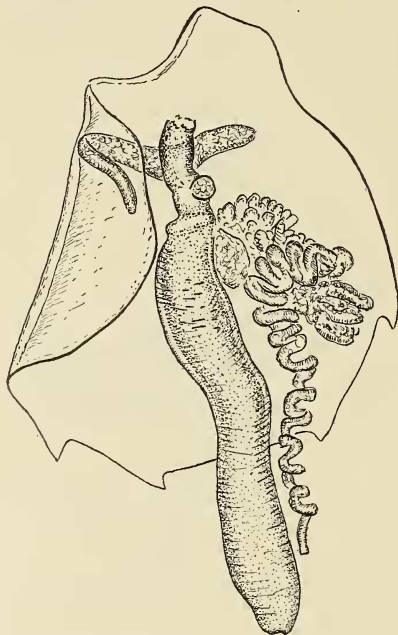


Fig. 205. *Galetta australis*; group of appendages,  $\times 50$ ; from a specimen from Albatross Sta. 4727.

raises the interesting question whether the future fate of such buds (i. e., to form superior or inferior bells) is determined from their first appearance, or whether it depends upon which of the two bells has become detached from the stem.

As more than two large bells have never been seen in any specimen of *Galetta*, we have as yet no knowledge of how many may be formed in succession: nor do we know whether the successive detachment and subsequent replacement by younger bells is a normal process, or whether it is simply a method of repairing accidental mutilation. But in view of the facts that the process has now been demonstrated in three species of the genus (*quadrivalvis*, *quadridentata* and *australis*), and that reserve buds have been found in most (if not all) of the specimens with stem attached on which they have been sought, the former alternative seems the more likely.

<sup>13</sup> None of the *Arcturus* specimens show this, having lost all trace of stems.

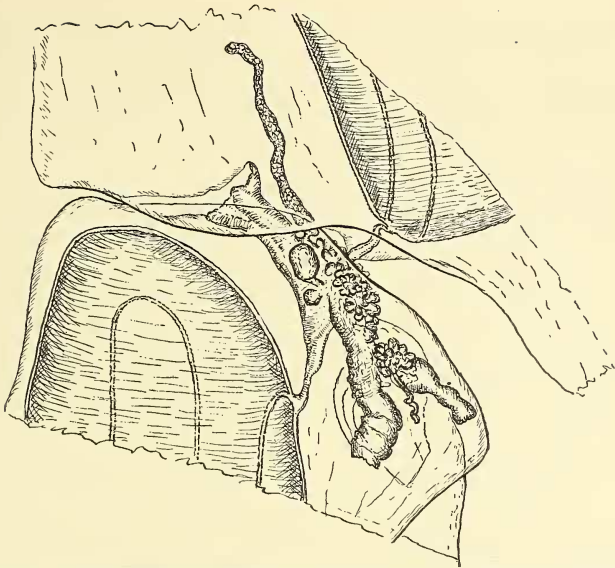


Fig. 206. *Galetta australis*; base of superior, and apex of inferior nectophore, to show their attachment, and the reserve-buds; from a specimen from Albatross Sta. 4704.

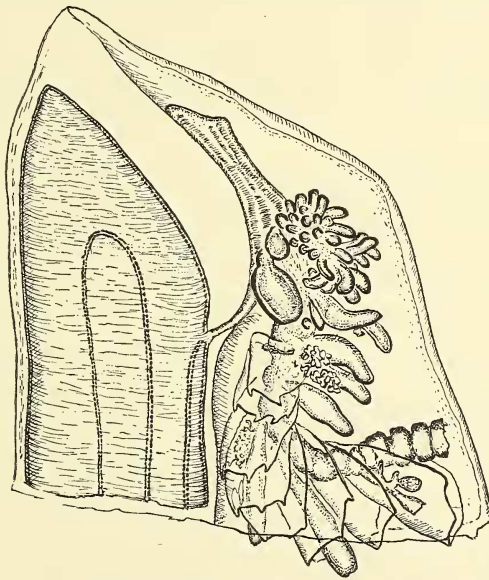


Fig. 207. *Galetta australis*; apex of inferior nectophore,  $\times 15$ ; to show base of stem, and reserve-buds; from Albatross Sta. 2747.

From the systematic standpoint, the fact that the occurrence of this succession of bells characterizes a group of species is of much interest, for it sets this category apart from the Diphyinae much more sharply, and in a more significant way, than do such morphological features as depth of the hydroecial indentation in the base of the superior nectophore, or the prominence of the ridges on the surface of the latter.

The *Arcturus* captures of *Galletta australis* (all from the general vicinity of Bermuda, in the Atlantic) call for no special comment, for this species is now known to be widespread in all oceans (identity of the Atlantic *biloba* with the Indo-Pacific *australis* having been sufficiently established by comparison between series from the different oceans). It has already been taken at many stations between Bermuda, Bahamas, and Chesapeake Bay by the *Bache*. It is rather surprising, however, that none of the many tows that the *Arcturus* made in the Panama-Galapagos region yielded it, for the *Albatross* had it at a number of stations in this part of the Pacific (Bigelow, 1911 a, p. 238).

*Diphyes dispar*, Chamisso & Eysenhardt.

*Diphyes dispar*, Chamisso & Eysenhardt, 1821, p. 365, pl. 33, fig. 4.  
For synonymy, see Bigelow, 1911 b, p. 257; Moser, 1925, p. 170; Browne, 1926, p. 79.

Stations 3, 11, 47, 69, 98, 102; hauls between the surface and 300-0 meters; two pairs of nectophores still united, with part of stem intact; also, nine loose superior and two loose inferior nectophores.

This well-known species has often been described and figured; its superior nectophore is so characteristic in appearance that it is one of the most easily recognized of siphonophores. The present series, all more or less fragmentary, add nothing to previous accounts of better material: see especially Haeckel, (1888 a, p. 153, pl. 33, 34, "*D. compressa*"), and Moser, (1925, p. 185, pl. 5-7, pl. 8, figs. 1, 2) who has given a summary of the characters that separate it from *D. bojani*.

Like so many siphonophores, *D. dispar* is now known to be cosmopolitan in tropical and warm temperature latitudes, except that it has not been found in the Mediterranean, a curious fact to which Moser (1925, p. 180) has already called attention. It had already been reported from the general regions, Atlantic and Pacific, covered by the *Arcturus* cruise.

*Diphyes appendiculata*, Eschscholtz.

*Diphyes appendiculata*, Eschscholtz, 1829, p. 138, pl. 12, fig. 7.  
For synonymy, see Bigelow, 1911 a, p. 248; Moser, 1925, p. 231 (as "*Diphyes sieboldii*," K lliker), Browne, 1926, p. 71).

Moser (1925) has revived K lliker's (1852) name *sieboldii* for this cosmopolitan and well-known species, on the ground that Eschscholtz' (1829) description might apply equally to any one of three species of the genus. Even were that the case, stability of nomenclature would be served, and the generally accepted rules best adhered to by following the lead of the several reviewers who have used the name *appendiculata* for the Diphyid in question, which otherwise will always remain a stumbling block. And the original description does sufficiently warrant this course, for Eschscholtz' account and illustration mention features making it practically certain that his *appendiculata* was the



same species that has subsequently been so often reported as *D. bipartita* Costa or as *D. sieboldii* Kölliker.

Thus he states (p. 139) that in neither nectophore does the opening bear teeth (clearly this refers to the dorsal and lateral teeth of the nectosac, not to the dorsal hydroecial wall). His description (p. 138) of the superior nectophore as showing only two angles on the side occupied by the nectosac, but three angles on the side occupied by the hydroecium, is a clear statement of the suppression of the dorsal ridge of the species in question—meaningless if applied to any other Diphyid yet known. Lastly his illustration of the superior nectophore shows the outline of the hydroecium, as well as the relative proportions of nectosac and somatocyst, a combination of characters sufficient for identification in this case.

Few, in fact, of the early accounts or illustrations of the bells of siphonophores, prior to the middle of the nineteenth century, are more diagnostic than Eschscholtz' of *appendiculata*.

