Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
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REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM OCTOBER, 1904, to MARCH, 1905, LIEUT. COMMANDER L. M. GARRETT, U. S. N., COMMANDING.

## XXIII.

# THE SIPHONOPHORAE.

By HENRY B. BIGELOW.

WITH THIRTY-TWO PLATES.

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CAMBRIDGE, U. S. A.:
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# EASTERN TROPICAL PACIFIC.

*The following publications of the Museum contain Reports on the Dredging operations, in charge of Alexander Agassiz, of the U. S. Fish Commission Steamer "Albatross," during 1904 and 1905, Lieut. Commander L. M. Garrett, U. S. N., Commanding.*

I. A. Agassiz. Three letters to the Hon. G. M. Bowers on the Cruise in the Eastern Tropical Pacific. Bull. M. C. Z., April, 1905. Vol. 46, no. 4. 22 pp.

II. H. Richardson. Description of a new genus of isopods, typical of a peculiar family. Bull. M. C. Z., July, 1905 Vol. 46, no. 6. 4 pp. 1 plate.

III. C. A. Kofoid. Craspedotella, a new genus of the Cystoflagellata, an example of convergence. Bull. M. C. Z., September, 1905. Vol. 46, no. 9. 5 pp. 1 plate.

IV. W. E. Ritter. Octacnemus. Bull. M. C. Z., January, 1906. Vol. 46, no. 13. 22 pp. 3 plates.

V. A. Agassiz. General report of the Expedition. Mem. M. C. Z., January, 1906. Vol. 33. 90 pp. 96 plates.

VI. T. W. Vaughan. Madreporaria. Bull. M. C. Z., August, 1906. Vol. 50, no. 3. 14 pp. 10 plates.

VII. C. R. Eastman. Sharks' teeth and cetacean bones. Bull. M. C. Z., November, 1906. Vol. 50, no. 4. 26 pp. 4 plates.

VIII. S. F. Clarke. The hydroids. Mem. M. C. Z., February, 1907. Vol. 35, no. 1. 20 pp. 15 plates.

IX. C. A. Kofoid. New species of Dinoflagellates. Bull. M. C. Z., February, 1907. Vol. 50, no. 6. 48 pp. 18 plates.

X. M. J. Rathbun. The Brachyura. Mem. M. C. Z., August, 1907. Vol. 35, no. 2. 54 pp. 9 plates.

XI. F. E. Schulze. Die Xenophyophoren. Bull. M. C. Z., November, 1907. Vol. 51, no. 6. 22 pp. 1 plate.

XII. S. Garman. The reptiles of Easter Island. Bull. M. C. Z., June, 1908. Vol. 52, no. 1. 14 pp. 1 plate.

XIII. E. C. Starks. Atelaxia. Bull. M. C. Z., July, 1908. Vol. 52, no. 2. 8 pp. 5 plates.

XIV. W. H. Dall. The Mollusca and Brachiopoda. Bull. M. C. Z., October, 1908. Vol. 43, no. 6. 285 pp. 22 plates.

XV. J. Thièle. Bathysciadium, Lepetella, und Addisonia, Bull. M. C. Z., October, 1908. Vol. 52, no. 5. 11 pp. 2 plates.

XVI. H. B. Bigelow. The Medusae. Mem. M. C. Z., February, 1909. Vol. 37. 243 pp. 48 plates.

XVII. J. Murray and G. V. Lee. The depth and marine deposits of the Pacific. Mem. M. C. Z., June, 1909. Vol. 38, no. 1. 170 pp. 5 plates, 3 maps.

XVIII. R. Woltereck. Amphipoda. Bull. M. C. Z., June, 1909. Vol. 52, no. 9. 26 pp. 8 plates.

XIX. L. J. Cole. Pycnogonida. Bull. M. C. Z., August, 1909. Vol. 52, no. 11. 10 pp. 3 plates.

XX. C. A. Kofoid. Mutations in Ceratium. Bull. M. C. Z., September, 1909. Vol. 52, no. 13. 48 pp. 4 plates.

XXI. R. von Ledenfeld. The siliceous sponges. Mem. M. C. Z., August, September, 1910. Vol. 41. 323 pp. 56 plates.

XXII. C. A. Kofoid and J. R. Michener. New genera and species of Dinoflagellates. Bull. M. C. Z., August, 1911. Vol. 54, no. 7. pp.

XXIII. H. B. Bigelow. The Siphonophores. Mem. M. C. Z., December, 1911. Vol. 38, no. 2. 231 pp. 32 plates.

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# THE SIPHONOPHORAE.

## INTRODUCTION.

The collection of Siphonophores obtained by the "Albatross" in the Eastern Tropical Pacific in 1904–1905, together with the few specimens previously collected by her in other parts of the Pacific, is one of the most extensive series which has been made. Out of a total of forty-six genera and about ninety species which deserve recognition, it contains no less than thirty-five genera and fifty-two species.

Since formalin has come into use, the preservation of the Siphonophores is no longer attended with any great difficulty, and the collection, as a whole, is in excellent condition. I have already (:09a, p. 11) called attention to the value of chloretone as a stupefying reagent and given short directions for using it.

Throughout the Cruise I had the opportunity of studying the Siphonophores in life; and of making numerous drawings and these have been of great assistance.

Two new genera and six new species are described. That no more novelties were obtained is, of course, a corollary of the holoplanktonic habit of the group. Especially noteworthy, from the standpoint of morphology and classification are: — the discovery of a new Nectopyramis with its Eudoxid, a genus previously known from one specimen; the capture of a large series of Amphicaryon, previously unfigured and known from one record only; the rediscovery of the *Diphyes dubia* of Quoy and Gaimard, known only from the original record, and for which a new genus is required, and the discovery of a new species of the same genus; the discovery of a new Rhodalid, represented by a large and excellently preserved series allowing anatomic study; the capture of a large series of the little-known genus Porpema, and of *Porpita pacifica*. On these two I was able to make a study of the "central organ," as well as of the anatomy in general.

I have studied the extensive collection in the Museum of Comparative Zoölogy, rich in West Indian material, and also the collections of the U. S. National Museum, including a valuable series of Velella and Physalia from the Pacific.

With such a wealth of material the time seemed ripe for a more adequate presentation of our knowledge of the group than would be associated with the mere description of the "Albatross" specimens. Haeckel's monograph, loaded down as it is with no less than twenty-three *nomena nuda* of his own making, and with many new species, beautifully figured, but none of them critically studied from the systematic standpoint, can not be used as a manual of the group. The list of Atlantic species given by Chun in his report of the collections made by the "Plankton" Expedition, is a great advance; but this takes no account of the Indo-Pacific species, and, besides, during the last twelve years our knowledge of the group has grown along many lines. A revision has been attempted by Schneider; but the reductions which he proposed are so sweeping and in many cases so unnatural, that they have not been generally adopted.

I have sought less for a well-balanced scheme of classification, than to present the actual state of our knowledge. The *lacunae* are still far too great to allow a systematic revision of the group in the sense in which such is possible for birds, or for mammals. By emphasizing these gaps, other researches may be stimulated, and thus the desirable end be obtained.

Among Siphonophores we constantly encounter doubtful species, which may or may not be distinct from their nearest allies. To justify their union with other forms we must have something more than a fair probability. Otherwise we are likely to mask existing and important differences. In several such cases I have been able to base unions on the actual comparison of specimens of the forms concerned, and whenever unable to do this, it is so noted.

In cases where direct comparisons have not been made, and where the published descriptions are not conclusive, it is better to allow both species to stand.

The nomenclature of the Siphonophores has long been a *bête noire.* The labors of Bedot and of Chun, have brought some improvement, but there is still much confusion. In such a group as the present, uniformity can only be hoped for through a strict application of the law of priority; and especially must we follow the rule of applying to a species as a whole the name first applied to any part of it or its larva. But what should be done with the older names applied by some modern authors to one species, by others to another, especially when, as is often the case, the original figures do not agree very well with any actual form? If we abandon them altogether, they remain as constant sources of confusion, for they cannot be considered *nomena nuda*. If used there is the danger of applying them to wrong species, their true identity being discovered later. More than one such case has occurred. In the present Memoir I have used an old name whenever the figures allow. Otherwise they are given in the doubtful list (p. 354–357). Many *nomena nuda* have been used, especially by the older writers; these are omitted.

The classification employed is based on that outlined by Chun ('97b), because of the various schemes which have been proposed, this most nearly represents the natural relationships of the several groups. But I have not hesitated to make various changes which more recent studies have shown to be necessary. The family relationships of the Calycophorae form such a case, to which attention is called.

It is a pleasure to acknowledge my indebtedness to Alexander Agassiz, the lamented leader of the Expedition, not only for the opportunity to accompany him on the Cruise, but for encouragement without which the present Memoir could never have been prepared.

## CALYCOPHORAE Leuckart, 1854.

The classifications proposed by the two authors who have most recently attempted the revision of the Calycophorae are essentially different both in premise and in conclusion. Chun ('97b) has adopted the number of nectophores as the most important character, and as a result, divides the order into three families, Monophyidae with one, Diphyidae with two (rarely more), and Polyphyidae with several nectophores. This is essentially the system used by Haeckel in his "Challenger" report. Schneider ('96, '98) on the other hand, has maintained that the number of the nectophores is not an important systematic character, but that the Calycophorae are divisible into two families, Prayidae and Diphyidae, according as the older and the younger definitive nectophores are structurally similar or dissimilar. Schneider's explanation of the well-known dissimilarity of the nectophores in Diphyids and Abylids is that while the posterior bells in these groups are true nectophores, the anterior ones and all the swimming bells of Hippopodius, of the Prayids, and of Sphaeronectes, are combinations of nectophore and bract. The homologies thus outlined by Schneider have been criticised severely by Chun ('97b, '98a).

According to Schneider the chief evidence that the swimming bells are partly bract is the presence of the somatocyst, which according to him is never found in a true nectophore; but while it is true that in some Calycophorae the somatocyst is a highly specialized organ deeply embedded in the gelatinous substance, I cannot find any evidence either in anatomy or development sufficiently strong to invalidate the homology between the somatocyst and the so-called "Oelbehälter" in the nectophores of Agalmids, drawn by Leuckart ('53), and recently denied by Schneider ('98). The mere statement by the latter author ('96, p. 581) that "Es ist nun aus mehreren Gründen unmöglich den Saftbehälter mit sammt seiner Gallert umgebung als blossen Anhang des Glockentheiles zu betrachen" is insufficient to prove his theory; nor has he supported with sufficient facts, his view that the degenerate oldest nectophore of Amphicaryon is a bract. Indeed the actual course of development in that genus seems quite opposed to such a conclusion (p. 195). The other arguments adduced in favor of a double origin of the nectophores of the Prayids seem of no more weight.

Chun ('98a) has so thoroughly discussed this question, that it is unnecessary to do more here than state my agreement with his general conclusion that the two bells of Diphyids and others are homologous — both are pure nectophores. The very significant fact remains however, that in Diphyids and Abylids the anterior and posterior bells are structurally dissimilar, while in Prayids, Stephanophyids, and Hippopodids the two or more bells are all structurally alike.

Chun ('97b, p. 13) maintains that the "*Diphyes ornata*" of Kefferstein and Ehlers ('61) is a connecting link between these two types. But no one since Kefferstein and Ehlers has ever seen a Siphonophore answering to their description of this species, and apart from this doubtful form, the distinction between the posterior bells of Diphyids and Abylids on the one hand, and those of Prayids and Hippopodids on the other is perfectly clear cut. It therefore seems more important as a systematic character than Chun ('97b) supposed.

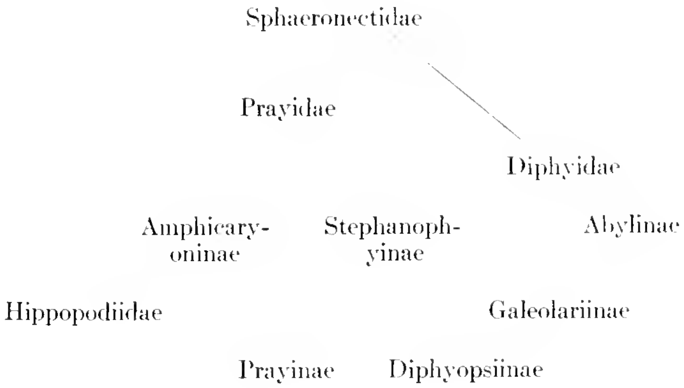
On the other hand the number of nectophores, as most students now agree, whether two or more, is of comparatively little importance, because while the Hippopodiidae, with several, are undoubtedly a natural group, Prayids and some Diphyids normally develop a succession of bells, though they successively cast off the older ones. This is especially true of *Praya cymbiformis* (Chun, '97a, p. 66, fig. 8), and of Galeolaria. Since therefore, there is no question but that the bells of Prayids and of Hippopodids are budded in the same fundamental manner (Chun, '97a, p. 66), the only essential difference, so far as their number is concerned, is that they are retained longer in one group than in the other. This fact, together with the structural unity of all the bells in the Hippopodids as well as in the Prayids points to a closer relationship between the two, than between either of them and the Diphyids or Abylids. The absence of bracts in Hippopodids demarks them so definitely from their allies, that it undoubtedly justifies the distinct family recognized by Chun.

We have now to consider the most puzzling Calycophorids of all, namely the forms usually grouped together as Monophyidae (Haeckel, '88b, Chun, '97b, Lens and Van Riemsdijk, :08). These animals agree in that neither second nectophores nor "reserve buds" are ever formed, and that, so far as known, their groups of appendages are detached to become free-swimming Eudoxids; but they differ widely from one another in form, and although as a rule external form is only of minor significance in phylogeny, in the present case it assumes unusual importance because there is a remarkable parallelism in this respect between the various Monophyids and the other more complex Calycophorae. Thus, one group of Monophyids, the Sphaeronectids, resembles the Prayids both in nectophore and Eudoxid, a second, represented by Cuboides, is, in both these respects, of the Abylid type, while the components of a third, Muggiaea and Doromasia, parallel Diphyes and Diphyopsis to such a remarkable degree that they might readily be mistaken for each other; and finally there is a recently discovered genus, Nectopyramis (p. 191), where the somatocyst, represented by a series of branching canals, recalls that of Stephanophyes and of Nectodroma (p. 205).

Of course the important question is, are all these Monophyids primitive types, as the simplicity of their organization suggests, or are some of them primitive, others degenerate. The first view is the one which has generally been held (Haeckel, '88b, Chun, '97b). Schneider has recently maintained however, that while the Sphaeronectids are primitive, Muggiaea is merely a Diphyes with the second nectophore aborted. Sphaeronectes, judging from the adult, has an excellent claim to be regarded as ancestral, because its definitive nectophore so closely resembles the transitory primary nectophore of Hippopodius that it may reasonably be considered homologous with that structure, though whether or not correctly, can be determined only when the development of Sphaeronectes is studied. The case of Muggiaea is not so easily settled.

In the first place the definitive bell of Muggiaea is not the primary bell; the latter is early lost just as it is in Hippopodius and in Galeolaria. Then too, we must consider the parallelism between Muggiaea and Doromasia on the one hand, and Diphyes and Diphyopsis on the other, which is complete even to the most trivial details of nectophore and of Eudoxid. The resemblance is too close to be accidental; the only reasonable conclusion is that either Diphyes has been derived from Muggiaea, or Muggiaea from Diphyes. Schneider's conclusion that Diphyes is the parent, Muggiaea the derivative, can be justified only on the assumption that Muggiaea becomes mature before the appearance of the second bell, which fails to develop, and of course, precisely the same ground might be taken from which to argue that Cuboides, of which the development is unknown, is an Abylid with the second bell aborted, though in this case the parallelism in the form of nectophore and Eudoxid is much less close than it is between Muggiaea and Dyphyes. The entire absence of even the trace of a bud for a second nectophore in all the many specimens of Muggiaea which have now been examined (p. 185) is a strong argument against this view, and, furthermore, the essential difference between Prayids and Hippopodids on the one hand, and Diphyids and Abylids on the other with respect to the second nectophores indicates clearly that the two groups have originated from different Monophyid ancestors: *i. e.*, the former from Sphaeronectids, the latter from Muggiaea- and Halopyramis-like forms. Thus there are both structural and phylogenetic reasons for adopting the Muggiaea-Diphyes, rather than the Diphyes-Muggiaea sequence. For the case of Doromasia, and its relationships to Diphyopsis, see p. 265. For this reason I have recognized Chun's Monophyidae, but since Monophyes is undoubtedly a synonym of Sphaeronectes, the name of the family must be changed to Sphaeronectidae.

The accompanying diagram will represent the probable relationships of



the Calycophorae better than a linear arrangement. The various families and subfamilies may be defined as follows: — (the definitions of the subfamilies are practically those of Chun, '97b, p. 12).

1. Sphaeronectidae — only one nectophore.
    1. Sphaeronectinae. With rounded nectophore probably representing the "primary" bell of the non complex Calycophorae.
    2. Muggiinae. With pyramidal nectophore of Diphyid or Abylid outline. The definitive nectophore is a secondary bell.
    3. Nectopyramidiinae. With rounded nectophore: the somatocyst represented by a system of branching canals.

Diphyidae Eschscholtz. With 2 (or temporarily 3 or 4 nectophores: the oldest definitive nectophore differs from the one (s) subsequently formed in the presence of a somatocyst.

1. Abylinae L. Agassiz. Superior nectophore prismatic and much smaller than the inferior one. Free Eudoxids have prismatic bracts.

2. Galeolariinae Chun. Nectophores of about the same size; rounded, mostly without sharp ridges. Groups of appendages permanently sessile.
3. Diphyopsiinae Haeckel. Nectophores pyramidal, with strong ridges. Groups of appendages detached as free Eudoxids, with rounded bracts.

Prayidae Kölliker. With 2 (or temporarily 3–4) nectophores, all structurally alike.

1. Amphicaryoninae Chun. Oldest nectophore with its nectosac degenerating into a bract-like shield partially enclosed by the younger one. No "reserve bells." Has free Eudoxids.
2. Prayinae Haeckel. The two rounded nectophores are replaced successively by the formation of new ones. Groups of appendages remain sessile (?).
3. Stephanophyinae Chun. Several nectophores arranged in a ring. Somatocyst replaced by a system of branching canals. Groups of appendages sessile.

Hippopodiidae Kölliker. With many nectophores, all structurally alike. Groups of appendages sessile. Without bracts.

## Sphaeronectidae Huxley, 1859.

## Sphaeronectinae Haeckel, 1888.

The two genera of this subfamily, Sphaeronectes and Monophyes, recognized by Haeckel ('88b) and by Chun ('92, '97b) are separated only by differences in the form of the hydroecium and of the somatocyst, so slight that they are only of specific importance. I therefore follow Schneider ('98) in uniting them under the older name, Sphaeronectes. The recently discovered genus Nectopyramis is also included here, provisionally, because its affinities are evidently closer with this subfamily than with the Muggiinae. But until its development is known its position cannot be determined.

### SPHAERONECTES Huxley, 1859.

The structure of this interesting compound genus has been so thoroughly studied by Claus ('74) and by Chun ('92) that it is necessary to examine only the validity of the five species *S.* (*Monophyes*) *gracilis* Claus, *S. köllikeri* Huxley, *S.* (*Monophyes*) *irregularis* Claus, *S.* (*Monophyes*) *brevitruncata* Chun, and *S.*

(*Monophyes*) *princeps* Haeckel, which share the generic characters. According to Schneider ('98) all but *princeps* are merely members of one varietal series. I very much regret that I have been unable to study actual specimens referable either to *irregularis* or to *brevitruncata*, but judging from my examination of *köllikeri*, and from the various published descriptions, I am convinced that though a reduction of species is called for, Schneider has gone too far.

The most cursory study shows that *gracilis* and *köllikeri* are very closely related to each other. Chun who believes that they are distinct, *gracilis* being an Atlantic, *köllikeri* a Pacific form, maintains ('92, p. 86) that they can be separated by the somatocyst, which turns downward (toward the bell opening) in *köllikeri*, upward in *gracilis*. To this Schneider has replied that he has observed the "*köllikeri*" form at Naples, while Agassiz and Mayer ('99) have figured a specimen from the Fiji Islands with the typical "*gracilis*" somatocyst, and Mayer (:00, p. 74) states that "there appears to be much individual variability in respect to the curvature of the phyllocyst in the Pacific species."

I have studied this character in the series listed below, finding, with Schneider, that it is variable. In general, small specimens are of the "*gracilis*," larger ones of the "*köllikeri*", type. In many of intermediate size the somatocyst is horizontal but in one of the largest individuals it turns sharply upward. It is evident from these facts that this character cannot serve as the basis for specific separation; and therefore *gracilis* and *köllikeri* must be united. As Chun ('92) pointed out, the Eudoxids of this compound species had been described by Will as *Ersaea truncata* long before the discovery of the polygastric state, and Will's figure ('44, pl. 2), is so satisfactory that this conclusion may safely be adopted. Chun relegated this early name to the synonymy of *S. gracilis*, but, as Schneider has more recently remarked, the rules of zoölogical nomenclature require that it be applied to the species as a whole. *S. irregularis* and *brevitruncata* are another pair of closely allied forms. According to Chun they are separated from each other by the very much reduced somatocyst of the former, and the very short stem and small number of groups of appendages in the latter. But Schneider has pointed out that the last character is of very doubtful importance, in view of its variability in various Diphyids; a variability probably connected with the setting free of the groups of appendages. As to the size of the somatocyst, the importance of this character depends wholly on its constancy. Unfortunately this has never been tested; but the difference in this respect between *irregularis* and *brevitruncata* is so slight that it suggests varietal, rather than specific separation. On the whole, then, the two are so closely allied that it is better to unite them under the older name, *irregularis* Claus.

The characters by which *irregularis* is separated from *truncata* are its proportionately much larger nectosac, its thinner gelatinous substance, short hydroecium, more upright somatocyst, and especially the bowed course of its dorsal and lateral subumbral canals. I have not observed any specimen of *truncata*, either large or small, which approaches *irregularis* in any of these respects. Schneider ('98, p. 78), it is true, states that "von der irregularis Form giebt es Übergänge zur gracilis Form," but he has not described these supposed intermediates, nor has he analyzed the value of the diagnostic characters. In view of the constancy of the course of the subumbral canals in other Calycophorae, and the very marked difference in this respect between the two species under consideration, this character alone would suffice to separate them, and when we add to this the difference in form, *irregularis* certainly deserves recognition as a good species.

The form from the Indian Ocean recorded by Haeckel as *Sphaeronectes princeps* ('88a, p. 34), and later described by him ('88b, p. 129), as *Monophyes princeps* has not been discussed either by Chun or by Schneider. Its subumbral canals resemble those of *irregularis*, but the nectosac is proportionately even higher, and the hydroecium is a mere groove, much as in certain Prayids. Should it prove that these characters are constant, and that the specimen was in fact a Monophyid, *princeps* would deserve recognition. But to determine whether this is the case will require renewed examination of material agreeing with Haeckel's account. A knowledge of its appendages would be particularly valuable.

The other species of Monophyes mentioned by Haeckel ('88b, p. 128) are *M. diptera* and *M. hydrorrhoa*. The first of these is applied to the posterior nectophore of *Diphyes subtilis* (p. 347), first described by Chun ('85) as the "primary bell" of *S. truncata* ("*gracilis*"); the second, described merely as being similar to the former, is no doubt the same. *M. primordialis* Chun ('82) is a synonym of *Muggiaea kochii* Will, to the "primary" nectophore of which it was applied.

### **Sphaeronectes truncata** (Will) Schneider.

*Ersaea truncata* Will, '44, p. 82, taf. 2, fig. 28. Eudoxid.

*Diplophysa inermis* Gegenbaur, '53, p. 9, taf. 16, fig. 3; Claus, '74, p. 27, taf. 4, figs. 1–4; Fewkes, '81, p. 166, pl. 6, fig. 12; Haeckel, '88b, p. 107; Chun, '92, p. 85. Eudoxid.

*Sphaeronectes kollikeri* Huxley, '59, p. 50, pl. 3, fig. 4; Haeckel, '88b, p. 130; Chun, '92, p. 84; Agassiz and Mayer, '99, p. 177, pl. 17, fig. 53.

*Monophyes gracilis* Claus, '73, p. 258; '74, p. 30, taf. 4, figs. 8–10; Chun, '85, p. 265, taf. 2, figs. 1, 2.
*Praya inermis* Metschnikoff, '74, p. 46.
*Sphaeronectes* (*Monophyes*) *inermis* Fewkes, '80a, pl. 3, fig. 6.
*Sphaeronectes gracilis* Chun, '88, p. 1154; Haeckel, '88b, p. 130; Mayer, :00, p. 73, pl. 27, fig. 89.
*Monophyes köllikeri* Haeckel, '88a, p. 34.
*Diplophysa truncata* Haeckel, '88a, p. 32. Eudoxid.
*Diplophysa köllikeri* Haeckel, '88a, p. 32, '88b, p. 108. Eudoxid.
*Sphaeronectes gigantea* Fewkes, '89b, p. 119.
*Sphaeronectes truncata* Schneider, '98, p. 75, (partim).

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The forty-one specimens range in diameter from 1–8 mm.; and are all fairly well preserved. The variability in the form of the somatocyst has already been noted. In several examples the groups of appendages were sufficiently far advanced to show the typical "Diplophysa" form of bract so often described, and so far as these young stages show there is no visible difference in this structure between Atlantic and Pacific specimens. The various records show that *S. truncata* occurs generally over the tropical and subtropical regions of all three great oceans.

## **Muggiinae**, nom. nov.

*Cymbonectidae* Haeckel, '88a, '88b; Chun, '88, '92.

The name Cymbonectidae must be abandoned because as Chun ('92) and Schneider ('98) point out Cymbonectes Haeckel is undoubtedly identical with Muggiaea Busch. To replace it I suggest Muggiinae. At present three genera can be distinguished: Muggiaea and Doromasia, both of Diphyid outline, but separated by the presence of a special nectophore in the latter, contrasted with its absence in the former, and Cuboides (= Halopyramis) easily distinguished by its peculiar pyramidal shape (p. 189). Schneider unites Doromasia and Muggiaea, but the difference above mentioned seems as worthy of generic recognition here as among the Diphyidae. It is possible, however, that Doromasia will finally be abandoned on another ground, namely that it is not a Sphaeronectid but a Diphyid (p. 265).

### **MUGGIAEA** Busch 1851.

Four species have been described which must be referred to Muggiaea, as above defined, viz. *M. kochii* (Will) Chun (= *M. pyramidalis*, Busch = *Monophyes primordialis* Chun), *M. pyramidalis* Haeckel, *M.* (*Cybonectes*) *huxleyi* (Haeckel), and *M. atlantica* Cunningham. The *Diphyes chamissonis* of Huxley, referred to this genus by Haeckel, proves to be a true Diphyid (p. 244). *Diphyes arctica* Chun, is likewise classed here by Schneider ('98, p. 89) on the ground that the "einmal beobachtete Schwimmglocken-anlage dürfte eher einem Rudiment als einer Ersatzglocke entsprechen." But so far as we know, neither rudimentary nor reserve bells occur among the Monophyidae; and it is therefore better to retain *arctica* among the Diphyidae, at least until it is known whether or not a posterior nectophore is normally present.

Neither Chun ('92) nor Schneider ('98) recognize *M. pyramidalis* Haeckel as distinct from *M. kochii*. According to Haeckel *pyramidalis* "differs from the former [*kochii*] mainly in the size of the conical hydroecium, the top of which attains half the length of the nectosac" ('88b, p. 137). This particular feature *i. e.* length of the hydroecium, is so important among Diphyids, that it might be expected to be significant in the case of Muggiaea. And Cunningham's ('92, p. 214) studies of large series of this genus from Plymouth, England, have proved that such is the case. His *M. atlantica* is easily separated from *M. kochii* by the great length of the hydroecium, and by the fact that the somatocyst, reaching barely to the mid-level of the nectosac in *kochii*, reaches to its apex, or even beyond it in *atlantica*. I have myself been able to test these characters in series of the former both from the Atlantic (:11b, p. 340) and the Pacific, and of the latter from the Pacific, with the result that they prove so constant as to be valuable for diagnosis. Cunningham thought it extremely probable that the form observed by Haeckel at the Canary Islands was the same species as that which he obtained at Plymouth, and no doubt this view is correct. Haeckel's name, however, cannot be used, because preoccupied by Busch for *M. kochii*; and *atlantica* must therefore be applied to the compound species characterized by deep hydroecium and long somatocyst. The status of *M. huxleyi*, known from one record only, is doubtful. Chun ('86) has worked out the development of *M. kochii*, finding that the primitive bell is soon lost, and that the definitive nectophore is a secondary structure. *M. kochii* is known from the Mediterranean, the Canaries (Chun '86), and the Bay of Biscay (Bigelow :11b), *M. atlantica* from the Canaries (Haeckel) from the English Channel and the Irish Sea (p. 376). It has also been recorded from Skagerak, but this record probably belongs to *Diphyes arctica* (p. 188); and the capture of both in the Eastern Tropical Pacific, shows that their distribution is parallel in the warmer parts of both oceans.

### Muggiaea atlantica Cunningham.

*Muggiaea pyramidalis* Haeckel, '88b, p. 137 (non Busch '51).
*Cucubalus pyramidalis* Haeckel, '88b, p. 109. Eudoxid.
*Muggiaea atlantica* Cunningham, '92, p. 211; Gough, :05, p. 1; Vanhoffen, :06, p. 13.
(Non *Eudoxia eschscholtzi* Johannsen and Levinsen, :03).

Plate 7, Fig. 1; Plate 9, Figs. 7, 8.

| | | | | |
|---|---|---|---|---|
| Station | 4571 | surface | 1 specimen | 8 mm. long. |
| " | 4598 | 300 fathoms to surface | 1 " | 7 " " |
| " | 4611 | " " " " | 68 specimens | 3–5 " " |
| " | 4655 | " " " " | 25 " | 6–7 " " |
| " | 4673 | " " " " | 2 " | 6, 7 " " |

The specimens agree even to minor details with Cunningham's account and figure.

Although at least the basal part of the stem was well preserved in most cases, in none could I find any bud which might be identified as a reserve bud for a future posterior nectophore.

The diagnostic features of *M. atlantica* are as follows:— There are five ridges at the apex, and these run to the base without branching; there are no basal teeth, and the only suggestion of such structures is a slight prominence of the angles at the basal terminations of the ridges (Plate **7**, fig. 1). The degree of serration of the ridges is variable, some specimens showing it strongly from apex to base, others, hardly at all; and there are various intermediates between these two extremes. The hydroecium, which varies very little, reaches to slightly less than one third the length of the nectosac, as Cunningham shows it; but it extends basally some distance below the bell opening, so that its entire length is nearly one half that of the nectosac. In no example does it reach the mid-level of the nectosac, as Haeckel describes it; but his account is altogether insufficient. Apically the hydroecium is conical. The dorsal hydroecial wall, below the level of the bell opening, is divided longitudinally, forming two symmetrical lateral wings (Plate **9**, fig. 8), a character not mentioned by Cunningham. The lateral basal margins of the hydroecium are nearly straight. (Plate **9**, fig. 7.)

*Somatocyst.* This structure is nearly cylindrical, very slender, and as a rule terminally dilated with a large oil bubble. It is closely apposed to the ventral wall of the nectosac. In the smaller specimens (3–4 mm.) it considerably surpasses the apex of the nectosac (Plate **7**, fig. 1); but with increasing growth it becomes proportionately shorter and shorter. In specimens 6 mm. long, it about equals the apex of the nectosac, as Cunningham shows it, and in one example of 7 mm. it falls somewhat short of that level.

*Stem and appendages.* In none of the examples were any of the appendages sufficiently advanced to show the final shape of the bract; they consist simply of siphon, tentacle, very young bract, and the bud for the future gonophore. Cunningham who observed "detached eudoxomes" ('92, p. 215) has not described them. Vanhöffen's provisional identification of the Eudoxids recorded by Johannsen and Levinsen under the name *Eudoxia eschscholtzi* as belonging to this species rests only on the ground that "Die Eudoxien sind unbekannt, werden aber jedenfalls der Eudoxia eschscholtzi Busch nahe stehen." (:06, p. 14).

### **Muggiaea kochii** (WILL) CHUN.

Plate 12, Figs. 2–4.

*Diphyes kochii* WILL, '44, p. 77, taf. 2, fig. 22; BUSCH, '51, p. 46, taf. 4, figs. 3–5.
*Ersaea pyramidalis* WILL, '44, p. 81, taf. 2, fig. 17. EUDOXID.
*Muggiaea pyramidalis* BUSCH, '51, p. 48, taf. 4, fig. 6.
*Eudoxia eschscholtzi* BUSCH, '51, p. 33, taf. 4, figs. 7–10, taf. 5, figs. 1–9; CHUN, '92, p. 90 (non JOHANNSEN and LEVINSEN :03). EUDOXID.
*Monophyes primordialis* CHUN, '82, p. 677, taf. 12, fig. 1.
*Muggiaea kochii* CHUN, '82, p. 679, taf. 17, figs. 2; '88, p. 15; '92, p. 89 (partim); HAECKEL, '88b, p. 137; SCHNEIDER, '98, p. 88 (partim); BIGELOW, :11b, p. 340.
*Cucubalus eschscholtzi* HAECKEL, '88b, p. 109. EUDOXID.

Stations 4679, 4681, 4691; all 300 fathoms to surface. At each, 1 nectophore. All about 12 mm. long.

The identification of these three nectophores, none of which were in very good condition, rests on an actual comparison between them and the Biscayan specimens already mentioned. Apart from the absence of a posterior nectophore, or of reserve buds for such structures, the diagnostic features of *M. kochii* are as follows:— There are five ridges, running undivided from apex to base, but the lateral ones terminate a short distance above the basal margin. This fact, easily demonstrable in specimens as relaxed as the present ones, is often concealed in better preserved and more contracted examples, as was the case in the Biscayan series (Bigelow :11b, p. 340).

The somatocyst is cylindrical and reaches only from one third to one half the length of the nectosac, instead of reaching or surpassing the apex of the latter as in *M. atlantica.* The hydroecium, as already noted (:11b), lies wholly below the opening of the nectosac, and its shortness together with the form of the somatocyst is one of the most valuable field marks to separate this species from *M. atlantica.*

*M. kochii* was previously known only from the warmer parts of the Atlantic, as far north as the Bay of Biscay (Bigelow, :11b). The record by Murbach and Shearer of this species from the North Pacific probably belongs to *Diphyopsis chamissonis* Huxley.

### **CUBOIDES** QUOY AND GAIMARD, 1827.

In 1888 Chun described, from the Canary Islands, a very well-marked Cymbonectid under the name *Halopyramis adamantina*. Almost simultaneously it was described and figured by Haeckel ('88b) as *Cymba crystallus*. In 1892 Chun published a second, very detailed account, with beautiful figures; and he then recognized that instead of being unknown to the early students, it was in fact the polygastric state of the Eudoxid described by Quoy and Gaimard in 1827 as *Cuboides vitreus*. Chun also recognized the possibility that his Halopyramis might be identical with the *Enneagonum hyalinum* of the latter authors, though, owing to the unsatisfactory nature of the figures and description of Enneagonum, he retained the name Halopyramis. Since that time Halopyramis has been adopted by Bedot ('96) and by Lens and Van Riemsdijk (:08), but Schneider argues that the form studied by Chun was in reality the Enneagonum of Quoy and Gaimard. The figures of Enneagonum (Quoy and Gaimard, '27) are so indefinite that after studying them together with the original description I feel as uncertain as did Chun ('92) whether or not Enneagonum and Halopyramis are identical or distinct. However, whatever may be the decision on this point, the use of the generic term Halopyramis is contrary to the International code of zoölogical nomenclature, because all recent authors, Chun himself included, agree that the Eudoxid of Halopyramis was long ago described by Quoy and Gaimard as *Cuboides vitreus*. The principle that a name, generic or specific, applied to any part of an animal, or to the larva, or to any one generation, before the animal itself is named, is to be retained, is now well established and generally accepted. And this principle, of course, gives Cuboides precedence over Halopyramis; and inasmuch as Cuboides is recognizable, whereas Enneagonum is at best dubious, and both were proposed in the same publication, and figured on the same plate, there is good reason for accepting the former definitely. For the history of *Enneagonum hyalinum*, and the various names under which it has been quoted, see Chun, '92, p. 113.

Leaving out of the question the problematical *Enneagonum hyalinum* it is probable that all the members of Cuboides ("Halopyramis") yet described belong to a single species. This is certainly true of the forms studied by Chun and by Haeckel; and though Chun ('92) believed that *Abyla vogtii* Huxley, from the Indian Ocean represented an Indian, distinct from the Atlantic, species, the capture, by Bedot ('96), by the "Siboga" (Lens and Van Riemsdijk, :08), and by the "Albatross" of Indo-Pacific specimens indistinguishable from material from the Tropical Atlantic, shows Chun's view to be ill founded. Chun, '92, p. 112, though expressly stating that *C. vitreus* is the Eudoxid of his *Halopyramis adamantina*, calls "Die freien Eudoxiengruppen" *Cuboides adamantina*. But this is contrary to usage.

### **Cuboides vitreus** Quoy and Gaimard.

*Cuboides vitreus* Quoy and Gaimard, '27, p. 19, pl. 2E, figs. 1–3. Eudoxid.
*Cymba cuboides* Eschscholtz, '29, p. 135.
*Abyla vogtii* Huxley, '59, p. 46, pl. 2, fig. 3.
*Cuboides vitreus* Huxley, '59, p. 63, pl. 4, fig. 5. Eudoxid.
*Halopyramis adamantina* Chun, '88, p. 1155; '92, p. 111, taf. 10, fig. 10, taf. 12; Bedot, '96, p. 369; Lens and Van Riemsdijk, :08, p. 7.
*Cuboides adamantina* Chun, '88, p. 1156; '92, p. 112; Bedot, '96, p. 369; Lens and Van Riemsdijk, :08, p. 8. Eudoxid.
*Cuboides crystallus* Haeckel, '88a, p. 53; '88b, p. 111, pl. 42. Eudoxid.
*Cuboides vogtii* Haeckel, '88b, p. 111.
*Cymba vogtii* Haeckel, '88a, p. 34; '88b, p. 138.
*Cymba crystallus* Haeckel, '88a, p. 34; '88b, p. 138, pl. 41, 42.
*Enneagonum hyalinum* Schneider, '98, p. 91 (non Quoy and Gaimard, '27).

The following names may perhaps belong to this species; they are all founded on the description of Enneagonum by Quoy and Gaimard:

? *Enneagonum hyalina* Quoy and Gaimard, '27, p. 18, pl. 2D, fig. 1–6; Blainville, '34, p. 133, pl. 4, fig. 5b; Lesson, '43, p. 455.
? *Diphyes enneagonum* Quoy and Gaimard, '34, p. 100, pl. 5, fig. 1–6.
? *Cymba enneagonum* Eschscholtz, '29, p. 134.

The polygastric generation was taken at Stations 4613, 4617, 4619, 4634, 4646, 4652, 4663, 4667, 4669, 4673, both on the surface and in hauls from 300 fathoms to surface. The series consists of thirty-four well-preserved specimens ranging in height from 3–10 mm.

The Eudoxid was taken at Stations 4661, 4663, 4667, 4669, 4673, 4676, 4699, 4743, both in surface and in 300 fathom hauls. There are fifty-six well-preserved specimens, from 3–5 mm. high.

This species has been figured and described in such detail by Chun ('92) that no account is necessary here. The present series is indistinguishable from his specimens from the Canary Islands, and from West Indian examples which I have studied. The largest example of the polygastric stage, measuring 10 mm. in height by 8 mm. in breadth, is rather larger than the "Siboga" specimens (7 × 5 mm.), and approaches the specimens recorded by Chun (10 mm.). It is evident, then, that there is no distinction in size between Cuboides from the

Atlantic and from the Indo-Pacific region. Enough captures of *C. vitreus* have been recorded to show that it is widely distributed over the tropical Atlantic, the Indian Ocean (Huxley), the Malaysian region (Lens and Van Riemsdijk), and that it occurs rather commonly in the Eastern Tropical Pacific.

## **Nectopyramidinae,** nom. nov.

### **NECTOPYRAMIS** Bigelow.

Nectopyramidinae with rounded nectophore; somatocyst represented by a series of diverging canals.

Nectopyramis was founded (Bigelow, :11b) for a Monophyid distinguished from all other members of the family by the above characters. To the type species *N. thetis*, the present collection has added a second, of which the Eudoxid as well as the polygastric state is represented. As stated in the original description, this has no special nectophore, thus resembling the Eudoxids of the Sphaeronectinae.

The new species, *N. diomedeae*, is distinguished from the type species not only by a very differently shaped nectophore and hydroecium, but by an even more complex system of somatic canals.

It was particularly fortunate that in one of the specimens there was a group of appendages old enough to show their identity with a very large Eudoxid, differing in many important features from any previously described. It is possible that the problematical *Clausophyes galatea* of Lens and Van Riemsdijk may belong in this subfamily. If it is a Monophyid as Lens and Van Riemsdijk suggest, the large size of the nectophore points to this location, but the single specimen was so fragmentary that it is impossible to get a correct idea of its structure.

### **Nectopyramis diomedeae,** sp. nov.

Plate 1, figs. 1–6.

| | | | | | | |
|---|---|---|---|---|---|---|
| Station | 4652 | 400 | fathoms | to | surface | 2 excellent examples of the polygastric state. *Types.* |
| " | 4661 | 300 | " | " | " | 2 Eudoxids. |
| " | 4669 | " | " | " | " | 1 Eudoxid. |
| " | 4711 | " | " | " | " | 1 Eudoxid. |
| " | 4732 | 2012 | " | " | " | 1 Eudoxid. |

All the specimens, with the exception of one Eudoxid, were in excellent condition.

*Nectophore.* The nectophore, in the better of the two examples, reaches the unusual dimensions of 38 mm. in length by 26 mm. broad. It is roughly rectangular as seen in side view (Plate 1, fig. 1), laterally compressed (Plate 1, fig. 2) with a ridge extending from the level of the hydroecium to the dorsoapical corner, and with the two lateral faces meeting along the dorsal edge in a rounded subacute angle. In cross-section the nectophore is roughly triangular. At the base the gelatinous substance projects below the level of the opening of the nectosac in a triangular, but rounded, ventral, and a wedge-shaped dorsal prominence (Plate 1, fig. 1). The nectosac is shallow, rounded; the hyroecium lies transverse to the main axis of the nectophore, reaching dorsad nearly as far as the dorsal face of the nectosac; it is deeper than broad, and opens on the ventral edge by a narrow slit. Dorsally it is rounded, and sac-like, and it is asymmetrical in form, as is seen in ventral view (Plate 1, fig. 2).

*Somatic canal system.* The system of canals which replaces the somatocyst is more complex than in *N. thetis.* Commencing with the point at which the pedicular canal reaches the hydroecium, we can recognize a descending and an ascending branch, as in the Prayinae. The former is very short and soon turns apically, to run over the left-hand face of the hydroecium, where it branches once (Plate 1, fig. 4), or twice (Plate 1, fig. 3). The ascending system is much more extensive. In its passage over the dorsal surface of the hydroecium it gives off two large branches, one subdividing twice, and running to the dorsobasal angle (Plate 1, fig. 1, C. $Pa^1$) the other branching four or five times, and running to the apicodorsal angle (Plate 1, fig. 1, C. $Pa^2$). The ascending canal does not follow the upper wall of the hydroecium, but turns and runs to the apicoventral corner of the nectophore (Plate 1, fig. 1, C. $Pa^3$). At the point at which it bends apically it gives off a branch which runs over the left-hand face of the hydroecium, and a short distance further on gives off a second trunk which passes over its right-hand face. These two canals of the hydroecium are asymmetrical, the right-hand one branching one and three, and the left-hand one five and seven times respectively in our two specimens. (*Cf.* Plate 1, fig. 3 and fig. 4). In both *N. thetis* and *N. diomedeae,* ascending and descending branches can be distinguished, the former giving off the more or less complex hydroecial canals. But, whereas it is the latter which are the parents of the two canals running to the distal portions of the nectophore in *N. thetis,* in *N. diomedeae* these arise from the ascending trunk. The relation of the subumbral canals to the somatic system is likewise different; for while in *N. diomedeae* there is a single pedicular canal, in *N. thetis* all four subumbral canals extend beyond the nectosac to the hydroecium; but although the canal system of *N. diomedeae* is much the more complex, the difference is not an essential one, being of degree only. The difference is therefore better regarded as of specific than of generic significance. The subumbral canals are direct, not bowed.

*Stem and appendages.* These, though much contracted, were well preserved. An important feature is the absence of any signs of the previous attachment of a posterior nectophore, or of any reserve buds which might suggest the future development of such an organ. The appendages consist, for the most part, of very young siphons and tentacles and of the buds for gonophores and bracts; but near the extremity of the stem in one example all three organs are much further advanced. Most important is the bract because it links this species with the Eudoxid described below. The largest bract is about 1.5 mm. long; in outline it is triangular, laterally compressed, with prominent antero- and posterobasal angles. There is a deep basal concavity enclosing the proximal portion of its pedicular canal, and foreshadowing, not only in situation but in form, its future hydroecial cavity. Its somatocyst is represented by four canals arising together from the apex of the basal concavity, one running to the apex, one to the anterior basal angle, the other two toward the posterior basal angle, but over the faces of the future hydroecium. The apical trunk already shows the beginning of a branch, and each of the two hydroecial canals bears a branch of considerable length (fig. A).

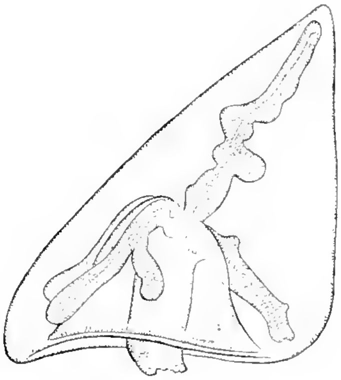
Fig. A.—NECTOPYRAMIS DIOMEDEAE. Bract.

The siphons, each of which shows a well-marked basigaster, are of the usual type.

The tentilla are of the usual Calycophorid type, but are unusually large, and differ in form from those of other Monophyids (*e. g.* Cuboides Chun, '92, pl. 12, fig. 14). Their most distinctive features are the thickening, marking the beginning of the contractile portion of the stalk, and the arrangement of the nematocysts as the walls of a cylinder, which in young stages is comparatively long, in older ones shorter and more knob-like. It likewise appears to be very contractile. The young gonophores, among which both ♀ and ♂ could be distinguished, already show the deep ventral furrow noticeable in their ripe state.

*The Eudoxid.* The Eudoxids of *N. diomedeae* (Plate 1, fig. 5) rival in size the "Ceratocymba" of *Abyla leuckartii,* the bract of the largest specimen being 33 mm. long. But these enormous bracts, except for size, and for minor details as to the branching of their canals, resemble so closely the bract described above that there is no doubt that they belong to the *N. diomedeae.* Thus they are of the same triangular, laterally flattened form, show the same basal hydroecial cavity, and similar basal gelatinous prominences. The canal system consists of the same four main trunks. The odd basal one now gives off three or four short transverse branches, the apical trunk from four to six, already foreshadowed in the young bract. The branching of the paired hydroecial trunks is now more complex than it was in the young stages already described. Furthermore it is asymmetrical as in the adult nectophore. Here, as in the latter, the branching of the canals shows a good deal of individual variation. It is easily derived from the condition in the young bract as the result of growth, a conclusion supported by the fact that its branching is progressively more and more complex in larger and larger specimens.

The gonophores show little change except for the much greater size, from the form described above for their earlier stages. In each of the Eudoxids there is one large gonophore, either male or female, and one or two buds for future ones.

The siphon, which has a well-marked basigaster (Plate 1, fig. 6), is of the usual type.

The tentilla are of the form described above. The agreement between their structure, and those of the cormidia of *N. diomedeae* while still attached to the stem is a further reason for uniting these Eudoxids with that species.

## **Prayidae** Kölliker, 1853.

*Diphyidae* Chun partim.

### **Amphicaryoninae** Chun, 1888.

This subfamily is treated first of the Prayidae because the failure to develop more than two nectophores or even additional reserve buds, clearly shows that it has departed but little from its Monophyid ancestors. In the more highly specialized members of the family the older nectophores are successively dropped as new ones develop, the number thus remaining approximately constant. In the Amphicaryoninae, however, the older of the two nectophores is retained permanently, but decreases both in relative size and in function.

The type of the subfamily, and indeed its only undoubted representative, is Amphicaryon, described by Chun ('88) from the Canary Islands. As a second member Chun ('97b) lists Mitrophyes Haeckel. Schneider ('98) has made the latter a synonym of Amphicaryon; and although Haeckel's figure shows a long stem and a very remarkable hydroecium, the undoubted resemblance between the two, and the fact that both were taken at the same locality, supports Schneider's view.

### AMPHICARYON Chun, 1888.

So far as I can learn, Amphicaryon has never been definitely recorded since described by Chun ('88, p. 1162). The several specimens in the "Albatross" collection and two examples from the West Indies are therefore of unusual interest.

The genus may be defined as Prayidae with two nectophores of very unequal size, the older one degenerating, so that in the adult, at least, the younger is much the larger; nectosac of the older nectophore much reduced; stem very short.

Chun's ('88) description of *A. acaule*, unfortunately not figured, is so brief that I should have been in some doubt whether or not the present Pacific specimens are identical with it, were it not that they agree very closely with a West Indian specimen which I have studied.

### Amphicaryon acaule Chun.

Plate 4, figs. 1–8.

*Amphicaryon acaule* Chun, '88, p. 1162.
? *Mitrophyes peltifera* Haeckel, '88a, p. 34; '88b, p. 131, pl. 28; Chun, '97b, p. 102.

| | | |
|---|---|---|
| Station 4613 | 300 fathoms to surface | 1 specimen. |
| " 4638 | " " " " | " " |
| " 4676 | " " " " | " " |
| " 4683 | " " " " | " " |
| " 4701 | " " " " | " " |
| " 4705 | " " " " | " " |
| " 4732 | " " " " | " " |

The largest specimen is 9 mm., the smallest 3 mm. in length. All are well preserved. In the larger specimens the two nectophores are very unequal in size. The larger are rounded, higher than broad, ventrally concave, its ventro-lateral edges partly enclosing the other much smaller flattened bract-like nectophore. In the largest specimens of *A. acaule*, 15 mm. in height, according to

Chun, the larger nectophore entirely encloses the smaller, and there is no reason to suppose that with further growth this condition may not be attained in the Pacific specimens. In earlier stages in growth the smaller nectophore, as Chun observed, is proportionately much larger. In our smallest individual it is plano-convex, nearly circular, and considerably overlaps the larger nearly spherical nectophore. At this stage there is no distinct hydroecium, but with advancing growth the larger nectophore becomes deeply, the smaller one slightly concave along the ventral surface, so that in the older stages (Plate **4**, fig. 1) there is a well-developed hydroecial tube extending from end to end of the smaller nectophore. The nectosac of the larger nectophore is of the usual type; it reaches to about the mid-level of the nectophore, is narrow and cylindrical in form, and its canals pursue a direct course suggesting the condition among Diphyids rather than the convolutions which they follow in the Prayinae. But, as noted above (p. 195), the corresponding structure in the smaller nectophore is very much reduced. In large specimens it is extremely small (Chun, '88, p. 1163); but even here the four radial canals can easily be traced (Plate **4**, fig. 4). Apparently the bell-mouth is permanently closed; at least I have seen no evidence, other than a slight indentation of the surface of the nectophore, to indicate that it could be opened in life. In the younger stages the nectosac is relatively larger (Plate **4**, fig. 8), but its opening is as tightly closed. Indeed so degenerate is it even at this stage that it is doubtful whether it ever functions as a swimming bell. If we judged from the adult only, and from analogy with the other Prayinae, we should expect the enclosed nectophore to be the younger; but its relatively larger size in younger stages, when it overlaps the nectophore which later encloses it, and its subsequent relative degeneration, shows that it is in reality the older, and that the younger overtakes it by its much more rapid growth.

*Stem and appendages.* The stem is so short that Chun ('88, p. 1162) speaks of it as "zu einer Scheibe umgebildet." In none of the specimens studied is it extended any further than in the figure (Plate **4**, fig. 1, 3). The characteristic form of the bracts (Plate **4**, fig. 7), each with two long lateral canals, was likewise observed by Chun.

In the two specimens in the series which are sexually mature all the gonophores are ♀, a fact suggesting that like "Amphicaryon", (Haeckel '88b, p. 193) Mitrophyes may be dioecious; but the material studied is insufficient to establish the point. The gonophores bear small swellings, or tentacular rudiments on the bell margins opposite the terminations of the four radial canals, as in various other Siphonophores.

The previous records for Amphicaryon are the Canary Islands (Chun, '88), where "Mitrophyes" likewise was found (Haeckel, '88b), and possibly also Bermuda (Chun, '97b, p. 16).

## **Prayinae** Haeckel, 1888.

Considering that the published accounts justify the recognition of only seven species, two of which are insufficiently known, the synonymy of this subfamily is remarkably confused. The earliest descriptions of any Prayids are probably those of *Rosacea plicata* and of *R. ceutensis* (Quoy and Gaimard, '27). The figure of *R. ceutensis* is so insufficient that it is impossible to identify it beyond the mere fact that it was taken from a single nectophore belonging to this subfamily. But the figure of *R. plicata* (Quoy and Gaimard, '27, pl. 4B), shows clearly the short broad outline, and the terminal dilation of the ascending branch of the somatocyst which are characteristic of the animal since described by Kölliker ('53) and by Vogt ('54) as *Praya diphyes*. Chun ('85) has founded Lilyopsis for species with special nectophores, such as *Lilyopsis diphyes*. Of course the identification of figures so lacking in detail as the original ones of *Rosacea plicata*, can never be absolutely certain; but for the sake of stability it is most desirable to give old names a final resting place; and since Quoy and Gaimard's figure of *R. plicata* shows the two trivial characters, *i. e.* form of the nectophores and dilation of the somatocyst, which must readily serve to distinguish *L. diphyes* from *P. cymbiformis* which strongly resembles it in external appearance, and when, furthermore, the figure certainly belongs to one or to the other, as Leuckart ('53) and Huxley ('59) long ago pointed out, no course is open but to follow Schneider ('98) in identifying it with *L. diphyes*. Lilyopsis then becomes a synonym of Rosacea, *L. diphyes* of *R. plicata*.

The following also belong to Rosacea, because of the presence of special nectophores:—*Praya diphyes* Graeffe ('60), *Praya medusa* Metschnikoff ('70), *Lilyopsis rosea* (Chun, '85). These agree with one another so closely, especially in the form of the definitive nectophores, and in the structure of bract, gonophore, and special nectophore, that there is every reason to unite them. *Praya blaino* Fewkes ('83a) and *P. gracilis* Fewkes ('83a) also belong here, so far as the rather unsatisfactory descriptions indicate. The same is true of Haeckel's *Lilyopsis catena*, from the Canary Islands, all we know of which being that it is similar to *rosea* (Haeckel, '88b, p. 150). The resultant compound species is easily distinguished from *R. plicata* by the triangular shape of the definitive nectophores, the relatively large nectosacs, and the presence of tentacular rudiments on the special nectophores. Schneider ('98) has retained the specific name *diphyes*, but this is preoccupied by Kölliker ('53) and by Vogt ('54), and the next available name, *medusa* Metschnikoff, must be used.

A member of the subfamily, without special nectophores, well known from the Mediterranean, seems to have been described by Delle Chiaje ('42) as *Physalia cymbiformis*. And since the middle of the last century it has been known almost universally as *Praya cymbiformis* Delle Chiaje, or *Praya maxima* Gegenbaur. The genus Praya was proposed in 1834 by Blainville for a species which he called *Praya dubia*. In his description he states that it is the same as the *Diphyes dubia* of Quoy and Gaimard ('34) whose unfinished manuscript he had examined, and his brief account agrees fairly well with that species. But his figure shows no resemblance whatever to Quoy and Gaimard's figures of *D. dubia*. On the contrary it much more nearly resembles their *D. prayensis*. The latter has usually been taken to be *Rosacea plicata*, but the figures agree with the well-known *cymbiformis* much more closely than with *prayensis*. By identifying them with the latter Blainville's *dubia* becomes a synonym of *cymbiformis* (it is the figures which must be used as the clue, rather than the insufficient account), and *cymbiformis* thus the type of Praya. This is very desirable, for it gives assured standing to a name which has long been in use.

*Praya californica* Gravier ('99) very closely resembles *cymbiformis* in its general form. It is separated from it, according to Gravier ('99), by the form of its bracts and by the structure of the tentilla. But, as I have observed, preserved and distorted bracts of *cymbiformis* often agree very well with Gravier's figure. The swelling which he observed at the base of the tentilla is of no more importance as a diagnostic character, because a similar appearance has been figured for contracted tentilla in *cymbiformis* by Haeckel ('88b, pl. 32, fig. 14), and I may add that I have observed it both in Mediterranean and in Pacific specimens. It is merely an evidence of the contraction of the stalk immediately proximal to the nematocyst-band. As to Gravier's supposition that his species might perhaps have only one nectophore normally, I may point out that the older nectophore is so easily detached that its absence in one specimen can have no weight. Therefore I have no hesitation in uniting *californica* with *cymbiformis*, especially since the present collection shows that the latter occurs in the Pacific.

Praya and Rosacea are united by Schneider ('98) in one genus, Rosacea. But I agree with Chun and with most other authors that the presence or absence of special nectophores in the groups of appendages is of generic importance both here and among the Diphyopsiinae. So striking a parallelism between the two subfamilies surely deserves more than specific recognition. It may well be that more detailed study of Rosacea will reveal other important differences. Thus in Praya the nectophores are similar in form; but in the only species of Rosacea of which we can speak with confidence, *i. e. R. plicata*, they differ from each other in form and in the extent of the hydroecium. Furthermore, it is not unlikely that the succession of nectophores may differ in the two species, for while new ones seem to be formed continuously, or at least frequently in *cymbiformis*, with the concomitant dropping of the oldest, as described and figured in detail by Chun ('97a), such a process seems never to have been observed in *R. plicata*.

Quoy and Gaimard's *Diphyes dubia* has never been recorded since first described. Schneider ('98) has identified it with the *Stephanophyes superba* of Chun ('88, '91), but an excellent specimen of *dubia* in the present collection (p. 204) agreeing in all its essentials with Quoy and Gaimard's figures, proves to be so different not only from Stephanophyes, but also from all known Prayinae in the arrangement and number of the subumbral canals, as to warrant a new generic name, Nectrodroma. For the present it is retained in this subfamily, but when we know the number and arrangement of its definitive nectophores it may be necessary to locate it elsewhere.

Finally, Haeckel's ('88b) genera Desmalia and Desmophyes are undoubtedly Prayids, the former without, the latter with special nectophores in the groups of appendages. But instead of only two chief nectophores, Desmalia has four, Desmophyes six, *i. e.* three pairs. Schneider ('98, p. 82) has identified Desmophyes with *R. medusa* (= "*diphyes*" Graeffe). But though it is true that there is a succession of nectophores in that species (Chun, '88), it is equally certain that the normal number of well-developed bells retained at one time in that genus, and in Praya, is two only. Should further study prove that the number of definitive nectophores retained simultaneously in Haeckel's species is six, as in his single example, it would deserve generic separation. I therefore retain Desmophyes and Desmalia, at least provisionally. The former was described, and beautifully figured — but we know the latter only from an insufficient notice.

## **PRAYA** Blainville, 1834.

### **Praya cymbiformis** (Delle Chiaje) Leuckart.

Plate 2, figs. 1–6.

*Physalia cymbiformis* Delle Chiaje, '42, tab. 33, fig. 1.
*Praya dubia* Blainville, '34, p. 137, pl. 6, fig. 4 (non *Diphyes dubia* Quoy and Gaimard, '34).
*Diphyes prayensis* Quoy and Gaimard, '34, p. 106, pl. 3, fig. 37, 38.
*Praya diphyes* Lesson, '43, p. 144 (non Kölliker, '53).
*Praya cymbiformis* Leuckart, '53, p. 2, taf. 1, fig. 4; '54, p. 286, pl. 11, fig. 18–24; Huxley, '59, p. 30; Keferstein and Ehlers, '61, p. 20, pl. 1, fig. 28; Haeckel, '88b, p. 146; Chun, '97b, p. 66, fig. 8; '97b, p. 102.
*Praya maxima* Gegenbaur, '54a, p. 19, pl. 17, fig. 1–6; Haeckel, '88b, p. 146; Lens and Van Riemsdijk, :08, p. 17.
*Praya diphyes* ? Huxley, '59, p. 52, pl. 3.
*Praya galea* Haeckel, '88a, p. 35; '88b, p. 146, pl. 31, 32.
*Endoxella galea* Haeckel, '88b, p. 108, pl. 32.
*Praya (Huxleya) californica* Gravier, '99, p. 87, fig. 1–4.

| | | | |
|---|---|---|---|
| Station | 4574 | surface | 2 entire colonies and 1 detached nectophore. |
| " | 4648 | 300 fathoms to surface | 1 superior nectophore, 20 mm. long. |
| " | 4687 | " " " " | 1 nectophore, with basal part of stem and 1 reserve nectophore. |
| " | 4703 | " " " " | 1 fragmentary nectophore. |

This species is so well known, and has been so well described and figured by Leuckart ('54), Gegenbaur ('54), and Haeckel ('88b) that no detailed account is necessary. The identification of the material has been made more certain by comparison with two excellently preserved colonies from the Naples Zoölogical Station than could otherwise have been possible, and I have not found a single character, either in the chief nectophores, or in the groups of appendages, to separate Pacific from Mediterranean specimens.

As elsewhere stated (Bigelow :11b, p. 342) one of the most serviceable field characteristics for distinguishing this species from *Rosacea plicata* which it resembles closely in general aspect, is the form of the hydroecium of the younger of its two chief nectophores. That this extends nearly or quite the entire length of the ventral surface of the younger (Plate 2, fig. 2), just as it does of the older nectophores in *P. cymbiformis*, has long been known; but its importance as a diagnostic character seems to have been overlooked. Comparison of the figures of the nectophores of the two species (Plate 2, fig. 1, 7) will show how evident the difference is. Furthermore no specimen shows the terminal dilation of the somatocyst, so characteristic of *Rosacea plicata*. In the colony figured (Plate 2, fig. 1), in which the chief nectophores were about 11 and

14 mm. long, only one very small bud for a reserve nectophore is to be seen (Plate **2**, fig. 3) but in another specimen in which only one full grown nectophore is present, there is a reserve bell of considerable size.

The single nectophore observed by Huxley, evidently the younger of the two definitive ones because part of the stem was attached, is included in the present species, because it has the long hydroecium characteristic of *P. cymbiformis*. The only records of *P. cymbiformis* from the Indo-Pacific region are from the Indian Ocean and from Torres Straits (Huxley), from the Malaysian region (Lens and Van Riemsdijk) from the coast of Lower California (Gravier), besides the present series from the Eastern Tropical Pacific. These few, however, are sufficient to show its wide distribution, and taken in connection with its known occurrence in the Mediterranean and in the Atlantic indicate that it may be expected to occur throughout the warmer regions of the three great oceans.

## **ROSACEA** Quoy and Gaimard, 1827.

*Lilyopsis* Chun, '85.

### **? Rosacea plicata** Quoy and Gaimard.

Plate 2, figs. 7–9.

*Rosacea plicata* Quoy and Gaimard, '27, p. 177, pl. 4B, fig. 4; Schneider, '98, p. 78.
*Rosacea ceutensis* Blainville, '34, p. 140 (partim), pl. 6.
*Praya diphyes* Kölliker, '53, p. 33 taf. 9; Vogt, '54, p. 99, pl. 16, 17; Bedot, '82, p. 122 (non Lesson, '43, p. 144).
*Diphyes bragae* Vogt, '51, p. 140.
*Praya filiformis* Keferstein and Ehlers, '61, p. 20, taf. 5, fig. 8–11.
*Lilyopsis diphyes* Chun, '85, p. 280; '97b, p. 102; Haeckel, '88b, p. 150.
? *Rosacea ceutensis* Quoy and Gaimard, '27, p. 176, pl. 4B, fig. 2, 3.
? *Rhizophysa filiformis* Delle Chiaje, '29, tav. 50, fig. 3, '42, p. 135, pl. 149, fig. 3.

| | | |
|---|---|---|
| Station 4661 | 300 fathoms to surface | 2 fragmentary nectophores. |
| “ 4684 | “ “ “ “ | 1 specimen with both nectophores. |
| “ 4685 | surface | 1 “ “ “ “ |
| “ 4705 | 300 fathoms “ “ | 1 fragmentary nectophore. |
| “ 4732 | “ “ “ “ | 1 “ “ |
| “ 4740 | “ “ “ “ | 1 specimen, with both nectophores. |

In none of the specimens was anything but the basal end of the stem with a few small buds preserved. The nectophores were all separated. Those listed above as belonging together are united on the strength of being taken together, and since this species was comparatively rare throughout the area traversed, it is probable that the association is natural. They are easily distinguished from *R. medusa* (p. 203) by the depth of the hydroecium and the small nectosac. The provisional identification as *plicata* rests on their general resemblance to the Biscayan specimens of that species (Bigelow, :11b), especially in the shortness of the hydroecium of the younger nectophores. There is, however, a difference in the somatocyst.

In all the Biscayan examples of *plicata* the upper end of the somatocyst turns dorsally, away from the dorsal face of the hydroecium which it follows for the rest of its length, and its terminal region is slightly thickened; in some specimens it forms a definite egg-shaped dilation, and a more or less pronounced terminal swelling has usually been described. But in the Eastern Pacific specimens, the ascending branch of the somatocyst lies in the hydroecial wall to its very tip, and there is no terminal dilation. At first sight this difference suggested that the Pacific specimens might be specifically separate from the Atlantic ones. But the conditions in the latter are so variable that I doubt whether there is any actual discontinuity between the two; if not, the extremes would at the most represent varieties of the one species. To settle the question will require better preserved, and more extensive material from the Pacific. And until such is forthcoming the question may be left open.

The hydroecium in the younger nectophores (Plate 2, fig. 7) is much shorter and deeper than it is in *Praya cymbiformis*; as I have already noted (:11b), the difference affords a good field mark, even in the case of battered specimens, for the separation of the two. None of the older figures show the extent of the hydroecium in the younger nectophore, or even whether there is one, though Vogt ('54, pl. 17, fig. 3), has given a good representation of it in the older of the two chief nectophores. But neither Kölliker nor Vogt gave detailed figures of this portion of the colony, though they described the appendages fully.

The older nectophores (Plate 2, fig. 9) are proportionately shorter and broader than those of *P. cymbiformis* (Plate 2, fig. 2), and their hydroecial furrows much shallower, a feature probably connected with the loose association of the two nectophores, shown by Kölliker and by Vogt. But this feature is so often masked by distortion in preserved material that identification of the separate nectophores would be difficult or even impossible unless they were captured side by side with the better characterized younger nectophores to which they are normally attached. In none of the specimens was there a reserve nectophore, nor could I certainly identify the bud for such a structure. On account of the condition of the material, no description of the appendages is possible.

The only previous records from the Indo-Pacific, which could belong to *Rosacea plicata* are the specimens from the Malaysian region, described by Lens and Van Riemsdijk (:08) as ?*Lilyopsis diphyes* Vogt.

### **Rosacea medusa** (METSCHNIKOFF.)

*Praya diphyes* GRAEFFE, '60, p. 11, taf. 1, figs. 1–3 (non KÖLLIKER, '53; VOGT, '54).
*Praya medusa* METSCHNIKOFF, '70, p. 925, pl. 1.
*Lilyopsis medusa* CHUN, '85, p. 280.
*Lilyopsis rosacea* CHUN, '85, p. 280; BEDOT, '96, p. 369, pl. 12, fig. 1.
*Praya sp.* ? FEWKES, '80a, pl. 3, fig. 2.
*Praya blaino* FEWKES, '83a, p. 845.
*Praya gracilis* FEWKES, p. '83a, p. 841.
*Rosacea diphyes* SCHNEIDER, '98, p. 81.
? *Lilyopsis catena* HAECKEL, '88b, p. 150.

Station 4665, 300 fathoms to surface, one specimen.

In the single specimen the two chief nectophores were still attached to each other, but both were somewhat battered. Only a very much contracted portion of the stem and appendages remains intact. So fragmentary is the latter that I can give no account either of bracts or special nectophores, both of which according to Graeffe ('60), Metschnikoff ('70), and Chun ('85) are characteristic; the latter especially so in the presence, on the margin, of the tentacular rudiments. The nectophores are of equal size (11 mm. long), and similar in shape, both being somewhat triangular, and obliquely truncate basally with proportionately large nectosacs. So characteristic are these features, according to the figures and accounts of all previous authors, that they serve as excellent field marks to distinguish this species either from *R. plicata* or from *Praya cymbiformis* (p. 200). As indicated by Metschnikoff ('70) and by Bedot ('96, pl. 12, fig. 1), neither nectophore encloses the other, but the two are merely closely opposed. The hydroecial grooves are broad but very shallow, and extend the entire length of the ventral surface, but, apparently, in life they do not form a closed tube except near the anterior end. None of the older figures show these ventral furrows clearly, but on the specimen studied they are plainly seen. The subumbral canals, though fragmentary, are sufficiently preserved to show that their course is a complex one, as observed by Chun and by Bedot, not straight as Fewkes ('80a, pl. 3, fig. 2) represented them.

In neither nectophore is there a distinct terminal dilation of the nematocyst, such as has been figured by both Metschnikoff and Bedot; but the shrivelled condition of these organs has no doubt obscured their normal form.

The records of the occurrence of this species:—Mediterranean (Graeffe, Metschnikoff, Chun), Western Atlantic (Fewkes), Malaysian region (Bedot) and Eastern Tropical Pacific, suggest that it will be found generally distributed over the warmer regions of all three great oceans. So far as our present knowledge goes, it is a much less common form than either *R. plicata* or *P. cymbiformis*.

### **NECTODROMA,** gen. nov.

Prayinae with the somatocyst represented by a system of branching canals. Subumbral canals numerous (more than four); they may branch or anastomose.

The only described species referable to the genus is the type, *Diphyes dubia* Quoy and Gaimard. But the present collection contributes a second, *N. reticulata*, sp. nov. (p. 206) equally well defined.

The branching somatocyst recalls the condition in Nectopyramis among Monophyids, and in Stephanophyes among Prayids. But the arrangement of the subumbral canals sharply distinguishes Nectodroma from the latter. The genus is included in the Prayinae rather than in the Stephanophyinae because the presence of a well-developed hydroecial groove in each nectophore suggests a biserial rather than a coronal arrangement of the bells. But the exact plan of architecture can not be determined until complete specimens are studied.

### **Nectodroma dubia** (Quoy and Gaimard).

Plate 3, fig. 8, 9.

*Diphyes dubia* Quoy and Gaimard, '34, p. 104, pl. 5, fig. 34–36.
*Praya dubia* Lesson, '43, p. 143; (non Blainville, '34, p. 137, pl. 6, fig. 4).
*Rosacea dubia* Schneider, '98, p. 79 (partim).

Station 4652, 100 fathoms to surface; 2 nectophores, each about 40 mm. long.

The rediscovery of a species so long unrecorded as *N. dubia* is not the least interesting find in the present collection. And before proceeding with the description, I must observe that comparison between the "Albatross" specimens and Quoy and Gaimard's figures show that the latter, far from being founded on an "apokryphen Art," as Chun ('97b, p. 115) believed, were in reality extremely accurate representations of an important species.

Unfortunately both of the "Albatross" nectophores are somewhat battered, but they are sufficiently well preserved to allow me to give an account of their more important anatomic features.

*Younger nectophore.* It is probably correct to identify as the younger nectophore the one which is still attached to the stem (Plate 3, fig. 8), for among the Prayinae it is usually the older one which is most easily detached. The general form of the nectophore is nearly cylindrical, truncate so obliquely at the base that the ventral wall extends below the level of the opening of the nectosac. Our example is proportionately longer and narrower than Quoy and Gaimard's figure; but as these authors expressly state that the gelatinous substance is very soft, this difference is merely an evidence of contraction or of preservation. The hydroecial groove is deep, and runs the entire length of the nectophore, though it is partially closed over anteriorly by a small gelatinous flap, and is enclosed by two lateral flaps, as Quoy and Gaimard observed.

The somatocyst, as noted above, strongly suggests the corresponding structure in *Stephanophyes superba*; indeed, it was on the strength of this resemblance that Schneider believed that the two species were identical, a possibility negatived by the subumbral canals. Below the point of origin of the pedicular canal it runs as a single unbranched tube, along the dorsal surface of the hydroecium, to a point slightly below the bell opening. Its ascending trunk, however, splits into three branches near the anterior end of the nectophore, the median branch running directly dorsad (Plate **3**, fig. 8) and the two laterals (Plate **3**, fig. 9) curving posteriorly, with several minor lateral branches, to terminate slightly above the apex of the nectosac. Except for the exact positions and lengths of the minor branches, this agrees very well with the original account of the species.

The most interesting feature of *N. dubia* is afforded by the subumbral canals. These were described by Quoy and Gaimard as being numerous, and running radially, as they do in various Medusae. And in the present specimens the subumbrella surface is ribbed radially (Plate **3**, figs. 8, 9), precisely as they represented it. To determine whether these ridges do actually represent canals, I cut transverse serial sections of three, and on examination found that each was provided with an open lumen surrounded by a distinct layer of entoderm. The precise number of canals could not be determined because in each case one side of the nectosac was torn. Apparently there are twelve at the apex of the bell; and these branch so that there are about thirty-five at the margin. The number and arrangement of the canals distinguishes Nectodroma from all other Siphonophores as yet known.

*Stem and appendages.* Though a considerable length of spirally coiled stem is still intact, all of the appendages except a large number of proximal buds have been stripped off. It is important to note that in addition to the large and well-preserved muscular lamella to which the older nectophore was attached, there is a third much smaller lamella which probably bore a "reserve-bell" in life. Of course from the present material it is quite impossible to make out whether more than two developed nectophores were normally present at one time; but the conditions outlined suggest three as the maximum.

The older posterior nectophore, though much battered, is proportionately shorter and somewhat broader than the younger one. The structure of the somatocyst, with three branching ascending limbs, is the same, and there are numerous radial subumbral canals.

The original record for this species was from the neighborhood of Kangaroo Island, off Adelaide, South Australia.

### **Nectodroma reticulata**, sp. nov.

Plate 1, figs. 7, 8; Plate 3, figs. 1–7.

| | | | |
|---|---|---|---|
| Station 4681 | 300 fathoms to surface; | 2 nectophores, and 3 bracts. | *Type.* |
| " 4709 | " " " " | 1 nectophore. | |
| " 4709 | " " " " | " " | young, 15 mm. long. |

The nectophores and bracts taken at Station 4681 apparently all belong to one colony; and they are therefore made the basis of the description and figures. Both nectophores are about 55 mm. long, by 20 mm. in greatest diameter; they are similar in shape, and neither has the base of the stem still attached. In general form they are subcylindrical; truncate transversely at the anterior, obliquely at the posterior end.

The hydroecial canal is deep (Plate 3, fig. 2) and extends the entire length of the ventral surface. In one nectophore it is entirely covered over by the lateral flaps, but in the other, the flaps are widely separate. Probably the latter was the older and partially enclosed the other, the younger. The nectosac is proportionately smaller than in *N. dubia.*

The somatocyst alone is sufficient to distinguish this species from *P. dubia.* Its descending branch, which extends below the level of the bell-opening (Plate 3, fig. 1), bears several short lateral branches. Its ascending branch runs along the surface of the hydroecium nearly to the anterior end of the nectophore, and then turns abruptly dorsad (Plate 3, fig. 2). Throughout its ascending course it gives off short transverse lateral trunks, which are themselves often divided at their extremities, and in its ventrodorsal extension there are numerous very much smaller lateral branches. In all the three large nectophores the general type of branching is the same, though the precise number, length, and arrangement of the lateral trunks varies slightly.

The subumbral canals are numerous, as in *P. dubia*, and fundamentally radial, but their primitive arrangement is masked by branching and anastomosis.

At the apex in the younger nectophore there are eight radial canals (Plate **3**, fig. 4); but these all branch dichotomously at different distances from their points of origin; and the resultant canals anatomose by means of short transverse trunks until they form an irregular reticulum covering the subumbrella surface (Plate **3**, fig. 2). Fortunately in this one example the nectosac was in such good condition that the canals could be traced over most of its surface with ease. To make certain that the ridges actually represent canals, serial transverse sections were cut of two adjacent ones, and in each the open lumen, surrounded by entoderm, was visible.

*Bract.* Of course, in the entire absence of the stem, the identity, with *P. reticulata*, of the bracts (Plate **3**, fig. 6) is rather doubtful. They are referred to it because of their occurrence in the same haul, and because they differ from the corresponding structures yet described for any other Prayid, in their large size (20 mm. in length), and lateral flattening.

The condition of the somatocyst and of the subumbral canals in the young nectophore (Plate **1**, figs. 7, 8) suggest that it is a young stage of *P. reticulata*. The somatocyst is thicker, its lateral branches proportionately stouter, and its ventrodorsal arm bends posteriorly corresponding to a curving of the nectophore as a whole. The subumbral canals are evidently radial, and the development of cross-trunks has not proceeded so far as in the older nectophores. But the condition in the latter may be easily derived from the former by progressively increasing anastomosis. Indeed the beginnings of the process are clearly foreshadowed by the few transverse canals which already connect several of the radial canals. The general form, and the well-developed hydroecium extending from end to end, also suggest that the specimen is a young nectophore of *N. reticulata*.

## Hippopodiidae Kölliker, 1853.

Following (Chun, '97b) two genera, Hippopodius and Vogtia, are recognized. Schneider ('98) has united these. But though they are no doubt closely allied, the difference in the structure of the nectophores seems of more than specific importance. Were subgenera recognized, Vogtia would be considered one.

### HIPPOPODIUS Quoy and Gaimard, 1827.

For the reasons for the use of this name rather than Gleba, see Chun ('97b) and Schneider ('98). Chun recognizes two species of Hippopodius, the well-known Atlantic and Mediterranean form so often described under the names

*H. luteus* and *H. gleba*, and the *H. (Polyphyes) ungulata* of Haeckel. The *H. neapolitanus* of Kölliker and Weismann, was retained as distinct by Haeckel ('88b) on the grounds that in it ♂ and ♀ gonophores are associated with each other, whereas in *luteus* they are all separate. The structure and arrangement of the gonophores in this genus has been examined in detail by Richter (:07). He has shown that normally male and female gonophores are associated together, but not with the numerical regularity ascribed to them by Weismann ('83). I may add that all the specimens studied, both Atlantic and Pacific, which were well enough preserved to show the gonophores at all, agreed with his account. I therefore follow Chun ('97), Schneider ('98), and Lens and Van Riemsdijk (:08) in uniting *neapolitanus* and *luteus* under *H. hippopus* Forskål.

The status of the *Polyphyes ungulata* of Haeckel which is undoubtedly a Hippopodius, is doubtful. It is retained by Chun as distinct, but united with *H. hippopus* by Schneider. Leaving out of account the question of unisexual or bisexual cormidia, *ungulata* is supposed to differ from *hippopus* only in the presence of six prominent irregular teeth, four dorsal and two ventral, on the margin of its nectophores. According to Schneider the presence or absence of these teeth is merely an evidence of individual variation. And several of the many nectophores of *H. hippopus* which I have examined approach Haeckel's figures in this respect. It is of course the constancy of the difference which must determine its importance in classification. Under the circumstances it seems best to class *H. ungulatus* as a doubtful synonym of *hippopus*.

I believe that Schneider was justified in substituting Forskål's name *hippopus* for *luteus* as the specific designation of the one well-known member of the genus, because, though Forskål's figures are not sufficiently detailed for absolute determination, the probability of their identity with *H. luteus* is very strong. That they do belong to some Hippopodius has generally been accepted; indeed Chun, who uses the name *luteus*, includes *hippopus* as a doubtful synonym of it; and since they can hardly be identified with *H. ungulatus* for the want of prominent teeth, there seems no course open but to refer them to the only other species of the genus. On general principles it is always desirable, for the sake of stability, to identify the older figures and accounts with actual species; and it seems entirely justifiable in the present instance.

### **Hippopodius hippopus** (Forskål) Schneider.

*Gleba hippopus* Forskål, 1775, p. 14, 1776, taf. 43, fig. E; Fewkes, '82b, p. 304, pl. 1, figs. 31–33.
*Gleba excisa* Otto, '23, p. 309, taf. 42, fig. 3 a–d.
*Hippopodius luteus* Quoy and Gaimard, '27, p. 172, pl. 4A, fig. 1–12; Eschscholtz, '29, p. 146; Delle

Chiaje, '42, tav. 92, fig. 7, tav. 149, fig. 1, 2; Lesson, '43, p. 473; Vogt, '54, p. 93, taf. 14, fig. 7–12, taf. 15, fig. 1, 2; Müller '70–'71, taf. 11, fig. 8, taf. 13, fig. 1–8; Chun, '88, p. 1165; '97b, p. 34; Lens and Van Riemsdijk, :08, p. 62.
*Hippopus excisus* Delle Chiaje, '29, p. 64; '42, pl. 149, fig. 1, 2.
*Stephanomia hippopoda* Quoy and Gaimard, '34, p. 67, taf. 2, fig. 13–21.
*Protomedea lutea* Blainville, '30, p. 110; '34, p. 121, pl. 2, fig. 4.
*Protomedea uniformis* Blainville, '30, p. 110.
*Protomedea calcearia* Blainville, '30, p. 110.
*Protomedea notata* Blainville, '30, p. 110.
*Hippopodius mediterranaeus* Costa, '36, p. 3, taf. 2.
*Elaphantopes neapolitanus* Lesson, '43, p. 473.
*Hippopodius neapolitanus* Kölliker, '53, p. 28, taf. 6, fig. 1–5; Weismann, '83, p. 191, taf. 20, taf. 21, fig. 9–13.
*Hippopodius gleba* Leuckart, '54, p. 299, taf. 12, fig. 1–4; Keferstein and Ehlers, '61, p. 22, taf. 5, fig. 18–21; Haeckel, '88b, p. 178.
*Polyphyes luteus* Haeckel, '88a, p. 36.
*Polyphyes elephantopus* Haeckel, '88b, p. 364.
*Hippopodius hippopus* Schneider, '98, p. 82, Richter, :07, p. 589, taf. 28, figs. 27–34, taf. 29.
? *Polyphyes ungulata* Haeckel, '88b, p. 179, pl. 29, fig. 1–8.
? *Hippopodius ungulatus* Chun, '97b, p. 103.

| | | |
|---|---|---|
| Station 4644 | surface | 4 loose nectophores. |
| " 4646 | 300 fathoms to surface | 2 " " |
| " 4652 | 400 " " " | 4 specimens with 3, 1 with 5, and 1 with 2 nectophores, and 4 larger detached nectophores. |
| " 4655 | 400 fathoms to surface | 2 excellent specimens, with 4 and 5 nectophores respectively. |
| " 4659 | 300 fathoms to surface | 1 large detached nectophore. |
| " 4704 | surface | 2 excellent specimens, with 3 and 7 nectophores respectively. |
| " 4734 | 300 fathoms to surface | 3 detached nectophores. |

The largest nectophore is 15 mm. long.

The identification of the very well-preserved material listed as belonging to the well-known Atlantic species rests upon actual comparison between it and a number of good specimens from the West Indies and from the Mediterranean. I have not been able to find a single character to separate the two; this same conclusion was reached by Lens and Van Riemsdijk for the Malaysian specimens collected by the "Siboga." *H. hippopus* has so often been described and figured that no account is needed here, further than to note that while the younger nectophores have the basoventral margin more sharply concave and the dorsolateral prominences more tooth-like than do older ones, the two dorsal prominences though somewhat variable in size, are merely small, rounded knobs, in all that I have examined, both young and old. They are never triangular and pointed as Haeckel has described and figured them for his *H. ungulata*. So far as the outline of the basoventral margin is concerned there is very little variation in the form of the older nectophores except such as is due to violent contraction. With regard to the coloration of this species I may note that while most of the specimens were entirely colorless except for the yellow tentilla, the nectophores in the two examples from Station 4707 were pale emerald-green, the tentacles bright yellow, and the siphons a brilliant carmine. This color difference, certainly not of any systematic value since the brilliant specimens were anatomically indistinguishable from the others, is probably the external indication of different physiological states, perhaps of nutrition.

So far as I can learn, Hippopodius has only once been recorded from the Indo-Pacific region (Lens and Van Riemsdijk). The present captures show that it is generally distributed over the Eastern Tropical Pacific.

### **VOGTIA** Kölliker, 1853.

At most only two species of Vogtia can be recognized, *V. pentacantha* Kölliker, and *V. spinosa* Keferstein and Ehlers ( = *V. köllikeri* Haeckel); neither of which has been thoroughly studied. Indeed the latter is known from detached nectophores only. Fortunately the "Albatross" collection contains a well-preserved series which agree so closely with the figures of *V. spinosa* by Keferstein and Ehlers and Haeckel, that I have no hesitation in uniting them. The question whether *spinosa* is actually distinct from *pentacantha*, with which it is united by Schneider, is still an open one. The evidence afforded by the single specimen of the latter which I have had the opportunity to study (:11b, p. 35), together with the various figures of it which have been published (Kölliker, '53, Kefferstein and Ehlers, '61, Chun, '97b), seem to show that the differences in the form of the nectophores, and especially in the location of the gelatinous spines, are sufficient to separate the two species. However, a final decision is impossible until the constancy of the two characters in question has been tested on a considerable series of *pentacantha*.

The union of Haeckel's *V. köllikeri* with *spinosa*, proposed by Chun ('97b, p. 35) is undoubtedly necessary.

### **Vogtia spinosa** Keferstein and Ehlers.

Plate 15, fig. 5–12.

*Vogtia spinosa* Keferstein and Ehlers, '61, p. 24, pl. 5, fig. 16; Haeckel, '88b, p. 364; Chun, '97b, p. 103.
*Vogtia köllikeri* Haeckel, '88b, p. 182, pl. 29, fig. 9–14.

| | | | |
|---|---|---|---|
| Station | 4646 | 300 fathoms to surface | 1 specimen with 4 nectophores and 6 detached nectophores. |
| “ | 4652 | surface | 1 specimen with 6 definitive nectophores. |
| “ | 4671 | “ | loose nectophores. |
| “ | 4673 | 300 fathoms to surface. | “ “ |
| “ | 4679 | “ “ “ “ | 1 specimen with 10 nectophores, and 7 detached nectophores. |
| “ | 4681 | “ “ “ “ | 1 specimen with 13 nectophores. |
| “ | 4705 | “ “ “ “ | 1 specimen with 11 nectophores. |
| “ | 4740 | “ “ “ “ | 3 large detached nectophores, in poor condition. |

The arrangement of the nectophores follows exactly the same plan as it does in the better known genus Hippopodius. As in that genus the nectosome is composed of two series of obliquely placed alternating nectophores, the oldest at the bottom. Their concave ventral surfaces form a typical hydroecial canal, within which the stem with its appendages is entirely retracted in all the specimens studied (Plate **15**, fig. 5).

Observations on the living colonies showed that the nectosome is no more effective as a swimming organ in Vogtia than it is in Hippopodius. Indeed the arrangement of the nectophores precludes the possibility of any but the oldest two so serving. In all the others the opening of the nectosac is closed by the anterior surface of the neighboring nectophore. As in Hippopodius the nectophores are attached to a zigzag muscle band, which, as Chun has shown ('97a), is nothing more than the very much prolonged "Knospungszone." So close is the resemblance in this particular between the two genera that except for the form of the nectophores Chun's figure ('97a, fig. 11) of a longitudinal section of the siphosome of Hippopodius might equally well apply to Vogtia.

*Nectophores.* The older nectophores, as shown by Haeckel ('88b, pl. 29, fig. 12) may be likened in their outlines to short pentagonal prisms (Plate **15**, fig. 9). The largest are about 20 mm. broad. The arrangement of the characteristic gelatinous tubercles or spines can be better shown in the figure than in the description; but I may call attention to the fact that they occur closely crowded not only on the margins of the facets, but on the lateral and dorsal facets themselves. In *V. pentagona*, so far as we yet know, they are entirely restricted to the angles. The ventral facet, which is deeply concave, is without spines. The youngest nectophore in one colony, 3 mm. broad, is more nearly rectangular, when seen from the basal side, and it has spines only on the dorsal facets, as yet hardly divided by the dorsal angle (Plate 15, fig. 11). In a slightly older example (Plate 15, fig. 12), the dorsal angle is so much more prominent, that the form is now clearly pentagonal.

All the specimens were examined to test the constancy of the occurrence and arrangement of spines, and in all but one they showed the typical condition outlined above, though with some minor individual variation in the number and precise location of the spines, a variation which might have been expected. In a single example, however, while the youngest nectophores were spinous on their dorsal and dorsolateral facets, the oldest three have no spines on either angles or facets, although they are of the usual pentagonal form. The colony is in such good condition as a whole that the absence of spines can not be charged to poor preservation. So constant in occurrence and location are these structures in all the other specimens and so typical are they in the young nectophores of the aberrant example, that their absence in the older nectophores is difficult to account for. But a sporadic variation of this kind does not point to a connection between the "*spinosa*" and "*pentacantha*" types of spination. On the contrary, in this specimen there is an entire abortion of spines which are well developed at a younger stage, whereas in *V. pentacantha* (Bigelow, :11b, p. 351) there are no spines on the facets at any stage in growth.

The nectosac is broad and shallow as in Hippopodius, and its four radial canals (Plate 15, fig. 9–12) follow a nearly direct course, as in that genus. Haeckel ('88b) has already observed that there is a crescent-shaped ventral sinus connected with the ventral radial canal. In young nectophores this sinus, walled with flat tile-shaped cells, covers nearly the entire upper surface of the nectosac (Plate 15, fig. 11), but with the increasing development of the nectophore, it becomes proportionately much smaller. The pedicular canal, of course, connects with the axial canal of the "Knospungszone."

*Stem and appendages.* In life the stem was extensible to a considerable length. The individual appendages so closely resemble those of Hippopodius that no extended account is necessary here. I may, however, call attention to the fact that, as Kölliker observed for *V. pentacantha*, each cormidium has both ♂ and ♀ gonophores (Plate 15, fig. 8). The tentilla (Plate 15, figs. 6, 7) very closely resemble those of Hippopodius. In *V. pentacantha*, according to Kölliker ('53), Keferstein and Ehlers ('61), and Claus ('63), the tentilla are bright yellow, but in the present specimens they were brick-red in life. Should this color difference prove constant it might be considered a specific character. But color among Siphonophores is so often variable that it is unsafe to lay stress upon it until it has been tested.

The only previous records for *V. spinosa* are from off the coast of Brazil (Keferstein and Ehlers), from the South Atlantic 37° 3′ S., 44° 17′ W. (Haeckel), and probably from the Bay of Biscay (Bigelow, '11b, p. 351). The present captures, from widely separated localities in the Eastern Pacific suggest that, like so many other Siphonophores, it is distributed generally over the warmer regions of all three great oceans. *V. pentacantha* is known from the Mediterranean and from the Atlantic (Bay of Biscay, Bigelow, :11b, p. 351; Equatorial current, Chun, '97b, p. 35). The genus is also credited by Délage and Herouard (:01, p. 272) to the Pacific.

## **Diphyidae** Eschscholtz, 1829.

## **Abylinae** L. Agassiz, 1862.

As Chun ('97b) has pointed out, it is much more difficult to separate the Abylinae into several natural genera than the other Diphyidae. Since the appendages of all species of the subfamily are set free as Eudoxids, and since none have special nectophores in the Cormidia, the genera or subgenera as yet proposed rests on such characters as the structure of the bracts, and the external sculpture of the nectophores.

Haeckel ('88b) recognized three genera of Abylinae:— Abyla, Bassia, and Calpe, basing the distinction on the form of the bracts and of the posterior nectophore. Chun ('97b) has adopted the same classification, with the exception that he reduces the divisions to the rank of subgenera, and substitutes Abylopsis for Calpe, because the latter is preoccupied for a genus of Lepidoptera. A rather different scheme is used by Lens and Van Riemsdijk (:08), who list two genera, Abyla and Abylopsis, though without defining them, (leaving out of account, for the moment, their new genus Diphyabyla); while Schneider ('98) recognizes only one genus, Abyla. The present collection, embracing as it does all the well-founded species of the subfamily, including both nectophores of the little known *leuckartii*, together with the various Eudoxids, gives an opportunity to test the importance of the characters on which the schemes of Haeckel and of Chun rest.

When we analyze the structure of the posterior nectophore, we find that its form is best expressed, not as trigonal, tetragonal, or pentagonal as Haeckel characterized it, but in terms of the number of ridges, which are the basis for its external outlines. In three species, *i. e. tetragona*, *eschscholtzii* ("*quincunx*" Chun), and *leuckartii*, there is a dorsal, and on either side a well-developed lateral ridge, in addition to the ventral angles. In one species, *trigona*, in which the nectophore has been described as trigonal, the right lateral ridge is nearly but not altogether, suppressed. In one, *bassensis*, the dorsal ridge is entirely lacking, and in the latter alone is the hydroecium a closed tube. Thus, although the nectophore of *bassensis* is truly tetragonal as Haeckel supposed, we can not draw any sharp line between the "pentagonal" nectophore, *e. g.* of *tetragona*, and the "trigonal" one of *trigona*; therefore the structure of this nectophore alone would justify only two groups, *bassensis* being opposed to all the other species.

When we study the anterior nectophore, we find that so far as it is concerned, the Abylinae fall into two main groups. In the one are *leuckartii*, *trigona*, and *haeckeli*, which agree in that the nectophore has a rectangular apical facet, and in the general arrangement of facets and ridges, the only difference of much importance between them being that the simple ventrolateral facet of *leuckartii* is subdivided in the other two species by a transverse ridge. This may be called the "trigona" type. In the other group are *tetragona*, *eschscholtzii*, and *bassensis* in which the nectophores, distinguishable from one another only by minutiae of form, have no apical facets, the lateral ones of the two sides joining apically in a ridge.

It is evident that while the use either of the anterior or of the posterior nectophore as the prime factor in generic subdivision results in two groups of Abylinae, the line of demarcation between the two differs, according as we choose one or the other nectophore as our guide. On *a priori* grounds we might expect that the anterior one, being phylogenetically the older, might be the more important, and this view is supported by the structure of the bract. It appears that Haeckel was in error in drawing a parallel between the bract and the posterior nectophore in all cases, because the "Amphiroa" type, instead of being restricted to species with apparently trigonal lower nectophore as he supposed, is also found in one species, *leuckartii*, in which both dorsal and lateral ridges are well developed in the posterior bell. But the two other species which agree with the latter in the pentagonal form of the posterior nectophore, have very different bracts, namely the "Aglaisma" type. *Bassia bassensis* alone is distinguished from all other Abylinae by the structure of both posterior nectophore and bract. In comparing the bract with the anterior nectophore, we find a close correspondence in place of the confusion just outlined. Thus in all species with the "trigona" type of anterior nectophore (including *leuckartii*, as I have determined, p. 218), the bract is an "Amphiroa." And of the three species with "tetragona" type of anterior nectophore in two, *tetragona* and *eschscholtzii*, the bract is an "Aglaisma."

In brief, then, Haeckel's three genera, as he defined them, rest on a misinterpretation of the structure of *trigona*, and an ignorance of *A. leuckartii*. But the combined evidence of the anterior nectophore and bract shows that the three divisions recognized by Haeckel and Chun are valid, though on grounds other than those employed by Haeckel.

To these must be added *Diphyabyla hubrechti* Lens and Van Riemsdijk, a form as yet known from the anterior nectophore only. In its essential features it agrees with the corresponding structure in *A. leuckartii*; but its pyramidal external outline, and the form of the nectosac, are so aberrant that it is best retained as a separate genus, at least until its posterior nectophore and Eudoxid are known. This is the only Abylid which can not be connected, even provisionally, with any known Eudoxid.

Most students agree that the species listed by Chun ('97b) are all worthy of recognition; and to them must be added *Abyla haeckeli* Lens and Van Riemsdijk, closely allied to—*A. trigona*, but separated from it by a constant, if minor character. I regret that in the following description two nomenclatural changes have been found necessary:—*A. pentagona* Quoy and Gaimard, a name long used, must be supplanted by *tetragona* Otto (p. 224); and *quincunx* Chun, by *eschscholtzii* Huxley (p. 227).

There are three Eudoxids, probably belonging to this subfamily, as yet unconnected with their respective polygastric stages; these are *Ceratocymba sagittata* (Quoy and Gaimard) Chun, *Enneagonoides quoyi* Huxley, and *E. picteti* Bedot.

*Key to the polygastric state.*

1. Anterior nectophore with rectangular apical facet; posterior nectophore essentially pentagonal, its hydroecium open; bract of "Amphiroa" type. ABYLA.
    a. Anterior nectophore with one ventrolateral facet on each side; not divided transversely.
        a′. Posterior nectophore with a well-developed ridge on either side; somatocyst of the bract recurved at its tip ("Ceratocymba"). *A. leuckartii.*
    b. Two ventrolateral facets, apical and basal, on either side of the anterior nectophore. Posterior nectophore with lateral ridge almost suppressed, strongly asymmetrical.

b′. Anterior nectophore with simple ventral facet, contracted near the middle.

*A. trigona.*

c. Anterior nectophore with the ventral facet divided into two by a transverse ridge.

*A. haeckeli.*

2. Anterior nectophore without apical facet, the lateral facets on the two sides meeting at apex in a ridge. Posterior nectophore with both dorsal and lateral ridges well developed. Its hydroecium open.

ABYLOPSIS.

a. Basal portion of posterior nectophore strongly asymmetrical; the canals of its nectosac with basal dilations, and following an aberrant course (Plate **14**, fig. 7).

*A. tetragona.*

b. Basal portion of posterior nectophore subsymmetrical; canals of its nectosac of ordinary type.

*A. eschscholtzii.*

3. Anterior nectophore as in Abylopsis; posterior nectophore with dorsal ridge entirely absent; its hydroecium a closed tube. Bract of "Sphenoides" type.

BASSIA

*B. bassensis.*

4. Anterior nectophore pyramidal; pointed apically: resembling externally the Diphyids; its facets agreeing in their essentials with those of *A. leuckartii.* Nectosac reaching high above the level of its pedicular canal.

DIPHYABYLA.

*Diphyabyla hubrechti.*

## **ABYLA** QUOY and GAIMARD, 1827.

### **Abyla leuckartii** HUXLEY.

Plate 13, fig. 5–8; Plate 15, fig. 3, 4 Eudoxid.

*Abyla leuckartii* HUXLEY, '59, p. 49, pl. 3, fig. 2; AGASSIZ and MAYER, :02, p. 165 (partim); LENS and VAN RIEMSDIJK, :08, p. 34, pl. 5, fig. 42–46.
*Enneagonum leuckartii* SCHNEIDER, '98, p. 93.
? *Abyla trigona* CHUN, '97b, p. 31 (partim).

| | | | | | | |
|---|---|---|---|---|---|---|
| Station | 4592 | | surface | 1 | anterior | nectophore. |
| " | 4661 | | " | " | " | " |
| " | 4667 | 300 fathoms to | " | " | " | " |

| | | |
|---|---|---|
| Station 4671 | 300 fathoms to surface | 1 anterior nectophore |
| " 4676 | " " " " | " " " |
| " 4707 | " " " " | " " " |
| " 4708 | surface; | 2 specimens with both anterior and posterior nectophore. |

The largest anterior nectophore is 9, the smallest 4 mm. long. The posterior nectophore is 4.5 mm. long.

*Abyla leuckartii* has been recorded twice since it was described by Huxley with a total of eleven specimens; and of the two described by Agassiz and Mayer (:02, p. 165) one, from its "narrow elongated, five sided" pyramidal form, certainly does not belong here. The description of the nectosac as long and tapering to a point near the apex of the bell, as well as a sketch from life submitted to me by Dr. Mayer, shows that the individual in question was in reality a Diphyabyla.

The external form of the anterior nectophore of this species, which is so characteristic that there is no danger of confusing it with any other Siphonophore, has been well figured by Lens and Van Riemsdijk, and its ridges and facets described by them in great detail. As a guide to identification the following brief account is given.

The nectophore is pentagonal in side view; the upper portion rectangular; slightly longer than broad, and laterally compressed. The ridges are 2 dorsals, 2 laterals, 2 ventrals, and two which bound the roughly rectangular apical facet. The two ventral ridges come together basally to form a single tooth, and each of the two dorsal ridges ends in a large basal tooth. There is also a prominent triangular tooth on each side interrupting the basal margin of the nectophore opposite the dorsal face of the hydroecium. But the lateral ridges instead of reaching these teeth terminate some distance above them. These lateral ridges follow a characteristically curved course. The basal parts of all the ridges are strongly serrate in the present specimens, but apparently less so in the "Siboga" material. The nectosac is cylindrical, and reaches nearly to the apex, as does the hydroecium (Plate 13, fig. 5). The somatocyst is very large, ovoid, its long axis lying nearly apicobasal. At its upper end it connects with the stem by a narrow canal. Up to the present time the species has been known from anterior nectophores only, and Schneider has referred it to Enneagonum (= Cuboides) on the assumption that no posterior nectophore occurs. Two specimens in the present series (Plate 13, fig. 5) with small posterior nectophores still attached, and others with easily distinguishable reserve buds were therefore especially valuable. The posterior nectophore in both instances was still entirely enclosed in the hydroecium, being attached to the base of the stem by a long pedicular canal. But when detached and studied each proved to be far enough advanced in development to show the general characters, (Plate 13, fig. 5). The posterior nectophore is comparatively long and narrow (Plate 13, fig. 6) and laterally compressed; its general appearance suggests the corresponding structure in *Diphyes bojani* (p. 253). There is a well-marked dorsal ridge extending from apex to base, and on each side a lateral ridge arising at about the level of the top of the nectosac. Each of these ridges terminates in a large triangular serrate tooth, and there is also on either side a tooth at the dorsobasal margin of the hydroecium, the left hand one being much the larger. The hydroecial groove, as in *D. bojani*, is open throughout its length, but it is covered over by two lateral wings. A characteristic feature is that the left wing bears a secondary flap with undulating margin, on its inner face near the base, while the right wing bears two such flaps (Plate 13, fig. 7). The nectosac is of the usual form, nor do its canals present any features of special interest.

The discovery of a group of appendages, rather far advanced in development, is likewise important, not only because the structure of the cormidia was previously entirely unknown, but especially because the structure of the somatocyst of the bract suggests that it may be an early stage of the interesting Eudoxid known as "Ceratocymba." In the present example the somatocyst is of the "Amphiroa" type, consisting of a descending sac, and two more slender diverging canals; and the former, seen in side view, is curved upward sharply near its free end. A comparison between it and the various figures of Ceratocymba (Bedot, :04, Lens and Van Riemsdijk, :08) as well as with the "Albatross" specimens of the latter (Plate 15, fig. 3, 4) shows that the resemblance between the two, in so far as this character is concerned, is an extremely close one. The general form of the bract is not yet sufficiently advanced to show its final outline, but its large descending scale-like portion resembles in its general form and proportions the corresponding region in Ceratocymba. It is already divided into three facets, a dorsal, and two laterals, and of the latter the right hand one is already the larger, a character which foreshadows the asymmetry of the bract in the free "Ceratocymba" Eudoxid. The apical portion of the bract, still divided for the passage of the stem, corresponds to the dorsal facet of the latter.

As to the arrangement of its ridges nothing can yet be said. There are two gonophores, one well developed (apparently ♂), one still merely a bud. The larger is proportionately very broad; but the basal tooth and particularly the pronounced serrations of the hydroecial wings suggest the conditions in the corresponding regions in Ceratocymba (Bedot, :04, pl. 1, fig. 1). The siphon has a well-developed basigaster, but neither it, nor the tentacle, shows any features of special interest. The tentilla are of the ordinary Abylid type. On the whole, the resemblance of the cormidium to Ceratocymba is so close that I have no hesitation in identifying the latter as the free Eudoxid of *Abyla leuckartii*.

Chun ('88, '97b) has already suggested that the polygastric stage of the "Ceratocymba" Eudoxid would prove to be an Abylid, basing this view on the remarkably close resemblance between the bracteal canals in Ceratocymba and in the Eudoxid of *Abyla trigona*, though admitting ('97b) the possibility that it might be derived from a Monophyid. Schneider ('98) as noted above, united it previously with *Abyla leuckartii*, though he believed that the latter was a Monophyid.

Two species of Ceratocymba, *C. sagittata* (Quoy and Gaimard) Chun, from the Atlantic, and *C. asymmetrica* Lens and Van Riemsdijk, from the Malaysian region, have been described. Lens and Van Riemsdijk (:08) refer the specimens from between the Azores and Portugal, described by Bedot (:04) as *C. sagittata* to their *asymmetrica*. In as much as they have had the opportunity of examining well-preserved material of *C. sagittata*, identified by Chun, I accept their identification. The slight asymmetry of the descending posterior portion of the bract which is already visible in the early stage described above, suggests that it is *asymmetrica*. The facts that *asymmetrica* occurs side by side with *A. leuckartii* in the Indo-Pacific region, that it was taken by the "Albatross," and that both it and *A. leuckartii* are known from the Atlantic as well, is good evidence that it is *asymetrica* which is the Eudoxid of *leuckartii*.

The synonymy of the Eudoxid is:—**Ceratocymba asymetrica** LENS and VAN RIEMSDIJK.

*Ceratocymba asymmetrica* LENS and VAN RIEMSDIJK, :08, p. 9, pl. 1, fig. 2–5.
*Ceratocymba sagittata* BEDOT, :04, p. 1, pl. 1, fig. 1, (non CHUN, '88).

It was taken at Stations 4667, 4669, 4671, 4673, 4708, 4715, 4723, 4725, both in surface and in 300 fathom hauls. The total number of specimens is fifteen.

All the bracts, of which the largest was 19 mm., the smallest, 6 mm. long, were in good condition. The large gonophores were all badly crushed and distorted; but most of the smaller ones, 6–10 mm. long, were well preserved. The form of the bract is characteristic, and shows the most important feature distinguishing the species from the Eudoxid described by Chun as *C. sagittata.* Even in the smallest examples it already shows the characteristic form and asymmetry. Its various angles and facets have been described by Lens and Van Riemsdijk; but their account is so complex that a more simple summary, with the accompanying figures, may be useful for identification. The bract is composed of five distinct facets (six if we follow Lens and Van Riemsdijk in applying this term to the hydroecial cavity). These are a ventral, an apical, and three which together compose the arched dorsal surface. The apical (anterior) is an irregular tetrahedron, placed obliquely. The three dorsal facets are separated from each other by two dorsal ridges, running to the base from the two dorsal angles of the apical facet. These ridges are not symmetrically placed, for the right hand one lies nearly in the main longitudinal axis of the nectophore, whereas the left hand one is far to the left of it (Plate 15, fig. 4). Consequent on the positions of the ridges the three dorsal facets are asymmetrical, the left hand one very short, the central and right hand ones much longer and broader. Lens and Van Riemsdijk suggest that the asymmetry is due to the absence of a ridge which may be supposed to have primitively been present on the right hand side, subdividing the right dorsal facet longitudinally. But it seems to me that no such assumption is required. If we compare the bract of this form with that of *Abyla trigona* ("*Amphiroa alata*") we find that its apical facet corresponds in position to that of the latter, and that it would require only a slight distortion to make its mid-dorsal facet correspond to the dorsal, its right and left dorsal facets to the right and left laterals of "Amphiroa." In other words were the apical facet of Ceratocymba a true rectangle as it is in Amphiroa, instead of a rhomboid with unequal angles, and were the basal outline transversely truncate instead of angular, the asymmetry characteristic of the former would disappear, and the two would agree. If we accept this explanation it is easy to derive the form of the adult bract from that of the younger one described above. The two laterals of the latter would correspond to the right and left dorsals, the dorsal to the mid-dorsal of the former. The only facet of the "Amphiroa" which is not represented in "Ceratocymba" is the basal one. This is suppressed by the form and large size of the hydroecial cavity. A diagnostic character only second in importance to the asymmetry of the bract is afforded by the somatocyst, the stout single median descending branch of which is curved dorsad near its tip in an extremely characteristic manner. So far as I know, no other Amphiroa-like Eudoxid possess this character; and it therefore assumes greater systematic importance than its slight anatomical significance would suggest. It is, as noted above, largely on account of the curved somatocyst in the bracts of *Abyla leuckartii* that I have identified the latter as the young stage of the "Ceratocymba."

In several examples there are two gonophores.

*A. leuckartii* has so far been recorded, in its polygastric state, only from the Indo-Pacific region, where it is widely distributed in warm waters. But that it also occurs in the Atlantic, where it has been generally overlooked, is proved by an excellent and altogether typical specimen which I collected in the West Indies, and which is now in the collection of the Museum of Comparative Zoölogy. Its occurrence in the West Indies has also been reported to me by Dr. A. G. Mayer.

### **Abyla trigona** QUOY and GAIMARD.

Plate 13, figs. 3, 4.

*Abyla trigona* QUOY and GAIMARD, '27, p. 14, pl. 2B, fig. 1–8; ESCHSCHOLTZ, '29, p. 131; BLAINVILLE, '30, p. 123; '34, p. 135, pl. 4, fig. 4; GEGENBAUR, '60, p. 337, taf. 26, taf. 27, fig. 9–12; CHUN, '88, p. 1160; 97b, p. 31; SCHNEIDER, '98, p. 90; LENS and VAN RIEMSDIJK, :08, p. 28, pl. 4, fig. 34–36 (non HUXLEY, '59, p. 47, pl. 3, fig. 1).

*Amphiroa alata* BLAINVILLE, '30, p. 121; '34, p. 133, pl. 4, fig. 1 (Lesueur, Manuscr.); HUXLEY, '59, p. 64, pl. 5, fig. 1; CHUN, '88, p. 1160; '97b, p. 31; LENS and VAN RIEMSDIJK, :08, p. 28, pl. 4, fig. 37, 38. EUDOXID.

*Diphyes abyla* QUOY and GAIMARD, '34, p. 87, pl. 4, fig. 12–17.

*Eudoxia trigonae* GEGENBAUR, '60, p. 349, taf. 27, fig. 10–12. EUDOXID.

*Abyla carina* HAECKEL, '88b, p. 156, pl. 35.

*Amphiroa carina* HAECKEL, '88a, p. 33; '88b, p. 114, pl. 36. EUDOXID.

*Amphiroa trigona* HAECKEL, '88a, p. 33; '88b, p. 113. EUDOXID.

The polygastric stage was taken at Stations 4646, 4673, 4684, 4713, 4715; seven entire specimens and two loose anterior nectophores, in both surface and 300 fathom hauls. The largest anterior nectophores are about 6 mm. long, the posterior ones 7–13 mm.

I have been able to compare these very well-preserved specimens with an Atlantic series, with which they agree so closely that I have no doubt of their specific identity. The same conclusion was reached by Lens and Van Riemsdijk for the "Siboga" collection. *A. trigona* has been so well described by the various authors listed in its synonymy that no detailed account is called for. The only species of the genus with which it might be confused is *A. haeckeli* Lens and Van Riemsdijk, and the presence of a single ventral facet in the superior nectophore of *trigona* (Plate **13**, fig. 4) instead of two ventral facets as in *haeckeli* (Plate **13**, fig. 2) readily separates the two. For a detailed account of the facets and ridges, see Lens and Van Riemsdijk, :08, p. 29. The posterior nectophores agree very well with the accounts by Gegenbaur ('60) and by Haeckel ('88b).

Their apparently trigonal form is diagnostic, but, as Haeckel observed, this form is apparent rather than real, because the right lateral ridge, though insignificant, can be traced at least for the lower one third of its course. The importance of the posterior nectophore in classification, has already been discussed (p. 214).

The identity of the *Amphiroa alata* of Huxley, from Torres Straits with the corresponding Eudoxid from the Atlantic described by Blainville, Gegenbaur, and Haeckel has been maintained recently by Lens and Van Riemsdijk; and comparison of the present series with a collection from the West Indies shows that they were correct. Gegenbaur, who traced the development of *Amphiroa alata* proved that it is the Eudoxid of *A. trigona*. The bracts, even before their detachment, show the characteristic "Amphiroa" structure, (Haeckel, '88b).

*A. trigona* is widely distributed over the Mediterranean and the warmer portions of the Atlantic, as well as the Eastern Tropical Pacific, and the Malaysian region. Apparently it has not been recorded from the Indian Ocean; but in view of its known distribution it may be expected to occur there.

## **Abyla haeckeli** Lens and Van Riemsdijk.

Plate 13, fig. 1, 2.

*Abyla haeckeli* Lens and Van Riemsdijk, :08, p. 32, pl. 5, fig. 39–41.
*Abyla trigona* Huxley, '59, p. 47, pl. 3, fig. 1 (non Quoy and Gaimard, '27).
? *Amphiroa angulata* Huxley, '59, p. 64, pl. 5, fig. 2. Eudoxid.
?*Abyla alata* Haeckel, '88b, p. 156 (non Amphiroa alata, Blainville, '30).
? *Amphiroa dispar* Bedot, '96, p. 373, pl. 12, fig. 5, 6. Eudoxid.

| | | | |
|---|---|---|---|
| Station | 4634 | 300 fathoms to surface | 1 anterior nectophore. |
| " | 4646 | " " " " | " " " |
| " | 4665 | " " " " | " " " |
| " | 4668 | " " " " | " " " |
| " | 4729 | " | " " " |
| " | 4746 | " " " " | " " " |

These detached anterior nectophores, 5–6 mm. long, agree very well in their ridges and facets, with the detailed account of *A. haeckeli* given by Lens and Van Riemsdijk. The inclusion under this species of the specimen from Torres Straits described by Huxley ('59, p. 47) as *A. trigona*, rests upon his very clear account of the structure of the nectophore, from which it is evident that in his example there were two ventral facets separated by a transverse ridge, instead of the single ventral facet of the true *A. trigona*.

The comparison between the anterior nectophores of the two species by Lens and Van Riemsdijk is so detailed that to go over the ground again here would be a needless repetition. The one important point of difference is the nature of the ventral facet, whether simple and with concave lateral margins (*A. trigona*), or divided into a lower pentagonal and an upper rectangular portion by a well-marked transverse ridge (*A. haeckeli*). The upper lateral facet is likewise proportionately larger in *haeckeli* than it is in *trigona* (compare fig. 1 with fig. 3, Plate **13**).

The posterior nectophore of *A. haeckeli* is so far known only from Huxley's description and figure ('59, pl. 3, fig. 1), from which it is clear that it closely resembles the corresponding structure in *A. trigona*. Without a study of actual specimens of *haeckeli* it is impossible to state whether or not the posterior nectophores of the two species show any constant differences in form or structure.

Eudoxid. Neither the "Siboga" nor the "Albatross" material throws any light on the Eudoxid of *A. haeckeli*. Huxley described and figured a bract, which, though detached, was taken together with his one specimen of *A. haeckeli*, as resembling the Eudoxid of *A. trigona* ("*Amphiroa alata*") except that the basoventral margin of the hydroecium is deeply concave, instead of being straight. And it is just this character which distinguished his *Amphiroa angulata* (taken once only), which he thought might prove to be a young stage of the Eudoxid of *A. trigona*. Recently Bedot ('96) has described, from Amboina, an "Amphiroa" which likewise has a deeply concave ventrobasal hydroecial margin, besides having asymmetrical lateral hydroecial walls with a prominent basal tooth on the right, and none on the left side, under the name *Amphiroa dispar*. On comparing Huxley's figure ('59, pl. 5, fig. 2) of *angulata* with the lateral view of *dispar* given by Bedot ('96, pl. 12, fig. 6) we see that *angulata*, like the latter, has a prominent basal tooth on the side of the hydroecium. And this, together with the concavity of the basoventral hydroecial margin present in both, and their generally close agreement in other respects, is sufficient ground for concluding that both are the Eudoxids of one species. In the basoventral concavity they agree so well with the bract figured by Huxley, that I have no doubt that they are specifically identical with it. And although it is not altogether certain that the bract in question belonged to *A. haeckeli*, there is every reason to suppose that such was the case. There is thus a strong probability that the Eudoxids *Amphiroa angulata* Huxley, and *A. dispar* Bedot, are the free cormidia of *Abyla haeckeli*; but to determine conclusively whether this view is correct will require an examination of specimens of that species with stem and appendages intact.

So far, *A. haeckeli* is known only from the Malaysian region and from the

Eastern Tropical Pacific. Considering, however, how closely it resembles *A. trigona*, and how long the very common, and easily distinguishable *A. eschscholtzii* (= *quincunx*) escaped notice, it is not unlikely that it may occur in the Tropical Atlantic.

## **ABYLOPSIS** CHUN, 1888.

### **Abylopsis tetragona** (OTTO).

Plate 14, figs. 6, 7; Plate 15, fig. 2.

*Pyramis tetragona* OTTO, '23, p. 306, taf. 42, fig. 2a–2e.
*Aglaja baerii* ESCHSCHOLTZ, '25, p. 743, taf. 5, fig. 14.
*Plethosoma crystalloides* LESSON, '26, pl. 4, fig. 2 (partim), '30, p. 64.
*Calpe pentagona* QUOY and GAIMARD, '27, p. 11, pl. 2A, fig. 1–7; BLAINVILLE, '30, p. 132; '34, p. 134, pl. 4, fig. 3; LESSON, '43, p. 449.
*Aglaisma baerii* ESCHSCHOLTZ, '29, p. 129, taf. 12, fig. 5.
*Abyla pentagona* ESCHSCHOLTZ, '29, p. 132; LEUCKART, '53, p. 56, taf. 3, fig. 1–6; '54, p. 11, taf. 11, fig. 1–10; KÖLLIKER, '53, p. 41, taf. 10; VOGT, '54, p. 121, taf. 20, fig. 4–7, taf. 21, fig. 3–6, 10–13; HUXLEY, '59, p. 40, pl. 2, fig. 2; GEGENBAUR, '60, p. 349, taf. 28, fig. 17–19; KEFERSTEIN and EHLERS, '61, p. 14, taf. 3, fig. 5, 6; SPAGNOLINI, '70, p. 21; FEWKES, '74, p. 318, pl. 3; CHUN, '97b, p. 30; LENS and VAN RIEMSDIJK, :08, p. 17, pl. 2, fig. 17–20.
*Diphyes calpe* QUOY and GAIMARD, '34, p. 89, pl. 4, figs. 7–11.
*Aglaisma pentagonum* LEUCKART, '53, p. 150, taf. 3, figs. 2, 3.
*Eudoxia cuboides* LEUCKART, '53, p. 54, taf. 3, figs. 7–10; MÜLLER, '70–'71, taf. 11, figs. 6, 7, taf. 13, fig. 9; CHUN, '85, p. 525, taf. 2, fig. 11; BEDOT, '96, p. 375. EUDOXID.
*Aglaismoides elongata* HUXLEY, '59, p. 61, pl. 41, fig. 3. EUDOXID.
*Aglaisma gegenbauri* HAECKEL, '88b, p. 119, taf. 40. EUDOXID.
*Calpe gegenbauri* HAECKEL, '88b, p. 164, pl. 39, 40.
*Calpe huxleyi* HAECKEL, '88a, p. 36; '88b, p. 164.
*Aglaisma cuboides* CHUN, '97b, p. 30; LENS and VAN RIEMSDIJK, :08, p. 19, pl. 2, fig. 21. EUDOXID.
*Abyla tetragona* SCHNEIDER, '98, p. 89.
*Abyla huxleyi* AGASSIZ and MAYER, :02, p. 166, pl. 11, figs. 48.

*Abylopsis tetragona* was taken from the following Stations: 4642, 4646, 4652, 4655, 4657, 4659, 4669, 4671, 4676, 4701, 4702, 4708, 4715, 4716, 4722, 4724, 4731, 4732, 4734, 4737, 4740. The material consists of 4 specimens from 3 surface, 93 from 20 intermediate, hawls with open nets, chiefly 300–0 fathoms.

Its Eudoxid was taken at Stations 4655, 4657, 4676, 4679, 4681, 4715, 4724, 4673. 25 specimens in one surface, 18 in 7 intermediate, hawls with open nets. The largest anterior nectophore is 8 mm., the largest posterior one 35 mm., the largest Eudoxid 7 mm. long.

My choice of Otto's name *tetragona* for this species, in place of the commonly accepted *pentagona*, rests on Chun's statement that he has examined Otto's type specimen (specimens?) which is still in good condition, in the Museum at Breslau, and that he "erkannte sofort, dass thatsachlich die *Abyla pentagona* vorliegt." ('97b, p. 31.) In the face of the statement, by one of the most experienced students of coelenterates, that the type specimen of *tetragona* is identical with *pentagona*, the more recent name must, of course, become a synonym, no matter how incorrect the description and figure on which the older name rests. That this course must be followed, to accord with the International rules of zoölogical nomenclature, has already been pointed out by Schneider ('98).

Inclusion in the above synonym of the *Aglaja baerii* of Eschscholtz ('25) is necessary, because the figure of that form, especially of the posterior nectophore, shows clearly that it was in reality *A. tetragona*.

*Plethosoma crystalloides* Lesson, is a combination of the siphosome of some Physophorid, with an Abylid; Huxley long ago pointed out that the latter was almost certainly *A. tetragona*, with which Lesson's figure agrees very well.

Neither Chun ('97b) nor Lens and Van Riemsdijk (:08) have placed the *Aglaisma pentagona* of Leuckart ('53) here. Leuckart's figures show that his specimens were young Abylopsis, either *A. tetragona* or *A. eschscholtzii* (= *quincunx*). Unfortunately the one feature absolutely distinguishing the two, *i. e.*, the canal-course of the posterior nectosac, is not shown. But the shape of the posterior nectophore suggests identity with the former rather than with the latter. In including here the *A. pentagona* of Huxley, which Haeckel ('88b) and Chun ('97b) considered a separate species, I follow Lens and Van Riemsdijk, and I need only add that examination of Huxley's figures has convinced me that they were correct in thinking that Huxley's specimens were merely small examples of *A. tetragona*. *Aglaismoides elongata* Huxley, agrees according to the figures, with the many accounts of the "*cuboides*" Eudoxid of *A. tetragona*, and differs correspondingly from the Eudoxid of *A. quincunx*.

It is probable that the *A. huxleyi* of Agassiz and Mayer (:02) also belongs here, especially since I have found specimens of *A. tetragona* in the material on which their report was based. But in as much as their figure shows canals of the ordinary Abylid type in a specimen otherwise resembling *A. tetragona*, the identification remains doubtful.

The present large and excellently preserved series allowed me to make a thorough comparison between this species and *A. eschscholtzii*, with the result that I am convinced the two species are entirely distinct.

Several adequate accounts of *A. tetragona* have been published. It is not likely to be confused with any species except *A. eschscholtzii*, and from the latter it can readily be distinguished by its very large size; its relatively much longer posterior nectophore (between four and five times as long as the anterior one), and especially by the structure of that organ. The asymmetry of the nectophore, and the diagnostic features of the hydroecium are mentioned in the account of *A. eschscholtzii* (p. 228). The peculiar arrangement of the canals of the posterior nectosac has been well described and figured by Gegenbaur ('60), and the importance of this character has recently been emphasized by Lens and Van Riemsdijk. The present series show it very well (Plate **14**, fig. 7). There is no variation from the typical arrangement in any of the specimens.

The free Eudoxids have often been described, and Lens and Van Riemsdijk have pointed out the differences between them and those of *A. eschscholtzii.* These consist, it is true, chiefly of minor particulars in the form of the bract; but they are so constant that it is easy to distinguish the two species. The most diagnostic feature is the outline of the dorsal facet, which is a regular pentagon in *eschscholtzii*, but subrectangular in *tetragona.* The ventral facet is basally deeply convex in the former, straight in the latter; and the basolateral facets also differ in proportions. (Compare Plate **15**, fig. 7 with fig. 2.)

*Abylopsis tetragona* is common in the Mediterranean, in the Tropical Atlantic, where I have taken it among the West Indies, in the Malaysian region, and over the entire region covered by the present cruise of the "Albatross." It is also known from the Indian Ocean (Huxley).

### **Abylopsis eschscholtzii** (HUXLEY).

Plate 14, Figs. 1–5; Plate 15, Fig. 1.

*Aglaismoides eschscholtzii* HUXLEY, '59, p. 60, pl. 4, fig. 2; CHUN, '88, p. 1160; LENS and VAN RIEMSDIJK, :08, p. 25, pl. 3, fig. 18–31. EUDOXID.
*Abylopsis quincunx* CHUN, '88, p. 1160; BEDOT, '96, p. 375.
*Abyla (Abylopsis) quincunx* CHUN, '97b, p. 29.
*Aglaismoides quincunx* CHUN, '97b, p. 29. EUDOXID.
*Aglaisma quincunx* AGASSIZ and MAYER, '99, p. 180; MAYER, :00, p. 78; (non AGASSIZ and MAYER, :02, p. 164, pl. 10, fig. 45). EUDOXID.
*Aglaisma cuboides* MAYER, :00, p. 77, pl. 30, fig. 104 (non LEUCKART). EUDOXID.
*Abyla quincunx* MAYER, :00, p. 78, pl. 34, fig. 115–117, AGASSIZ and MAYER, :02, p. 163, pl. 11, fig. 46, 47; LENS and VAN RIEMSDIJK, :08, p. 21, pl. 3, fig. 22–27.
*Abyla tetragona* SCHNEIDER, '98, p. 89 (partim).
*Abyla pentagona* MAYER, :00, p. 77, pl. 30, fig. 101–103 (non ESCHSCHOLTZ, CHUN).
*Chunia capillaria* MAYER, :00, p. 78, pl. 27, fig. 90.

The polygastric state of this species was captured at Stations 4592, 4594, 4613, 4637, 4646, 4659, 4665, 4673, 4687, 4707, 4715, 4732, 4734, 4737; the total number of specimens being 25. The largest anterior nectophore is 5 mm., the largest posterior one 8 mm., and the largest Eudoxid 5 mm. long. The records are both from the surface and from open hauls between 300 fathoms and the surface. The free Eudoxid was taken only at Stations 4671, 4673, and in Acapulco Harbor, a total of four specimens. The union of this Pacific series with the Atlantic species, rests not only on the similar identification by Lens and Van Riemsdijk (:08), but on actual comparison of specimens from both oceans.

When Chun ('88) first described the polygastric state of this species he believed that the Eudoxid which he observed in connection with it was identical with the *Aglaismoides eschscholtzii*, of Huxley, but in his later work he abandoned this view. More recent authors, who have described Eudoxids as *A. eschscholtzii*, or as *A. quincunx*, have not been able to trace the actual development of the cormidia of the polygastric stage into the free Eudoxid. Fortunately in several of the present specimens the stems bear groups of appendages sufficiently far advanced for comparison with the few examples of *Aglaismoides eschscholtzii*, as well as with the figures of the latter given by Huxley and by Lens and Van Riemsdijk. As I shall show below (p. 229), there is every reason to conclude that *Aglaismoides eschscholtzii*, is actually the Eudoxid of *A. quincunx*; Haeckel ('88b), confused it with the Eudoxid of *A. tetragona*. This being the case, Huxley's name must be substituted for the more recent *quincunx*.

That the species recorded by Mayer (:00) as *A. pentagona* in reality belongs to *A. eschscholtzii*, has already been pointed out by Lens and Van Riemsdijk (:08, p. 25), and an examination of Mayer's figure confirms this conclusion. As for *Chunia capillaria* Mayer, though Lens and Van Riemsdijk retain this specific name, it seems to be absolutely indistinguishable from *A. eschscholtzii*; the "long slightly curved, bristle-like spine" (Mayer, :00, p. 79) is evidently nothing but the denuded stem.

*Anterior nectophore.* Structurally the anterior nectophore closely resembles that of *A. tetragona*, with which it agrees in the number and arrangement of ridges and facets. It has been described and figured in great detail by Lens and Van Riemsdijk. I may point out, however, that an examination of very considerable numbers of each species, from both Atlantic and Pacific, shows that the minor characters which they mention as distinguishing the two, *e. g.*, acute angles in *eschscholtzii*, blunt ones in *tetragona*, and the exact outline and degree of curvature of the ridges, is so variable that identification from these features alone is often impossible. But there is one character in the anterior nectophore which appears to be diagnostic, *i. e.* the course of the subumbral canals (*cf.* Plate **14**, fig. 6 with fig. 1).

*Posterior nectophore.* Both Chun and Lens and Van Riemsdijk, have pointed out the striking differences in this structure in *A. eschscholtzii* and in *A. tetragona*. Briefly stated they are as follows:—In the former the posterior nectophore is much smaller, in proportion to the anterior one; and the gelatinous substance much thicker. Important features are afforded by the structure of the base, and the subumbral canals of the nectosac. In each species there are five well-developed basal teeth, one dorsal, two lateral, and two marking the dorsal wall of the hydroecium. But while in *A. eschscholtzii* these are symmetrical, except that the right hydroecial tooth is somewhat larger than the left one (Plate **14**, fig. 3), in *A. tetragona* they are so asymmetrical that it is only by tracing out the ridges with which they are connected that their essential orientation can be determined (Plate **14**, fig. 8). The hydroecium also is diagnostic. In both it is covered over by two lateral wings, but whereas in *A. eschscholtzii* the right hand wing bears three prominent teeth near its base, and the margin of the left hand wing is entire (Plate **14**, fig. 2), in *tetragona* the right wing is only slightly serrate on its transverse basal margin, while the left hand wing is toothed throughout its length (Plate **14**, fig. 7) instead of being entire. The most important diagnostic feature of the posterior nectophore is afforded by the canals of its nectosac, for while these are of the usual radial type in *A. eschscholtzii*, in *A. tetragona* they follow a very peculiar course (Plate **14**, fig. 7).

*Stem and appendages, and free Eudoxids.* In the oldest cormidia which are still attached to the stem the bract (Plate **14**, fig. 4) has already assumed its characteristic pentagonal outlines; and though it still shows evidences of immaturity, it already agrees with the free Eudoxids (Plate **15**, fig. 1) not only in the essentials of facets and ridges, but even in such a trivial feature as the presence of a tooth on the basal hydroecial margin on either side. The dorsal facet is already of the regular pentagonal form, so characteristic of the free Eudoxid. The serration of the ridges, prominent at this early stage, is progressively lost, a fact I have been able to observe on several specimens of slightly different ages.

The somatocyst has already assumed its final form; and the gonophore, except for its small size, shows the structure characteristic of its later stages. Indeed, the resemblance between these cormidia and the free Eudoxids is so close that there is no doubt of their genetic connection. The latter agree so well with the account given by Lens and Van Riemsdijk that no account of them is necessary here, further than to point out that they are easily distinguished from the Eudoxids of *A. tetragona* by the regular pentagonal outlines of the dorsal facet, by the proportionately shorter anterolateral and the proportionately longer posterolateral facets. (Compare Plate **15**, fig. 1, 2.) The form of the hydroecium is likewise different in the two, and connected with it, the ventral facet is basally deeply concave in *eschscholtzii* instead of entire as in *tetragona*.

Huxley's figures of his *Aglaismoides eschscholtzii* ('59, pl. 4, fig. 2–2a, 2b) show the same characteristic form of the bract, and of its somatocyst; and I am therefore convinced that the original diagnosis by Chun ('88) of the Eudoxid of his *Abyla quincunx*, and by Lens and Van Riemsdijk of the "Siboga" specimens, as identical with Huxley's species, was correct.

*Distribution.* *Abylopsis eschscholtzii*, as shown by the records by Bedot ('96), and by those of the "Siboga" and "Albatross," is very generally distributed over the Tropical Pacific and the Malaysian region. It was previously known to be very common in the Tropical Atlantic (Chun, '88, '97b); and I have examined a considerable series from the West Indies. So far as known it is restricted to tropical and subtropical regions.

### **BASSIA** L. AGASSIZ, 1862.

The genus Bassia has usually, but erroneously, been credited to Quoy and Gaimard. It was first mentioned by Blainville ('30) who quoted *Bassia quadrilatera*, a manuscript name proposed by Quoy and Gaimard without description or figure. Since the latter do not give this name in their published work ('34) it is necessarily a *nomen nudum*. L. Agassiz in 1862 considered that *Abyla perforata* Gegenbaur (= *Diphyes bassensis* Quoy and Gaimard) belonged to Bassia, hence *bassensis* is the type and as yet the only known species of the genus.

### **Bassia bassensis** (QUOY and GAIMARD).

Plate 12, fig. 8; Plate 14, fig. 9.

*Diphyes bassensis* QUOY and GAIMARD, '34, p. 91, pl. 7, fig. 18–20.
*Calpe bassensis* LESSON, '43, p. 451.
*Abyla bassensis* HUXLEY, '59, p. 45, pl. 2, fig. 1; SCHNEIDER, '98, p. 91; LENS and VAN RIEMSDIJK, :08, p. 26, pl. 4, fig. 32.
*Sphenoides australis* HUXLEY, '59, p. 62, pl. 4, fig. 4, CHUN, '88, p. 1160; HAECKEL, '88b, p. 360; BEDOT, '96, p. 375; LENS and VAN RIEMSDIJK, :08, p. 26, pl. 4, fig. 33. EUDOXID.
*Abyla perforata* GEGENBAUR, '60, p. 356, taf. 29, fig. 20, 21; CHUN, '97b, p. 32.
*Bassia perforata* L. AGASSIZ, '62, p. 372; CHUN, '88, p. 1190; HAECKEL, '88b, p. 160; BEDOT, '96, p. 374.
*Bassia obeliscus* HAECKEL, '88a, p. 36; '88b, p. 160, pl. 37.
*Sphenoides obeliscus*, HAECKEL, '88a, p. 33; '88b, p. 116, pl. 38. EUDOXID.
*Sphenoides perforata*, HAECKEL, '88a, p. 33; '88b, p. 116; CHUN, '97b, p. 32. EUDOXID.
? *Parasphenoides amboinensis* BEDOT, '96, p. 376, pl. 12, fig. 2, 3.

The polygastric state was taken at Stations 4598, 4611, 4617, 4659, 4661, 4667, 4673, 4679, 4699, 4716, 4724, in both surface and 300 fathom hauls. The total number of specimens is 113; at Station 4617 a swarm was encountered.

The Eudoxid was taken at Stations 4588, 4611, 4639, 4646, 4654, 4661, 4663, 4665, 4667, 4669, 4671, 4673, 4714, 4715, 4716, 4743, and in Acapulco Harbor; both surface and 300 fathom hauls; about 180 specimens.

In the largest specimen the superior nectophore is 5 mm. long, the inferior one 8 mm. long.

The material as a whole is in very good condition. After comparing it with numerous Atlantic specimens, as well as with the descriptions and figures of Gegenbaur and Haeckel, I have been unable to find a single difference sufficiently constant to warrant the recognition of but one species. The same conclusion was reached by Bedot ('96) for specimens from Amboina, and I can bear out his observations as to the variability of the outlines of the two nectophores and their proportions, and of the inclination of the anterior one. Lens and Van Riemsdijk have summarized the history of the species; but as their material was too fragmentary for satisfactory identification they retain a Pacific and an Atlantic species.

*B. bassensis* has been well described and figured by Huxley, Gegenbaur, and Haeckel. Its most diagnostic features are the form of the posterior nectophore which is quadrilateral, the right lateral ridge entirely suppressed except at its basal extremity, and especially the coalescence of the two ventral wings, by which the hydroecium is closed for the upper two thirds of its length. This feature alone is sufficient to distinguish *B. bassensis* from all species of Abyla and Abylopsis.

The anterior nectophore resembles that of *A. pentagona* and *A. eschscholtzii*, in the general arrangement of its facets and ridges. But it is easily distinguished from them, because in it the base of the hydroecium does not project as it does in those species. This difference is more readily illustrated by figures than by description (Plate **14**, fig. 1, 6, 9). Huxley long ago suggested that his *Sphenoides australis* was the free Eudoxid of *B. bassensis*, and both Chun ('88) and Haeckel ('88b) have observed the actual development of the cormidia of this species into "Sphenoides." In many of the "Albatross" specimens the bracts are sufficiently developed to show that they are undoubtedly the younger stages of *S. australis*; and the same was true of Haeckel's material ('88b, pl. 38). Therefore there is no longer any excuse for retaining the name *Sphenoides australis*. The young bracts, as shown in Haeckel's figures ('88b, pl. 38, fig. 13, 14), have more prominent angles and ridges than the older ones, and the same is true of the gonophores. The bract in the largest "Sphenoides" is 9 mm. long. The Eudoxid described by Bedot as *Parasphenoides amboinensis*, in the extreme development of its ridges and angles, suggests the bracts of *B. bassensis* while still attached, and for this reason is included here as probably belonging to the latter species. Most likely it represents a case where the changes in form, outlined above, have been delayed. Bedot does not state whether he observed more than one such specimen.

*B. bassensis* is known to occur very generally throughout the Mediterranean and Tropical Atlantic, the Malaysian region, the Eastern Tropical Pacific, and it is recorded from off the southeast coast of Australia (Bass Straits) and from south of Tasmania. I can find no record of it from the Indian Ocean, but it may be expected to occur there, and thus to parallel *Abylopsis tetragona* (p. 226) in its distribution.

## **DIPHYABYLA** Lens and Van Riemsdijk, 1908.

This interesting genus is so far known from only one species, *D. hubrechti* Lens and Van Riemsdijk, founded for a single specimen in the "Siboga" collection, and represented by a second rather better preserved example in the present series.

### **Diphyabyla hubrechti** Lens and Van Riemsdijk.

Plate 12, fig. 7.

*Diphyabyla hubrechti* Lens and Van Riemsdijk, :08, p. 36, pl. 6, fig. 47.

Station 4683, 300 fathoms to surface; 1 anterior nectophore, 7 mm. long.

The nectophore agrees in shape with the account by Lens and Van Riemsdijk, who have called attention to the essential similarity in external form between this species and *Abyla leuckarti*. The most interesting feature of Dyphyabyla is the apical projection of the nectophore in a narrow pyramidal form. And it was the consequent external resemblance to the Diphyids which suggested the generic name. This external modification obscures its close relationship to *A. leuckartii*; but when the ridges and facets are analyzed their fundamental unity is at once apparent. Lens and Van Riemsdijk have given such an extended and complex discussion of the two that the following summary of the superior nectophore will suffice here. In Diphyabyla there are four ridges at the pointed apex, two dorsal, and two ventral. The two dorsals run direct to the base, enclosing a triangular dorsalfacet. Each of the two ventrals branches dichotomously at the level of the apex of the nectosac, so that from this point downward, there are two ventrals, and a lateral on each side running without further subdivision to the base, though the ventrals reach the base together, forming a single tooth. The facets are thus a triangular dorsal, a dorsolateral, and a ventrolateral on each side, and a fusiform ventral. The ridges all terminate in prominent triangular teeth at the base. The hydroecial opening lies high above the opening of the nectosac (Plate **12**, fig. 7). The nectosac extends apically far beyond the level at which the pedicular canal joins it, and consequent on this prolongation its dorsoradial canal follows a Diphyid rather than an Abylid course (Plate **12**, fig. 7). The other canals present no features of special interest. In the "Siboga" example the nectosac was narrow and tubular for the last part of its course. But in our example it terminates bluntly slightly above the level at which the ventral ridges branch. This apparent difference is probably due to the distortion of that region mentioned by Lens and Van Riemsdijk (:08). This same level marks the beginning of the apical projection (Plate **12**, fig. 7). This is bent; but as the bending is dorsad in the "Siboga," ventrad in the "Albatross" specimen, it is probably an accidental distortion.

To derive the pyramidal form of Diphyabyla from the rectangular nectophore of *Abyla leuckartii*, all that is necessary is to imagine the apicodorsal angle of the latter, with the apex of the nectosac, drawn out into a triangular point. The dorsal facets of the two correspond; but the ventral of the Diphyabyla represents both the ventral and the rectangular apical facets of *A. leuckartii*. It is true that the transverse ridge separating the two in the latter is unrepresented in the former, but the presence or absence of the ridge is a very minor matter, depending on whether the ventral facet is straight as in Diphyabyla or bent at a right angle as in *A. leuckartii*. It is entirely comparable to the transverse ridge which subdivides the ventral facet in *A. haeckeli*, but is absent in the closely related *A. trigona*.

The somatocyst is large, oval, and extends basally from its connection with the hydroecium, as in *Abyla leuckartii*. The ventral ridges in the two follow the same course, particularly in their basal junction, as do the lateral ridges except for the fact that in *A. leuckartii* they terminate a short distance above the lateral teeth (Plate **13**, fig. 5) instead of reaching the basal margin as in Diphyabyla. The basal teeth likewise correspond in both species. The correspondence in such minor details as the basal teeth and in the degree of serration is of great interest from the phylogenetic standpoint for it points in an unmistakable manner not only to the genus, Abyla, but even to the particular species, *i. e. leuckartii*, from which Diphyabyla is descended. The Abylid affinities of Diphyabyla are so close that the subfamily Diphyabylinae of Lens and Van Riemsdijk is unnecessary (p. 215). To preserve it would only obscure the relationship of the genus. The Diphyid appearance of the pyramidal nectophore is nothing more than an instance of parallelism. And the same is true of the Diphyid form of the nectosac. The apical prolongation of the latter above the level of the pedicular canal is a concomitant of the alterations of the general external form, not an indication of relationship to Diphyinae.

There is no trace of an inferior nectophore, nor of any reserve bud which might foreshadow such a structure. The appendages are represented by several small buds, and a single definitive siphon with tentacles and very immature bract. The latter structure has been described by Lens and Van Riemsdijk as scale-like.

## Galeolariinae Chun, 1897.

### GALEOLARIA Blainville, 1834.

Galeolaria, the only known genus of the Galeolariinae, sometimes, though wrongly, credited to Lesueur, was proposed by Blainville in 1830, but must date from 1834, when one of its species was first described. In the same year, 1834, Quoy and Gaimard described two species, one of them being described also and figured by Blainville. The genus is usually credited to Blainville and the two species to Quoy and Gaimard, and nothing would be gained by changing this arrangement.

We must first consider the species listed by Blainville in his second diagnosis ('34) of the genus, since it is one of these which must be taken as the type. They are *G. australis* Quoy and Gaimard, *G. quadridentata* Quoy and Gaimard, *G. rissoi*, and *G. bilobata*, but the last two are manuscript names of Lesueur, and have no standing.

Chun ('97b, p. 16) mentions *australis* and *quadridentata* merely as "zwei obere Schwimmglocken aus dem Indischen Ocean," but Haeckel ('88b) recognized their importance. *G. quadridentata* was figured by Quoy and Gaimard ('34); and their *Diphyes quinquedentata* was probably its posterior nectophore. The conformation of the base of both nectophores approaches in complexity that of *G. monoica* Chun. But it differs so much from the latter in the number and arrangement of the basal teeth that it can not be identified with it, or with any other actual species. *G. quadridentata* must still, and perhaps always, remain a doubtful form.

*Galeolaria australis* (Quoy and Gaimard, '34, pl. 5, fig. 29,[1] 30, 31) was very

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[1] Fig. 29 is given by Quoy and Gaimard as "*Diphyes quinquedentata*," but there are two figures numbered 29, and the internal evidence of the figures themselves shows that one is *australis*, the other *Diphyes quinquedentata*.

well figured. As is shown both in side and basal views of the anterior nectophore, there are two basoventral wings, but no basal teeth, either lateral or dorsal. This conformation of the base agrees perfectly with the Malaysian species described by Lens and Van Riemsdijk (:08) as *G. biloba* Sars, as well as with a considerable series in the present collection. Since *australis* can now be identified with actual specimens, it must be chosen as the type of the genus. The question whether Sars's Norwegian *biloba* is actually identical with the Malaysian form, as Lens and Van Riemsdijk suppose, is important from the standpoint of distribution. It is certainly true that Sars's ('46) figures afford no basis for separating the two. Unfortunately, however, they are not sufficiently diagnostic, and no recent author has studied the North Atlantic form for the purpose of testing its specific characters. Until this is done, the only course to follow is to consider *biloba* as a doubtful synonym of *australis*.

In the Atlantic, *G. biloba* is so far known certainly from northern regions only, doubtfully from the Mediterranean. In the Indo-Pacific region, on the contrary, *australis* is a common surface form in regions of very high temperatures. At present it is impossible to say whether the two are identical, having been overlooked in the warmer parts of the Atlantic, or whether they are distinct, but closely allied species, one peculiar to cold, the other to warm waters. But they are so closely related that the former is probably correct; *biloba* is therefore listed as a doubtful synonym of *australis*.

Lens and Van Riemsdijk (:08), who have attempted a much needed revision of the genus, recognize four well-founded species in addition to *biloba*, viz. *G. truncata* Sars, '46 (= *G. inflata* Chun), *G. monoica* Chun, *G. quadrivalvis* Blainville, *G. chuni* Lens and Van Riemsdijk, and two problematical forms, *Diphyes turgida* Gegenbaur and *Diphyes ovata* Kefferstein und Ehlers ('61).

*Diphyes ovata*, if the description be correct, is a very remarkable Diphyid. But as it has never been observed since 1861, its existence is problematical. At any rate it is idle to speculate on its affinities until it is reexamined.

*Diphyes turgida*, according to the original account (Gegenbaur, '54), has no somatocyst. But such a peculiarity would be so remarkable among Calycophorae, that probably this structure was overlooked, as Lens and Van Riemsdijk suggest (:08, p. 57) or the species was founded on abnormal material. In all other respects, *i. e.*, sculpture of the base of the nectophore, general form, and outline of the bracts, *turgida* resembles *biloba*, with which Schneider has united it and the same course is followed provisionally here. *G. chuni* Lens and Van Riemsdijk, known from three superior nectophores only, is closely related to *G. australis*, with which it agrees in the possession of two small basal-ventral wings, and the absence of either dorsal or lateral teeth. It is distinguished from the latter only by its small size (3.5–4 mm. long), and "in the course of the canals which is as in Diphyopsiinae, the lateral canals not standing in any connection with the ventral one" (:08, p. 61), as well as by a longer somatocyst. But size can not be made the basis of specific separation in the case of so small a series, for of course every specimen of *G. australis* must at one time be no longer than 3 mm. And in spite of the statement that the canals are of the Diphyopsid type, the figure (Lens and Van Riemsdijk, :08, pl. 9, fig. 7) clearly shows the transverse trunk connecting lateral and ventral subumbral canals characteristic of other Galeolariinae. As to the length of the somatocyst, Lens and Van Riemsdijk have themselves found that this character is variable in otherwise typical *australis*, an observation I have been able to verify in the "Albatross" collection. None of the supposed diagnostic characters of *chuni* are, then, sufficient to separate it from *australis*, and there is every reason to think that it is the young of the latter.

The union by Lens and Van Riemsdijk of *G. inflata* Chun with *G. truncata* Sars, is probably justified though it can not be more than provisional, owing to the briefness of Chun's account. With *G. truncata* they likewise unite the *Diphyes conoidea* of Kefferstein and Ehlers. But although according to their figure *conoidea* agrees well enough with *truncata* in the conformation of the base of the anterior nectophore, its general resemblance to *Diphyes appendiculata* is so close, that it is hard to believe that it is accidental.

Finally I must mention *Diphyes stephanomia* Brandt, described from Mertens's unpublished drawing. Haeckel, who was able to examine the original figure, assures us that the species is a Galeolaria; but Brandt's ('35) description, which is the only published account, is insufficient to establish its position in the genus.

The characters by which the nectophores of the various species of Galeolaria, both anterior and posterior, may be most readily distinguished are the conformation of the base, *i. e.* number and arrangement of basal wings and teeth. There are also differences in the arrangement of the subumbral canals, though in all species the lateral canal on either side is connected with the ventral one by an oblique transverse trunk.

### *Key to the species.*

Anterior nectophore.

1. Without any basal teeth, or wings.

   *G. truncata* Sars, = *G. inflata* Chun?
   = *G. conoidea* Keferstein and Ehlers?

2. With basal teeth or wings.
   - a. With 2 large ventral wings only.

     *G. australis* Quoy and Gaimard =?
     *G. biloba* Sars = *G. chuni* Lens and Van Riemsdijk.
   - b. With 2 large ventral wings, and 2 small dorsal teeth.

     *G. quadrivalvis* Blainville.
   - c. With 2 large ventral wings, 3 small dorsal teeth, and on each side a small triangular lateral angle. *G. monoica* Chun.

Posterior nectophores.

1. Basoventral wing, single, undivided.
   - a. No dorsal or lateral teeth.
     - a¹. With prominent longitudinal lateral wing-like enlargements, terminating above the basal margin.

       *G. australis* Quoy and Gaimard.
       =? *G. biloba* Sars.
     - a². Without prominent lateral wing-like enlargements.

       *G. truncata* Sars.
   - b. With 3 dorsal teeth, and 2 lateral triangular lateral angles.

     *G. monoica* Chun.
2. Two basoventral wings.
   - a. With 2 large lateral and 2 dorsal teeth. Nectosae with circular transverse constrictions. *G. quadrivalvis* Blainville.

*G. truncata* is so far known from the Atlantic alone; and its distribution is considered later (p. 369). The records of the occurrence of the remaining species of the genus show that they are widely distributed over the Indo-Pacific region as well as the Atlantic.

Until recently *G. biloba* (= *australis*) was supposed to be a northern species but the captures by the "Siboga" and by the "Albatross" show that this is doubtful.

### **Galeolaria quadrivalvis** (BLAINVILLE) CHUN.

Plate 5, fig. 1–7.

*Sulculeolaria quadrivalvis* BLAINVILLE, '30, p. 126; '34, p. 138, pl. 6, fig. 6. (LESUEUR, MS.)
*Epibulia auriantaca* VOGT, '52, p. 524, taf. 14, fig. 1, 2.
*Epibulia filiformis* LEUCKART, '53, p. 2.
*Galeolaria auriantiaca* VOGT, '54, p. 110, taf. 18, 19, 20; WEISMANN, '83, p. 199, taf. 21, fig. 1–8; HAECKEL, '88b, p. 151; BEDOT, '96, p. 370.
*Diphyes quadrivalvis* GEGENBAUR, '53, p. 315, taf. 16, fig. 8–11; KEFFERSTEIN and EHLERS, '61, p. 18; SCHNEIDER, '98, p. 87.
*Galeolaria filiformis* LEUCKART, '54, p. 280, taf. 11, fig. 14–17; HUXLEY, '59, pl. 12, fig. 1 (non HUXLEY, '59, p. 38, pl. 3, fig. 5).
*Diphyes (Galeolaria) quadrivalvis* Costa, '62, p. 90, pl. 3.
*Epibulia auriantaca* var. *canariensis* CHUN, '88, p. 1158.
*Galeolaria quadrivalvis* CHUN, '97b, p. 17; LENS and VAN RIEMSDIJK, :08, p. 58, pl. 9, fig. 74.

This species was taken at Stations 4635, 4651, 4657, 4659, 4663, 4665, 4667, 4676, 4743, 4841, both at the surface and in open hauls from 300 fathoms to the surface. It is represented by three very well-preserved entire colonies, fourteen loose anterior, and six loose posterior nectophores. The largest anterior bell is 18 mm. the largest posterior one 19 mm. long. The three entire specimens were captured while floating fully extended on the surface; and are in an excellent state of preservation; and I have been able to compare them with excellent material from the Bay of Naples. The canals of both nectophores follow the course described for them by Gegenbaur, differing correspondingly from those of the Diphyopsiinae.

*G. quadrivalvis* has been so well described and figured by Vogt ('54) and by Gegenbaur ('54) that a detailed account is unnecessary. I need only note that in the conformation of the base of the nectophores, and in the double constriction of the posterior one, the present specimens are entirely typical. The diagnostic features of the species are enumerated in the key (p. 236); and this, together with the photographs (Plate 5, figs. 1–3) may serve for identification.

The only previous records of *G. quadrivalvis* from the Indo-Pacific region are those of the "Siboga" specimens (Lens and Van Riemsdijk, :08), which agreed perfectly with Mediterranean specimens; and Bedot's ('96, p. 370) statement that it is "abondante à Amboine, et les exemplaires que nous avons observés etaient absolument semblables a ceux de la Mediterranée." Huxley's *G. filiformis* is doubtfully classed here by Lens and Van Riemsdijk, but it probably belongs to *G. australis*.

### **Galeolaria australis** Quoy and Gaimard.

Plate 5, figs. 8, 9, Plate 6, figs. 1, 2, 3.

*Galeolaria australis* Quoy and Gaimard, '34, p. 42, pl. 5, fig. 29–31;[1] Blainville, '34, p. 139, pl. 6, fig. 6; Lesson, '43, p. 140; Haeckel, '88b, p. 151.
*Galeolaria filiformis* Huxley, '59, p. 38, pl. 3, fig. 5 (non Leuckart, '54).
*Galeolaria chuni* Lens and Van Riemsdijk, :08, p. 61, pl. 9, fig. 78, 79, pl. 5, fig. 8–10, pl. 6, fig. 1–3.
? *Diphyes biloba* Sars, '46, p. 45, taf. 7, fig. 16–21, Schneider, '98, p. 86.
? *Diphyes sieboldii* Gegenbaur, '53, p. 340 (non Kölliker, '53).
? *Diphyes turgida* Gegenbaur, '53, p. 344; '54, p. 442, taf. 23.
? *Diphyes sarsii* Gegenbaur, '60, p. 372, taf. 29, fig. 30, 31.
? *Epibulia turgida* Haeckel, '88a, p. 35.
? *Galeolaria turgida* Haeckel, '88b, p. 151, 362; Lens and Van Riemsdijk, :08, p. 57.
? *Galeolaria biloba* Haeckel, '88b, p. 151; Chun, '97b, p. 17; Vanhöffen, :06, p. 16; Römer, :02, p. 173.

This species was taken at Stations 4592, 4600, 4605, 4607, 4611, 4635. 4657, 4659, 4661, 4663, 4671, 4680, 4684, 4686, 4696, 4698, 4700, 4702, 4704, 4707, 4708, 4720, 4723, 4725, 4729, 2731, 4733, 4741, 4743, both on the surface and in hauls from 300 fathoms to the surface. The material consists of two entire colonies, 55 loose anterior, and 42 loose posterior nectophores. The former are from 5–17 mm., the latter from 5–23 mm. in length.

For my reasons for considering *biloba* Sars as a doubtful synonym of *australis*, see p. 234.

Haeckel ('88b, p. 151) has already suggested that Huxley's *G. filiformis* from the Indian ocean is *australis* while Lens and Van Riemsdijk (:08) have identified it provisionally with their *biloba*. Huxley's figure, with a single large ventral wing, and the total absence of dorsal or lateral teeth, show that both were correct.

Lens and Van Riemsdijk have pointed out that the somatocyst in *G. australis* varies in length, relatively to the size of the nectophore as a whole, and that the gelatinous substance varies in thickness. These observations are borne out by our material.

The nectophores have been well described by these authors, by Sars, and by Gegenbaur. The presence of a pair of ventral wings in the anterior, and of a single ventral wing in the posterior nectophore, in connection with the absence of either dorsal or lateral teeth in either, separates *G. australis* from all the other members of the genus. I may add that the lateral canals in the posterior nectophore are looped, as in *G. quadrivalvis*, instead of being nearly straight as they are described by Sars ('46) for *G. truncata*. In the anterior nectophore the lateral canals arise, as usual, from the ring canal, not from the ventral one, as they do in *G. monoica* (p. 240).

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[1] By a typographical error the reference in their text is to fig. 30–31.

Another distinctive feature is that the posterior nectophore has lateral ridges, or wings (Plate 6, fig. 3, R. L.). The specimens had lost all but the basal end of the stem when taken, so I can give no description of the various appendages.

### **Galeolaria monoica** Chun.

Plate 6, figs. 4–9.

*Epibulia monoica* Chun, '88, p. 1157.
*Galeolaria monoica* Chun, '97b, p. 17; Lens and Van Riemsdijk, :08, p. 60, pl. 9, fig. 76–77.
*Diphyes biloba*, Schneider, '98, p. 86 (partim).

This species was taken at Stations 4592, 4617, 4634, 4635, 4640, 4644, 4646, 4681, 4691, 4700, 4702, 4716, 4718, both on the surface and in hauls from 300 fathoms to the surface. The material consists of twenty-seven loose anterior nectophores and thirty-one loose posterior nectophores. The identification of the latter rests partly, on their occurrence side by side with the anterior nectophores, often in pairs with them; but chiefly on the fact that they differ in several structural particulars from the posterior bells of any other known species of Galeolaria. These grounds taken together are sufficient demonstration of identity with *G. monoica*.

Although the original description of this species by Chun is very brief, Lens and Van Riemsdijk have pointed out that he mentions two important characters, namely, that the somatocyst is minute, and that the development of basal teeth is unusually complex. Unfortunately Chun ('88, p. 1158) does not describe the teeth further than to mention an "abweichende Bildung der sogenannten Verschlussklappen am Schirmrande." Lens and Van Riemsdijk (:08, p. 60) identify two badly preserved nectophores taken by the "Siboga" as *G. monoica*, on account of the extraordinarily small size of the somatocyst and the complicated structure of the teeth.

Fortunately the present series includes many excellent specimens both of anterior and of posterior nectophores, and these agree closely with the "Siboga" material. It is true that the basal teeth of the anterior nectophores (Plate 6, fig. 6) differ in dorsoventral orientation from Lens and Van Riemsdijk's account, the single odd tooth being dorsal instead of ventral as they describe it. But their own figure of the lateral aspect (Plate 9, fig. 76) shows ventrally a pair of flaps, just as in the specimens studied. From this it appears that the terms "dorsal" and "ventral" were accidentally transposed in their description.

In both "Siboga" and "Albatross" specimens, then, the anterior nectophore has a pair of large ventral flaps or wings, which may or may not overlap.

Opposite them is a single narrow dorsal tooth, flanked on either side by a much broader triangular tooth (Plate **6**, fig. 6, To. L); and between each of the latter and the corresponding ventral flap is a second triangular tooth or wing. The latter vary greatly in apparent size with the condition of the specimens under examination. In contracted material, as the result of the incurving of the bell-margin, they are apparently very large. And it is thus that they were described for the "Siboga" specimens; but in expanded examples, it is evident that much of their bulk in reality belongs to the margin, not to the teeth (Plate **6**, fig. 8). They are not such definite structures as the other basal prolongations. The ventral flaps, as seen in good specimens, are much the largest, and each bears a minor tooth on its dorsal surface.

The small size of the somatocyst has proved a constant character for the entire series, and of itself would be sufficient to separate *G. monoica* from any other member of the genus except the somewhat problematical *G. turgida* Gegenbaur.

Even when the margin is entirely destroyed anterior nectophores of *monoica* can be distinguished from those of *australis*, which they nearly resemble in form, by the course of the canals. While in the latter the lateral canals arise from the ring canal as usual (Plate **6**, fig. 3), in *monoica* they arise from the ventral vessel just above its union with the circular vessel (Plate **6**, fig. 5).

*Posterior nectophores.* The posterior nectophore of this species has not been described. Its basal teeth are complex, there being a single undivided median wing, bearing on its dorsal surface two secondary spines (Plate **6**, fig. 7, X.), and an odd dorsal tooth, flanked on each side by a triangular lateral one as in the anterior nectophore. Of the last two, the dorsal is the larger. As is shown in the key (p. 235) the structure of the base separates it from the corresponding nectophore of any other Galeolaria. The lateral canals are looped, as in *G. quadrivalvis* and *G. australis*, instead of being nearly straight as in *G. truncata*. Unfortunately the stem was broken off short in all our specimens, so I can not give an account of the appendages.

## **Diphyopsiinae** HAECKEL, 1888.

Most students recognize the two genera Diphyes and Diphyopsis. Schneider ('98), it is true, doubts if the presence or absence of special nectophores in the Eudoxids is sufficient to warrant generic separation. But I agree with Haeckel ('88b), and Chun ('97b), that the occurrence in the Prayinae and in the present subfamily of series of species parallel in this respect fully deserves recognition. Such a difference is of much too great phylogenetic significance to be classed as a mere specific character.

Chuniphyes of Lens and Riemsdijk belongs here also. Although the authors who described it could give it no systematic position, the structure of a specimen in the present collection with both nectophores still connected, shows that it is certainly a Diphyid. Unfortunately all of the specimens yet taken lack the older groups of appendages, so it is impossible to state certainly whether special nectophores are developed. For that reason it is possible that the genus ought to be placed in the Galeolariinae; but the pyramidal form of the nectophore and the strongly marked ridges support rather an affinity with the present subfamily. The species is so different in its general form from any known Diphyid that it is certainly entitled to generic rank.

The excellent condition of the present series of Diphyes and of Diphyopsis together with the rich collection of both these genera in the Museum of Comparative Zoölogy, warrant an attempt at a much needed revision of their species.

The species described from the Pacific and Indian Oceans may be considered first. They are: —

*Diphyes dispar* Chamisso and Eysenhardt, since recorded by Brandt ('35), by Huxley ('59), and by Lens and Van Riemsdijk (:08); *D. appendiculata* Eschscholtz, since recorded by Huxley ('59), Agassiz and Mayer (:02), and myself (:04); *D. angustata* Eschscholtz, since recorded by Agassiz and Mayer ('99, :02); *D. mitra* Huxley; *D. chamissonis* Huxley, since recorded by Browne (:04); *D. gracilis* Gegenbaur, recorded by Bedot ('96), *Diphyopsis campanulifera* Eschscholtz, recorded by Browne (:04) and by Lens and Van Riemsdijk (:08); *D. compressa* Haeckel, recorded by Bedot ('96) as var. *picta*. Also the following new species, described by Lens and Van Riemsdijk: — *Diphyes contorta*, *D. nierstraszi*, *D. indica*, *D. malayana*, *D. gegenbauri*, *D. subtiloides*, *Diphyopsis diphyoides*, *D. weberi*, *D. anomala*, *and Chuniphyes multidentata*, all from the "Siboga" collection. To these must be added an Eudoxid, indistinguishable, according to them, from the monogastric generation of the Atlantic *D. bipartita* Costa (= *D. sieboldii* Kölliker), as well as their own *Doromasia pictoides*. Finally the "Albatross" specimens described below, show that the specimen described by Chun ('92) as *Doromasia bojani* on the supposition that no inferior nectophore was present, unquestionably belongs here.

*D. dispar* Chamisso and Eysenhardt, *D. campanulifera* Eschscholtz, *D. nierstraszi* Lens and Van Riemsdijk, *D. anomala* Lens and Van Riemsdijk, and

*Diphyopsis compressa* Haeckel, var. *picta* Bedot agree very closely with each other, in the shape of the anterior nectophore. The first three were long ago united by Huxley ('59). This reduction is accepted by Schneider ('98), and Chun ('97b, p. 27), who has retained both *dispar* and *campanulifera*, the former for a Pacific, the latter for an Atlantic form, considers that they are "Ausserordentliche nah" to each other. Lens and Van Riemsdijk again separate *dispar* and *campanulifera*. They record a large series as *Diphyopsis campanulifera* on the strength of the presence of special nectophores in the groups of appendages, and a single specimen which apparently lacked these structures as *Diphyes dispar*. Even if special nectophores were absent in this individual, it is not clear why they record it under the specific name *dispar*, when they themselves say that the description by Chamisso and Eysenhardt shows that the original specimens of *dispar* had such organs. But, apart from this criticism, the condition of their single specimen was such that it could not show whether it was a Diphyes or a Dyphyopsis. Although the stem bore fourteen "developed groups" of appendages, the fact that no gonophores but merely "some small buds" were present, shows that all the cormidia were very young, the older ones having been detached. In the one in which they figure that there was, in addition to bract, siphon, and tentacle, only one very small bud, which might develop equally well into gonophore, into nectophore, or into both, as in *Doromasia picta* (Chun, '92). The large size of the specimen has no bearing. It is a question of the state of development of the individual cormidia, not of the colony as a whole. In its general form it agreed perfectly with their specimens of *Diphyopsis campanulifera*, and was no doubt identical with them. On the grounds of priority *dispar* takes preference over *campanulifera*.

The *angustata* of Agassiz and Mayer likewise belongs to *Diphyopsis dispar* as I am convinced from an examination of their specimens from the Fiji Islands, and of Mayer's (:06) material from the Hawaiian Islands.