*D. appendiculata* was taken at Stations 11, 84, 87, 97, 98 and 100, in hauls between the surface and 1000-0 meters. The material consists of about 75 superior and three inferior nectophores. This species is now so well known morphologically that the present series calls for no special comment. It affords cumulative evidence that the left lateral ridge invariably rises some distance below the apex in the superior nectophore; no variant from this state has yet been recorded. Examination of Atlantic and Pacific Diphyids of this type have shown that they are indistinguishable.

Because of their transparency, the inferior nectophores are apt to be overlooked among the other plankton; probably the poverty of their representation in the *Arcturus* material is so to be explained.

*D. appendiculata* has already been reported on various occasions from the parts of the Pacific and Atlantic oceans sampled by the *Arcturus* hauls.

*Diphyes bojani*, Eschscholtz.

*Eudoxia bojani*, Eschscholtz, 1825, p. 43, pl. 5, fig. 13.

For synonymy and description, see Bigelow, 1911 a, p. 251, pl. 7, figs. 2, 3; pl. 8, fig. 6; pl. 9, figs. 1, 2; pl. 10, figs. 2, 3; pl. 11, fig. 5; pl. 12, fig. 1; 1918, p. 424; 1919, p. 340; Moser, 1925, p. 208, pl. 13: fig. 1; Browne, 1926, p. 80.

Stations 2, 11, 87, 97, 102; hauls between the surface and 1500-0 meters; four pairs of nectophores still united, about 80 loose superior and two loose inferior nectophores, also nine superior and one inferior nectophores labelled simply "Atlantic."

The morphology of this species has been described and figured in such detail in the publications quoted above, that it is now one of the best-known of Diphyids. And the fact that its representatives in the Atlantic and in the Pacific are specifically indistinguishable has been sufficiently established by actual comparison of series from the two oceans.

As Moser (1925) has shown, the one diagnostic feature than can be relied upon to separate the superior nectophore of *D. bojani* from that of *D. dispar* at all stages in development, is the presence in the former of a crest on the dorsal wall of the hydroecium below the level of the nectosac. Usually this crest or ridge bears from one to three or four teeth, but Browne (1926) records specimens in which these teeth were lacking.

The details of origin of the ridges at the apex of the superior nectophore, and the degree to which the lateral ridge are expanded, wing-like, shows much individual variation. It is therefore worth noting that the great majority of the present series, both from the Atlantic and from the Pacific show wing-like expansions of considerable breadth (c/f Bigelow, 1911 a, *pl. 8, fig. 6*) and have five ridges at the apex.

*D. bojani* is cosmopolitan in tropical and subtropical seas, already recorded in the general regions (Atlantic as well as Pacific) covered by the *Arcturus* records. For a survey of its distribution as now known, see Moser, 1925, *p. 211*, to whose summary the Philippine waters must be added (Bigelow 1919, *p. 3*). The depths of capture of the various series so far reported show that *bojani* inhabits chiefly the upper stratum of water.

*Diphyes mitra*, Huxley.

*Diphyes mitra*, Huxley, 1859, *p. 6, pl. 1, fig. 4.*

For synonymy, see Moser, 1925, *p. 256*; for description, Bigelow, 1911 a, *p. 258, pl. 7, fig. 9; pl. 9, fig. 4; pl. 10, figs. 4, 5; pl. 11, fig. 6; pl. 12, fig. 5; Moser, 1925, p. 260, pl. 8, figs. 6-8; pl. 13, figs. 8-11; pl. 14; Browne, 1926, p. 73.*

Stations 45, 69, 74, 98; hauls between the surface and 1500-0 meters; six superior and one inferior nectophores.

These few loose nectophores add nothing to the detailed studies of this species that have recently been made (see above).

*D. mitra* was already known to be widespread in the tropical and warm temperate belts of all the oceans. Having been reported at many localities in the Eastern Tropical Pacific, it was to be expected at the *Arcturus* stations there. For the most recent geographic summary, see Moser, 1925, *p. 258*.

*Chuniphyes multidentata*, Lens & Van Riemsdijk.

*Chuniphyes multidentata*, Lens & Van Riemsdijk, 1908, *p. 13, pl. 1, figs. 9-11, pl. 2, figs. 12-15; Bigelow, 1911, p. 348; 1911 a, p. 262, pl. 8, fig. 9; pl. 10, fig. 7; pl. 12; fig. 6; 1913, p. 73; 1918, p. 425; 1919, p. 344; Moser, 1925, p. 357, pl. 23, figs. 1-4, pl. 24, figs. 1, 2.*

Station 10, 909-0 meters, one superior nectophore.

Although the single nectophore (about 30 mm. long), is much crumpled, the bells of this species are so characteristic in appearance that identification is positive.

This species has been described fully, in the accounts of the *Albatross*—Eastern Pacific, Biscayan and *Gauss* collections, quoted above. The only morphological feature calling for comment here is the arrangement of the ridges, and the conformation of the base of the superior nectophore. All specimens so far examined have shown four such ridges, dorsal, ventral, and a lateral on each side, meeting, quadrate, at the apex: apparently there is no variation in this respect. The dorsal and ventral ridges divide, dichotomously, a short distance below the apex (for lateral views, see Bigelow, 1911 a, *pl. 8, fig. 9*, and Moser, 1925, *pl. 23, fig. 1*). The ventral ridge runs, undivided, along about one-third the length of the nectophore (Fig. 208). There, according to my earlier account, it meets the opening of the hydroecium, (1911 a, *p. 262*), whereas Moser (1925, *p. 358*), describes it as dividing to continue as "Paarigen Ventralkanten flügelartig verbreitert im Bogen zur Basis, das offene Hydroecium zwischen sich fasend . . .". Correspondingly, I have interpreted the

base of the whole marginal sector, extending antapically from the beginning of the hydroecial groove, as belonging to the "base," whereas Moser uses the latter term in a more restricted sense.

The difference, however, is merely one of interpretation and of descriptive wording, not of observation nor of fact. All specimens so far examined show a well-defined groove, commencing at the point where the ventral ridge either

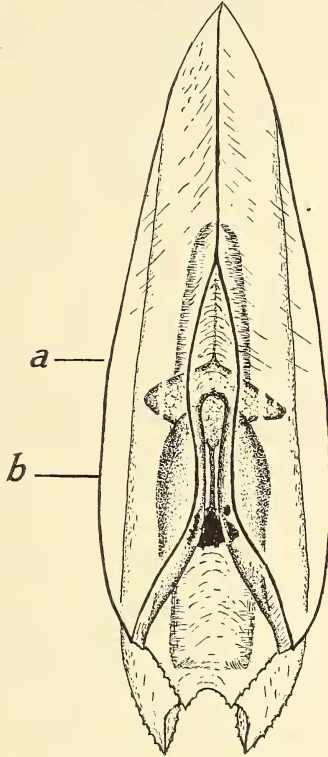


Fig. 208. *Chuniphyes multidentata*; ventral view of superior nectophore,  $\times 7$ ; from Albatross Sta. 4759.

divides (according to the interpretation) or merges into the two hydroecial walls. Proceeding antapically, this groove widens and deepens; at about the mid-level of the bell, and about opposite the mid-level of the somatocyst, it abruptly deepens, merging into a deep and voluminous hydroecial cavity.

Cross-sections of the bell at successive levels thus have the outlines shown in figure 209. A comparison with Moser's illustration (1925, *pl. 23, fig. 2*) will bring out the correspondence in this respect between Pacific and Atlantic specimens.

The leaf-like marginal extensions of the left and right hydroecial wings,

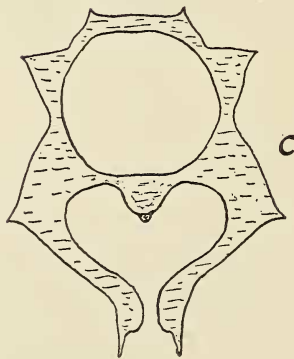
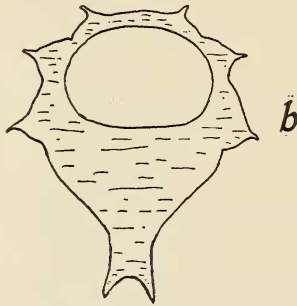
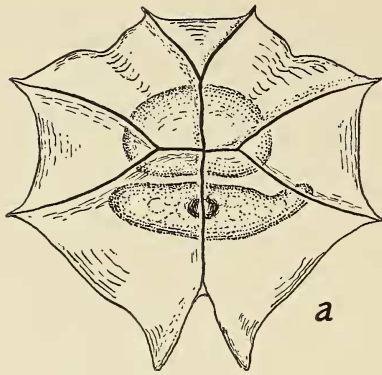


Fig. 209. *Chuniphyes multidentata*; superior nectophore; apical view (A), and cross sections (B & C) at the levels marked A and B on Figure 208; from Albatross Sta. 4759.

regarded by Moser as continuations of the ventral ridge, continue around the margin, being joined by the ventro-lateral ridges, until finally they merge into the dorso-basal margin of the hydroecium. Thus, whether the bell is to be described as having seven ridges at the base, or only six, depends on just where, along the ventro-basal margin, the "base" is interpreted as commencing.

As appears in side view, the base shows the following definite projecting angles: one, (smaller) at the termination of each dorsal ridge; one (larger) at the termination of each dorso-lateral ridge; and one (less prominent) on each side at the point where the margin of the dorsal wall of the hydroecium joins each of the lateral wings that enclose the latter. There are no marginal teeth or projecting angles at the termination of the ventro-lateral ridges. These six basal angles or teeth are more or less prominent, according to the state of contraction or flaccidity of the bell as a whole.

According to Moser (1925, p. 360), adult nectophores show no denticulation on ridges or on basal margin, though young bells are always to some extent serrate. Preserved specimens vary in this respect. Thus in one of the *Albatross* specimens from the Eastern Tropical Pacific (Bigelow, 1911 a, *pl.* 8, *fig.* 9), the lateral and dorsal ridges and the basal margin were weakly denticulate. And a strongly contracted and well preserved specimen from Alaskan waters (Fig. 208) shows much this same condition, with the dorsal margin of the hydroecium, the lateral and dorsal margins of the bell opening, and the basal parts of the dorsal and dorso-lateral ridges all weakly and irregular serrate. A Philippine specimen bears very small and sparse denticulations along the margin, but no trace of serration on the ridges: one bell from the Bay of Biscay shows much this same state, but in others from the same collection margin and ridges are perfectly smooth.

In the *Arcturus* example the somatocyst has been destroyed; but remaining indications of its outline show that its median dilation had an ovate outline, longer in the transverse than in the longitudinal axis, thus falling well within the range of variation previously recorded.

All records for this species have been from tows from considerable depths; clearly it is bathypelagic in habit. And like so many other members of this faunal community, it is widespread in all the great oceans. Although so far reported from only seven collections, the records include Malaysian and Philippine waters; Eastern Tropical and Northwestern Pacific; Eastern Sea between China and Japan; the Bay of Biscay and the mid-Atlantic between 28° N. and 32° S.

#### Family UNCERTAIN.

#### Genus *Archisoma*, Bigelow 1911.

*Archisoma natans*, Bigelow.

*Archisoma natans*, Bigelow, 1911 a, p. 266, *pl.* 20, *fig.* 6; 1919, p. 344; Moser, 1925, p. 383.

Station 61, 909-0 meters, one specimen; bract 54 mm. long and swimming bell 31 mm. long.

Only two specimens of this remarkable eudoxid, of problematical parentage, had previously been taken, both of them by the *Albatross*, the first in the Eastern

Tropical Pacific, the second in the Gulf of Boni, Celebes. This third example is therefore a welcome find.

The general characteristics of *Archisoma* have already been described (see above): the present specimen, however, shows some minor divergences that deserve notice, though their systematic significance cannot be determined until larger series are studied. As has already been pointed out in earlier accounts,

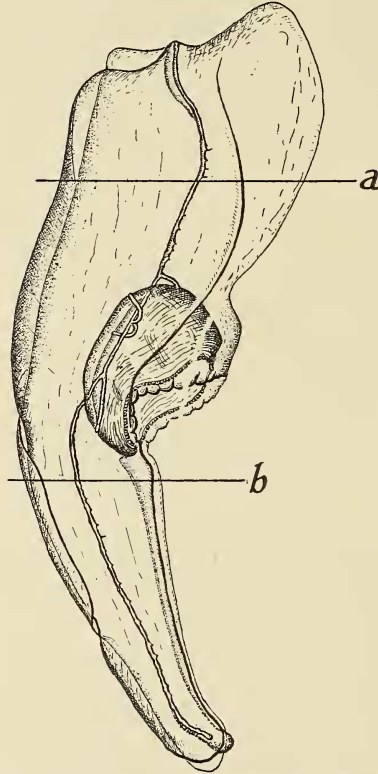


Fig. 210. *Archisoma natans*; lateral view of special nectophore,  $\times$  about 3; from *Arcturus* Sta. 61.

both special nectophore and bract are highly characteristic in conformation; the excellent example of the former in the *Arcturus* collection makes its illustration (Figs. 210–216) desirable.

I must add to the earlier account, that the ventral-lateral faces of the nectophore are expanded in two wings. In their present state, these overlap, (right and left wings alternately) as shown in figure 210 so as to form an enclosed hydroecial tube extending from end to end of the bell.

The ventral face of the nectosac is also deeply indented along the longitudinal axis of the bell, a feature that seems characteristic, not the result of

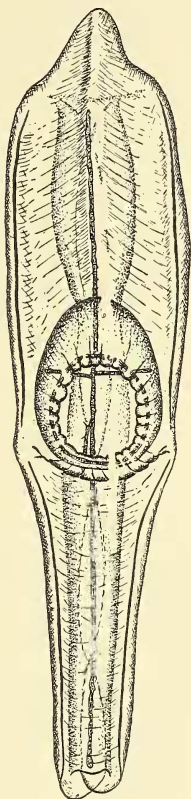


Fig. 211. *Archisoma natans*; dorsal view of nectophore illustrated in Figure 210,  $\times$  about 3.

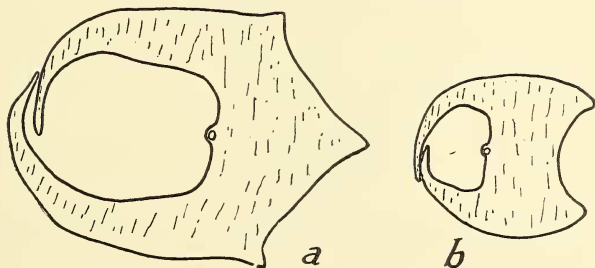


Fig. 212. *Archisoma natans*; schematic cross sections of the nectophore,  $\times$  4.7, at the levels indicated on Figure 210.

contraction since this was also true of the type specimen (Bigelow, 1911 a, *pl.* 20, Fig. 6). The arrangement of the canals of the nectophore is precisely as in

the Celebes specimen (Bigelow, 1919, p. 345); i. e. there is one main trunk running lengthwise along the dorsal side of the hydroecium from the point of

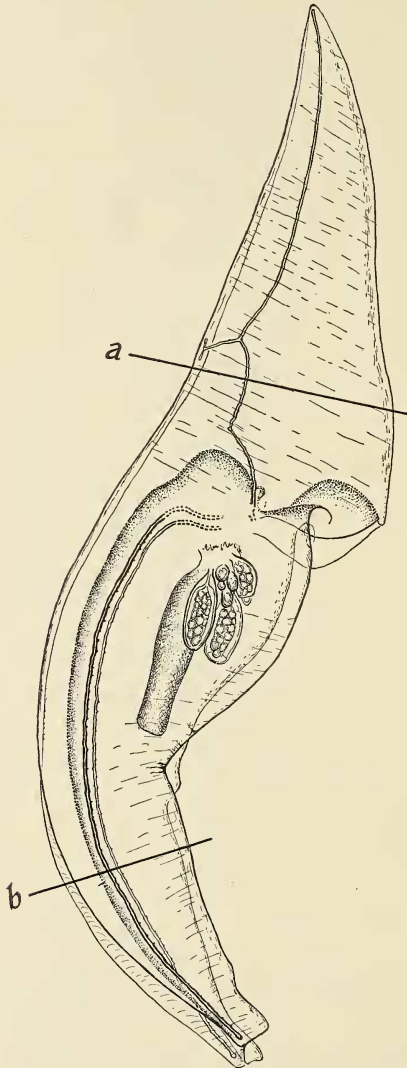


Fig. 213. *Archisoma natans*; lateral view of bract,  $\times$  about 2.5, of specimen illustrated in Figure 210.