According to Lens and Van Riemsdijk, *Diphyes nierstraszi* is separated from *Diphyopsis dispar* (= *campanulifera*) by the absence of special nectophores, by smaller size, slender form, and greater length of stem between the groups of appendages. The first of these statements is not well grounded. On the contrary, the small size of the specimens (7–15 mm. long) indicates that the absence of special nectophores is evidence of immaturity of the cormidia, a conclusion supported by the fact that the authors observed only four groups of appendages in any specimen. So far as size and form are concerned, the former indicates nothing more than an early stage in growth; and the latter is of no more value, because specimens in the present collection of the *nierstraszi* type are connected by an unbroken series with the broadest specimens of *D. dispar*. Finally, the length of stem between groups of appendages, especially in preserved material, is so variable that it is worthless as a specific character. There is no good reason for retaining *D. nierstraszi* as a distinct species.

*Diphyopsis anomala* was founded for a specimen with abnormal canals. Lens and Van Riemsdijk themselves suggest (:08, p. 55) that it will "probably be struck out before long." From its form it no doubt belongs to *D. dispar*. With the latter we must also unite Bedot's var. *picta* of *D. compressa* Haeckel, which is nothing more than a local variety. (Chun, '97b, has shown that *compressa* is a synonym of *D. campanulifera* Eschscholtz.)

To settle whether or not this species is identical with the Atlantic *D. campanulifera*, I have compared Pacific specimens with a series taken at various localities in the Atlantic. Bearing in mind the well-known variability of *D. campanulifera* (Chun, '97b, p. 27) I have been unable to find any characters whatever to separate them. I therefore follow Huxley and Schneider in uniting them. From an examination of the figure by Bory de St. Vincent ('04) of his "Biphore biparti," I am convinced, as was Huxley, that it is identical with the species under consideration. But Bory's name, "*Salpa* (*bipartita*) *lanceolata*, *bipartita*," has never been considered a binomial, either by Huxley, by Chun, or by Schneider, nor, from the text of his description, would there be any grounds for so regarding it. Therefore, the next oldest name, *dispar*, must be employed for the compound species.

*D. appendiculata* Eschscholtz, is easily distinguished from the other Pacific species by the characters given below. It was thought by Huxley to be identical with the Atlantic *D. bipartita* Costa (= *D. sieboldii* Kölliker), a union accepted by Schneider. Other authors, however, *e. g.* Chun ('97b), Vanhöffen (:06), Römer (:02), and Mayer (:00), have retained *bipartita* as a separate species. I have been able to test this question on large and very well-preserved series from all three great oceans, with the result that I can not find a single character to separate *D. appendiculata* from *D. bipartita*. I therefore unite them under the older name. From the standpoint of geographic distribution this result was to be expected, for this species is not restricted to warm waters, but attains high latitudes (Römer, :02).

*D. mitra* Huxley. This species was classed by Haeckel among the Monophyidae, on the supposition that no inferior nectophore occurred; but the presence of a specimen in the "Albatross" collection, agreeing with Huxley's figures, but with a small second nectophore still attached, shows that it is really a Diphyid. The figures of *Diphyopsis diphyoides*, by Lens and Van Riemsdijk (:08), who also observed the bud for the inferior nectophore, agree so closely with *D. mitra*, even to trivial details, that there is no escaping the conclusion that the two are identical. The specimens described from Amboina by Bedot ('96) as *D. gracilis* Gegenbaur also resemble *D. mitra* so closely in the form of both anterior and posterior nectophores that they too must be referred to it. They are discussed in the description below (p. 260).

*Diphyopsis mitra* has not been recorded from the Atlantic, nor does it agree with any Atlantic species, unless perhaps *D. hispaniana* Mayer. It is true that it differs from the figure of the latter in having a shorter somatocyst and a more pronounced dorsobasal tooth; but the fact that the collection of this Museum contains a series of typical *D. mitra* from the West Indies suggests that the two may be identical.

*D. chamissonis* Huxley, like *D. mitra*, has been classed by both Haeckel ('88b) and Chun ('92) as a Monophyid. But the remarkably close resemblance between Huxley's figures and the figures given by Lens and Van Riemsdijk of their *Diphyopsis weberi*, which is certainly a Diphyid, because it had the buds for the inferior nectophore, leaves little question that the two are identical. The "Albatross" collection contains no representatives of this species, but I have studied typical examples from the Philippines. Whether or not the specimens described as *Muggiaea kochii* by Murbach and Shearer are the same as *D. chamissonis*, as they suppose, can not be determined from their brief description (without figures). But the *D. chamissonis* of Browne (:04, pl. 54, fig. 6) from the Maldives no doubt belongs here.

*D. subtiloides* Lens and Van Riemsdijk, though closely allied to the Atlantic *D. subtilis* Chun, is easily distinguished from the latter by the characters noted below (p. 247). In general form it closely resembles *Muggiaea kochii*, but Lens and Van Riemsdijk observed the bud for an inferior nectophore, which places it definitely among the Diphyopsiinae.

Next we must consider a group of species which agree in their narrow pyramidal form, long somatocyst, and prominently developed dorsobasal and laterobasal teeth; these are *D. indica*, *D. malayana*, and *D. gegenbauri* of Lens and Van Riemsdijk, the *Doromasia pictoides* of the same authors, and *Diphyes* ("*Doromasia*") *bojani* Chun.

The first three are separated only by such minor characters as size, degree of serration, shape of lateral teeth, number of ridges at the apex, and the presence or the absence of wing-like expansions of the ridges. To summarize Lens and Van Riemsdijk's account, *D. gegenbauri* is the smallest ($6\frac{1}{2}$–$8\frac{1}{2}$ mm.), it has four serrate ridges at the apex, the lateral teeth are small, and there are no "wings." *D. indica* is 9–11 mm. long; the dorsal ridge is not serrate; there are five ridges at the apex; lateral teeth are very large; "wings" are present. *D. malayana* is 9–10 mm. long; the dorsal ridge is slightly serrate in its distal part; the lateral teeth are large; there are four ridges at the apex, but no "wings." The present excellent series allows me to test these characters; and the condition in fifty specimens of varying size, tabulated below (p. 252), shows that all of them are subject to so much individual variation as to be quite worthless for specific diagnosis. The series shows every gradation between the three species, which must, therefore, be united in one. Lens and Van Riemsdijk have already noted that *Doromasia pictoides* closely resembles their *Diphyes gegenbauri*, and though they class the latter among the Monophyidae, they admit that future study may prove it to be a Diphyid. That it is a Diphyid is shown by a specimen in our collection which, though agreeing with *D. pictoides* in form and in the presence of a single terminal group of appendages, is slightly larger and has an easily identified bud for an inferior nectophore (Plate 12, fig. 1). Lens and Van Riemsdijk have already noted the close resemblance between their several species, and the *Doromasia bojani* of Chun. The position of the latter (known from only one specimen lacking any trace of stem or appendages) among the Monophyidae rests merely on the supposition that it is the polygastric generation of *Ersaea bojani*. But the resemblance between Chun's ('92) figure and several of our specimens with "wings" which have inferior nectophores still attached, is too close to allow any conclusion other than that they are identical with the *gegenbauri-indica-malayana* group. On the grounds of priority *bojani* must be chosen for the compound species resulting from the union of *D. gegenbauri*, *D. indica*, *D. malayana*, *Doromasia bojani*, and *D. pictoides*. This name, it is true, has long been used for an Eudoxid; but the latter probably belongs either to the present species, or to another family (p. 265), and in either case the name *bojani* can be used for the Diphyes.

*D. bojani*, as Lens and Van Riemsdijk point out, is closely allied to two Atlantic species, *D. steenstrupii* Gegenbaur and *D. serrata* Chun. The former, it is true, has been classed by Schneider ('98) as a synonym of *D. appendiculata* (= *bipartita*) but an examination of Gegenbaur's account convinces me that its true relationship is as here noted. Unfortunately, Chun's description (without figures), of *serrata*, where he says that the outline of the hydroecium differs from that of *steenstrupii*, does not state what the difference is. But the fact that our collection of *bojani* shows that neither the number of rows at the apex, nor the relative size of the lateral teeth, mentioned by Chun as features in which the two differ, is as important as he thought, suggests that the two are identical. I should not be surprised if the Pacific *bojani* and the Atlantic *steenstrupii* and *serrata* eventually prove to belong to one species. But whether this is the case can only be determined by a fresh examination of Atlantic specimens, and unfortunately there have been none available.

*Diphyes contorta* Lens and Van Riemsdijk is a well-characterized species, easily distinguished from all other Diphyopsiinae by a peculiar asymmetry of the somatocyst.

In addition to *Diphyopsis dispar*, *Diphyes appendiculata*, and the puzzling *D. steenstrupi-serrata* group, only three Atlantic species deserve definite recognition. These are *Diphyes arctica* Chun, *D. subtilis* Chun, and *D. fowleri* Bigelow. The probable identity of *Diphyopsis hispaniana* Mayer and *D. mitra* is noted above. On the other hand there is a possibility that *Doromasia picta* Chun may belong here (p. 265). *D. fowleri* is here recorded from the Pacific and the collection contains one Diphyid, *D. spiralis* (p. 249), described as new on account of the remarkable spiral torsion of the entire superior nectophore.

The corm, or the secondary nectophore, is so often destroyed in preserved specimens of Diphyes and Diphyopsis that it would be a great convenience to find a set of characters, sufficient for specific identification in the anterior nectophore alone. As it turns out, such are afforded by general form within certain limits, by the number of ridges at the apex, by whether their number is constant, by the presence or absence of basodorsal and basolateral teeth, and by the comparative length of the hydroecium. Somewhat to my surprise the latter proves to be one of the most constant characters.

The following key to the species of Diphyopsiinae is based upon these features.

### *Key to the Species.*

1. With prominent basolateral and smaller dorsolateral teeth.
    A. 5 (or 4) ridges at the apex.
        $a^1$. Somatocyst long; general form very broad; nectosae ending distally in a tubular coecum.
        *D. dispar* Chamisso and Eysenhardt.
        $a^2$. Somatocyst long; general form, narrow; nectosae fusiform at the apex; ridges at the apex either 5 or 4; lateral teeth very long.

*D. bojani* Chun (incl. *serrata* Chun and *steenstrupi* Gegenbaur).

$a^3$. Somatocyst short, reaching only to the opening of the nectosae; hydroecium deep; general form narrow.

*D. chamissonis* Huxley (= *D. weberi* Lens and Van Riemsdijk).

B. 7 ridges from apex to base; very shallow hydroecium; nectosac short; somatocyst much longer.

*Chuniphyes multidentata* Lens and Van Riemsdijk.

2. Basolateral teeth absent; basodorsal tooth very small.

A. Hydroecium short, truncate; somatocyst pear shaped, reaching only to mid-level of nectosac.

*D. mitra* Huxley (= *D. diphyoides* Lens and Van Riemsdijk, = *hispaniana* Mayer?)

3. With neither basodorsal nor basolateral teeth.

A. 3 ridges only at the apex.

$a^1$. Somatocyst straight, median.

*D. appendiculata* Eschscholtz (= *D. bipartita* Costa).

$a^2$. Somatocyst curved to the right, ventral facet asymmetrical.

*D. contorta* Lens and Van Riemsdijk.

B. 4 ridges at the apex.

$a^1$. Nectophore spirally twisted, fusiform; somatocyst straight.

*D. spiralis*, sp. nov.

$a^2$. Nectophore not spirally twisted, somatocyst curved to the right.

*D. contorta* Lens and Van Riemsdijk.

C. Constantly 5 ridges at the apex.

$a^1$. Hydroecium very shallow.

Somatocyst spherical or pear shaped, lying transverse to the main axis of the nectophore.

*D. fowleri* Bigelow.

$a^2$. Hydroecium almost entirely suppressed.

1. Somatocyst of the ordinary fusiform type, reaching to $\frac{1}{3}$ the length of the nectophore. Apex pointed.

*D. subtiloides* Lens and Van Riemsdijk.

2. Somatocyst thread-like with a large spherical terminal dilation. Apex rounded.

*D. subtilis* Chun.

*Diphyes arctica* Chun is omitted as no details as to the number of ridges are given in Chun's description. It is easily distinguished from all other species of Diphyes and Diphyopsis by the fact that the rather deep hydroecium is open along its mid-ventral line, and from Chuniphyes by the smoothness of the external surface, the rounded apex, and the absence of basal teeth.

## DIPHYES Cuvier, 1817.

### Diphyes appendiculata Eschscholtz.

Plate 7, figs. 5–6; Plate 8, figs. 7–8; Plate 9, fig. 6; Plate 10, fig. 6; Plate 11, fig. 1.

*Diphyes appendiculata* Eschscholtz, '29, p. 138, pl. 12, fig. 7; Huxley, '59, p. 34, pl. 1, fig. 2; Schneider, '98, p. 85; Bigelow, :04, p. 265. :11, b, p. 344.
*Diphyes bipartita* Costa, '36, p. 4, taf. 4; Chun, '88, p. 1158; '97b, p. 24; Mayer, :00, p. 74, pl. 34, fig. 114; Römer, :02, p. 175.
*Diphyes elongata* Hyndman, '41, p. 165, fig. 1–4.
*Diphyes acuminata* Leuckart, '53, p. 61, taf. 3, fig. 11–20; Gegenbaur, '60, p. 375.
*Diphyes sieboldii* Kölliker, '53, p. 36, taf. 11, fig. 1–8; Gegenbaur, '54, p. 453; Kefferstein and Ehlers, '61, p. 15.
*Diphyes gracilis* Gegenbaur, '53, p. 309, taf. 16, fig. 5–7 (non *D. gracilis* Bedot, '96).
*Eudoxia campanula* Leuckart, '53, p. 43; Müller, '70–'71, taf. 11, fig. 1–4, taf. 13, fig. 10, Lens and Van Riemsdijk, :08, p. 48, pl. 7, fig. 62. Eudoxid.
*Eudoxia messanensis* Gegenbaur, '53, p. 285. Eudoxid.
*Eudoxia alata* McCrady, '57, p. 172, pl. 8, fig. 9, 10. Eudoxid.
*Eudoxoides sagittata* Huxley, '59, p. 59, pl. 4, fig. 1. Eudoxid.
*Cucullus gegenbauri* Haeckel, '88b, p. 110. Eudoxid.
*Cucullus elongatus* Haeckel, '88b, p. 110. Eudoxid.
*Cucullus campanula* Haeckel, '88b, p. 111. Eudoxid.
?*Diphyes pusilla*, McCrady, '57, p. 174.
Non *Ersaea appendiculata* Agassiz and Mayer, :02.

The polygastric generation was taken at Stations 4571, 4574, 4575, 4641, 4644, 4646, 4650, 4661, 4676, 4679, 4681, 4683, 4699, 4701, 4704, 4705, 4707, 4710, 4713, 4715, 4716, 4717, 4720, 4724, 4725, 4734, 4740, 4742, and 4743, in twelve surface hauls, and in seventeen hauls from 300 fathoms to the surface. The material consists of three entire colonies (with the two nectophores still connected), one hundred and forty-six loose anterior and four loose posterior nectophores. The material was nearly evenly divided between the two classes of hauls. The Eudoxid was taken at Stations 4580, 4583, 4588, 4598, 4613, 4617, 4644, 4650, 4657, 4665, 4679, 4696, 4707. This material consists of twelve specimens from six surface, and twenty from seven 300 fathom hauls.

Although this species has long been known and often figured, its most diagnostic characters deserve attention here. The most characteristic external feature is the conformation of the upper part of the anterior nectophore, the importance of which seems to have been generally overlooked, although it allows specimens of this species to be recognized at a glance. There are only three ridges at the apex; two of which enclose the ventral facet, while a third, at first lying in a dorsal position, turns to one side to become the right lateral ridge.

The left lateral ridge arises some distance below the apex, usually at about the level of the upper end of the nectosac. In a series of one hundred Pacific and one hundred Atlantic specimens there is no variation except for very slight individual differences in the precise level at which the left lateral ridge arises. Such constancy is in marked contrast to the variability in the number of ridges at the apex in *D. bojani* (p. 252).

As long ago pointed out by Gegenbaur ('60), the dorsal ridge, which extends upward from the basal margin, is very short (Plate **9**, fig. 6). The serration of the lateral and ventral ridges, so often noticed, is chiefly restricted to the central two thirds of their length. They are smooth near the apex, and as a rule, though not always, close to the basal margin. Besides the ridges, the great length of the somatocyst, the absence of dorsal or lateral teeth, and the basal outline of the hydroecium (Plate **7**, figs. 5, 6) are all characters of specific importance.

The posterior nectophore has so often been figured that I may merely note for ready identification, that its hydroecial canal is closed, and that the basal teeth which are prominent, bear smaller teeth in their dorsal margins (Plate **10**, fig. 6).

The Eudoxid of *D. appendiculata* is so well known, as to require no description here. Agassiz and Mayer have described the Eudoxid of the Pacific *D. appendiculata* as an "Ersaea," not an "Eudoxia" as it is in the Atlantic form. But Lens and Van Riemsdijk found typical *Eudoxia campanula* in the "Siboga" material; and the figures of Agassiz and Mayer suggest that what they took for the monogastric generation of *D. appendiculata* was in reality the "Ersaea" of *Diphyopsis dispar* (*cf.* Agassiz and Mayer, :02, pl. 9, fig. 40, with their own pl. 10, fig. 41, and with Lens and Van Riemsdijk, pl. 7, fig. 62).

### **Diphyes spiralis,** sp. nov.

Plate 7, fig. 4, Plate 8, fig. 1, 2, Plate 9, fig. 3, Plate 11, fig. 4.

| | | | | | | |
|---|---|---|---|---|---|---|
| Station | 4583 | surface | 7 | anterior | nectophores. | |
| " | 4587 | 300–0 fms. | 1 | " | " | |
| " | 4663 | 300–0 fms. | 1 | " | " | |
| " | 4686 | surface | 59 | " | " | |
| " | 4688 | " | 36 | " | " | |
| " | 4690 | " | 4 | " | " | |
| " | 4696 | " | 1 | " | " | |
| " | 4700 | " | 10 | " | " | |
| " | 4702 | " | 2 | " | " | *Types.* |

The largest is six, the smallest is two mm. long.

These small nectophores differ so markedly in general from all previously known Diphyids that a new species is necessary to receive them. Their most remarkable feature is that the entire nectophore is spirally twisted, the tortion in all cases being in the same direction as the hands of a clock (Plate 7, fig. 4, Plate 8, fig. 1). This is so pronounced that the specimens, though very small, are recognizable at a glance. In contracted individuals (Plate 7, fig. 4) the tortion is so extreme as to render resolution of the facets and ridges extremely difficult, but on expanded material (Plate 8, fig. 1) these can be easily followed. There are four ridges at the apex (Plate 8, fig. 2), dorsal, ventral, and a lateral on either side. Owing to the general tortion the dorsal lies to the left, the ventral to the right of the mid-line. The dorsal and lateral ridges run to the basal margin without branching, following a spiral course, more easily represented in the drawing than by description. At the margin the dorsal ridge is nearly dorsal, but the left lateral lies dorsal, the right lateral ventral, to the mid-ventral line. The ventral ridge bends at first sharply to the right, and then divides into two, which enclose a ventral facet. The right hand one of the two resultant ridges runs obliquely to the left, so that it reaches the basal margin of the hydroecium near the mid-ventral plane. The left ventral ridge follows a corresponding parallel course, but at about the level of the opening of the nectosac it bends sharply toward the mid-ventral plane, and terminates (Plate 8, fig. 2), so that the ventral and left ventrolateral facets become confluent. All the ridges are strongly serrate, except near the apex. The arrangement of the ridges is constant in all the specimens examined, except for greater or less twisting, concomitant with greater or less contraction. But even in specimens which had lost the musculature of the subumbrella, and were consequently fully expanded, the tortion is well marked. There are neither basolateral nor basodorsal teeth in this species.

The hydroecium is rather short, and pointed at the apex; its base shows an asymmetry so characteristic that it is possible to identify the species from this region alone. Its basolateral margins are strongly concave (Plate 8, fig. 1); each ends dorsally in a pronounced tooth. The dorsal wall below the level of the bell opening is divided so as to form two lanceolate wings of which the right hand one is much the larger in all our specimens. The ventrobasal wall of the hydroecium is deeply incised in the mid-line, where the right ventral ridge reaches it, and the entire basal margin of the hydroecium is strongly serrated.

The somatocyst, which is cylindrical and rather more than half as long as the nectosac, lies obliquely to the right of the main axis of the nectophore (Plate 8, fig. 2), it is not twisted itself. The very muscular nectosac shows a tortion corresponding to that of the nectophore as a whole. In none of the specimens was the subumbrella in good enough condition for me to trace the canals.

*Stem and appendages.* In two specimens the stem bore a very small bud which was apparently the forerunner of a posterior nectophore. It is the presence of these buds which has caused me to refer the species to the Diphyidae rather than to the Sphaeronectidae. The stalk is much contracted in all the specimens, but in a few the groups of appendages are sufficiently loose for study. In these (Plate 11, fig. 4), there is, in addition to siphon, tentacle, and bract a single large bud, so far advanced as to be easily identified as the future gonophore.

In view of the conditions in *Diphyopsis dispar* (p. 258), where the special nectophores first appear at a late stage in development, at least in some individuals, it is possible that such organs might be developed later, in *spiralis*. Should this finally prove to take place, the species must be removed from Diphyes to Diphyopsis.

The records of capture show that *D. spiralis* is a surface form.

### **Diphyes bojani** (Chun).

Plate 7, fig. 2, 3; Plate 8, fig. 6; Plate 9, fig. 1, 2; Plate 10, fig. 2, 3; Plate 11, fig. 5; Plate 12, fig. 1.

*Doromasia bojani* Chun, '92, p. 108, 110, fig. 8.
*Diphyes indica* Lens and Van Riemsdijk, :08, p. 44, pl. 7, fig. 54.
*Diphyes malayana* Lens and Van Riemsdijk, :08, p. 45, pl. 7, figs. 55, 56.
*Diphyes gegenbauri* Lens and Van Riemsdijk, :08, p. 46, pl. 7, fig. 57, pl. 8, fig. 58.
*Doromasia pictoides* Lens and Van Riemsdijk, :08, p. 3, pl. 1, fig. 1.

This species was taken at the following Stations:— 4587, 4588, 4592, 4605, 4644, 4665, 4673, 4676, 4684, 4687, 4695, 4704, 4707, 4708, 4710, 4721, 4722, 4724, 4727, 4734, 4735, 4740, and 4741. The records are from both surface and intermediate (300-0 fathom) hauls. The material consists of two entire colonies, sixty-two anterior, and fifteen posterior nectophores. The largest anterior nectophore is 21 mm. long, the smallest, 6 mm. The largest posterior nectophore is 19 mm. The collection forms a continuous series between these extremes.

As a test of the constancy of the characters of the anterior nectophore on which Lens and Van Riemsdijk separate their *D. indica*, *malayana*, and *gegenbauri*, *i. e.*, size and form of the basolateral teeth, number of ridges at the apex, and degree of serration of the ridges, I have tabulated them in fifty specimens, including the largest and the smallest, with the following results: —

| | | | |
|---|---|---|---|
| Ridges at apex | 3, | 4, | 5. |
| Number of specimens | 3, | 15, | 32. |

The ridges in the latter class are two ventrals, two laterals, and one dorsal.

The individuals with four ridges at the apex, fall into two main divisions.

1. The original ridges are dorsal, two ventral and one lateral, and the second lateral results from the division of one of the ventrals, which is the left in eleven specimens, and the right hand one in two. This is the condition in *D. malayana*, and in *D. gegenbauri* (Lens and Van Riemsdijk, :08).
2. The four ridges at the apex are the dorsal, two laterals, and one ventral; the latter divides into two ventrals which enclose the ventral facet. This agrees with Gegenbaur's ('60) description of *D. steenstrupi*.

In the three specimens with only three ridges at the apex, there are a dorsal and two ventrals, both of the latter branching, to form the two laterals. The level at which division of the ridges occurs is variable, and often so close to the apex that it is hard to say how many ridges there are at that point. Since the three classes intergrade it is clear that the number of ridges at the apex is not of specific importance, at least in *D. bojani*.

On correlating this character with the presence or absence of wing-like enlargements of the upper third of the ridges, it proved that of twenty-one specimens in which these were evident, twelve had five ridges, eight had four, and one had three at the apex. There is, then, no correspondence between the two characters, and I may add that there is every gradation between individuals in which "wings" are prominent (Plate 7, fig. 2) and those in which no trace of them is to be seen (Plate 7, fig. 3).

The size and form of the basolateral teeth also proves to be so variable that I can not follow Lens and Van Riemsdijk in making it the basis for specific determination. It can not be correlated either with presence or absence of "wings," or with the number of ridges at the apex. In a general way the proportional size of the lateral teeth increases with the growth of the colony. But this is irregular. In the larger individuals the margins of the teeth are strongly convex (Plate 9, fig. 1) in the small ones (7–10 mm.) concave. But there is every possible gradation between the extremes. In this respect "*D. gegenbauri*," "*D. malayana*," and "*D. indica*" show three successive stages, as they do in size.

The degree of serration varies independently of the characters already examined, and therefore is of no more importance. Small specimens are usually more strongly serrate than large ones; such is the case in the small "*D. gegenbauri.*"

From this evidence the only conclusion, it seems to me, is that *D. gegenbauri*, *D. malayana*, and *D. indica* represent three successive stages in the development of a single species. My reasons for uniting them with *Doromasia bojani* and *D. pictoides* are given above (p. 245).

*Diphyes bojani*, though it varies in general form almost as much as *Diphyopsis dispar*, is easily distinguished from other Pacific Diphyids by the following characters:—The anterior nectophore is slender, pointed at the apex, truncate at the base; there are five prominent ridges except at the apex in some individuals, and as noted, these are often expanded to form "wings" in the upper one third of their course; the serrations of the ridges are everywhere variable, especially so at the apex; the nectosac reaches nearly to the apex.

The hydroecium is pointed at the top, and reaches nearly to one third the height of the nectosac. The somatocyst is fusiform, and its form and length very constant. Both dorsobasal and laterobasal teeth are large, though variable in form as already noted. The dorsobasal wall of the hydroecium, below the bell opening, is entire, its margin slightly concave, and the teeth serrate. The lateral basal margins are concave in small specimens (Plate **12**, fig. 1) as described by Lens and Van Riemsdijk ("*D. gegenbauri*"), straight in large ones (Plate **7**, fig. 3), and serrate in all.

*Posterior nectophore.* The entire specimens afford an opportunity to describe the inferior nectophore. In general outline (Plate **10**, fig. 2) it much resembles the corresponding nectophore in *Diphyopsis dispar* (Plate **10**, fig. 1), and as in the latter the two lateral flaps which cover the hydroecium remain separate, instead of uniting to form a closed canal as they do in *Diphyes appendiculata* (Plate **10**, fig. 6). It is easily distinguished from *D. dispar* by its more slender form, and by the pronounced serration of the two lateral basal edges and lateral teeth of the hydroecium, regions which are entirely smooth in *dispar;* in its basal region, and in its serration, it resembles the corresponding nectophore of *D. steenstrupi* (Gegenbaur, '60), a species with which *bojani* may finally be united (p. 246). The measurements of an entire colony are superior nectophore, length 12 mm., inferior nectophore, 9 mm.

*Cormidia.* The most advanced groups of appendages (Plate **11**, fig. 5). consist of siphon, tentacle, bract, and gonophore. As Lens and Van Riemsdijk (:08) have pointed out, there is no special nectophore. The bract with two prominent basal teeth, is of a characteristic form.

The species was first encountered off Manzanilla; and thence occurred along the coast of Central America as far as Guatemala. It was not taken in the Panamic region. From the Galapagos, however, it was taken regularly on all our lines, both within and without the Humboldt Current. Chun's specimen was taken between Hawaii and the Carolines, and the "Siboga" collection was from the Malaysian region. Its close allies *D. steenstrupi* and *D. serrata* are known from various parts of the Tropical Atlantic.

### **Diphyes contorta** Lens and Van Riemsdijk.

Plate 7, fig. 7, 8; Plate 8, fig. 3; Plate 11, fig. 2.

*Diphyes contorta* Lens and Van Riemsdijk, :08, p. 39, pl 6, fig. 48–50.

| | | | | | | |
|---|---|---|---|---|---|---|
| Station | 4580 | 300 | fathoms | — surface | 1 | specimen. |
| " | 4583 | | | " | 3 | " |
| " | 4587 | " | " | " | 5 | " |
| " | 4594 | " | " | " | 1 | " |
| " | 4598 | " | " | " | 1 | " |
| " | 4605 | " | " | " | 1 | " |
| " | 4634 | " | " | " | 1 | " |
| " | 4644 | | | " | 7 | " |
| " | 4646 | " | " | " | 3 | " |
| " | 4688 | " | " | | 2 | " |
| " | 4692 | | | " | 1 | " |
| " | 4694 | | | " | 1 | " |
| " | 4696 | | | " | 7 | " |
| Acapulco Harbor | | | | " | 4 | " |

Only anterior nectophores were taken; but as was the case in the "Siboga" collection, several show the bud for the inferior nectophore. The largest specimen is 7 mm. long.

This species was described in such detail by Lens and Van Riemsdijk that I will only emphasize such characters as are useful for specific identification. From this standpoint the most characteristic feature is the peculiar structure of the somatocyst, which arises from the hydroecium in the mid-ventral line, but turns sharply to the right, so that its upper end lies beside, and at the right of, the nectosac. Its form, with narrow stalk and distal dilation, so well figured by Lens and Van Riemsdijk, is likewise unusual.

The ventral facet is twisted and asymmetrical, to correspond with the torsion of the somatocyst. The left lateral facet is broader than the right hand one; the dorsal facet is symmetrical, broadly oval, and bounded by the two prominent lateral ridges. The dorsal ridge is discernible only near the base of the nectophore.

In the original account Lens and Van Riemsdijk state (:08) that there are four ridges at the apex. But in all of the specimens studied I find that the right-ventral ridge arises a short distance below the apex (Plate 8, fig. 3). Neither dorsobasal nor laterobasal teeth are present. The hydroecium is shallow, its cavity hardly extending beyond the base of the nectosac (Plate 7, fig. 8). The dorsal wall of the hydroecium, below the bell opening, is not divided into separate wings, but is merely slightly concave. In no case was the bud for the inferior nectophore sufficiently advanced to throw any light on its future form, nor was the "Siboga" series any more instructive in this respect.

The apparent absence of a special nectophore in the groups of appendages has been noted by Lens and Van Riemsdijk, who have seen a gonophore in some specimens. In our most advanced cormidia only one bud, besides bract, tentacle, and siphon, was ever visible. This was probably the future gonophore (Plate 11, fig. 2, Go.). It must be confessed, however, that to establish the absence of a special nectophore, will require a study of material with the groups of appendages further developed.

This species is entirely colorless in life.

*D. contorta* is so far known only from the Malaysian region and from the Eastern Tropical Pacific.

### **Diphyes fowleri** Bigelow.

Plate 8, fig. 4; Plate 9, fig. 5.

*Diphyes fowleri* Bigelow, :11b, p. 346, Pl. 28, fig. 5

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Station | 4587 | 300 | fathoms | to | surface | 2 | anterior | nectophores. |
| " | 4634 | " | " | " | " | 1 | " | " |
| " | 4638 | " | " | " | " | 1 | " | " |
| " | 4646 | " | " | " | " | 2 | " | " |
| " | 4657 | " | " | " | " | 1 | " | " |
| " | 4659 | " | " | " | " | 1 | " | " |

The largest specimen is 12 mm. long. The identity of the series listed above with *D. fowleri* rests on an actual comparison between the Pacific and the Biscayan specimens. As I have elsewhere noted (:11b, p. 346) the anterior bell of *D. fowleri* very closely resembles *D. subtiloides* Lens and Van Riemsdijk in general form. As in *subtiloides* there are five ridges running from the pointed apex to the base; there are no laterobasal teeth and the dorsal tooth is represented merely by a slight prominence of the dorsal angle, while the very short conical hydroecium lies wholly below the level of the bell-opening. But it is separated from *subtiloides* by two characters which are sufficient basis for specific separation, since they have proved constant on the considerable series of the two species which have yet been studied (110 *subtiloides*, 67 *fowleri*).

In the first place, the dorsal wall of the hydroecium below the opening of the nectosac, is entire in *subtiloides* (Lens and Van Riemsdijk, :08), but in *fowleri* it is divided into two wings of which the right hand one is the larger in those from the Pacific, as in those from the Atlantic (Bigelow, :11b, p. 347). In the second place the somatocyst in *fowleri* is pear-shaped or spherical, and occupies a position transverse to the long axis of the nectophore, reaching hardly, if at all, above the level of the mouth of the nectosac (Plate 8, fig. 4), instead of being of the ordinary fusiform type and of considerable length as it is in *subtiloides*.

In the Biscayan specimens the point of attachment for the second nectophore could usually be detected, but on the fragmentary stems in the present series neither this, nor any but the youngest appendages remain. My reference of this species to Diphyes rather than to Diphyopsis rests on the apparent absence of special nectophores in the only Atlantic specimen which still had a group of appendages in an advanced state of development attached to the stem. Without knowing whether the groups of appendages remain attached permanently, or whether they are set free, it is, of course, impossible to determine finally whether the species belongs to the Diphyopsiinae or to the Galeolariinae. But the structure of the hydroecium and the pyramidal form of the anterior nectophore indicate the former.

The absence of basolateral teeth separates this species from *Diphyopsis dispar*, *D. chamissonis*, and *Diphyes bojani* among Pacific species, as it does from the Atlantic *D. serrata* Chun, and *D. steenstrupi* Gegenbaur. From *Diphyes appendiculata*, *Diphyopsis mitra*, and *Muggiaea atlantica* it is easily distinguished by the structure of hydroecium and somatocyst. The only Pacific Diphyid or Monophyid with which it might possibly be confused are *Diphyes subtiloides* Lens and Van Riemsdijk, and *Muggiaea kochii* Will, both of which resemble it in the shape of the hydroecium. But from both it is separated by the structure of the somatocyst, while between it and the latter there is the further distinction that while in *D. fowleri* the lateral ridges extend to the basal margin, in *M. kochii* they end some little distance above that level (p. 188).

No species of Galeolaria as yet recorded from the Pacific could be confused with it.

The localities from which the species is recorded, Eastern Tropical Pacific, Bay of Biscay, and West Indies, suggest that it will be found widely distributed over the warmer zones of all oceans. Though it has now been taken in twenty-four hauls (seventeen of which were in the Bay of Biscay), only once has it been found in a surface haul. On the other hand, the shallowness of most of the Atlantic captures (fifteen from 100 fathoms or less, one from 250, one from 300, all in open nets) shows that it belongs to the "epiplankton," though it is apparently uncommon immediately at the surface.

## **DIPHYOPSIS** Haeckel, 1888.

### **Diphyopsis dispar** (Chamisso and Eysenhardt) Haeckel.

Plate 10, fig. 1; Plate 11, fig. 3.

*Salpa (bipartita) lanceolata bipartita* Bory de St. Vincent, '04, **1**, p. 134, taf. 6, fig. 3.
*Diphyes dispar* Chamisso and Eysenhardt, '21, p. 365 pl. 33, fig. 4; Eschscholtz,' 29, p. 137; Huxley, '59, p. 30, pl. 1, fig. 1; Schneider, '98, p. 197; Lens and Van Riemsdijk, :08, p. 42, pl. 6, fig. 51, 52.
*Diphyes angustata* Eschscholtz, '25, p. 743, taf. 5, fig. 16; '29, p. 136, taf. 12, fig. 6.
*Diphyes campanulifera* Eschscholtz, '29, p. 137, taf. 12, fig. 6; Gegenbaur, '60, p. 366, taf. 30, fig. 23–26.
? *Ersaea gaimardi* Eschscholtz, '29, p. 128, taf. 12, fig. 4. Eudoxid.
*Eudoxia lessonii* Eschscholtz, '29, p. 126, taf. 12, fig. 2. Eudoxid.
*Diphyes boryi* Blainville, '30, p. 123, fig. 100; '34, p. 135, taf. 5; Quoy and Gaimard, '34, p. 83, pl. 4, fig. 1–6.
*Diphyes regularis* Van Meyen, '34, p. 334, tab. 46.
*Diphyes cucullus* Quoy and Gaimard, '34, p. 92, pl. 4, fig. 21–23. Eudoxid.
*Cucullus doreyanus* Blainville, '34, p. 131. Eudoxid.
*Eudoxia lessonii* Huxley, '59, p. 57, pl. 3, fig. 6; Fewkes, '81, p. 166, pl. 6, fig. 8, 9; Chun, '97b, p. 26; Mayer, :00, p. 75; Lens and Van Riemsdijk, :08, p. 50. Eudoxid.
*Diphyopsis compressa* Haeckel, '88a, p. 35, '88b, p. 153, pl. 33, 34
*Cucullus lessonii* Haeckel, '88a, p. 32; '88b, p. 110. Eudoxid.
*Ersaea compressa* Haeckel, '88a, p. 32; '88b, p. 123, pl. 34. Eudoxid.
*Diphyopsis dispar* Haeckel, '88b, p. 152; Chun, '97b, p. 27.
*Diphyopsis angustata* Haeckel, '88b, p. 152; Agassiz and Mayer, :02, p. 162, pl. 8, 10, fig. 37, 42.
*Diphyopsis campanulifera* Haeckel, '88b, p. 153; Chun, '97b, p. 26; Mayer, :00 p. 75, pl. 28, fig. 93–95; Lens and Van Riemsdijk, :08, p. 51, pl. 8, fig. 63.
*Diphyopsis compressa* var. *picta*, Bedot, '96, p. 372.
*Ersaea appendiculata*, Agassiz and Mayer, :02, p. 161, pl. 9, fig. 2.
*Diphyes nierstraszi* Lens and Van Riemsdijk, :08, p. 43, pl. 7, fig. 53.
*Diphyopsis anomala* Lens and Van Riemsdijk, :08, p. 54, pl. 8, fig. 69, pl. 9, fig. 70.

This species was taken at Stations 4571, 4574, 4583, 4587, 4588, 4592, 4596, 4609, 4615, 4617, 4619, 4627, 4630, 4646, 4684, 4698, 4720, 4721, 4725, 4727, 4734, 4737, and 4743. The records are from surface hauls, and hauls with open nets from 300 fathoms to the surface.

The material consists of two entire colonies, ninety-seven superior nectophores, and twenty-four inferior nectophores. I have also had access to a large series from other parts of the Pacific, and from the Atlantic.

The Eudoxid was taken at Stations 4570, 4571, 4588, 4615, 4617, 4646, 4659, 4663, 4676, 4692, 4694, 4696, 4700, and 4707. For the synonymy of this stage, see Chun ('97a) and Lens and Van Riemsdjik, (:08, p. 50). As noted elsewhere (p. 249) the "*Ersaea appendiculata*" of Agassiz and Mayer (:02, p. 161, pl. 9, fig. 40) belongs to this species. Comparison of Atlantic and Pacific specimens shows no specific difference.

*Diphyopsis dispar* is so well known that no account is necessary here. The diagnostic features of the superior nectophore are given in the key (p. 246). So far as my observations on Atlantic and Pacific material go, the inferior nectophore never shows such prominent serration of its ridges and base as is to be seen in Haeckel's figure ('88b, pl. 33, fig. 4). On the contrary, these regions are entirely smooth in the "Albatross" specimens. An interesting feature of the posterior nectophore is, that the lateral flaps which cover the hydroecium remain separate, instead of uniting to form a closed canal.

Chun ('97b) has already pointed out that the superior nectophore is extremely variable in form. In several of the specimens the groups of appendages were far enough advanced to show both gonophore and special nectophore (Plate **11**, fig. 3). It is interesting that in one individual with eight groups, only the oldest bore both buds, the younger ones having only the common bud. This observation illustrates the difficulty of determining from a study of young material, or of specimens with only the younger parts of the stems and appendages intact, whether any given species belongs to Diphyes or to Diphyopsis.

*Diphyopsis dispar* is known from the Mediterranean, from various localities in the Tropical Atlantic, from the Gulf Stream (Hargitt, :05, p. 60) and even as far north as Newfoundland (Bigelow, :09b, p. 316). Its range also includes the Indian Ocean (Quoy and Gaimard, Lesson), the Malaysian region and the Tropical Pacific in general. Its distribution through the warmer waters of all oceans, parallels that of *Rhopalonema velatum* and of *Aglaura hemistoma* among holoplanktonic Medusae.

### **Diphyopsis mitra** (HUXLEY).

Plate 7, fig. 9; Plate 9, fig. 4; Plate 10, figs. 4, 5; Plate 11, fig. 6; Plate 12, fig. 5.

*Diphyes mitra* HUXLEY, '59, p. 36, pl. 1, fig. 4.
*Cymbonectes mitra* HAECKEL, '88a, p. 34, '88b, p. 133.
*Muggiaea mitra* CHUN, '92, p. 89.
*Muggiaea kochi* (partim. non WILL, '14) SCHNEIDER, '98, p. 88.
*Diphyes gracilis* BEDOT, '96, p. 370, pl. 12, fig. 4, 8 (non *D. gracilis* GEGENBAUR, '53).
*Diphyopsis diphyoides* LENS and VAN RIEMSDIJK, :08, p. 51, pl. 8, fig. 65, 66.

| | | | | | | |
|---|---|---|---|---|---|---|
| Station | 4583 | 300–0 fms. | 4 | anterior | nectophores. | |
| “ | 4587 | “ “ | 5 | “ | “ | |
| “ | 4598 | “ “ | 9 | “ | “ | |
| “ | 4611 | surface | 1 | “ | “ | |
| “ | 4613 | 300 to surface | 5 | “ | “ | |
| “ | 4634 | “ “ “ | 8 | “ | “ | |
| “ | 4638 | “ “ “ | 4 | “ | “ | |
| “ | 4639 | “ “ “ | 4 | “ | “ | |
| “ | 4640 | surface | 4 | “ | “ | |
| “ | 4644 | surface | 6 | “ | “ | 1 posterior nectophore. |
| “ | 4646 | 300–0 fms. | 2 | “ | “ | |
| “ | 4650 | “ “ | 2 | “ | “ | |
| “ | 4657 | surface | 1 | “ | “ | |
| “ | 4659 | 300–0 fms. | 1 | “ | “ | |
| “ | 4665 | “ “ | 1 | “ | “ | |
| “ | 4669 | “ “ | 1 | “ | “ | |
| “ | 4673 | surface | 1 | “ | “ | |
| “ | 4676 | 800–0 fms. | 3 | “ | “ | |
| “ | 4676 | 300–0 fms. | 2 | “ | “ | |
| “ | 4679 | “ “ | 2 | “ | “ | |
| “ | 4681 | “ “ | 8 | “ | “ | |
| “ | 4683 | “ “ | 1 | “ | “ | |
| “ | 4687 | “ “ | 1 | “ | “ | |
| “ | 4688 | “ “ | 1 | “ | “ | |
| “ | 4705 | “ “ | 1 | “ | “ | |
| “ | 4707 | “ “ | 2 | “ | “ | |
| “ | 4715 | “ “ | 4 | “ | “ | |
| “ | 4716 | 600–0 fms. | 1 | “ | “ | |
| “ | 4717 | 300–0 “ | 3 | “ | “ | |
| “ | 4719 | “ “ | 4 | “ | “ | |
| “ | 4734 | “ “ | 1 | “ | “ | |

Also several typical specimens from the West Indies.

The anterior nectophores of this species have been well described by Lens and Van Riemsdijk. They are readily separated from those of *Diphyes appendiculata* which they resemble in general appearance by the following characters: the general form is high, pyramidal, ridges but slightly arched; symmetrical. There are *five* ridges at the apex; and there is no variation from this number in any specimen which I have seen. The nectosac extends nearly to the apex. There are no basolateral teeth, and the dorsolateral tooth is very small (Plate 9, fig. 4). The length of the hydroecium below the opening of the nectosac is much greater than its extent above that level. At the top it is truncate, an outline which with the short pear-shaped somatocyst, separates *D. mitra* from other Pacific Diphyids. The somatocyst reaches only to the mid-level of the nectosac.

The dorsal wall of the hydroecium below the bell opening is divided into two wings, as it is in *D. appendiculata*, but they are more pointed than in the latter, and the left hand one invariably (?) bears a triangular secondary flap or tooth (Plate 9, fig. 4, To. $H^3$). The basolateral margins are distinctly concave.

All the ridges of the nectophore are serrate, except near the apex. But the prominence of the serrations is variable. In all these features both Eastern Pacific and West Indian specimens resemble the "Siboga" material on which Lens and Van Riemsdijk based their *D. diphyoides*, while there is such a close agreement between all of these and Huxley's figures of *Diphyes mitra* that I have no doubt of their identity with it. Huxley's specimen differs from those more recently described only in being somewhat broader, in having an even smaller dorsal tooth, and less concave basal hydroecial margins, divergences all of which are too trivial to suggest specific difference. The supposition that *D. mitra* is a Monophyid (Haeckel, '88b, Chun, '92), rests merely on the absence of an inferior nectophore in Huxley's single and "obviously imperfect" ('59, p. 37) specimen. That this absence was accidental can hardly be questioned in view of the resemblance between his figure and the undoubted Diphyids of the "Siboga" and "Albatross" collections. My identification of Bedot's *Diphyes gracilis* as a synonym of the species under consideration rests on the truncate hydroecium, the short pear-shaped somatocyst, and the conformation of the base (Bedot, '96, pl. 12, fig. 4), as well as on the form of the inferior nectophore noted below.

*Inferior nectophore.* In the "Siboga" series only the buds for inferior nectophores were present; and this is true of most of the "Albatross" specimens. But in one this structure is sufficiently developed to identify an inferior nectophore, found loose in the collection (Plate 10, fig. 4) as belonging to *D. mitra*. There can be little doubt about this identification, because the differences between the two are only such as might be expected at such different stages in growth. The more important features are that the hydroecial canal is open, though covered over near the upper end by two flaps, of which the left one is the larger, and that there is a prominent basal tooth on the right hand side, while the corresponding angle on the left side is merely acute and somewhat prominent. Two inferior nectophores, agreeing perfectly with those of *D. mitra*, were referred, doubtfully by Lens and Van Riemsdijk, to *D. chamissonis* ( = *D. weberi* Lens and Van Riemsdijk), and these authors have noted the close resemblance between them and Bedot's figures of the corresponding nectophores of his *D. gracilis* ( = *D. mitra*), in which the hydroecium is apparently open as it is in the "Albatross" specimen. This feature alone, is sufficient to show that Bedot's *D. gracilis* has nothing to do with Gegenbaur's *D. gracilis*, which is a synonym of *Diphyes appendiculata* (p. 248). And the structure of both nectophores shows that *D. gracilis* Bedot, is identical with *D. mitra*.

*Cormidia*. The position of this specis in Diphyopsis rather than in Diphyes rests on the discovery, by Lens and Van Riemsdijk, of a special nectophore in the groups of appendages. In the "Albatross" material even the most advanced cormidia bear only one bud, not yet old enough to show its final destination (Plate **11**, fig. 6).

*D. mitra* occurred regularly on all our lines, both on surface, and in intermediate hauls. It was not taken in closing nets. Huxley's specimen was taken in the Indian Ocean, southeast of Mauritius. The Atlantic series, in the Museum of Comparative Zoölogy, shows that it is common among the West Indies. The possibility that it may be identical with *Diphyopsis hispaniana* Mayer, likewise a West Indian species, has been noted (p. 244), but I do not feel sufficiently sure to include this in the synonymy.

### **CHUNIPHYES** Lens and Van Riemsdijk, 1908.

Until we know the structure of the groups of appendages in this genus, it is impossible to formulate a final definition for it. I retain it in the sense used by its proposers, because the general structure of the nectophores of its type and single representative is sufficiently characteristic to warrant generic separation. My reasons for including it among the Diphyopsiinae are given above (p. 241).

In addition to the specimens listed below I have had the advantage of studying the more extensive series collected by Mr. G. H. Fowler in the Bay of Biscay (Bigelow, :11b, p. 348). Comparison of the two collections has convinced me that the differences in the form of the nectosac and of the somatocyst described below (p. 263), are so slight and inconstant as to be quite worthless as specific characters. So far as I can judge from the account of the rather fragmentary "Siboga" specimens they too were identical with the present series. All known representatives of the genus, then, must be referred to its type species.

### **Chuniphyes multidentata** Lens and Van Riemsdijk.

Plate 8, fig. 9, plate 10, fig. 7, plate 12, fig. 6.

*Chuniphyes multidentata* Lens and Van Riemsdijk, :08, p. 13, pl. 1, fig. 9–11, pl. 2, fig. 12–15; Bigelow, :11b, p. 348.

| | | |
|---|---|---|
| Station 4703 | 300 fathoms to surface | 1 specimen with both nectophores still connected. |
| " 4724 | " " " " | 2 anterior and one posterior nectophores. |

In none was anything but the proximal end of the stem preserved. In the entire specimen the superior nectophore is 22, the inferior 26 mm. long.

The loose superior nectophores measure 20 and 17 mm., the inferior one 24. The complete specimen is in good enough condition to allow a much more detailed study than Lens and Van Riemsdijk were able to make from the fragmentary and much distorted "Siboga" material. And in this case, as so often, it turns out that what at first seemed complex and remarkable on fragmentary specimens, is easily explained from better material.

*Anterior nectophore.* There are four ridges at the apex, one ventral, one dorsal, and two laterals. As the describers of the species observed, the ventral ridge runs undivided to the opening of the hydroecium, whereas both the dorsal and the lateral ridges branch dichotomously. The result is that there are seven ridges at the base of the nectophore, one ventral, two dorsal, and on each side a dorsolateral and a ventrolateral. These ridges enclose a narrow triangular dorsal facet, and on each side a triangular dorsolateral facet extending from base to apex, a shorter, triangular medianlateral one, and a ventrolateral of irregular outline. There is of course no ventral facet, since the ventral ridge does not branch. The facets have been described in great detail, by Lens and Van Riemsdijk for the "Siboga" specimens. The dorsolateral ridges end in prominent teeth, the two dorsals and the two ventrolaterals in minor ones. There is no ventral tooth. There is a prominent tooth breaking the basal margin of each medianlateral facet as noted by Lens and Van Riemsdijk, and likened by them to the letter Z.

*Hydroecium.* The hydroecium is in the form of a deep furrow reaching to the level of the upper end of the nectosac, open ventrally for its entire length, and with its deepest point, at which the stem is attached, at about its mid-level. In the "Siboga" specimens it apparently extended nearly to the apex, but this was no doubt due to their fragmentary condition. The hydroecium shows some resemblance in general outline to the corresponding structure in *Diphyes arctica* (Chun, '97b, pl. 1, fig. 4).

*Nectosac.* This structure, wholly destroyed in the "Siboga" material, is in fair condition in one of the "Albatross" specimens, as it was also in the Biscayan collection. It is short, reaching only slightly above the mid-level of the nectophore, and rounded at the top; of about the same diameter throughout its length. In the Biscayan specimens it is proportionately slightly longer, though of the same general form. But in view of the possibility of distortion due to contraction so slight a difference can not be considered as indicating the existence of two separate species. In one individual the canals, though much damaged, could be traced throughout most of their extent. In the figure (Plate 8, fig. 9) they are necessarily somewhat reconstructed.

*Somatocyst.* In the only specimen in which this structure was in good enough condition to describe, it becomes dilated shortly above its point of origin (Plate 8, fig. 9); but then narrows once more to become tubular. It extends very nearly to the apex. In the other specimens its length is equally great; but in them its central region is entirely destroyed.

In the Biscayan specimens the dilation, present in all is transversely prolonged into a horn on either side (Bigelow :11b). But since these horns show various gradations in size, and are very small in one example, I doubt whether any sharp line can be drawn between specimens where they are present and those in which the dilation is a simple spheroid.

The "appendage, so strangely divided into three" described by Lens and Van Riemsdijk (:08, p. 15) and provisionally identified by them as the somatocyst was in reality three distinct structures, viz., the basal part of the somatocyst, the pedicular canal of the inferior nectophore from which the latter was detached, and the proximal end of the corresponding canal of the superior nectophore (Plate 12, fig. 6).

Nothing is left of the stem but the proximal end, and a number of immature siphons.

*Inferior nectophore.* The inferior nectophore of the complete specimen, though attached when taken, was broken off before it reached Cambridge. Fortunately, however, a sketch of the position was made before preservation, and the accompanying figure (Plate 8, fig. 9) is based on this. As observed by Lens and Van Riemsdijk the asymmetrical nectophore has only three ridges at the apex, a dorsal and two laterals. But all of these branch so that there are six at the base. The hydroecial canal, or in this case furrow, though limited by the two ventrolateral ridges, is entirely open for the greater part of its length. But near its proximal end it is closed over by two short flaps (Plate 10, fig. 7) one on either side, much as it is in *Diphyopsis mitra*. Apparently these flaps were destroyed in the inferior nectophore referred provisionally, but no doubt correctly, by Lens and Van Riemsdijk to Chuniphyes. Each of the six ridges terminates at the base in a serrated tooth, the ventrolateral on the right hand side being much the largest (Plate 10, fig. 7).

The nectosac is somewhat battered, but its canals, so far as these could be traced, are of the usual Diphyid type. Lens and Van Riemsdijk supposed that the mode of attachment of the two nectophores must be a very singular one, but as the "Albatross" specimens show, it is of the usual type.

One of the most noticeable external features, already noted by these authors is the transparency of both superior and inferior nectophores, and the brownish color of the ridges.

This species has not been taken on the surface. The "Siboga" record is from between 1,500 fathoms and the surface, and the Biscayan specimens were collected both in open net hauls from 300–0 to 1,250–0 fathoms, and in closed nets at depths of 1,500–750 and 2,000–1,000 fathoms. These captures show that it is a typical "intermediate" or "mesoplanktonic" organism, a habitat which no doubt explains the fact that it so long escaped notice in the Atlantic.

## **Ersaea bojani** (Eschscholtz) Chun.

Plate 11, figs 7, 8.

*Eudoxia bojani* Eschscholtz, '25, p. 743, taf. 5, fig. 15; '29, p. 125, taf. 12, fig. 1; Huxley, '59, p. 59, pl. 3, fig. 7.
*Cucullus gracilis* Haeckel, '88b, p. 110.
*Ersaea dispar* Haeckel, '88b, p. 361.
*Ersaea bojani* Chun, '88, p. 1154; '92, p. 108, fig. 7; Lens and Van Riemsdijk, :08, p. 6, fig. 1–6.
*Ersaea picta* Chun, '92, p. 98, 101, fig. 6, pl. 11, fig. 8.

The family relationship of this Eudoxid is uncertain; it was taken at Stations 4587, 4590, 4598, 4605, 4661, 4663, 4667, 4669, 4673, 4676, 4688, 4707, 4710, 4725, 4732, and 4741, in both surface hauls and hauls with open nets from 300 fathoms. The series consists of forty-three excellent specimens. Lens and Van Riemsdijk, who have made a critical examination of an even larger series, have found that neither of the two characters which Chun ('92) used to separate an Atlantic from a Pacific species, *i. e.* shape of the somatocyst, and degree of serration of the bract, are sufficiently stable to be of value for diagnosis, because in their material they found every gradation between the two supposed forms. In this I entirely agree with them. Thus in some specimens of the present series, the somatocyst is symmetrically rounded; in some it has the asymmetrical lateral process which, according to Chun, characterizes the Pacific species. *E. bojani* has been described so well by Huxley, by Chun, and by Lens and Van Riemsdijk, that no account is necessary here. It is of a very characteristic form, easily recognizable by the transverse phallocyst, and by the conformation of the base of the special nectophores. The accompanying figures may serve for identification.

Chun identified the Pacific form with his *Doromasia bojani*, which now proves to be a Diphyid: but the union of the two rested merely on supposition. According to him the Atlantic form is the free Eudoxid of *Doromasia picta* Chun; an identification generally accepted. The association of *E. bojani* with *Doromasia picta* is made certain, according to Chun ('92, p. 100) by the resemblance between its tentilla and bract and the corresponding structures in the oldest cormidia of Doromasia. He does not seem to have observed its actual development from the latter. The tentilla do not afford a safe clue, for, so far as they are concerned, the Eudoxid might belong to any one of several Diphyiids. When we compare Chun's figure of the bract of Doromasia ('92, taf. 8, fig. 3) with the bract of the Eudoxid we find that the resemblance is certainly no closer than between it and the bract of the Pacific *Diphyes bojani.* Indeed the bracts of Doromasia and of *Diphyes bojani* resemble each other so closely, even in details, that they might well belong to one species. In short, then, *Ersaea bojani* might as well be the Eudoxid of one as of the other. The case is further complicated by the fact that not only in the form of the bract, but in every other respect *Doromasia picta* and *Diphyopsis dispar* resemble each other so closely that there would be slight reason for separating them, were it not that one is a Monophyid, the other a Diphyid. The evidence that Doromasia has only one nectophore is that Chun ('92, p. 95) found no posterior one, or even the bud for one, in any of the forty specimens which he studied alive. This evidence is valuable; but inasmuch as Chun's specimens were all young as shown by the fact that very few of them had as many as four developing Eudoxids, and since Mayer (:00) has recently noted a form from the West Indies resembling Doromasia in every respect except that it has two bells,[1] it is not conclusive. I may point

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[1] Dr. Mayer in conversation has confirmed this.

out that the second bells of undoubted Diphyids may first appear at a late stage, *i. e.* in *D. mitra* (p. 260).

The collection contains a single large Eudoxid which can not be located in its proper systematic position until we know from what polygastric form it is liberated. In the form of the bract and of the gonophore it differs widely from any other Eudoxid yet known, and since the animal must have some name, if only for convenience sake, it may be called *Archisoma natans.* Whether or not this name proves permanent will depend, of course, on whether the polygastric state has been described, or whether it is as yet unknown. The rounded form of the bract suggests that the Eudoxid in question belongs to some Prayid, possibly to *Nectodroma reticulata.* Such a connection is also suggested by the structure of the somatocyst.

### **ARCHISOMA,** gen. nov.

### **Archisoma natans,** sp. nov.

Plate 20, fig. 6.

Station 4719. 300 fathoms to surface. 1 specimen in good condition. *Type.*

In the single example the bract is of the remarkable length of 37 mm.

*Bract.* The soft transparent bract is greatly elongate both above and below the point of attachment of the stem. Anteriorly it is pyramidal, ending in an acute point, but with rounded edges. Posteriorly its dorsal face is rounded, its ventral face so deeply furrowed, that it encloses a well-marked hydroecial groove which is deepest proximally. The bracteal canals (somatocyst) follow an unusual course. Two main trunks arise at the usual point of origin, one ascending, the other descending. The former follows a somewhat sinuous course to the apex of the bract, giving off a single transverse branch which extends to the dorsal surface. The descending trunk, shortly after its origin, branches dichotomously, the two resultants running along the two sides of the hydroecial groove. But instead of continuing independent, the two canals reunite at the end of the hydroecium, to run as a single vessel to the extremity of the bract (Plate **20**, fig. 6).

*Nectophore.* The special nectophore, like the bract, is very large (15 mm. long) and is of a characteristic form. Apically it is rounded, but basoventrally it is prolonged in a narrow conical prominence, just above which lies the mouth of the nectosac. Bract and nectophore together form an "arrow head." The canal system of the nectophore, like that of the bract, is complex.

Just below the point of attachment of the nectophore, its somatic canal gives off a short transverse branch. It connects with the subumbrella by a single trunk as is usual. At about the mid-level of the bell-cavity there are a pair of short branches. Finally just below the lower level of the nectosac there is a single dorsoventral branch. Below this point the axial somatic canal runs in a wavy course to the extremity of the nectophore. Owing to the condition of the specimen I could not trace the subumbral canals.

*Gonophore.* The specimen has one small gonophore, apparently ♀, and the bud for a second one. The older gonophores, if any had been developed, have been detached.

The siphon is of the usual type, the tentacle has been stripped of most of the tentilla. Such of the latter as are intact are too young to show their final form. The specimen is colorless.

## Physophorae Eschscholtz, 1829.

*Physonectae* Haeckel, 1888.

Five families of Physophorae, Apolemidae, Agalmidae, Physophoridae, Forskaliidae, and Anthophysidae, are so generally accepted and seem so well founded that their status need not be discussed. There is every reason to believe that each of them represents a natural grouping of intimately related species. The Nectaliidae of Haeckel (represented by the genus Nectalia) is retained as a separate family by Chun ('97b), but united with the Agalmidae by Schneider ('98). For the reason given elsewhere (p. 289) Nectalia is considered more closely allied to the Agalmidae than to other Physophorids; but its divergence from its nearest allies is sufficiently great to warrant a subfamily at least.

In addition to these families there is another group of genera which must be included in this order, namely the forms united by Haeckel in his order Auronectae. Claus ('89) long ago pointed out that the resemblance of the Auronectae to the Physophorids was so close that they actually formed a family of the latter, a conclusion subsequently supported by Chun ('97b), by Schneider ('98), and by Lens and Van Riemsdijk (:08).

Since the status of Haeckel's Auronectae is discussed in detail in connection with the description of the "Albatross" representatives of the group, it will suffice to say that I entirely subscribe to the foregoing view. Chun employed the name Auronectidae for the family, but this name is invalid because not derived from a generic name. Schneider and Lens and Van Riemsdijk have avoided this difficulty by using the older name Angelidae of Fewkes. But Angela, the genus from which "Angelidae" is derived, belongs to a different family, the Anthophysidae (p. 301). This fact invalidates Angelidae, and to replace it Rhodaliidae Haeckel ('88a, p. 43, '88b), based on Rhodalia Haeckel may be revived.

Two other families of Physophorae, both monogastric, were described by Haeckel ('88b), *i. e.*, Circaliidae and Athoriidae. The only representative of the latter which has been sufficiently described, *Athoria larvalis*, was undoubtedly a larval stage, probably belonging to some Agalmid. *Circalia stephanoma* the type of the Circaliidae, though retained by Chun in his list of Atlantic Siphonophores ('97b, p. 104), is also probably a young stage: indeed the mere fact that it is monogastric is almost proof that such is the case, for no other Siphonophore is known to retain the primitive monogastric condition permanently. Circalia has been associated provisionally by Schneider and by Vanhöffen (:06, p. 34) with the Rhodaliidae, as the young of Stephalia, but whether it actually belongs there can only be settled on fresh material.

The phylogenetic relationships between the various families of Physophorae form an inviting field for speculation; and especially is this true of the resemblance between Athorybia and the "Athorybia" larvae of various Agalmidae. It is easy to summarize the known facts in a few lines. Some Agalmidae, and probably all, according to the recent studies of Woltereck (:05a, :05b), pass through a complex larval stage, the "Athorybia" stage. This larva assumes the adult structure as the result of a metamorphosis in which the primitive bracts are lost. Now, Athorybia resembles this larva to an extraordinary degree. It is true that we do not yet know whether the bracts of Athorybia are the primitive ones permanently retained; but the development of the individual bracts of the neighboring genus Anthophysa is so typical, and so different from the early stages of nectophores as the latter are known in other Physophorids, that it shows they are true bracts, not degenerate nectophores as some authors have suggested.

Chun's ('97b) discovery of rudimentary nectophores in Athorybia makes the resemblance between it and that stage of the "Athorybia" larva just previous to the dropping of the primitive bracts, when the buds for the future nectophores are first visible, especially significant. On the other hand the pneumatophore of Athorybia is more highly specialized in its internal structure, particularly in the great number of septa, than that of any Agalmid.

The specialization of the pneumatophore and of the bracts, and the obliteration of the siphosome, far advanced in Athorybia, and complete in Anthophysa, together with the absence of a secondary porus in the pneumatophore of Athorybia, contrasted with its presence in Physophora, show that though both these latter genera have the stem reduced in length, they are not members of a single developmental series. Now, although the complexity of the pneumatophore of Athorybia is good evidence that the genus is not ancestral (Chun, '97), the resemblance between it and the "Athorybia" larva is too close to be accidental. The most plausible explanation is one partially advanced by Schneider ('98, p. 159), namely that Athorybia represents the "Athorybia" larva become sexually mature without undergoing the usual metamorphosis but with the pneumatophore highly specialized. In other words, it is an instance of development arrested in some lines, accelerated along others. Derived from the parent Agalmid stock are four groups with shortened axis. These are: 1, Nectaliinae, with axial pneumatochone, with both nectophores and bracts, and siphosome alone reduced; 2, Physophoridae, with highly specialized ventral pneumatochone, with nectophores and no bracts, and much reduced siphosome; 3, Anthophysidae, with highly specialized bracts, rudimentary nectophores if any; no specialized pneumatochone; 4, Rhodaliidae, with highly specialized dorsal pneumatochone, with nectophores, but no bracts.

The probable position of Anthophysidae has just been noted. Physophoridae and Rhodaliidae could both be derived from Nectalia. But it is impossible to connect the two in direct genetic series with each other or with the Anthophysidae. The position of the pneumatochone is an unsurpassable obstacle to regarding Physophora as the parent of the more highly specialized Rhodaliidae, while the absence of nectophores and presence of bracts, and the regressive development of the pneumatochone in Anthophysidae, forbids the association of that group with either. They represent diverging lines of evolution.

## Forskaliidae Haeckel, 1888.

Haeckel ('88b) recognized four genera in this family: viz Strobalia, Forskalia, Forskaliopsis, and Bathyphysa. But as Bedot ('93a) has pointed out in his revision of this family, the only species of Forskaliopsis, *F. magnifica* Haeckel, was never described; it was probably a Forskalia. Strobalia is equally vague, only the generic characters having been given by Haeckel, and it is at least problematic whether any existing species corresponds to his account. Finally it has been shown that Bathyphysa belongs to a different suborder, the Rhizophysaliae (p. 320). Neither Bedot ('93a), Chun ('97b), nor Schneider ('98) recognize more than the one genus of Forskaliidae, Forskalia; this view is undoubtedly correct.

Lens and Van Riemsdijk have included the little-known genus Erenna among the Forskaliidae. And this course is followed in the present Memoir, though the location of this genus is only provisional (p. 271).

## **FORSKALIA** Kölliker, 1853.

The synonymy of Forskalia is perhaps more confused than that of any other Siphonophore genus. Bedot ('93a) and Schneider ('98) the two authors who have most recently attempted to revise its species have come to very different results; the former recognizing five, the latter three species. The relations between the two systems are shown in the following table:

| Bedot ('93a). | Schneider ('98). |
|---|---|
| *F. contorta* Milne Edwards (partim). | = *F. contorta* Milne Edwards. |
| *F. leuckarti* Bedot (= *contorta* Leuckart) | |
| *F. cuneata* Chun | |
| *F. edwardsi* Kölliker | = *F. ophiura* Delle Chiaje. |
| *F. tholoides* Haeckel | = *F. hydrostatica* Delle Chiaje. |
| *F. contorta* Milne Edwards (partim) | |

Chun ('97b) recognizes three Atlantic species, *F. contorta* Milne Edwards, *F. ophiura* (Delle Chiaje) Leuckart, and *F. cuneata* Chun. Lens and Van Riemsdijk report *F. contorta* Milne Edwards, and *F. edwardsi* Kölliker from the "Siboga" collection.

The key given by Schneider ('98, p. 199) is:

1. Nectophore with red pigment spots on the subumbral canals; *contorta:*
2. Nectophore with yellow fleck on the velum; *ophiura:*
3. Nectophore without pigment spots; *hydrostatica.*

Bedot ('93a, p. 250) likewise bases his diagnosis chiefly on color.

It is hopeless to arrive at any sound conclusion as to the respective value of these schemes without a study of extensive series of living or well-preserved material of the different forms. It is especially necessary to test the constancy of the relatively trivial characters, *e. g.* pigmentation and shape of the nectophores, and shape and relative size of the appendages of the siphosome, by which the supposed species are distinguished. Unfortunately all the specimens in the "Albatross" collection are so fragmentary that I have been unable to do this. Indeed they have all lost every trace of appendage except a few nectophores and the pedicles to which the siphons were attached. Specific identification is therefore impossible, but their position in the genus Forskalia is fairly well assured by the shape of the few remaining nectophores and by the pedicles.

### **FORSKALIA** species?

Forskalia was taken at Stations 4665, 4667, 4671, 4683, and 4731, one specimen at each Station. The captures were both from surface hauls and from open net hauls from 300 fathoms. The examples, all of which are violently contracted, range in length from 10–25 mm.

### **ERENNA** BEDOT, 1904.

The genus Erenna has been recorded only twice, by Bedot (:04) who studied detached tentacles, and by Lens and Van Riemsdijk (:08) who were able to figure a fairly complete example, as *E. bedoti*, from the "Siboga" collection. It is to these authors that we owe our knowledge that the genus is an undoubted Physophore, with the typical structure of nectosome and siphosome, though with peculiar and characteristic tentilla. But its systematic position must remain doubtful until the arrangement of the nectophores has been studied in better material than any yet available. Its closest affinities are apparently with the Forskaliidae where it is classed by Lens and Van Riemsdijk.

The "Albatross" collection contains a single very fragmentary specimen which must be referred to this genus because of the structure of its tentilla. Unfortunately it has lost all its nectophores, as well as most of its bracts and siphons, while the few that remain are so much crumpled and torn that accurate description is out of the question. Furthermore the stem is twisted and contracted. In fact the condition is so bad that it is impossible to state whether or not it is specifically identical with the "Siboga" example. Nor, for that matter, is it clear whether the latter is distinct from Bedot's *E. richardi.*

### **Erenna richardi** BEDOT.

*Erenna richardi* BEDOT, :04, p. 10, pl. 2.

Station 4715, in trawl from 1743 fathoms. 1 very fragmentary specimen.

## Agalmidae Brandt, 1835.

The history of the Agalmidae has been reviewed in detail by Bedot ('96) in his revision of the family. The species here included form a homogeneous group. But though several of them are now well known the two students who have attempted to revise them since Haeckel ('88b), have come to totally opposite conclusions as to what characters are generic and how many genera deserve recognition. Bedot ('96) concluded that the most important systematic character within the family is the structure of the tentilla, and that general "habitus," whether long and contractile, or short and stiff, and form of the bracts whether thick or thin, are of subordinate value only. Proceeding on this basis, he recognizes eight genera and thirteen species. Schneider ('98) accepts only one of Bedot's genera, Anthemodes. All the other species, or supposed species, according to his view, properly fall provisionally into three genera, Stephanomia, Agalmopsis, and Cupulita. Instead of using the tentilla as generic characters, he states that they are entirely worthless, and bases his classification "einzig und allein in Rücksicht auf den characteristischen Habitus dreier Artgruppen" ('98, p. 118) that is to say, his Stephanomia comprises short, stiff forms; his Agalmopsis is longer, softer, and more contractile; while his Cupulita, with extremely extensible axis and loosely arranged bracts, is the end of the series. The adoption, entirely or in part, of one or other of these schemes, depends on the relative value of tentilla and of general form. I have been unable to find any other characters which could possibly be considered of generic value, in any of the five species which I have studied.

General form, particularly contractility of the stem and shape of the bracts, was long ago used by Haeckel ('88b) to distinguish two subfamilies of Agalmidae, *i. e.*, Crystallodinae and Anthemodinae. But a critical examination of this character shows that it is not so significant as he supposed. It is true that every species, so far as known, is comparatively constant in this respect. But the various species, from the shortest and most rigid, to the longest and most contractile, form an unbroken series which is divisible by purely artificial lines only. Furthermore, relative length can not be correlated in a natural grouping with any other characters. Thus species with tricornuate tentilla may be either stiff, or soft and slender; and the same is true of those with unicornuate tentilla. "Habitus," then, seems to me, as to Bedot, quite worthless as a generic character, although it is no doubt one of the most useful field marks for specific determination.

The form of the tentilla is much more precise. The primary tentacle of all Agalmids in which it is known, bears tentilla quite different from those of the later formed cormidia. They are usually only transitory, in fact the oldest siphon is usually dropped bodily. But in one species all the tentacles have tentilla of the primitive type. This species is the only representative of the genus Anthemodes. In all other Agalmids the definitive tentilla have either one terminal filament, two filaments and a median ampulla, or many filaments with an ampulla; in other words they are either unicornuate, tricornuate, or polycornuate. The latter condition characterizes one species alone, *Agalmopsis utricularia* Claus (*Lychnagalma vesicularia* Haeckel). This species is not included in Chun's ('97b) list: but the description and figures of it are detailed, and show that it is a very well-defined form.

In the development of the individual tentilla, so far as is known, the rudiments for the full number of filaments, and the ampulla if present are formed simultaneously at a very early stage. They are not added successively. Later on, the involucre develops in those species in which it occurs. It is evident that we can speak of successive degrees of specialization of the tentilla, something we cannot do in connection with the general "habitus"; and a character showing degrees of specialization is eminently fit to serve as the basis for classification. Now, in the two groups with unicornuate and with tricornuate tentilla, other minor characters, *e. g.*, form of the bracts, distinguish several species; and therefore it is entirely justifiable to follow Bedot ('96) in using the structure of the tentilla as the chief generic character.

On this basis, two genera, Anthemodes with tentilla of the primitive type, and Lychnagalma in which the tentilla have a whorl of eight (or more?) terminal filaments and a very large median ampulla, may be accepted without further discussion. The only Anthemodes yet known is *A. ordinata* Haeckel (*A. moseri* Agassiz and Mayer has unicornuate tentilla and is a synonym of *Stephanomia (Cupulita) bijuga* Delle Chiaje). *Lychnagalma vesicularia* Haeckel ('88b) the type of its genus was later shown to be a synonym of *Agalmopsis utricularia* Claus ('79).

Neither of these genera is represented in the "Albatross" collection.

The remaining species of Agalmidae are divided by Bedot into six genera, Agalma, Crystallomia, Stephanopsis, and Agalmopsis with tricornuate; Halistemma and Cupulita with unicornuate tentilla. The members of the first group are separated by such minor characters that I have no hesitation in uniting them. Thus the supposed hydroecial cavity of Agalma is probably accidental, as Schneider has pointed out, and even if normal it would indicate merely a special arrangement of the bracts. The feature on which Bedot's genus Stephanopsis is based, namely, that the terminal filaments of the tentilla can be retracted within the involucre, is certainly not of importance equal to that of the essential structure of those organs. Cupulita and Halistemma (Agalmopsis Schneider) are separated by the presence of an involucre in the former, contrasted with its absence in the latter. But the involucre is a secondary structure in development and its absence therefore is not sufficiently important to necessitate a separate genus; at most it may indicate a subgenus; and certainly the slight difference in the arrangement of the palpons described by Chun ('88) and by Schneider ('98) is not more than a specific character. Accordingly two genera, one tricornuate, the other unicornuate are recognized in addition to Anthemodes and Lychnagalma.

The earliest undoubtedly tricornuate species is *Agalma okeni* Eschscholtz ('25), the type of the genus Agalma. The siphosome of a species of the second, unicornuate, genus was described by Péron and Lesueur in 1807 as *Stephanomia amphitrides.* Fortunately the figure, though schematic and on a small scale, clearly shows that each tentillum has a coiled cnidoband with single terminal filament (this is not to be seen in the copy by Lesson '43, pl. 10, fig. 1, 1a), and this species, studied later by Huxley, is represented in the present collection. Stephanomia, of course, long antedates both Cupulita, and Halistemma; indeed, it was the first Agalmid described. It must therefore be used for the unicornuate genus.

### **AGALMA** Eschscholtz, 1825.

Agalma comprises two well-known species which have often been recorded, a third, which has been well described and is quite distinct, but which has been taken very seldom, and a fourth which is of doubtful validity. And, in addition, some of the older descriptions listed below (p. 354) as unrecognizable may belong here. The two well-known Agalmas have usually been known as *Crystallomia polygonata* Dana (*Crystallodes rigidus* + *vitreus* Haeckel) and as *Agalmopsis* or *Agalma elegans* Sars (*A. sarsi* Kölliker). But, as Schneider has recently shown, the former is in reality *Agalma okeni* Eschscholtz. Eschscholtz's figures are so accurate and show so clearly the characteristic "habitus" and the very diagnostic prismatic bracts ('29, pl. 13, fig. 1), that Fewkes long ago proposed this union, and it is surprising that it has not been generally adopted.

Bedot ('96) seems to have overlooked the importance of the bracts as specific characters, and in consequence groups *A. okeni* with *A. eschscholtzi* Haeckel, from which it is easily distinguished by the outlines of these organs as well as by other minor features. The fragments described by Quoy and Gaimard ('34) as *Stephanomia triangularis*, *S. alveolata*, and *S. heptacantha* probably belong here. At any rate there is nothing in their figures to suggest that they were dealing with more than one species, while the form both of bracts, and of nectophores, and the tricornuate tenillae agree very well with *A. okeni*.

The Agalmid siphosome which Lesson ('26) combined with *Abylopsis tetragona* (p. 225) under the name *Plethosoma crystalloides*, likewise suggests *A. okeni*. Schneider has identified with *A. okeni* the detached nectophores described by Eysenhardt ('21a, p. 369) as *Cuneolaria incisa*. But the only ground for this is the supposition that the nectophores in question were identical with the fragment described and figured by Chamisso and Eysenhardt ('21) as *Stephanomia amphitritis*. The latter, it is true, probably does belong to *A. okeni*, but in view of the facts that the *incisa* nectophore was neither figured, nor described, that Chamisso and Eysenhardt themselves disagreed as to its identity with their "*Stephanomia amphitritis*," and that it might equally well belong to any Agalma, or even to a Stephanomia, it is useless to identify it with *A. okeni*.

*Agalma pourtalesii* Agassiz and Mayer ('99) resembles *A. okeni* in the thickness of its bracts and in their prismatic form, as well as in general habitus. It is true that Mayer (:00) has described its tentilla as without involucre, although tricornuate. But Dr. Mayer himself informs me that later studies have shown that an involucre is present, and he has very kindly shown me drawings in which this character appears. Furthermore, the probable type of *pourtalesii* (now in the collection of the Museum of Comparative Zoölogy) differs in no way from *A. okeni*, so far as its rather unsatisfactory preservation allows me to judge. For these reasons there is every justification for uniting it with the latter species.

Lens and Van Riemsdijk have described the Agalmas ("Crystallomias") of the "Siboga" expedition, all of which are of the general *okeni* type, under two headings, "Crystallomia Spec. Group I."; and "C. Spec. Group II.," separating them by the structure of the tentilla. The excellent condition of the present series of *A. okeni* has allowed me to make a careful test of the supposed divergences, and since the tentilla are described below (p. 280) in detail, it will suffice here to state that the differences between them are all evidences either of different stages in growth, or of individual variation.

The second well-known Agalma was first described by Sars ('46), who combined it with a Stephanomia usually known as *Cupulita picta*, under the name *Agalmopsis elegans*. It has long been recognized that Sars's *A. elegans* was a combination of two different species. Indeed this was pointed out by Sars himself in a subsequent publication ('57) and for this reason both Kölliker ('53) and Bedot ('96) have abandoned the name *elegans* altogether, calling the Agalma (Agalmopsis) constituent of the pair by the second name under which it appeared, *A. sarsi* Kölliker. Fewkes ('81) and Schneider, on the other hand, retain the name *elegans* for the Agalma; and the latter has justified this course on the ground that the Stephanomia constituent had long before been described by Delle Chiaje ('42) as *Physsophora bijuga*. This identification is apparently well founded (p. 283); and the name *elegans* therefore belongs to Sars's Agalma.

Besides these two well-known species of Agalma, the following forms must be referred to it, viz.: — *Agalma breve* Huxley; *A. sarsi* Fewkes (non Kölliker); *A. clausi* Bedot, the type of his genus Stephanopsis ('96); and *A. eschscholtzi* Haeckel. The first of these may perhaps be a synonym of *A. okeni*, but Huxley's ('59) figures are not sufficiently detailed to show definitely whether this is the case.

*A. sarsi* Fewkes and *A. clausi* Bedot undoubtedly belong to one species, and fortunately Bedot's ('88) account and figures are sufficiently detailed to give a good idea of its characters. It is readily distinguished from *A. okeni* by the foliaceous form of the bracts and by their red pigment spots, as well as by its large size, and from *A. elegans* by the stiff non-contractile stem, and the thickness of the siphosome, as well as by minor details in the shape of the bracts and of the nectophores. It is likewise the only species of the genus, so far as we know, in which the terminal filaments of the tentilla can be retracted within the involucre. The name *clausi* must be used for this species instead of the earlier *sarsi* of Fewkes, because the latter was already preoccupied by Kölliker.

Schneider ('98, p. 121) has united *A. clausi* Bedot and *A. eschscholtzi* Haeckel under the name *sarsi* Fewkes; and there can be no doubt that the two resemble each other closely in general "habitus," as well as in the shapes of the nectophores and bracts. But inasmuch as the nectophores are pigmented in Haeckel's species, and the bracts are not, while the reverse is true in *clausi*, it is better to postpone the union of the two until fresh material from the Indian Ocean (the type locality of *eschscholtzi* is Ceylon) can be studied.

Haeckel's choice of *eschscholtzi* as the specific name for his species was unfortunate, because *Agalma eschscholtzi* had long before been preoccupied by Lesson ('43, p. 511) for a form figured, but not named, by Eschscholtz ('29), Eschscholtz's specimen was too fragmentary for identification with any actual species. But the facts that it was clearly an Agalmid, and that it had involucrate tricornuate tentilla (Eschscholtz, '29, taf. 13, fig. 4c) place it in Agalma. This leaves Haeckel's Ceylon species nameless, and I propose *haeckeli*, until the question of its validity is finally settled.

### **Agalma okeni** Eschscholtz.

Plate 17.