pedicular attachment at the superior end of the bell. This trunk gives off one short branch running to the superior face of the nectosac, another to the inferior



face of the latter, and a pair of branches (arising in union), running to the ventral face of the nectosac, slightly above its mid-level. In the nectophore of the type specimen the main trunk gives off a short transverse branch, dorsad,

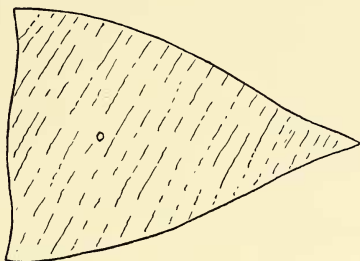


Fig. 214. *Archisoma natans*; schematic cross section of the bract,  $\times 4.5$ , at the level marked A on Figure 213.

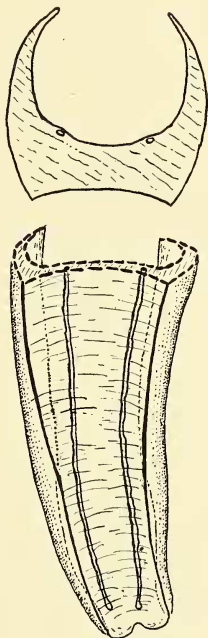


Fig. 215. *Archisoma natans*; dorsal view of inferior portion of bract,  $\times 4.5$ , with schematic cross-section at the level marked B on Figure 213.

slightly below the level of the nectosac. In the present example this branch is lacking, but the wall of the main trunk shows various minor irregularities.

The dorsal surface of the inferior gelatinous prolongation of the nectophore is definitely concave (not mentioned in the earlier accounts) with each of its

dorso-lateral angles extending upward, toward the apex, across the dorso-lateral face of the superior half of the bell, as a fairly distinct ridge. These ridges did not appear on the type—but the latter was not in such good condition. The schematic cross-sections (Fig. 212) illustrate the resultant contour.

The canalization of the bract (Fig. 213) differs in one interesting respect from that of the two examples previously described. In both of these the two descending hydroecial trunks arise together, but at once separate; and by re-examination, I have verified my account of them as “descending over the two

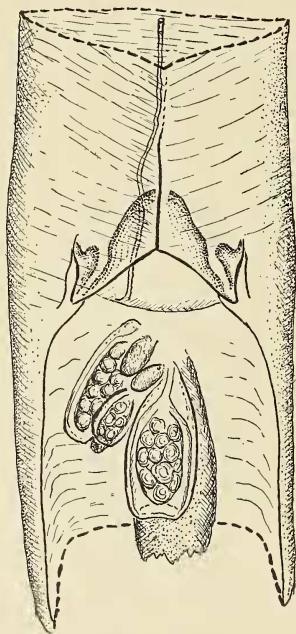


Fig. 216. *Archisoma natans*; ventral view of mid-sector of bract,  $\times 4.5$ , illustrated in Figure 213.

faces of the hydroecium, on the right and left respectively to unite near the tip of the bract” (1919, p. 345), beyond which a single trunk extends a short distance further. In the present example the trunks arise similarly, and follow in general a similar course down the hydroecium, but instead of uniting, they continue independent to the tip of the bract, where each terminates in a small dilation (Fig. 213). The ascending trunk has a transverse branch running to the dorsal surface as in the Celebes specimen (in the type this part was damaged).

In its general form the bract resembles that of the original specimen (Bigelow, 1911 a, pl. 20, fig. 61), but is more strongly pyramidal above the level of the hydroecium; triangular in cross-section (Fig. 214); its angles are sharper; its dorsal surface (rounded in the *Albatross* specimen) is concave below the mid-level of the bract, with concavity increasing toward its inferior tip (Fig. 215).

The apex of the hydroecial cavity of the bract also shows a peculiarly complex conformation, with secondary recesses (Fig. 216), that were not seen in the type, though in this case preservation may have been responsible for the apparent difference. Finally, in the present example the hydroecial furrow extends inferiorly right to the extremity of the bract (Fig. 213), as was also true of the Celebes specimen,<sup>14</sup> whereas in the type it terminates some distance above the tip.<sup>14</sup>

In the *Arcturus* specimen the region of attachment for siphon and pedicular canal has been destroyed, as has the tentacle. But three well developed gonophores containing large eggs are still intact, with young buds for several more (Fig. 216). Evidently *Archisoma* is dioecious.

The significance of the small differences between the three specimens of *Archisoma*, that have so far been seen, is bound up with the problem of the parentage of this peculiar eudoxid.

In my discussion of the Celebes example I pointed out that the canals of the nectosac were of a type peculiar (so far as known) to the Monophiid *Nectopyramis thetis* (Bigelow, 1911), suggesting identity with that species, rather than with some Prayid as I had previously (1911 a) suggested. Moser (1925), however, thinks it likely that *Archisoma* is the eudoxid of *Praya dubia*.

This point can not be settled until the stem-groups of *Praya dubia* and of *Nectopyramis thetis* have been studied. It is clear, however, that if *Archisoma* is the eudoxid of a *Nectopyramis*, it belongs either to *N. thetis* or to some species as yet undescribed, because the eudoxid of *N. diomedea* not only has a bract very different in form, but lacks the special nectophore (Bigelow 1911 a, pl. 1). If, however, *Archisoma* belongs to *Praya*, *P. dubia* is the probable parent as Moser believes, because (if my identification of the stem-groups described above is correct), *P. reticulata* lacks a special nectophore, and has a very different bract.

#### Family AGALMIDAE, Brandt 1835

*Agalma okeni*, Eschscholtz.

*Agalma okeni* Eschscholtz, 1825, p. 744, pl. 5, fig. 17; 1829, p. 151, pl. 12, figs. 1 a-1 d.

For synonymy and detailed descriptions see Bigelow 1911 a, p. 277, pl. 17.

This species was taken at Stations 26, 28, 38, 39, 45, 51, 52, 56, 57, 62, 74, 78 and 107, in hauls ranging in depth from surface to 1274-0 meters. This material consists of parts of upwards of 18 colonies, plus a large number of detached nectophores and bracts. None of the specimens are as well preserved as might be wished. But fortunately the species is made so easily recognizable by the characteristic outline and unusually firm texture of swimming bells and bracts, as well as by the relatively stiff, short stem, that identification is positive.

Kawamura (1911) has recently reopened the question as to the relationship of the *A. polygonata* of Dana (1858) to *A. okeni*, with which most recent authors have united it; unfortunately I have not been able to consult this paper. All the present series and most of the other specimens that I have seen (1911 a, pl. 17, fig. 12) show the conformation of the nectophores pictured by Dana (1858), in which each lateral face is transversely divided by two ridges, so that each

<sup>14</sup> These have been re-examined.

side of the bell may be described as consisting of three facets. Eschscholtz' (1829) figures of the swimming bells of his *A. okeni* are so generalized that they are not diagnostic in this respect, for they do not show the transverse ridges at all. So far as they go, however, they are more compatible with the presence of only one of the ridges in question rather than with two on each lateral face of the nectophore. Among the collection of *Agalma* of this general type in the Museum of Comparative Zoölogy, there are a few specimens in which the bells (in the preserved state) show only one transverse ridge on each lateral face. These specimens, however, are all in a very flaccid condition, while the prominence of the ridge in question varies considerably in the specimens with show two. Furthermore, while Haeckel's (1869, *pl.* 10, *fig.* 67) figure of the nectophores of his *Crystallodes rigidum* show only one ridge, his pictures of *C. vitrea* (1888 a, *pl.* 17, *fig.* 10) show both types of bells, presumably from a single specimen. Present indication, therefore, is that this difference in the number of ridges is either an individual variation, or is perhaps associated with the state of preservation (or of muscular contraction) of the specimens in question.

And this explanation is rendered the more likely by the fact that bracts also show an interesting variation, some of them having only the four chief marginal facets, while in others there are one or two subsidiary facets in addition (1911 a, *pl.* 17, *fig.* 10). Here there can be no question of a specific difference, because one of the *Arcturus* series (station 74, good condition) has bracts of both these types still attached to the one siphonsome.

In short, there seems no justification for reviving the name *polygonata* as distinct from *okeni*.

This species of *Agalma* was already known to be widespread, and general in its occurrence in the warm belts of all oceans including the Mediterranean, as recently found by Moser (1925).

#### Family AGALMIDAE, genus and species?

Bracts, nectophores and fragments of stem of agalmids, too fragmentary for identification, were also taken at Stations 32, 38, 39, 51, 112, 113.

#### Family FORSKALIIDAE, Haeckel, 1888.

##### *Forskalea* species?

One stem, denuded of all appendages except a few young nectophores, is referred to *Forskalea* because these show traces of the pedicles characteristic of this genus.

Station 59, 1090-0 meters.

#### Family PHYSOPHORIDAE, Eschscholtz 1829 (sensu Huxley 1859).

##### *Physophora hydrostatica*, Forskål.

*Physophora hydrostatica*, Forskål, 1775, *p.* 114, 1776, *tab.* 33, *fig.* e.  
For synonymy, see Bigelow, 1911 a, *p.* 293.

This well known species was represented at Stations 29, 59, and 74; in hauls between the surface and 909-0 meters, a total of 17 specimens, most of them in very fragmentary condition.

*Physophora hydrostatica*, thanks to the simplicity of its architecture, and

to the fact that it preserves well, even in alcohol, is the best known of the Physophorae. At the same time it is the most easily recognized in its group. The present fragmentary material adds nothing to the previous accounts.<sup>15</sup>

Brandt (1835) long ago recorded *Ph. hydrostatica* (as "*Ph. ambigua*") from the Eastern Tropical Pacific. The *Albatross* had it at several stations in the same general region of the Pacific as the *Arcturus*—also in the Sulu Sea; while Huxley (1859) records it from the southern part of the Indian Ocean, and Lens & Van Riemsdijk (1908) from Malaysia. Evidently it is as widely distributed in the Indo-Pacific as it is in the Atlantic and Mediterranean. So far as I am aware, however, it has not yet been recorded from as high latitudes in the Pacific as in the Atlantic where it appears not infrequently in the Norwegian Sea around Iceland and right up to the Arctic Circle (Paulsen 1909, Romer, 1902).

#### Family ANTHOPHYSIDAE Brandt 1835.

*Anthophysa rosea*, Brandt.

*Anthophysa rosea*, Brandt, 1835, p. 35; Bigelow, 1911 a, p. 296, pl. 20, figs. 7-13; pl. 21, figs. 1-5; pl. 23, figs. 1-5; Moser, 1925, p. 441; Browne, 1926, p. 83.

Probably also identical is the Atlantic species with the following synonymy.

*Athyobia formosa*, Fewkes, 1882, p. 271-275, pl. 5, figs. 3, 4; pl. 6, figs. 7-14; Schneider, 1898, p. 162.  
*Plocophysa agassizii*, Fewkes, 1888, p. 318, pl. 17, figs. 1, 2.  
*Diplophybia (formosa)*, Fewkes, 1888, p. 320, Footnote.  
*Anthophysa formosa*, Haeckel, 1888, p. 43, 1888 a, p. 276; Chun 1897, p. 61, pl. 3, figs. 7, 8; Bedot 1904, p. 5, pl. 1, figs. 4-15.  
*Anthophysa darwini*, Haeckel, 1888, p. 43, 1888 a, p. 278, pl. 12, figs. 7-9.  
 ?*Angela cytherea* Lesson, 1843, p. 496, pl. 9, fig. 1.

Station 26, surface, two specimens, without bracts but otherwise in excellent condition.

Station 107, offing of Cape Hatteras, 1454-0 meters, one very fragmentary specimen.

The two Pacific specimens (station 26) agree so closely with the *Albatross* specimens from the same general region (Bigelow 1911 a) that no account of them is called for. Beyond the fact that the Atlantic specimen is a typical *Anthophysa*, little can be made out of it, for not only have all the bracts and siphons, and most of the palpons been detached, but the corm is so much damaged that the position of the siphons cannot be seen. That it is so fragmentary is much to be regretted, for no one has yet been able definitely to settle the relationship of the Atlantic to the Pacific representative of *Anthophysa* by actually comparing material from the two oceans. The most that can be said of this Atlantic example is that the peculiar cap-like arrangement of the bractel lamellae, partially surrounding the pneumatophore, agrees with the Pacific specimens. But this agreement has perhaps little bearing on the specific relationship, being common to the genus; specific characters are rather to be looked for on bracts, etc.

<sup>15</sup> See especially Sars 1877, Chun, 1897; for development, Haeckel, 1869 ("*Physophora magnifica*"). The Report on the Albatross Eastern Pacific Collection (Bigelow, 1911 a, pl. 16, contains a series of photographs.

*Athorybia rosacea*, Forskål.

*Physophora rosacea*, Forskål, 1775, p. 120; 1776, pl. 43, fig. B.  
For synonymy, see Bigelow, 1911 a, p. 349.

This species was represented at Stations 29, 53, 54, 59 and 74, in hauls varying in depth from 272-0 meters to 2000-0 meters. The material consists of seven fragmentary corms only two of which (stations 53 and 74) still bear any of the appendages, and 30 loose bracts.

Although *Athorybia* was one of the earliest studied of siphonophores (recog-

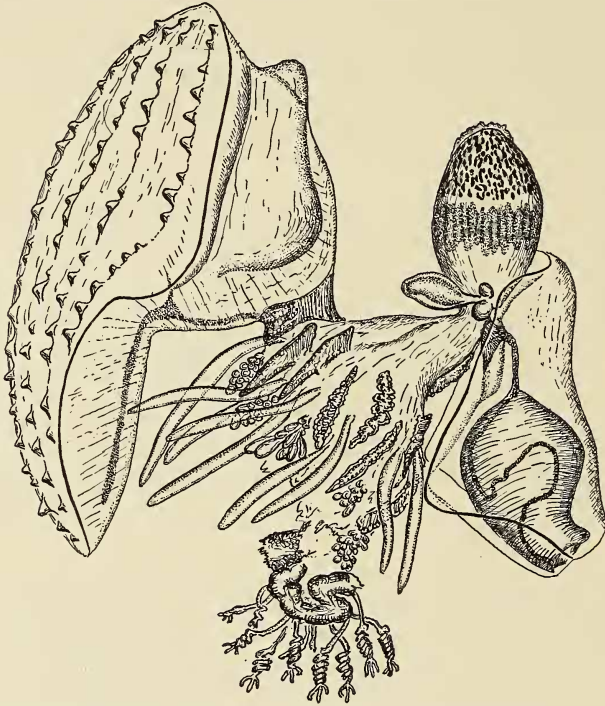


Fig. 217. *Athorybia rosacea*; general view of fragmentary specimen,  $\times 7$ ; from Arcturus Sta. 59. This specimen has lost most of the bracteal attachments, palpons and siphons.

nizable figure dates back to 1776), it has not appeared in any of the recent collections that have added so much to our knowledge of this interesting group. The present series is therefore of interest, especially as it offers an opportunity for comparison with the various older accounts that appeared during the last half of the past century, by Kölliker (1853, p. 24, Taf. 7); Gegenbaur (1860, p. 412, pl. 32, fig. 43, 44 "*Athorybia heliantha*"); Haeckel (1888 a, p. 276, pl. 11, figs. 10-18 "*Athorybia ocellata*"); Chun (1897, p. 49, Taf. 4 "*Athorybia melo*"); and Schneider (1898).