*Agalma okeni* Eschscholtz, '25, p. 744, taf. 5, fig. 17; '29, p. 151, pl. 13, fig. 1a–1d; Lesson, '43, p. 510; Gegenbaur, '60, p. 403, taf. 32, fig. 45, 50–52; Fewkes, '83b, p. 81; '86, p. 964; Bedot, '96, p. 105.
*Stephanomia triangularis* + *alveolata* + *heptacantha* Quoy and Gaimard, '34, p. 71–76, pl. 3, fig. 1–7, 16–18, 19–23.
*Crystallomia polygonata* Dana, '58, p. 459, pl. 1; Bedot, '96, p. 106; Chun, '97a, p. 84, fig. 18; '97b, p. 103; Lens and Van Riemsdijk, :08, p. 70.
*Crystallodes rigidum* Haeckel, '69a, p. 49, pl. 10, fig. 65–71; Chun, '88, p. 1170.
*Crystallodes rigida* Haeckel, '88a, p. 40.
*Crystallodes vitraea* Haeckel, '88a, p. 40; '88b, p. 222, pl. 17.
*Agalma polygonata* Haeckel, '88a, p. 40; '88b, p. 366.
*Agalma rigidum* Bedot, '88, p. 78.
*Stephanomia incisa* Schneider, '98, p. 120.
*Agalma pourtalesii* Agassiz and Mayer, '99, p. 180; Mayer, :00, p. 79, pl. 31, fig. 106, 107; pl. 32, 33.
? *Stephanomia amphitrides* Chamisso and Eysenhardt, '21, p. 367, taf. 33, fig. 5a–5f.
? *Cuneolaria incisa* Eysenhardt, '21a, p. 369.
? *Agalma mertensii* Brandt, '35, p. 34.
? *Agalma breve* Huxley, '59, p. 75, pl. 7.
? *Crystallodea mertensii* Haeckel, '88a, p. 40; '88b, p. 222.

*Agalma okeni* was taken at Stations 4596, 4600, 4611, 4617, 4619, 4624, 4627, 4631, 4635, 4640, 4642, 4644, 4657, 4659, 4681, 4708, 4710, 4713, 4714, 4715, 4716 ,4717, 4728, 4743, and at Station 3397, "Albatross" Panamic expedition, 1891.

The records are mostly from surface hauls, but the species was taken five times in open net hauls from 300 fathoms, and twice in the trawl. The material, which is in very good condition, consists of ninety-three entire specimens (fifty-seven from Station 4600), varying in length from 5–95 mm., and of a great number of detached cormidia, bracts, and nectophores.

I was also able to study an example from the Fiji Islands, which is probably the type of the *Agalma pourtalesii* of Agassiz and Mayer, besides several excellent specimens from the West Indies; none of these differ from the Pacific series listed above in any important feature.

Representatives of this species, both from the North Atlantic and from Ceylon, have been fully described and figured by Haeckel ('69a, '88b). But the very good state of preservation of the "Albatross" specimens and the fact that I was able to study them alive, allows me to add some details to his account, as well as to that by Lens and Van Riemsdijk. The characters most readily distinguishing *A. okeni* from other Agalmids are the short, non-contractile stem and the thick, stiff, closely crowded bracts. Its general form and its habit of floating horizontally in the water are so characteristic that it is recognizable at first sight. The largest examples in the "Albatross" series measure about 95 mm. in length, while Dana's single example was about 60 mm. long. This size, equalled by only one of the "Siboga" specimens, is apparently about the maximum, for Chun's ('97a) largest specimen was only 75 mm., while Haeckel's examples and those which I have examined from the West Indies were all much smaller.

*Nectosome.* The pneumatophore is invariably deeply pigmented apically. The arrangement of the nectophores, which are closely crowded together in two regular opposed rows, has been described and figured by Haeckel. In the largest specimen there are about twenty-eight nectophores (excluding several very young ones which had not attained their definitive form). Chun has recorded twenty-four in his largest example (75 mm.). In examples 40–50 mm. long, there are usually 14–18 nectophores, and in the younger individuals proportionately fewer. The exact number cannot be determined for any of our small specimens, for all of them had lost most of their nectophores. Indeed they were in all ways less satisfactory than the larger ones. The nectophores themselves are of such a characteristically flattened and prismatic form (Plate **17**, fig. 12) that they are readily recognizable even when detached. And the course of their subumbral canals agrees perfectly well with Haeckel's figure ('69a, pl. 10, fig. 67). The nectosac itself is prolonged laterally into two horns, a characteristic form which is constant even in the most contracted specimens. The largest nectophores measure 11–12 mm. in breadth.

*Siphosome.* The largest number of siphons in any colony was nine, the same number that Chun records for his largest examples; most of the specimens (40–50 mm. long) had six or seven. The smallest number (except in some mutilated fragments) was two, in a somewhat contracted colony 4 mm. long.

*Bracts.* The bracts have been well described by Haeckel. They are prismatic in outline, roughly triangular (Plate **17**, fig. 10, 11), and thickest at the distal end. The distal margin is divided into four concave facets by three vertical transverse ridges in an extremely characteristic manner, and the number of facets, which are very early developed (Plate **17**, fig. 9), is apparently constant. The only exception to it which I have seen among many hundred bracts is that in very small specimens the bracts associated with the oldest (primary ?) siphon have only two distal facets, there being only one transverse ridge. The peripheral glands discovered by Lens and Van Riemsdijk (:08, pl. 13, fig. 104) are present in some bracts at least, but apparently not in all.

The arrangement of the bracts on the stem is extremely precise and regular. The firm and regular pavement-like cylinder of closely opposed bracts has been aptly described by Haeckel ('88b) as a "carapace," but he is in error in stating that the dorsal half of the axial trunk is "exclusively composed of bracts." In reality the bracts are attached exclusively to the ventral half of the stem, a fact easily demonstrated on well-preserved specimens. The bracts occupy the space between the siphons as Haeckel supposed, for being ventral like the latter, they must necessarily alternate with them. Each bract is borne on a semilunar muscular lamella, the youngest ones ventral, and nearest the siphons; the older ones more dorsal, and nearer the centre of the "internodes" (Plate **17**, fig. 13). The broad axis of each bract lie transverse to the long axis of its muscular lamella; and by the curving of the older lamellae the armor of bracts is made even more complete on the dorsal than on the ventral side of the siphosome. Chun's statement ('88) that only the bracts nearest the siphons have canals is only partly correct. In point of fact, every bract has a canal when young, but as they grow older and are forced further and further dorsad, the canals become less conspicuous, and in some cases cannot be detected at all. The largest bracts which I could find are 15 mm. broad, and all are extremely hard and rigid.

The succession of the siphons, palpons, and gonophores is regular and characteristic. If we take any well-preserved segment of the stem, we find in each cormidium the siphon, several palpons, and the two gonodendra, ♀ and ♂. The gonodendra lie immediately distal[1] to the siphon, in conjunction with two or three palpons; the ♀ next to the siphon (Plate **17**, fig. 13). Proximal to each siphon is a cluster of several palpons. I have found no essential variation from this arrangement in any of the cormidia studied, except that the shortening of the stem in contracted material may cause the gonodendra to lie nearly midway between pairs of siphons. But in expanded examples the true condition is easily traced, and in such there is a free space, occupied only by bracts, between each two cormidia. Chun ('88, p. 1170) it is true, says that "die männlichen geschlects trauben proximal, die weiblichen distal angeordnet sind," but he does not give any figures of this. The ♂ and ♀ gonodendra differ so

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[1] I speak of the end of the siphosome nearest the nectosome as *proximal*, that furthest from it (*i. e.*, oldest) as *distal*.

much in general appearance that they are easily recognizable. In the former the gonophores are stalked and loosely clustered, and the gonophores themselves are comparatively large, with their cavities entirely filled by the swollen spadix. In the ♀, the individual gonophores are much smaller, each containing but a single large egg, and they are closely crowded on one main stalk (Plate **17**, fig. 13).

The palpons (Plate **17**, fig. 14) are of the usual type, each bearing a contractile filament near its base. The siphons show no features of special interest.

*Tentilla.* The tentilla deserve special mention, since it was a supposed diversity in these organs which lead Lens and Van Riemsdijk to separate the Agalmas ("Crystallomias") of the "Siboga" Expedition into two groups. These authors describe four types of tentilla. Of these, types III and IV, as they themselves recognize, are merely successive stages of one type, which is the usual condition in all but the youngest cormidia. The others, I and II, are small, and occur only on a few of the oldest cormidia. It is according to the presence either of I or of II, on the earliest formed tentacles, that they limit their two groups of Agalmas. All these kinds of tentilla occur in the "Albatross" series, and the better material allows me to state definitely that there is no essential difference between types I and II of Lens and Van Riemsdijk. Indeed, according to their own account both have a closed involucre and from one to two and one half turns of the cnidoband, with the terminal filaments and ampulla typical of the genus. The only difference between the two is that in II the lateral filaments are coiled, in I they are not. This is an unimportant feature, so much so that I have seen both types on one tentacle. In younger stages of their type I + II the involucre only partially encloses the cnidoband and the earliest stages are indistinguishable from those of the type described below. This small form of tentilla, with but few coils, is characteristic of the oldest siphons. I have never found an individual with more than one tentacle of this sort, and only two showing them at all. But Lens and Van Riemsdijk found examples with as many as four such cormidia. In the later formed cormidia the tentilla are much larger, as those authors observed and the cnidoband has many more coils when mature. The involucre, at first only a basal swelling (Plate **17**, fig. 4), encloses more and more of the coils with its progressive development (Plate **17**, fig. 5, 6), and may finally enclose them all (Plate **17**, fig. 7). But there is evidence that it does not always do so, for I have found old tentilla with up to as many as seventeen coils of which at least half protruded, while others on the same tentacle had only from seven to nine, all enclosed. The study of the development of these organs is much facilitated by the fact that there is apparently no exception to the rule that they are formed exclusively near the base of the tentacle, and that the most distal ones are the oldest. The finer structure of the tentilla resembles that in other Agalmidae and has been described by Haeckel.

These facts show that the division of the "Siboga" specimens into two groups was an unnecessary one. But it is not clear whether or not the tentilla of the small type correspond to the kidney-shaped tentilla developed in some other Agalmidae in conjunction with the primary siphon. The fact that these tentilla may occur in connection with as many as four siphons argues against such a homology (Lens and Van Riemsdijk, :08). But the question can be settled only when better material of the young stages has been studied. Apparently the small tentilla (which are after all essentially similar to the larger ones), are developed in connection with a variable number of the earlier formed siphons. Their absence from all of our large specimens means merely that the oldest siphons have been broken off. The large number of detached but otherwise normal cormidia in the "Siboga" and in the "Albatross" collections shows that fragmentation does take place easily, perhaps even normally. And the absence of loose cormidia with the young type of tentilla would easily be explained on the supposition that they were detached while still very small.

*Color.* In life the pigment spots of the pneumatophore are reddish purple, the stem is opaque white or yellow, the tentilla brilliant brick-red.

*Distribution.* Enough records of *A. okeni* have been made to show that it is very generally distributed over the warmer regions of all three great oceans, and that it occurs in the Red Sea (Schneider, '98, p. 120).

### **Agalma elegans** (SARS) FEWKES.

Plate 18, fig. 9–13; Plate 19, fig. 1–4.

*Agalmopsis elegans* SARS, '46, p. 32, tab. 5, 6 (partim).
*Agalmopsis sarsii* KÖLLIKER, '53, p. 10, taf. 3; LEUCKART, '54, p. 331, taf. 12, fig. 21–27, taf. 13, fig. 1; HAECKEL, '88b, p. 234; BEDOT, '96, p. 409.
*Agalma punctata* LEUCKART, '53, p. 3, taf. 1, fig. 1, 19, 20, taf. 2, fig. 1, 2, 5–7, 23; (non KÖLLIKER, '53; non VOGT, '54).
*Agalma clavata* LEUCKART, '53, p. 3, tab. 2, fig. 3; '54, p. 337, tab. 13, fig. 2–12.
*Agalmopsis clavatum* L. AGASSIZ, '62, p. 369.
*Agalma elegans* FEWKES, '80a, p. 141; '80b, p. 618, fig 1; '81, p. 163, pl. 9, 10; '82b, p. 301; SCHNEIDER, '98, p. 122; RÖMER, :02, p. 178.
*Cuneolaria elegans* HAECKEL, '88a, p. 40.
*Agalmopsis catena* HAECKEL, '88b, p. 234.
*Agalmopsis elegans* HAECKEL, '88b, p. 234; CHUN, '97b, p. 104; SCHNEIDER, '98, p. 122; RÖMER, :02, p. 178; VANHÖFFEN, :06, p. 24, fig. 31–36.
?*Cupulita sarsi* DAMAS, :09, p. 107.

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|---|---|---|---|
| Station | 4637 | 300 fathoms to surface | 2 specimens, 10 mm. long, fairly well preserved. |
| " | 4646 | surface | 3 specimens, two of 10 mm., with most of the nectophores gone, and one of 20 mm. (Plate **19**, fig. 1). |
| " | 4714 | " | 1 specimen of 15 mm., with only one complete cormidium, 3 bracts and 4 nectophores. |

I have likewise been able to study an excellent specimen from Naples, 150 mm. long.

Römer (:02) has retained both the *Agalmopsis elegans* of Sars, and the *Agalma elegans* of Fewkes as separate species. But in saying that the former is known from the original record only, he has overlooked the fact that it is identical with a well-known Mediterranean form. Geographic distribution points to the identity of the forms described by Sars and Fewkes, instead of suggesting that they are distinct, because the former penetrates yearly the Norwegian Sea from the South (Damas, :09, p. 107), a phenomenon long known for the northerly records of Agalma on the American coast.

Our largest example is at about the same stage as the young specimen figured by Fewkes, and much resembles it (compare Plate **19**, fig. 1, with Fewkes, '81, pl. 9, fig. 1). But, although the colony as a whole is so small, its tentilla, bracts, and nectophores already show the adult characters so plainly that they make the identification positive. This species has been so well described and beautifully figured by Sars ('46), Kölliker ('53), Leuckart ('53, '54), and especially Fewkes ('81), that I need merely summarize its diagnostic features.

*General "habitus."* In young stages the stem is short and but slightly contractile. In the adult it is long and contractile, and the siphosome so much more slender than in *A. okeni* that the two species are separable at first glance. In the adult the siphosome is much longer than the nectosome.

The nectophores are flattened as in *A. okeni*, but their margins are rounded instead of being distinctly facetted, and the nectosac is deeper, more nearly triangular with broader mouth. The difference might seem trivial, were it not so constant. The bracts (Plate **18**, fig. 12) are triangular, foliaceous, thickest near the centre and very thin at the distal margin, instead of truncate and facetted distally as they are in *A. okeni*. So pronounced is the difference in form between the bracts of the two species that isolated ones may be identified readily. The distal margin of the bract is tridentate and its upper surface marked by three ridges.

The tentilla are of the tricornuate type, and when adult the involucre entirely encloses the cnidoband (Plate 18, fig. 10, *cf.* Fewkes, '81, pl. 9, fig. 21). Apparently this is the invariable condition in fully developed tentilla. In their individual development these organs pass through the same stages that they do in *A. okeni* (p. 280).

*A. elegans* was previously known from the Mediterranean, from the coast of Europe as far north as Norway; the east coast of North America from the West Indies to Cape Cod, perhaps even to the Bay of Fundy. So far as I can learn, there is no previous record of its occurrence in the Pacific, but it has been recorded from Malayan waters (Amboina, Bedot, '96).

### **STEPHANOMIA** Péron and Lesueur, 1807.

According to Schneider ('98) the various forms described up to that time which fall in Sephanomia as here defined, all belong to one or other of three species. Essentially this same conclusion was previously reached by Bedot ('96), but though he suggested the identity of *Nanomia cara* A. Agassiz ('65) and of *Anthemodes canariensis* Haeckel ('69b) with the well-known *S.* (*Cupulita*) *picta* Metschnikoff, he maintained them temporarily as distinct. These three are united by Schneider ('98) under the specific name *bijuga* Delle Chiaje. The identification of Delle Chiaje's form with the well-known "*picta*" is justified, because his figure ('42, pl. 181) of the young tentilla shows both the coiled cnidoband with a single terminal filament, and the basal swelling fated to grow into the involucre (*cf.* Claus, '78, taf. 1, fig. 6c). Adoption of this view will establish the nomenclature of the Agalmidae on a firmer basis than heretofore, because it will leave Sars's ('46) Agalma in undisputed possession of the name *elegans* (p. 276). Bedot ('96) does not include Delle Chiaje's name in his synonymy.

On the other hand, both Chun ('97b), Römer (:02), and Vanhöffen (:06) retain the name *cara*, for the northern form, as distinguished from the southern *bijuga* (= *picta*). There is some evidence in favor of this course, although the two are close allies. Thus, *cara* grows to an enormous size (four feet long when expanded, three feet when contracted according to Fewkes, '88a), whereas *bijuga* is a rather small form. Then, the bracts are apparently more obtuse in the former than in the latter, the tentilla of the primary tentacles of the two are of different shapes (*cf.* Plate 20, fig. 3, with Fewkes, '88a, pl. 2, fig. 8). The geographic occurrence of the two points in the same direction, for *cara* is restricted to and typical of Arctic waters, rarely straggling as far south as Massachusetts Bay, whereas *bijuga* is at home in the Mediterranean, at the Canaries (Chun, '88), and among the West Indies (Fewkes, '82a).

But a definite answer to the question will depend upon an actual comparison of specimens. Certainly it can never result from Fewkes's rather generalized account or figures. I made a visit to Grand Manan during the summer of 1910, with this in view, but although Fewkes found *cara* very common there, I did not see a single specimen. Until such a comparison is made, it is better to retain *cara* as a distinct species, lest by combining the two the necessity for a critical examination of them be obscured.

The description of Sars's Norwegian Stephanomia is so incomplete that it is impossible to determine whether it is identical with the southern *bijuga* until it is reëxamined. In the meantime the whole question of the geographic distribution of the *cara-bijuga* group must be left unsettled.

A third species of Stephanomia is the *S.* (*Halistemma*) *rubra* of Vogt, the tentilla of which have no involucre; a fourth is *Stephanomia amphitrides* Pétron and Lesueur, the type of the genus.

Recently Lens and Van Riemsdijk (:08), have described as new *S.* (*Halistemma*) *cupulifera,* distinguished from *S. rubra* by the terminal filament of each tentillum bearing "at its terminal end a small acorn-shaped appendage" (:08, p. 85). Judging from their figure (:08, pl. 16, fig. 117) the tentilla seem sufficiently distinct to warrant recognizing at least provisionally their species. *Stephanomia bijuga* and *S. amphitridis* are represented in the "Albatross" collection, and I have been able to study excellent examples of *S. rubra* from Naples.

### **Stephanomia bijuga** (DELLE CHIAJE).

Plate 19, figs. 5–11, Plate 20, figs. 1–3.

*Physsophora bijuga* DELLE CHIAJE, '42, pl. 181, fig. 3–6.
? *Agalmopsis elegans* SARS, '46, p. 32, tab. 5, 6; CLAUS, '78, p. 38 (partim).
*Anthemodes canariensis* HAECKEL, '69b, p. 36, taf. 1; '88a, p. 40; CHUN, '88, p. 1170.
*Halistemma pictum* METSCHNIKOFF, '70, p. 305, tab. 2; CHUN, '88, p. 1167.
*Stephanomia* (*Anthemodes*) *canariensis* METSCHNIKOFF, '74, p. 36.
*Stephanomia pictum* METSCHNIKOFF, '74, p. 36.
*Halistemma tergestinum* CLAUS, '78, p. 1, taf. 1, 2.
*Agalmopsis fragile* FEWKES, '82a, p. 267, pl. 5, fig. 2, pl. 6, fig. 16, 17, 23–25.
*Anthemodes picta* HAECKEL, '88a, p. 40.
*Halistemma fragile* HAECKEL, '88a, p. 40.
*Cupulita picta* HAECKEL, '88b, p. 367; BEDOT, '96, p. 407.

*Cupulita tergestina* Haeckel, '88b, p. 367.
*Cupulita fragilis* Haeckel, '88b, p. 367.
*Cupulita canariensis* Haeckel, '88b, p. 367; Bedot, '96, p. 408.
*Cupulita* (*Halistemma*) *picta* Chun, '97a, p. 86, fig. 19.
*Cupulita bijuga* Schneider, '98, p. 123.
*Anthemodes moseri* Agassiz and Mayer, :02, p. 167, pl. 12.
(For the synonymy of *S. cara* see p. 349).

| | | |
|---|---|---|
| Station 4587 | 300 fathoms to surface | 1 small fragmentary example. |
| " 4613 | " " " " | 1 " " " |
| " 4635 | surface | 1 excellent specimen, 11 mm. long, with 6 (?) nectophores and the primary siphon (Plate **19**, fig. 1). |
| " 4681 | 300 fathoms to surface | 1 very contracted example. |
| Acapulco harbor | surface | 1 excellent specimen about 45 mm. long, with 12 nectophores and 14 siphons (Plate **19**, fig. 5). |

"Albatross" '91 Expedition, Station 53, fragments.

The descriptions of this species by Metschnikoff ('70), Claus ('78), and Chun ('88) are so complete that I can add but little to them. There is no doubt that the specimens here recorded are identical with *Anthemodes moseri*, Agassiz and Mayer.

I have been unable to obtain satisfactory specimens of the Atlantic *S. bijuga*. Therefore my identification of the "Albatross" series does not rest on direct comparison. But the agreement is so close, not only in general "habitus," but in the shape of nectophores, bracts, and tentilla, and in the arrangement of the appendages on the stem, that I have no hesitation in uniting them.

Apart from *S. cara* (p. 349), the only known species with which *S. bijuga* could be confused are *S. rubra* Vogt, and *Anthemodes ordinata*, but in the latter the bracts are quadrangular, nearly rectangular (Haeckel, '88b) and very characteristic, and the tentilla have numerous terminal filaments, while in *S. rubra* the tentilla are naked, without involucre. In *S. amphitridis*, which resembles *S. bijuga* so far as the tentilla are concerned, the siphosome is much shorter proportionately, stiffer, and less contractile, and the bracts different in form (p. 287).

The nectophores are useful field marks for the species, their nearly spherical form, and dilated nectosac (Plate **19**, fig. 6, 7) distinguishing them at once from those of *Agalma elegans* (Plate **19**, fig. 2, 3). And the same is true of the bracts, which are slender and very soft. As a rule these structures are terminally tridentate, but in any one specimen some may be of this shape, others abruptly truncate, or slightly pointed. (Claus, '78, taf. 2, figs. 2, 3). The peculiar arrangement of the palpons which, as has long been known, alternate with the siphons, has been described by Chun ('88, '97a) and I am able to confirm his statement that of the 4–6 palpons between every two siphons the ones nearest the proximal siphon are the youngest, and that they are progressively older and older as we approach the distal siphon, in other words, new members are formed next the proximal siphon. This condition can be followed on the photograph (Plate 19, fig. 9), though of course less readily than on a more diagrammatic drawing (for further details as to arrangement of palpons and bracts see Chun, '88, p. 1168). The close agreement in this respect between Atlantic and Pacific specimens is one of the strongest reasons for uniting them in one species, since in the closely related *S. rubra* the palpons are irregularly arranged along the internodes. Female and male gonodendra are attached in pairs to the bases of the palpons (Plate 20, fig. 2).

The siphons, which are of the usual type, are borne on rather long pedicles, and from these pedicles bracts are developed (Plate 20, fig. 1).

*Tentilla.* These have often been described, especially by Fewkes. One of the present specimens still has the primary tentacle with its characteristic primitive tentilla (Plate 20, fig. 3), resembling those described by Agassiz ('65), by Claus ('78), and by Fewkes ('88a). The definitive tentilla which are borne on all the later formed tentacles develop through a series of changes similar to those described above (p. 280) for *Agalma okeni*. Since young stages have been figured by Claus, only the adult condition is represented here. The stage figured by Delle Chiaje ('42, pl. 181) almost exactly duplicates one studied by Claus. ('78, pl. 2, fig. 6).

*Color.* The "Albatross" specimens were colorless except for the brilliant red tenillae and the brownish red pneumatophore, but in this species pigment flecks often occur at the bases of the palpons and on the stem.

The various records of the capture of *Stephanomia bijuga* listed in the synonymy show that it is very widely distributed in warm waters, being known both from the West Indies (Fewkes, '82a), from the Mediterranean, and from various localities in the Tropical Pacific, and from Amboina (Bedot, '96). Should it finally prove to be identical with *S. cara* it would afford an instance of eurythermal distribution, from the tropics to the polar sea. But for the present we can not claim such a range for it.

### **Stephanomia amphitridis** Péron and Lesueur.

Plate 18, figs. 1–8.

*Stephanomia amphitridis* Péron and Lesueur, '07, pl. 29, fig. 5; Huxley, '59, p. 72, pl. 6; Schneider, '98, p. 118.
? *Stephanomia foliacea* Quoy and Gaimard, '34, p. 74, pl. 3, fig. 8–12.
*Stephanomia amphitritis* L. Agassiz, '62, p. 368.
? *Stephanomia nereidum* Haeckel, '88a, p. 40; '88b, p. 221.
*Phyllophysa squamacea* Haeckel, '88a, p. 40; '88b, p. 225.
*Cupulita amphitritis* Bedot, '96, p. 408.
*Stephanomia* sp., Lens and Van Riemsdijk, :08, p. 84, pl. 15, fig. 113–114.

| | | |
|---|---|---|
| Station 4704 | surface | 1 segment of the siphosome 95 mm. long, with 7 siphons (Plate **18**, fig. 1). |
| " 4705 | 300 fathoms to surface | 6 segments of the siphosome, 20–30 mm. long. The material is all in beautiful condition. |

The original figure of this species by Péron and Lesueur ('07), though sufficient for identification, shows only the general external aspect of the siphosome and the fact that the tentilla have a single terminal filament.

Our only knowledge of the structure of this interesting Siphonophore is contained in the accounts by Huxley ('59) and by Haeckel ('88). Fortunately the present material is well preserved, though only the siphosome was taken.

The nectosome has been seen by Haeckel alone, who states ('88b, p. 221, "*Stephanomia nereidum*") that "the biserial nectosome composed of twelve complete nectophores had nearly the same form as that of *Crystallodes vitrea*." But since his *S. nereidum* has never been described in detail, or figured, its identity with *S. amphitridis* must remain doubtful. Bedot classes it under the heading "espèces incomplètement connues" ('96, p. 411). Schneider, without discussing *nereidum*, suggests that *amphitridis* may actually lack a nectosome. But when we consider how seldom the species has been taken, the strong probability that Haeckel's species was identical, and the fact that no other Physophore lacks a pneumatophore, even if nectophores be wanting, we must conclude that such a supposition is most improbable.

*Siphosome.* The stem is stiff and but slightly contractile. The bracts form a stout cylindrical carapace, although they are less regularly arranged than Huxley supposed. They lie arranged in four or five irregular somewhat diagonal rows, instead of in four rows, as he describes them. Furthermore, their external location does not necessarily indicate the level at which their supporting lamellae join the stem. Haeckel states that there are six irregular rows in his *nereidum*, but he gives no further details. The bracts which lie dorsal are roughly bilateral, proximally pointed, and distally tridentate (Plate 18, fig. 8). Those covering the lateral faces of the siphosome are irregular in outline, and often much distorted, perhaps as the result of crowding. They are usually tridentate, with a fourth tooth on one of the margins (Plate 18, fig. 7). Many of the ventral bracts, between which the tentacles are protruded, have a peculiar cup-like recess on one of their margins (Plate 18, fig. 6), but this is not always the case (Huxley, '59, p. 72). All the bracts are soft and foliaceous, thickest near the middle, and very thin at the distal margin.

The cormidia have been described by Huxley, but the location of the various zooids is more precise than he supposed. In the present series there are nineteen siphons, with corresponding segments of stem, and in all of them the arrangement is as follows:—Proximal to any given siphon there are from 2–5 palpons; distal and close to it are the two gonodendra, ♀ and ♂, and crowded against them 3–6 palpons. On the pairs the ♂ cluster is always next the siphon (Plate 18, fig. 2). Next to the ♀ gonodendron there is a vacant space occupied only by bracts; but midway between every two siphons there is a cluster of 3–6 palpons of different ages. These intermediate groups are clearly shown in Huxley's figure ('59, pl. 6, fig. 1); and they are represented as filaments in the original figure of the species. Haeckel states that in *nereidum* the "long internodes were free" ('88b, p. 221), but without figures or a detailed account of the location of the palpons it is impossible to judge how much weight should be attached to this statement.

Each siphon has a well-defined basigaster. The palpons, each provided with a filament, are of the usual type. The gonophores have been described so fully by Huxley ('59) that I need merely call attention to the fact that the ♂ bells have tentacular rudiments on the margin (Plate 18, fig. 4, T. B.). Each ♀ bell contains a single large egg. The tentilla of the "Albatross" specimens, with short involucre and single terminal filament (Plate 18, fig. 3) agree very well with Huxley's account. In the development each tentilla passes through the usual series of changes (p. 280).

In life the basigaster of each siphon was pale reddish, the tentilla brilliant scarlet. Bracts, palpons, and stem were colorless, the former very transparent.

The original specimen of the species was taken in the Atlantic; it is recorded from the Pacific (Huxley), from the Malaysian region (Lens and Van Riemsdijk), and probably from Ceylon (Haeckel).

## Nectaliinae.

*Nectalidae* HAECKEL, 1888.

Agalmidae with very much shortened stem, with highly developed ensiform bracts.

The only representative of this subfamily is the monotypic genus Nectalia Haeckel, known only from Haeckel's account and figures, and from Chun's ('97b) description of the pneumatophore. According to Haeckel, the bracts, palpons, siphons, and gonophores are arranged around the very much shortened stem in successive whorls. But Schneider, arguing from Haeckel's figures, has attempted to show that the supposed whorls are only superficial, and that the palpons, siphons, and gonophores of Nectalia are in reality in a continuous line as in other Agalmidae, except that the line is twisted in a spiral as it is in Physophora. This explanation would fit in much better with the actual conditions in the Agalmidae on the one hand and the Physophoridae on the other, and the only example of the genus which I have been able to examine lends support to it so far as its rather imperfect preservation allows me to judge. The exact arrangement of the various appendages is described below (p. 290).

The agreement between Nectalia and the other Agalmidae in the structure of the pneumatophore and nectosome, in the bracts and in the individual appendages of the siphosome is too close to allow any conclusion other than that it is an offshoot of that family. Indeed the only important feature by which it is separated from the latter is the very much shortened stem. For this reason Schneider has united it with the Agalmidae, instead of following Haeckel ('88b) and Chun ('97a, '97b), who have regarded it as a distinct family.

Nectalia and Physophora have diverged from the parent stock, Agalmidae, along lines similar so far as the shortening of the stem is concerned. But the condition of the bracts seems to negative the possibility that the two stand in a direct generic series, because they are entirely aborted, in Physophora, whereas in Nectalia they are specialized to an unusual degree. This difference between Nectalia and Physophora is even more significant than is the presence of a secondary porus in the pneumatophore of the latter, contrasted with the absence of such an opening in Nectalia. In the one case, *i. e.*, that of the bracts, we have to do with the specialization in opposite directions, regressive and progressive, of organs existing in the parent; in the other with the formation of a new organ. And of course we can as easily conceive of the porus as appearing *de novo* in Physophora, as in one of its ancestors.

These considerations lead to the conclusion that Nectalia and Physophora represent diverging lines of development, of which the latter has progressed much the further from the ancestral state. The most satisfactory way to express this concept in terms of classification is to institute a subfamily of Agalmidae for Nectalia, while retaining the separate family Physophoridae for Physophora.

## **NECTALIA** Haeckel, 1888.

### **Nectalia loligo** Haeckel.

Plate 20, figs. 4, 5.

*Nectalia loligo* Haeckel, '88a, p. 41; '88b, p. 352, pl. 13; Chun, '97b, p. 37, taf. 3, figs. 1, 2; Schneider, '98, p. 124.

| | | |
|---|---|---|
| Station 4717 | in the trawl from 2153 fathoms | 1 specimen in fairly good condition. |

The measurements of this example are:— Length of contracted nectosome 12 mm.; of siphosome about 5 mm.; of the longest bract 54 mm.; breadth of nectophore 13 mm. This, as is shown by the number of nectophores, bracts, and siphons, is a younger individual than the one figured by Haeckel, but I have found no reason to separate it specifically.

*Nectosome.* I was especially glad to find that the pneumatophore was intact and so transparent that its internal anatomy could be worked out in optical section, since Schneider ('98) has suggested that Chun might have overlooked a secondary porus. Most careful search confirmed Chun's account in failure to reveal the slightest trace of any such opening. The chitin ring figured by him ('97b, taf. 3, fig. 1), is clearly visible, as is the secondary ectoderm of the pneumatosaccus.

There are only four fully formed nectophores, instead of nine, as in Haeckel's figure; their rounded shape, the dilated nectosac and the course of the subumbral canals (Plate 20, fig. 5) agree closely with his account.

*Siphosome.* Immediately below the most distal nectophore there are two small bracts on the opposite side of the stem, and the bud for a third. These lie above the "blastocrene," or zone of proliferation for the siphons. The upper bracts are much thicker than the larger ones which lie below, though they agree with them in being distally tridentate. They correspond to the more numerous small bracts observed by Haeckel. In the "Albatross" example they are both much crumpled. Immediately below the small bracts is the zone of proliferation for palpons and siphons, bearing several small buds. Below this there are successively a group of four palpons, with their filaments, a siphon with its tentacle, two palpons, and finally a second siphon. The length of stem occupied by these much crowded appendages is only about 3 mm. At this early stage the palpons and siphons still lie in a nearly straight line. Spiral coiling, if it takes place, is associated with an increase in the number of appendages, without a corresponding increase in the length of the stem. The two large bracts are lanceolate, distally tridentate; convex on the dorsal and deeply concave on the ventral face, just as Haeckel has represented them, and each has a bracteal canal running to its tip. They are attached by the usual muscular lamellae, on opposite or nearly opposite sides of the stem, the shorter one at the level of the "blastocrene," the longer one opposite the upper group of palpons. In the present condition of the specimen, these two large bracts lie in the plane opposite the nectophores, the small ones in the same plane as the latter, and the same condition was observed by Haeckel. But the "Albatross" specimen is so much twisted that it is impossible to state whether this is the normal orientation.

There are no gonodendra, nor is there any sign that the sexual organs had been present, but were detached; unfortunately, however, the lower end of the stem is so battered that it is impossible to make certain as to these organs. Only the youngest tentilla are intact. Adult ones are figured by Haeckel ('88b, pl. 13, fig. 14), and are of a characteristic Agalmid structure, with a single terminal filament.

When captured, the siphons were brilliant carmine; otherwise the specimen was colorless.

The type specimen of *Nectalia loligo* was taken at the Canary Islands, evidently on or near the surface. The only subsequent records which I have been able to find are two specimens from the "Plankton" Expedition, one taken in a closing net between 800 and 600 meters, 3° 6′ N., 33° 2′ W.; the other in an open haul from 400 meters near the northern border of the Gulf Stream, south of Iceland; and a third collected by Chun ('97b, p. 37) on the surface near Orotava. The present record extends the range of this species to the Tropical Pacific.

## **Physophoridae** Eschscholtz, 1829. (*Sensu* Huxley).

*Discolabidae* Haeckel.

The question whether all known members of this family belong to one genus, Physophora, or whether there are two genera, Physophora with two, Discolabe with four rows of nectophores, is still open. Schneider ('98, p. 126) maintains that the difference is evidence of stages in growth, and instances in support of this view his own observation that "Exemplare mit unten kreuzweise geordneten Glocken kommen aber bei *Ph. hydrostatica* vor." He also suggests that the arrangement of the bells in four rows from end to end of the nectosome in Haeckel's *Discolabe quadrigata* and Philippi's *P. tetrasticha* is to be explained on the assumption that "diese tetrastiche Anordnung gelegentlich an grossen alten Exemplaren auf die ganze Schwimmsäule ubergreift." Philippi's form probably was *hydrostatica*, with the stem spirally twisted, as Gegenbaur ('53) pointed out. But Haeckel's Discolabe can not be explained thus; and inasmuch as a biserial nectosome is certainly the rule even in large specimens of Physophora, and since *Discolabe quadrigata* has been recorded only once, it is better to retain it as a provisional species until it can be studied again.

## **PHYSOPHORA** Forskål.

The union by Chun ('97b) of the various Atlantic and Mediterranean Physophoras was undoubtedly justified, and is generally accepted. Although the genus has long been known from the Pacific and Indian Oceans, from the records by Quoy and Gaimard ('34) and Brandt ('35), the older descriptions were not sufficiently accurate to establish the relationship of their subjects with the Atlantic species. Even Huxley ('59) dared venture no identification of the species of which he gave so accurate an account. So far as I can learn the only recent record of the genus from the Indo-Pacific region is by Lens and Van Riemsdijk (:08), who were unable to separate the "Siboga" specimens from *P. hydrostatica*, and therefore record them under that name. The better preserved series at my disposal leads to a similar conclusion. I have not been able to compare our specimens from the Pacific with specimens from the Atlantic. But the structure of *P. hydrostatica* is now so well known, thanks especially to the investigations of Gegenbaur ('60), Claus ('60, '78), Sars ('77), and later authors, that it is easy to judge the relationship between it and the Pacific form.

The presence of *P. hydrostatica* in the Eastern Pacific as well as in the Malaysian region, the Atlantic, and its occurrence in high latitudes in the latter ocean and even within the Arctic Circle (Römer, :02) and off Iceland (Paulsen, :09) shows that it has a distribution comparable with that of *Nausithoë punctata* among Medusae.

## **Physophora hydrostatica** Forskål.

Plate 16.

*Physsophora hydrostatica* Forskål, 1775, p. 114; 1776, tab. 33, fig. e., Modeer, 1789, p. 280; Gmelin, 1790, p. 3159; Eschscholtz, '29, p. 145; Gegenbaur, '60, p. 382, taf. 30; Claus, '60, p. 295, taf. 25–27; Chun, '97b, taf. 2, taf. 3, fig. 3–6; Schneider, '98, p. 126; Lens and Van Riemsdijk, :08, p. 86, pl. 16, fig. 120–122.
*Physophora muzonema* Péron and Lésueur, '07, p. 43, taf. 29, fig. 4; Costa, '36, p. 7–12, taf. 3.
*Physophora nicea* Griffith, '21, pl. 5, fig. 3.
*Physophora forskål* Quoy and Gaimard, '24, p. 583, pl. 87, fig. 6.
*Physophora disticha* Lesson, '26, pl. 16, fig. 3; '30, p. 49.
*Rhizophysa discoidea* Quoy and Gaimard, '27, p. 179, pl. 5, B, fig. 1–3.
*Discolabe mediterranea* Eschscholtz, '29, p. 156.
*Rhodophysa discoidea* Blainville, '30, p. 112, '34, p. 123.
*Physophora discoidea* Quoy and Gaimard, '34, p. 59, pl. 1, fig. 22–24
*Physophora ambigua* Brandt, '35, p. 32.
*Physophora rosacea* Della Chiaje, '42, tab. 33, fig. 2.
*Physophora tetrasticha* Phillippi, '43, p. 58, taf. 5.
*Physophora glandifera* Sars, '50, p. 158.
*Physophora vesiculosa* Sars, '50, p. 159.
*Physophora philippi* Kölliker, '53, p. 19, taf. 5.
*Stephanospira insignis* Gegenbaur, '60, p. 67, taf. 33, fig. 53–56.
*Physophora magnifica* Haeckel, '69a, p. 36, taf. 3; Chun, '88, p. 32.
*Physophora borealis* Sars, '77, p. 32, taf. 5, taf. 6, fig. 1–8.
*Discolabe mediterranea* Haeckel, '88b, p. 263 (non Eschscholtz).

| | | | |
|---|---|---|---|
| Station 4663 | 300 fathoms to surface | 1 specimen | 7 mm. in length. |
| " 4676 | " " " " | " " | 40 mm. " " |
| " 4707 | " " " " | " " | 12 mm. " " |
| " 4709 | " " " " | " " | 16 mm. " " |
| " 4713 | " " " " | " " | 22 mm. " " |
| also | | | |
| 10°14′N. 96°28′W. | 200 " " " | " " | 15 mm. " " |

Fragmentary and much contracted in alcohol.

The anatomy of this species has been so carefully studied that repetition is unnecessary here, further than to note that I have examined the excretory pore of the pneumatophore to determine whether it opens into the pericystic cavity (gastrovascular space) as Chun has described it, or into the cavity of the air sac as Schneider ('98) has maintained. In both cases, the actual conditions, which are readily demonstrated by gross dissections of such large pneumatophores as those of Physophora, as well as by sections, support Chun's statement. To make comparison with Atlantic specimens easy for other students, a series of photographs illustrating the more important external features of the Pacific individuals are reproduced (Plate 16).

## **Anthophysidae** Brandt, 1835. (*Sensu* Haeckel).

*Athorybiadae* Huxley.

In this family Haeckel ('88b) recognized four genera, Athorybia, Anthophysa, Rhodophysa, and Melophysa. The last two, which were neither described in detail nor figured, were each founded on a single specimen which was soon lost; they are problematical. In the case of Melophysa Chun ('97b, p. 50) has cut the Gordian knot by discarding it altogether. Rhodophysa can hardly be treated in such a summary fashion, because of the supposed presence of rudimentary swimming cavities on its bracts. But until the genus is re-examined (if it ever is?) further discussion of it is futile. However, I may point out that the name Rhodophysa was preoccupied by Blainville ('30) for the species earlier described by Eschscholtz ('29) as Athorybia, a fact which Haeckel himself recognized.

Athorybia and Anthophysa are very well-marked genera. Schneider ('98), it is true, united them on the supposition that the apparent absence of stem in the latter is due to contraction. But my own examination of living, as well as of preserved specimens of Anthophysa entirely supports the conclusions of Chun ('97b), and Bedot (:04) that not only the presence of two kinds of tentilla, but especially the absence of any true stem, the absence of rudimentary swimming bells, the peculiar arrangement of the bracts, and the internal structure of the pneumatophore are sufficient to separate Anthophysa from Athorybia.

The genus Athorybia, though long known, has seldom been recorded. Chun ('97b) recognized two species: — *A. melo* (Quoy and Gaimard) with longitudinal ribs on the outer surface of the bracts, and *A. rosacea* (Forskål) with smooth bracts. But all recently recorded Athorybias are of the former type. As pointed out by Schneider, the true explanation of the apparent difference between the specimens, "*A. heliantha*," examined by Gegenbaur ('60) on the one hand and Haeckel and Chun ('97) on the other, is that the nematocyst ribs are very variable in prominence, just as they are in Anthophysa. Apart from this very doubtful character, the various descriptions do not afford a single feature to separate two species of Athorybia. Therefore they are all united here as *A. rosacea* (Forskål) Eschscholtz (p. 349).

The genus is also recorded from the Indian Ocean by Huxley ('59), and from the Pacific by Fewkes ('89b); and so far as their figures show, there is no difference between the Atlantic, the Pacific, or the Indian forms. But to settle this question definitely will require a comparison of specimens.

## **ANTHOPHYSA** Brandt, 1835.

The history of this genus has been carefully reviewed by Chun ('97b), and by Lens and Van Riemsdijk (:08). My reasons for adding the genus Angela of Lesson to the list of synonyms of Anthophysa given by these authors are noted below (p. 301). A fairly complete knowledge of the general organization of Anthophysa has resulted from the successive studies of Fewkes ('82a, '88b), Haeckel ('88b), Chun ('97b), and Bedot (:04). But owing to the paucity of material as yet examined and to its poor condition, many of the details of the anatomy of the genus demand further study. Especially is this true of the internal structure of the pneumatosaccus, of the septa uniting the latter with the pneumatocodon, of the tentilla, and of the arrangement of the cormidia on the siphosome. Further knowledge would likewise be of service regarding the minor external characters which may be expected to prove of specific importance. The "Albatross" collection, for the most part well preserved, and probably more extensive than any examined by earlier students, affords the opportunity to study these questions. Furthermore, I had the opportunity of observing several of the specimens in life.

The original species of the genus is *A. rosea* Brandt ('35) from the North Pacific. So far as I am aware this species has not since been recorded. In the Atlantic, one species only can be recognized, *A. formosa* Fewkes, first described ('82) as *Athorybia formosa*, subsequently recorded by him ('88b) for contracted specimens, as *Ploeophysa agassizii*, and since described by Haeckel (*A. darwinii*), Chun ('97b), and Bedot (:04).

Examination of Lesson's figure ('43, pl. 9, figs. 1–1e) of *Angela cytherea* suggests that it is identical with *A. formosa*. But since neither his representation nor his description is sufficiently detailed to indicate with certainty anything more than the generic characters, and since even the locality from which the animal came is doubtful, its specific identity can not be determined.

The only recent record of an Anthophysa from the Indo-Pacific region is by Lens and Van Riemsdijk (:08), who call the "Siboga" specimens *A. formosa*, though without being able to reach any definite conclusion as to the relationship of *A. formosa* and *A. rosea* Brandt. So far as I can judge from Brandt's meagre description, and from the brief account of the fragmentary "Siboga" specimens, there is nothing to separate these, or to differentiate them specifically from the "Albatross" specimens. The localities of capture, too, strongly support my conclusion that all these Pacific records belong to but a single species; for which the old name *A. rosea* must be employed.

Determination of the exact relationship of the Pacific *A. rosea* (the type of the genus) to the Atlantic *A. formosa* would be a valuable addition to our knowledge of the geographic distribution of the Siphonophores. Unfortunately, however, I have no Atlantic specimens to compare with our excellent Pacific series, and the fragmentary condition of most of the Atlantic specimens as yet described makes such a comparison necessary for a final decision of this question. The "Albatross" specimens differ from *A. formosa* only in features which may readily be explained as due to different stages in growth, to contraction, or to preservation. Should the two species be united *rosea* must be employed.

### **Anthophysa rosea** Brandt.

Plate 20, figs. 7–13; plate 21, figs. 1–5; plate 23, figs. 1–5.

*Anthophysa rosea* Brandt, '35, p. 35.
*Anthophysa formosa* Lens and Van Riemsdijk, :08, p. 88, pl. 16, fig. 123a, 123b.
(If *A. rosea* and *A. formosa* prove synonymous the references given on p. 3491 should be considered)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Station | 4617 | surface | 1 | specimen | 5 mm. | in | diameter. |
| " | 4619 | " | 4 | " | about 3 mm. | " | " |
| " | 4644 | " | 3 | " | 8–10 mm. | " | " |
| " | 4659 | " | 6 | " | 3–13 mm. | " | " |
| " | 4671 | " | 1 | " | 8 mm. | " | " |
| " | 4682 | " | 2 | " | 4 mm. | " | " |
| " | 4713 | 300 fathoms to surface | 1 | " | 3 mm. | " | " |
| " | 4718 | " | 1 | " | 6 mm. | " | " |
| " | 4722 | 300 " " " | 1 | " | 5 mm. | " | " |
| " | 4729 | " | 1 | " | 13 mm. | " | " |
| " | 4739 | 300 " " " | 2 | " | 3 and 8 mm. | " | " |

The most remarkable external feature of Anthophysa is the manner in which the bracts are arranged on the corm. In this respect the specimens agree very well with the account given by Haeckel ('88b) and especially with Bedot's (:04) description. As observed by the former, the bracts are borne on muscular lamellae, and these, as Bedot (:04, p. 6) has well expressed it, "recouvrant en partie le pneumatophore ont une disposition qui trouble la symétrie radiaire de cet organe. Leur pointe de départ est placé excentriquement à une certaine distance du pôle apical. Partent de là en divergeant, elles arrivent à envelopper la plus grande partie du pneumatophore, mais en laisant toujours un espace libre. On peut donc distinguer, sur le pneumatophore une *aire musculaire*. . . .et une *aire libre*." As pointed out by Chun ('97b, p. 62) it is these muscular bands arching over the pneumatophore which Fewkes ('88b) described as the "hood, elsewhere unknown among the physophores." And it is the region near the apex where they arise and where new bracts are budded, which was the nipple-like structure noted by Lesson ('43, p. 496) in his account of *Angela cytherea.* Bedot has already corrected Haeckel's statement that there are invariably four muscle-bands in each group. In his specimens he noted four or five, but in the large individuals collected by the "Albatross" there are usually six, sometimes seven. In large specimens there are eight or nine groups of muscle-bands separated by as many naked zones and, in addition, there are many young lamellae along the ventral face of the pneumatophore, *i. e.* at the zone of proliferation. When expanded the lamellae take the form of broad, thin sheets (Plate **23**, fig. 3). An accurate account of their muscular structure has been given by Bedot (:04, p. 6, pl. 1, fig. 14).

The bracts themselves, in their spatulate form and in the presence of a prominent tooth on either margin (Plate **23**, fig. 3), agree with Fewkes's figures. They have five longitudinal nematocyst ridges. They change in outline with growth, younger ones being short and broad, older ones longer, narrower and proportionately shallower at the region of attachment.

*Cormidia.* The zone of proliferation of the cormidia lies on the ventral face of the corm immediately below the region where the bracts are formed. Haeckel believed that he could discern evidences of bilateral symmetry in this region, but although I have examined the "Albatross" specimens with care, I am unable to corroborate him.

The arrangement of the cormidia on the siphosome in the specimens studied does not agree with Haeckel's ('88b) account which has so far formed the chief basis for our knowledge. According to him the cormidia in the Anthophysidae in general ('88b, p. 271), are arranged symmetrically in a flat spiral which is twisted around the broad base of the shortened vascular stem. The condition in the "Albatross" specimens, easily seen in two examples with the corm denuded of its appendages (Plate **23**, fig. 5), is quite different. Instead of two rows of siphons there is a single row, not in a spiral, but in a straight line extending from the ventral side over the lower surface of the corm to the dorsal side. The youngest siphons, of course, lie on the ventral face, the oldest one on the dorsal face just below the level of the bracts. Moreover, the eight or nine well-developed siphons alternate in position with the groups of bracts. The gonodendra, situated as observed by Chun ('97b) in pairs, ♀ and ♂, immediately below the bracts, lie opposite the latter, and thus alternate with the siphons. The very numerous palpons lie in groups between the siphons, close below the gonodendra, and alternating with the latter. New ones in various stages in growth, are to be seen in various regions.

The gonodendra have already been described by Chun ('97b), I need merely add that they bear palpons as well as gonophores. The siphons, each with its well-marked basigaster, offer no features of special interest. The palpons are of the usual type, each bearing a long filament charged with nematocysts. Fewkes ('82), observed these filaments, but was not certain as to their nature.

*Tentilla.* The tentacles bear two kinds of tentilla (Plate **20**, fig. 10, Plate **23**, fig. 4) corresponding to the involucrate tricornuate, and dendritic types described by Fewkes ('82a) and by Haeckel ('88b). Chun ('97b) and Lens and Van Riemsdijk (:08) observed the tricornuate only. But the absence of the dendritic in their material was probably due to imperfect condition. Bedot (:04) describes no less than six other forms of tentilla, in addition to these two types. But comparison of his figures with the various stages in development exhibited by the specimens studied shows, as Lens and Van Riemsdijk suggest, that they all represent dendritic or tricornuate stages in growth. Thus Bedot's types $\eta$, $\zeta$, $\gamma$, and $\beta$ are successive stages of the tricornuate (*cf.* his figs. 6, 7, 10, 11, Plate **1**, with Plate **20**, figs. 8, 10), his $\theta$, $\delta$, $\epsilon$, are undoubtedly three stages reducible to the dendritic type. This is the more likely, as the latter varies in the form of its papilliform processes.

*Pneumatophore.* A study of serial sections allows me to add certain details as to the septa and the structure of the pneumatosaccus to the accounts of Chun ('97b) and Bedot (:04). The septa were described by Bedot as thirteen in number, unequally developed, only the four on the dorsal side reaching the pneumatocodon and forming complete partitions. Bedot's conclusion that such a condition is normal is supported by transverse sections of one of the "Albatross" specimens; but in this case there are sixteen septa, the five dorsal being complete. These five (Plate **21**, fig. 1) arise near the apex; and continue downward to the level of the lower end of the bracts, as can be seen on longitudinal sections. But they are connected with the pneumatocodon for only about one half this distance. On the ventral side the septa arise at a somewhat lower level. As Bedot observed, the septae contain numerous "giant cells", usually longitudinally placed. In favorable sections the ectoderm cells which separate the giant cells from the supporting layer can be distinguished (Plate **21**, fig. 5), much as Chun ('97b, taf. 4, fig. 8) has figured them Athorybia.

*Pneumatosaccus.* The pneumatosaccus, best studied on longitudinal sections (Plate **23**, fig. 1), is divided morphologically into two portions, upper and lower. The latter, the "infundibulum," of Chun, is reduced to a thin layer, composed of two series of tile-shaped cells, ectodermic and entodermic. In its extent it closely follows the outline of the lower portion of the pneumatocodon. It is evident that Bedot was correct in his statement that there is no trace of a typical stem in Anthophysa. The upper portion of the pneumatosaccus has not been described in detail. Its most striking feature is that its cavity, above the thin "infundibulum," is completely lined by a very thick ectoderm layer composed of several rows of polygonal cells which here and there enclose irregular spaces containing remnants of "giant cells." Chun could trace this layer over only about "zwei Drittel der Innenfläche der Luftflasche" ('97b, p. 63), but as his specimen was in poor condition, it is doubtful whether his account reproduces a condition normal for the Atlantic form. Near the apical pole the layer in question is separated from the entoderm of the pneumatosaccus only by the "stutzlamella." At a lower level, however, (Plate **23**, fig. 2), a third cell layer, one cell thick, lying between the stutzlamella, and the lining tissue, and separated from the latter by several much torn gelatinous or chitinous strands, can be seen. The relationships of these various layers can best be worked out on longitudinal sections at the zone of transition between the upper thick-walled, and lower thin-walled portions of the pneumatosaccus. Commencing below, we find that the latter is composed of flat tile-shaped cells. Over most of it the two layers, entoderm and ectoderm, are in contact with each other. But just below the critical region the stutzlamella is to be seen. Slightly above this level the ectoderm becomes thicker, and as we pass upward, it divides into two layers between which a second stutzlamella, described by Chun ('97b, p. 62), as a "Chitin ring," appears. Here all three cell layers are one cell thick, but immediately above this point the lining ectoderm becomes several cells deep. The outer layer of ectoderm, on the other hand, remains one cell thick; but its cells become more columnar, and it is thrown into several folds (Plate **23**, fig. 2). The outer ectoderm layer can be traced from this point upward about one half the distance to the apex, beyond which point it loses its character as a continuous layer, being represented only by scattered and very much flattened cells. Near the upper pole of the pneumatosaccus no trace of it is found (Plate **21**, fig. 4). The stutzlamella which separates the two layers of ectoderm entirely encloses the lining layer, and, probably owing to preservation, it is much torn at the apex. Where the outer ectoderm is absent, the stutzlamella is in immediate contact with the much denser supporting layer which primarily separated ectoderm from entoderm.

My observations corroborate Chun's statement that there is no open porus. But there is a small area at the top of the pneumatophore where the ectoderm and entoderm of the pneumatocodon, and the entoderm of the pneumatosaccus are confluent. Even in this region, however, the lining ectoderm of the latter is as distinct as it is elsewhere. These facts point directly to the explanation that the outer layer of ectoderm in the wall of the pneumatosaccus is the primary ectoderm, and that its lining layer corresponds, as Chun believes, to the secondary ectoderm of Athorybia, Physophora, etc. The fact that the primary ectoderm is absent in the upper portion may be explained as a result of the high degree of specialization of the secondary ectoderm. I may also point out that Lens and Van Riemsdijk (:08), have recorded an individual of Archangelopsis in which the secondary ectoderm lines the entire pneumatosaccus.

*Color.* At the apex of the pneumatophore the ectoderm of the pneumatosaccus is densely pigmented with large granules, collected in clusters (Plate **21**, fig. 4). This results in a central circular area densely dotted with flecks arranged somewhat radially and varying in color from brilliant red to dark brown. In other portions of the colony the color is also variable, perhaps depending on the state of nutrition. In some specimens the upper part of the corm is reddish in life, in others it varies from greenish to amber-yellow. The palpons were either pinkish or yellowish. The siphons were pinkish in most specimens; but in one large individual they were green with amber basigaster.

*Distribution.* The records for this genus are from the Pacific south of the Bonin Islands (Brandt), the Malaysian region ("Siboga"), the Eastern Tropical Pacific ("Albatross"); Gulf Stream (Fewkes), the South Atlantic (Haeckel), and the Sargasso Sea, 31, 5° N. 40, 7° W., (Chun).

## **Rhodaliidae** Haeckel, 1888.

*Auronectae* Haeckel, 1888.

*Auronectidae* Chun, 1897.

*Angelidae* Fewkes 1886, Schneider, 1898.

The name Angelidae used by Schneider and by Lens and Van Riemsdijk to replace Auronectae, the latter having been used by Haeckel under the supposition that the group was a distinct order, is unfortunate on nomenclatural grounds. Fewkes ('86) supposed that Angela Lesson ('43) was closely related to his own

Angelopsis; hence his institution of the Angelidae to include the two. Schneider ('98) followed Fewkes in retaining Angela as the type genus of the family; and Lens and Van Riemsdijk did the same; Haeckel ('88b) referred Angela doubtfully to the Rhizophysaliae, placing it in his family Epibuliidae. Lesson's account and figures of Angela clearly show that instead of being allied to Angelopsis or to the Rhizophysaliae, in reality it belongs to the Anthophysidae. Lesson's brief description ('43, p. 496) is as follows:—"Corps entièrement vésiculeux, ou vessie aérienne évasée, subarrondie, élargie à sa base, à sommet comme mamelonné, et garni de valvules claustrales; plateau couvert d'un grand nombre de tubes digestifs, vermiculés, allongés, cylindracés, dilatables en sac ventru à la base, rétréci au sommet, qui a une bouche arrondie et plissée sur les côtés. Du plateau partent huit tentacules fins, très-longs, formant tube, et garnis sur leur côtés de petits suçoirs alternes, courts, terminés par trois glandes" and this is a very good account of the general appearance of Anthophysa. Comparing the description with the figures (Lesson, '43, pl. 9, figs. 1–1c) drawn from life by Rang, it is evident that the "tubes digestifs" are the palpons; the appearance of a nipple ("mamelonné") at the apex of the "vessi aérienne" is the zone of proliferation of the bracts. Although Rang did not discriminate between siphons and palpons, his discovery of eight tentacles in a single row agrees with arrangement of the cormidia in Anthophysa, while his determination of tricornuate tenillae speaks highly for his powers of observation. In short, so close is the correspondence between Angela and Anthophysa in all respects, that I have no hesitation in placing it in that genus (p. 295). As a result, according to the International rules of nomenclature (Art. 4), it is necessary to abandon the family name Angelidae, at least in the sense in which it was used by Schneider and by Lens and Van Riemsdijk. To replace it the name Rhodaliidae, proposed in 1888 by Haeckel, must be used. Chun ('97b) has used Auronectae and Auronectidae in a family sense but these are untenable as they are not derived from a generic name.

In reducing the group from the rank of an order to that of a family, I follow all recent students of Siphonophores. Thus Claus ('89), Chun ('97b), Schneider ('98), and Lens and Van Riemsdijk (:08) have all clearly shown that instead of being worthy of ordinal rank on account of the presence of a supposedly unique organ, the "aurophore," the animals in question are in reality closely allied to the Physophorae in general. To illustrate the ease with which original descriptions are accepted, and the difficulty of bringing criticisms of them before zoölogists, Lens and Van Riemsdijk have pointed out that the order "Auronectae" usually appears in works on invertebrate zoology, even in such an excellent work as the "Traité" of Délage and Herouard, as a very remarkable group, although but shortly after it was instituted Claus and Chun adduced conclusive reasons for abandoning it.

Apart from Angela, which must be removed from this family, the following genera, all monotypic, no doubt belong here:— Angelopsis Fewkes ('86), Stephalia Haeckel ('88b), Stephonalia Haeckel ('88b), Auralia Haeckel ('88b), Rhodalia Haeckel ('88b), and Archangelopsis Lens and Van Riemsdijk (:08). All of these have been described from more or less fragmentary specimens, but it is certain that not all are distinct. Haeckel himself suggested the probability that his Auralia might be identical with the Angelopsis of Fewkes, and Claus ('89) has united Stephonalia with Stephalia, the former being merely a more advanced stage of the latter. Both these reductions are accepted by Chun ('97b, p. 104) and are no doubt justified. In examining the four remaining genera we must bear in mind that none of the descriptions are satisfactory except in some respects that of Archangelopsis. Thus Fewkes's account was taken from very fragmentary material, while Haeckel's descriptions are not only based on poor material but his figures are so largely reconstructed that it is difficult to estimate them fairly. And even though the account and figures given by Lens and Van Riemsdijk (:08) of Archangelopsis are based on serial sections, their specimens were also so fragmentary that completeness was out of the question.

With the foregoing caution in mind, three of the older genera can claim to be distinct, notwithstanding the opinion of Schneider ('98) who united them all under Angela. According to Haeckel ('88) Stephalia (Stephonalia) is distinguished by the presence of a permanent axial canal passing through the centre of the bulbous trunk and connected with the primary siphon, as well as by the absence of tentilla. In Rhodalia and in Angelopsis (Auralia), on the other hand, the canal system of the corm forms an irregular network, and tentilla are present. The difference was made by Haeckel the basis for two families, Stephaliidae and Rhodaliidae, but it is certainly of not more than generic importance. I may also point out that inasmuch as no one, since Haeckel, has studied Stephalia, it is impossible to determine how far his account of it is correct.

Angelopsis is distinguished from Rhodalia by the presence of a very large hypocystic cavity, a feature of importance (p. 309), and likewise by the presence of a single row of nectophores (Angelopsis) contrasted with several rows (Rhodalia). I may point out however that the nectophores of the "Challenger" specimens of Rhodalia were all detached (Haeckel, '88b, p. 303); therefore it is doubtful whether the latter difference is an actual one. And even if it is, it is questionable whether it is of systematic importance or an indication of different stages of development. The three genera Stephalia, Rhodalia, and Angelopsis all have a solid, bulbous, gelatinous corm; and in all, at least by Haeckel's account, the aurophore is a smooth-walled, bag-like structure, opening to the exterior by a single pore, if at all. In the recently described Archangelopsis Lens and Van Riemsdijk the corm is represented by a voluminous thin-walled sac while the aurophore bears numerous papilliform appendages on its surface. To these four genera I add Dromalia, characterized by having a bulbular corm, but at the same time bearing papillae on the aurophore. The probability that *Circalia stephanoma* Haeckel is the young of some Rhodalid, probably of Stephalia, has been noted, p. 268.

The two most interesting features of the family are the presence of the aurophore, and the position of the zone of proliferation of nectophores and cormidia. These questions have been the subject of much discussion by Claus ('89), Chun ('97b), Schneider ('98), and especially by Lens and Van Riemsdijk (:08). But inasmuch as some new light is thrown on them by the present collection, I can best treat them after describing the specimens.

In the Eastern Pacific collection there is a single somewhat injured example of Angelopsis. I am also fortunate enough to have at hand fifteen specimens collected by the "Albatross" in 1887, which form the basis for the new genus Dromalia, described here because of their great importance. A typical and very well-preserved specimen of Archangelopsis Lens and Van Riemsdijk, taken by the "Albatross" in the N.W. Pacific, near Japan, has also been available for comparison though unfortunately received too late for description.

## **DROMALIA,** gen. nov.

Rhodaliidae with solid bulbous corm; with papilliform appendages on the aurophore; tentacles with tentilla.

### **Dromalia alexandri,** sp. nov.

Plate 23, figs. 6–11; Plate 24.

21° 12′ N.; 157° 44′ W. 293 fathoms to surface. 15 specimens, the *Type* 30 mm. high by about 30 mm. in greatest diameter.

The specimens are all very well preserved in alcohol, with most of the cormidia still attached. But all of the nectophores, except the younger ones are wanting, and none were found in the bottle. The specimens now are colorless, as might be expected after twenty years in alcohol. Fortunately their histological condition is fairly good, and several are so perfect and so little distorted that the more important external features are not only clearly visible, but easily reproduced in photographs.

In general aspect they all resemble Haeckel's ('88b, pl. 3, fig. 13, 14) figures of *Rhodalia miranda,* except for external structure of the aurophore, and the absence of nectophores. There is a large pneumatophore, a distinct nectosome of considerable length, and, underlying the latter, an expanded bulbous siphosome (Plate **23**, fig. 6, 7).

*Pneumatophore.* An important systematic characteristic is afforded by the fact that the pneumatophore, instead of being rounded and smooth, is somewhat flattened apically and bears 8–11 triangular gelatinous prominences on its outer rim (Plate **23**, fig. 8). These, though variable in number and size, are present in all the specimens. So far as I am aware no such development of the outer wall of the pneumatophore is known in any other Siphonophore. It suggests the similar extreme gelatinous development in certain Medusae (Halicreasidae) and would of itself be of sufficient importance to warrant the establishment of a new genus. I may add that the present collection reveals no prominences either in Angelopsis or in Archangelopsis. The pneumatosaccus has no open porus.

*Aurophore.* The most interesting external feature of the pneumatophore is of course the peculiar structure named by Haeckel the aurophore. This name has been abandoned by Lens and Van Riemsdijk (:08) on the ground that the organ in question is not the peculiar medusoid Haeckel supposed, but in reality something entirely different. However, it is convenient to retain the term for the structure in question, though abandoning Haeckel's explanation, because no single inclusive name, other than aurophore, seems to have been applied to it as a whole.

The aurophore lies on the surface of the pneumatophore just above the junction of that structure with the nectosome (Plate **23**, fig. 6, 7) in the same position occupied by it in other members of the family. Externally it may be described as a sac, with numerous papilliform appendages about 2 mm. long on its surface. In all the specimens these papillae were well developed, but I was unable to find any evidence of the interpolation of new ones.

Fortunately the material was sufficiently well preserved to allow a study of the internal structure of the aurophore, from serial sections, both radial and transverse, on which the cell layers could be traced, though in places they are damaged or obscured. In its essentials the aurophore agrees with the account of it given by Lens and Van Riemsdijk for Archangelopsis. As in that genus, it is nothing more than an evaginated portion of the pneumatophore; and all the cell layers of the latter can be traced through it.[1] Its outer wall, consisting of ectoderm, supporting layer, and entoderm, is continuous with the pneumatocodon. The inner wall, composed of the same three layers, is the continuation of the pneumatosaccus; its entoderm, of course, faces that of the pneumatocodon. The peculiar structure called by Haeckel the "pistillum" is exactly comparable to the pneumatochone, or "air funnel" of Physophora, as Lens and Van Riemsdijk have shown. But the secondary ectoderm here reaches a much higher state of development than in that genus.

Although this general account is true both for Dromalia and for Archangelopsis, radial sections through the aurophore of the two genera show very different appearances, due to the excessive development of the pneumatochone in Dromalia. While this is conical and connected with the pneumatosaccus by a narrow neck in Archangelopsis, in Dromalia it is cylindrical, about five times as long as broad. Furthermore the chitinous ring, developed from the ectoderm-lining of the pneumatosaccus, is so much more highly developed in Dromalia that it forms a thick-walled cylinder which, except at its distal extremity, entirely separates the primary ectoderm from the secondary ectoderm filling its lumen (Plate **24**, fig. 6, 8). As in Archangelopsis a shining chitinous layer continuous with this tube lines the entire inner surface of the pneumatosaccus except in the immediate neighborhood of the pneumatochone, where it is overlaid by a disc-like expansion of the secondary ectoderm. In one specimen of Archangelopsis Lens and Van Riemsdijk found the secondary ectoderm lining the entire pneumatosaccus, but this is not the case in any of the "Albatross" examples of Dromalia. The portion of the secondary ectoderm which lies within the chitinous cylinder encloses numerous spherical cavities explained, and probably correctly, by Lens and Van Riemsdijk (:08), as formed by the gas secreting cells. Likewise in the region where the primary and secondary ectoderm merge into each other, there are traces of giant amoeboid cells, such as have been described by previous authors in other Siphonophores. In Archangelopsis these cells are very prominent (Lens and Van Riemsdijk, :08, p. 95). To complete the account of the pneumatochone I need only mention that the chitinous cylinder is of a distinctly fibrous nature.

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[1] The nomenclature used is that of Lens and Van Riemsdijk. The pneumatophore consists of an outer wall "pneumatocodon" (Luftschirm), and an interior sac, the "pneumatosaccus" (Luftsac).

The portion of the pneumatosaccus which is invaginated to form the inner wall of the aurophore, is connected with the outer wall, the pneumatocodon, by a series of radial septa, just as it is in Rhodalia and Archangelopsis. Transverse sections (Plate **24**, fig. 7) in the mid-region of the aurophore show from 12 to 16 septa.. Both entoderm and supporting layer are concerned in the formation of these septa, just as they are in the septa which subdivide the pericystic space surrounding the distal portion of the pneumatosaccus in other Physophores. Of course the cavity of the aurophore is nothing more than an evaginated portion of the pericystic space.

*Appendages of the aurophore.* These are simple papilliform structures; externally smooth walled. They are hollow, and their cavities communicate freely with that portion of the general pericystic space lying within the aurophore. Their cavities open to the exterior by terminal pores (Plate **24**, fig. 9). The external layer of ectoderm is composed of tile-shaped cells except at the distal extremity where the cells are higher; the lining entoderm layer, which is of course continuous with the entoderm of the pneumatocodon, is much thicker and composed of columnar cells with very conspicuous nuclei. The two cell-layers are separated from each other by a well-developed supporting layer.

*Zone of proliferation of nectophores and cormidia.* Two diametrically opposed accounts of the zone of proliferation have been published. According to Haeckel this region is opposite the aurophore; on the other hand Lens and Van Riemsdijk maintain that the aurophore itself is the zone of proliferation, its papilliform appendages being the young cormidia and nectophores. The conditions in our specimens of Dromalia give a very decided answer to this question, entirely bearing out Haeckel's statement. This is of course a question of great theoretic interest, since on it depends the interpretation of the dorsoventral symmetry of the Rhodaliidae. Therefore it is very fortunate that the specimens are so large, and the actual appearances so easily shown by photographs, that there is no difficulty in tracing the location of the various structures outlined below.

A view of the corm, facing the side on which the aurophore is located (Plate **23**, fig. 7) shows that directly below that structure there is a vacant zone, extending the whole length of the nectosome, on which neither cormidia, nectophores, nor buds of any kind are to be seen. Neither are there any indications that any such have been detached. On the contrary, in all the specimens the surface in this region is perfectly smooth. Flanking this naked zone on either side, are the longitudinal muscular ridges to which the nectophores were attached in life. The presence of the naked zone, and its relation to these muscular lamellae, is exactly comparable to the corresponding dorsal zone flanked by the bracts in Anthophysa. There is no evidence whatever that the appendages of the aurophore in Dromalia ever develop into nectophores or cormidia.

Furthermore the cormidia which lie immediately below the vacant zone are all large, with well-developed gonophores, and there is no evidence except as described later (p. 308) of the interpolation of newly developed ones among them. I may point out, however, that the two or three muscle bands lying nearest the vacant zone on either hand are considerably shorter than their neighbors, a fact which, as I shall show (p. 315) has an important bearing on Haeckel's figures of Rhodalia. But while no young appendages are found on the same side of the corm as the aurophore, a photograph of the lateral aspect of the corm (Plate **23**, fig. 6) shows clearly that young cormidia and nectophores are being formed at a point *exactly opposite* the aurophore, immediately below the union of pneumatophore with nectosome. This fact is as evident on all the specimens, as is the presence of the pneumatophore itself, and it is even more clearly demonstrated in a radial section (Plate **24**, figs. 4, 5). The details of the zone of proliferation are best seen in a surface view of the face of the corm opposite the aurophore (Plate **24**, fig. 1, 3). Just below the pneumatophore, and in the radius exactly opposite the aurophore, is a well-marked ridge, the "blastocrene" of Haeckel, some 1–2 mm. long. This bears numerous very young appendages on its outer edge. Below it is to be seen a single row of young cormidia in successive stages of development. Close on either side of the blastocrene lie the young nectophores. The youngest are next to it, and immediately below the pneumatophore, the older ones successively farther apart laterally as well as lower down (Plate **24**, fig. 2, 3). In the photograph (Plate **24**, fig. 3) four nectophores are to be seen, the two oldest already showing well-developed muscular lamellae. In none of the specimens were any of the older nectophores attached. But their growth is indicated by the successively increasing length of their muscle bands at greater and greater distances laterally from the blastocrene. Before passing on to the account of the older cormidia, I wish to emphasize the important fact that nothing in the entire anatomy of Dromalia is more certain, or more clearly and easily distinguishable, than that the aurophore and the zone of proliferation lie on opposite sides of the corm. For a comparison of this statement with Haeckel's observations and the opposite conclusions of Lens and Van Riemsdijk, see page 314.

*Arrangement of the cormidia on the siphosome.* From the blastocrene to the level where the nectosome joins the bulbular siphosome, the young cormidia lie in a straight line. At this level, however, the series turns abruptly to the left (as viewed from the side on which they are situated, *i. e.* the ventral face), and from here onward they run in a helical spiral until they reach the basal extremity of the siphosome. The spiral arrangement is often obscured by the closely crowded cormidia, but it is clearly shown in views of the basal surface of the corm with the distal portions of the cormidia torn off (Plate **23**, fig. 11). A similar arrangement has already been noted by Haeckel, who says ('88b, p. 288) of Rhodaliidae in general, that "the cormidia . . . are arranged in regular circles or spiral coils." In the "Siboga" specimens of Archangelopsis the cormidia were so crowded and contracted that Lens and Van Riemsdijk were unable to make out their arrangement. But in the single "Albatross" example of that genus a similar spiral arrangement appears to occur, though, owing to the contraction, it is not so clear as it is in Dromalia.

The adult cormidia very closely resemble those of Rhodalia and of Stephalia, (Haeckel '88b). They are situated on conical gelatinous prominences each traversed by a canal connecting with the general vascular system of the corm (Plate **23**, fig. 9). Near the region where the young cormidia are formed, each one stands alone on its prominence. But with advancing age, additional cormidia are formed from buds which develop from the prominences near the bases of the existing siphons, the result being that near the base of the corm each prominence bears two or three complete cormidia just as in Stephalia (Haeckel, '88b, pl. 6, fig. 35).

Each cormidium consists of the usual parts, siphon, gonodendron, and tentacle. The siphons show no features of special interest. Each gonodendron, as in Rhodalia, consists of a gelatinous stalk with several terminal branches, which bear the numerous gonophores and also from two to four long, thin-walled palpons. Unfortunately all of the older gonophores were lost, only the young stages remaining attached. For this reason it is impossible to determine whether there are both ♀ and ♂ cormidia on the same corm in Dromalia, as Haeckel thought was the case in Rhodalia, or whether gonophores of only one sex are present as Brooks and Conklin have more recently ('91) maintained for a specimen probably belonging to the latter genus. For an account of the complicated structure of the ♀ gonophore in this family see Brooks and Conklin ('91).

*Tentacles.* These have a well-developed suspensorial membrane (Plate **23**, fig. 9) and bear tentilla just as in Rhodalia. The structure of the tentilla is one of the points of difference between Dromalia and Rhodalia, for while in Rhodalia they have no involucre and only a single terminal filament (Haeckel, '88b, pl. 4, fig. 23), in Dromalia they are clearly tricornuate (Plate **23**, fig. 10). Unfortunately no mature tentilla are preserved. But the immature stages which I was able to study have basal thickenings which strongly suggest early stages in the development of an involucre.

*Internal structure of the nectosome and siphosome.* These two regions of the corm are structurally very similar to those of Rhodalia, with the important exception that while there is a shallow hypocystic cavity of considerable breadth in that genus, in Dromalia no such space is distinguishable. The general pericystic cavity is but little more voluminous here than elsewhere (Plate **24**, fig. 4, 5) and connects immediately with the vascular system of the underlying parts of the corm. A second minor difference is that Haeckel found the bulbous siphosome of Rhodalia traversed by a network of innumerable small canals, while in Dromalia the vascular system is chiefly restricted to near the surface, but few canals penetrating the deeper lying region (Plate **24**, fig. 4). The general ground substance of the siphosome is cartilaginous in consistency, and extremely rigid; and this is apparently true of both Rhodalia and Stephalia, as it certainly is of Angelopsis (p. 313). This structure of the siphosome is very different from the condition in Archangelopsis, where the siphosome is a thin-walled bag, enclosing a voluminous hypocystic cavity which communicates freely with the pericystic space.

## ANGELOPSIS Fewkes, 1886.

*Auralia* Haeckel, 1888.

Rhodaliidae with solid bulbous siphosome traversed by a network of numerous canals; with smooth-walled aurophore lacking papilliform processes: with very voluminous hypocystic cavity extending to or below the lower end of the siphosome. Tentilla present (?).

Two species have been described which can be referred to this genus, *Angelopsis globosa* Fewkes, taken by the "Albatross" in the Gulf Stream, and *Auralia profunda* Haeckel, from "the depths of the tropical Atlantic."

Fewkes's two descriptions ('86, '89a) have been thoroughly reviewed and compared with Archangelopsis by Lens and Van Riemsdijk. Fewkes was able to make out many of the important anatomical features of the genus, but his material was in such condition that he could trace but few of the external features, *i. e.* the structure of the cormidia or arrangement of nectophores, which might prove of specific importance. It is probable that the conformation of the hypocystic cavity is significant for classification, because in Fewkes's specimens, which were almost certainly mature, it was not only much more extensive but more nearly subdivided than it is in the "Albatross" specimen.

The only account of Haeckel's species which has yet appeared, is his summary of its more important generic characters, and the statements that it is allied to Fewkes's *Angelopsis globosa*, that it resembles *Stephalia corona* Haeckel externally, and that its tentacles resemble those of Rhodalia. This brief notice is of course entirely insufficient for specific diagnosis. But as it applies perfectly well to *A. globosa*, so far as it goes, and inasmuch as there is no geographic barrier between the localities of capture of the two, it is probably better to unite them.

The specimen in the "Albatross" collection agrees in general structure with *A. globosa*, so far as the latter is known, but differs from it, as already mentioned, in the form and extent of the hypocystic cavity. Unfortunately, however, it is somewhat fragmentary. We have here another of those cases, so commonly encountered by the student of the pelagic Coelenterata, where it is difficult to decide whether the cause of science is best served by creating a new species, by referring the specimen to an old species on doubtful grounds, or by leaving it without specific identification. The difference in the hypocystic chamber is probably sufficiently important for recognition and may therefore justify a new species. But I must add the warning that research on better material may well prove it unfounded; therefore it should not be used as an instance of geographic distribution until tested further.

### **Angelopsis dilata,** sp. nov.

Plate 21, figs. 6–8; Plate 22.

Station 4641 633 fathoms to surface. 1 specimen 12 mm. high by 6 mm. in diameter. *Type* preserved in formalin.

In the single specimen all the nectophores, except two very young ones, and most of the cormidia are lost. Fortunately, however, it is in sufficiently good histological condition to allow an investigation of the aurophore. After being photographed (Plate **21**, fig. 6), one of the cormidia was detached for study, and the corm was divided longitudinally a little to one side of the midplane; one of its parts was sectioned in the radial, the other in the transverse plane.

In general appearance the specimen resembles the figure given by Haeckel of Stephalia ('88b, pl. 6, fig. 32), except that there is no large central primary siphon. The pneumatophore is voluminous, 5 mm. in diameter, rounded, and smooth walled. There was no pigment visible, even when the specimen was first taken. The nectosome is narrow, and this with the globular extension of the siphosome below, gives the corm a dumbbell-like outline. Although most of the nectophores are detached, the radial muscle bands to which they were connected are easily traced. But they are more contracted and distorted than in Dromalia. The aurophore lies in the usual position on the surface of the pneumatophore near its junction with the nectosome. It is sac-like, and smooth walled (Plate **21**, figs. 6, 7) except for one small prominence near its outer margin. There is no trace whatever of the papillae which occur in Archangelopsis and Dromalia, nor can we suppose that such were normally present but have been torn off, because the outer wall of the aurophore is smooth, and shows no traces of the injury which such mutilation must necessarily have caused. To test this I tried the experiment of detaching a few of the papillae from a specimen of Dromalia, and found that it caused very evident damage.

*Zone of proliferation.* On account of the damaged condition of the specimen the location of this zone is not so evident as it is in Dromalia. But the following facts can be determined:—there are no papillae on or just below the aurophore; there is a bare zone immediately below the aurophore, just as in Dromalia, (p. 306) on which there are neither nectophore plates, buds, nor cormidia. On the other hand on the nectosome, exactly opposite the aurophore there are two very young nectophores, and between them several small buds, probably young siphons (Plate **21**, fig. 6, 7). These facts taken in connection with the very clear evidence afforded by Dromalia show that in Angelopsis as in the latter genus the zone of proliferation is not the aurophore, but lies exactly opposite to it.

*Cormidia.* So few of the cormidia remain attached that I can only say of their arrangement on the siphosome, that it is apparently spiral.

The cormidia of Angelopsis like those of Rhodalia and Dromalia are situated on conical gelatinous prominences. In the one example studied there was a single cormidium on each prominence. However, as all the older cormidia, originally borne on the basal part of the siphosome, were detached, we can not assume that additional ones may not be developed on each prominence in this genus, as they are in Dromalia. The siphons are of the usual type. All the tentacles were broken off, and the tentilla, if any were present, detached. My suggestion (p. 309) that the genus may be characterized by the presence of tentilla is based solely on Haeckel's ('88b) statement that the tentacles resemble those of Rhodalia, where such organs occur.

The gonodendron, in the example studied (Plate **21**, fig. 8), is borne on a gelatinous stalk, and has two main branches. On one of these the numerous buds are evidently all female, but on the other the buds are too young for their sex to be determined. On each branch there are also palpons in various stages of development.

*Aurophore.* Unfortunately the aurophore is somewhat damaged. But although its cell layers are entirely destroyed in places, they can be traced sufficiently to show that, with the important exception of the absence of papillae on the outer wall (*i. e.* the evaginated portion of the pneumatocodon), it agrees very closely in its structure with the aurophore of Dromalia (p. 304). In Angelopsis, as in Dromalia, the evagination of the double wall of the pneumatophore which forms the aurophore is more extensive than it is in Archangelopsis, with the result that the pneumatochone, or air-funnel apparatus, is much longer than in the latter genus. The chitinous ring, in the form of an elongated cylinder with the lumen filled by a solid plug of secondary ectoderm, recalls the corresponding structure in Dromalia. The secondary ectoderm encloses several spherical cavities; owing to the condition of the material it is doubtful whether giant cells occur in the primary ectoderm. The chitinous sheath as seen in median radial sections apparently encloses the secondary ectoderm even at its distal end (Plate **22**, fig. 2). But in sections further to one side there is an opening through the chitin in its distal region, though there is no actual communication between the two ectoderm masses. And although this opening looks like an artificial tear in the sections, conditions in allied genera make it more probable that it represents the location where the primary and secondary ectoderm were joined, rather than that the two ectoderm masses are secondarily separated by the excessive formation of chitin.

The septa connecting pneumatocodon and pneumatosaccus in the aurophore are not so numerous as in Dromalia. In this respect Angelopsis more nearly resembles Archangelopsis. The cavity is in free communication on the one side with the pericystic cavity, and on the other with the voluminous hypocystic space. The inner surface of the pneumatosaccus is so much damaged that it is impossible to determine whether or not a disc-like expansion of the secondary ectoderm occurs here as in other genera of Rhodaliidae. And the chitinous pneumatocyst is entirely destroyed except in a few places.

I have been unable to decide definitely whether or not there is an excretory pore connecting the cavity of the aurophore with the exterior. As already noted there is one papilla on the surface which may indicate the presence of a porus; and conditions in Physophora on the one hand and Dromalia on the other, make the presence of such an opening not unlikely.

*Nectosome and siphosome.* The pericystic space, as noted above (p. 309), expands below the pneumatosaccus to form an extensive hypocystic chamber which extends downward to the level where nectosome joins siphosome (Plate **21**, fig. 7). The walls of the cavity differ in the different planes; on both ventral and dorsal surfaces they are thin, and smooth internally; but on the two lateral faces their inner surfaces are thrown into numerous transverse horizontal ridges (Plate **22**, fig. 6). The walls are traversed by a loose network of canals communicating on the one hand with the muscular nectophore-plates, on the other with the hypocystic cavity. Basally this chamber communicates with the network of canals which ramify throughout the semicartilaginous substance of the solid siphosome (Plate **21**, fig. 7). The number of canals opening into the large chamber has not been determined; probably it is variable. The network is much more extensive in Angelopsis than in Dromalia; its component canals branch and rebranch irregularly, and most densely near the surface where the vascular system communicates with the cormidia. Although the canals vary in size, there is no one which can be identified as the primary central canal of Haeckel. The entoderm layer lining the canals is, of course, continuous with the entoderm of the pneumatocodon.

*Aurophore and zone of proliferation in the Rhodaliidae.* The description by Haeckel ('88b) of his order Auronectae, and his detailed, but, as has since been proved, largely erroneous account of the aurophore, has given rise to a great deal of discussion. The improbability that the aurophore was a peculiar Medusoid, as Haeckel suggested, was pointed out at once by Claus ('89, p. 14), who remarked that such a structure would hardly be developed on the side of the pneumatophore opposite to the zone of proliferation — *i. e.* on the dorsal surface. Haeckel himself was not very confident that his explanation of the aurophore as a Medusoid was correct, for he suggests ('88b, p. 284) that "it is possible that it was originally only a secondary organ of the pneumatophore a basal apophysis of the air funnel." Chun ('97b) has pointed out that its dorsal location made the latter supposition improbable, according to his view untenable. And in the endeavor to account for the aurophore he offered the ingenious suggestion that the aurophore represents the modified distal portion of the pneumatophore, *i. e.* the pneumatosaccus, instead of corresponding to the pneumatochone, and that the voluminous portion of the pneumatophore represents the latter. This view has been violently attacked by Schneider ('98). Meanwhile, though all these students agree that the aurophore was not the unique structure Haeckel supposed, the explanation given by the latter found its way into most text-books. Such, in brief, was the history of the subject up to 1908, when Lens and Van Riemsdijk published their very valuable researches on Archangelopsis, from which they were able to demonstrate that the aurophore differs in no essential anatomical feature from the pneumatochone of Physophora. So close is the agreement between the two, and so entirely is it corroborated by the aurophore in Dromalia and in Angelopsis, that I think no doubt can longer remain that the two structures, aurophore and pneumatochone, are homologous. It does not seem to me, however, that their remodeling (:08, p. 99) of Haeckel's longitudinal section ('88b, pl. 5, fig. 24) of the aurophore of Rhodalia is altogether sound. No doubt his representation of a central canal traversing the pneumatochone ("pistillum") and connecting the cavity of the pneumatosaccus with the exterior via the aurophore, represents nothing more than the spherical cavities so common in the secondary ectoderm both of Archangelopsis and of Dromalia. But it is by no means certain that the "porus" in Rhodalia is accidental. On the contrary, although there was no connection between it and pneumatochone (the supposed junction in Haeckel's figure being a portion of one of the septa) the condition in Dromalia where the papillae all open by terminal pores, suggests that Haeckel observed a true excretory pore opening into that portion of the pericystic cavity which is enclosed within the aurophore. Furthermore, in view of the fact that the aurophore is smooth walled in Angelopsis, it is unnecessary to assume that it possessed papillae or appendages of any sort in Rhodalia. It is not likely that Haeckel would have overlooked structures so prominent as the papillae, especially when Lens and Van Riemsdijk themselves found (:08, p. 91) that his material, now in the British Museum, is still fairly well preserved. Furthermore we can hardly assume that papillae would later develop, because the large size of the "Challenger" specimens of Rhodalia (60 mm. in diameter) and the advanced condition of their gonophores show that they were mature.

The authors just mentioned have also sharply criticised Haeckel's description and figures of a zone of proliferation lying opposite the aurophore. And since this question is important we must examine the validity of their arguments.

It seems that the difficulty of reconciling the homology of aurophore with pneumatochone if the former occupied a dorsal position was largely instrumental in leading to their conclusion. Had it not been for this consideration, they would hardly have assumed that the aurophore was the zone of proliferation in Archangelopsis, merely on the grounds that it bore papillae, and that no buds of either nectophores or siphons were to be found on the opposite side of the corms in their very fragmentary specimens, although they found no stages connecting the simple and very uniform papillae of the aurophore with the complex cormidia lying below. The actual evidence to which they had access was entirely of a negative kind. Nor can any more weight be laid on their observation that no buds are now to be found opposite the aurophore in the "Challenger" specimens of Rhodalia, because the latter were somewhat fragmentary to start with, and by now have passed through so many hands that any buds which were originally attached might well have been torn or shaken off. However, we must admit that in view of the usual dorsoventral orientation, and of the frequent inaccuracies of Haeckel's work, their standpoint was perhaps the most reasonable one. Simple and attractive as was their explanation that new nectophores and cormidia are formed on the aurophore itself, the conditions in Dromalia, in Angelopsis and in the excellent example of Archangelopsis mentioned (p. 303) show beyond any question that it is the exact reverse of the truth. And if we compare the photographs of the ventral zone of proliferation in Dromalia (Plate **24**, fig. 1, 2) with Haeckel's figures of a longitudinal section and an apical view of Rhodalia, and his figure of the blastocrene ('88b, pl. 4, figs. 15, 16, 17), it is evident that they are very accurate. I may mention that the figure of the blastocrene clearly shows that the cormidia are arranged in spiral, exactly as they are in Dromalia. On Haeckel's figure of an apical view, with the nectophores in place ('88b, Plate **1**, fig. 1), Schneider ('98) and Lens and Van Riemsdijk thought they could discern internal evidence that the young nectophores were budded on the same side as the aurophore. But, as Haeckel himself states ('88b, p. 303), it is a reconstruction; and even if the arrangement of the nectophores, as represented, is correct, it is not necessary to assume that the small ones near the aurophore are the youngest. On the contrary, the fact that the nectophores in this region are smaller than their neighbors in Dromalia, as shown by the shortness of their muscle-plates (p. 307), whereas proliferation undoubtedly takes place on the opposite side of the corm, indicates that in Rhodalia likewise, those nearest the aurophore are the oldest instead of the youngest, although small.

The determination in Dromalia, and in well-preserved material of Archangelopsis, that aurophore and zone of proliferation lie upon opposite sides of the corm, is gratifyingly easy; and to find a satisfactory explanation for this phenomenon is not so difficult at it appears at first. It is true that we are once more face to face with the anomaly experienced by Chun, from which Lens and Van Riemsdijk tried to escape, that while in Physophora the pneumatochone with its enclosed portion of the gastrovascular space is ventral, in Rhodaliidae the organ which exactly corresponds to it is as certainly dorsal. The explanation, as already suggested (p. 269), is that Physophora is not the parent of the Rhodaliidae, but that both are descended from members of the Agalmid stock. And in the Agalmidae, as is well known, the primitive pneumatochone is neither dorsal nor ventral, but axial. Even in the highly specialized genus Nectalia this is the case, and it is also true of Anthophysa, in which the pneumatochone organ may be supposed to have undergone regressive changes.

For light on this question we must await renewed researches on more extensive material. Especially desirable would be a knowledge of the very young stages of any one of the Rhodaliidae; but of these we yet know practically nothing, because Haeckel's ('88b) account of his "Auronula" larva was so superficial and based on such a fragmentary specimen that it is of little value.

*Distribution of the Rhodaliidae.* Stephalia is recorded from the eastern part of the Gulf Stream, from the Faroe Channel and Shetland Islands, and Stephonalia from the South Pacific; west of New Zealand, lat. 38° 50′ S., long. 69° 20′ E. (Haeckel); Angelopsis, from the Gulf Stream (Fewkes), from the Tropical Atlantic (Haeckel) and Tropical Eastern Pacific ("Albatross"); Rhodalia, from the South Atlantic, 37° 17′ S., 53° 52′ W. (Haeckel), and probably from the Tropical Pacific in the neighborhood of the Galapagos (Brooks and Conklin, '91); Archangelopsis, from the Malaysian region ("Siboga") and from the northwest Pacific ("Albatross").

Respecting the bathymetric range of the Rhodaliidae I may point out that all the hauls from which they have been recorded were made with open nets and therefore afford no real clue to the depths from which the specimens in question came. That they are not such good evidence of abyssal habitat as Haeckel supposed is indicated by the fact that the "Siboga" specimens of Archangelopsis were taken within 100 and 112 m. of the surface. Moreover Fewkes ('89a), and more recently Lens and Van Riemsdijk have given strong reasons for believing that the extraordinary development of the pneumatophore suggests a habitat near the surface, rather than at great depths.

## **Rhizophysaliae** Chun, 1882.

According to Schneider ('98, p. 164), and to Lens and Van Riemsdijk, (:08, p. 100), the two main subdivisions of this group, Rhizophysids and Physalids, are too closely allied to each other to deserve the appellations of suborders "Rhizoidea" and "Physaloidea" given them by Chun. However, they form well-marked families. Haeckel divided the Rhizophysids (exclusive of the Bathyphysids which he classed among the Physophorae) into four families, Cystaliidae, Rhizophysidae, Salaciidae, and Epibuliidae. But as Chun ('97b) has pointed out, the Cystaliidae are merely the young stages of Epibulids, while Salacia, the only genus of Salaciidae, is so closely allied to Rhizophysa that it certainly is of not more than generic rank. Chun himself recognized two families of Rhizophysids, Epibuliidae and Rhizophysidae, dividing the latter into two subfamilies, Rhizophysinae and Bathyphysinae. Schneider unites all these in one family, but Lens and Van Riemsdijk, who do not give any complete scheme, mention two families, Rhizophysidae and Bathyphysidae. It seems to me that Schneider's reduction goes too far, especially in the case of the Epibuliidae, which are sharply demarked from their allies by a very much shortened stem, exactly as are the Nectaliinae from the typical Agalmidae (p. 289). On the other hand it would certainly be erroneous to class the Epibulids and Bathyphysids as subdivisions of as high rank as the Physalids, for they are too closely allied to the Rhizophysids by the presence of hypocystic villi in the pneumatophore, and by the structure and arrangement of the appendages. They are therefore regarded, in this Memoir, as subfamilies, Rhizophysinae, Bathophysinae, and Epibuliinae, of the Rhizophysidae.

## **Rhizophysidae** Brandt, 1835.

### **Rhizophysinae** Chun, 1897.

Two genera of Rhizophysinae can be distinguished, Rhizophysa and Salacia, the former with monogastric, the latter with polygastric cormidia. Schneider ('98), it is true, has united the two, but it can not be questioned that this difference in the structure of the cormidia is more important than the differences in the tentilla usually considered of specific significance in Rhizophysa.

Salacia is monotypic. I have not had an opportunity to study *S. uvaria* Fewkes.

## **RHIZOPHYSA** Peron and Lesueur, 1807.

For criticism of Haeckel's genera Cannophysa, Linophysa, Aurophysa, and Nectophysa, and for the reasons which show that they are synonyms of Rhizophysa, I refer the reader to Chun ('97b, p. 77), who also includes Linophysa Haeckel. Although this genus is not valid, the species for which it is instituted, *Rhizophysa conifera* Studer ('78) belongs, not to Rhizophysa but to Pterophysa (Schneider, '98, Lens and Van Riemsdijk, :08, p. 106).

Apart from *conifera*, Chun ('97b, p. 104) recognized the following species in the compound genus Rhizophysa: — *R. filiformis* Forskål, *R. eysenhardtii* Gegenbaur, *R. clavigera* Chun (= *Cannophysa filiformis* Mayer), *R. gracilis* Fewkes, and *R. murrayana* Haeckel. But Fewkes's account of *R. gracilis* and Haeckel's description and beautiful figures of *R.* (*Cannophysa*) *murrayana* agree so well with *R. filiformis*, especially in the form of the tentilla, that I follow Schneider, and Lens and Van Riemsdijk in uniting them with the latter. Whether *R. clavigera* is really a distinct species can hardly be determined from Mayer's very confused account, or from his figure which was evidently drawn from a fragmentary specimen. My opinion is that it was probably *R. filiformis*, with siphons and tentacles twisted together. Schneider includes in this genus the *R. uvaria* of Fewkes, but this form has polygastric cormidia, and therefore belongs to Salacia (Haeckel and Chun).

Lens and Van Riemsdijk, after examining the literature of the genus, came to the conclusion, with which I entirely agree, that only two species, *filiformis* and *eysenhardtii*, are valid. These are distinguished from each other by the presence in the former of three kinds of tentilla, tricornuate, dendritic, and "vogelkopfähnlich," and in the latter of simple filiform tentilla only.

Schneider ('98) used the name *R. mertensi* Brandt to replace *eysenhardtii* Gegenbaur, evidently supposing that Brandt's ('35, p. 33) description of the tentilla as "Tentacula composita ramulis, i. e. tentaculis porpriis, simplicibus" meant that they were filiform. But Haeckel ('88b, p. 329) who examined Merten's unpublished figures of this species expressly states that it "exhibits distinctly two different kinds of branched tentilla." Unfortunately I have not been able to verify this statement; but under the circumstances there seems to be only one course open, namely, to consider *mertensi* a synonym of *filiformis*, on the strength of its having two kinds of tentilla, and to retain the name *eysenhardtii*, as is done by Lens and Van Riemsdijk, for the species with filiform tentilla.

The name *filiformis* Forskål is now universally used for the form with complex tentilla; and it is in every way desirable to maintain this position for the sake of definitely locating the old descriptions. But I may point out that in none of the accounts of the genera before that of Gegenbaur ('53) were the tentilla described in detail.

### **Rhizophysa filiformis** (Forskål) Lamarck.

*Physsophora filiformis* Forskål, 1775, p. 120; 1776, tab. 33, fig. F; Modeer, 1789, p. 282; Gmelin, 1790, p. 3159.
*Rhizophysa planestoma* Péron and Lesueur, '07, pl. 39, fig. 3; Eschscholtz, '29, p. 147; Blainville, '34, p. 118; Lesson, '43, p. 491.
*Rhizophysa filiformis* Lamarck, '16, p. 477; Blainville, '34, p. 118; Lesson, '43, p. 190; Gegenbaur, '53, p. 324, pl. 18, fig. 5–11; Haeckel, '88b, p. 329; Chun, '97b, p. 104; Schneider, '98, p. 170; Richter, :07, p. 559, taf. 27, fig. 1–13; Lens and Van Riemsdijk, :08, p. 100, pl. 18, fig. 141–145.
*Epibulia filiformis* Eschscholtz, '29, p. 148.
*Rhizophysa gracilis* Fewkes, '82a, p. 269, pl. 6, fig. 1–6.
*Cannophysa gracilis* Haeckel, '88a, p. 44.
*Cannophysa murrayana* Haeckel, '88a, p. 44; '88b, p. 324, pl. 24.
*Pneumophysa gegenbauri* Haeckel, '88b, p. 328.
*Cannophysa eysenhardtii* Mayer, '94, p. 239, pl. 3, fig. 1–4.
*Rhizophysa murrayana* Chun, '97b, p. 84; Mayer, :00, p. 72.
? *Epibulia (Macrosoma) mertensi* Brandt, '35, p. 32.
? *Rhizophysa mertensi* Lesson, '43, p. 492; Haeckel, '88b, p. 329.
? *Pneumophysa mertensi* Haeckel, '88b, p. 45.
? *Cannophysa filiformis* Mayer, '94, p. 241, pl. 3, fig. 3.
? *Rhizophysa clavigera* Chun, '97b, p. 104.

| | | |
|---|---|---|
| Station 4638 | 300 fathoms to surface | 1 specimen, pneumatophore, 4 cormidia. |
| " 4707 | " " " " | " specimen, pneumatophore 8 mm. long, 3 cormidia. |
| " 4715 | " " " " | " specimen, pneumatophore, lacking stem, 9 cormidia. |
| " 4730 | " " " " | " specimen, pneumatophore, 4 cormidia. |

All of the specimens came up on the dredging wire, and all were fragmentary; those individuals in which trifid tentilla were detected are included here. Their condition was too poor to allow me to add anything to the accounts given by Gegenbaur ('53), by Haeckel ('88b), and by Lens and Van Riemsdijk (:08). The description and figures by the latter authors are especially pertinent since they give the only detailed account of Indo-Pacific specimens of the species.

The capture of this species in the Eastern Tropical Pacific and its previously known distribution in the Mediterranean, in various parts of the Tropical Atlantic, and in the Malaysian Region ("Siboga") indicate that its range, like that of so many other pelagic Coelenterates, extends over the warmer waters of all oceans.

### **Rhizophysa eysenhardtii** Gegenbaur.

*Rhizophysa filiformis* Huxley, '59, p. 90, pl. 8, fig. 13–20 (non Forskål).
*Rhizophysa eysenhardtii* Gegenbaur, '60, p. 408, taf. 31, fig. 46–49; Fewkes, '83b, p. 82, pl. 1, fig. 1; Chun, '97b, p. 83; Lens and Van Riemsdijk, '08, p. 103, pl. 20, fig. 147, pl. 21, fig. 150, pl. 24, fig. 172.
*Nectophysa wyvillei* Haeckel, '88a, p. 45; '88b, p. 327, pl. 23; Agassiz and Mayer, :02, p. 169, pl. 8, fig. 36.
*Aurophysa ordinata* Haeckel, '88a, p. 44; '88b, p. 323.
*Pneumophysa mertensii* Haeckel, '88a, p. 45; '88b, p. 328.
*Rhizophysa mertensii* Schneider, '98, p. 170 (non Brandt).
? *Rhizophysa inermis* Studer, '78, p. 13, taf. 1, fig. 3, 8–10.
? *Aurophysa inermis* Haeckel, '88a, p. 44; '88b, p. 324.

Station 4653 surface 1 specimen, pneumatophore and 3 cormidia.

Although the single specimen was in very poor condition, the tentilla were sufficiently well preserved to show the simple thread-like form characteristic of *R. eysenhardtii*, well described and figured by Huxley for his specimen from the Indian Ocean. The specimen differs in no way from the "Siboga" specimens of this species described by Lens and Van Riemsdijk.

*R. eysenhardtii* was previously known from various parts of the Tropical Atlantic, from the Indian Ocean (Huxley, Haeckel), and from the Malaysian region. Its occurrence in the Eastern Tropical Pacific shows that, like *R. filiformis*, it occurs throughout the warm regions of all oceans.

## **Epibuliinae,** nom. nov.

*Epibulidae* Haeckel, 1888.

Only one genus, Epibulia, of this subfamily, is known. For the early history of the name, see Haeckel ('88b, p. 334). One species, *E. ritteriana* Haeckel, from the Indian Ocean, has been carefully described and beautifully figured. Two others from the Pacific, *E.* (*Rhizophysa*) *chamissonis* Eysenhardt, the type, and *E. erythrophysa* Brandt, are known, but from such incomplete accounts that their relationship to Haeckel's form remains doubtful (p. 350).

The genus is not represented in the "Albatross" collection.

## **Bathphysinae** Chun, 1897.

*Bathyphysidae* Bedot, :04; Lens and Van Riemsdijk, :08.

Lens and Van Riemsdijk (: 08) have reviewed the history of this little-known group, and their own researches on the material of the "Siboga" expedition have afforded detailed information as to the anatomy of three species.

They recognize two genera, Pterophysa, in which the siphons are sessile, *i. e.* attached directly to the stem, and Bathyphysa, in which they are borne on long pedicles. Judging from their descriptions this distinction seems to be a valid one. The minor features such as might be expected to serve for specific diagnosis within the two genera are still but little known, the only species sufficiently well described being *Pterophysa grandis* Fewkes (Lens and Van Riemsdijk, :08). The "Albatross" collection throws no light on the question.

There are two known species of Bathyphysa, *B. abyssorum* Studer, and *B. sibogae* Lens and Van Riemsdijk. We may safely assume that these two are distinct because the latter authors were able to examine Studer's original specimen.

In Pterophysa there are *P.* (*Rhizophysa*) *conifera* Studer, *P.* (*Bathyphysa*) *grimaldii* Bedot, and *P. grandis* Fewkes. These three are so closely allied that I doubt whether they can be distinguished. Finally there is the *Pterophysa* (*Bathyphysa*) *studeri* of Lens and Van Riemsdijk, which the describers were unable to class definitely in either genus.

The Bathyphysinae are represented in the present collection by some fragmentary segments of the stem with a few siphons attached. They can not be identified, except that the presence of pedicles throws them into Bathyphysa rather than into Pterophysa.

### **Bathyphysa** species ?

| | | | | |
|---|---|---|---|---|
| Station | 4645 | 300 fathoms to surface | on sounding wire; | fragments. |
| " | 4689 | " " " " | " dredging | " " |
| " | 4724 | 800 " " " | " " " | " " |

## Physaliidae Brandt, 1835.

I follow Chun ('97b) and his successors in recognizing only a single genus of this family, Physalia. The three other genera diagnosed by Haeckel ('88b), are merely as many stages in its development, as Chun's ('87b) earlier work had shown.

The early history of Physalia has been given in much detail by Chun ('97b). As is well known, the genus, long accepted by zoölogists in general, was founded by Lamarck (1801) for the *Holothuria physalis* of Linné (1758). Gill (:07), it is true, has recently maintained that this species must be regarded as the type, not of Physalia, but of Holothuria, in which it was the first example mentioned by Linné, on the ground that "Unquestionably the type of the genus and description was the first species." But Poche (:07), who has reviewed the early history of Holothuria in detail, and whose conclusions are in accord with the International code of nomenclature, has shown that this conclusion is not justified. He points out that inasmuch as "Linné einem typus naturlich nicht bestimmt hat, so mussen wir zur Festlegung desselben das Eliminations — verfahren ausvenden." He has shown that the use of this method of choosing the type absolutely precludes the selection of *physalis*, since this species was removed from Holothuria to Physophora by Modeer in 1789, while two of the species enumerated in the former genus by Linné in the 10th edition of the Systema Naturae were still allowed to remain in it. Under the International code it is one of the latter which must be selected as its type. The choice of Linné's *Holothuria physalis* for the type of Lamarck's genus Physalia, is then valid, and the further fate of the genus Holothuria need not concern us. The relationship between Physalia and Holothuria is the same as that between Porpita and Medusa (p. 329). In both the same conclusions are reached as to the validity of the Siphonophore genera in question, a result fortunate for the sake of stability.

### **PHYSALIA** LAMARCK, 1801.

The collections of Physalia which I have examined, from the Atlantic, Pacific, and Indian Oceans, entirely support Chun's ('97b) view that there are two species, and two only, an Atlantic and an Indo-Pacific, the former chiefly characterized by the presence of many, the latter of only a single "Haupttentakel." Schneider ('98), believes that the two are merely varieties of one species. But the fact that among the considerable number of specimens of the Pacific species which have now been studied, not only by the early authors, but recently by Chun ('97b), Agassiz and Mayer (:02), Lens and Van Riemsdijk (:08) and by myself, none have more than one main tentacle, is good evidence that this condition is the final one in this form.

The fact that in its adult state the Pacific species resembles an immature stage of the Atlantic Physalia has led to much confusion in the early literature of the subject.

Justification of the choice of *utriculus* as the specific name for the Indo-Pacific species is given by Chun ('97b, p. 86), to whom I refer the reader for a more extended review of the subject. I have not been able to consult the original description myself. The Atlantic species is *P. physalis* Linné. Many authors have used the earlier name *arethusa* Browne (1756), but this is pre-Linnean.

### **Physalia utriculus** (La Martinière) Eschscholtz.

*Medusa utriculus* La Martinière, 1787, p. 365, pl. 2, fig. 13, 14; Gmelin, 1788, p. 3155; La Perouse, 1798, atlas, pl. 20, fig. 13, 14.
*Physalis lamartinieri* Tilesius, '10, p. 99; Eysenhardt, '21, p. 421; Blainville, '30, p. 103.
*Physalis cornuta* + *fosbeckii* + *afer* Tilesius, '10, p. 104.
*Physalia utriculus* Eschscholtz, '29, p. 163, taf. 14, fig. 2; Blainville, '34, p. 113; Lesson, '43, p. 557; Huxley, '59, p. 101, pl. 10, pl. 12, fig. 12; Haeckel, '88b, p. 351; Chun, '97b, p. 86; Agassiz and Mayer, :02, p. 169; Browne, :04, p. 744; Lens and Van Riemsdijk, :08, p. 118, pl. 24, fig. 174, 175.
*Physalia australis* Lesson, '26, pl. 5, fig. 1, 2; '30, p. 38.
*Physalia megalista* Brandt, '35, p. 37; Bigelow, :04, p. 265 (non Péron and Lesueur, '07).
*Alophota mertensii* Haeckel, '88b, p. 348.
*Arethusa thalia* Haeckel, '88b, p. 349.
*Physalia physalis* Schneider, '98, p. 190 (partim).

| | | | | | | |
|---|---|---|---|---|---|---|
| Station 4695 | Surface | 1 | specimen | | 60 mm. | long. |
| " 4730 | " | 3 | " | both about | 30 mm. | " |
| " 4542 Hyd. | " | 5 | " | | 10–30 mm. | " |
| " 4544 " | " | 2 | " | both | 17 mm. | " |
| Easter Island | " | 1 | " | | 60 mm. | " |
| Manga Reva I. | " | 1 | " | | 40 mm. | " |

A critical revision of the species of Physalia from the region of the Cape of Good Hope, where they are described as abundant, would be of the greatest value.

## **Chondrophorae** Chamisso and Eysenhardt, 1821.

*Disconectae* Haeckel, 1888.

This suborder contains two well-marked families, the Porpitidae and the Velellidae.

### **Porpitidae** Brandt, 1835.

The Porpitidae are readily separable into two groups, one with high vaulted corm, the other flattened and disc-like. Haeckel proposed two genera for the former, on the supposition that the tentacles in this subdivision were arranged after two distinct plans, either in separate groups, or regularly over the entire surface of the tentacular zone. The former condition, according to his view, characterizes Porpalia, the latter Porpema. His own figures, however, show that the distinction is not a valid one, because in his figure (pl. 48, fig. 2) of the denuded corm of *Porpalia prunella* the tentacle-scars are not arranged in groups, but are evenly distributed exactly as they are in Porpema or in Porpita. The apparent grouping of the tentacles in this case corresponds exactly to the similar phenomenon in his supposed genus Porpitella, where it merely represents difference in size between tentacles of different ages. Additional evidence that Porpalia is the young of Porpema is afforded by the facts that Haeckel's specimen of Porpalia was only 4–5 mm. in diameter, and, still more important, that only eight gonozooids appear to have been present. But I can not follow Schneider ('98) in uniting both Porpalia and Porpema with the species with disc-like corm, *i. e.*, Porpita, because as I shall show there are very important structural differences which distinguish them from Porpita. Chun, in his monograph of the Siphonophores of the "Plankton" expedition, mentions neither Porpalia or Porpema in text or in synonymy; or even in his list of Atlantic species ('97b, p. 102) including all "bisher aus dem Atlantischen Ocean beschriebenen und ausreichend charakterisirten Siphonophoren." I have chosen Porpema, rather than Porpalia, as the name for the compound genus because while both were proposed in the same publication the former was based on the adult, the latter on a young stage.

Modern authors agree in uniting all Porpitidae with flattened corm in one genus, Porpita.

## **PORPEMA** Haeckel, 1888.

*Porpalia* Haeckel, 1888.

Haeckel proposed several specific names under Porpalia and Porpema, with neither descriptions nor figures, nor any indication whatever except the localities of capture; a fact which makes systematic revision of the genus difficult. The oldest species which can be referred to Porpema is *globosa*, of Eschscholtz ('29); his brief description, and figures are amply sufficient for generic and perhaps even for specific identification. Haeckel ('88a) referred *P. globosa* to Porpalia, and mentioned as a second species *P. prunella*, from the Pacific, which he shortly after ('88b) described in detail. Under Porpema he mentions ('88a, and '88b) *P. lenticula* from the Indian Ocean and *P. pileata* from the coast of Chile by name only, and fully described *P. medusa* from the Atlantic. Fortunately he clearly designated a type species for Porpalia, in the words ('88b, p. 58) "the genus Porpalia is founded upon a new species, *Porpalia prunella*" and this is a starting point.

A comparison of Eschscholtz's ('29) figures of *P. globosa* and Haeckel's account of *P. medusa* shows a close agreement between the two; and inasmuch as both were taken in the Tropical Atlantic, I have no hesitation in uniting them.

The relationship of *P. globosa* to the Pacific *P. prunella* can not be determined from the accounts yet published, because Haeckel studied only young stages of the latter. Fortunately, however, the present collection contains a large and excellently preserved series of adults, which differ from *P. prunella* only in such features, *i. e.*, greater number of gonozooids and tentacles, as are undoubtedly due to a more advanced stage in growth, and which must therefore be referred to that species, as indeed we would expect from the locality of capture. A comparison between them and Haeckel's account and figures of *P. globosa* ("*P. medusa*"), shows that it is doubtful whether any specific demarcation can be drawn between the Atlantic and Pacific forms. Such minor differences as do exist in form, number, and size of tentacles are readily explained as due to slightly different stages in growth and to different methods of preservation. But Haeckel's account is too general and his figures too diagrammatic to allow of a certain conclusion. And since I have no Atlantic specimens at hand, it is better to follow the more conservative course of retaining *prunella* and *globosa* as two separate species, at least until Atlantic material can be restudied.

Judging from the localities of capture it is probable that *P. lenticula* Haeckel, from the Indian Ocean, and *P. pileata* Haeckel from Chile are both in reality *P. prunella*; but in the absence of any description, we can not be certain of this. They must be treated as *nomena nuda*, since a mere geographic location can not be considered as "indication" in the nomenclatural sense.

*Discalia medusina* Haeckel is the young of some Porpitid; the comparatively great thickness of its disc suggests that it belongs to Porpema, and its locality, South Pacific, points to identity with *P. prunella*.

### **Porpema prunella** (HAECKEL).

Plate 25, 26, 27; Plate 28, fig. 11, 15.

*Porpalia prunella* HAECKEL, '88a, p. 30; '88b, p. 58, pl. 48.
? *Discalia medusina* HAECKEL, '88a, p. 20; '88b, p. 46, pl. 49, fig. 1–6.
*Porpita globosa* SCHNEIDER, '98, p. 195 (partim).

Station 4685 surface 37 specimens, 5–6 mm. in diameter, preserved in formalin, in alcohol, in corrosive acetic, and in Flemming's fluid.
" 4686 " 4 specimens, 6 mm. in diameter.

The general structure of a young stage of this species has been described and figured by Haeckel in some detail. The present adult specimens differ from his account in the various characters which change with growth, while in several particulars better material allows correction and emendation of his observations.

In general outline the largest specimens are rather higher than his, height and breadth, leaving out of account the central gastrozooid, being about equal, whereas his figures are almost twice as broad as high; but the fact that his description was based entirely on contracted alcoholic material, makes it unsafe to lay stress on this apparent difference. It may be a concomitant of different stages in growth.

Adult individuals of *P. globosa* (= *P. medusa*), according to his figures, agree in height with the "Albatross" specimens. The tentacles, as already pointed out, are distributed evenly over the tentacular zone, not in groups.

Haeckel ('88b, pl. 48, fig. 4) represented the limbus as radially lobed, instead of entire, as it is in the "Albatross" specimens and in Porpita. But since he has himself shown it entire in two other views ('88b, pl. 48, fig. 1, 2), and since it is often artificially split radially in alcoholic material, the apparent lobes were probably the result of mutilation. Indeed, although he states in his diagnosis of the genus that the margin is lobed, in his account of the "limbus umbrellae" of this species he fails to mention any such appearance. As shown by Haeckel, the limbus is proportionately very much broader than it is in Porpita, and the palial canal system much less complex. In his view of the upper surface ('88b, pl. 48, fig. 4) he shows fifteen broad radial canals near the centre, connected with one another by a ring canal, and branching irregularly so that at the margin of the limbus there are forty-one. In one of the present specimens there are fourteen canals near the centre of the disc, and forty-five at the margin (Plate 26, fig. 3). The entoderm of the canals, especially near the outer end in the region of the limbus, sends out numerous amoeboid processes, simple and branched, just as happens in the canals of the limbus in Porpita. At the margin of the limbus, the radial canals are connected by a circular canal, but so crowded are the marginal muciparous glands that it is only on sections that this canal can be distinguished. Each radial canal branches at the zone of junction of limbus and pneumatophore, one branch running into the limbus, the other running downward into the tentacular zone as will be described later.

*Pneumatocyst.* In the specimens sectioned, there were from 12–15 circular chambers, besides the central chamber. There are no radial chambers; but, as is seen in the cross sections, the outer wall of the central chamber is folded so as to form eight vertical pockets (Plate 26, fig. 4). Haeckel states that the central chamber is surrounded by eight radial chambers; but his figures show that his specimens of *P. prunella* and *P. globosa* both exhibit the condition seen in the present series. No doubt he was deceived by surface views, mistaking the lobes of the central chamber for separate compartments. This error is a natural one, on account of the location of the eight inner stigmata which surround the central stigma and which, in surface views, appear to open into the eight lobes of the latter. Their true location, however, is shown in longitudinal sections (Plate **26**, fig. 2, Plate **27**, fig. 5), on which it is seen that the central chamber broadens basally, and that the first circular chamber partly covers it distally. The eight "primary" stigmata in reality open into the first circular chamber. I shall have occasion to return to this subject in the account of Porpita (p. 335). In a specimen 5 mm. in diameter there are eight rows of stigmata (Plate **26**, fig. 3); but their number in each row varies at different ages with the increase in the number of concentric chambers.

The vaulted form of the pneumatocyst and the ridges in its lower surface which interlock with the radial ridges of the centradenia have been described in detail by Haeckel ('88b). The tentacles (Plate **25**, fig. 6) and gonozooids (Plate **25**, fig. 8, 9) resemble the corresponding organs in Porpita. In the long and the two short rows of tentacular nematocyst knobs there are the same number, 19–24, in adult tentacles. The number of these is a systematic character of some importance in Porpita, and it may prove to be significant in the present genus.

*Canal system of the tentacular zone.* Although Haeckel's account of the general organization of Porpema leaves little to be desired, his description of the vascular system requires some correction. The canals which proceed downward from the junction of limbus and pneumatophore break up in the tentacular zone into an irregular network (Plate **26**, fig. 5, C. T.) which connects with the hollow entodermic cores of the tentacles. This canal-net is represented in the "Challenger" report (Haeckel, '88b, pl. 48, fig. 3) as continuing downward between the centradenia and the bases of the gonozooids, and finally opening into the central zooid. As a matter of fact, however, the canals of the tentacular zone open into the superior canals of the centradenia, exactly as they do in Porpita. The gonozooids open directly into the centradenial canals; thus neither tentacles nor gonozooids are in communication with the central zooid except through the medium of the centradenia. Haeckel's description of *P. globosa* ('88b, p. 62) suggests that he himself observed this fact, though his figure is not clear.

*Centradenia.* The conical form of this structure in Porpema (Plate **26**, fig. 2) has been noted by Haeckel ('88b) as has the fact that its structure is less complex than in Porpita. Its apical surface, as seen when stripped of the overlying pneumatocyst and surrounding tentacular zone, bears prominent radial ridges (Plate **27**, fig. 12), interlocking with the lower surface of the pneumatocyst. In one specimen there are seventeen ridges (each indicating the course of one of the superior canals) at the periphery; but of these only the "octoradial liver star" of Haeckel, reaches the apex. In the centre there is a small circular area where no ridges are present, but in this region the union of the eight primary superior canals (Plate **27**, fig. 13) can be easily traced. The figure thus formed more nearly resembles that in Velella (Bedot, '85b, pl. 9, fig. 2) than in Porpita (Plate **28**, fig. 16). Between the canals the tracheae, passing down into the underlying region (Plate **27**, fig. 6), can be seen.

The main mass of the centradenia, as in Velella and Porpita, consists of a dense parenchyma of ectoderm cells and cnidoblasts in every stage of development, through which the complex network of canals can be traced. The latter arise in the apical region as downward branches from the superior canals, exactly as they do in Porpita (p. 336); basally they connect with the central zooid. Haeckel ('88b, p. 62) states that even in the adult (*P. medusa*) there are only eight canals opening into the latter. Judging from analogy with the condition in Porpita (p. 338) this statement is probably true of very young stages. But in the large specimens collected by the "Albatross", in addition to these eight primary openings, there are about thirty others, which lie near the periphery of the base of the zooid (Plate **28**, fig. 11). These are easily traced on sections (Plate **27**, fig. 7, 8, 9); but in alcoholic material the lumen of the canals is often entirely masked. The eight primary canals do not run directly to the eight primary superior canals of the centradenia as Haeckel supposed, but connect with the general canal-net of that organ. Concerning the tracheae I need merely confirm Haeckel's statement that they ramify throughout the centradenia, and frequently run into the walls of gonozooids and of the central gastrozooid.

The entodermic walls of the centradenial canals in Porpema are less complex histologically than they are in Porpita. There is some distinction between the canal walls in the upper "liver" [1] and in the lower "kidney" portions; it is less marked than in the latter genus. In the "liver" portion the cells are small, and pale-staining, containing granules; in the "kidney" they are more columnar, and enclose masses of large pigmented spherules lying both in the cell bodies and in the intercellular spaces, while among them are to be seen larger, deeper-

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[1] The use of the terms "liver" and "kidney" in this connection is purely conventional.

staining cells of irregular outline (Plate 28, fig. 15). In none of the specimens sectioned have I been able to find the guanin crystals so characteristic of the "kidney" region in Porpita. In this respect Porpema resembles Velella, as indeed it does in the general simplicity of the centradenia.

*Color.* *Porpema prunella* is a very beautiful object when floating on the water, the central disc being deep ultramarine blue, most intense at the centre, on which the radiating ridges are marked by pale lines. When seen from the side, the pneumatophore shines through the nearly transparent zone composed of the bases of the tentacles as a deep blue central core; the general mass of the centradenia below it is a pale reddish purple. The gonozooids are pale blue, their medusae yellowish; tentacles bluish at the base, but soon becoming pale yellow, their nematocyst knobs violet.

### **PORPITA** LAMARCK, 1801.

It has recently been suggested that the name Medusa, instead of Porpita, should be employed for the genus now under consideration. I may therefore summarize the grounds upon which I retain the latter. The first appearance in binomial literature of an animal referable to this genus is in the 10th edition of the Systema Naturae, where, under the name *Medusa porpita*, Linné briefly diagnoses a form earlier (1754) described by him under the name "*Medusa (Porpita) orbicularis*" and which from his earlier figures (1754) is undoubtedly founded on a fragmentary Porpita. In 1776 O. F. Müller described the Atlantic Porpita under the name *Medusa umbella*. Forskål (1775, 1776), however, who gave an excellent account of the Mediterranean form now generally known as *P. umbella*, referred it to the *Holothuria denudata* of Browne, although, as Chun ('97b) has recently pointed out, the latter name evidently belonged to a fragmentary Salpa.

Gmelin (1790) retained Forskål's species in the genus Holothuria, as *H. nuda*, distinguishing, and rightly, between it and Browne's *H. denudata*, but he doubted whether *H. nuda* really belonged to *Medusa umbella*. Almost simultaneously Modeer (1790) used for Porpita the name Phyllodice, apparently without realizing that the animal (Velella) to which Browne (1789) had already applied that name was generically distinct. The genus Porpita was instituted in 1801 by Lamarck, for the *Medusa porpita* of Linné. Since that date it has been usually accepted. The only grounds on which the name Medusa could be substituted for Porpita would be that the species *porpita*, of Linné, was the type of the genus Medusa.

An exactly parallel case, that of Coluber, has recently been examined by Dr. L. Stejneger (:07). Both Coluber and Medusa are Linnaean genera, each including widely diverse species now referred to various genera and even families, and of course Linné did not indicate a type species for either. From each, the early reviewers, Lamarck in the case of Medusa, removed certain species, and left certain other species in the original genus, without, however, designating any species as types. As Stejneger points out, according to the International code of nomenclature, subsequent designation of the types for the Linnaean genera must be made from among the species left in them by the first reviewers. Although the first reviewer did not designate a particular species as type, still the fact that he allowed certain species to remain in the original genus shows that it is one of these which is to be considered as typifying it. Such being the case, whatever species may, or might have been selected as type of the genus Medusa, it can not be *M. porpita*; and therefore there is no justification for discarding Porpita in favor of Medusa.

The question, how many species of Porpita deserve recognition, is difficult to answer because of the brief and unsatisfactory nature of the descriptions upon which many of the proposed names rest. It is important however, to reach a sound conclusion in this regard. Porpita is such a typical pelagic surface animal that an accurate knowledge of the occurrence of its species would be of much service to students of the geographic distribution of pelagic organisms in general. For that reason I attempt a review of the subject, though it can not be final without additional knowledge of the Pacific, and especially of the Indian Ocean forms.

In treating the Atlantic and Mediterranean forms there is every reason to follow Chun ('97b) in uniting all described forms under the name *P. umbella* (O. F. Müller, 1776).

We must next consider the species which have been recorded from the Pacific. The oldest notice is by Lesson ('26) who figured and named *P. chrysocoma* from near New Guinea, and *P. pacifica* from off the coast of Peru, in the atlas of the zoölogical results of the voyage of "La Coquille." In the interim between the appearance of these figures and his very meagre and altogether insufficient description (1830), Eschscholtz ('29) gave his account of the Tropical Pacific *P. ramifera* and *P. coerulea*. The first of these was based on very young specimens ("Eine halbe Linie" in diameter). There is nothing in the description to differentiate them specifically from any of the various recorded races of Porpita. *P. coerulea*, however, was based on larger specimens, up to

25 mm. in diameter, on which Eschscholtz noted the well-marked tubercles on the upper surface of the disc, which since prove to be a very important character. Afterward, another Pacific species, *P. radiata* Brandt, was recorded, with only a very cursory diagnosis.

The accounts of *P. pacifica* Lesson, and *P. radiata* Brandt, based as they are on such trivial features as size, color, and the form and length of the tentacles, contain nothing to show that they are not identical with *P. coerulea* Eschscholtz. The localities of capture add further support to such a union. *P. ramifera* Eschscholtz likewise comes under the same category, as a young stage of *coerulea*. To the combined species thus formed, the oldest name, *P. pacifica* Lesson ('26) must be applied. *P. pacifica* has recently been recorded by Agassiz and Mayer (:02) and by Mayer (:06) from the Tropical Pacific, and from the Hawaiian Islands.

The case of *P. chrysocoma* is less clear, inasmuch as the bright yellow color of limbus and tentacles figured and noted by Lesson ('30) differs markedly from the brilliant blue of these parts in the Pacific specimens which I have examined in life. In *P. umbella*, however, I have found that these regions may appear yellowish in certain lights and against certain backgrounds. The locality of capture of *chrysocoma*, close to New Guinea, suggests that it was probably identical with the "Siboga" specimens from the Malaysian region studied by Lens and Van Riemsdijk, and referred by them to *P. umbella*.

Finally, to conclude our survey of the Pacific species, we must examine Haeckel's two species, *Porpita fungia* and *Porpitella pectanthis*, both of which were described and figured in detail. The two are placed by him in separate genera on the supposition that the tentacles in Porpita are evenly distributed over the tentacular zone, but arranged in groups in Porpitella. In the latter genus he includes *P. coerulea* Lesson and *P. radiata* Brandt. This separation is exactly analogous to the distinction drawn by him between Porpema and Porpalia (p. 323). Porpitella is the young of Porpita; and I may note that exactly similar stages have been long known for *P. umbella* (A. Agassiz). Since *Porpitella pectanthis* and *Porpita fungia* were both taken in the same general region of the Pacific, it is almost certain that they represent two stages in the growth of but a single species.

A comparison between Haeckel's description of *P. fungia* and Eschscholtz's account of *P. coerulea* shows such close resemblance between the two, especially in the presence of prominent tubercles on the upper surface of the float, that I have no hesitation in uniting them. All Porpitas, then, as yet known from the

Pacific, except the problematical *P. chrysocoma* which more properly belongs to the Malaysian region, must be referred to *P. pacifica* Lesson, a species, as I shall later show, very distinct from the Atlantic *P. umbella*.

To *P. pacifica* must likewise be referred the Pacific species of Haeckel's genera Discalia and Disconalia, because the supposition that these forms are monogastric, the sole ground for distinguishing between them and very young Porpitas, appears to rest on no better evidence than the surface views of the gonozooids. Of course to prove that these organs possess no terminal openings would require the study of serial sections. Haeckel also mentions, as new, *P. australis*; but since this name rests on neither description nor figures, nor even any more definite locality than that it is a "Southern form" it is of course a *nomen nudem*.

Finally, before describing our series of *P. pacifica*, I may summarize briefly our extremely scanty knowledge of the Porpitas from the Indian Ocean. The oldest of these, as pointed out above (p. 329), is the *P. porpita* of Linné (=*P. indica* Bosc). There have since been described *P. lutkeana* Brandt, besides *Disconalia pectyllis* Haeckel, which is undoubtedly the young of some Porpita. As pointed out, *P. chrysocoma* may belong here, as do the specimens recorded by me (:04) from the Maldives under the name *P. lutkeana* Brandt, and from the Malaysian region by Lens and Van Riemsdijk (:08) as *P. umbella*. Probably all of these are identical, and ought to be united under the old name *P. porpita*. Unfortunately our knowledge of them is not sufficient to give a definite answer to the question whether *P. porpita* is identical with the Atlantic *P. umbella*, or with the Pacific *P. pacifica*, or whether, as is possible, it is a species distinct from either.

The published descriptions, so far as they go, and my own insufficient examination of the Maldive specimens, seem to favor their union with *P. umbella*, rather than their retention as distinct, as I formerly believed. The conclusion that they are not referable to *P. pacifica* rests on the ground that though the tubercles of the latter are prominent features even in macerated specimens, no such structures were observed either on the "Siboga," or in the Maldive specimens. The strongest evidence in favor of the view that *P. porpita* and *P. umbella* are identical is the statement by Lens and Van Riemsdijk (:08, p. 123), that they "found no difference whatever between them and *Porpita linnaeana*." Unfortunately, however, their material was not of the best, and until better series can be examined the identity of the Indian forms must remain in doubt. A study of Porpitas from the region of the Cape of Good Hope, and a knowledge whether the geographic range of the Indian and Atlantic forms is continuous or discontinuous, would be of great value.

### **Porpita pacifica** Lesson.

Plate 28, fig. 1–10, 12, 13, 14; Plate 29.

*Porpita pacifica* Lesson, '26, pl. 7, fig. 3, $3^1$; '30, p. 2, 59: Agassiz and Mayer, :02, p. 159; Mayer, :06, p. 1134.
*Porpita ramifera* Eschscholtz, '26, p. 745; '29, p. 178, taf. 16, fig. 3.
*Porpita coerulea* Eschscholtz, '25, p. 744; '29, p. 179, taf. 16, fig. 5.
*Porpita radiata* Brandt, '35, p. 40.
*Porpita* species ? Huxley, '59, p. 122, 126, fig. A–C.
*Porpitella coerulea* Haeckel, '88a, p. 130.
*Porpitella radiata* Haeckel, '88a, p. 30.
*Porpita fungia* Haeckel, '88b, p. 67, pl. 45.
*Porpitella pectanthis* Haeckel, '88b, p. 64, pl. 46.
*Porpitella coerulea* Haeckel, '88a, p. 30.
*Disconalia ramifera* Haeckel, '88b, p. 357.
*Disconalia gastroblasta* Haeckel, '88a, p. 30; '88b, p. 48, pl. 49, fig. 7–12; pl. 50, fig.
? *Discalia primordialis* Haeckel, '88a, p. 30; '88b, p. 46.

| | | | | | |
|---|---|---|---|---|---|
| Station | 4585 | surface | 1 | specimen | 3 mm. in diameter, fragmentary. |
| " | 4613 | " | 1 | " | 2.5 mm. in " " |
| " | 4619 | " | 2 | " | both 3 mm. in diameter, well preserved. |
| " | 4631 | " | 2 | " | 1.5 and 4 mm. in diameter, well preserved. |
| " | 4640 | " | 1 | " | 11 mm. in diameter, fairly preserved. |
| " | 4649 | " | 18 | " | 40–55 mm. in diameter, well preserved.<br>At this Station a swarm was encountered. |
| " | 4707 | " | 1 | " | 12 mm. in diameter, fair. |

Also:— Lat. 9° 57′ N., long. 137° 47′ W.; surface ("Albatross" Ex. 1899–1900, Station 13). 7 specimens, 14–25 mm. in diameter in excellent condition, being the specimens recorded by Agassiz and Mayer (:02); and Hawaiian Islands:— surface ("Albatross" Hawaiian Expedition 1902, Station 4188); 4 specimens 7–16 mm. in diameter, recorded by Mayer (:06).

The large series from Station 4649, where a swarm was encountered, gives opportunity to add something to our knowledge of *P. pacifica*. The general external form, and arrangement of zooids, in which it resembles *P. umbella*, has been well described and figured by Haeckel. Certain features, however, need special mention on account of their specific importance. Chief among these are the tubercles on the superior surface of the disc. Haeckel ('88b) observed and figured these; but he gave them no systematic weight. In the large specimens collected by the "Albatross" (Plate 28, fig. 1) they are very prominent, easily visible to the naked eye, largest and most crowded near the centre of the disc. They have no connection with the stigmata and this fact is important, because in *P. umbella* the latter organs, especially in large specimens, are surrounded by slight collars, causing a roughness, noted by A. Agassiz ('83). The tubercles in *P. pacifica* are conical thickenings of the chitinous layer of the pneumatocodon; and the canals of the pneumatophore often pass over them (Plate 28, fig. 4). Although the tubercles are extremely prominent, the radial plications of the surface of the disc are so slight as to be hardly noticeable except near the margin. In *P. umbella*, on the contrary, the ridges are rather prominent. The presence of tubercles in Huxley's ('59) specimens seems to me sufficient reason for including them in *P. pacifica.*

A second feature which proves to be of systematic importance is the arrangement of the stigmata. In the adults of *P. umbella*, as has long been known, these organs are extremely numerous in the marginal region of the disc, although in large specimens the stigmata in the central region become closed (Plate 28, fig. 13). In *P. pacifica* (Plate 28, fig. 2) the stigmata are very much less numerous. There are no open ones for a distance from the centre of almost ½ the diameter of the disc; and even beyond this point very few open into each circular chamber of the pneumatocyst. In a small specimen (1.5 mm.) the stigmata in the central region are still open, as Haeckel has described them ('88b, "*Porpitella pectanthis*").

A third specific distinction, though of minor importance, is that in large specimens of *P. pacifica* the limbus is relatively much narrower than it is in *P. umbella* of about the same size (Plate 28, fig. 2, 13). Further points of difference are found in the canals of the limbus, and in the tentacles. In *P. umbella* the former permanently retain their general radial arrangement (Plate 28, fig. 14), though with much branching and irregularity. In *P. pacifica*, however, the canals form an irregular network in adults (Plate 28, fig. 5) though in small specimens they are of the same type as in *P. umbella.* Finally the tentacles, at least in large specimens, form an excellent specific character, for whereas in *P. umbella* the stalked tentacular nematocyst clusters are not known to surpass 9–12 in the long, and 6–8 in the two short rows (A. Agassiz, '83, Chun, '97b), a fact I have been able to substantiate on numerous specimens, there are from

25–29 in the long rows, and from 11–14 in each of the short rows in the largest specimens of *P. pacifica.*

In general structure the pneumatocyst agrees with Haeckel's account, except for the important fact that there are no radial chambers surrounding the central chamber. As Bedot ('85a) has pointed out for *P. umbella*, the supposed radial chambers are nothing more than radial lobes of the central compartment, just such as occur in Porpema (p. 326). The supposed septa separating them, which are very noticeable on surface views, are nothing more than furrows on the upper surface of the central chamber (Plate 28, fig. 7). The structure of this region was accurately described by Huxley ('59, p. 123), who also observed that the stigmata near the centre of the disc were closed.

*Centradenia. Adult.* The courses of the tracheae have been so thoroughly worked out by Kölliker ('53), Huxley ('59), A. Agassiz ('83) and others, that I will merely note that my slides show frequent instances of the penetration of these organs into the walls of the central gastrozooid and of the gonozooids.

The general structure of the centradenia is now fairly well known, but we possess little more information as to its finer details in Porpita than is contained in the brief account (without figures) by Bedot ('85a). It is therefore fortunate that the present series is sufficiently well preserved to allow the study of serial sections. In general form the centradenia of *P. pacifica* agrees closely with that of *P. umbella*, as it does in its finer anatomy, so far as that of the latter is known. The superior surface (Plate 28, fig. 3) of this organ, in *P. pacifica* as in *P. umbella*, is thrown into numerous ridges interlocking with the plications of the floor of the pneumatocyst. Haeckel ('88b, p. 69) calls these ridges "innumerable radial folds (thirty-two of which are stronger)." In point of fact, there are only about sixteen at the centre, while the number increases distally until in a specimen 55 mm. in diameter upwards of two hundred could be counted near the margin. At the centre there is a small circular, or sometimes octagonal, area, corresponding in size to the superposed central chamber of the pneumatocyst, where the surface is smooth. In this region the canals, which further distally occupy the radial ridges, unite in an irregular network (Plate 28, fig. 16) the exact form of which varies in different specimens. In the space between the canals, groups of tracheae pass downwards into the substance of the centradenia.

Haeckel says of the inferior surface of the central gland that it is divisible into a white central disc ("kidney") and a peripheral brown radiate zone ("liver"). Leaving out of account the colors, the present specimens show that this statement, though essentially correct, needs emendation.[1] The mass of canals known as the "kidney" occupies the entire lower face of the central gland outward from the central zooid so far as the inner margin of the tentacular zone, and it is only by removing the latter that the outer ends of the superior ("liver") canals become visible from below (Plate 29, fig. 1).

The radial canals, which run downward from the junction of limbus with disc, open into the outer ends of the superior canals or sinuses (Plate 29, fig. 1). The latter in their turn connect with the tentacles by means of a complex net of thin-walled canals, which form a plexus underlying the entire tentacular zone (Plate 29, fig. 1). So far as I have been able to learn from a study of numerous sections, only the youngest, most peripheral tentacles ever connect directly with the radial canals. This is evidently only temporary, for with growth the point of demarcation between the two categories of canals moves further and further distally, successively overlapping the new tentacles shortly after their formation.

The difference between the structure of the tentacular zone in Porpita and in Porpema (p. 327) is no doubt correlated with the differences in the shape of the corm in the two genera. There are a few gonozooids scattered among the tentacles and these connect either directly or *via* the tentacular plexus with the superior canals (Plate 29, fig. 1). Haeckel is thus correct in stating that some of the gonozooids are connected with the "kidney" others with the "liver." Central to the tentacular zone the superior canals rest upon the mass of ectoderm cells and cnidoblasts traversed by the inferior canals, which form the great bulk of the centradenia. The inferior canals arise, as noted by Bedot ('85a) as downward branches from the superior canals (Plate 29, fig. 7) and form a complex network. At the inferior surface of the centradenia, immediately in contact with the supporting layer ("lamelle anhiste" of Bedot, '84) they give rise to an extremely close reticulum of small horizontal canals (Plate 29, fig. 6) to which alone the term "inferior" was applied to Bedot. It is, however, in their arrangement alone, not in their structure, that the latter differ from their parent canals.

According to Haeckel ('88b, p. 70) there are sixteen main canals, arising from the central gastrozooid and running peripherally, "Along the subumbrella toward the peripheral edge of the limb....they give off innumerable branches; of these the ascending ones enter into the centradenia, the descending vessels

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[1] To avoid the use of the terms "liver" and "kidney" until more accurate knowledge of the functions of the various regions of the centradenia is gained, the following nomenclature, somewhat emended from that of Bedot ('84) is employed. The canals forming the ridges on the upper face of the organ are known as "superior," those below forming the greater mass of the organ ("kidney"), as "inferior". The canals running downward from the level of the limbus toward the tentacular zone, following Haeckel, as radial."

partly into the gonostyles, partly into the tentacles." This concept, as Bedot's work has already suggested, is entirely erroneous. In the first place many more than sixteen canals, arranged in two definite series, an inner and an outer, open into the central gastrozooid. These canals are more fully described below, (p. 339) in small specimens. Instead of running meridionally over the lower surface of the centradenia, they enter the formation of the general complex of inferior canals (Plate 29, fig. 4). The gonozooids (except such as are interpolated among the tentacles in the tentacular zone) connect directly with inferior canals, either with ones passing into the deeper regions of the centradenia, or with the network covering its lower surface. And the cavities of the larger gonozooids often connect with two, or even more canals. Furthermore, contrary to Haeckel's views, a study of sections shows that the canals which open into the central zooid never connect with the tentacles except through the medium of the superior canals, a statement agreeing with Bedot's observations on *P. umbella.*

The brief account by the latter author of the histology of the superior and inferior canals in *P. umbella* agrees so closely with the conditions in *P. pacifica* that I can do no more than substantiate it. But as he did not illustrate it, I add a few figures. The layer of ectoderm underlying the chitinous pneumatocyst is composed of flat tile-shaped cells with deep-staining nuclei (Plate 29, fig. 12). Separating this tissue from the entoderm of the superior canals is a well-marked supporting layer. The walls of these canals are composed of several layers of small, round, closely crowded cells, with large nuclei and granular cytoplasmic bodies of a greenish color in formalin material. They do not enclose the colored spherules so characteristic of the superior canals of Velella. Scattered among them, but much fewer in number, are deep-staining cells, with much larger oval nuclei, and fairly large cytoplasmic bodies of irregular outline.

The walls of the inferior canals are composed for the most part of a single layer of columnar cells, with large cytosomes and small nuclei. Scattered among them there are occasional deep-staining cells with cytosomes resembling those of the deep-staining cells in the walls of the superior canals, but with much smaller nuclei (Plate 29, fig. 14).

Throughout the courses of the inferior canals the columnar cells frequently contain masses of large dense spherules, reddish brown in formalin material. Near the lower surface of the centradenia the spherules occur in the intercellular spaces as well as within the cytoplasm of the cells. Bedot suggests that the spherules result from a metamorphosis of the small granules which fill the bodies of the small round cells in the walls of the superior canals. But the fact that there are apparently no stages connecting the two types of granules, even in the transition region between inferior and superior canals, seems to forbid this conclusion. In general appearance as well as in their relation to the cells, they strongly suggest the colored granules which are so prominent in the endoderm of various Medusae, and I believe they are by-products of digestion. The entoderm cells of the inferior canals enclose great numbers of the transparent greenish guanin crystals (Plate 29, fig. 13) so often described for *P. umbella*. They occur in greatest numbers nearest the lower surface of the centradenia, *i. e.*, furthest from the superior canals. I have likewise observed them in the radial canals of the medusa-buds on the gonophores. It is to be observed that they do not occur in the walls of the canals which open into the central gastrozooid, at least in the neighborhood of the latter; indeed, if they are to be regarded as by-products of digestion, as is no doubt true, their presence would not be expected there.

With regard to the probable function of the different regions of the centradenia but little can be said with confidence. The region of the superior canals was long ago suggested as a liver, that of the intermediate and inferior canals a kidney. The canal system of the whole is no doubt digestive, and the interpretation of the guanin secreting portion as a kidney is probably correct. However it is doubtful whether there is any region of actual excretion. On the contrary, in the absence of excretory pores, it should be rather looked on as an organ for the storage of the waste products of metabolism. The interpretation of the superior canals as functioning as a liver in Porpita is supported by little actual evidence. Whether or not it is correct is doubtful.

*Young stages of Porpita pacifica, 1.5–4 mm. in diameter.* Although the studies of Woltereck (:04) on the larval stages, and of Bedot ('85b) on the "Rataria" stage of Velella have afforded an excellent survey of the development of that genus, the early ontogeny of Porpita still remains almost unknown. A. Agassiz ('83) it is true, was able to trace the changes which take place in the canals of the limbus and of the pneumatophore with development, as well as the formation of tentacles of successive generations after what may be known as the "Discalia" stage. But our only knowledge of the early structure of the centradenia is contained in the brief account by Haeckel of the "Disconula" larvae, and of the "Discalia" and "Disconalia" stages. Of the former he says ('88b, p. 32) that "in the smallest Disconula-larvae which I observed the centradenia is a small circular, biconvex, lenticular disc; its upper face is in direct contact with the pneumatosaccus, whilst its lower face is separated from the central siphon by the gastrobasal plate ("plancher" of Bedot). The entire mass of this solid disc is composed solely of exodermal cells and cnidoblasts; it is not traversed by any canals. The only canals of the centradenia are the eight simple radial canals which run upon its upper face; they arise from the eight ostia of the basigaster, embrace the surface of the lenticular centradenia like eight meridian lines, and unite in the centre of its upper face, forming a typical octoradial 'liver star'." A similar condition is described by him ('88b, p. 48) for the "Discalia" stage.

Although no figures of the "Disconula" are given as evidence for this account, the structure as he outlines it agrees so closely with the oldest Velella larva figured by Woltereck (:04, taf. 19, fig. 18) that we can safely assume that it is correct.

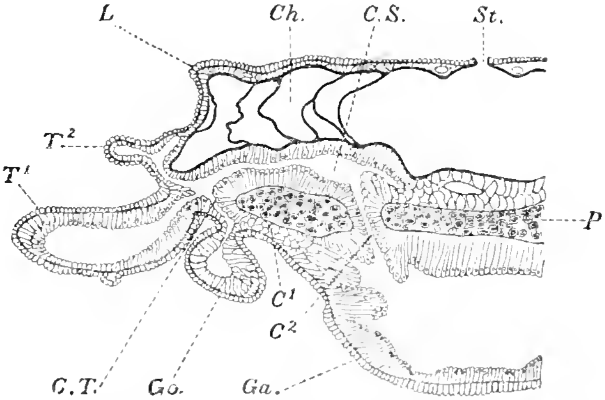

Fig. B. Section of young *Porpita pacifica* 2 mm. in diameter. Ch., circular chamber. C.S superior canal. C¹,C²., descending canals of the younger and older series. C. T., tentacular canal. Go., gonozooid. Ga., central gastrozooid. L, limbus T¹, T², older and younger tentacles. St, central stigma.

A somewhat more advanced, but still very primitive condition is to be seen in specimens of *P. pacifica* 1.5–2 mm. in diameter, with eight gonozooids, and twenty-four tentacles (Fig. B). A surface view of the centradenia of one of these shows that the eight primary superior canals, uniting at the centre as observed by Haeckel, fork di- or trichotomously until there are twenty canals or ridges at the margin, and, as can be worked out on serial sections, the number of ostia opening into the central zooid has increased to twenty-eight. These are arranged in two series, an inner row of eight, connecting by means of short vertical canals with the eight primary superior canals, and an outer series of twenty, close to the margin of the zooid. The outer ostia connect with the outer ends of the canals (fig. B) by solid cell strands without lumen, a fact which, of course, indicates that the communication between them and the canal system of the central gland is more recent than it is in the case of the eight ostia of the inner series, which no doubt correspond to the eight gastric ostia of Haeckel's "Disconula" larva. In our specimen each inner ostium connects with a canal with open lumen, but Woltereck's observations show that this is a secondary condition, for in his larva of Velella these eight first-formed points of communication are represented at first by solid entodermal strands (: 04, taf. 19, fig. 18, K), just as are the communications of the outer series of ostia in our specimens. As yet there is no differentiation between the cell elements composing the walls of the superior canals and the trunks connecting them with the gastric ostia.

In a specimen 4 mm. in diameter, with eleven circular chambers, the gastric ostia of the outer series have increased to about thirty-two, with a corresponding increase in the branching of the superior canals. Furthermore in most instances the connections between the ostia and the latter are by means of open canals, no longer direct but in a network joining the gonozooids on one hand, and the superior canals on the other. The connection, too, between the eight ostia of the inner series and the superior canals, is now indirect, by a network which is only slightly less complex than it is in the adult.

Histologically as well as morphologically, superior and inferior canals can now be separated. In both, the walls are composed of a single layer of cells of two kinds, the first and most numerous, columnar, with granular bodies, the second, small, deep-staining, irregular in outline. In the cells of the inferior canals there occur the large dense spherules, often in masses, which give the characteristic reddish brown color to the lower portion of the centradenia in the adult. But as yet, no crystals have been formed, though they are present in specimens but slightly larger (7 mm.).

*Pneumatophore.* The smallest specimen is intermediate with respect to this structure between the "Discalia" and "Disconalia" stages described by Haeckel, "Discalia" having one, the "Albatross" specimen five, and "Disconalia" seven circular chambers. Radial sections of this example (Fig. B) and of the individual of 4 mm. show that there are no radial chambers here, any more than there are in the adult. On the contrary the eight stigmata of the innermost circle open into the first circular chamber, just as they do in Porpema (p. 327). Surface views of this region are deceiving, because owing to the partial enclosure of the central by the first circular chamber, these eight stigmata appear to open into the former, while the eight ridges on the "ceiling" of the pneumatosaccus appear to divide it into eight compartments. In these stages, all the stigmata are open. I have not been able to determine at what age the central ones become closed over.

Before closing this description I may mention two features, interesting though of less importance than the preceding. These are the limbus and the gonozooids. Regarding the former, it is interesting to note that it is formed much later in Porpita than in Velella. While in the latter it is present in the Conaria larva even before metamorphosis into the Rataria, in the smallest specimen of Porpita collected by the "Albatross" it is only just appearing as a slight ridge on the margin of one side of the disc (fig. B). In the 4 mm. specimen it is well developed. In the smallest specimen only one of the eight gonozooids has a terminal opening, so far as I could determine; in the 4 mm. individual, however, all have open mouths. The fact that they all bear young medusa buds as well, even at this early stage, argues strongly against Haeckel's view that the presence of buds in his "Discalia" and "Disconalia" was evidence of maturity.

## Velellidae Brandt, 1835.

Chun ('97b) has considered in such detail the reasons for reuniting Haeckel's ('88a, '88b) Rataria and Armenista with Velella, that I need only state that like Schneider ('98) and Lens and Van Riemsdijk (:08) I entirely agree with his conclusion that they represent nothing more than early and mature stages in the life history of the later. Velella thus remains the only representative of the family.

### VELELLA Lamarck, 1801.

Modern students of Siphonophores generally support Chun ('97b) in his conclusion that the numerous species of Velellas which have been described from the Atlantic and from the Mediterranean, are at most only local varieties of a single species. For this form Chun employed the name *V. spirans* Forskål. But according to the rules of nomenclature, Schneider was justified in substituting the older name *V. velella* of Linné, because the earliest appearance of the species in binomial literature is *Medusa velella* Linn.

No less than eleven species of Velella have been described from the Indo-Pacific region, but it is certain that they are not all distinct. Chun ('97b, p. 96) though with hesitation on account of the paucity of his material, suggests that all of them, like all of the Atlantic forms, represent only one good species, which he believes to be distinct from the Atlantic *V. velella*. This standpoint has been adopted by Agassiz and Mayer (:02) and by Lens and Van Riemsdijk (:08), who record their specimens from the Pacific and from the Malaysian region, as *V. pacifica* Eschscholtz. But Schneider ('98, p. 194) has taken the more radical ground, from a study of specimens "aus den verschiedensten Meeresgebieten," that all Velellas, both Atlantic and Indo-Pacific, belong to but a single species.

Leaving out of the discussion the early descriptions, none of which are based on sufficiently stable features to be of any real assistance, we find the following characters suggested as points of difference between the Atlantic and Indo-Pacific Velellas. According to A. Agassiz ('65) the numerous specimens which he collected in the Straits of Fuca are much more nearly rectangular in outline than those from the West Indies. Chun ('97b, p. 96) found that "die Form des Mantels (limbus) weicht immerhin so auffällig von jener der *V. spirans* ab, dass jedenfalls die pacifische Art von der atlantischen zu trennen ist." Unfortunately, however, he gave no details as to exactly what the difference is. Fewkes ('89b) and Lens and Van Riemsdijk (:08) suggest that the Pacific species is characterized by a triangular crest.

I have been able to test the importance of these supposed differences on the considerable series from various parts of the Pacific and Atlantic, listed below, with the result that I believe that the separation of the two species is justified. The difference in form, especially of the shell, suggested in Eschscholtz's figures ('29, taf. 15), appears to be constant even if slight, the breadth in proportion to the length being greater in Pacific than in Atlantic specimens: in the former the shell is more nearly rectangular with the long sides straighter; in the latter, it is elliptical, with the long sides more curved.

The exact proportions of a series of sixteen specimens of each species are given in the table below, from which it is also evident that the difference is not only considerable, but discontinuous since all the Pacific examples are broader proportionately than any of the Atlantic specimens. The difference can not be regarded as signifying local variation, for the representatives of the two classes were selected from widely separated localities.

Preserved specimens furnish less satisfactory data on the form of the limbus than they do on the outlines and proportions of the shell. However, in very large Pacific specimens (30–40 mm. long) preserved in formalin, in which this region was in good condition, it is entire, the only subdivisions being obviously accidental tears, instead of irregularly lobed as it has so often been described for *V. velella*. In other respects, I could find no constant difference.

The supposed difference in the form of the crest is not borne out by the series studied, for in small specimens both from the Atlantic it is triangular. Even in the Pacific species this character is transitional, the crest becoming rounded in large specimens: but the triangular form seems to be retained longer in them than it is in *V. velella*.

So far as specimens from different regions of the Pacific are concerned, the present collection shows no features to differentiate more than the one species, and I have no hesitation in following Chun in uniting all previously described Pacific Velellas. However, I am not prepared to follow him in uniting with them the various Indian forms, simply for the reason that it is futile to attempt any revision of the latter without access to a considerable series of specimens from the Indian ocean. It is impossible to tell from the descriptions by Chamisso and Eysenhardt ('21), Eschscholtz ('29) and Brandt ('35) whether their material more nearly resembled the Atlantic, or the Pacific species, or whether they formed a connecting link between the two.

In determining a specific name for the composite Pacific species I may point out that although A. Agassiz ('65b) called his specimens *V. septentrionalis* Eschscholtz, and in spite of the fact Agassiz and Mayer (:02) and Lens and Van Riemsdijk (:08) used the name *V. pacifica* Eschscholtz for Tropical Pacific and Malaysian Velellas, two Pacific species had been described previous to Eschscholtz's work. These are *V. oblonga* and *V. lata* of Chamisso and Eysenhardt ('21). My choice as between the two falls upon *lata,* for the reason that, while both are described on the same page and figured on the same plate, *lata* agrees very well in general form with the Pacific specimens I have examined, whereas *oblonga* is so much longer in proportion to breadth than even the longest Atlantic specimens that it is probably founded on an abnormal individual.

The only Velellas described from the Pacific within recent years, so far as I can learn, are *V. meridionalis* Fewkes ('89b) from the coast of California, and *V. lobata,* Haeckel ('88b) from the South Pacific. The first of these, founded on young specimens as Fewkes himself suggested, is supposed to be separated from the other species from the same region (*V. septentrionalis* = *V. lata* Chamisso and Eysenhardt) by a more oval mantle. But the fact that in the "Albatross" series small specimens have a rounded, larger ones a more nearly rectangular, outline shows that this difference is merely a growth character. *V. lobata* Haeckel was neither described nor figured. It is, therefore, a *nomen nudem.*

## **Velella lata** Chamisso and Eysenhardt.

*Velella lata* Chamisso and Eysenhardt, '21, p. 364, tab. 32, fig. 3 A–B; Eschscholtz, '29, p. 172.
*Velella oblonga* Chamisso and Eysenhardt, '21, p. 364, tab. 32, fig. 2 A–C; Eschscholtz, '29, p. 171; Haeckel, '88b, p. 83.
*Velella sandwichiana* de Haan, '27, p. 493.
*Velella radackiana* de Haan, '27, p. 493.
*Velella emarginata* Quoy and Gaimard, '24, p. 586, pl. 86, fig. 9.
*Velella septentrionalis* Eschscholtz, '29, p. 171, taf. 15, fig. 1; A. Agassiz, '65b, p. 217.

*Velella pacifica* Eschscholtz, '29, p. 174, taf. 14, fig. 4; Agassiz and Mayer, :02, p. 159; Lens and Van Riemsdijk, :08, p. 123.
*Velella cyanea* Lesson, '26, pl. 6, fig. 3, 4; '30, p. 54.
*Velella patellaris* Brandt, '35, p. 38.
*Velella oxyothone* Brandt, '35, p. 39.
*Vellaria oblonga* Haeckel, '88a, p. 31.
*Armenista lata* Haeckel, '88b, p. 84.
*Velella meridionalis* Fewkes, '89b, p. 112, pl. 1, fig. 1–3, pl. 2, fig. 3.
*Velella velella* Schneider, '98, p. 194 (partim).
? *Velella indica* Eschscholtz, '29, p. 175, taf. 15, fig. 5.
? *Velaria indica* Haeckel, '88a, p. 31.

| | | | | |
|---|---|---|---|---|
| Station | 4691 | 14 | specimens | 1–5 mm. long; Rataria stage. |
| " | 4694 | 1 | " | 6 mm. " |
| " | 4696 | 5 | " | All about 2 mm. long; Rataria. |
| " | 4698 | 1 | " | 7 mm. long |
| " | 4707 | 1 | " | " " " |
| " | 4708 | 2 | " | 3 and 8 mm. long. |
| " | 4710 | 3 | " | All about 8 mm. long. |
| " | 4714 | 2 | " | 9 and 12 mm. " |
| " | 4718 | 1 | " | 5 mm. " |
| " | 4720 | 2 | " | 8 and 10 mm. " |

Also:— 5° 36′ N., 86° 55′ W.; 1 specimen 10 mm. long.

| | | | |
|---|---|---|---|
| Long Beach, California | 13 | specimens | all about 50 mm. long. |
| Hawaiian Islands | 20 | " | " " 40 mm. " |
| Hawaiian Islands | 2 | " | " " 35 mm. " |
| Japan or China? | 18 | " | 10–60 mm. " |
| "Voyage S. Francisco–Unalaska" | 8 | specimens | 20–55 mm. long. |
| Port Townsend, Washington | 2 | " | about 50 mm. " |
| 29° 52′ N., 116° 15′ W. | 4 | " | " 40 mm. " |
| Point Buchon, California | 9 | " | 25–40 mm. long |
| Ponape, Caroline Islands | 42 | " | 30–50 mm. long: poor condition |
| 28°3′ N., 126° 57′ W. | 2 | " | 70 mm. and 110 mm. long. |
| 21° 18′ S., 173° 31′ W. | 1 | " | 22 mm. long |
| Bonin Islands | 7 | " | 20–30 mm. long. |
| "Off Lower California" | 3 | " | all about 50 mm. |

I have been able to compare these specimens with large series from Key West and the Tortugas, as well as with a few individuals from Bahia Honda, and from the Mediterranean.

The absence of mature specimens in the "Albatross" collection of 1904–1905 is made even more striking by the fact that only a single large Velella was seen during the Expedition. The clue to this phenomenon is to be found in the fact that the smallest Ratariae were taken in the earliest hauls, while the individuals of later captures grow on the whole larger and larger. A month later large specimens might have been abundant.

The actual dimensions of the shells in a series of Atlantic and Pacific specimens is given in the following table.

| ATLANTIC | | | PACIFIC | | |
|---|---|---|---|---|---|
| Breadth | Length | Ratio Breadth — length (approximate) | Breadth | Length | Ratio Breadth — length (approximate) |
| 11.5 | 31 | 1–2.8 | 11 | 23 | 1–2 |
| 13.5 | 35 | 1–2.8 | 18 | 35 | 1–1.9 |
| 16 | 43 | 1–2.7 | 19 | 39 | 1–2 |
| 17 | 52 | 1–3 | 19 | 40 | 1–2.1 |
| 17 | 54 | 1–3.1 | 20 | 42 | 1–2.1 |
| 18 | 52 | 1–2.8+ | 21 | 42 | 1–2 |
| 18 | 53 | 1–2.9 | 19 | 43 | 1–2.2 |
| 19 | 51 | 1–2.7 | 20 | 44 | 1–2.2 |
| 20 | 63 | 1–3.1 | 22 | 45 | 1–2 |
| 21 | 60 | 1–3 | 22 | 47 | 1–2.1 |
| 22 | 63 | 1–2.8 | 24 | 52 | 1–2.1 |
| 22 | 69 | 1–3.1 | 25 | 54 | 1–2.1 |
| 23 | 68 | 1–2.9 | 27 | 57 | 1–2.1 |
| 24 | 74 | 1–3 | 26 | 59 | 1–2.2 |
| 25 | 67 | 1–2.6 | 36 | 73 | 1–2 |
| 30 | 82 | 1–2.7 | 46 | 104 | 1–2.2 |
| Extremes 1–2.7, 1–3.1 | | | Extremes 1–1.9, 1–2.2 | | |

Of the one hundred and thirty-eight Pacific specimens which are large enough to show obliquity of the crest, seventy-three are "S. W." 64 "N. W." (according to the nomenclature of Chun, '97b). This, together with the fact that the crest is N. W. in all of the five "Siboga" specimens recorded by Lens and Van Riemsdijk (:08, p. 123), contrasted with Chun's observations of 74 S. W. to 6 N. W. in *V. velella*, and A. Agassiz's failure to find a single N. W. specimen among the many hundreds of that species which he studied, shows that the N. W. condition is much more common in the Pacific *V. lata* than in the Atlantic *V. velella*.

*Distribution.* The records of *V. lata* show that it is very generally distributed over the warmer regions of the Pacific, extending northward to Japan, and to Puget Sound. How far it may extend southward is not yet known.

# SYNONYMICAL LIST OF SPECIES NOT COLLECTED BY THE "ALBATROSS."[1]

## Sphaeronectidae.

### Sphaeronectes irregularis (Claus).

*Monophyes irregularis* Claus, '73, p. 259; '74, p. 32, taf. 4, fig. 5, 6, 15, 16; Chun, '88, p. 1154; Haeckel, '88b, p. 128; Chun, '92, p. 82; Chun, '97b, p. 102.
*Monophyes brevitruncata* Chun, '88, p. 1153; '92, p. 79, taf. 8, fig. 1, 2, taf. 9, fig. 1–4; '97b, p. 102.
*Sphaeronectes truncata* Schneider, '98, p. 78 (partim).

### Sphaeronectes princeps Haeckel.

*Sphaeronectes princeps* Haeckel, '88a, p. 34.
*Monophyes princeps* Haeckel, '88b, p. 129, pl. 27, fig. 13, 14.
*Sphaeronectes truncata* Schneider, '98, p. 78 (partim).

### Doromasia picta Chun.

*Doromasia picta* Chun, '88, p. 1154; '92, p. 91, taf. 8, fig. 3–5, taf. 9, fig. 5–10, taf. 10, fig. 1–9; '97b, p. 9.
*Muggiaea bojani* Schneider, '98, p. 88.
*Diphyopsis picta* Mayer, :00, p. 75.

For the synonymy of the Eudoxid referred to this species by Chun, see p. 264.

### *Nectopyramis thetis Bigelow.

*Nectopyramis thetis* Bigelow, :11b, p. 338, pl. 28, fig. 1–4.

## Prayidae.

### Stephanophyes superba Chun.

*Stephanophyes superba* Chun, '88, p. 1164; 91, p. 3, pl. 1–7; '97b, p. 102.
*Rosacea dubia* Schneider, '98, p. 79 (partim. non *Praya dubia* Quoy and Gaimard).

### Desmophyes annectens Haeckel.

*Desmophyes annectens* Haeckel, '88a, p. 36; '88b, p. 170, pl. 30.
*Rosacea diphyes* Schneider, '98, p. 81 (partim).

## Diphyidae.

### Galeolaria truncata (Sars) Huxley.

*Diphyes truncata* Sars, '46, p. 41, pl. 7, fig. 1–12.
*Galeolaria truncata* Huxley, '59, p. 38; Haeckel, '88b, p. 151; Chun, '97b, p. 17; Vanhöffen, :06, p. 15, fig. 10–12; Lens and Van Riemsdijk, :08, p. 57.
*Epibulia truncata* Haeckel, '88a, p. 35.
*Diphyes appendiculata* Schneider, '98, p. 85 (partim).

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[1] This list includes the names of forms entitled to specific recognition. An * indicates the species I have studied.

? *Diphyes conoidea* KEFFERSTEIN and EHLERS, '61, p. 16, taf. 5, fig. 6, 7.
? *Epibulia inflata* CHUN, '88, p. 1157.
? *Galeolaria inflata* CHUN, '97b, p. 17.

### **Diphyes arctica** CHUN.

*Diphyes arctica* CHUN, '97b, p. 19, taf. 1, fig. 1–10; VANHÖFFEN, '98, p. 274, taf. 2, fig. 3; RÖMER and SCHAUDINN, '99, p. 245; :00, p. 55; RÖMER, :02, p. 174; VANHÖFFEN, :06, p. 17, fig. 16–18; DAMAS and KOEFOED, :07, p. 318; BROCH, :08, p. 3.
*Diphyes borealis* CHUN, '97b, p. 99.
*Muggiaea arctica* SCHNEIDER, '98, p. 89.
*Eudoxia eschscholtzii* JOHANSEN and LEVINSEN, :03, p. 282 (non BUSCH, '51).
*Muggiaea atlantica* Bull Conseil Int. :04, p. 81, 118, 156 (non CUNNINGHAM, '92).