There is no question but that the forms described by Kölliker, Haeckel and Schneider under the names above listed represent a single species identical

with the *Rhizophysa melo* earlier described and illustrated by Quoy & Gaimard (1827), for in addition to the shortened stem, petal-like arrangement of bracts and tricornuate tentilla of the genus, all of them are characterized by bracts not only distinctive in outline, as described below, but longitudinally ribbed on

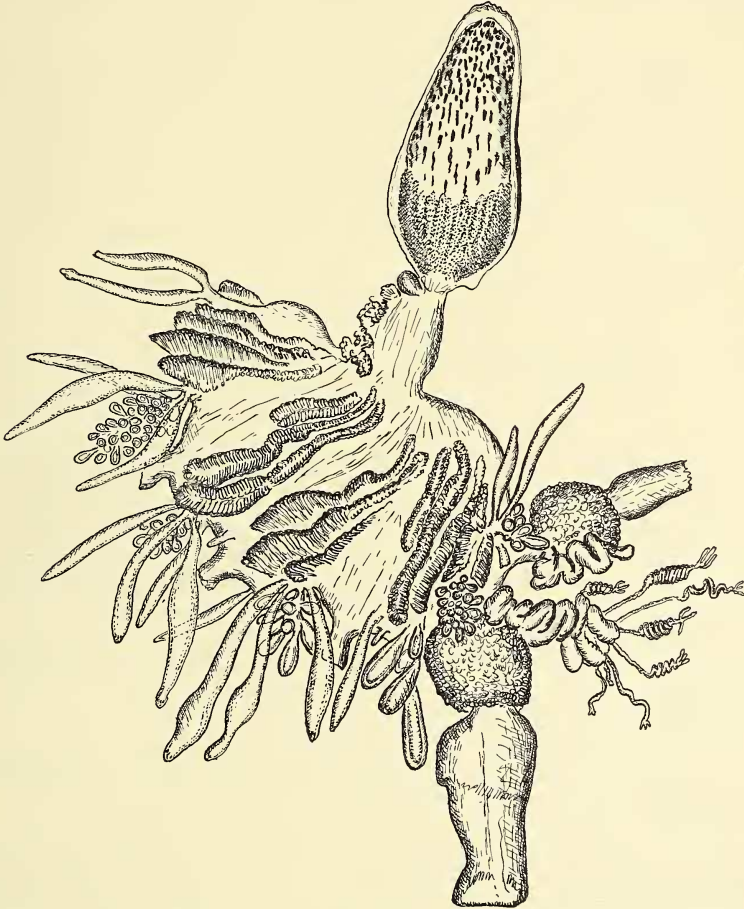


Fig. 218. *Athorybia rosacea*; general view of specimen,  $\times 8$ ; from Arcturus Sta. 74.

the distal surface with series of short conical gelatinous papillae. Unfortunately it will never be possible to settle conclusively whether or not it was this same form that Forskål described and pictured as *Physophora rosacea*, for his figures and account would apply equally to any *Athorybia*. But it will tend towards stability to employ Forskål's name, there being no internal evidence to forbid. Gegenbaur's (1860) *Athorybia heliantha* may be a distinct species, for while

his account agrees in general with those of K lliker, Haeckel and Schneider, he states that the surfaces of the bracts were not ribbed nor papillose. And as his material was evidently in good condition we cannot suppose that so close and accurate an observer would have overlooked a character as obvious as is the sculpture of the bracts of *A. rosacea*: especially when Gegenbaur especially emphasized this difference between his specimens and K lliker's. Furthermore Gegenbaur described the bracts as arranged in a spiral, which is not the case in *A. rosacea* (see p. 581 on this point). Gegenbaur identified his *Athorybia* with the *Physophora heliantha* of Quoy & Gaimard (1827), the bracts of which are similarly described and pictured by these French zoologists as smooth, with only "une strie longitudinale dans leur milieu," in contrast to the ribbed bracts of their *A. melo*. But their statement (1827, p. 178) that the stem of their *heliantha* was "susceptible de s'allonger indefiniment" raises the question whether their picture may not have been taken from a much contracted Agalmid of some sort.

The several accounts of *A. rosacea* have given us a good understanding of the general organization of this interesting genus, except as to the arrangement of siphons, palpons and gonodendra on the abbreviated corm, and their number. While the present specimens are too much contracted, and too fragmentary to clear this matter, they allow some additional notes on the individual organs especially welcome in the case of the stem and nectophores. The stem, as Haeckel seems first to have recognized, is separated into two distinct sectors, the upper nectosome, the lower siphosome, just as it is in all the long-stemmed Physophores and in *Physophora* as well. In contracted individuals it is so shortened that the attachments of the bracts are crowded up close against the pneumatophore; the latter may even be drawn downward until it is partially invaginated within the upper part of the stem, as Schneider (1898) found it in the specimens that he sectioned. But in relaxed specimens (formalin preservation is here of great advantage) the nectosome-sector is approximately as long as the siphosome-sector (Figs. 217, 218). And there is a considerable contrast between the two in breadth, the former relatively narrow, the latter expanded in a conical vesicle as Haeckel observed.

All of the *Arcturus* specimens show this distinction into an upper, neck-like and a lower swollen portion, though in most of them the former is more contracted than in the examples illustrated (Figs. 217, 218).

Careful examination of the present material is convincing to the effect that the siphosome-sector (as in all the long-stemmed Physophores, and in *Physophora*) bears only the nectophores—in this case mostly rudimentary. Early accounts to the effect that the bracts are attached immediately below the pneumatophore seem to have been based on contracted material and on the misconception that the muscular lamella that bears the one definitive nectophore, was that of a bract. Even Chun seems to have fallen into this last error, for although he described and beautifully pictured the one large nectophore (1897, pl. 4, fig. 3), the lamella, which was almost certainly its support, is designated on his figure of the contracted corm as the support for a bract (1897, pl. 4, fig. 1).



Every one of the present series shows 1-4 rudimentary nectophore buds just below the pneumatophore, and one muscular lamella, the identity of which is definitely established by the fact that in one example it still bears the larger definitive nectophore (Fig. 217). Otherwise the siphosome is bare of appendages or lamellae. That is to say, there is a definite zone of proliferation for nectophores.

These nectophore buds show various stages in development, from mere knobs to a stage when the bell cavity is visible though the bell is still closed terminally (Fig. 217). The only large bell that is still intact agrees in general with Chun's account and picture. Especially notable is the complex course of the lateral subumbral canals, and the apical prolongation of the gelatinous substance, with stiel-canal of considerable length. There is a minor difference, however, in the fact that the ventral face of the present example is deeply furrowed, with its two wings somewhat clasping the base of the pneumatophore and the siphosome sector of the stem. The muscular lamella bearing this nectophore is well developed; no trace is to be seen of any other such structure that might have borne a second large nectophore.

A question of much interest is whether there is a succession of these large nectophores, or whether only one such definitive bell develops, as is suggested by the fact that the specimens examined by Chun and by me showed only one supporting lamella.

Better material is needed before the details of arrangement of the various organs on the stem can be worked out. The bracts are especially interesting in this connection. As Chun (1897) seems first to have observed, these (like the nectophores) are borne on strongly contractile muscular lamellae,<sup>16</sup> which have subsequently been described in some detail by Schneider (1898). Several of these lamellae are to be seen on each of the present specimens, though invariably so contracted that they give no indication of the degree to which they are extensible in life. Kölliker (1853, p. 24) describes them as arranged in two or three circles close below the pneumatocyst; Gegenbaur (1860) as surrounding the stem in a double spiral; Haeckel (1888 a) as in three or four circles one above another; Chun (1897) as circling the axis of the stem. According to Schneider (1898) they radiate from one point, which he interpreted as the zone of proliferation for the whole series of bracts.