Römer in his synonymy (:02, p. 174) credits *Cymbonectes borealis* to Vanhöffen, '98, p. 274; but it does not occur at that citation, nor in Vanhöffen's explanation of plates.

### **Diphyes steenstrupi** GEGENBAUR.

*Diphyes steenstrupi* GEGENBAUR, '60, p. 369, taf. 29, fig. 27–29; CHUN, '97b, p. 103; LENS and VAN RIEMSDIJK, :08, p. 44.
*Diphyes dispar* SCHNEIDER, '98, p. 84 (partim).

### **Diphyes serrata** CHUN.

*Diphyes serrata* CHUN, '88, p. 1158; '97b, p. 26; LENS and VAN RIEMSDIJK, :08, p. 44.
*Eudoxia serrata* CHUN, '88, p. 1159; '97b, p. 26.
*Diphyes appendiculata* SCHNEIDER, '98, p. 85 (partim).

*D. steenstrupi and D. serrata* are closely allied to each other, and to *D. bojani* (p. 245).

### ***Diphyes subtilis** CHUN.

*Ersaea elongata* WILL, '44, p. 8, pl. 2, fig. 30, 31. EUDOXID (non *Diphyes elongata* HYNDMAN, '41).
*Monophyes gracilis* CHUN, '85, p. 513, (partim) fig. 3–5 (non CLAUS, '74).
*Diphyes subtilis* CHUN, '86, p. 681; '97b, p. 103; LENS and VAN RIEMSDIJK, :08, p. 17.
*Monophyes diptera* HAECKEL, '88b, p. 129.
*Cucullus subtilis* HAECKEL, '88b, p. 111. (EUDOXID.)
*Diphyes elongata* SCHNEIDER, '98, p. 85 (non HYNDMAN, '41).

### **Diphyes subtiloides** LENS and VAN RIEMSDIJK.

*Diphyes subtiloides* LENS and VAN RIEMSDIJK, :08, p. 46, pl. 7, fig. 59–61.

### ***Diphyopsis chamissonis** (HUXLEY).

*Diphyes chamissonis* HUXLEY, '59, p. 36, pl. 1, fig. 3; BROWNE, :04, p. 712, pl. 51, fig. 6; :05, p. 155.
*Muggiaea chamissonis* HAECKEL, '88a, p. 31; '88b, p. 137; CHUN, '92, p. 89.
*Muggiaea kochii* MURBACH and SHEARER, :03, p. 189.
*Diphyopsis weberi* LENS and VAN RIEMSDIJK, :08, p. 53, pl. 8, fig. 67, 68.

### **Diphyopsis hispaniana** MAYER.

*Diphyopsis hispaniana* MAYER, :00, p. 76, pl. 29, fig. 98–99.
*Ersaea hispaniana* MAYER, :00, p. 78.

Closely allied to *D. mitra*, p. 244.

## Apolemiidae.

### **Apolemia uvaria** (Lamarck) Eschscholtz

*Stephanomia uvaria* Lamarck, '16, p. 462 (*Stephanomia uviformis* Lesueur, Ms.).
*Apolemia uvaria* Eschscholtz, '29, p. 143, taf. 13, fig. 2; Kölliker, '53, p. 18, taf. 6, fig. 6–9; Gegenbaur, '53, p. 319, taf. 18, fig. 1–4; Keferstein and Ehlers, '61, p. 25; Claus, '63, p. 537, taf. 46; Chun, '97b, p. 103; Schneider, '98, p. 117.
*Apolemia urania* Blainville, '34, p. 119, pl. 3, fig. 1, 1a, 1b (copied from Lesueur, Ms.).
*Physophora uloplylla* Costa, '36, p. 12, taf. 4.
*Apolemia leseuria* Lesson, '43, p. 518.
*Agalma punctata* Vogt, '54, p. 83, taf. 12.
*Apolemopsis uviformis* (or *Apolemia lesueuria*) Haeckel, '88b, p. 213.
? *Dicymba diphyopsis* Haeckel, '88a, p. 39; '88b, p. 210, pl. 18, fig. 1–7.
? *Apolemopsis dubia* Brandt, '35, p. 35.
? *Apolemia dubia* Haeckel, '88a, p. 39.

## Forskaliidae.

It is useless to attempt a synonymical list of the species of Forskalia, without studying series of specimens from various localities (p. 270). For lists of citations of the genus see Bedot, '93a, p. 250–252, and Schneider, '98, p. 157.

### **Erenna bedoti** Lens and Van Riemsdijk.

*Erenna bedoti* Lens and Van Riemsdijk, '08, p. 66, pl. 11, fig. 85–90.

Closely allied to *E. richardi*, p. 271.

## Agalmidae.

### **Anthemodes ordinata** Haeckel.

*Anthemodes ordinata* Haeckel, '88a, p. 40; '88b, p. 229, pl. 14, 15; Bedot, '96, p. 409; Chun, '97b, p. 104; Schneider, '98, p. 117.

### **Agalma clausi** Bedot, '88.

*Agalma sarsi* Fewkes, '80a, p. 137, pl. 2, fig. 2 (non *Agalmopsis sarsii* Kölliker, '53, p. 101, taf. 3).
*Agalma clausi* Bedot, '88, p. 74, pl. 3, 4.
*Crystallodes clausi* Bedot, '88, p. 91.
*Stephanopsis clausi* Bedot, '96, p. 406.
*Stephanomia sarsi* Schneider, '98, p. 121.

### **Agalma haeckeli**, nom. nov. (p. 277).

*Agalma eschscholtzi* Haeckel, '88b, p. 226, pl. 18, fig. 8–17; Bedot, '96, p. 405. (non Lesson, '43, p. 511).
*Stephanomia sarsi* Schneider, '98, p. 121 (partim).

Closely allied to *A. clausi* Bedot (p. 276).

### ***Stephanomia rubra** (Vogt).

*Agalma rubra* Vogt, '52, p. 522; '54, p. 62, taf. 7–11.
*Agalmopsis punctata* Kölliker, '53, p. 15, tab. 4.
*Agalmopsis rubra* Leuckart, '53, p. 3; Schneider, '98, p. 123; '99, p. 27, taf. 4, fig. 34–42.

*Agalma rubrum* Leuckart, '54, p. 321, taf. 12, fig. 12–20; Schneider, '96.
*Agalma minimum* Graeffe, '60, p. 15, taf. 2, 3.
*Halistemma rubrum* Huxley, '59, p. 70; Haeckel, '88b, p. 367; Bedot, '96, p. 407; Woltereck, :05b, p. 612.

### **Stephanomia cupulifera** (Lens and Van Riemsdijk).

*Halistemma cupulifera* Lens and Van Riemsdijk, :08, p. 85, pl. 16, fig. 116–119.

### **Stephanomia cara** (A. Agassiz) Metschnikoff.

*Nanomia cara* A. Agassiz, '65a, p. 181; '65b, p. 200, fig. 331–350; Moss, '79, p. 123; Fewkes, '88a, p. 213.
*Stephanomia cara* Metschnoikoff, '74, p. 62.
*Agalmopsis (cara)* Fewkes, '80, p. 135.
*Agalmopsis (Nanomia) cara* Fewkes, '89a, p. 965.
*Halistemma carum* Haeckel, '88a, p. 40.
*Cupulita cara* Haeckel, '88b, p. 367; Bedot, '98, p. 408; Chun, '97b, p. 103; Römer, :02, p. 177; Vanhöffen, :06, p. 177.

For a complete list of references, see Römer (:02).

### **Lynchnagalma utricularia** Claus.

*Agalmopsis utricularia* Claus, '79, p. 1 (190), taf. 18.
*Callingalma utricularia* Fewkes, '82a, p. 268, footnote.
*Agalma utricularia* Carus, '85, p. 48.
*Lynchnagalma vesicularia* Haeckel, '88a, p. 40; '88b, p. 235, pl. 16.
*Lynchnagalma utricularia* Haeckel, '88a, p. 40; '88b, p. 235; Bedot, '96, p. 410.
*Cupulita utricularia* Schneider, '98, p. 124.

## Anthophysidae.

### **Athorybia rosacea** (Forskål) Eschscholtz.

*Physophora rosacea* Forskal, 1775, p. 120. 1776, taf. 43, fig. B; Modeer, 1789, p. 283.
*Rhizaphysa rosacea* Lamarck, '16, p. 478.
*Rhizophysa melo* Quoy and Gaimard, '27, p. 180, pl. 5e, fig. 1–9.
*Rhizophysa heliantha* Quoy and Gaimard, '27, p. 177, pl. 5a, fig. 1–8.
*Athorybia heliantha + melo + rosacea* Eschscholtz, '29, p. 153, 154.
*Rhodophysa helianthus* Blainville, '30, p. 112; '34, p. 123.
*Rhodophysa melo* Blainville, '30, p. 112; '34, p. 123.
*Rhodophysa rosacea* Blainville, '30, p. 112; '34, p. 123.
*Atharybia rosacea* Kölliker, '53, p. 24, taf. 7; Schneider, '98, p. 162.
*Athorybia heliantha* Gegenbaur, '60, p. 112, taf. 32, fig. 43, 44.
*Atharybia melo* Chun, '88, p. 1172.
*Athorybia rosacea + heliantha* Haeckel, '88b, p. 275.
*Athorybia ocellata* Haeckel, '88a, p. 42; '88b, p. 276, pl. 11, pl. 12, fig. 10–18.
*Melophysa melo* Haeckel, '88a, p. 42; '88b, p. 274.
*Athorybia melo* Chun, '97b, p. 49, taf. 4.
*Athorybia rosacea* Chun, '97b, p. 49.
? *Athorybia rosacea* Huxley, '59, p. 86, pl. 9.
? *Athorybia indica* Haeckel, '88b, p. 275.

### **Anthophysa formosa** (Fewkes) Haeckel.

*Athorybia formosa* Fewkes, '82a, p. 271–275, pl. 5, fig. 3, 4, pl. 6, fig. 7–14; Schneider, '98, p. 162.
*Ploeaphysa agassizii* Fewkes, '88b, p. 317, pl. 17, fig. 1, 2
*Diplorybia (formosa)* Fewkes, '88b, p. 320, footnote.

*Anthophysa formosa* Haeckel, '88a, p. 43; '88b, p. 278.
*Anthophysa darwinii* Haeckel, '88a, p. 43; '88b, p. 278, pl. 12, fig. 7–9.
*Anthophysa formosa* Chun, '97b, p. 61, taf. 3, fig. 7, 8; Bedot, :01, p. 5, pl. 1, fig. 4–15.
? *Angela cytherea* Lesson, '43, p. 496, pl. 9, fig. 1.

Closely allied to *A. rosea* (p. 296).

## Rhodaliidae.

### Rhodalia miranda Haeckel.

*Rhodalia miranda* Haeckel, '88a, p. 42; '88b, p. 302, pl. 1–5; Chun, '97b, p. 104; Lens and Van Riemsdijk, :08, p. 91.
*Angelopsis globosa* Schneider, '98, p. 157 (partim).
? *Rhodalia species* Brooks and Conklin, '91.

### Stephalia corona Haeckel.

*Stephalia corona* Haeckel, '88a, p. 43; '88b, p. 297, pl. 7; Chun, '97b, p. 104; Vanhöffen, :06, p. 33, fig. 52.
*Stephonalia bathyphysa* Haeckel, '88b, p. 298, pl. 6.
*Angela corona* Schneider, '98, p. 156.
? *Circalia stephanoma* Haeckel, '88b, p. 198, pl. 21, fig. 1–4; Vanhöffen, :06, p. 34, fig. 54.

### Angelopsis globosa Fewkes.

*Angelopsis globosa* Fewkes, '86, p. 972, pl. 10, fig. 4, 5; '89a, p. 146, pl. 7, fig. 1–3; Chun, '97b, p. 104; Schneider, '98, p. 157 (partim), Lens and Van Riemsdijk, :08, p. 89.
*Auralia profunda* Haeckel, '88a, p. 42; '88b, p. 301.

Closely allied to *A. dilata* (p. 310).

### * Archangelopsis typica Lens and Van Riemsdijk.

*Archangelopsis typica* Lens and Van Riemsdijk, :08, p. 91, pl. 17, pl. 18, fig. 137–140.

## Rhizophysidae.

### Epibulia ritteriana Haeckel.

*Epibulia ritteriana* Haeckel, '88b, p. 335, pl. 22, fig. 6–8.
*Cystalia challengeri* Haeckel, '88a, p. 44.
*Cystalia monogastrica* Haeckel, '88b, p. 316, pl. 22, fig. 1–5.
*Epibulia erythrophysa* Schneider, '98, p. 172.
? *Epibulia (Brachysoma) erythrophysa* Brandt, '35, p. 33; Haeckel, '88b, p. 334.
? *Rhizophysa chamissonis* Eysenhardt, '21b, p. 420, pl. 35, fig. 3.
? *Epibulia (Rhizophysa) chamissonis* Eschscholtz, '29, p. 149; Haeckel, '88b, p. 334.
? *Brachysoma chamissonis* Lesson, '43, p. 493.
? *Brachysoma erythrophysa* Lesson, '43, p. 493.
? *Cystalia larvalis* Haeckel, '88a, p. 44.
? *Arethusa erythrophysa* Haeckel, '88a, p. 46.
? *Arethusa chamissonis* Haeckel, '88a, p. 46.

### Salacia uvaria (Fewkes) Haeckel.

*Rhizophysa uvaria* Fewkes, '86, p. 967, pl. 10, fig. 6; Schneider, '98, p. 170.
*Salacia polygastrica* Haeckel, '88a, p. 45; '88b, p. 331, pl. 25; Chun, '97b, p. 104.
*Salacia uvaria* Haeckel, '88a, p. 45; '88b, p. 330.

### **Bathyphysa abyssorum** Studer.

*Bathyphysa abyssorum* Studer, '78, p. 21, taf. 3; Haeckel, '88b, p. 248; Chun, '97b, p. 104; Schneider, '98, p. 171 (partim); Lens and Van Riemsdijk, : 08, p. 105.

### **Bathyphysa sibogae** Lens and Van Riemsdijk.

*Bathyphysa sibogae* Lens and Van Riemsdijk, : 08, p. 114, pl. 20, fig. 148, pl. 23, fig. 160–161, pl. 24, fig. 173.

### **Pterophysa studeri** Lens and Van Riemsdijk.

*Pterophysa (Bathyphysa) studeri* Lens and Van Riemsdijk, : 08, p. 111, pl. 20, fig. 149, pl. 22, fig. 153–155, 157–159, pl. 23, fig. 165, pl. 24, fig. 171.

### **Pterophysa grandis** Fewkes.

*Pterophysa grandis* Fewkes, '86, p. 969, pl. 10, fig. 1–3; Chun, '97b, p. 104; Lens and Van Riemsdijk, : 08, p. 107, pl. 19, pl. 24, fig. 167–170.
*Bathyphysa grandis* Haeckel, '88b, p. 249.
*Bathyphysa abyssorum* Schneider, '98, p. 171 (partim).
? *Rhizophysa conifera* Studer, '78, p. 4, taf. 1, fig. 2, 4–7, taf. 2, fig. 13–18.
? *Linophysa conifera* Haeckel, '88a, p. 45; '88b, p. 326.
? *Pterophysa conifera* Schneider, '98, p. 171; Lens and Van Riemsdijk, : 08, p. 106.

### **Pterophysa grimaldii** (Bedot) Lens and Van Riemsdijk.

*Bathyphysa grimaldii* Bedot, '93b, p. 4, pl. 1; : 04, p. 14, pl. 3, 4; Chun, '97b, p. 104.
*Pterophysa abyssorum* Schneider, '98, p. 171 (partim).
*Pterophysa grimaldii* Lens and Van Riemsdijk, : 08, p. 107.

Closely allied to *Pt. grandis* (p. 321).

## Physaliidae.

### * **Physalia physalis** (Linné) Schneider.

*Holothuria physalis* Linné, 1758, p. 657; Gmelin, 1790, p. 3139.
*Medusa caravella* O. F. Müller, 1776, p. 190, taf. 2, fig. 2; Gmelin, 1790, p. 3156.
*Physsophora physalis* Modeer, 1789, p. 285, taf. 10, fig. 1, 2.
*Physalis pelagica* Lamarck, '01, p. 356; Bory de St. Vincent, '04, p. 288, pl. 54, fig. 1; Lamarck, '16, p. 480; Eysenhardt, '21b, p. 45, taf. 35, fig. 2; Eschscholtz, '29, p. 162; Olfers, '32, p. 38; Lesson, '43, p. 545; Huxley, '59, p. 100; Haeckel, '88b, p. 351; Mayer, : 00b, p. 73.
*Physalia pelasgica* Bosc, : 02, p. 159.
*Physalia gigantea* Bory de St. Vincent, '04, p. 288.
*Physalia arethusa* Tilesius, '10, p. 91; Eysenhardt, '21b, p. 420, pl. 35, fig. 1; Olfers, '32, p. 155, taf. 1–2; Delle Chiaje, '11, taf. 33, fig. 1; L. Agassiz, '62, pl. 35; Chun, '97b, p. 89.
*Physalis glauca* Tilesius, '10, p. 92; Blainville, '34, p. 113.
*Physalis pelagica* Tilesius, '10, p. 94.
*Physalia elongata* Lamarck, '16, p. 481.
*Physalia tuberculosa* Lamarck, '16, p. 481.
*Physalia caravella* Eschscholtz, '29, p. 160, taf. 4, fig. 1; Carus, '85, p. 49; Chun, '88, p. 1173.
*Physalia atlantica* Lesson, '26, pl. 4, fig. 3, 4, '30, p. 36.
*Physalia antarctica* Lesson, '26, pl. 5, fig. 2, '30, p. 36.
*Physalia azoricum* Lesson, '26, pl. 5, fig. 4; '30, p. 42; '43, p. 555.
*Physalus arethusa* Blainville, '34, p. 113.
*Physalia (Alophota) olfersii* Brandt, '35, p. 37.
*Physalia utriculus* Leuckart, '51, p. 190, taf. 6, fig. 1–6 (non Eschscholtz, '29; Chun, '97b; Lens and Van Riemsdijk, : 08).

*Physalia olfersii* Quatrefages, '54, p. 109, pl. 3, 4.
*Physalia aurigera* McCrady, '57, p. 74.
*Alophota olfersii* Haeckel, '88a, p. 46.
*Alophota giltschiana* Haeckel, '88a, p. 46; '88b, p. 348, pl. 26, fig. 1–3.
*Arethusa challengeri* Haeckel, '88a, p. 46; '88b, p. 349, pl. 26, fig. 4–8.
*Caravella maxima* Haeckel, '88b, p. 352, pl. 26, f. 1, 2.
*Caravella gigantea* Haeckel, '88b, p. 352.
*Physalia maxima* Goto, '97, p. 175, taf. 15.
*Physalia physalis* Schneider, '98, p. 190; Richter, :07, p. 571, taf. 27, fig. 14–18, taf. 28, fig. 19–26.
? *Physalia megalista* Péron and Lesueur, '07, p. 42, pl. 29, fig. 1; Lamarck, '16, p. 481 (non Brandt, '35; Bigelow, :04).
? *Physalia gaimardii* Blainville, '26, p. 132.

## Porpitidae.

### **Porpema globosa** (Eschscholtz).

*Porpita globosa* Eschscholtz, '25, p. 744; '29, p. 178, taf. 16, fig. 4; Schneider, '98, p. 195 (partim).
*Porpalia globosa* Haeckel, '88a, p. 30; '88b, p. 58.
*Porpema medusa* Haeckel, '88a, p. 30; '88b, p. 61, pl. 47.

### * **Porpita umbella** (O. F. Müller) Eschscholtz.

*Holothuria denudata* Forskål, 1775, p. 103; 1776, taf. 264.
*Medusa umbella* O. F. Müller, 1776, p. 295, taf. 9, fig. 2, 3.
*Holothuria nuda* Gmelin, 1790, p. 3143.
*Phyllodoce denudata* Modeer, 1790, p. 201.
*Porpita nuda* Bruguière, 1791, p. 139, taf. 90, fig. 3–5.
*Porpita glandifera* Bruguière, 1791, p. 139, taf. 90, fig. 6–7; Lamarck, '16, p. 485; Blainville, '34, p. 307.
*Porpita radiata* Bory de St. Vincent, '04, p. 97, pl. 5, fig. 2A–2D
*Porpita gigantea* Péron and Lesueur, '07, pl. 31, fig. 6; Lamarck, '16, p. 485; Lesson, '43, p. 589.
*Porpita granulata* Cranch, '18, p. 418.
*Porpita atlantica* Lesson, '26, pl. 7, fig. 2, '30, p. 58.
*Polybrachionia linneana* Guilding, '27, p. 297.
*Porpita forskali* Van der Hoeven, '28
*Porpita moneta* Risso, '26, p. 305.
*Porpita umbella* Eschscholtz, '29, p. 179; Huxley, '59, p. 121; Haeckel, '88b, p. 67; Chun, '97b, p. 90
*Porpita mediterranea* Eschscholtz, '29, p. 177; Lesson, '43, p. 586; Kölliker, '53, p. 57, taf. 12; Huxley, '59, p. 120; Bedot, '85a, p. 189; Haeckel, '88b, p. 67.
*Porpita linneana* Lesson, '43, p. 588; McCrady, '57, p. 42; L. Agassiz, '62, p. 366; A. Agassiz, '65b, p. 218; '83, p. 12, pl. 7–12; Mayer, :00, p. 72.
*Porpita porpita* Schneider, '98, p. 194 (partim).
? *Ratis medusae* Lesson, '30, p. 60; '43, p. 592.
? *Acies palpebrans* Lesson, '30, p. 61; '43, p. 592.

*Porpita umbella* and the following species *P. porpita* Linné are treated separately in this synonymy, because it is not yet known whether the Atlantic and Indian Porpitas are identical (p. 332). Should they finally be united, *umbella* must be superseded by *porpita*.

### **Porpita porpita** (Linné) Schneider.

*Medusa porpita* Linné, 1758, p. 659.
*Porpita indica* Lamarck, '01, p. 355; Bosc, '02, p. 155.
*Porpita porpita* Schneider, '98, p. 194 (partim).
? *Porpita reinwardtii* de Haan, '27, p. 493.
? *Porpita forskahli* de Haan, '27, p. 493.
? *Porpita kuhli* de Haan, '27, p. 491.
? *Porpita chrysocoma* Lesson, '26, pl. 7, fig. 1, 1'; '30, p. 58.
? *Porpita umbella* Lens and Van Riemsdijk, :08, p. 122.

## Velellidae.

### * **Velella velella** (Linné) Schneider.

*Medusa velella* Linné, 1758, p. 660; Gmelin, 1790, p. 3155.
*Holothuria spirans* Forskål, 1775, p. 104; 1776, taf. 26k; Gmelin, 1790, p. 3143; Bruguière, 1791, pl. 90, fig. 1, 2.
*Phyllodice velella* Browne, 1789, p. 387, pl. 48, fig. 1.
*Velella mutica* Lamarck, '01, p. 355; '16, p. 282; Bosc, '02, p. 158; Lesson, '26, pl. 6, fig. 1, 2; '30, p. 52; '43, p. 571, pl. 12, fig. 1, 2; A. Agassiz, '83, p. 2, pl. 1–6.
*Velella tentaculata* Lamarck, '01, p. 355; Bosc, '02, p. 159, pl. 19, fig. 3, 4.
*Velella scaphidia* Péron and Lesueur, '07, p. 44, pl. 60.
*Velella pocillum* Fleming, '15, p. 500.
*Medusa pocillum* Montagu, '15, p. 201, pl. 14, fig. 4.
*Aglaura crista* Oken, '16, p. 125.
*Velella limbosa* Lamarck, '16, p. 182; Grant, '33, p. 14; Blainville, '34, p. 304.
*Velella pyramidalis* Cranch, '18, p. 119.
*Velella emarginata* Quoy and Gaimard, '21, p. 586, pl. 86, fig. 9; Lesson, '43, p. 576; Thompson, '44, p. 281.
*Velella australis* De Haan, '27.
*Rataria mitrata* Eschscholtz, '29, p. 168, pl. 16, fig. 2.
*Rataria pocillum* Eschscholtz, '29, p. 168.
*Velella aurora* Eschscholtz, '29, p. 171.
*Velella spirans* Eschscholtz, '29, p. 172; Kolliker, '53, p. 47, taf. 11, fig. 9–15; Vogt, '54, p. 5, pl. 1, 2; Bedot, '84, p. 491; Haeckel, '88b, p. 83; Chun, '97b, p. 93.
*Velella caurina* Eschscholtz, '29, p. 173, pl. 15, fig. 2; Haeckel, '88b, p. 83.
*Velella tropica* Eschscholtz, '29, p. 174, pl. 15, fig. 3.
*Armenistarium velella* Costa, '41, p. 187, pl. 13, fig. 2.
*Chrysomitra striata* Gegenbaur, '56, p. 232, taf. 7, fig. 10, 11; Carus, '85, p. 49. (Medusoid gonophore.)
*Rataria cristata* Haeckel, '88a, p. 31; '88b, p. 79, pl. 44.
*Velaria mutica* Haeckel, '88a, p. 31.
*Rataria cristata* Haeckel, '88a, p. 31.
*Armenista sigmoides*, Haeckel, '88b, p. 84, pl. 43.
*Armenista mutica* Haeckel, '88b, p. 84.
*Velella velella* Schneider, '98, p. 194 (partim).
*Velella subemarginata* Stephens, :05, p. 65.
? *Velella antarctica* Eschscholtz, '29, p. 175.
? *Armenista antarctica* Haeckel, '88b, p. 84.

## DOUBTFUL SPECIES.

Forms insufficiently described which can not be identified, even provisionally, with any known species. The earlier names have appeared under various synonyms. For their history see Lesson, ('43) and Bedot, ('96).

### Calycophorae.

**Enneagonum hyalinum** Quoy and Gaimard.

*Enneagonum hyalinum* Quoy and Gaimard, '27, p. 18, pl. 20, fig. 1–6.
*Diphyes enneagona* Quoy and Gaimard, '34, p. 100, pl. 5, fig. 1–6.

**Tetragonum belzoni** Quoy and Gaimard.

*Tetragonum belzoni* Quoy and Gaimard, '24, p. 579, pl. 86, fig. 11.

**Diphyes truncata** Quoy and Gaimard.

*Diphyes truncata* Quoy and Gaimard, '34, p. 97, pl. 5, fig. 21–23.

**Diphyes hispida** Quoy and Gaimard.

*Diphyes hispida* Quoy and Gaimard, '34, p. 103, pl. 5, fig. 24.

**Diphyes tetragona** Quoy and Gaimard.

*Diphyes tetragona* Quoy and Gaimard, '34, p. 101, pl. 5, fig. 25, 26.

**Diphyes quinquedentata** Quoy and Gaimard.

*Diphyes quinquedentata* Quoy and Gaimard, '34, p. 102, pl. 5, fig. 27–29.

**Diphyes cucubalus** Quoy and Gaimard.

*Diphyes cucubalus* Quoy and Gaimard, '34, p. 94, pl. 4, fig. 24–27.

**Diphysa singularis** Blainville.

*Diphysa singularis* Blainville, '30, p. 107; '34, p. 117.

**Galeolaria quadridentata** Quoy and Gaimard.

*Galeolaria quadridentata* Quoy and Gaimard, '34, p. 45, pl. 5, fig. 32, 33.

**Galeolaria ovata** Keferstein and Ehlers.

*Diphyes ovata* Keferstein and Ehlers, '61, p. 17, pl. 5, fig. 1–5.
*Galeolaria ovata* Chun, '97b, p. 14, fig. 1; Lens and Van Riemsdijk, :08, p. 57.

**Desmalia imbricata** Haeckel.

*Desmophyes imbricata* Haeckel, '88a, p. 36.
*Desmalia imbricata* Haeckel, '88b, p. 169.

### **Clausophyes galatea** LENS and VAN RIEMSDIJK.

*Clausophyes galatea* LENS and VAN RIEMSDIJK, :08, p. 12, pl. 1, fig. 6–8.

## Physophorae.

### **Stephanomia laevigata** QUOY and GAIMARD.

*Stephanomia laevigata* QUOY and GAIMARD, '24, p. 585, pl. 86, fig. 2.

### **Stephanomia imbricata** QUOY and GAIMARD.

*Stephanomia imbricata* QUOY and GAIMARD, '34, p. 71, pl. 3, fig. 13–15.

### **Stephanomia tectum** QUOY and GAIMARD.

*Stephanomia tectum* QUOY and Gaimard, '34, p. 78, pl. 2, fig. 26.

### **Stephanomia foliacea** QUOY and GAIMARD.

*Stephanomia foliacea* QUOY and GAIMARD, '34, p. 74, pl. 3, fig. 8–12.

### **Stephanomia cirrhosa** QUOY and GAIMARD.

*Stephanomia cirrhosa* QUOY and GAIMARD, '34, p. 79, pl. 3, fig. 22–25.

### **Stephanomia contorta** MELVILLE.

*Stephanomia contorta* MELVILLE, '51.

### **Cupulita boodwich** QUOY and GAIMARD.

*Cupulita boodwich* QUOY and GAIMARD, '24, p. 380, pl. 87, fig. 14–16.

### **Polytomus lamanon** QUOY and GAIMARD.

*Polytomus lamanon* QUOY and GAIMARD, '24, pl. 87, fig. 12.

### **Pontocardia cruciata** LESSON.

*Pontocardia cruciata* LESSON, '27, p. 17, pl. 10B.

### **Plethosoma coerulea** LESSON.

*Plethosoma coerulea* LESSON, '30, p. 66.

### **Rhizophysa peronii** ESCHSCHOLTZ.

*Rhizophysa peronii* ESCHSCHOLTZ, '29, p. 148, pl. 13, fig. 3–3c.

### **Physsophora alba** QUOY and GAIMARD.

*Physsophora alba* QUOY and GAIMARD, '34, p. 53, pl. 1, fig. 1–9.

### **Physsophora intermedia** QUOY and GAIMARD.

*Physsophora intermedia* QUOY and GAIMARD, '34, p. 56, pl. 1, fig. 10–18.

### **Physsophora australis** QUOY and GAIMARD.

*Physsophora australis* QUOY and GAIMARD, '34, p. 57, pl. 1, fig. 19–21.

### **Agalma eschscholtzii** Lesson.

*Agalma eschscholtzii* Lesson, '43, p. 511.

### **Agalma gettyana** Melville.

*Agalma gettyana* Melville, '51.

### **Agalma papillosum** Fewkes.

*Agalma papillosum* Fewkes, '82a, p. 266, pl. 5, fig. 5, 6, pl. 6, fig. 27.

### **Agalma viridis** Mayer.

*Agalma viridis* Mayer, :00, p. 80, pl. 35, fig. 119–121.

### **Athoria larvalis** Haeckel.

*Athoria larvalis* Haeckel, '88a, p. 39; 88b, p. 202, pl. 21, fig. 5–8.

### **Athoralia coronula** Haeckel.

*Athoralia coronula* Haeckel, '88a, p. 39; 88b, p. 204.

The four preceding forms are larval Agalmids which can not be connected with adult species.

### **Rhodophysa corona** Haeckel.

*Rhodophysa corona* Haeckel, '88a, p. 42; 88b, p. 274 (non Blainville, '30; '34).

### **Haliphyta magnifica** Fewkes.

*Haliphyta magnifica* Fewkes, '82b, p. 302, pl. 1, fig. 37–40.[1]

### **Pleurophysa insignis** Fewkes.

*Pleurophysa insignis* Fewkes, '89e, p. 517.[1]

### **Plutus cnidoporus** Schneider.

*Plutus cnidoporus* Schneider, :00, p. 18, pl. 60, fig. 13, pl. 3, fig. 129, 130, pl. 5, 186.

## EUDOXIDS NOT CONNECTED WITH THEIR PARENT SPECIES.

### **Ceratocymba sagittata** Quoy and Gaimard.

*Cymba sagittata* Quoy and Gaimard, '27, p. 16, pl. 2C, fig. 1–9; Eschscholtz, '29, p. 134; Lesson, '43, p. 454.
*Diphyes cymba* Quoy and Gaimard, '31, p. 95, pl. 5, fig. 12–17.
*Nacella sagittata* Blainville, '30, p. 120; '34, p. 131, pl. 4, fig. 2.
*Ceratocymba spectabilis* Chun, '88, p. 1160
*Ceratocymba sagittata* Chun, '97b, p. 33 (non Bedot, :04)

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[1] Fragmentary material.

**Enneagonoides quoyi** HUXLEY.

*Enneagonoides qouyi* HUXLEY, '59, p. 65, pl. 1, fig. 6.

**Enneagonoides picteti** BEDOT.

*Enneagonoides picteti* BEDOT, '96, p. 377, pl. 12, fig. 7.

**Eudoxia rigida** SCHNEIDER.

*Eudoxia rigida* SCHNEIDER, '98, p. 93.

## GEOGRAPHICAL DISTRIBUTION.

### I. *The Tropical Pacific.*

The oceanographic features of the region traversed by the "Albatross" during the winter of 1904–1905 have been described in full by the leader of the Expedition (A. Agassiz, :06). But for a clear understanding of what is to follow, I must recapitulate here such facts as are of interest to the zoögeographer.

In the first place the Eastern Tropical Pacific, one of the largest oceanic areas on the globe, is interrupted by but few small islands. "Here, if anywhere we might expect to find the pelagic fauna unaffected by the disturbing elements, such as vertical circulation of water, food supply, and the like, which are associated with every coast line, no matter how abrupt it may be." (Bigelow, :09a, p. 221). In the second place the holoplanktonic coelenterate fauna of the region was previously known only from a few scattered records. And lastly, and most important, the lines run by the "Albatross" were planned to give sections of the great "Humboldt" or "Chile-Peruvian" Current and to afford a comparison between the fauna of its cold waters and that of the warmer regions to the west, southwest, and northwest of it. This Current, long known to geographers, has but seldom been brought to the notice of zoölogists. Its axis lies close to the coast, and its westerly margin is but poorly defined. At about 12° S. it bends to the westward; and between that point and the Galapagos merges into the general south-equatorial drift. In breadth, and in volume it is comparable to the Japan, the Benguela, and to the Guinea currents, or to the Gulf Stream. But it is the reverse of the latter in being a mass of cold water penetrating into a much warmer mass. At the latitude of Valparaiso the surface temperature in February is about 60°, from there northward the axis of the stream grows gradually warmer. Off Callao, in November, we observed a surface temperature of 65° (A. Agassiz, :06), and off Aguja Point, the lowest surface temperature of the Cruise was noted, 64°. North of Aguja Point the Humboldt Current is no longer traced as a definite current and the temperature rapidly rises to that of the Panamic region. Westward and southwestward from the axis of the stream the surface temperature rises steadily, though with various anomalies, until 74° is reached at Easter Island, and 80°–81° northeastward of Manga Reva.

Like most other ocean streams the Humboldt Current bears a very rich pelagic fauna and flora with it (A. Agassiz, :06, p. 15; Bigelow, :09a, p. 222). Indeed never, even in the Gulf Stream, have I seen a greater density of organic life than daily met our notice while our work lay within the Humboldt Current. This richness extends also to its westward flow, and to the general south-equatorial drift into which it merges. On the other hand southwest of the Current there is an area as poor in all forms of life, bottom as well as pelagic, as the Current is rich. The older voyagers, especially New England whale fishermen, long ago observed the faunistic contrast here outlined (Maury, '55, pl. 9). But it remained for the "Challenger," and especially for Alexander Agassiz to bring it to the notice of zoölogists, and to give it scientific standing.

In plotting the distribution of the Siphonophores in the region explored by the "Albatross" I was struck by the fact that several of the species which were taken often enough to afford a fair estimate of their occurrence were taken only sporadically, if at all, in the colder axial region of the Humboldt Current, although they occurred with some regularity along our lines in the warmer regions to the west.[1] The members of this group are *Diphyopsis dispar*, *Galeolaria monoica*, *G. australis*, and *Agalma okeni*. These were taken respectively at Stations 32, 13, 29, and 25. On the accompanying chart (Plate **30**), on which the occurrence of these four species is shown, it is seen that only one record of any species was made to the eastward of the curve of 68° surface temperature, and that all the captures lie considerably to the westward of the region where the temperature at twenty-five fathoms is 67° or less.[2]

Most species of Siphonophores taken during the Expedition were captured both in the cold waters of the Current, and in warmer waters. The records of five of the commoner of these, *Abylopsis tetragona*, *Bassia bassensis*, *Diphyes appendiculata*, *Diphyes bojani*, and *Diphyopsis mitra*, are shown on Plate **31**.

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[1] For these curves, see explanation of the chart.

[2] I should point out that the small number of records on the passage Manga Reva-Acapulco is due to the fact that unfavorable weather interrupted our work (Agassiz, :06, p. X).

Except for the difference between the cold waters close to the coastal slope, and the warmer regions to the west, the entire area explored was remarkably uniform so far as its qualitative Siphonophore fauna was concerned. The holoplanktonic surface Medusae showed no evidence of any faunal division (Bigelow, :09). On the contrary all the surface Medusae which occurred regularly enough for me to plot their distribution, were met with throughout the entire range of surface temperatures which we encountered.

*Quantitative distribution.* The interesting feature from this point of view is, of course, the conditions in the Humboldt Current and the equatorial flow on the one hand, and in the desert area on the other. The Siphonophores, like the Medusae and other pelagic organisms, illustrate the difference between the two. To show the comparative richness of the one and the poverty of the other, I have reckoned up the average number of specimens taken per haul, to the northeast and to the southwest of the dividing line between rich and poor surface fauna as plotted by A. Agassiz (:06, pl. 3e) for several of the commoner species, with the following results. The best illustration is afforded by the polygastric state of *Abylopsis tetragona*, because this species is so large and conspicuous that I was able to pick out all, or nearly all, the specimens in each haul, even when the catch was a solid mass of Salpae, pteropods, etc. In the case of the smaller Diphyids, on the contrary, many specimens were apt to be overlooked in rich hauls, while in the poor ones every example of every species was easily separated.[1] In the case of *Abylopsis tetragona* the average number per haul in the rich region of the Current was 19, per haul in the barren region, 2. In other words the proportion are roughly as 9.5 to 1. But in reality the discrepancy was much greater, because a swarm was encountered at one Station (4652) in the Current, and no swarms were met with elsewhere.

*Agalma okeni* affords a second example. Leaving out of consideration the cold axis of the Current where it did not occur at all, we find that the proportion between specimens per haul, "Current" and "extra Current," is about 13 to 1. And in the case of this species, the discrepancy between the desert and the *total* remaining area traversed is much greater than it is for *Abylopsis tetragona*, for out of a total of upwards of eighty colonies, only one was taken in the barren region.

Other common species, *e. g.*, *Diphyes appendiculata*, *D. bojani*, *Diphyopsis*

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[1] In this estimate I consider only our lines Galapagos — Callao — Easter Island — Manga Reva. The results are obtained by dividing the total number of specimens by the total number of hauls, made in the corresponding region.

*dispar*, *D. mitra*, and *Galeolaria australis* illustrate the same point though in less degree.

Although the Siphonophores show the quantitative difference between the two regions in a well-marked fashion, it is much more extreme among the Medusae. Thus Rhopalonema and Aglaura were represented at the "barren" stations by only one or two individuals, if at all, instead of by swarms, as in the Current (Bigelow, :09a, p. 223). In other words the Siphonophores are much more evenly distributed quantitatively than the holoplanktonic Medusae, though less so qualitatively.

Up to the time of the Expedition, the following well-authenticated species of Siphonophores had been described from the Tropical Pacific, under various names:—

Sphaeronectes truncata
Cuboides vitreus
Praya cymbiformis
Nectrodoma dubia
Abyla leuckartii
Abyla trigona
Abylopsis tetragona
Abylopsis eschscholtzii
Bassia bassensis
Diphyes appendiculata
Diphyopsis chamissonis
Diphyopsis dispar

Ersae bojani

Agalma okeni
Stephanomia amphitridis
Stephanomia bijuga
Physophora hydrostatica
Athorybia rosacea
Anthophysa rosea

Rhizophysa filiformis
Rhizophysa eysenhardtii
Physalia utriculus.
Porpema prunella
Porpita pacifica
Velella lata

and likewise the genera Hippopodius, Galeolaria, Forskalia, Apolemia, Stephalia, and Epibulia have been recorded, for species which can not now be identified with certainty.

Of the twenty-five identifiable species, no less than twenty-two are represented in the "Albatross" collection, and of the remaining three, one, *Athorybia rosacea*, is a form which has seldom been taken anywhere. Most of the species were previously known from the Pacific by a few scattered captures only. Indeed, the only ones which have been recorded often enough to allow their distribution to be plotted for the Pacific as a whole are Velella and Porpita. Both of these genera are very generally distributed over the entire tropical and subtropical regions of that ocean, and most of their records lie within the isotherms of 68° F., for the hottest months of the year. There are a few records of Velella far to the north of this limit, from waters of much lower temperature. But this genus, owing to its "sail," is readily influenced by winds so that its occurrence

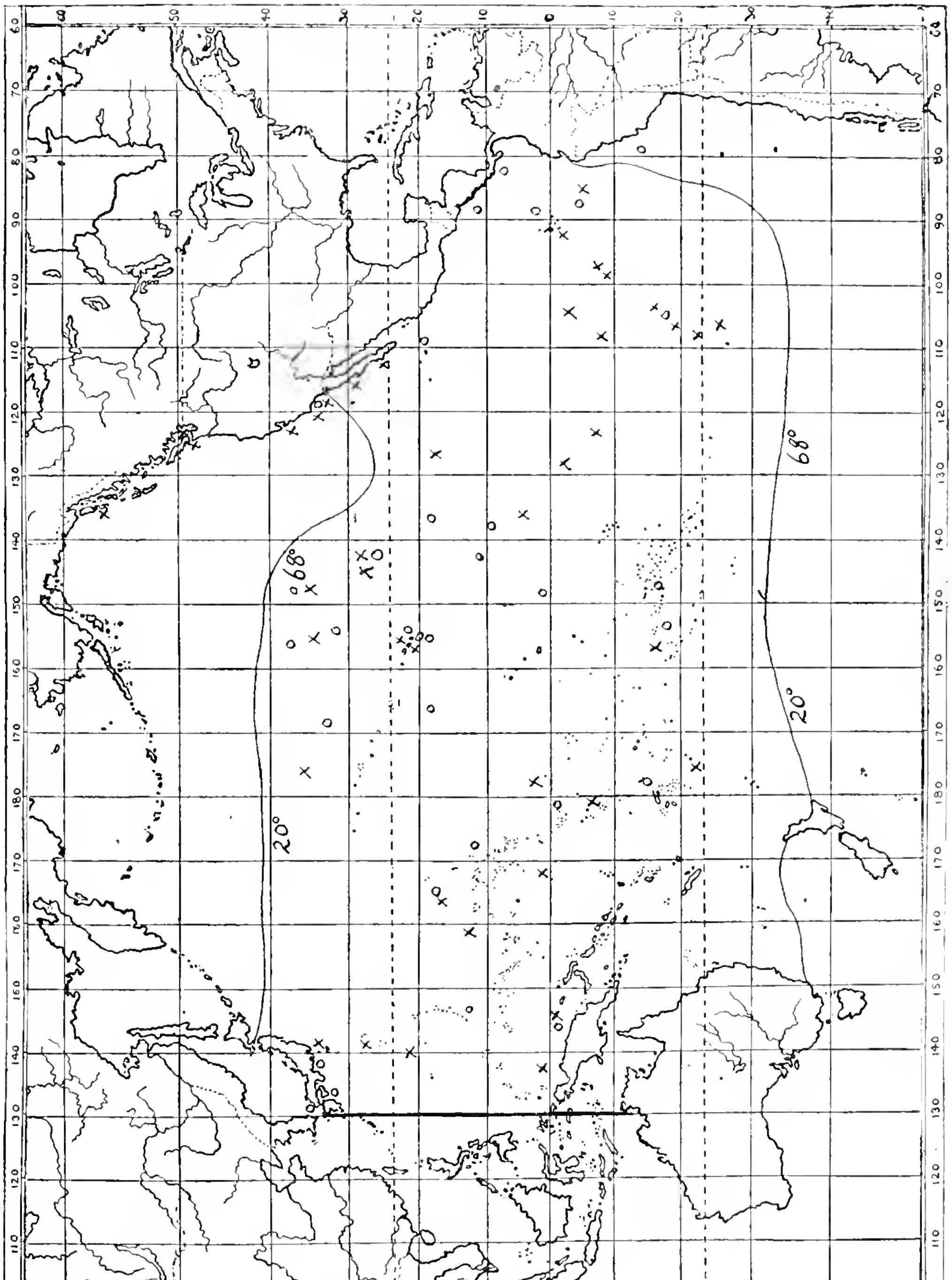

Fig. C. Distribution of Porpita (O) and Velella (X) in the Pacific.

in Puget Sound, and off the southern coast of Alaska is probably accidental, just as are its occurrences off the Irish coast; these occurrences are not indications of its normal habitat. (Fig. C.) About all we know of the northward extension of the Tropical Pacific Siphonophore fauna is contained in Doflein's (:06) brief notes in his graphic account of the oceanography of the coastal waters of Japan. From these we learn that Physalia, Porpita, Velella, and Forskalia, with other tropical organisms, are common in Sagami Bay when its shores are washed by the warm Kuro Shiro Current. But when the wind is west or northwest this warm water, with its inhabitants, is driven off shore, and replaced by the cold northern stream in which no Siphonophores were observed. This cold water carried with it a characteristic Arctic fauna, and it would be very interesting to know whether any of the Siphonophores known from the Arctic and Subarctic Atlantic are at home in the Pacific also. It is clear, from Doflein's observations, that Japan is a transition region for Siphonophores, as it is for Medusae. On the American coast tropical species, *e. g.* Sphaeronectes, have been taken as far north as the Santa Barbara channel (Lat. 34° N.).

Up to the present time we know nothing whatever about the Siphonophore fauna of the Arctic, or Antarctic parts of the Pacific; or even whether the group is represented in those regions.

### *Comparison between Pacific, Malaysian, and Indian Species.*

Within recent years two very important papers on the Siphonophores of the Malaysian region have appeared. These are Bedot's ('96) report on his collection made at Amboina, and the extensive memoir by Lens and Van Riemsdijk (:08) based on the "Siboga" collection. These two combined give the following list, leaving out a few doubtful forms, *e. g.* the genus Clausophyes Lens and Riemsdijk.

*Sphaeronectes truncata*
*Cuboides vitreus*
*Praya cymbiformis*
*Rosacea plicata*
*Rosacea medusa*
*Hippopodius hippopus*
*Abyla trigona*
*Abyla haeckeli*
*Abyla leuckartii*
*Abylopsis tetragona*
*Abylopsis eschscholtzii*
*Bassia bassensis*
*Diphyabyla hubrechti*
*Galeolaria quadrivalvis*
*Galeolaria australis*
*Galeolaria monoica*
*Diphyes appendiculata*
*Diphyes contorta*
*Diphyes bojani*
Diphyes subtiloides
*Diphyopsis dispar*
*Diphyopsis mitra*

Diphyopsis chamissonis
*Chuniphyes multidentata*
Forskalia contorta
Forskalia edwardsi
Erenna bedoti
*Agalma okeni*
*Agalma elegans*
Stephanomia rubra
Stephanomia cupulifera
*Stephanomia amphitridis*
*Stephanomia bijuga*
*Physophora hydrostatica*
*Anthophysa rosea*
*Archangelopsis typica*
*Rhizophysa filiformis*
*Rhizophysa eysenhardtii*
Pterophysa grandis
Pterophysa studeri
Bathyphysa sibogae
*Physalia utriculus*
*Velella lata*
Porpita umbella (?)

The species in italics are contained in the "Albatross" collection. Of the total of forty-four the "Albatross" collection contains thirty-two and of the remaining twelve, four are described as new from the "Siboga" collection, and two genera which were well preserved in the "Siboga" collection are likewise represented by fragments in the "Albatross" collection. On the other hand, all but fifteen of the fifty-one species collected in the Eastern Pacific are known from the Malaysian region as well. Considering how few collections have been made either in the Pacific or in the Malaysian area, the agreement between the two is so close that it is impossible to draw any faunal line between them, so far as their Siphonophores are concerned.

Our knowledge of the Siphonophore fauna of the Indian Ocean is due chiefly to Huxley, to Haeckel, and to a few scattered records by other authors. So far as I can learn, the list of well-authenticated species is restricted to the following:—

Sphaeronectes truncata
Sphaeronectes princeps
Muggiaea huxleyi
Cuboides vitreus
? Desmalia imbricata
? Desmophyes annectans
Abyla trigona
Galeolaria australis
Diphyes appendiculata
Diphyopsis dispar
Diphyopsis mitra
Diphyopsis chamissonis
Apolemia uvaria
Agalma okeni
Agalma haeckeli
Stephanomia amphitridis
Lynchagalma utricularia
? Discolabe quadrigata
? Rhodophysa corona
? Athorybia rosacea
Rhizophysa eysenhardtii
Epibulia ritteriana
Velella lata
Porpita porpita
Physalia utriculus

Leaving out of consideration the doubtful *Discolabe quadrigata* Haeckel, which may be nothing but *Physophora hydrostatica*, and the problematical *Desmalia* *imbricata* Haeckel, *Desmophyes annectens* Haeckel, and *Rhodophysa corona* Haeckel, the only Indian species which are certainly not known from the Pacific are *Sphaeronectes princeps*, *Muggiaea huxleyi*, and *Lychnagalma uvaria*. Until we know more about the Pacific Apolemia and Epibulia it is impossible to say definitely whether they are identical with the members of these genera from the Indian Ocean. But there is nothing in the published descriptions of them by Brandt ('35) to suggest that this is not the case. The agreement between the two oceans is the more striking when we recall how few records of Indian Siphonophores have yet been published.

These facts of distribution show that so far as the Siphonophores are concerned the Indian and Pacific oceans can not be separated. On the contrary, the entire tropical belt from the west coast of America on the one hand, to the western side of the Indian Ocean, on the other, is a single uninterrupted faunal zone. We have, as yet, no evidence of a distinctive Panamic fauna among Siphonophores, indeed, it was not to be expected in a purely holoplanktonic group. In their distribution the Siphonophores agree with the holoplanktonic surface Medusae, and they differ correspondingly from the typical leptoline forms, with long fixed, and short medusa stage, which, for distribution, are in the same category as littoral organisms in general. For the latter, the Tropical Pacific is "Separable into two more or less clearly defined areas; its western half being closely connected to, if indeed at all separable from, the Malaysian region....and its eastern shores on the other hand having a close affinity to the Gulf of Mexico and to the tropical Atlantic" (Bigelow, :09a, p. 228). And I may forestall my forthcoming account of the Philippine Medusae collected by the "Albatross" so far as to state that the data afforded by it is entirely in accord with these generalizations.

### *Comparison between the Species of the Indo-Pacific and the Atlantic regions.*

The intensive studies which have been made in the Mediterranean, among the West Indies, and at the Canaries; the explorations of the "Plankton" expedition, the investigations of the "Research" in the Bay of Biscay and the numerous records from the coasts of North America and Europe, as well as from scattered localities throughout the Atlantic, have given us a knowledge of its Siphonophore fauna as nearly complete as that of any other purely pelagic group of animals, though no doubt many gaps remain to be filled. Up to very recently our knowledge of the Indo-Pacific members of the group was insufficient for a comparative study of value between the representatives from the two oceans. But the collections made by the "Siboga" and by the "Albatross" are so extensive that such a comparison is now possible and timely.

The most important question to answer is whether these purely pelagic organisms support the thesis of the uniformity of the oceanic plankton in tropical and subtropical regions throughout the globe. The table of species (p. 383) shows that out of fifty Calycophorae, twenty-three occur both in the Atlantic and in the Indo-Pacific; twelve are as yet recorded only from the Atlantic, fifteen from the Indo-Pacific. And I may point out that in most cases my identification of Pacific with Atlantic Calycophores rests not only on published descriptions of the latter, but on studies of series from both oceans. At the first glance these numbers suggest a remarkably close resemblance in the Siphonophore faunae. And the unity becomes even more complete when we analyze the status of the exclusively Atlantic and Indo-Pacific species. One of the Atlantic forms, *Galeolaria ovata* Kefferstein and Ehlers, is problematical, and therefore can not be used one way or the other. One, *Diphyopsis hispaniana* Mayer (p. 344) is of doubtful validity. The *Diphyes steenstrupi-serrata* group is represented in the Pacific by an ally so close that it is very doubtful whether it is distinct. And the same is true of *Galeolaria biloba*. Two species, *Nectopyramis thetis* Bigelow and *Stephanophyes superba* Chun, are known from only one or two records each, and may, not improbably, come to light in the Pacific later. One, *Diphyes arctica* Chun, is an Arctic and Subarctic species and therefore would not be expected in the warmer zones of the Indo-Pacific, which are the only parts of that oceanic region from which any Siphonophores are known. This leaves only seven warm water Atlantic species which are certainly not yet known from the Indian Ocean, or from the Pacific. These are, *Sphaeronectes irregularis*, *Doromasia picta*, *Nectopyramis thetis*, *Stephanophyes superba*, *Diphyes subtilis*, *Vogtia pentacantha*, and probably *Galeolaria truncata*. But considering how few studies of the Siphonophores of the Indo-Pacific have been made it is not at all improbable that some of these will be found there.

Two of the peculiarly Indo-Pacific species, *Desmalia imbricata* Haeckel and *Desmophyes annectens* Haeckel, are problematical. It has been suggested that they belong to *Praya cymbiformis* and to *Rosacea plicata*, but they are recognized here provisionally. Two species, *Sphaeronectes princeps* Haeckel and *Muggiaea huxleyi* Haeckel, are known from only one record each; their validity has been questioned. *Galeolaria australis* and *Diphyes bojani* are represented in the Atlantic by allies so close that it is doubtful whether they are distinct. This leaves only *Nectopyramis diomedeae* Bigelow, *Nectrodroma dubia* Quoy and Gaimard, *Nectrodroma reticulata* Bigelow, *Abyla haeckeli* Lens and Van Riemsdijk, *Diphyabyla hubrechti* Lens and Van Riemsdijk, *Diphyes contorta* Lens and Van Riemsdijk, *Diphyes spiralis* Bigelow, and *Diphyopsis chamissonis* Huxley. Some of these may be found in the Atlantic in the future, a suggestion rendered probable by my own discovery of *Abyla leuckartii* (p. 321) and of *Diphyopsis mitra* (p. 261) in the West Indies.

The list includes twenty-seven Physophorae, twelve recorded from both oceans, besides the genus Forskalia (p. 270), seven so far recorded only from the Atlantic, eight from the Indo-Pacific. Of the Atlantic species four, *Agalma clausi*, *Erenna richardi*, *Anthophysa formosa*, and *Angelopsis globosa* are represented by extremely close allies in the Indo-Pacific. These are *Agalma haeckeli*, *Erenna bedoti*, *Anthophysa rosea*, and *Angelopsis dilata*. One Atlantic species, *Stephanomia cara*, is doubtful; at this moment it is impossible to determine whether or not it is distinct from *S. bijuga* (p. 283). If so, it is a boreal form. And it is likewise impossible to state from Brandt's ('35) brief description, whether the Pacific Apolemia is the same as, or different from the Atlantic representative of the genus (p. 348). The Indian Apolemia, however, ("*Dicymba diphyopsis*" Haeckel, '88b) is apparently indistinguishable from the Atlantic *A. uvaria*. This leaves only *Anthemodes ordinata*, *Stephalia corona*, *Rhodalia miranda* as Physonectae peculiar to the Atlantic; and it is possible that the latter belongs to the Pacific also (Brooks and Conklin, '91). The following exclusively Pacific species are well grounded:—*Stephanomia amphitridis* Péron and Lesueur, *Dromalia alexandri* Bigelow, and *Archangelopsis typica* Lens and Van Riemsdijk. But the last two, like Rhodalia, belong to a group so little known that no inferences as to distribution can yet be drawn from their few records. Another Stephanomia, *S. cupulifera* Lens and Van Riemsdijk was described as new from the "Siboga" collection; but its distinctive character was so trivial (p. 284) that its standing is doubtful. *Discolabe quadrigata* and *Rhodophysa corona* likewise require further study. There are eleven recognizable Rhizophysaliae, of which four are known from both oceans, three from the Atlantic only, and four from the Indo-Pacific. Each region has its own peculiar species of Physalia, and to the Indo-Pacific belongs the interesting genus Epibulia, while Salacia is so far known only from the Atlantic. The other Rhizophysalids peculiar to one or the other region only belong to the Bathyphysinae, a subfamily whose members have been taken so seldom that their records can not be used yet as a basis for geographic discussion.

Among Chondrophorae the genus Porpema is common to both oceans; but whether its representatives in the two are specifically distinct or identical can be determined only by a fresh study of Atlantic specimens. Porpita and Velella, like Physalia, are represented in the Atlantic and in the Pacific by distinct, though closely allied species. But the exact relationships of the representatives of these genera from the Indian Ocean are not known. In the case of Velella it is probable that we can speak of an Indo-Pacific species, just as we can of Physalia. But there is some, though not conclusive, evidence, that the Indian form of Porpita is more closely allied to the Atlantic than to the Pacific species.

Summarizing these results, and omitting the problematical species, and those whose validity is doubtful, we find no less than forty-one valid species of Siphonophores, out of a total of about 95, *i. e.* almost half, are already known to occur both in the Atlantic and in some part of the Tropical Indo-Pacific areas; six which are known only from one are represented in the other by allies so close that it is doubtful whether they are distinct; twelve are so far known only from the Atlantic, and sixteen from the Indo-Pacific. And judging from the rich harvest brought to light by the recent deep-sea expeditions, there is every reason to expect that this number common to the two great oceanic divisions will be augmented by the report on the "Valdivia" Siphonophores, now in preparation by Dr. Chun.

There is no great discrepancy between Calycophores and Physophores, so far as the proportion of species common to both oceans is concerned. But while several of the former, as for example *Abylopsis tetragona*, *Diphyes appendiculata*, and *Diphyopsis dispar* are constantly met with in the warmer portions of all oceans, this is the case with comparatively few Physophores, though many species of them are known from various localities in both the Atlantic and the Pacific. The only Physophore encountered by the "Albatross" with anything like the regularity of the commoner Calycophores was *Agalma okeni*, and only two others, *Physophora hydrostatica* and *Anthophysa rosea*, were taken at more than five stations each. The "Plankton" expedition took only four Physophores: — *Nectalia loligo* at two stations, *Physophora hydrostatica*, *Anthophysa formosa*, and *Athorybia rosea* at one station each (Chun, '97b). In the Bay of Biscay the "Research" found no Physophores at all, except one fragmentary Athorybia. The Anthophysidae and Rhodaliidae as a whole seem to be rare everywhere. But Forskaliidae and the long-stemmed Agalmids are common in the Mediterranean, at the Canaries, among the West Indies. *Agalma elegans* and *Stephanomia cara* occur regularly at various localities along the Atlantic coasts of North America and of Europe, and *Stephanomia bijuga* swarms at times among the Ellice group (Agassiz and Mayer, :02, p. 168). Chun ('97b) has suggested that the scarcity of Physophores in the Tropical Atlantic in summer observed by the "National," was a seasonal phenomenon, to be explained on the assumption that at that time the species in question were passing through their larval existence at considerable depths. Evidence in favor of this view is afforded by the facts that the Siphonophore fauna collected by the "National" agreed very closely with that observed by Chun ('88) himself at the Canaries from September to the last of December. It was only in winter that Forskalia, Agalma etc. appeared on the surface. Furthermore, it has long been well known that the Physophoras and Agalmids of the Mediterranean are seen regularly on the surface only during the autumn and winter, and Chun ('87) has found that during the summer the larvae of Physophora are living there at considerable depths. On the other hand the "Research" obtained no Physophore larvae even in the deepest hauls, and the latter were made so frequently that these organisms could hardly have escaped had they been as abundant as any of the commoner Calycophores. Furthermore, I have been unable to discover that any Forskalia, or Agalmid except *Agalma okeni*, occurs regularly anywhere on the high seas far from land, either in the Atlantic or the Pacific, at any season. The evidence afforded by their occurrence suggests that these animals find their most favorable environment in enclosed and sheltered basins, or near shore and among islands, not in open sea.

The explanation is, I believe, twofold. In the first place, as Chun has shown, most of the long-stemmed forms are undoubtedly seasonal in their appearance. During the rather extended period during which they pass through their larval existence they may live at considerable depths, and in any case they are then small, and easily overlooked. The second explanation, and as it seems to me the more important one, rests on the anatomic structure of the species in question. The only typically oceanic Agalmid, *A. okeni*, is of unusually short, stiff, non-contractile "habitus," and its nectophores, bracts, siphons, etc., are very firmly attached to the stem. Specimens of this species, like Physophoras and Anthophysas, may even be removed from the water without injury. Such organisms are well fitted to withstand buffetings by waves and currents. On the other hand, Forskalias, and the long-stemmed Agalmids in general, are proverbially delicate. They fall to pieces at the slightest touch, or even when the vessel in which they are contained is jarred. (For a graphic account of such dissolution, see Lens and Van Riemsdijk, :08, p. 64.) Evidently during heavy weather such animals are likely to be seriously damaged unless they can sink below the shallow zone where wave action is violent. Agalmids and Forskalias are such feeble and erratic swimmers that it can hardly be supposed that they can transport themselves to a more placid environment as the result of tactile stimulus. A Forskalia caught on the surface by a breaking sea, is likely to suffer the same fate that befalls a large and unwieldy Aurelia or Cyanea when overtaken by the same circumstances at the end of the season, *i. e.* to be broken to pieces. Thus physical conditions in the high seas prevent their attaining the faunal prominence in oceanic regions which they possess in the Gulf of Naples or among the Canary Islands.

### *Oceanic temperatures and their relation to distribution.*

We know one Siphonophore, and one only, *Diphyes arctica* Chun, of which we can say without hesitation that it is restricted to Arctic and Subarctic regions. Three other species may finally be grouped with it, *Galeolaria truncata* Sars, *G. biloba* Sars, and *Stephanomia cara* A. Agassiz. It is true that the first of these has been identified by Lens and Van Riemsdijk (:08) with a species from the Canaries, *G. inflata* Chun (p. 235); but the latter is so insufficiently described that the relationship is doubtful. *Galeolaria biloba* is indistinguishable, so far as Sars's ('46) rather brief description goes, from the Indian Pacific *G. australis;* and there is a possibility that it is likewise identical with the Mediterranean "*Diphyes turgida*" of Gegenbaur. But to settle this question will require a fresh study of the Norwegian and Mediterranean forms. *Stephanomia cara* is certainly closely allied to *S. bijuga*; but if it be identical with it, it would afford an anomalous case of distribution (p. 284). Arctic specimens of *S. cara*, as of *G. biloba*, must be reëxamined with their specific relationships in view, before the question of its standing can be settled.

*Diphyes arctica* is of more than ordinary interest in its geographic relations because of its temperature range. It is common at Spitzbergen (Römer); in the Arctic Ocean north of Russia (International committee lists), in the Greenland Sea both at the surface and at considerable depths (Damas and Koefoed); and along the coast of Norway to the Skagerak, where it is known from intermediate hauls only, the shallowest being 200 meters. On the Norwegian coast it occurs only accidentally, if at all, on the surface, but is a common constituent of the mesoplankton. Its records from the "Plankton" expedition are from 59° 20′ N., 11° 8′ W., and 60° 30′ N., 27° 0′ W., between 400 meters and the surface. Damas and Koefoed (:07) recently discussed the distribution of this species at some length. I agree with their conclusion that its occurrence is independent of the origin of the waters, Atlantic or Arctic, in which it is found. But to say as they do that it is independent of temperature is true only if we mean that its horizontal occurrence irrespective of vertical distribution is independent of slight differences in *surface* temperature. As a matter of fact there is good evidence that *D. arctica* is limited in dispersal chiefly by temperature. It is a form adapted to cold waters; and in truly Arctic regions, such as the Greenland Sea, is found indifferently on the surface, and in the intermediate depths. Further to the south, where the surface temperature is higher, as for example along the coast of Norway and in the Skagerak, it is exclusively confined to the mesoplankton. At the present moment it is not possible to state precisely what its temperature limits are. But it is known from only a few degrees above the freezing point of salt water, and it has never been found regularly in water warmer than 42° (Skagerak, 200 m., August).

A few species of Siphonophores are known to occur throughout a wide range of temperature. The best known member of this group, *Diphyes appendiculata*, is common on the surface throughout the Tropical Pacific (p. 248, Agassiz and Mayer, :02, p. 160) in temperatures of 78°, 80° or over. In the Atlantic it is common in the high surface temperatures of the tropics, *e. g.* among the West Indies, and is of very general occurrence. In this ocean it is known from much lower temperature than any as yet recorded for it from the Pacific. In the Mediterranean, Chun ('87) has recorded it from temperatures as low as about 56°, and in the Bay of Biscay it was abundant at 53°–52° (surface to 100 fathoms), and was apparently not only alive but reproducing itself at a temperature of about 50°. *D. appendiculata* has never, so far as I can learn, been taken in any numbers in water colder than this, though once recorded from below 45° (Chun '97b, p. 110, 60° 2′ N., 22° 7′ W.; closing-net, 800–1,000 meters). And since we now have so many records of the constituents of the surface Plankton of the boreal Atlantic, it is probably safe to say that its normal temperature range does not extend much, if any, below 50°.

*Physophora hydrostatica*, among Physophorae, occurs throughout a range of temperatures almost as great as those occupied by *D. appendiculata*. But unlike the latter, Physophora has been but seldom recorded from temperatures above 70°. The only recent records of this species from tropical regions which I have been able to find are the Canaries, 1° 1′ N., 16° 40′ W. ("Plankton" expedition), and Malaysian region (Lens and Van Riemsdijk), But the Canary records are all from the winter months (Chun, '88, Haeckel, '69a), when the surface temperature is from 65° –68°; the "Plankton" record is from an intermediate haul (400-0 m.), and at that Station the temperature at 200 m. was only 56° 6. The two "Siboga" records were from even deeper hauls (1,000–0 m., and 1,500–0 m. respectively). None of these records, then, suggest that the species is common in very high temperatures. And the same is true of the series collected by the "Albatross," for the species was not found at all on the surface, but always in intermediate hauls, though the surface temperatures at the six stations of capture were all below 75°.

Physophora is common on the surface in the Mediterranean during the winter, when the temperature falls to about 57°; but during the hot months it disappears from the surface (p. 380). In the Atlantic this species extends far northward. It is known from the coast of Scotland; is not uncommon on the Norwegian coast as far north as 71°. A list of its boreal occurrences has been given by Römer (:02); and since the appearance of his paper, the genus has been recorded from the south and west coasts of Iceland by Paulsen (:09). But since it is not known from Spitzbergen, and since the Duke of Orleans did not encounter it in the Greenland Sea, it probably does not occur in temperatures lower than 45°. In short, the various records of the species shows that it is at home neither in the Arctic, nor in the hottest tropical temperatures.

*Agalma elegans* is also found through a wide range of temperatures, *i. e.* tropics to Norway (p. 283). *Nectalia loligo*, likewise, has been taken at the Canaries, at a temperature of about 68° (Haeckel, January); south of Iceland (60° 2′ N., 22° 7′ W.; Chun, '97b) at a temperature of 46° and in a closing-net haul at 600–800 m. in the south equatorial current (3° 6′ S., 33° 2′ W.), a level at which the temperature was below 50°. The only other Siphonophores which have been credited with a distribution reaching from the tropics to the Subarctic zone are *Galeolaria biloba* and *Muggiaea atlantica*. But as already pointed out the identity of the former with *G. australis* of the Tropical Indo-Pacific is open to question (p. 234), and Broch (:08) has recently shown that the records of *M. atlantica* from the Skagerak by Johansen and Levinsen (:03) probably belong to *Diphyes arctica*. At present it is doubtful whether any Siphonophore is truly eurythermal, but if *Stephanomia cara* and *S. bijuga* finally prove to be identical, they would afford a typical example of this class of distribution.

All the other Siphonophores which are yet known from the surface belong to warm-temperate or to tropical regions, the two supposed Antarctic records (Rennie, :05 and Bedot, :08) being respectively the tentacle of a Scyphomedusa, and an Anthomedusa (Browne, :10).

### *Eastern and Western Sides of the Tropical and Subtropical Atlantic.*

Thirty-two species of Siphonophores, excluding some doubtful records, are known from the warm waters off the eastern coast of the United States, *i. e.* from the West Indies or from the Gulf Stream, and twenty-five of these are likewise known either from the neighborhood of the Canaries, from the Mediterranean, or from the Bay of Biscay. None of the remaining seven, *Diphyopsis hispaniana, D. mitra, Abyla leuckartii, Anthophysa formosa, Salacia uvaria, Angelopsis globosa*, or *Pterophysa grandis*, are peculiar to the West Indies except the first, and this is a doubtful species (p. 244). *Anthophysa formosa* and *Salacia uvaria* are known from other parts of the tropical Atlantic, *Diphyopsis mitra* and *Abyla leuckartii* from the Pacific and Indian oceans; *Pterophysa grandis* from Malayan waters, while *Angelopsis globosa* is represented in the Pacific by an extremely close ally.

On the other hand out of forty-seven Mediterranean and east-Atlantic species, over half are already known from the western Atlantic, and of those not yet recorded from there, all, except *Sphaeronectes irregularis, Diphyes subtilis, Agalma clausi, Anthemodes ordinata*, and *Pterophysa grimaldii*, have been found in the Indian Ocean, in the Pacific, or in both. The first two may have easily escaped notice in West Indian waters, indeed *D. subtilis* was long overlooked even in the Mediterranean; *Agalma clausi* is represented in the Indian Ocean by a close ally; *Anthemodes ordinata* is apparently very rare; and *Pterophysa grimaldii* belongs to a mesoplanktonic genus. Furthermore Chun ('97b) has pointed out that during the "Plankton" expedition several of the commoner Calycophorae were taken regularly throughout the warmer regions visited. Thus it is evident that there is no division in the Siphonophore fauna as we pass from one side of the Atlantic to the other, any more than there is in the Indo-Pacific region, though these are, of course, local anomalies.

One of the most striking of these is afforded by *Muggiaea atlantica*. This species is so far known with certainty only from British waters, and from the Eastern Tropical Pacific, though it is probably recorded from the Canaries (p. 186). Judging from the temperature range through which it occurs, 83°–52°, there would be every reason to expect to find it as widely and regularly distributed as *Diphyes appendiculata*; but apparently such is not the case. It is unlikely that its absence from the collections made by Dr. Fowler in the Bay of Biscay in July, 1900, is due to its being overlooked, because the methods employed on the Cruise were unusually painstaking and thorough. At any rate we can say without hesitation that it certainly was not a characteristic member of the plankton, yet at the same season it is approaching the zenith of its abundance in the English Channel. And it as certainly was not present in the large masses of West Indian plankton which I collected during Mr. Agassiz's Cruise in the winter of 1907. It is likewise surprising that it has not been found in the Mediterranean, though it may have been confused there with young *Diphyes appendiculata*. Another instance is the fact that *Stephanomia rubra*, so common in the Mediterranean, has never been recorded from either side of the Tropical Atlantic, although Bedot ('96) found it in the East Indies, at Amboina. The occurrence of *Diphyopsis mitra* among the Canaries is extremely probable, yet neither Haeckel nor Chun detected it there. On the other hand *Muggiaea kochii* has not been found in the West Indian waters though it probably occurs there.

Even if no line can be drawn between the warm-water Siphonophores of the two sides of the Atlantic, they are not an altogether homogeneous group geographically, for, as Chun ('97b) has pointed out, there is a considerable list of species which are common in the Tropical Atlantic, but which do not occur in the Mediterranean, though most of the Mediterranean Siphonophores are known from the Atlantic. The species of Physophorae which were then known from the Mediterranean only were *Stephanomia rubra*, *Agalma clausi*, and *Lynchnagalma utricularia*. But the first has since been found at Amboina; the second may be, and the third almost certainly is identical with a form from the Indian Ocean (p. 348, 349). In addition to these there are three Diphyids, *Galeolaria turgida*, *G. conoidea*, and *G. ovata*. But the first two are probably synonyms of other species (p. 234, 235) and the third is a problematical form. And only one species, *Plutus cnidoporus* Schneider, has been added to the list within recent years. We may safely say, therefore, that it is doubtful whether any Siphonophores are confined to the Mediterranean.

On the other hand the following inhabitants of the Eastern Tropical Atlantic which Chun mentioned as absent from the Mediterranean:—*Diphyopsis dispar*, the *Diphyes serrata* group, *Abylopsis eschscholtzi*, *Abyla trigona*, *Bassia bassensis*, *Cuboides vitreus*, Ceratocymba, *Agalma okeni*, *Nectalia loligo*, and *Rhizophysa eysenhardtii*, have not been recorded from that sea even yet. To make the list complete, we must add *Amphicaryon acaule*, *Stephanophyes superba*, and *Anthemodes ordinata*: and if the survey be extended to the western side of the Tropical Atlantic, as it ought, for as we have seen the Siphonophores of the West Indies correspond very closely to those of the Canaries, we may include *Abyla leuckartii*, *Diphyes fowleri*, *Diphyopsis mitra*, and the genera Anthophysa, Angelopsis, Salacia, and Porpema. (The Bathyphysinae may be left out of consideration because of their mesoplanktonic habitat and because so little is known about them). These are all such large and conspicuous animals that it is not likely that they would be overlooked in the intensive collecting carried on at Naples, and in the Adriatic.

It is likewise significant that none of the common and well-known Tropical Atlantic species:—*e. g.*, *Abylopsis eschscholtzii*, *Diphyes serrata*, *Diphyopsis dispar*, *Cuboides vitreus*, or even the oceanic *Agalma okeni*, was taken by the "Research" in the Bay of Biscay.

These facts show that the faunal division drawn by Chun was an actual one, and not based on incomplete observations. And when they are taken in connection with the Indo-Pacific records, and the considerable amount of data from the east coast of the United States, from the Bay of Biscay, from the northern European coasts, and from various scattered localities in the north Atlantic, they show that the Siphonophores of warmer waters are separable geographically into two chief groups. The members of the first are found in tropical regions of all great oceans, either on the surface or at intermediate depths, or both, and are characteristic of the epiplankton of the Mediterranean. In this sea, some of them are strictly seasonal, appearing only in the cooler months of autumn, winter or early spring, for example *Stephanomia rubra*, Physophora, and Praya, while Forskalia and Muggiaea are common throughout the year. Several of them, likewise, are regularly found on the American coast as far north as the influence of the Gulf Stream is felt (*e. g. Agalma elegans*, Narragansett Bay), and others, as for example *Diphyes subtilis*, *Hippopodius hippopus*, and *Rosacea plicata*, in the cooler waters of the Bay of Biscay (Bigelow, :11b). As examples of this group I may mention *Sphaeronectes truncata*, *Abylopsis tetragona*, *Gelcolaria quadrivalvis*, *Praya cymbiformis*, *Hippopodius hippopus*, *Agalma elegans*, *Stephanomia bijuga*, *Stephanomia rubra*, the genus Forskalia, *Rhizophysa filiformis*, Porpita and *Velella velella*. The species of the second group are exclusively tropical in their normal habitat:—they have been unable to establish themselves in the Mediterranean. There are also a few species which are so far known only from the Atlantic, from the Indian Ocean, or from the Pacific, but it is not unlikely that their range may be found to extend to the other oceans. And of course some have been recorded so seldom that their position in the distributional series is doubtful.

The factor which limits the areas of distribution of the two groups is no doubt temperature. Chun ('97b) has already suggested this explanation, and pointed out that the currents in the Straits of Gibraltar would offer no barrier to the entrance of surface organisms, but just the reverse. The surface water at the Canaries where the typical tropical species are common in winter, never falls below about 65.5°, whereas in the western half of the Mediterranean, the surface temperature falls in winter to about 56°. This is far colder than any waters in which the tropical Siphonophores are regular characteristics of the surface plankton. And it is significant that *Diphyopsis dispar* and *Agalma okeni* were absent from waters below 68° in the Eastern Pacific. We can say in general that none of the tropical species are constant members of the plankton in any regions where the surface waters fall below about 65° at any season, though they may occur sporadically, or even more or less regularly far to the north within the sweep of the Gulf Stream, or any other warm current.

Several tropical species, *e. g. D. dispar*, *Bassia bassensis*, and Ceratocymba, have been observed in the Straits of Gibraltar, as we might expect from the fact that the surface flow is into the Mediterranean. And it is probable, though not certain, that the Physalias which occasionally appear in the Bay of Naples are casual visitors from the Atlantic. The failure of these forms to establish themselves in the Mediterranean was correctly explained by Chun ('97b, p. 109) as due to the differences in temperature, which "der Reife der Geschlechtsprodukte von atlantischen und in das Mittelmeer eingeschwimmten Arten hinderlich in Wege stehen" is probably a correct explanation. Whether adult, or as larvae, they can not survive the winter of the western Mediterranean.

At present we have no evidence that any of the mesoplanktonic Siphonophores, *i. e.* Chuniphyes or the Bathyphysinae, have penetrated into the Mediterranean. And if further research proves that such is the case, the absence could be explained by the currents in the Straits of Gibraltar. It has long been known that the lower strata flow out of the Mediterranean into the Atlantic, and the recent work of the "Michael Sars" (Hjort, :11) has shown that there is no inflow below about 75 fathoms at any stage of the tide; and that the maximal outflow at 100–175 fathoms may reach a velocity of two meters per second. These conditions would be quite sufficient to exclude deep-water Siphonophores from the Mediterranean had they occupied the intermediate waters since that sea acquired its modern oceanographic features and were they absolutely limited to the intermediate depths throughout their existence. But it is quite possible that they have been overlooked in the Mediterranean, for they are, apparently, uncommon everywhere.

The foregoing data shows that the following thermal classes of surface Siphonophores can be distinguished: —

1. Arctic, with a maximum of about 45°.
2. Warm-water species, with a minimum of about 50°.
3. Tropical species, with a minimum of about 65°.
4. Species with a very wide temperature range, but not truly eurythermal because they do not exist under Arctic conditions; while one of them, at least, is seldom found in temperatures above 70°.
5. There are a few species which have been taken so seldom that it is impossible to make any statement about them as yet.

### *Seasonal Fluctuations in Horizontal Distribution.*

A résumé of our rather scanty knowledge in this field follows naturally after the discussion of temperature. It has long been known that in summer certain warm-water Siphonophores often occur far to the north of their winter range in regions within the influence of the Gulf Stream. Examples are afforded by the almost yearly occurrence of *Agalma elegans* in Narragansett Bay, and the occasional capture of *Diphyopsis dispar* off the south coast of Newfoundland (Bigelow, :09b); of Physalia in the Bay of Fundy, and of Velella at the Hebrides. Similarly, but more regularly, the Norwegian sea is invaded from the south via the Faroe-Shetland Channel in the middle of the summer by Physophora and Agalmidae ("*Cupulita sarsi*" Damas, :09, p. 107) which thereafter form a striking constituent of the plankton of the Norwegian Sea.

The movements of *Muggiaea atlantica* in the English Channel and the Irish Sea are known in some detail, thanks to Gough (:05). This species appears off Ushant at the end of April or beginning of May, and extends thence northward and eastward with the advance of the season. By September it has reached the Irish Sea, and has spread around the southwest shores of Ireland; but it never penetrates eastward in the English Channel beyond the Isle of Wight. By January it has once more disappeared from the region under consideration. Its northerly spread follows, but lags behind, the rising temperature of the surface waters. Thus it was noticed earliest in a temperature of between 50° and 52°. But whereas Muggiaea is not certainly known from north of Ireland, the isotherm of 52° includes the whole western coast of Great Britain, and the southern part of the Norwegian Sea by September; and by January it has once again receded until it meets the swarm of Muggiaea. This discrepancy suggests that the fluctuation in range of this species is caused less by dispersal through currents than by rapid reproduction in regions of favorable temperature. The failure of Muggiaea to penetrate beyond the Isle of Wight in the English Channel can not be due to temperature, because by June the surface throughout the channel is 57° or over. Nor is there any evidence that it is due to the complex currents in this region and in the North Sea. As pointed out below, (p. 381) salinity may be the active factor here.

### *Bathymetric Range.*

The "Albatross" did not obtain any Siphonophores in closing-nets, although a good many Medusae were taken in such hauls (Bigelow, :09a). The only previous records of the present group from closing-nets, so far as I can learn, are the following: —

1. *Cuboides vitreus*, Guinea current, 1,000–1,200 M: "Plankton"; Chun ('97b).
2. *Diphyes appendiculata*, Mediterranean, surface down to about 750 fathoms (1,300 M); most abundant at 80–100 M (Chun, '87); 60° 2′ N., 22° 7′ W., 800–1,000 M; "Plankton"; (Chun, '97b, p. 110); Sargasso Sea, 31° 5′ N., 5° 1′ W., 900–1,100 M; "Plankton"; (Chun, '97b, p. 110); 14° 19′ N., 27° 13′ W. 300–350 M, and 1,000 M; "Monaco"; (Bedot, :04, p. 26, 27); Bay of Biscay, four stations 200–100 fathoms, one station 500–400 fathoms, "Research" (Bigelow, : 11b, p. 345).
3. *Diphyes arctica*, various depths from the surface down to 800 M; "Nansen" closing-net. (Damas and Koefoed, :07.) I may point out that these deep-sea records are unreliable, because Paulsen (:09) has proved that this type of closing-net often fishes while being lowered.
4. *Chuniphyes multidentata*, Bay of Biscay, three Stations 1,250–1,000 fathoms two Stations 1,500–750 fathoms, one Station 2,000–1,000 fathoms (Bigelow, :11b, p. 348).
5. *Rosacea plicata*, Bay of Biscay, two Stations 200–300 fathoms (Bigelow, 11b, p. 342).
6. *Hippopodius hippopus*, larvae, Bay of Biscay, one Station 150–50 fathoms (Bigelow, :11b, p. 350).
7. *Vogtia spinosa*, Bay of Biscay, one Station 250–150 fathoms (Bigelow, :10b, p. 351).
8. *Apolemia uvaria*, Bay of Naples, one Station, 600 M (Chun, '87, p. 13).
9. *Nectalia loligo*, 3° 6′ S., 33° 2′ W., 800–600 M; "Plankton"; (Chun, '97b). And unidentifiable Bathyphysinae from 2,300 M (Chierchia, '85).