The *Arcturus* specimens show that no one of these more or less conflicting accounts clearly states the case, for none mentions the fact that the lamellae are arranged in groups, much as they are in *Anthophysa*. In the best-preserved example (Fig. 218) there are at least nine such groups (perhaps more), with 3-4 lamellae in each group, suggesting a total of at least 30 bracts, which corresponds to Kölliker's count of 20-40, Haeckel's of 30-50. The lamellae of each group are crowded close together, contrasting with free belts of considerable width between the groups. The long axes of the individual lamella run meridional to the main axis of the siphosome so that the bracts in life form a corona around the latter. Unfortunately the condition of the material is not good enough to show whether there is one primary zone of proliferation for all the bracts as Schneider believed:

<sup>16</sup> Kölliker (1853) suspected a muscular attachment from his observations that the bracts are mobile.

so far as it goes it suggests the contrary. Thus the largest lamellae are approximately of equal length in each of the groups, while within each group there is a wide variation in length, suggesting that fresh bracts are interpolated all around the siphosome as the colony grows. The fact that the only bract still attached (Fig. 217) though a young one, stand opposite the zone of proliferation for nectophores, is evidence in the same direction. The bracts themselves agree so closely with earlier descriptions and illustrations that no account is needed here. Their most distinctive feature, and one that offers a field-character by which this species may readily be recognized, is the presence of the radial tuberculate ridges already mentioned: in fact there is no danger of confusing the bracts of this species with those of any other Siphonophore with which I am acquainted. In three large bracts, chosen at random, the number of ridges was 9, 9, 8.

The relative size of the tubercles is shown in figure 217. On one bract their number, per ridge, varies from about 6 to about 27. Along some parts of the ridges they have the form of conical papillae, but in other places several, together, form continuous crests.

By earlier accounts there are approximately as many palpons as bracts (14-20 or more according to Kölliker; as many as the bracts according to Haeckel). The *Arcturus* specimens have lost part of the palpons; but enough remain to show that their number approximately equals that of the bracts, for two, three or four are to be seen just distal to each group of bracteal supports (Fig. 218). They thus form a corona surrounding the distal portion of the stem. Each of these groups of palpons (so far as can now be seen) arises from a common stem which, in turn, arises close by or perhaps actually as an outgrowth from the basal part of the trunk of a gonodendron, much as is shown by Huxley (1859, *pl. 9, fig. 12*). But the condition of the material makes it impossible to determine whether this is an invariable rule, or whether other palpons are borne on the meridional belts of the stem that alternate with gonodendra and groups of bracts. Some large palpons also arise just distal to (i. e. below) the gonodendra. Schneider (1898) has already recorded the close association of palpons with gonodendra, though by his interpretation the latter arise from the bases of the former. In addition to the large palpons, occasional much smaller ones are scattered over the basal surface of the siphosome. As only one specimen is in good enough condition to show any of these (Fig. 218), I cannot state whether or not they remain permanently small. In the example in question 8-10 are intact, but there may have been more in life.

I can add nothing (except by way of confirmation) to earlier accounts of the structure of the palpons. Their most characteristic feature is the presence of a corona of large nettle cells close to the tip. These are still to be seen in contracted examples, but in most cases have been lost. Haeckel (1888 a) describes a crystalline body (he interpreted it as refractive) as associated with the terminal pigment spot recorded by him and by Chun; but this was not visible on any of the present examples.

The siphons, as earlier students have stated, are of the ordinary Physophorid type, with thick walled basal part. They are much less numerous than the groups of bracts, earlier accounts giving eight as the number. The only

*Arcturus* specimen on which even an approximate count is possible (Fig. 218), bears two intact siphons and the broken bases of at least four others. They alternate radially with the groups of bracteal supports.

The tentilla, described in detail by Haeckel (1888 a) and by Chun (1897), are of the ordinary Agalmid type—tricornate, with involucre. According to Chun, the involucre encloses the entire cnidoband until the latter has developed seven turns; if more turns are formed they project free. I need only add that

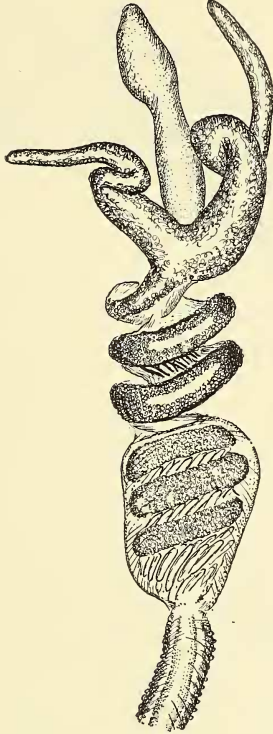


Fig. 219. *Athorybia rosacea*; tentillum,  $\times 72$ ; from *Arcturus* Sta. 74.

the involucre is not formed until the spiral coiling of the cnidoband is well advanced (Figs. 219, 220); that the largest number of coils found enclosed in any tentillum, in the present series, was 7-8. In most cases (probably as a result of preservation) the involucre is so strongly contracted as hardly to be recognizable as such (Fig. 220).

As has long been known, *Athorybia* is monoecious. Kölliker (1853) and Haeckel (1888 a) both report two gonodendra, a male and a female, close to the base of each siphon, while Huxley (1859, *pl. 9, fig. 12*) shows the male and female gonodendra as arising from a common trunk. In the *Arcturus* specimens the gonodendra alternate, radially, with the siphons, thus standing in the general radii of the groups of bracteal supports.

In only one instance did I find a pair (male and female) still intact. Chun (1897) has given an excellent illustration of the female gonodendron. The single large egg that is developed in each gonophore is plainly visible in the present material; male gonodendra bear few gonophores and agree in general with Haeckel's figure (1888 a, *pl. 12, fig. 18*) except that (perhaps owing to the rather poor preservation) I have not been able to detect the ring- and radial-canals.

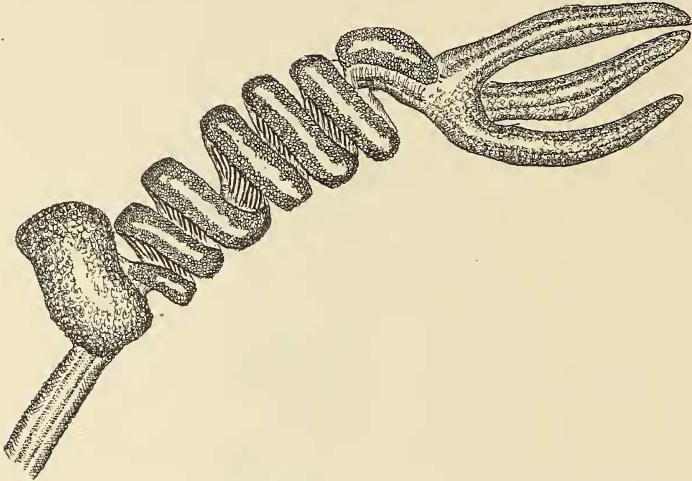


Fig. 220. *Athorybia rosacea*; tentillum with involucre contracted,  $\times 72$ ; from *Arcturus* Sta. 74.

Previous records of *Athorybia* that can be referred with certainty to the species *rosacea* have been confined to the Mediterranean, to the Straits of Gibraltar and to the North Central Atlantic (Latitude  $32-34^{\circ}$  N; Longitude about  $30^{\circ}$  W.). The genus is also recorded from the Indian Ocean and from the Pacific coast of Australia by Huxley (1859) as "*A. rosacea*." But as just remarked (*p. 0*) it is questionable whether his specimens actually belong to this species. The *Arcturus* records are therefore interesting geographically for they extend the known range of *A. rosacea* to the eastern side of the Tropical Pacific, between the Galapagos and Panama. It seems that this Siphonophore, like so many of its confreres, is cosmopolitan in warm seas.

#### Family RHIZOPHYSIDAE Brandt 1835.

*Rhizophysa eysenhardti*, Gegenbaur.

*Rhizophysa eysenhardti*, Gegenbaur, 1860, *p. 408, pl. 31, figs. 46-49*.  
For synonymy, see Bigelow 1911 a, *p. 320*.

Station 100, surface, two fragments.

Station 102, surface, fragments of three specimens, each with pneumatophore.

These fragmentary Rhizophysas are referred to this species because each

still bears filiform tentilla, but none of the complex tentilla characteristic of *R. filiformis*. Being mere fragments they add nothing to previous accounts of the species. The localities of capture are near and in the offing of Bermuda. *R. eyenhardti* is known to be widespread in the warm belts of all oceans, and has been recorded at various stations in the Tropical Atlantic.

*Rhizophysa*, (sp. ?)

Fragments of *Rhizophysa* without tentilla (hence not identifiable specifically), were taken at Stations 94, 98 and 100.

*Bathyphysa*, (sp. ?)

Expeditions that have done much deep towing, or trawling, have usually picked up examples of this genus, or of its close ally *Pterophysa*, on the wire. But the specimens have invariably been so much damaged that much is still to be learned even as to the chief morphological features of the species concerned. And until good material is obtained, specific and generic relationships can only tentatively be established.

Lens & Van Riemsdijk (1908), who have examined the largest series of the family that has yet been studied, recognize two genera, *Bathyphysa* and *Pterophysa*, separating them by the position of the oldest siphons, which are borne on pedicles in the former, but sessile on the stem in the latter. And their system may be accepted at least provisionally.

The *Arcturus* obtained the following representatives of this group (brought in as usual on the wire):—

Station 28, 500–0 meters, a fragment of stem, with three loose and very much damaged siphons.

Station 38, 545–0 meters, a fragment of stem, about 350 mm. long with pneumatophore, and bases of a number of siphons, the younger of which show traces of wing-like expansion, also two gonodendra.

Station 74, 1145–0 meters, a fragment 47 mm. long with pneumatophore, occasional tentacular bases and one large gonodendron.

In each case the stem is stripped bare of all but the bases of the older siphons and tentacles, though in one a few very young siphons, and several young gonodendra are still attached. They are referred here to *Bathyphysa* because, in each case, either the remaining siphons, or the bases of these organs that are still attached, suggest that they were borne on distinct pedicles: even this, however, is not certain.

Family PORPITIDAE Brandt 1835.

*Porpita pacifica*, Lesson.

*Porpita pacifica*, Lesson, 1826, pl. 7, figs. 3, 3<sup>1</sup>; 1830, p. 2, 59.  
For synonymy, see Bigelow, 1911 a, p. 338.

*Porpita* was taken at the surface at Stations 26, 32, and 33, a total of 11 specimens, ranging in diameter from 2 to 37 mm.

It is now sufficiently established that the several Porpitas that have been named in each of the great oceans represent, in each case, but a single species. But no general agreement has yet been reached as to what relationship the Atlantic representative of the genus bears to those inhabiting the Pacific and Indian Oceans.

The Porpitas collected by the *Albatross* in the Eastern Tropical and later in the Northwestern Pacific differed markedly from the Atlantic form, as it has been described, and from specimens of the latter that I have seen, in showing a tuberculate disc; more numerous tentacular cnidocysts; relatively narrower limbus; fewer open stigmata and more complex limbar canals. I therefore referred them to a separate species *P. pacifica* Lesson. And Raj (1927) has used this same name for specimens similarly characterized from the Gulf of Manar between India and Ceylon. Moser (1925), however, from her study of the *Gauss* collection, and of specimens from various localities in the Pacific and Indian Oceans (mostly poorly preserved) believes that the reported differences between the Indo-Pacific "*pacifica*" and the Atlantic "*umbella*" are not specific, but represent either different stages in growth (the *umbella* examined by me were small, the *pacifica* large), or the individual variation to be expected in a cosmopolitan form. Consequently she refers all of them to the earliest named *Porpita*, *P. porpita* which was originally described from the Indian Ocean. As she remarks, the matter cannot be settled for good until some one has the opportunity to compare large series, representing different stages in growth, from the three oceans. Material from the Indian Ocean is especially to be desired from the waters around South Africa, for *Porpita* may be expected to round the Cape of Good Hope from the Indian Ocean into the South Atlantic, in considerable number, at the season (January–March) when the warm Agulhas current reaches its greatest westward extension, and when the surface temperature off Southwestern Africa is highest, (c/f Schott, 1902, pl. 8).

Meantime it is of interest to find the *Arcturus* specimens—small as well as large—agreeing so closely with the *Albatross* series from the same general region as to suggest that this particular form—whether species or variety—is in fact characteristic of the eastern side of the Tropical Pacific. Thus the larger specimens (26 mm. in diameter) all show prominent tubercles on the disc, much as illustrated for still larger *Albatross* specimens (Bigelow 1911 a, pl. 8, fig. 1, 2). In fact they are relatively more prominent in one of 19 mm. than in any of the larger examples, and are to be seen even in a specimen of only 14 mm. In a very young example (2 mm. from Station 33) the disc is smooth; and unfortunately there are no intermediate sizes in the series. Thus it appears that the disc becomes definitely tuberculate in this form by the time a diameter of 12–14 mm. is reached. The *umbella* of this size that I have seen show no definite tubercles—but show radial ridges much more prominently than do any of the *pacifica* yet studied.

The *Arcturus* specimens have somewhat fewer stalked cnidocyst-clusters on the tentacles than the *Albatross* series, but a considerably larger number of these structures than have been recorded for Porpitas from the Atlantic (*umbella*). Thus the average number per row, on five tentacles each, in three specimens from Japan, 25–40 mm. in diameter, was 29, 17, 17. In the largest specimens from the *Albatross* collection from the Eastern Tropical Pacific there were from 25–29 per tentacle in the long rows, 11–14 in the short. In five *Albatross* specimens from the same general region, 32–36 mm. in diameter

(five tentacles examined in each), the numbers are 19–28 in the long rows, 8–15 in the short, averaging respectively 24, 10, 11, while in one example of 23 mm. the average is nearly as great, namely 22, 10, 10.

As the maximum number of tentacular nematocyst-clusters so far reported for *Porpitas* from the Atlantic is only 9–12 in the long, 6–8 in the short rows, it seems that these organs average considerably more numerous even on small Pacific specimens. But the discontinuity in this respect is not as wide as the *Albatross* collections suggested, and examination of larger series, from other localities may show an unbroken gradation between the extremes. Furthermore, new nematocyst-clusters may be interpolated at any stage in growth, for in several instances small (i. e. young) ones were seen between the larger.

The *Arcturus*, like the *Albatross* specimens also show fewer open stigmata than the Atlantic examples I have examined. And since this applies to three examples only 14–19 mm. in diameter, the difference can not be credited to different stages in growth, though it may to individual (or to swarm) variation. This statement also applies to the difference between Atlantic and Pacific *Porpitas*, with respect to the relative breadth of the limbus. Moser (1925) has pointed out that my photographs showing this difference (1911 a, *pl.* 28, *figs.* 2, 13), were not strictly comparable, the Pacific specimen being considerably larger than the Atlantic. It is therefore fortunate that the present series contains specimens of about the same size as the latter (20 mm.). On all of these the limbus is relatively only about half as broad as in the Atlantic specimen in question, occupying 5–6 per cent of the total diameter, as against about 11 per cent of the diameter. Final decision as to the meaning of this apparent discontinuity must rest on the examination of larger series.

*Arcturus* like *Albatross* specimens also show a more complex anastomosis and branching of the limbar canals (primarily radial arrangement entirely obscured) than any Atlantic specimen I have seen.

Until the relationships of the three *Porpitas* can be definitely established, nothing is to be gained by suppressing the name *pacifica*. But as Moser clearly points out, if the forms are finally united, the name first given to the *Porpita* of the Indian Ocean (*P. porpita*) takes precedence.

*P. pacifica* has already been taken by the *Albatross* in the general region (Panama-Galapagos) covered by the *Arcturus* records, at times in swarms. Evidently it is as characteristic an inhabitant of the Eastern Tropical Pacific as its relative *P. umbella* is of the corresponding thermal zone in the Atlantic.

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