All the other data on the vertical occurrence of Siphonophores consists of "intermediate" hauls with open nets of one sort or another, and of specimens entangled on sounding or dredging wire.

The only species which have never been taken in surface hauls are *Chuniphyes multidentata*, *Nectopyramis diomedeae*, *Nectodroma reticulata*, *Erenna richardi*, *Erenna bedoti*, *Dromalia alexandri*, *Angelopsis globosa*, *Angelopsis dilata*, *Archangelopsis typica*, and the various Bathyphysinae.

*Nectopyramis diomedeae* and *Nectodroma reticulata* are known from so few records that they may well have come from the surface, and it is altogether probable that Dromalia, Archangelopsis, and Angelopsis did come from the surface (p. 316). This leaves only Chuniphyes, Erenna, and the Bathyphysinae belonging exclusively to the mesoplankton. The shallowest haul which has produced a specimen of the former was 250–0 fathoms (Bigelow, :11b, p. 348); and the records from closing-nets just cited show that it is at home at much greater depths. We do not know the precise level from which any Bathyphysid or Erenna has come. But all of them are so large and conspicuous that they would hardly have been overlooked on the surface in the warmer parts of the globe, did they occur there. And the surface waters off the coast of Norway, about Spitzbergen (Römer) and in the Greenland Sea (Duke of Orleans) have been so thoroughly examined within the last few years that we can hardly suppose that any of them regularly come to the surface in these cold regions.

The great majority of Siphonophores are epiplanktonic at some time or place, many of them chiefly, or perhaps exclusively, so. Thus during the expedition of the "Albatross" seventy specimens of *Galeolaria australis* were taken in twenty-seven surface hauls, and only seven specimens in four intermediate hauls. The preponderance in favor of the former is so great that it strongly suggests a surface origin for the latter. Evidently this species was living in a shallow surface zone. In the Malaysian region, also, all (but perhaps one) of the "Siboga" specimens of *G. australis* were taken on the surface. As further examples of the epiplankton group I may mention *Sphaeronectes truncata*, *Galeolaria monoica*, *G. quadrivalvis*, and *Diphyopsis dispar*.

Among Physophorae, *Agalma okeni*, Athorybia, and Anthophysa are characteristic surface forms. During the Expedition seventy-eight colonies of the former were taken on the surface, and only three in intermediate hauls. It is common, likewise, on the surface at the Canaries, among the West Indies, near Ceylon (Haeckel, '88b, "*Cystallodes vitrea*"), and among the Malaysian Archipelago. And of course Velella, Porpema, Porpita, and Physalia, in the adult state, are known from the surface only, though the larvae of the first and perhaps of the others, are inhabitants of the deeper layers (p. 380).

*Diphyes arctica* has a considerable vertical range, and as already pointed out (p. 369), it follows down the isothermobath most favorable to it in regions where the surface waters are too warm. But there seems to be a limit to this vertical extension, because the species has never been taken at any depth south of 57° N. latitude, in spite of the many deep hauls which have now been made in various parts of the Atlantic. Were it independent of every physical factor except temperature, it would find a favorable environment at some depth in all latitudes. But since it is not found in tropical regions at any depth, there must be some other factor limiting its dispersal. I have elsewhere (Bigelow, :09a) suggested the possibility that the absence or presence of light may be a factor in determining the vertical range of holoplanktonic coelenterates, and Hjort (:11) has demonstrated that light is undoubtedly the factor governing the vertical range of the fishes of intermediate waters. Thus there is a group limited to darkness, and one occurring in the zone of very faint light, which show characteristic color differences. And, as I have pointed out (:11a), there is some evidence that the Medusae of intermediate waters can be divided into two corresponding groups, the iridescent — slightly pigmented forms occurring above the deeply pigmented red or brown species. Now that light has been shown to be so important in relation to the vertical distribution of other groups of pelagic animals, it would not be surprising to find it occupying a similar role in the case of the Siphonophores. We might suppose that *D. arctica* is positively phototropic to light above a certain intensity. Were this the case, being otherwise limited in its dispersal by heat, it would occupy the zone of most favorable temperature, *i. e.* 35°–45°, from the Arctic regions southward to the point where the latter sank below the level of appreciable light. But it would not extend further toward the tropics, because to follow its temperature downward would lead into regions when there is too little light for its ecologic needs. We could thus account for its occupancy of a zone from the surface downward for a considerable depth in the Greenland Sea; its absence from the surface further to the south, and its entire disappearance south of 57° N. It is true that Damas and Koefoed's (:07) records if taken at their face value, indicate a habitat below 400 fathoms. But as I have pointed out (p. 377) it is doubtful whether any of the specimens credited by them to 800 fathoms actually came from that depth. Whether or not light is the active factor can be determined only by actual experiment on the light reactions of *D. arctica*, which should not be a difficult task. Perhaps my suggestion may lead some Norwegian student to undertake it.

*Diphyes arctica* has been treated at some length because the data allows us to follow it over some twenty-five degrees of latitude, and because the question of its probable vertical limits is germane to the ecology of Siphonophores in general. But a considerable vertical range, irrespective of stage of development or of season, has also been established for *Diphyes appendiculata.* This species occupies a zone of considerable depth at all seasons in the Mediterranean, and the same is true of it in summer in the Bay of Biscay. But the numerous records of this species show that it is usually most abundant within seventy-five fathoms of the surface (Chun, '87, Bigelow, :11b).

### *Seasonal Fluctuations in vertical Distribution.*

Seasonal fluctuations in vertical distribution are known for several Siphonophores. The most important observations along this line are those made by Chun ('87), and Woltereck's (:04) studies on the development of Velella. Chun found that in the Mediterranean Physophora, Hippopodius, and *Stephanomia rubrum,* which are common on the surface during autumn, winter and early spring, seek deeper, and consequently cooler layers as summer approaches. During the summer the larvae of all these were taken by him at from 100–900 meters (for a complete list of the seasonal occurrence of Siphonophores in the Bay of Naples, see Lo Bianco, '99). In the Adriatic, the genus Praya is found on the surface from January to the middle of April, and appears again by the end of August; Stephanomia from October to February (Steuer, :10, p. 571; Stiasny, :11). As I have already pointed out temperature is the factor governing the vertical movements of these species, but this does not seem to be true of Velella. The life-cycle of this genus, as traced by Woltereck, is as follows: — it swarms on the surface in the Mediterranean at two periods, April–June, and October–December (Lo Bianco, '99); and the sexual Medusae (Chrysomitra), set free on the surface, sink to considerable depths before becoming sexually mature. The larvae (Conaria) then gradually rise by "die Bildung specifische leichter Stoffe" to the surface, where they pass through the remaining stages of development from the "Rataria" to the adult Velella. The fact that our knowledge of Porpita has exactly the same gaps as did that of Velella until its larvae were collected off Villefranche, suggests that it probably carries out the same vertical migration. And this may also be true of Physalia.

Woltereck has suggested that the Chrysomitrae are negatively phototropic, which could easily be tested, and no doubt soon will be; or they may descend by simple passive sinking.

### *Salinity, in its relation to Distribution.*

We know very little about salinity as a factor determining the distribution of Siphonophores, except in the most general way. We can say that Siphonophores are absent or at least uncommon in regions of very low salinity. Thus none have ever been recorded from the Black Sea or from the Baltic, although the Ctenophore *Pleurobrachia pileus* is found in both. The North Sea and the Baltic are especially instructive because the plankton of these regions has been so thoroughly explored.

There is no dearth of Siphonophores in those parts of the Atlantic from which they might enter the North Sea. Thus various species are common in the Bay of Biscay (Bigelow, :11b); at least eight genera are known from Irish waters (Stephens, :05), and the yearly invasion of the Norwegian Sea by Physophora and Agalmidae has been noted (p. 371). In the English Channel, too, *Muggiaea atlantica* is an important member of the plankton, Agalma often appears from there in the lists of the International committee, and Galeolaria is likewise recorded. But according to Gough *M. atlantica* does not penetrate the Channel beyond the Isle of Wight, though the temperatures are no barrier to it in summer (p. 376); and though *Physophora hydrostatica* and *Diphyes arctica* are known from the northern, and various Siphonophores have been recorded from the southern part of the North Sea, I can not learn that any Siphonophore ever attains any faunal prominence there. *D. arctica* extends as far as the Skaggerak, where it is known from the intermediate waters, but further east, *i. e.* in the Baltic, the Gulf of Finland, and the Gulf of Bothnia, Siphonophores are unknown. Comparing these phenomena of distribution with the salinity charts of the International committee, it appears that Siphonophores, in the region in question, are almost a negligible factor in the plankton in waters with a salinity less than 35‰, and that they are entirely absent where the salinity is below about 30‰.

On the east coast of the United States the coast water is comparatively fresh; and here, too, Siphonophores never form a conspicuous or constant constituent of the plankton, though various Medusae and Ctenophores are often extraordinarily abundant. For example, *Stephanomia cara* appears only sporadically in Massachusetts Bay or the Bay of Fundy, while the large collections from Labrador and Newfoundland which I have studied did not contain so much as a fragment of it. *Agalma elegans* enters Narragansett Bay only when the surface waters of the Gulf Stream are driven on shore by southerly winds, and the same is true of the other species recorded from there. Off the mouths of large rivers, too, like the Amazon, Siphonophores are rare or absent (Chun, '97b, p. 101).

## TABLE OF DISTRIBUTION.

In the ensuing table, the well-authenticated occurrences of all valid, and several doubtful species are given, so far as I have been able to find them. Unplaced Eudoxids are omitted.

The words "tropical," "temperate," etc, are vague, and do not always carry the same meaning. I have therefore divided the north Atlantic into four zones; 1, warm regions limited by the isotherm of 68°; 2, temperate, 68°–55°; 3, boreal, 55°–45°; and 4, Arctic, below 45°. These limits are all for the warmest month of the year, because the great majority of Siphonophores are warm-water forms, and often occur in summer far to the north of their usual range, particularly in the region of the Gulf Stream. The precise temperature limits have been chosen because they fit in best with the distribution of the group. A fifth region is the Mediterranean.

The curves on the small chart are taken from Krummel, the Deutsche Seewarte atlas, the "Ingolf" Expedition, Nansen (North Polar Expedition), and from the data collected by the "Conseil International."

The Indian and Pacific oceans are treated as a whole, because our knowledge of their Siphonophore fauna is practically limited to the tropical and subtropical regions. And the south Atlantic is omitted for the obvious reason that it is practically *mare incognitum* in this connection.

A complete list of the records of Siphonophores in northern waters up to 1902 has been compiled by Römer (:02).

The sign × indicates that the species is known; — that it is represented by an ally so close that the two may finally prove to be identical. **x** indicates that the species is known from intermediate or closing net hauls only. Species preceded by ? are problematical. O signifies that the genus is known, but that its specific representative is doubtful.

| | ATLANTIC ZONES | | | | | | | | | | | | INDO-PACIFIC | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. | | | 2. | | | 3. | | | 4. | | | | | |
| | West | East | Central | West | East | | West | East | | West | East | Mediterranean | Trop. Pacific | Malaysian | Indian Ocean |
| Sphaeronectes truncata | × | × | | × | | | | | | | | × | | | × |
| " irregularis | | × | | | | | | | | | | × | | | |
| " princeps | | | | | | | | | | | | | | | × |
| Muggiaea huxleyi | | | | | | | | | | | | | | | × |
| " atlantica | | ? | | | × | | | | | | | | × | | |
| " kochii | | × | | | × | | | | | | | × | × | | |
| Doromasia picta | × | × | × | | | | | | | | | | | | |
| Cuboides vitreus | × | × | × | | | | | | | | | | × | × | × |
| Nectopyramis thetis | | | | | × | | | | | | | | | | |
| " diomedeae | | | | | | | | | | | | | **X** | | |
| Amphicaryon acaule | × | × | | | | | | | | | | | × | | |
| Rosacea plicata | | × | | | × | | | | | | | × | × | | |
| " medusa | ? | × | | | | | | | | | | × | × | × | |
| Praya cymbiformis | | × | | | | | | | | | | × | × | × | |
| ? Desmalia imbricata | | | | | | | | | | | | | | | × |
| ? Desmophyes annectens | | | | | | | | | | | | | | | × |
| Nectodroma reticulata | | | | | | | | | | | | | **X** | | |
| " dubia | | | | | | | | | | | | | × | | |
| Stephanophyes superba | × | × | | | | | | | | | | | | | |
| Hippopodius hippopus | × | × | × | × | × | | | | | | | × | × | × | |
| Vogtia pentacantha | | | | | × | | | | | | | × | | | |
| " spinosa | | | × | | × | | | | | | | | × | | |
| Abyla leuckartii | × | | ? | | | | | | | | | | × | × | × |
| " trigona | × | × | × | | | | | | | | | | × | × | × |
| " haeckeli | | | | | | | | | | | | | × | × | |
| Abylopsis tetragona | × | × | × | | | | | | | | | × | × | × | × |
| " eschscholtzii | × | × | × | | | | | | | | | | × | × | × |
| Bassia bassensis | × | × | × | | | | | | | | | | × | × | ? |
| Diphyabyla hubrechti | | | | | | | | | | | | | × | × | |
| Galeolaria australis | | | | | | | | — | | | | | × | × | × |
| " biloba | | | | | | | | × | | | ? | | — | — | — |
| " quadrivalvis | × | × | | | | | | | | | | × | × | × | |
| " truncata | | | | | ? | | | | | | | | | | |
| " monica | | × | | | | | | | | | | | × | × | |
| ? " ovata | | | | | | | | | | | | × | | | |
| Diphyes arctica | | | | | | | | | | × | × | | | | |
| " subtilis | | × | | | × | | | | | | | × | | | |
| " bojani | — | — | — | | | | | | | | | | × | × | |
| " steenstrupi | — | × | — | | | | | | | | | | — | — | |
| " serrata | × | × | × | | | | | | | | | | — | — | |
| " appendiculata | × | × | × | × | × | × | × | | × | | | × | × | × | × |
| " spiralis | | | | | | | | | | | | | × | | |
| " contorta | | | | | | | | | | | | | × | × | |
| " fowleri | × | | | | × | | | | | | | | × | | |
| " subtiloides | | | | | | | | | | | | | | × | |
| Diphyopsis dispar | × | × | × | × | | | × | | | | | | × | × | × |
| " mitra | × | | | | | | | | | | | | × | × | × |
| " chamissonis | | | | | | | | | | | | | × | × | × |
| ? " hispaniana | × | | | | | | | | | | | | | | |
| Chuniphyes multidentata | | | | | **X** | | | | | | | | **X** | **X** | |

| | Atlantic Zones | | | | | | | | | | Indo-Pacific | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. | | | 2. | | 3. | | 4 | | | | | |
| | West | East | Central | West | East | West | East | West | East | Mediterranean | Trop. Pacific | Malaysian | Indian Ocean |
| Apolemia uvaria | | | | × | × | | | | | × | O | | × |
| Forskalia | × | × | | | | | | | | × | × | × | × |
| Erenna richardi | | | | | **X** | | | | | | × | | |
| ? " bedoti | | | | | | | | | | | | **X** | |
| Agalma okeni | × | × | × | | | | | | | | × | × | × |
| " elegans | × | × | | × | × | | × | | | × | × | × | |
| " clausi | | | | | | | | | | × | | | |
| " haeckeli | | | | | | | | | | — | | | × |
| Stephanomia amphitrides | | | | | | | | | | | × | × | × |
| " bijuga | × | × | | ? | | — | | — | | × | × | × | |
| " cara | | | | ? | | × | | × | | | | | |
| Stephanomia rubra | | | | | | | | | | × | | × | |
| ? " cupulifera | | | | | | | | | | | | × | |
| Anthemodes ordinata | | × | | | | | | | | | | | |
| Lychnogalma utricularia | | | | | | | | | | × | | | × |
| Physophora hydrostatica | | × | × | | × | | × | | | × | × | × | × |
| Nectalia loligo | | × | | | | | | × | | | × | | |
| ? Discolabe quadrigata | | | | | | | | | | | | | × |
| Athorybia rosacea | | × | × | | × | | | | | × | × | | × |
| Anthophysa formosa | × | | × | × | | | | | | | — | — | |
| " rosea | — | | | — | | | | | | | × | × | |
| ? Rhodophysa corona | | | | | | | | | | | | | × |
| Stephalia corona | | | | | | | × | | | | O | | |
| Angelopsis globosa | **X** | | | | | | | | | | — | | |
| " dilata | — | | | | | | | | | | **X** | | |
| Dromalia alexandri | | | | | | | | | | | **X** | | |
| Rhodalia miranda* | | | | | | | | | | | | | |
| Archangelopsis typica | | | | | | | | | | | **X** | **X** | |
| Rhizophysa filiformis | × | × | × | | | | | | | × | × | × | × |
| " eysenhardtii | × | × | × | | | | | | | ? | × | × | × |
| †Salacia uvaria | × | | | | | | | | | | | | |
| Bathyphysa abyssorum | | | | | **X** | | | | | | O | | |
| " sibogae | | | | | | | | | | | | **X** | |
| Pterophysa grandis | **X** | | | | | | | | | | | **X** | |
| " grimaldii | | **X** | | | | | | | | | | | |
| " studeri | | | | | | | | | | | | **X** | |
| Epibulia ritteriana | | | | | | | | | | | — | | × |
| Physalia physalis | × | × | × | × | × | | | | | × | | | |
| " utriculus | | | | | | | | | | | × | × | × |
| Porpema globosa | | | × | | | | | | | | — | | O |
| " prunella | | | — | | | | | | | | × | | |
| Porpita porpita | | | | | | | | | | | | ? | × |
| " umbella | × | × | × | × | × | | | | | × | | | |
| " pacifica | | | | | | | | | | | × | | |
| Velella velella | × | × | × | × | × | | | | | × | | | |
| " lata | | | | | | | | | | | × | × | — |

* South Atlantic, E. of Buenos Ayres, 37° 17′ S. Lat., 53° 52′ W. L.

† South Atlantic, 21° 15′ S., 14° 2′ W. L.

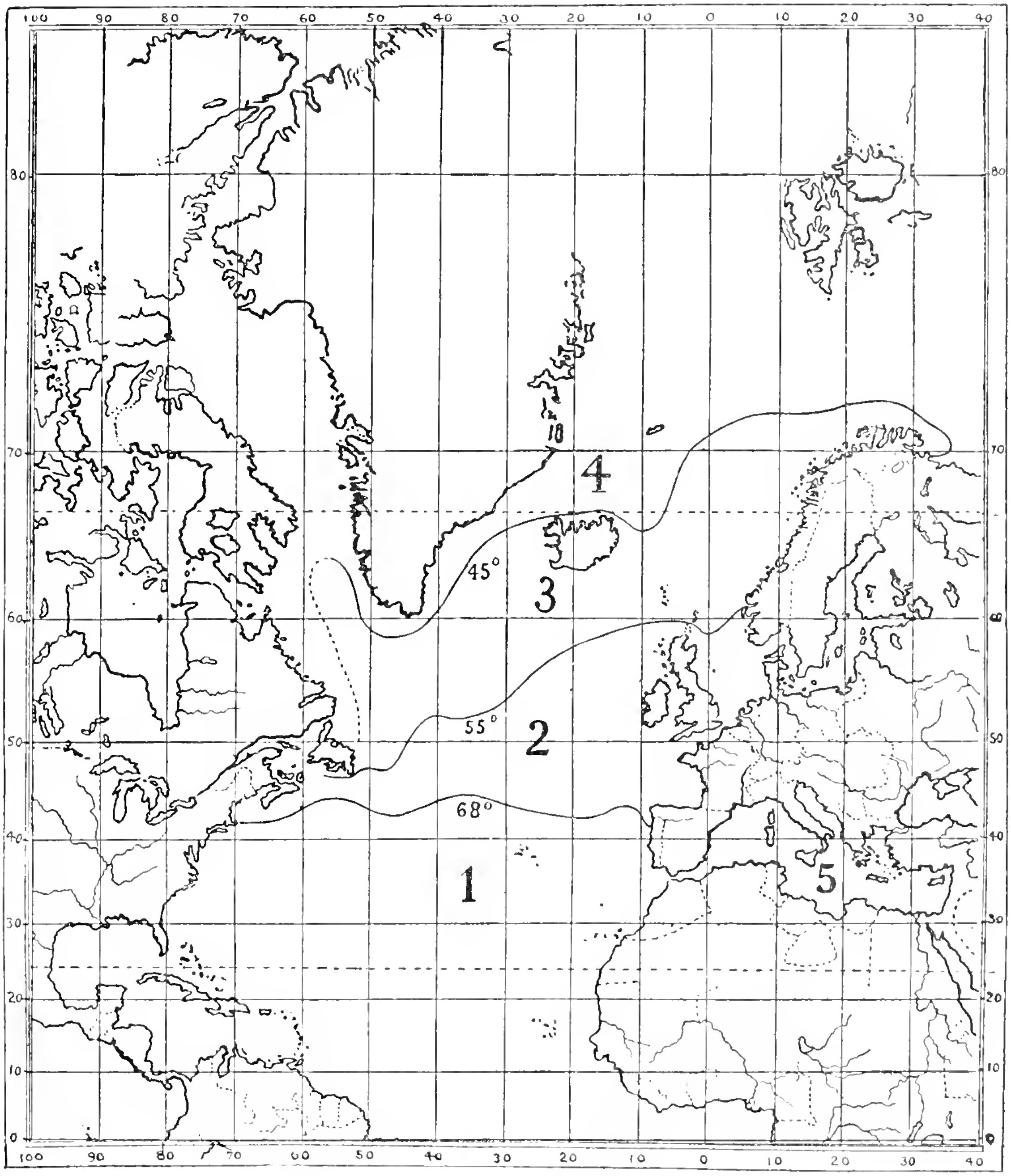

Fig. D. Distribution zones of North Atlantic.

# GENERAL CONSIDERATIONS.

As our knowledge of the geographic distribution of the various groups of pelagic Metazoa grows, it becomes increasingly profitable to compare them with one another. One field of discussion which has led to many interesting results in other groups, the relationship between Arctic and Antarctic faunae, is closed to us, because no Antarctic Siphonophore is yet known. But we have enough data to allow some important comparisons.

The qualitative richness of the Siphonophore fauna of warm waters as compared to its poverty in cold latitudes is paralleled by Medusae (Maas, :06) Ctenophores (Moser, :09), Pteropods (Meisenheimer, :08), Chaetognaths (Fowler, :06), Salpae (Apstein, :08) and by various other groups which share with Siphonophores a permanently pelagic existence, and helplessness to alter their environment by directive horizontal swimming.

The Siphonophores are as a whole restricted to an extremely uniform environment; much more so than the Medusae. Thus no Siphonophore has penetrated into brackish, much less into fresh water. Even in oceanic regions of low salinity Siphonophores are not common. Not one has adopted the bottom as its usual habitat, as have certain Medusae; none are parasitic, while Medusae are parasitic on molluscs, and on each other (various Narcomedusae). And like the cold-water members of several of these groups, the boreal and Arctic Siphonophores are not structurally primitive. They certainly are not ancestral types. For genera or families which might be looked on in such a light, *e. g.* Monophyids and Prayids among Calycophores, Apolemia among Physophores, we must turn to warmer zones. And on the other hand none of the highly specialized Siphonophores are known from cold waters. Thus there is no Arctic Hippopodid, no Anthophysid, no Rhizophysalid, no Chondrophorid. Arguing from such grounds Maas (:06), Meisenheimer (:05, :08) and Moser (:09) have reached the very important generalization that for Medusae, Pteropods, and Ctenophores, the centre of development lies in warm or in temperate seas, and that they have spread thence into cold zones to the north or south, where they may or may not have become differentiated specifically. The Medusae have likewise made an incursion, important both numerically and physiologically, into the peculiar though uniform environment provided by the intermediate water layers. And there is every reason to extend these generalizations to the Siphonophores as well. In the case of the latter group there has been a small northerly spread, and an even smaller expansion downward. Whether there has been any extension into the frigid zone of the southern hemisphere remains to be seen, though it is hardly conceivable that there should not. On this point, as on many others, we can expect much valuable information from the collections made by the "Valdivia."

The Siphonophores have been less successful in occupying cold waters than either Medusae or Ctenophores. The trachomedusan, narcomedusan, and scyphomedusan fauna of the Arctic and Antarctic waters, of which Maas (:06) has given a general account, are qualitatively rich, and quantitatively even more so. And when we turn to Ctenophores, we find that of eighty species recognized by Moser (:09) as valid, nine are known from the Arctic, or from the Antarctic. But among the rather larger list of Siphonophores (about 95), only three species have any claim to be regarded as normally Arctic forms. Specimens of other species, it is true, are occasionally taken far north, as for example Physophora and *Diphyopsis dispar*. But these records are nothing more than sporadic instances of the effects of currents. The animals have not succeeded in establishing themselves there. The difference between Siphonophores and Ctenophores in this respect is further emphasized by the fact that it is doubtful whether there is a single truly eurythermal Siphonophore, while there is at least one Ctenophore, *Pleurobrachia pileus,* the distribution of which is wholly independent of temperature. And the same is probably true of a second, *Beroe cucumis.* For the former, the known temperature range is from just above freezing to 28° C (82.4° F.); for the latter, from the same low limit to 23° C. (73.4° F.). The extreme temperature range known for the most nearly eurythermal Siphonophore is from about 45° F. to about 80° F.; considerably less than either of these Ctenophores, while its normal range, from about 55° to about 80°, is still narrower.

Another significant fact is that the Siphonophore component of the Arctic plankton is not only qualitatively, but quantitatively, much poorer than either the Medusae, the Ctenophore, the Pteropod or the Chaetognath component. Thus *Diphyes arctica* occurs far less regularly in Arctic currents than do the Pteropod *Clione limacina,* the Chaetognath *Krohnia hamata,* or the Trachomedusa *Aglantha digitale,* though it has been captured from a wide range of localities. Nor has it ever been found so abundant anywhere as Clione, Aglantha, Pleurobrachia, or Mertensia, which often gather in enormous swarms. The same thing is true, also, of *Stephanomia cara,* though it is large and conspicuous. And this species is even more irregular in its appearance.

Even in temperate, "mischgebiete" regions Siphonophores are comparatively unimportant members of the plankton, from the quantitative point of view, although, as I have already pointed out (p. 369), the number of species is already much greater than it is in colder waters. Thus in the Bay of Biscay for example, Mr. Fowler found only one Siphonophore regularly enough for me to plot its vertical distribution. But when we turn to the metazoan plankton of tropical and subtropical waters, we find Siphonophores relatively very much more important. It is true that they seldom fill the surface waters to the extent that Salpae often do; but there are few pelagic forms more regular in their occurrence in warm currents than *Diphyes appendiculata*, *Diphyopsis dispar*, or *Abylopsis tetragona*. And the swarms of Velella and Porpita have long attracted notice.

The fact that the warm-water Siphonophores are divided into two main groups, one restricted to characteristically tropical temperatures, *i. e.* above about 65°; the other with a range wide enough to allow them to occupy the Mediterranean, is likewise significant, because no such division can be made for the holoplanktonic Medusae, the Pteropods (Meisenheimer), nor Salpae (Apstein).

When we come to compare the intrusion of Siphonophores into the intermediate water layers with that of the Medusae, we find a state of affairs very similar to the differences in their extensions into Arctic regions. Medusae have been very successful colonists of deep water; they are surpassed by fishes alone in the diversity of the ancestral stocks which have sent offshoots into this environment. Thus among the Craspedotae no less than seven families, including Antho-, Lepto-, Tracho-, and Narcomedusae, have representatives among the mesoplankton; while the Scyphomedusae are represented by six families. On the other hand there are only two families of Siphonophores which have members belonging exclusively to the mesoplankton, and no one of these occurs as regularly or as commonly as do several of the "intermediate" Medusae, for example Colobonema or Halicreas.

In the poverty of their mesoplanktonic constituents the Siphonophores agree with Ctenophores (Moser, :09). These various facts taken together point in the first place to the conclusion that Siphonophores are as a whole much more sensitive to temperature than either Medusae, Ctenophores, or Pteropods, and, in the second, that they have been less able to adapt themselves to changes in temperature, and to occupy the oceanic zones which would thus have been opened to them. They are, too, far more sensitive to differences in salinity (p. 380).

*Note*:—Dr. F. Moser's preliminary discussion of the Monophyids and Diphyids of the German South Polar expedition (Über Monophyiden und Diphyiden. Zool. Anz., 1911, **38**, p. 430–432) was received when the foregoing pages were in press, too late for extended review. While awaiting her final account I may note some of the more important systematic results. She unites as one species *Diphyes bojani*, *D. gegenbauri*, *D. malayana*, *D. indica*, and *Doromasia pictoides* (*cf.* p. 244); and having Atlantic material she was able to prove that they are identical with *D. steenstrupi* Gegenbaur, a result suggested above.

She asserts definitely that *Doromasia picta* Chun is not a Monophyid, but is a young stage of *Diphyopsis dispar*, thus bearing out my suggestion arrived at from less extensive material.

In only one important point her observations contradict my own, namely in connecting the Eudoxid Ceratocymba in genetic series with Diphyabyla. The "Albatross" collection, on the contrary, affords strong evidence that the former is a stage in the life history of *Abyla leuckartii*. I had hoped that the next important collection would determine the parentage of *Ersaea bojani*. But Moser finds only a strong probability that it belongs to *Diphyes steenstrupi* (= *bojani*). Finally she mentions the discovery of new, and highly organized Monophyids. Among them we may perhaps look for members of the Nectopyramidinae.

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# EXPLANATION OF THE PLATES.

## ABBREVIATIONS.

| | |
|---|---|
| Am. | Ampulla of the tentillum |
| $B^1$. $B^2$. | Buds |
| Br. | Bract |
| C. | Canal |
| C. Br. | Bracteal canal |
| C.H. | Hydroecial canal |
| C. Pa. | Palial " |
| C. Ped. | Pedicular " |
| C. Ra. | Radial " |
| C. Su. | Subumbrellar " |
| Ce. | Cell |
| Cn. | Cnidoband of tentillum |
| Ec. | Ectoderm |
| En. | Endoderm |
| F. | Terminal filament of tentillum |
| Go. D. | Gonodendron |
| Go | Gonophore |
| H. | Hydroecium |
| I. | Involucre of tentillum |
| L. Mu. | Muscular lamella |
| N. | Nectophore |
| N.A | Superior nectophore |
| N.P. | Inferior " |
| N.S. | Nectosac |
| P. | Palpon |
| Pn. | Pneumatophore |
| R. D, R. L, R. V, | Dorsal, lateral, and ventral ridges |
| Sm | Septum |
| Sti. | Stigmata |
| S. L | Stutzlamella |

PLATE 1.

## PLATE 1.

### **Nectopyramis diomedeae.**

Fig. 1. Side view of the nectophore of Type. × 2.

Fig. 2. Ventral view of same.

Fig. 3. Left lateral view of hydroecium of another specimen.

Fig. 4. Similar view of hydroecium of Type. (In figs. 3 and 4, the lettering C. Ped and C. Pa$^3$ should be transposed.) × 4.

Fig. 5. Lateral view of the free Eudoxid. × about 3.

### **Nectrodroma reticulata.**

Fig. 7. Lateral view of young nectophore. × 6.

Fig. 8. Dorsal view of same.

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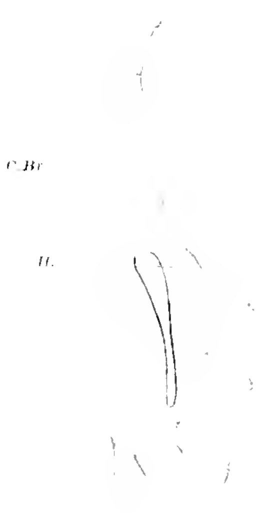

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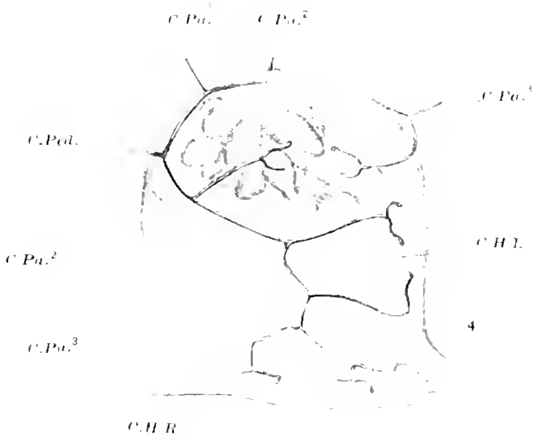

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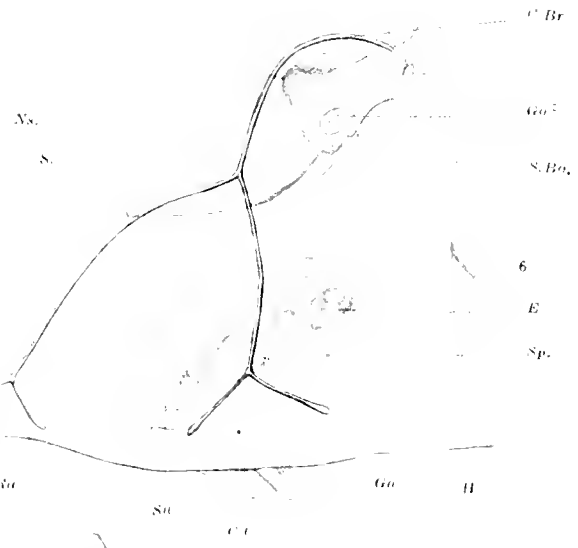

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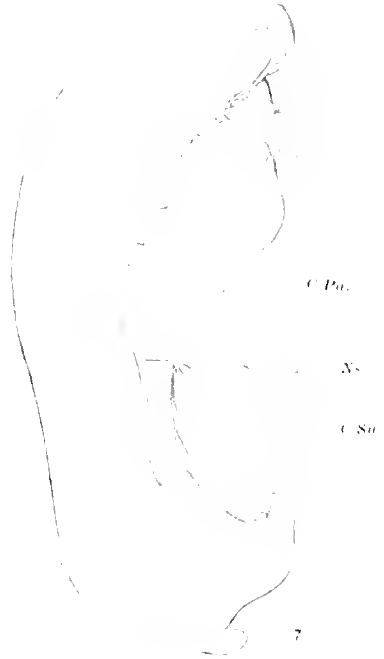

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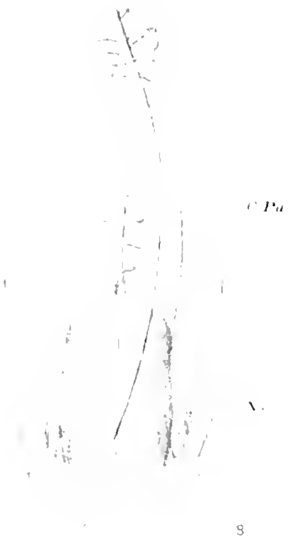

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PLATE 2.

## PLATE 2.

### Praya cymbiformis.

Fig. 1. The two definitive nectophores of a large colony, in their natural position. × 2.5.

Fig. 2. Ventral view of the younger of the two nectophores.

Fig. 3. Proximal portion of the corm, with buds for siphons, bracts, and gonophores, and the muscular lamellae which bore the nectophores. × 4.

Fig. 4. A mature group of appendages, with bract, siphon, tentacle, and gonophore. × 15.

Fig. 5. Male gonophore.

Fig. 6. Portion of bract, showing the canals.

### ? Rosacea plicata.

Fig. 7. Lateral view of the younger of the two chief nectophores. × 3.

Fig. 8. Ventral view of the same.

Fig. 9. Ventral view of the older nectophore. × 3.

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3

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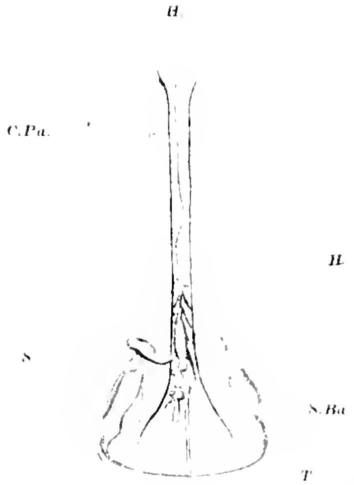

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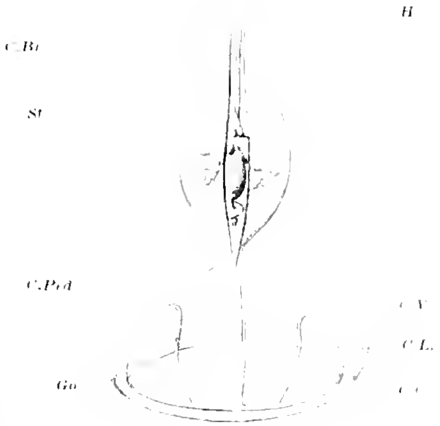

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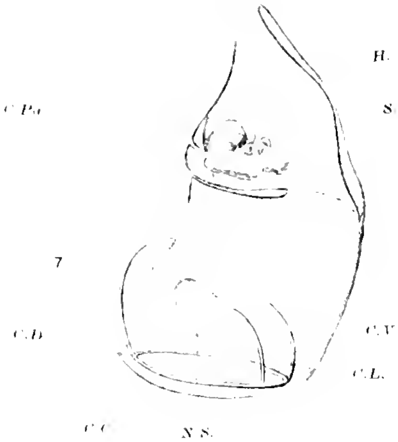

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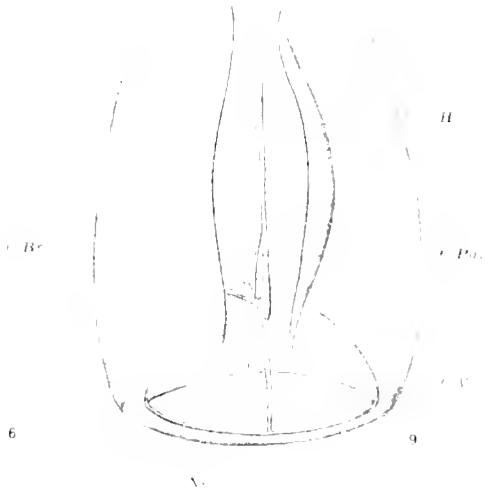

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PLATE 3.

## PLATE 3.

### **Nectodroma reticulata.**

Fig. 1. Ventral view of nectophore. Type; 55 mm. long.

Fig. 2. Lateral view of same.

Fig. 3. Apical view of same. × 2.5.

Fig. 4. Somewhat oblique apicoventral view of nectosac, to show its canal system, and relation to the pedicular canal (C. Ped.). × 5.

Fig. 5. Ventral view of hydroecium, showing the course and ramifications of the ascending palial canal.

Fig. 6. Lateral view of bract. × 3.

Fig. 7. Portion of same, to show its canals more highly enlarged.

### **Nectodroma dubia.**

Fig. 8. Lateral view of nectophore. × 2.

Fig. 9. Ventral view of same.

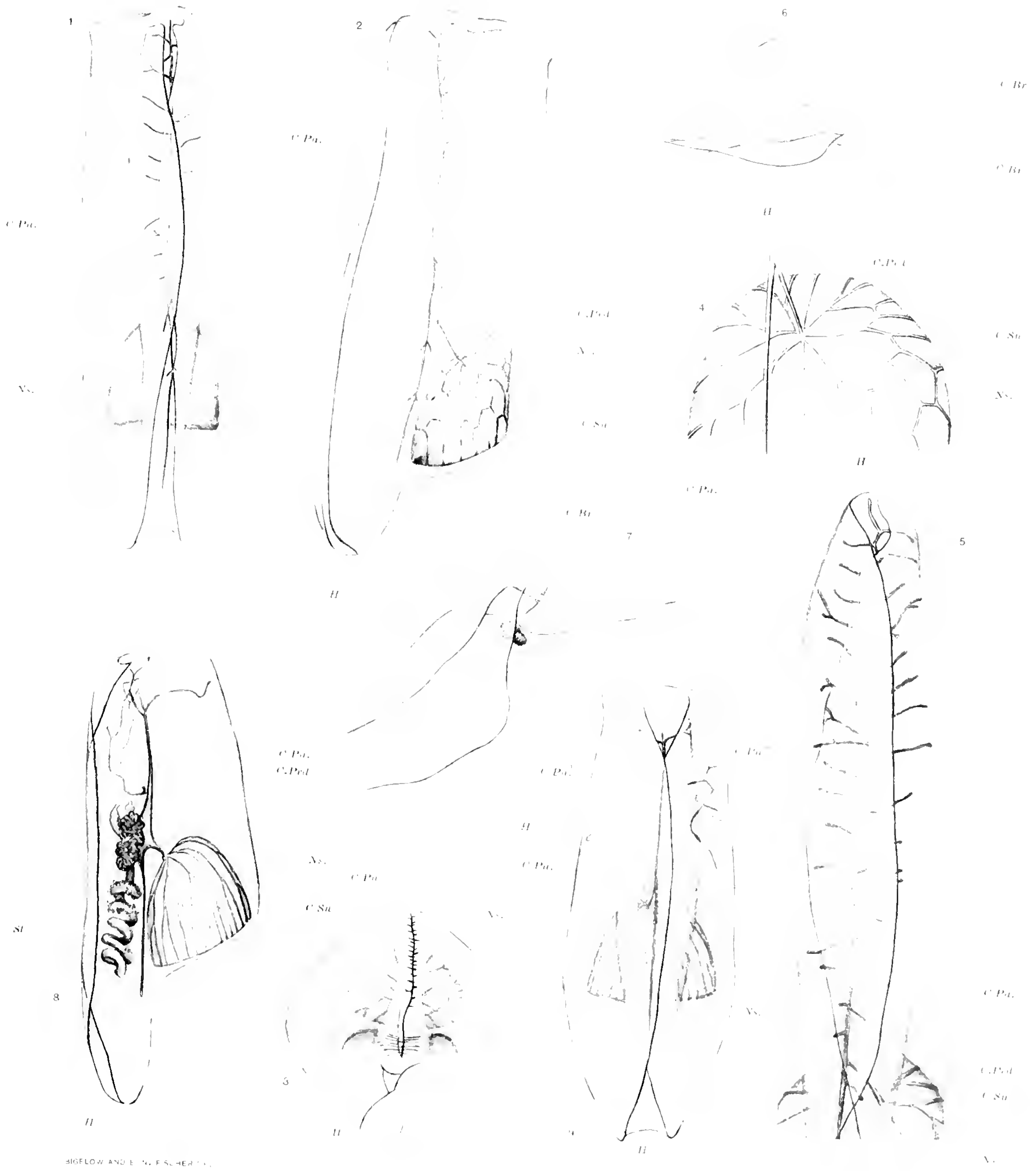

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PLATE 4.

## PLATE 4.

### **Amphicaryon acaule.**

Fig. 1. Lateral view of entire colony, showing relationship of the older nectophore (N.A) to the younger one (N.P). × 10.

Fig. 2. Apical view of same, showing the relative sizes of the two nectosacs (Ns.A and Ns.P).

Fig. 3. Central portion of the colony, showing the short corm with its appendages, and the canal system of the two nectosacs. The bract-like older nectophore (N.A) is turned to one side to expose the hydroecial furrow, with the stem, and the muscular lamellae bearing the nectophores. × 15.

Fig. 4. Dorsal view of the nectosac of the older nectophore. × 40.

Fig. 5. Bract and female gonophore. × 50.

Fig. 6. A group of appendages: siphon, bract, tentacle, and female gonophore. × 25.

Fig. 7. Ventral view of bract.

Fig. 8. A very young colony, 3 mm. long, showing how the relatively large older nectophore (n.a) overlaps the younger one (N.P).

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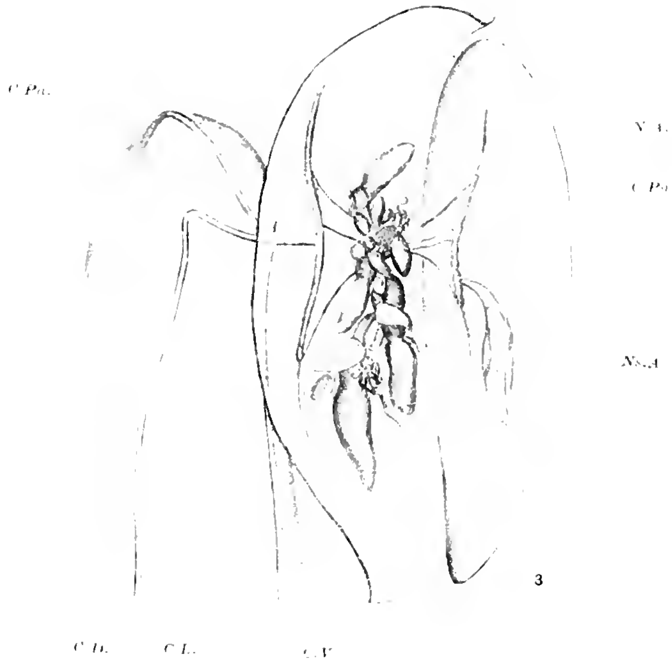

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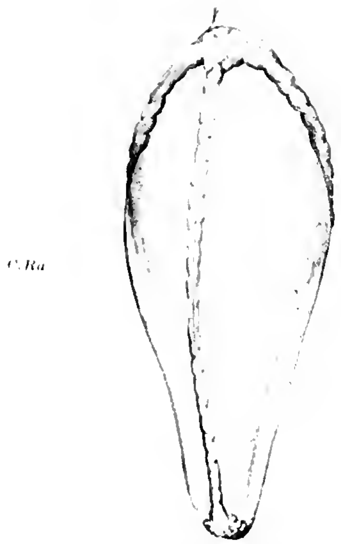

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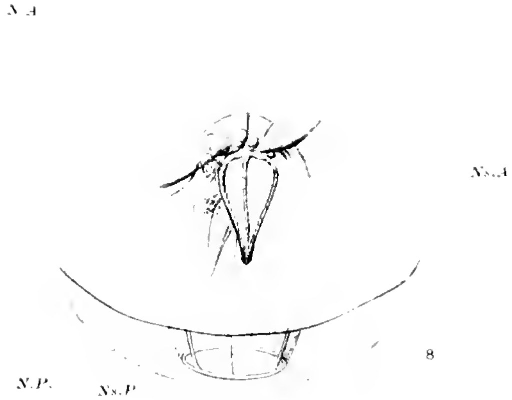

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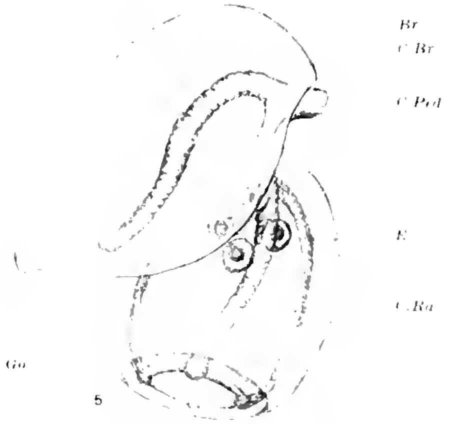

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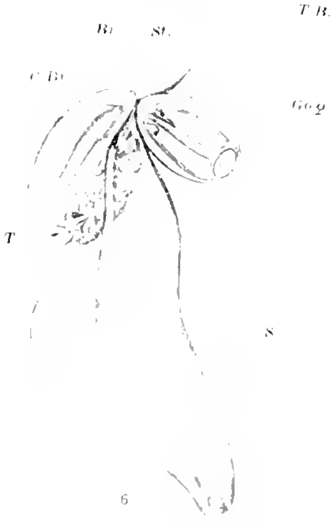

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PLATE 5.

## PLATE 5.

### **Galeolaria quadrivalvis.**

Fig. 1. Lateral view of inferior nectophore. × 4.5.
Fig. 2. Similar view of superior nectophore. × 4.
Fig. 3. Basal view of inferior nectophore, to show basal wings (W.V) and teeth (To.D. To.L). × 8.
Fig. 4. Similar view of superior nectophore. × 8.
Fig. 5. Two successive cormidia, showing bract (Br), tentacle (T), siphon (S) and gonophore (Go). × 20.
Fig. 6. Siphon (S), tentacle (T) and female gonophore (Go. ♀) with bract detached.
Fig. 7. Male gonophore (Go. ♂), siphon (S) and tentacle (T).

### **Galeolaria australis.**

Fig. 8. Lateral view of superior nectophore. × 5.
Fig. 9. Similar view of inferior nectophore. × 4.
Fig. 9 (*bis*). Dorsobasal view of inferior nectophore showing the lateral ridges (R. l). × 8.

All figures from photographs.

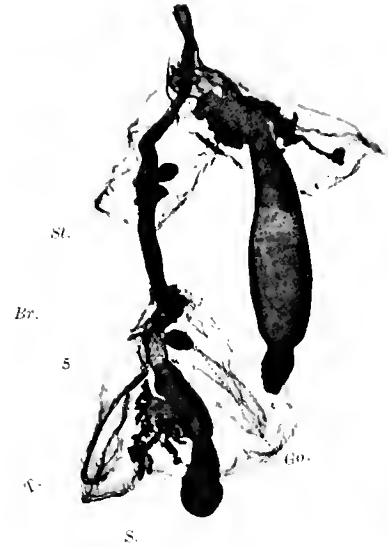

1


2

So.
St.


3

To D.1
To D.2
To L.
W.V.


5

St.
Br.
T.
Go.
S.


8

T


6

Go ♀
T.
S.


9

R.L.


4

To D.1
To D.2
W.V.1
W.V.2


7

St.
Go.♂
S.
Sp.


9

PLATE 6

PLATE 6.

## Galeolaria australis.

Fig. 1. Lateral view of superior nectophore. × 6.
Fig. 2. Ventral view of same to show subumbral canals and ventrobasal wings (W. V).
Fig. 3. Lateral view of inferior nectophore. × 5.

## Galeolaria monoica.

Fig. 4. Lateral view of inferior nectophore × 8.
Fig. 5. Ventral view of superior nectophore, with divided basoventral wing (W. V). × 8.

Fig. 6. Basal view of superior nectophore, to show dorsal (To. D) and lateral (To. L) teeth, and ventral wings (W. V). From a photograph.

Fig. 7. Lateral view of base of inferior nectophore, showing teeth (To. D, To. L, To. $L^2$) and ventral wing. × about 16.

Fig. 8. Lateral view of superior nectophore. × 9.
Fig. 9. Dorsal view of base of inferior nectophore.


C.L.
B. F.
Fo. D.
1
4

PLATE 7.

## PLATE 7.

Fig. 1. Muggiaea atlantica; lateral view of nectophore. × 12.

Fig. 2. Diphyes bojani; colony with two nectophores still connected. The superior nectophore shows wing-like expansions of the ridges in the upper $\frac{1}{3}$ of their course. × about 8.

Fig. 3. Diphyes bojani. Superior nectophore of another specimen, without wings. × 5.

Fig. 4. Diphyes spiralis. Lateral view of superior nectophore strongly contracted. × 15.

Fig. 5. Diphyes appendiculata. The two nectophores still connected. × 6.

Fig. 6. Diphyes appendiculata. Superior nectophore of same colony detached, to show conformation of base.

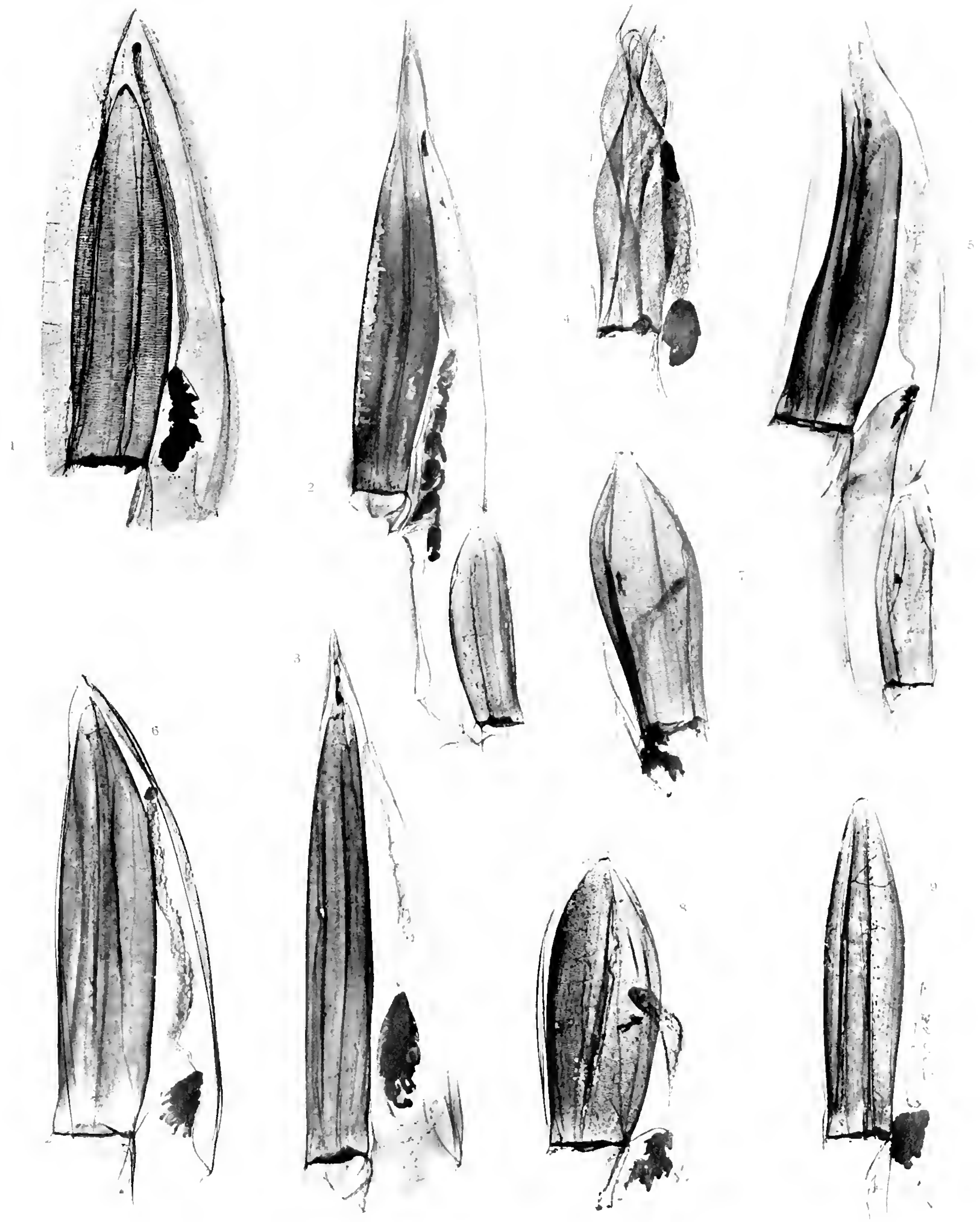
Fig. 7. Diphyes contorta. Dorsal view of superior nectophore, to show dorsal facet. × 10.

Fig. 8. Diphyes contorta. Lateral view of superior nectophore, showing asymmetrical somatocyst. × 10.

Fig. 9. Diphyopsis mitra. Lateral view of superior nectophore. × 8.

All figures from photographs.

"Albatross"—Eastern Pacific E. Siphonophorae. Plate 7.



BIGELOW PHOTO

PLATE 8.

## PLATE 8.

Fig. 1. Diphyes spiralis. Lateral view of superior nectophore, not contracted (*cf.* Pl. 7, fig. 4), showing the spiral course of the ridges (R. D, R. L). × 20.

Fig. 2. Ventral view of same, showing spiral ridges, ventral facet, conformation of base, and asymmetrical position of the somatocyst (So).

Fig. 3. Diphyes contorta. Apical view of superior nectophore. × 12.

Fig. 4. Diphyes fowleri. Lateral view of superior nectophore, showing short hydroecium (H) and transverse position of the pear-shaped somatocyst. × 8.

Fig. 5. Muggiaea atlantica. Lateral view of apex of nectophore, to show the ridges (R. D, R L, $R. V^1$, $R. V^2$).

Fig. 6. Diphyes bojani. Oblique dorsal view of apex of superior nectophore of a specimen in which the ridges are extended into wing-like enlargements.

Fig. 7. Diphyes appendiculata. Dorsal view of apex of superior nectophore, showing origin of ridges.

Fig. 8. Diphyes appendiculata. Oblique dorsal view of superior nectophore to show course and extent of lateral and dorsal ridges ($R. L^1$, $R. L^2$, R. D). × about 6.

Fig. 9. Chuniphyes multidentata. Lateral view of colony with the two nectophores still connected. × 5.

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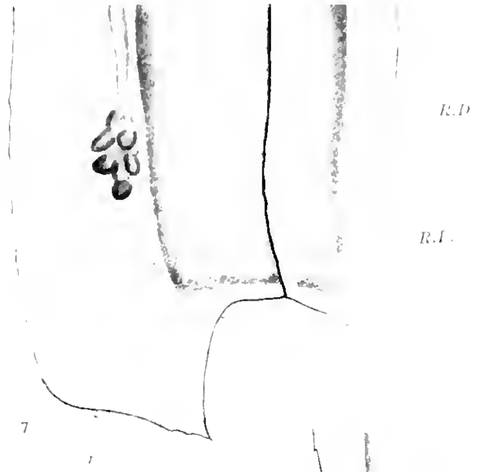
PLATE 9.

## PLATE 9.

Bases of superior nectophores of Diphyopsinae, and of Muggiaea.

Fig. 1. Diphyes bojani, lateral. × about 20.
Fig. 2. Diphyes bojani, dorsal. × 15.
Fig. 3. Diphyes spiralis, dorsal. × 50.
Fig. 4. Diphyopsis mitra, dorsal. × 16.
Fig. 5. Diphyes fowleri, dorsal. × 12.
Fig. 6. Diphyes appendiculata, dorsal.
Fig. 7. Muggiaea atlantica, lateral. × 18.
Fig. 8. Muggiaea atlantica, dorsal. × about 15.



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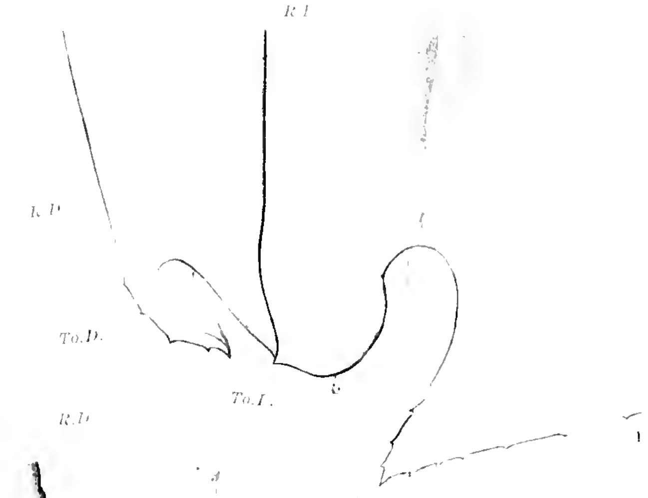

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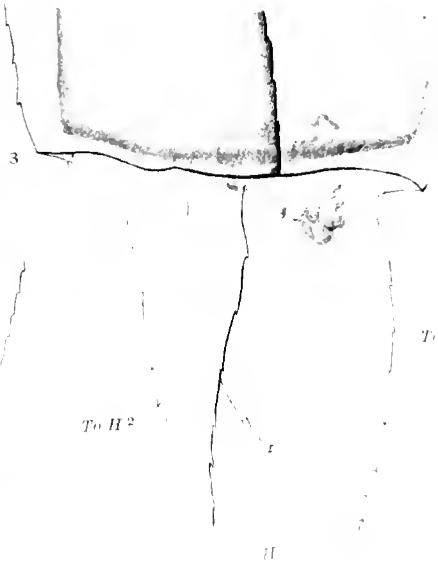

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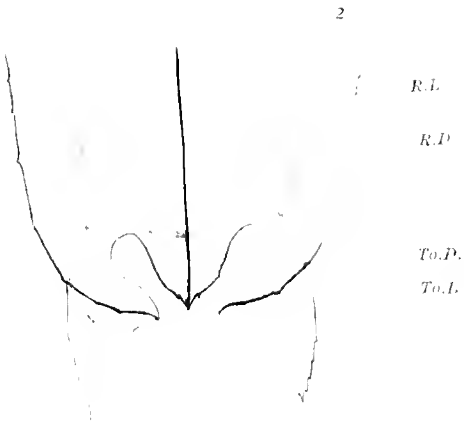

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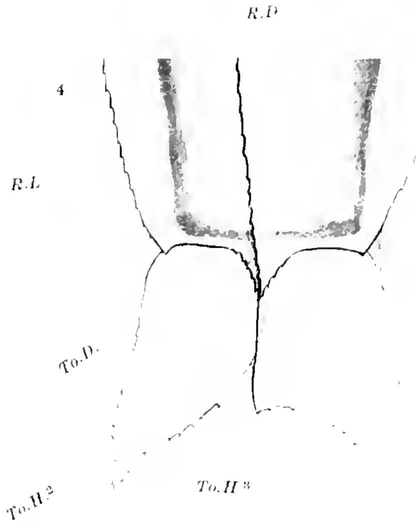

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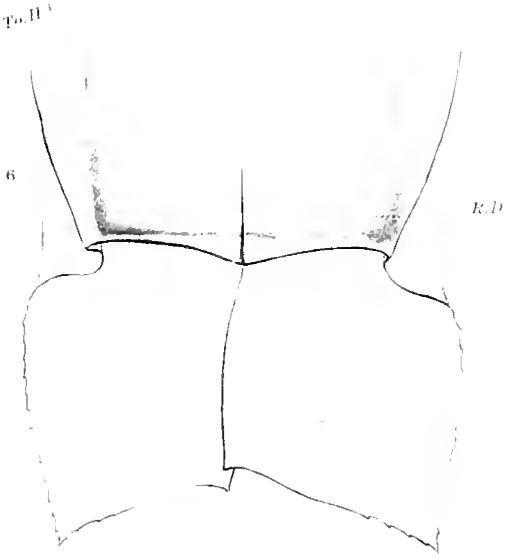

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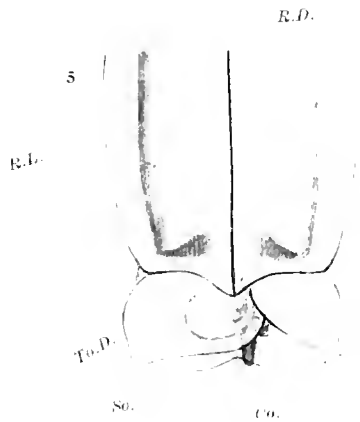

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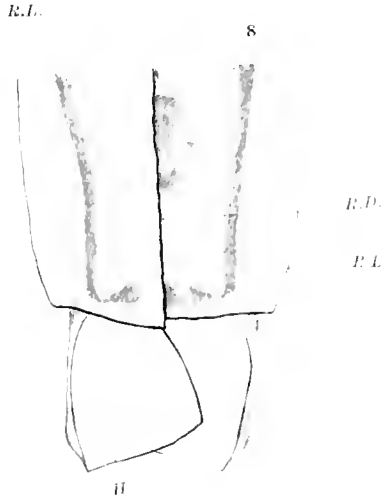

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PLATE 10.

## PLATE 10.

### Inferior nectophores of Diphyopsinae.

Fig. 1. Diphyopsis dispar, lateral. × 6.
Fig. 2. Diphyes bojani, lateral. × 6.
Fig. 3. Diphyes bojani, ventral. × 6.
Fig. 4. Diphyopsis mitra, lateral. × 10.
Fig. 5. Diphyopsis mitra, ventral. × 10.
Fig. 6. Diphyes appendiculata, ventral. × 9.
Fig. 7. Chuniphyes multidentata, ventral. × 4.5.

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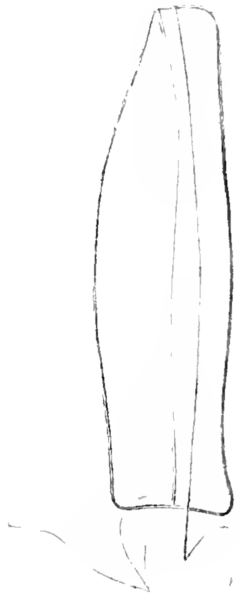

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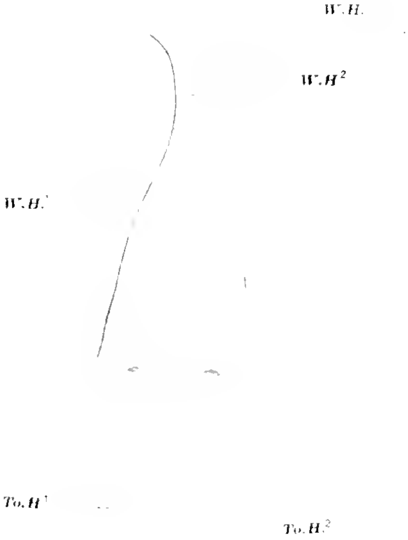

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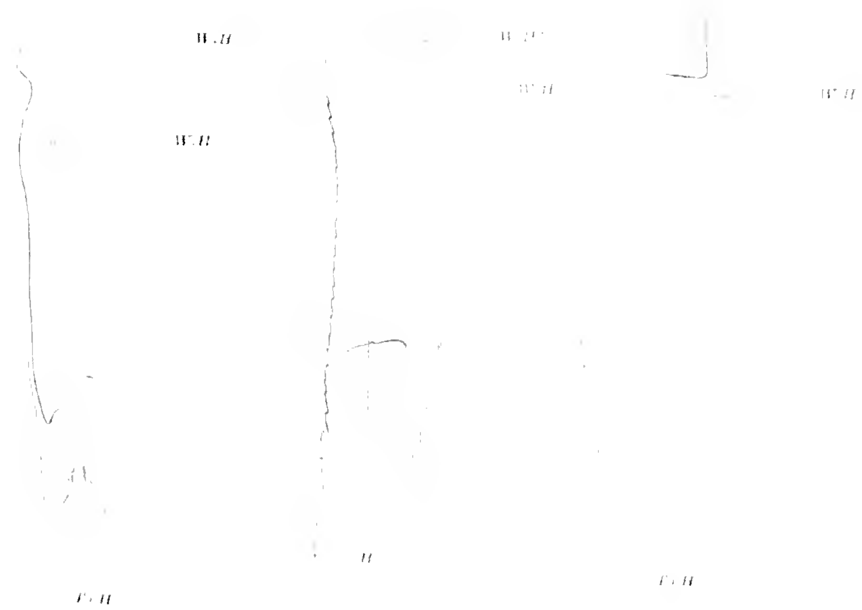

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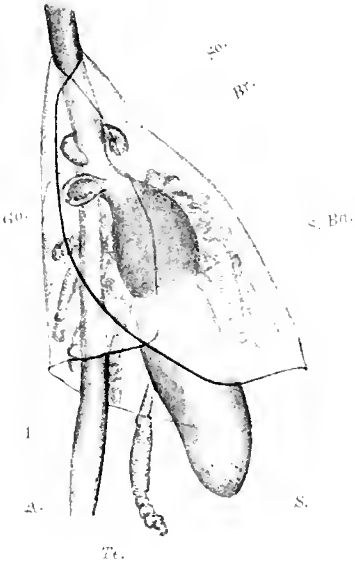
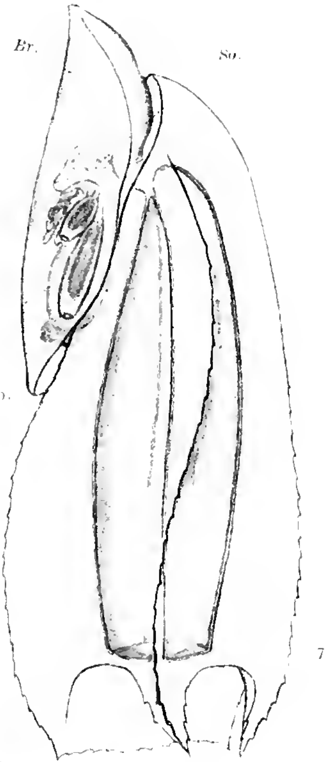
PLATE 11.

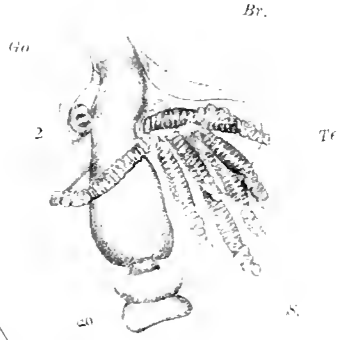
## PLATE 11.

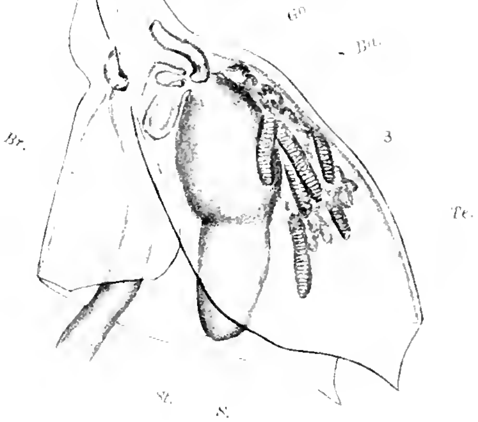
Figs. 1–6, attached cormidia of Diphyopsinae. × about 50.

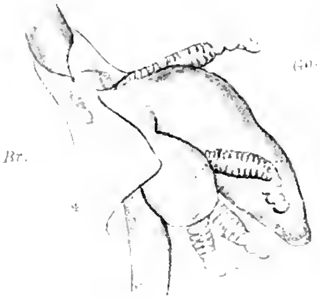
Fig. 1. Diphyes appendiculata.
Fig. 2. Diphyes contorta.
Fig. 3. Diphyopsis dispar, with bud for special nectophore, as well as the young gonophore (Go).
Fig. 4. Diphyes spiralis.
Fig. 5. Diphyes bojani.
Fig. 6. Diphyopsis mitra. The bud for the special nectophore is not yet visible.
Fig. 7. Ersaea bojani. Lateral view. × 20.
Fig. 8. Ersaea bojani. Ventral view. The somatocyst of the bract is asymmetrical, and one of its horns contains a large drop of oil (O). × 16.
Fig. 9. The free Eudoxid of Diphyes appendiculata. × 16.

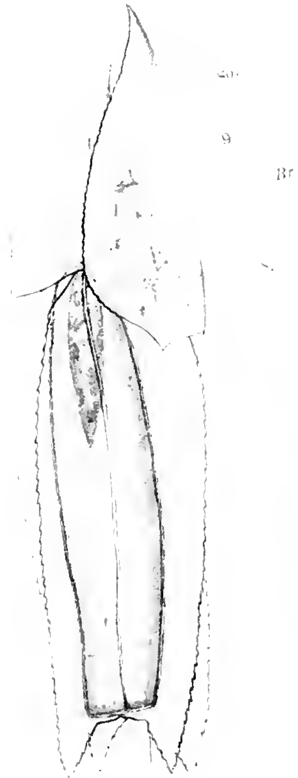


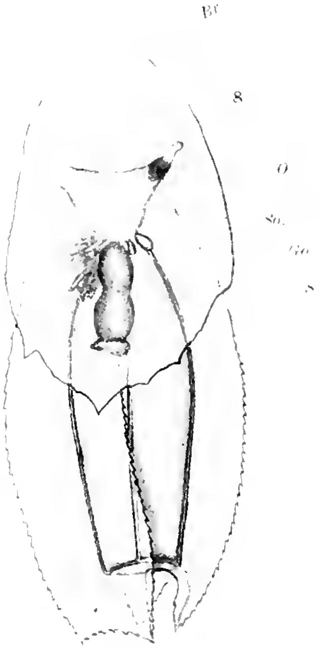


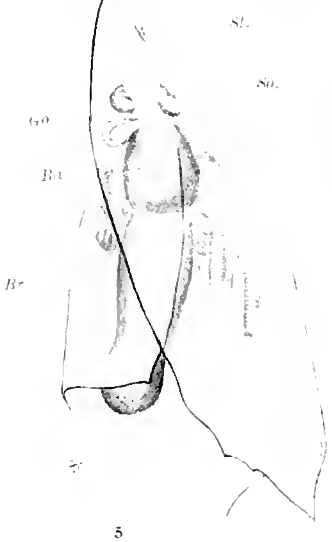












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BOSTON

PLATE 12.

## PLATE 12.

Fig. 1. Diphyes bojani. Lateral view of base of a very young specimen 6 mm. long, showing the bud for the future inferior nectophore ($N^2$), and a single well-developed group of appendages with large terminal siphon (S). × about 25.

Fig. 2. ? Muggiaea kochii. Lateral view of much expanded nectophore. × about 12.

Fig. 3. Dorsal view of base of same specimen, showing the termination of the lateral ridges (R. l) some distance above the actual margin.

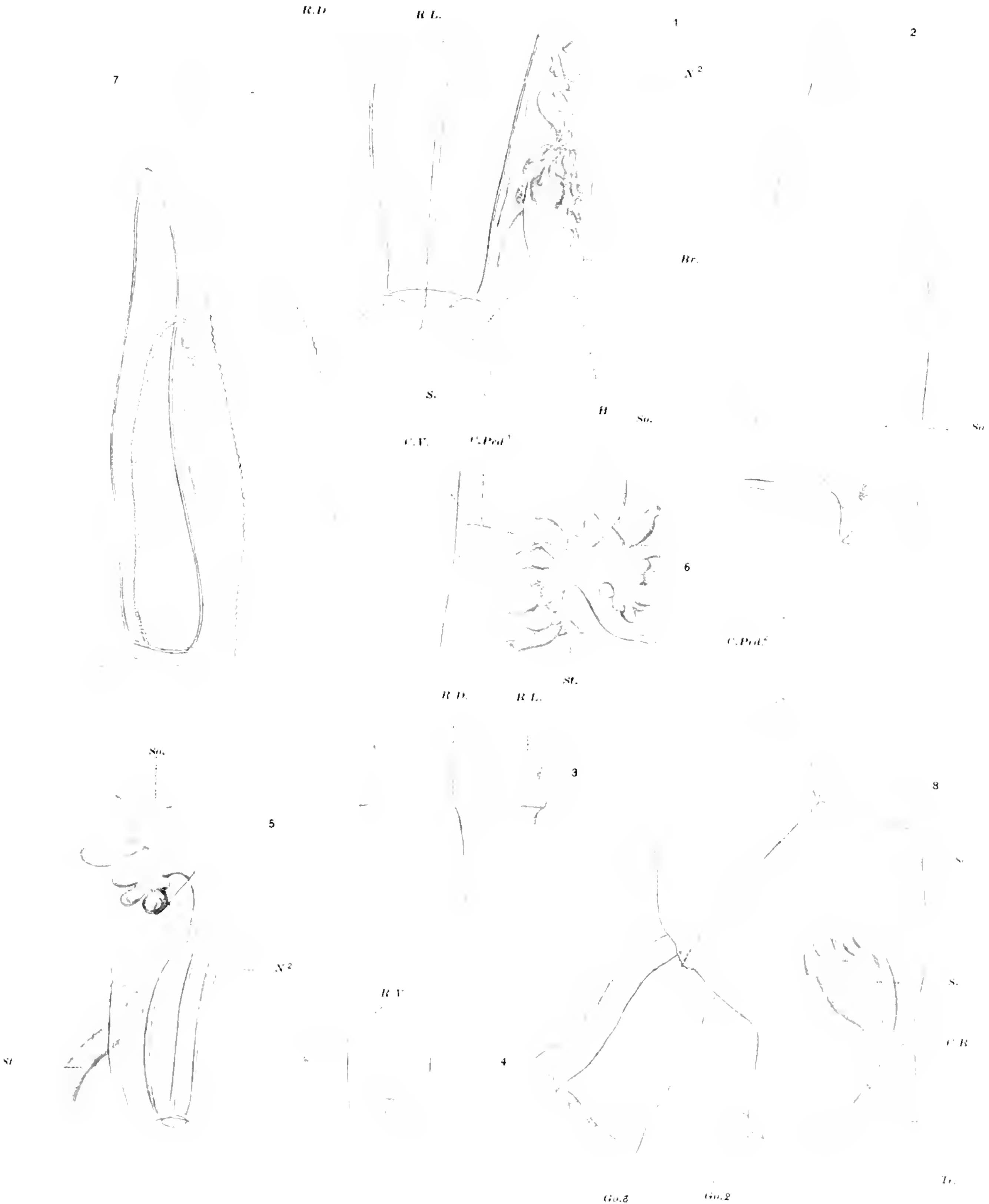
Fig. 4. Ventral view of base of same.

Fig. 5. Diphyopsis mitra. Base of stem of a large example, showing the young inferior nectophore ($N^2$). × about 35.

Fig. 6. Chuniphyes multidentata. Base of stem, showing pedicular canal of inferior nectophore ($C. Ped^2$), of superior nectophore ($C. Ped^1$), and base of somatocyst (So). × about 15.

Fig. 7. Diphyabyla hubrechti. Lateral view of superior nectophore, 7 mm. long.

Fig. 8. Bassia bassensis. Free Eudoxid ("Sphenoides australis"). Lateral view. × 12.



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HELIOTYPE CO., BOSTON.

PLATE 13.

## PLATE 13.

### **Abyla haeckeli.**

Fig. 1. Lateral view of superior nectophore. × 9.
Fig. 2. Ventral view of same, showing ventral facet divided by transverse ridge, X. × 9

### **Abyla trigona.**

Fig. 3. Lateral view of superior nectophore. × 9.
Fig. 4. Ventral view of same, showing single undivided ventral facet. × 9.

### **Abyla leuckartii.**

Fig. 5. Lateral view of colony with small inferior nectophore entirely contained within the hydroecium of the large superior nectophore. × 10.

Fig. 6. Detached inferior nectophore of same. Lateral view. × 30.

Fig. 7. Ventral view of same.

Fig. 8. A single cormidium still attached to the stem (St) with bract, siphon (S), tentacle, ♂ gonophore (Go ♂), and bud for a second gonophore ($Go^2$). × about 30.

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HELIOTYPE CO. BOSTON

PLATE 14.

## PLATE 14.

### **Abylopsis eschscholtzii.**

Fig. 1. Lateral view of superior nectophore. × 12.

Fig. 2. Lateral view of inferior nectophore. × 10.

Fig. 3. Dorsal view of base of inferior nectophore, to show teeth and ridges.

Fig. 4. A single cormidium, still attached to the stem, with bract, gonophore, siphon, and tentacle. × about 20.

Fig. 5. Bract of same; dorsal view.

### **Abylopsis tetragona.**

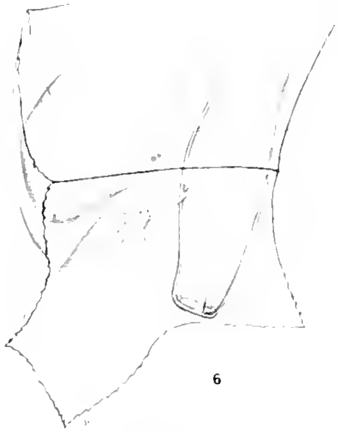
Fig. 6. Superior nectophore, lateral view. × 8.

Fig. 7. Inferior nectophore of another colony, lateral view, to show especially the conformation of the base, the hydroecium, and the subumbral canals of the nectosac. × about 4.

Fig. 8. Dorsal view of base of inferior nectophore, to show the asymmetry of ridges and teeth. × 6.

### **Bassia bassensis.**

Fig. 9. Lateral view of superior nectophore. × 12.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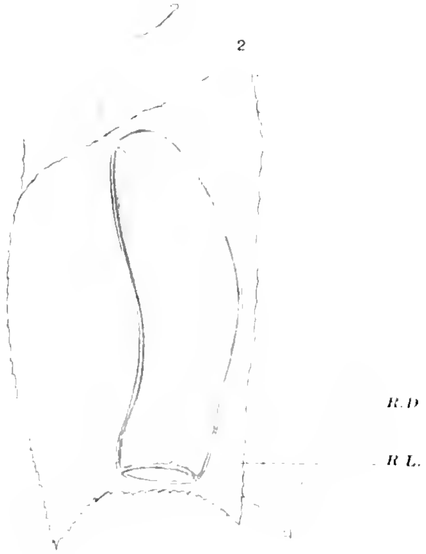
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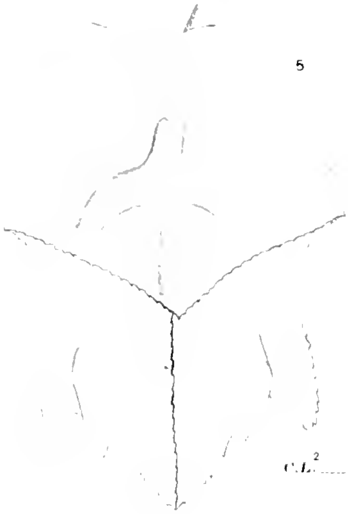
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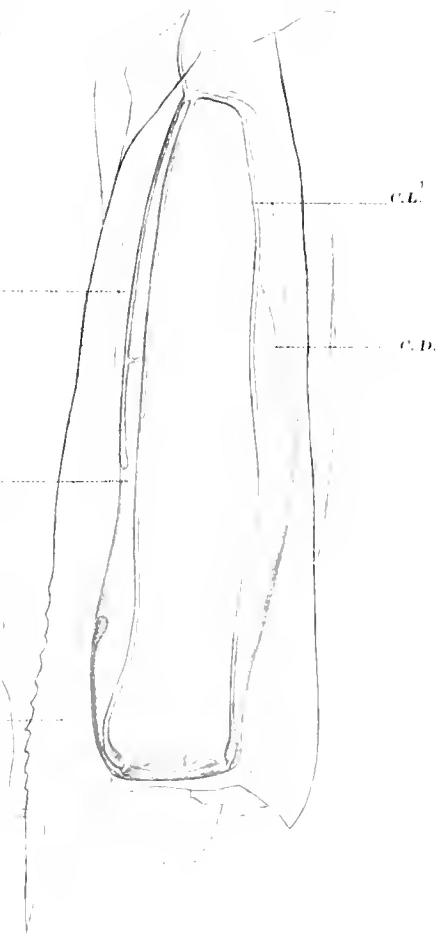
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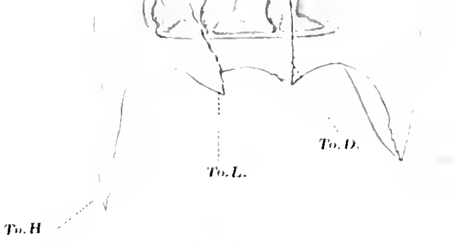
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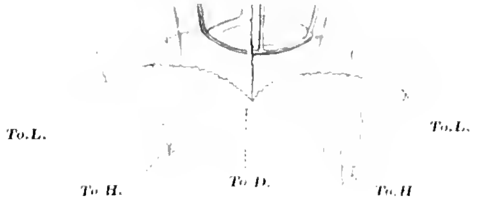
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PLATE 15.

## PLATE 15.

Fig. 1. Abylopsis eschscholtzii, lateral view of bract of free Eudoxid ("Aglaismoides eschscholtzii"). × 8.

Fig. 2. Abylopsis tetragona; lateral view of bract of free Eudoxid ("Aglaisma cuboides"). × 8.

Fig. 3. Abyla leuckartii, lateral view of bract of free Eudoxid ("Ceratocymba asymmetrica"). × 4.

Fig. 4. Dorsal view of same.

### Vogtia spinosa.

Fig. 5. General view of colony with nectophores in place, and stem with appendages strongly contracted. × 3.

Fig. 6. A young tentillum, with cnidoblasts of two kinds, small spindle-shaped ($Cn^2$) and large ovoid ($Cn^1$). × about 60.

Fig. 7. A fully developed tentillum. × about 45.

Fig. 8. A cormidium, showing the base of the siphon (S), and tentacle (T), and ♀ and ♂ gonophores (Go. ♀, Go. ♂). × 20.

Fig. 9. A mature nectophore, basal view. × 3.5.

Fig. 10. Ventral view of same.

Fig. 11. Very young nectophore. × 15.

Fig. 12. Somewhat older stage. × 8.

Fig. 13. A male gonophore. × 40.

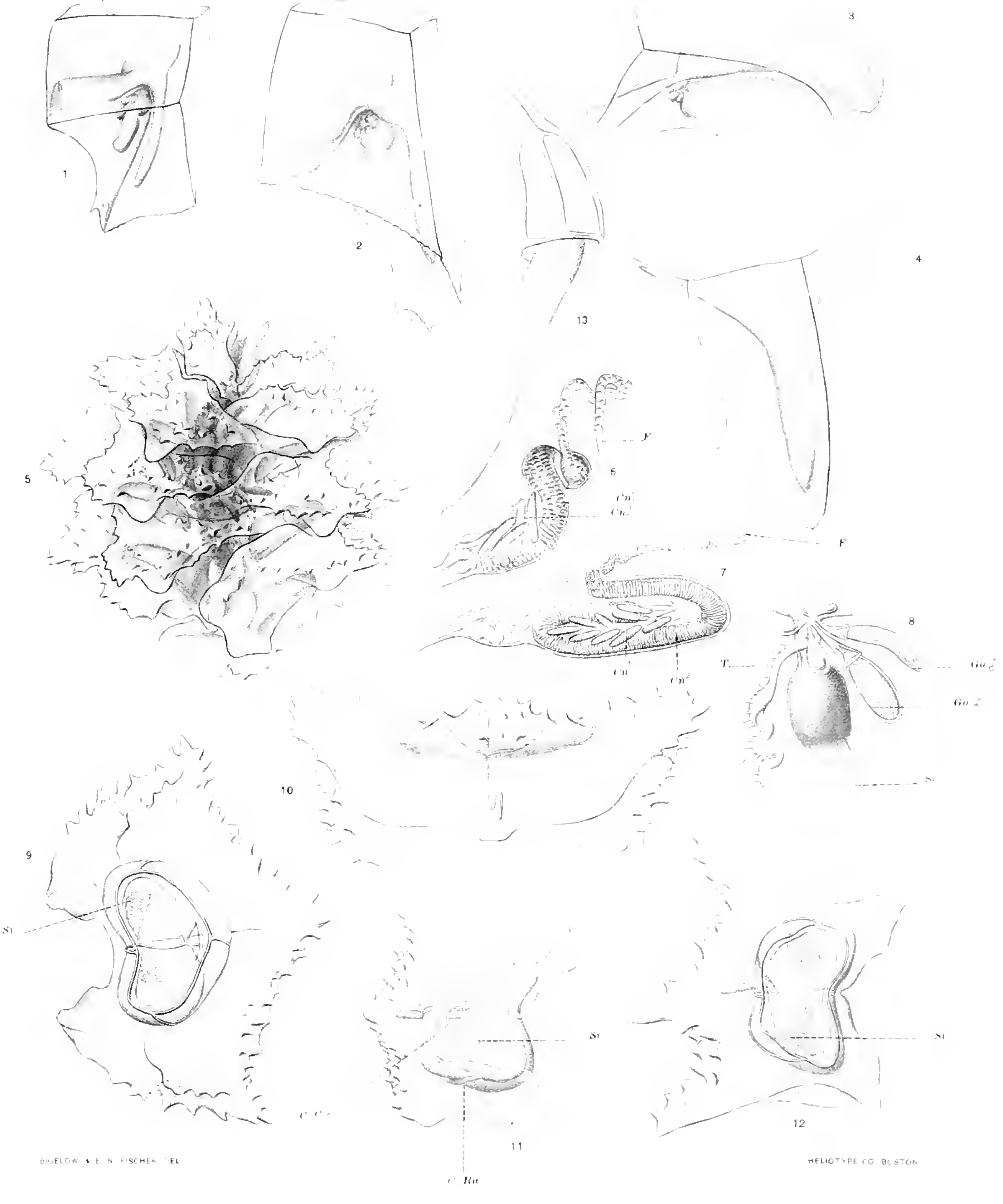

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PLATE 16.

# PLATE 16.

## **Physophora hydrostatica.**

Fig. 1. General view of young colony with only two pairs of developed nectophores. × 5.

Fig. 2. Siphon (S) and tentacle (T) with its tentilla (Te). × 9.

Fig. 3. Siphosome, and part of nectosome of older colony. Some of the palpons (P) and siphons (S) are removed to expose the gonophores (Go). × 4.

Fig. 4. Siphosome of another large colony. Several of the younger palpons (P) have been removed to show their scars of attachment to youngest cormidia ($Co^2$) and the spiral arrangement of the latter. × 5.

Fig. 5. Another colony, with most of the palpons removed, so as to show the gonodendra (Go). × 5.

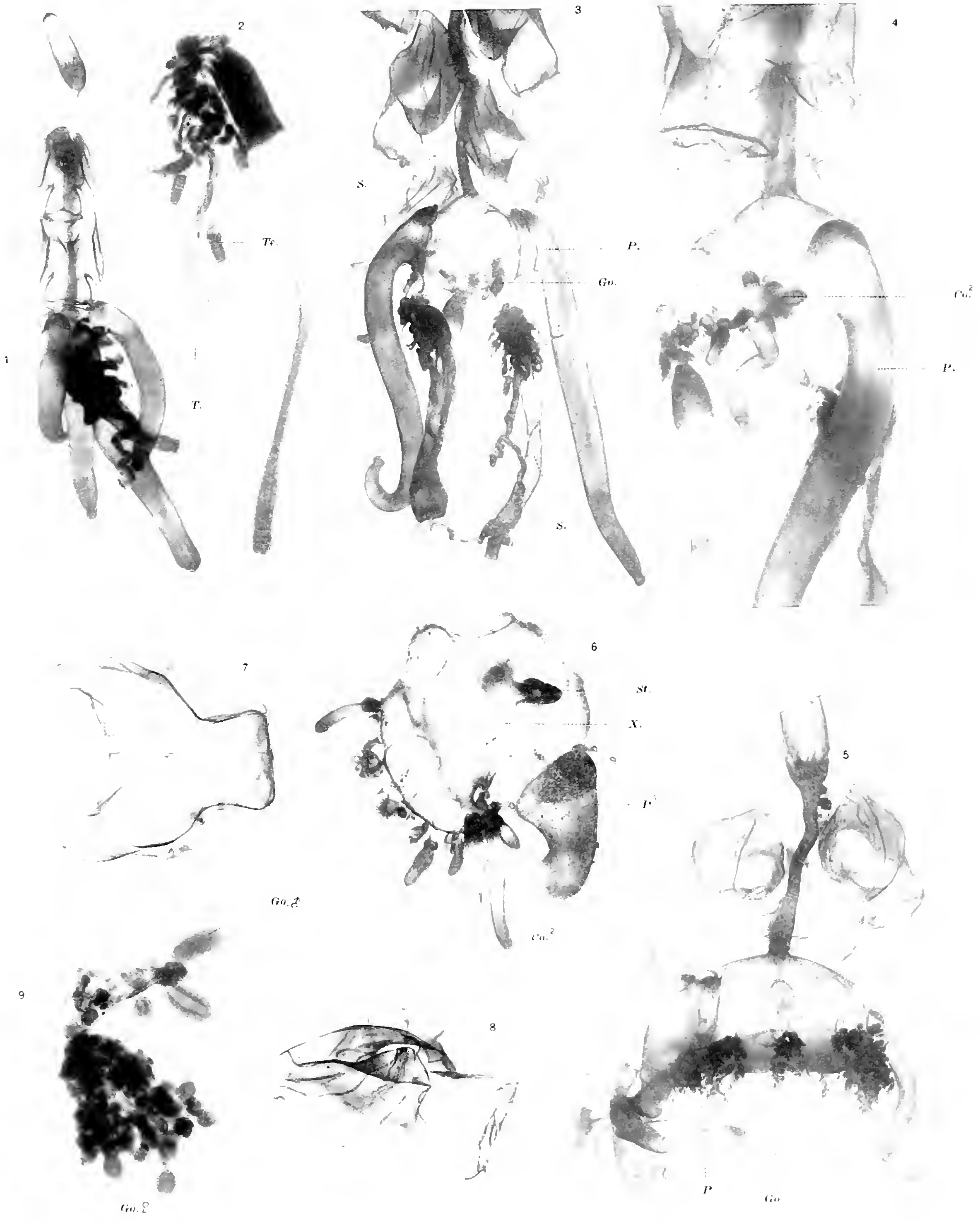
Fig. 6. Apical view of dilated siphosome, same specimen as fig. 4, showing the succession of palpons of different ages. The oldest one ($P^1$) is still attached. × 5.

Fig. 7. A nectophore. Ventral view. × 7.

Fig. 8. Nectophore, lateral view. × 7.

Fig. 9. Male and female gonodendra (Go. ♂, Go. ♀). × 10.

All figures from photographs.



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HELIOTYPE CO. BOSTON

PLATE 17.

## PLATE 17.

### Agalma okeni.

Fig. 1. General view of colony, in natural position. From a photograph. × 1.5.

Fig. 2. Siphosome of another colony, to show the arrangement of the bracts. The nectophores have all been detached. × 2.

Fig. 3. A very young tentillum. The two terminal filaments and the ampulla are already distinguishable. × 25.

Fig. 4. An older stage. The future involucre is represented by a basal swelling. × 25.

Fig. 5. Still older stage. The involucre now encloses one coil of the cnidoband. × 25.

Fig. 6. A tentillum, in which the involucre encloses three coils of the cnidoband. From its large size this example was probably mature. × 30.

Fig. 7. A small, but mature tentillum in which the involucre encloses all the seven coils of the cnidoband. × 20.

Fig. 8. A ♂ gonophore. × 20.

Fig. 9. A young bract ($\mathrm{Br}^1$), and the muscular lamellae to which older bracts were attached ($\mathrm{Br}^2$). St. segment of the stem. × 15.

Fig. 10. A mature bract. × 4.

Fig. 11. Lateral view of another mature bract × 4.

Fig. 12. A mature nectophore. × 4.

Fig. 13. A single cormidium. The bracts are all detached, but their muscular lamellae (Br) are shown. S. siphon; T. tentacle; P. palpons; Go. D ♀, Go. D ♂, female and male gonodendra. The right hand side of the figure is distal, the left hand proximal (p. 279). × 10.

Fig. 14. A large palpon (P), with its filament. × 15.

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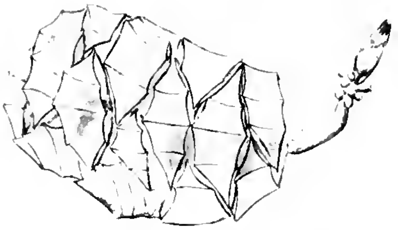

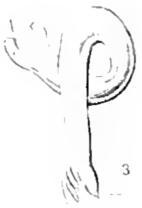

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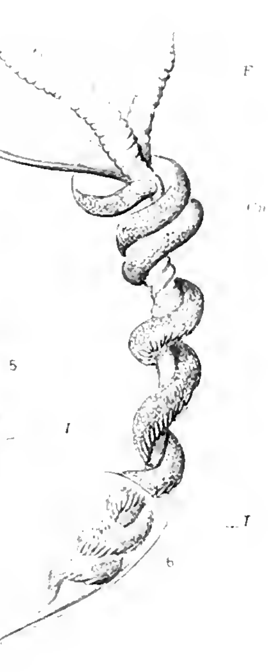

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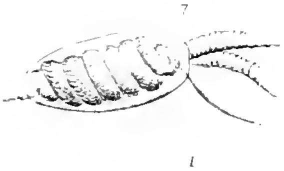

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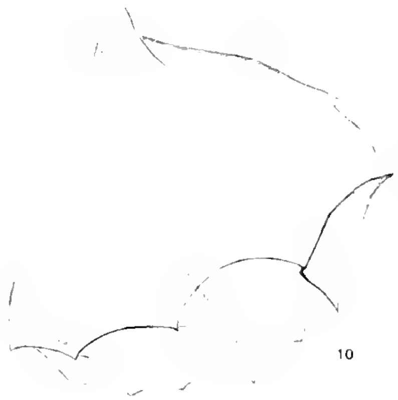

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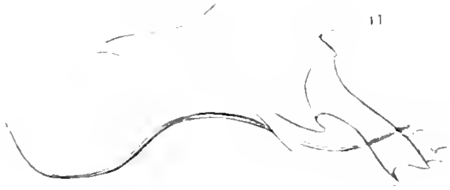

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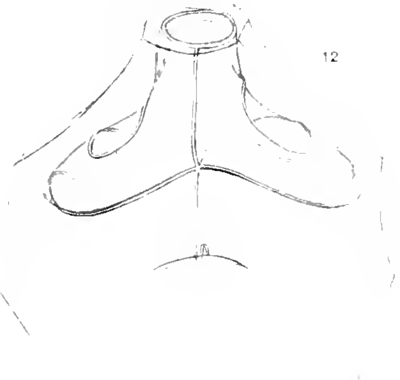

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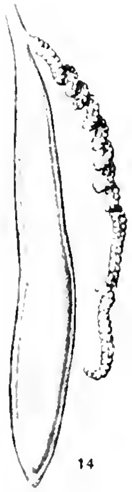

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13

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PLATE 18.

## PLATE 18.

### **Stephanomia amphitridis.**

Fig. 1. General view of the siphosome. From a photograph. Natural size.

Fig. 2. A portion of the siphosome. The bracts have been removed, but the muscular lamellae (Br.) on which they were borne show their positions on the stem. The right hand end is distal. × 4.

Fig. 3. An adult tentillum. × 20.

Fig. 4. A male gonophore. × 15.

Fig. 5–8. Various views of bracts. Figs. 5, 8, are from the dorsal surface of the siphosome, fig. 6 from the ventral, fig. 7 from the lateral. × 2.

### **Agalma elegans.**

Fig. 9. A segment of the siphosome, with the mature bracts removed, but with their muscular lamellae ($Br^2$.) still in place. There is one very young bract ($Br^1$.). × 20.

Fig. 10. Tentillum, nearly mature. × 35.

Fig. 11. A younger tentillum, in which the involucre encloses only one coil of the cnidoband. × 35.

Fig. 12. A mature bract, showing ridges, and tridentate margin. × 10.

Fig. 13. Lateral view of same.

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PLATE 19.

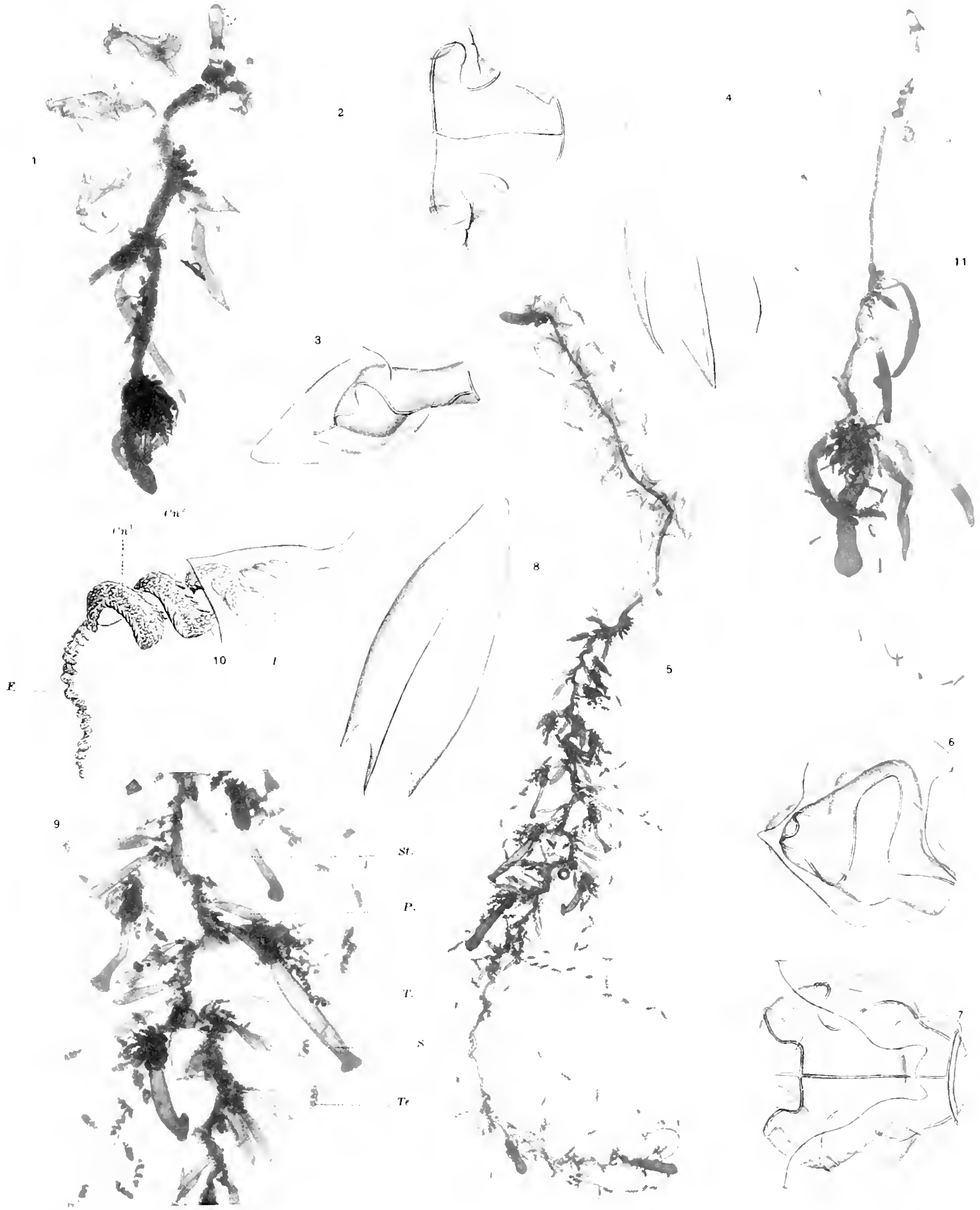
## PLATE 19.

### **Agalma elegans.**

Fig. 1. General view of a colony 10 mm. long. From a photograph.
Fig. 2. Nectophore. × 10.
Fig. 3. Lateral view of same. × 10.
Fig. 4. One of the older bracts. × 10.

### **Stephanomia bijuga.**

Fig. 5. General view of a colony 45 mm. long. From a photograph.
Fig. 6. Lateral view of a nectophore. × 12.
Fig. 7. Ventrobasal view of same. × 12.
Fig. 8. Mature bract. × 12.
Fig. 9. A segment of the siphosome, to show the successive development of palpons in the internodes. From a photograph. × 10.
Fig. 10. A mature tentillum. × 30.
Fig. 11. A young colony, 11 mm. long, still bearing the primary siphon and tentacle.



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HELIOTYPE CO. BOSTON

PLATE 20.

# PLATE 20.

## Stephanomia bijuga.

Fig. 1. A siphon with tentacle and three bracts of successive ages ($Br^1$, $Br^2$, $Br^3$). × 20.

Fig. 2. A segment of the stem from between two successive siphons, with palpon (p), and male and female gonodendra (Go. ♂, Go. ♀). × 20.

Fig. 3. Tentilla from the primary tentacle of the young colony represented in Pl. 19, fig. 11. × 35.

## Nectalia loligo.

Fig. 4. General view of colony. × about 2.5.

Fig. 5. Nectophore.

Fig. 6. Archisoma natans. General view of free Eudoxid (p. 266). × 3.

## Anthophysa rosea.

Fig. 7. General view of colony 13 mm. in diameter. The bracts have been removed, but their positions are indicated by the muscular lamellae (L. Mu).

Fig. 8. A young tentillum of the tricornuate type. × 50.

Fig. 9. Half-grown tentillum of the dendritic type. *Cf.* Pl. 23, fig. 4, which shows the adult tentillum of this type. × 50.

Fig. 10. Adult tricornuate tentillum. The involucre, bearing a marginal spur (x), entirely encloses the two complete turns of the coiled cnidoband. × 40.

Fig. 11. A palpon with its filament (F).

Fig. 12. A portion of the ventral surface of the denuded corm, showing the extremities of one group of muscular lamellae (L. Mu); and the relative positions of male and female gonophores (Go. ♂, Go. ♀) and palpons (P). Most of the organs are broken off. × 20.

Fig. 13. A reconstructed radial section of the corm, showing the septa, and on the exterior the muscular lamellae (L. Mu), the siphons (S), and a pair of gonodendra, male and female (Go. ♂, Go. ♀). Pn. C pneumatocodon, Pn. S pneumatosaccus. × 7.

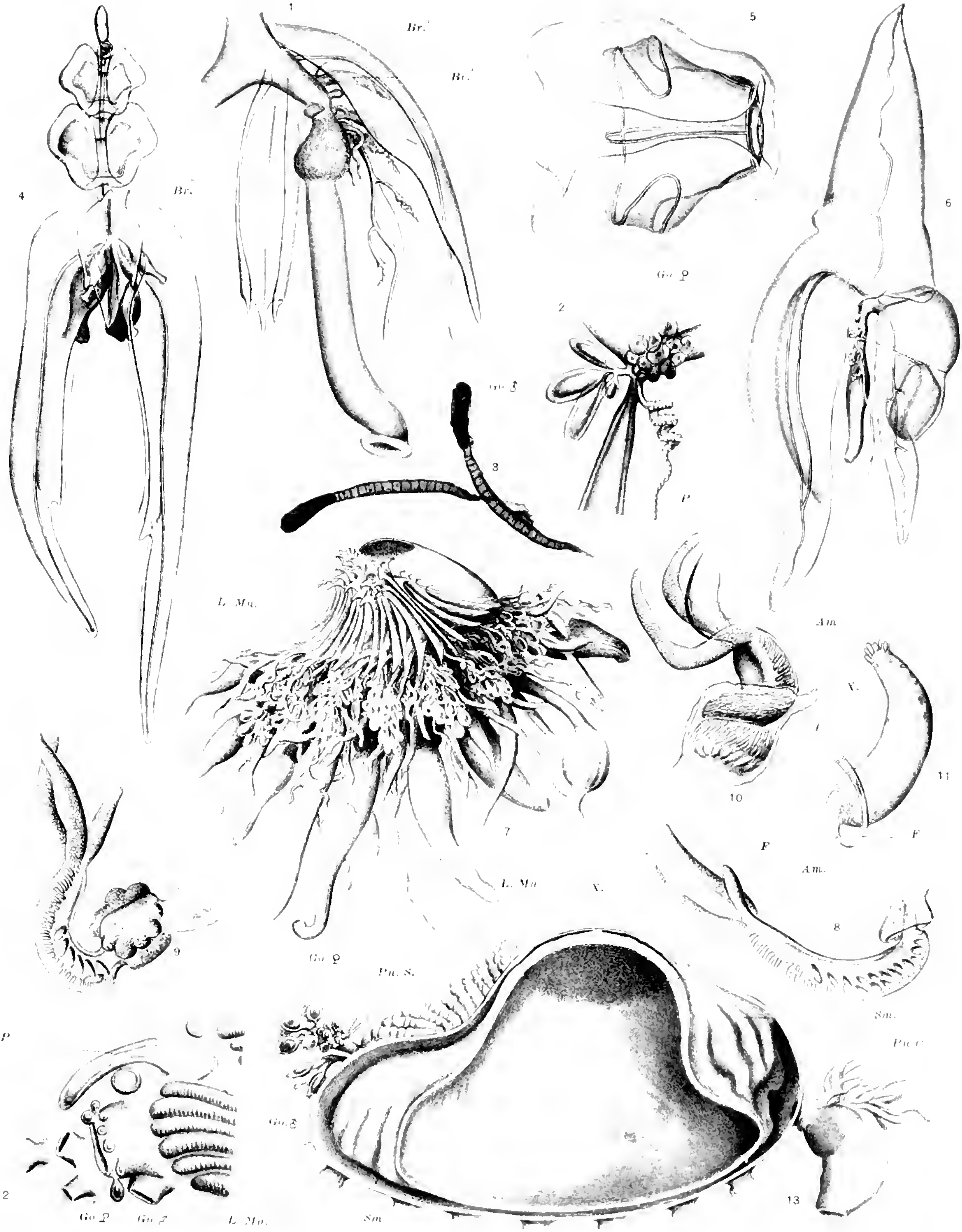

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PLATE 21.

## PLATE 21.

### **Anthophysa rosea.**

See also Plate 23, figs. 1–5.

Fig. 1. Transverse section of the pneumatophore near its apex. Five of the septa (Sm) on the dorsal side connect pneumatosaccus (Pn. S) with pneumatocodon (Pn. C). The thick layer lining the gas cavity ($Ec^2$) is the secondary ectoderm. The septa contain giant amoeboid cells (Ce. G). From a photograph. × 25.

Fig. 2. Transverse section of the pneumatophore about its mid-level. At this level all of the septa end freely in the pericystic space. The grouping of the muscular lamellae is well shown. From a photograph. × 25.

Fig. 3. Radial section of the apex of the pneumatophore. Pg, pigment; En, ectoderm; $Ec^2$, secondary ectoderm; S. L, stutzlamella. From a photograph. × 75.

Fig. 4. Portion of the same more highly magnified, to show the various cell layers. Lettering as in figs. 1 and 3. × 200.

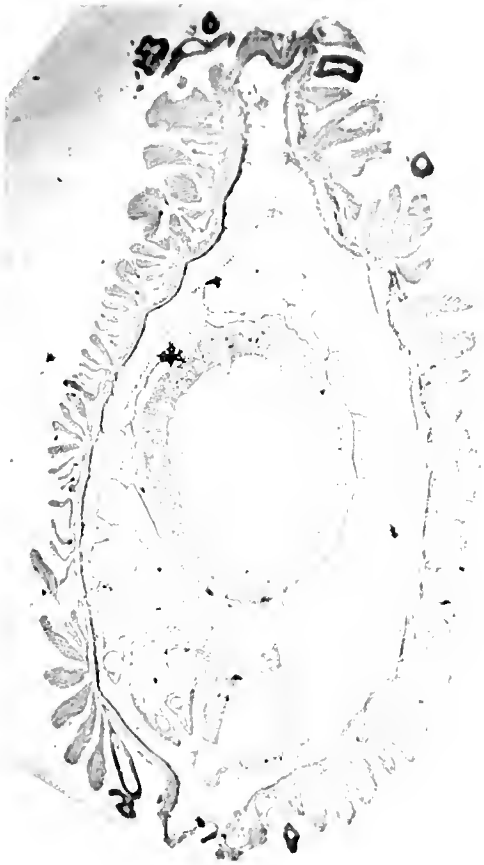
Fig. 5. Transverse section of a small portion of a septum, with its enclosed giant cells (Ce. G). En, endoderm; Ec, ectoderm. × 125.

### **Angelopsis dilata.**

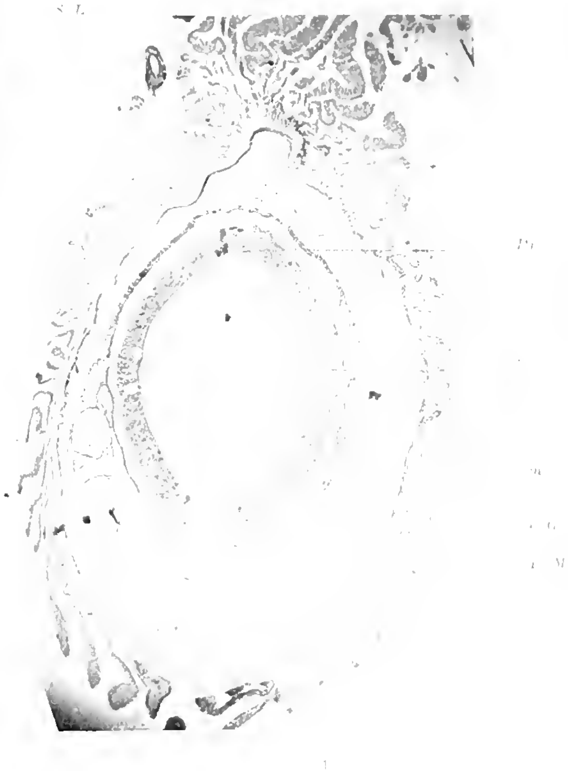
Fig. 6. General view of colony, which has lost most of its nectophores and siphons. From a photograph. Au, aurophore. × 6.

Fig 7. Radial section of the colony, through the aurophore (Au), drawn from the dissection. The outline of the pneumatophore is somewhat restored. There is a single young nectophore (N), intact, and also the muscular lamella (L. Mu) of an older one. × 9.

Fig. 8. A cormidium. The siphon is situated on a gelatinous prominence, and is associated with a pair of gonodendra borne on an independent stalk. T, tentacle; P. palpon; Go, gonophore. × 25.




En
L.M.
Pg
3
Ec


S.L.
Pg
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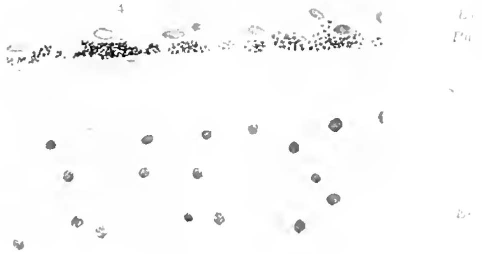
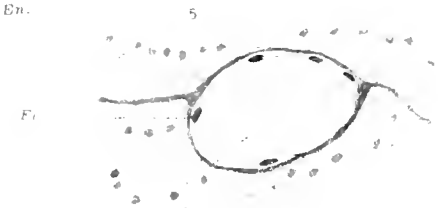
1


4
Pn
Ec


En.
5
Fi


8


Pn
L.M.

PLATE 22.

# PLATE 22.

## **Angelopsis dilata.**

Fig. 1. Radial section of the colony, a little to one side of the mid-plane, especially to show the structure of the bulbous siphosome. From a photograph. × 9.

Fig. 2. Radial section of the aurophore near the median plane. From a photograph. × 12.

Fig. 3. A portion of the same more enlarged. × 30.

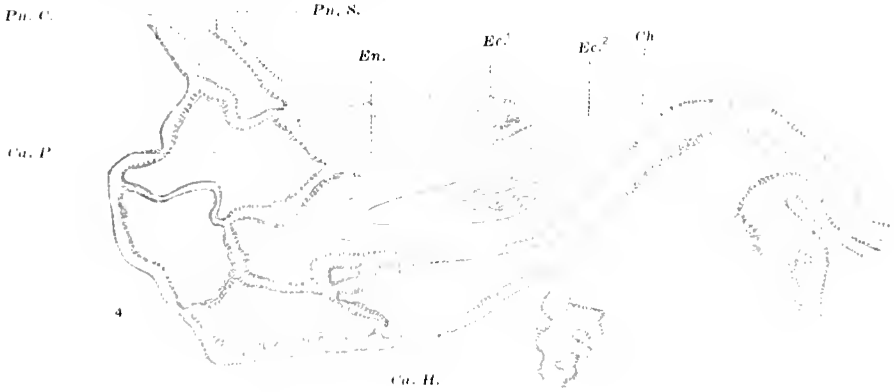
Fig. 4. A similar section reconstructed from four adjacent serial sections. Pn. C, pneumatocodon; Pn. S, pneumatosaccus; En, endoderm; Ec$^{1}$, primary, Ec$^{2}$, secondary ectoderm; Ch, chitinous layer; Ca. P, pericystic space; Ca. H, hypocystic cavity. × 15.

Fig. 5. Section through secondary ectoderm, chitinous layer, the evaginated portion of the pneumatosaccus, to show histology of the various layers. Sl, stutzlamella; other lettering as in fig. 4. × 250.

Fig. 6. Longitudinal section through the wall of the nectosome in the lateral plane (transverse to the aurophore). × 25.

Fig. 7. Part of the basal portion of the siphosome, to show positions of siphons (S), and their connection with network of canals. Photographed from a dissection. × 20.

Fig. 8. Small portion of the siphosome, showing branching canals. × 20.


Pn. C.
Pn. S.
En.
Ec.¹
Ec.²
Ch
Ca. P
Ca. H.

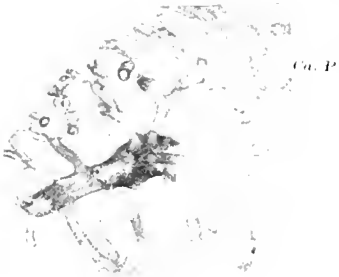
4


Pn. C.
Pn. S.
Ca. H.
St
C.

1


Ce. G.

3



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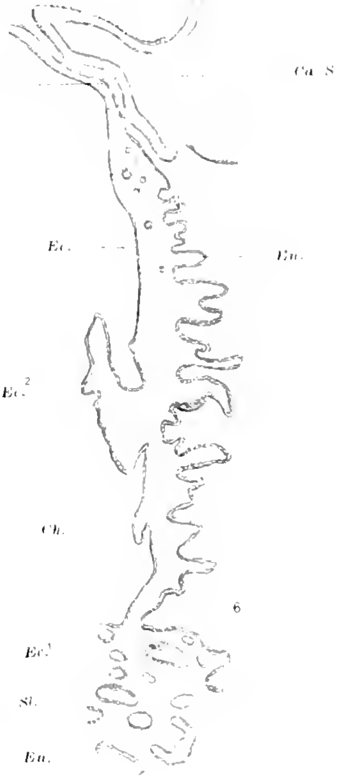
Ca. S
Ca. P
Ec.
En.
Ec.²
Ch.

6

2


Ec.¹
St.
En.

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7

8

PLATE 23.

# PLATE 23.

## **Anthophysa rosea.**

Fig. 1. Radial dorsoventral section of the entire colony. The thin wall of the lower part of the pneumatosaccus is torn. For lettering see Pl. 22, fig. 4. From a photograph. × 25.

Fig. 2. Radial section of the pneumatosaccus at the region where the secondary ectoderm ($Ec^2$) originates. En, endoderm; $Ec^1$, primary ectoderm; S. L, stutzlamella. × 150.

Fig. 3. Bract, with its muscular lamella (L. Mu). × 10.

Fig. 4. Mature tentillum of dendritic type. × 30.

Fig. 5. Lower surface of denuded corm, to show the positions of siphons (S), palpons (P), gonodendra (Go), and of the group of muscular lamellae (L. Mu). Only the stumps of the various appendages remain. × 10.

## **Dromalia alexandri.**

Fig. 6. Lateral view of Type. From a photograph. Only one young nectophore is intact (B. N), but the muscular lamellae (L. Mu) show the positions of the older ones. Immediately below the youngest nectophore are the buds for future siphons (B. S). The aurophore is seen at X, opposite the zone of proliferation. From a photograph. × 2.

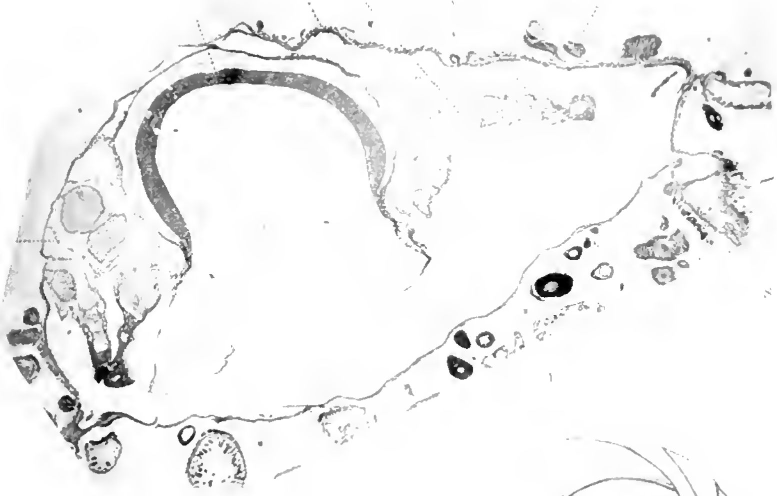
Fig. 7. Dorsal view of another specimen, showing the aurophore (X), the muscular lamellae, and the cormidia. Immediately below the aurophore is a naked zone reaching the entire length of the nectosome. From a photograph. × 2.5.

Fig. 8. Apical view of part of the pneumatophore, showing the gelatinous prominences. From a photograph. × 2.

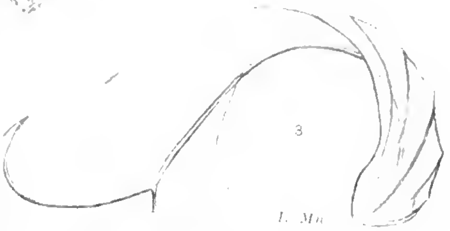
Fig. 9. A compound cormidium, consisting of two siphons ($S^1$, $S^2$) with their tentacles (T) and several gonodendra ($Go^1$, $Go^2$) with palpons, all situated on a single gelatinous prominence (St). × 5.

Fig. 10. A young tentillum. × 50.

Fig. 11. Basal view of the axial region of the siphosome, showing the spiral arrangement of siphons (St. S) and canals (C). Photographed from a dissection cleared in clove oil. × 4.

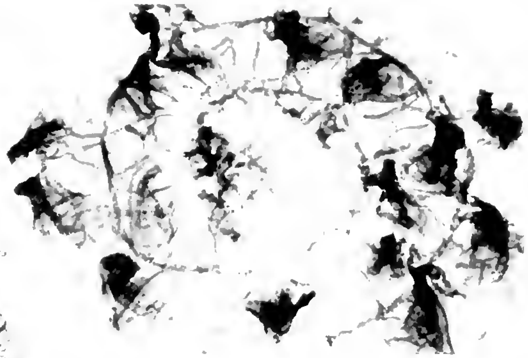

Ec
Pn.C
Gt.G.
Sc
L.Mu
Sm
S
1
Pn.S


$Ec^2$
2
$S.L^2$
$Ec^1$
$S.L^1$
En
P
E


3
L.Mu


S
St
Go'
S.
9
S'


4


St.S


L.Mu
P
5
S
Go


8


B.N
B.S
L.Mu
6
N.


10


L.Mu
St.S

PLATE 24.

## PLATE 24.

### **Dromalia alexandri.**

Fig. 1. The region of proliferation. B. N, very young nectophore; B. S, buds for the future siphons; St. S¹, gelatinous stalk on which a younger, St. S², on which an older, siphon was borne. L. Mu; muscular lamella of older nectophore. × 4.

Fig. 2. Enlarged view of same. Lettering as in preceding figure. Photographed from a dissection cleared in xylol. × 6.

Fig. 3. Still more enlarged view of the youngest nectophores, and buds for siphons. × 9.

Fig. 4. Radial section of colony through the aurophore (X) and zone of proliferation (B. S). Pn, pneumatophore; Pn. pr, gelatinous prominence of pneumatocodon; Pa. Pr, papilliform processes of aurophore; C, canals of siphosome. × 3.

Fig. 5. Similar section of larger specimen. Lettering as in fig. 4. × 4.

Fig. 6. Radial section of the aurophore. Ec¹, primary, Ec², secondary ectoderm; En, endoderm; Sm, septum connecting pneumatosaccus with pneumatocodon; Pa. Pr, papilliform process. × 20.

Fig. 7. Transverse section of aurophore in its mid-region. Lettering as in fig 6. × 20.

Fig. 8. Radial section of axial region of aurophore. Lettering as in fig. 6. This photograph has been slightly retouched. × about 30.

Fig. 9. Radial section of terminal portion of papilliform process, showing the open terminal pore. × 40.

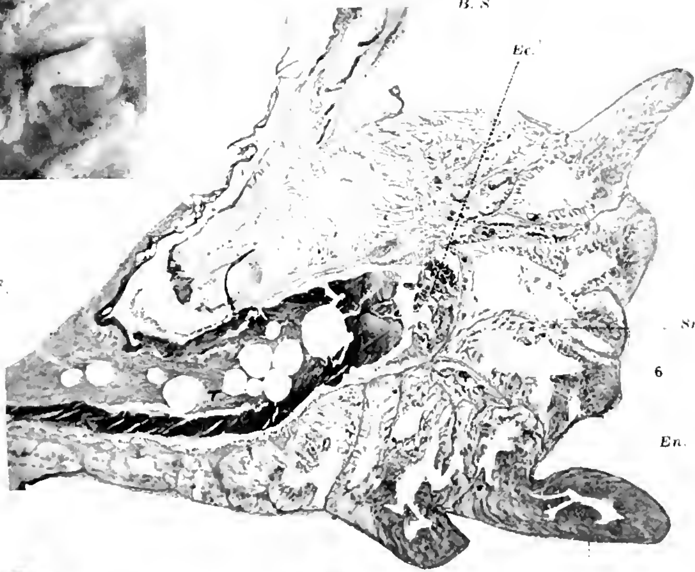
All figures from photographs.

1

3

2

6



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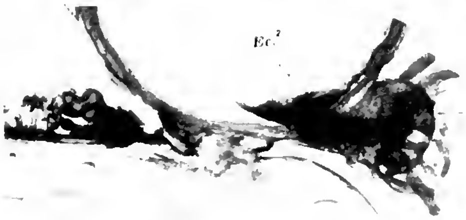

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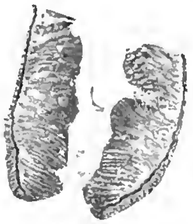

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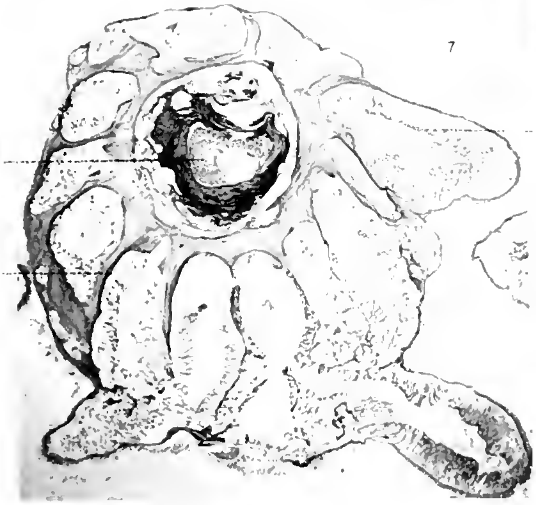

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HELIOTYPE CO. BOSTON

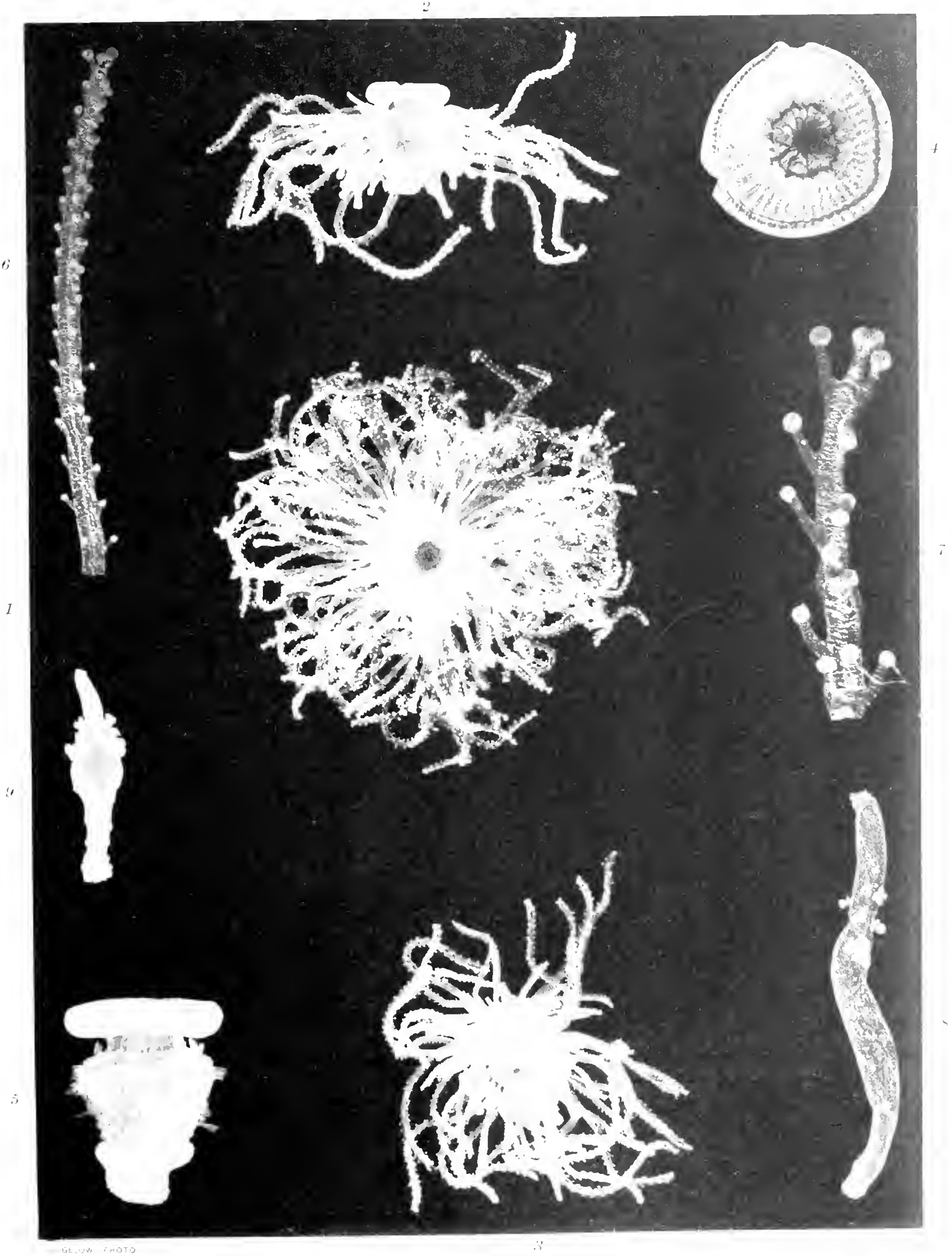
PLATE 25

## PLATE 25.

### **Porpema prunella.**

Fig. 1. A specimen floating in the natural position; seen from above. × 2.5.
Fig. 2. Lateral view. The tentacles have been partly stripped off to show the conical corm. × 4.
Fig. 3. Another specimen, seen from below. × 4.
Fig. 4. Upper surface of the disc. × 8.
Fig. 5. The corm, denuded of tentacles and gonozooids. × 7.
Fig. 6. A tentacle. × 12.
Fig. 7. Tip of a tentacle, more enlarged. × 18.
Fig. 8. A gonozooid. × 12.
Fig. 9. Another gonozooid, contracted. × 12.

All figures from photographs.



GELOW PHOTO

PLATE 26.

## PLATE 26.

### **Porpema prunella.**

Fig. 1. Radial section, from a photograph. Lettering as in fig. 2. × 11.

Fig. 2. Reconstructed radial section. The left half is between two radial ridges of the centradenia, the right half in the plane of one of the ridges.

> Sti$^1$, primary; Sti$^2$, secondary stigmata, opening into the central chamber (Ch), and into the circular chambers (Ch. C$^1$, Ch. C$^2$); Li, limbus; Gl. Mu, mucous gland; C. Li, canals of the limbus; C. T, radial canals of the tentacular zone; C. S, superior canals of the centradenia (Cd); Tr, trachea; Gz, central gastrozooid; Go, gonozooid; T, tentacle. × about 20.

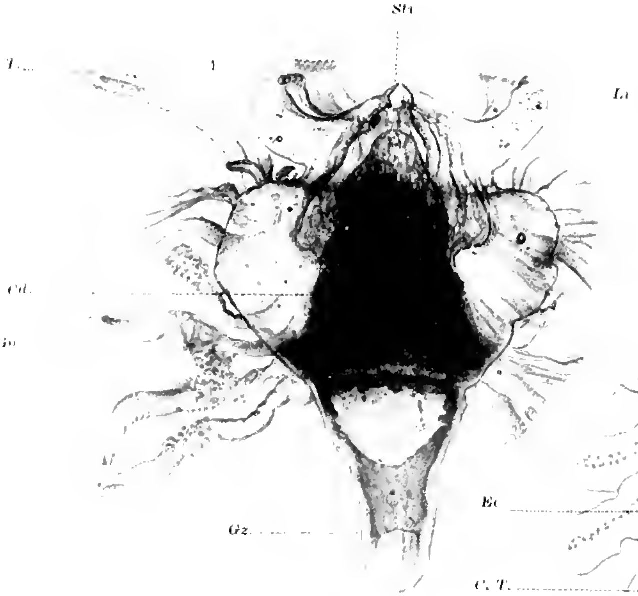
Fig. 3. Apical view, showing radial rows of stigmata (Sti), palial canals (C. Pa), and marginal mucous glands (Gl. Mu). × about 20.

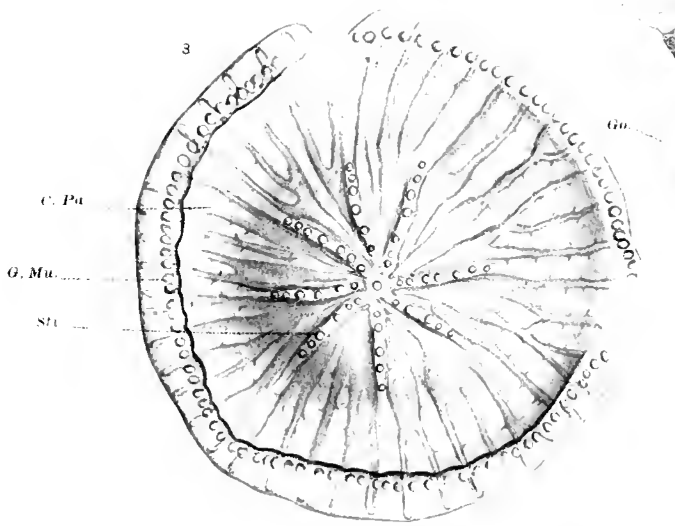
Fig. 4. Transverse section of the pneumatophore close to the apex. Lettering as in fig. 2. From a photograph. × 35.

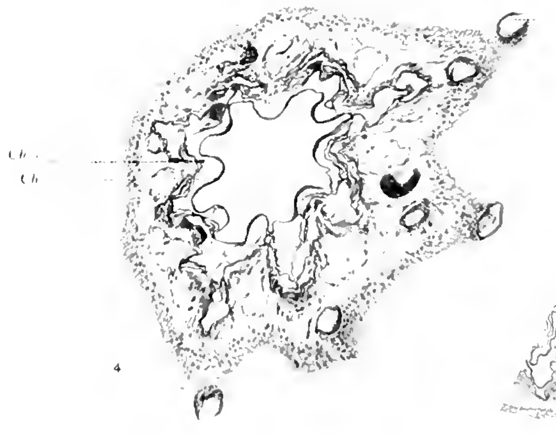
Fig. 5. Transverse section of corm just below the apex of the centradenia. Lettering as in fig. 2. From a photograph. × 20.

Fig. 6. Similar section at the mid-level of the centradenia. From a photograph. × 20.

Fig. 7. Longitudinal section of young tentacle. From a photograph. × 90.







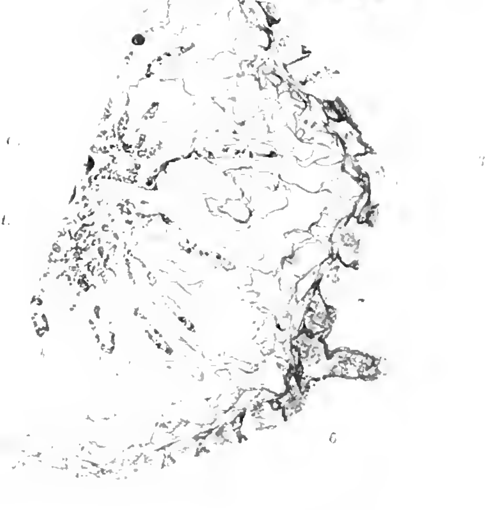


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PLATE 27.

## PLATE 27.

### Porpema prunella.

Lettering as in Plate. 26.

Fig. 1. Transverse section of corm near base of tentacular zone. At X the section passes through a parasitic trematode. From a photograph. × 20.

Fig. 2. A portion of wall of section shown in fig. 5, pl. 26, more highly magnified. From a retouched photograph. × 80.

Fig. 3. Similar section at level of fig. 6, pl. 26. From a photograph. × 40.

Fig. 4. Portion of the same more highly magnified to show the connection between the tentacular canal (C. T) and the endoderm of the centradenia, and relationship between the cnidoblast mass of the centradenia (X) and the ectoderm of the pneumatosaccus ($Ec^2$). From a photograph. × 80.

Fig. 5 Radial section through apex of the pneumatophore. Ce, centradenia. Other lettering as in Pl. 26. From a photograph. × 50.

Fig. 6. Section through apex of pneumatophore showing cell layers and stigmata ($Sti^1$, $Sti^2$). × about 80.

Fig. 7. Longitudinal section through base of corm, showing the centradenia of one of the canals (C. Ce) by which it connects with the margin of the central gastrozooid (Gz). From a photograph. × 40.

Fig. 8. A similar section, showing the open lumen of the canal. From a photograph. × 40.

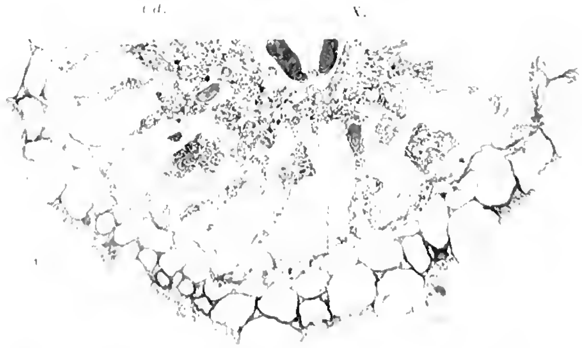
Fig. 9. A similar section, showing one of the canals (C. Ce) of the inner series which connect with the gastrozooid (Gz). From a photograph. × 40.

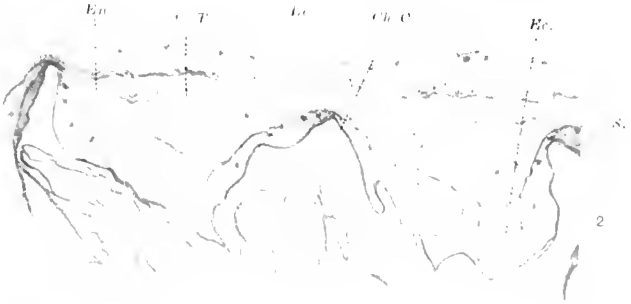
Fig. 10. Longitudinal section of the wall of the central gastrozooid. From a photograph. × 80.

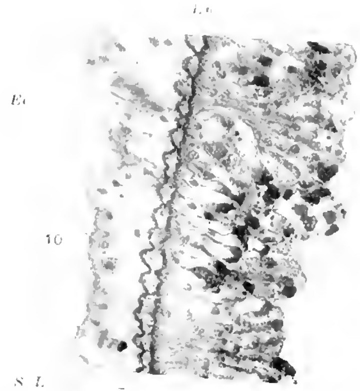
Fig. 11. Longitudinal section through a young tentacle, to show histology. From a photograph. × 80.

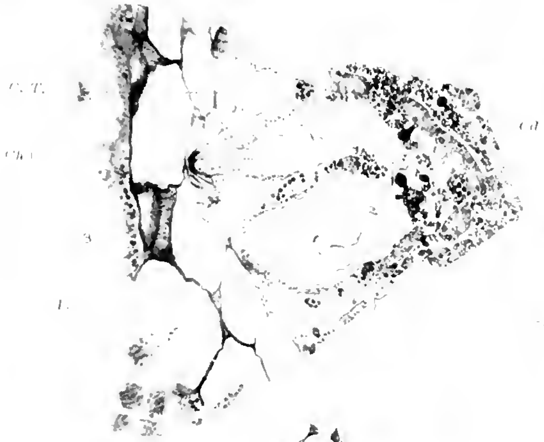
Fig. 12. Apical view of a model of the centradenia, constructed by the plate process. × 40.

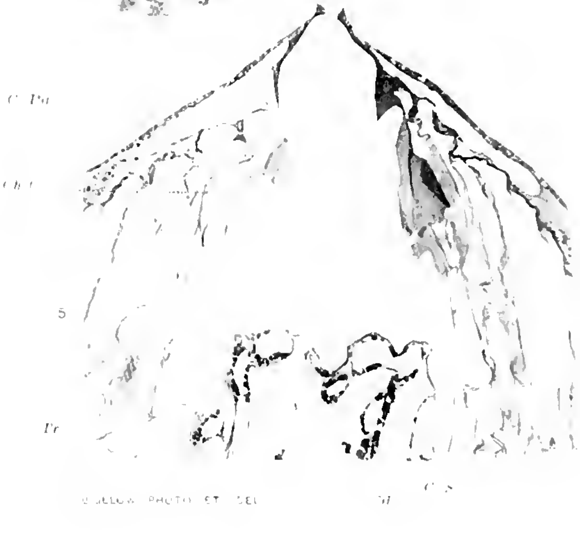
Fig. 13. Apical view of centradenia, reconstructed from serial sections, showing the superior canals (C. S) and trachea (Tr). × about 80.

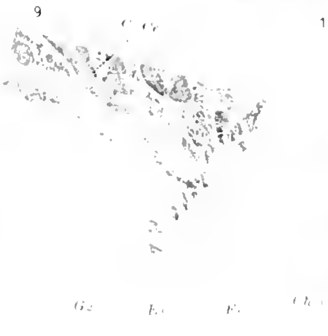












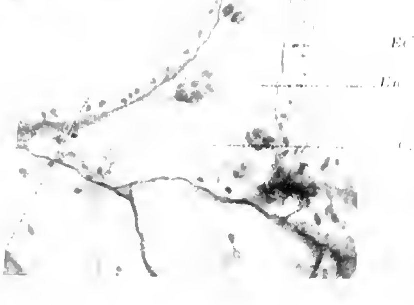


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PLATE 28.

# PLATE 28.

**Porpita pacifica.** Figs. 1–10, 12, 16. **Porpema prunella.** Figs. 11, 15.
**Porpita umbella.** Figs. 13, 14.

Fig. 1. General view of a specimen 50 mm. in diameter from above. From a photograph.

Fig. 2. A segment of the upper surface of the pneumatophore and limbus, to show the prominences (Pr) and stigmata (Sti). From a photograph. × 4.

Fig. 3. A segment of the upper surface of the centradenia, with the pneumatophore stripped off. T, tentacle. From a photograph. × 3.5.

Fig. 4. Central region of upper surface of float, to show the palial canals. From a photograph. × 9.

Fig. 5. A segment of the limbus with its canals (C. Li) and marginal mucous glands (Gl. Mu). C. pa, palial canal. × 12.

Fig. 6. A portion of one of the canals of the limbus. × 40.

Fig. 7. Roof of central chamber and first circular chamber of the pneumatocyst, from below, to show the aborted primary stigma (Sti$^1$) opening from the former, and the aborted secondary stigmata (Sti$^2$) from the latter. Reconstructed from serial sections. × 40.

Fig. 8. Vertical section through central part of pneumatocyst; Ch, central chamber; Ch. C, circular chamber; Sti, primary stigma. From a photograph. × 40.

Fig. 9. Vertical section through the aborted primary stigma; more enlarged. × 150.

Fig. 10. A dissection showing the extremities of the superior canals of the centradenia (C. S), from above; C. Li, canals of the limbus. × 12.

Fig. 11. Porpema prunella. Roof of the central gastrozooid, seen from below, to show the openings of the inner and outer series of the centradenia canals (C. Ce$^1$, C. Ce$^2$). Reconstructed from serial sections. × 20.

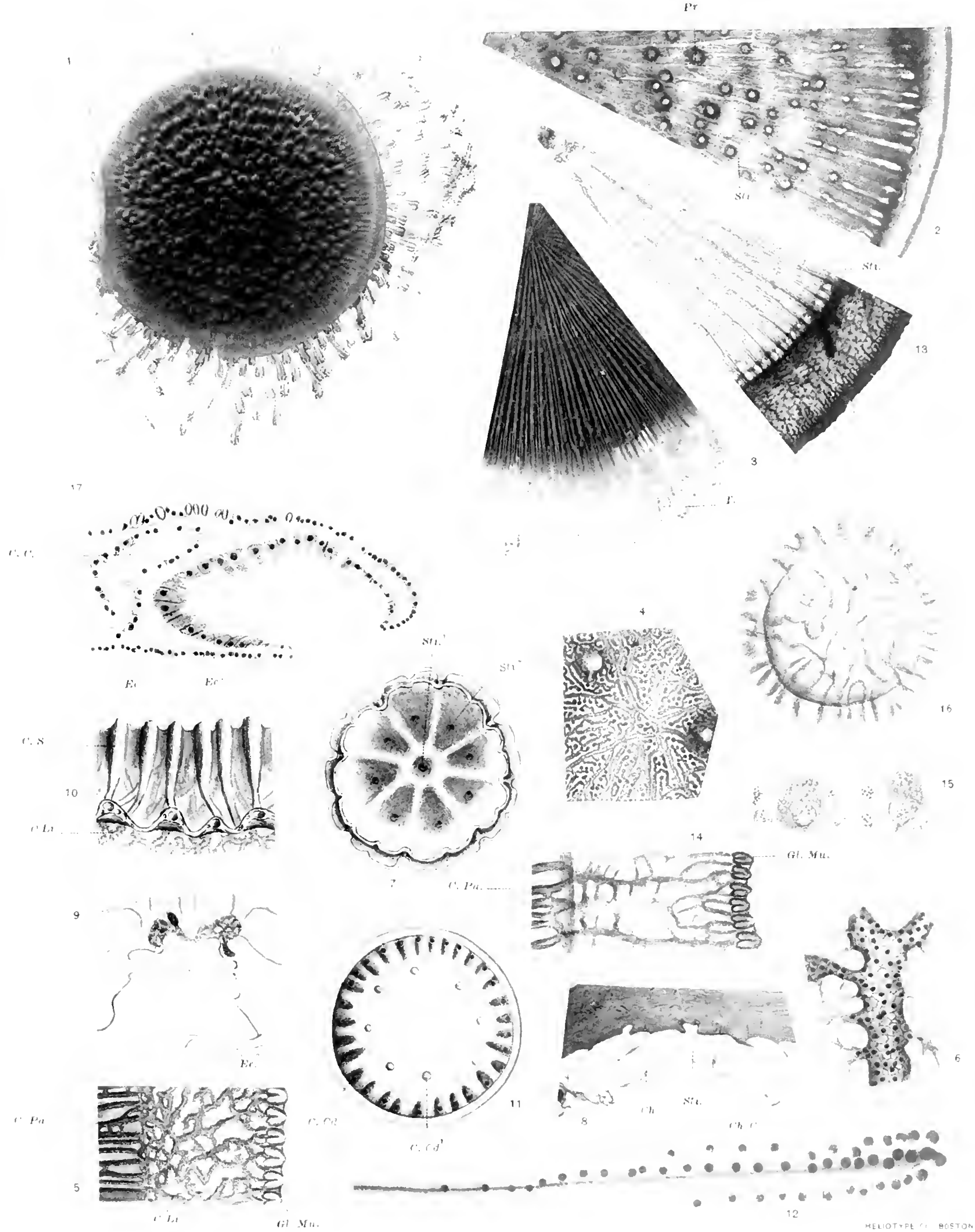
Fig. 12. Porpita pacifica. Extremity of a mature tentacle. × 5.

Fig. 13. Porpita umbella. Segment of the pneumatophore and limbus. From a photograph. × 8.

Fig. 14. Porpita umbella. Portion of the limbus, with its canals. × 20.

Fig. 15. Porpema prunella. Section through the endoderm wall of one of the superior centradenia canals. × 250.

Fig. 16. Porpita pacifica. The centre of the centradenia, from above. × 20.



BIGELOW PHOTO. ET. DEL.                HELIOTYPE CO. BOSTON

PLATE 29.

## PLATE 29.

### Porpita pacifica.

Fig. 1. Radial section through the tentacular zone, and margin of the centradenia. All but the extreme margin of the pneumatophore has been stripped off; C. Ra, descending radial canals; C. T, canals of the tentacular zone; C. S, superior canals of the centradenia (Ce); $T^1$, young, $T^2$, older tentacle; Go, gonozooid. From a dissection. × 20.

Fig. 2. Radial section. Margin of tentacular zone, centradenia and pneumatophore; Li, limbus; Ch. c, circular chamber. Other lettering as in fig. 1. From a photograph. × 40.

Fig. 3. Similar section, showing communication between the lumen of a young tentacle (Te) and tentacular canals (C. E). From a photograph. × 40.

Fig. 4. Section through the centradenia. × 30.

Fig. 5. Centre of the floor of the central gastrozooid, from below. × 40.

Fig. 6. Section through lower part of centradenia; C. I, inferior canals. From a photograph. × 40.

Fig. 7. Section through centradenia, showing superior (C. S) and inferior (C. I) canals. From a photograph. × 30.

Fig. 8. Similar section, showing connection between gonophore (Go) and inferior canals; Ch. C, circular chambers of the pneumatophore; C. S, superior canals. From a photograph. × 20.

Fig. 9. Section through margin of central gastrozooid, showing its connection with one of the outer series of the centradenia canals (C. ). From a photograph. × 40.

Fig. 10. Similar section, showing the opening of one of the canals of the inner series (C. I); Go, gonozooid. From a photograph. × 40.

Fig. 11. Section through the base of gonozooid (Go), to show its connection with one of the inferior canals of the centradenia (C. I). × 40.

Fig. 12. Section through the upper wall of a superior centradenial canal, and of the overlying pneumatosaccus. Ch. C, chitinous lower wall of the pneumatocyst; $Ec^2$, ectoderm of pneumatosaccus; Sl, stutzlamella; En, entoderm of superior canal. × 250.

Fig. 13. Transverse section of one of the lowest inferior canals; En, entoderm lining the canal; Ec, ectoderm of the lower surface of the corm; Cr, guanin crystals. × 250.

Fig. 14. Section through wall of inferior canal at intermediate level; Ec, ectoderm-parenchyma. × 250.

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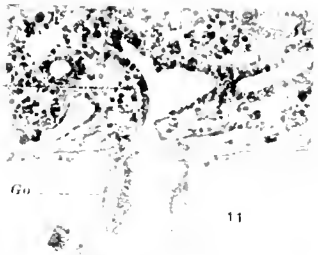

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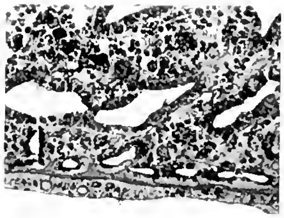

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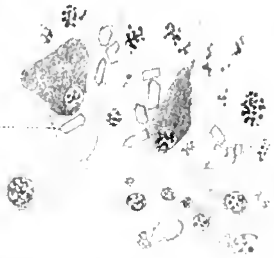

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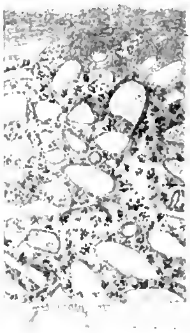

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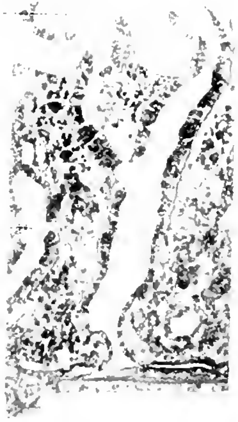

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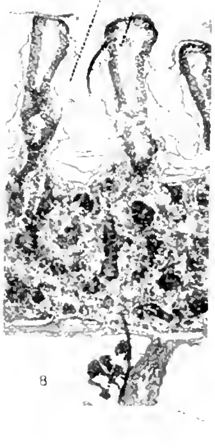

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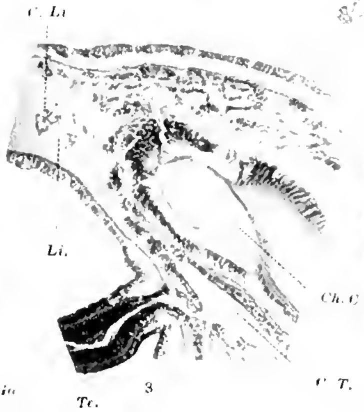

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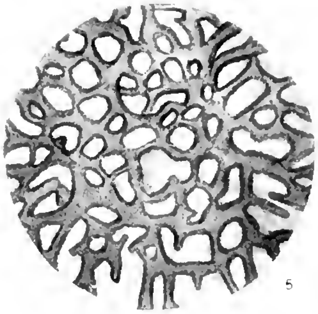

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PLATE 30.

## PLATE 30.

Occurrence of Galeolaria australis (X), Galeolaria monoica (–), Diphyopsis dispar (O) and Agalma okeni (Δ) in the Eastern Tropical Pacific. The solid curve indicates the eastern limit of the surface temperatures of 68° and over. (There are some local anomalies, omitted here). The broken curve is the eastern limit of temperatures of 67° and over at 25 fathoms. (See A. Agassiz : 06.)

"Albatross"—Eastern Pacific Ex

Siphonophorae Plate 30

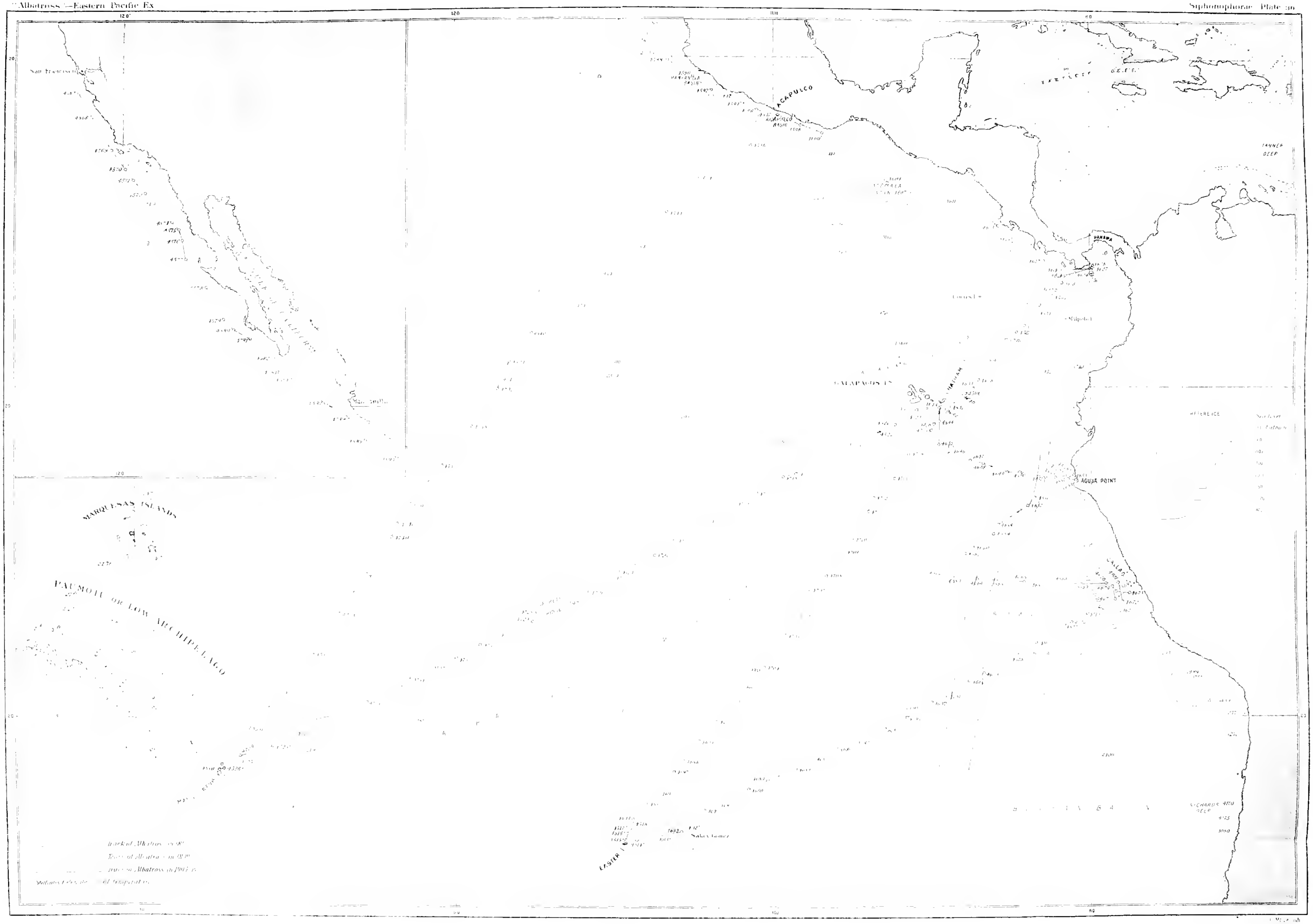

PLATE 31.

## PLATE 31.

Occurrence of Abylopsis tetragona (O), Bassia bassensis (X), Diphyes appendiculata (↾), Diphyes bojani, (Z) and Diphyopsis mitra (Δ) in the Eastern Tropical Pacific. Temperature curves as in Plate 30.

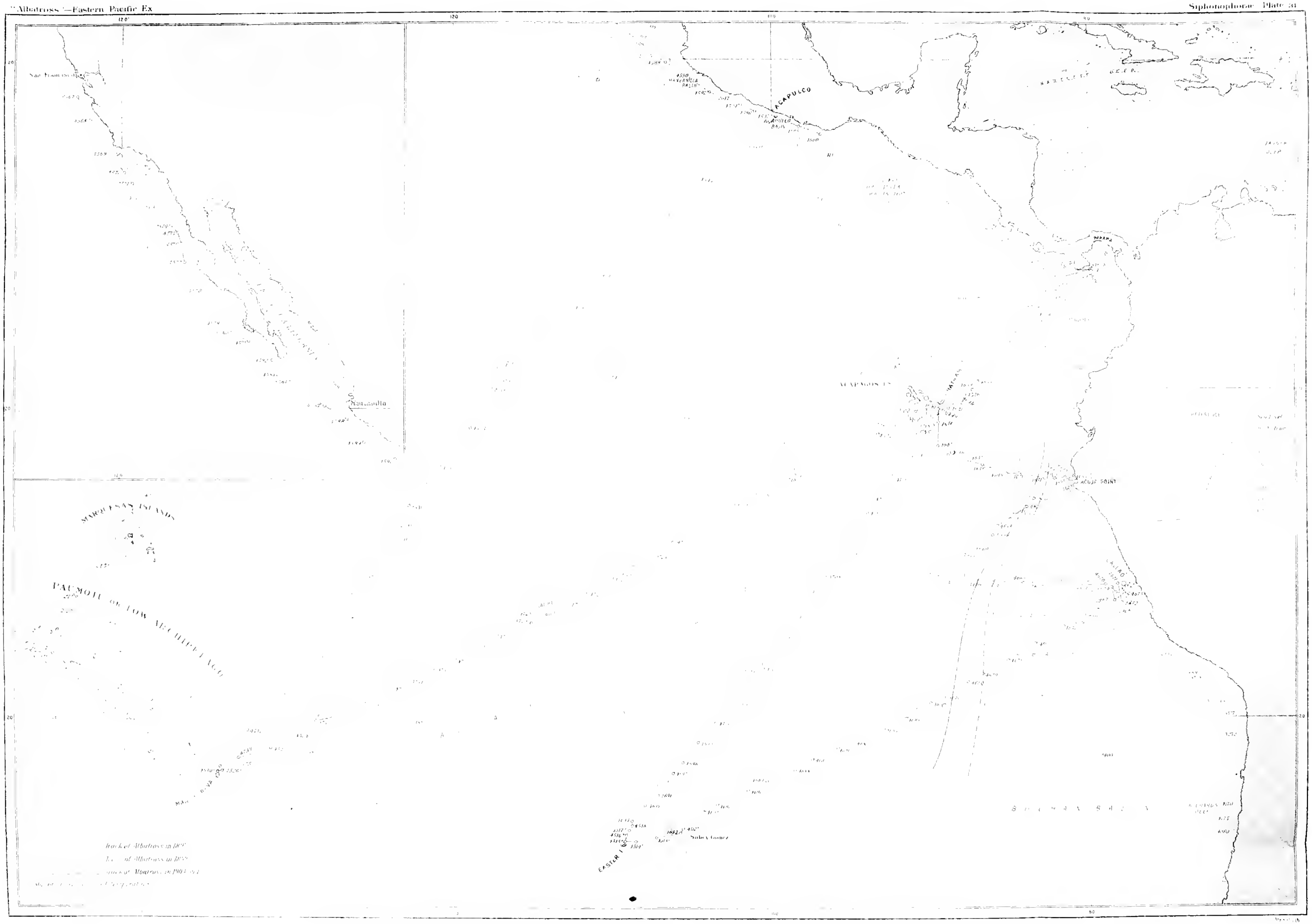
San Francisco
Manzanillo
ACAPULCO
ACAPULCO BASIN
PANAMA
GALAPAGOS IS.
CALLAO
MARQUESAS ISLANDS
PAUMOTU OR LOW ARCHIPELAGO
EASTER I.
Sala y Gomez
120°
100
80
20

PLATE 32.

# PLATE 32.

Distribution of five Siphonophores representative of three thermal groups, arctic, warm to temperate, and tropical.

Diphyes arctica Γ.
Diphyes appendiculata ⊙.
Physophora hydostatica ⦶
Diphyopsis dispar •.
Abylopsis eschscholtzii X.

# TROPICAL PACIFIC.

*The following Publications of the Museum contain Reports on the Dredging Operations in charge of Alexander Agassiz, of the U. S. Fish Commission Steamer "Albatross," during 1899 and 1900, Commander Jefferson F. Moser, U. S. N., Commanding.*

I. A. Agassiz. Preliminary Report and List of Stations. With Remarks on the Deep-Sea Deposits by Sir John Murray. Mem. M. C. Z., Vol. XXVI. No. 1. January, 1902. 114 pp. 21 Charts.

II A. G. Mayer. Some Species of Partula from Tahiti. A Study in Variation. Mem M. C. Z., Vol. XXVI. No. 2. January, 1902. 22 pp. 1 Plate.

III. A. Agassiz and A. G. Mayer. Medusae. Mem. M. C. Z., Vol. XXVI. No 3. January, 1902. 40 pp. 13 Plates, 1 Chart.

IV. A. Agassiz. The Coral Reefs of the Tropical Pacific. Mem. M. C. Z., Vol. XXVIII. February, 1903. 33, 410 pp. 238 Plates.

V. C. R. Eastman. Shark's Teeth and Cetacean Bones from the Red Clay of the Tropical Pacific. Mem. M. C. Z., Vol. XXVI. No. 4. June, 1903. 14 pp. 3 Plates.

VI. W. E. Hoyle. Cephalopoda. Bull. M. C. Z., Vol. XLIII. No. 1. March, 1904. 71 pp. 12 Plates.

VII. H. Ludwig. Asteroidea. Mem. M. C. Z., Vol. XXXII. July, 1905. 12, 292 pp. 35 Plates, 1 Chart.

VIII. W. E. Ritter and Edith S. Byxbee. The Pelagic Tunicata. Mem. M. C. Z., Vol. XXVI. No. 5. August, 1905. 22 pp. 2 Plates.

IX. Mary J. Rathbun. The Brachyura. Mem. M. C. Z., Vol. XXXV. No. 2. August, 1907. 54 pp. 9 Plates.

X. C. H. Gilbert. The Lantern Fishes. Mem. M. C. Z., Vol. XXVI. No. 6. July, 1908. 24 pp. 6 Plates.

XI. A. Agassiz. Echini: The Genus Colobocentrotus. Mem. M. C. Z., Vol. XXXIX. No. 1. November, 1908. 8, 33 pp. 49 Plates.

XII. J. Murray and G. V. Lee. The Depth and Marine Deposits of the Pacific. Mem. M. C. Z., Vol. XXXVIII. No. 1. June, 1909. 170 pp. 5 Plates, 3 Maps.

XIII. W. C. Kendall and E. L. Goldsborough. The Shore Fishes. Mem. M. C. Z., Vol. XXVI. No. 7. February, 1911. 106 pp. 7 Plates.

XIV. H. Heath. The Solenogastres. Mem. M. C. Z., Vol. XLV. No. 1. June, 1911. 180 pp. 40 Plates.

XV. A. M. Westergren. Echini: Echinonëus and Micropetalon. Mem. M. C. Z., Vol. XXXIX. No. 2 August, 1911. 34 pp. 31 Plates.

Date Due