MEDUSAE OF THE WORLD

VOLUME III

THE SCYPHOMEDUSAE

BY

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CONTENTS.

VOLUME III.

MEDUSAE OF THE WORLD.

THE SCYPHOMEDUSAE.

INTRODUCTION.

The present volume is a continuation of the work the two former parts of which dealt with the Hydromedusæ. The acknowledgments which I was privileged to render in the introduction to the first volume need not here be repeated, pleasurable to me as such a repetition would be. Suffice it to say that the work was commenced in 1892 at the suggestion of Dr. Alexander Agassiz whose generous aid enabled me to pursue these studies for many years under the most advantageous conditions; and apart from the sense of personal gratitude I cherish toward Dr. Agassiz I hope that enough of scientific worth may be found within these volumes to cause it to appear that I have made appreciative use of the opportunities he so magnanimously accorded to me. Throughout the years I have hoped that Dr. Agassiz might live to see this work and that he might be pleased by this fruit of his inspiration, but on March 27, 1910, the great student of the oceans died upon the sea, only a few weeks before the publication of these volumes.

Since the first two volumes passed under the press I have been most kindly aided by the United States Bureau of Fisheries and by the National Museum of the United States, at Washington. The authorities of the former permitted me to study the important collection of Scyphomedusæ recently made by the *Albatross* in the Philippine Islands, and those of the latter institution were so courteous and helpful as to set aside for my use a table in the Smithsonian building in order that I might study this collection to the best advantage. It is due especially to Dr. Hugh M. Smith, Deputy Commissioner of the Bureau of Fisheries, and to Dr. Richard Rathbun, Assistant Secretary of the Smithsonian Institution that I owe these highly appreciated favors.

Plates 61 and 64A and several text-figures are taken from drawings made from nature by my friend, the late Prof. William K. Brooks. These drawings were most kindly presented to me for publication in this work by Prof. E. A. Andrews, of the Johns Hopkins University, soon after the death of Professor Brooks. They will serve as memorials of the rare skill in observation and in draftsmanship of the great naturalist who made them.

SCYPHOMEDUSÆ.

Phanerocarpæ, Eschscholtz, 1829, Syst. der Acal.
Steganopthalmæ, Forbes, 1848, British Naked-eyed Medusæ.
Acraspedæ, Gegenbaur, 1856, Zeit. für wissen. Zool., Bd. 8.
Discophoræ, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4.
Acraspedæ, Haeckel, 1880, Systems der Medusen, Hälfte 2.
Scyphomedusæ, Lankester, 1881, Encyclopædia Britannica, Ed. 9, Hydrozoa, p. 547.

Medusiform *Cnidaria* with tentacle-like, entodermal filaments upon the subumbrella floor of the stomach-cavity. With entodermal gonads, and without a velum such as is characteristic of the Hydromedusæ. Development by strobilization from scyphostoma larvæ.

There is but little evidence to support the supposition that the Scyphomedusæ have been derived from the Hydromedusæ. The medusa shape of the sexual generation in both has in all probability been acquired independently. Indeed, various animals have assumed the external appearance and peculiar mode of locomotion by pulsation which is characteristic of the medusæ. Such for example are the protozoan *Craspedotella* and the holothurian *Pelagothuria*. Moreover there is reason to believe that the medusa-bell of the Narcomedusæ has

been acquired independently of and is not homologous with the bell of the Leptolina medusæ. (See Goette, 1907, Zeit. für wissen. Zool., Bd. 87, p. 289.)

The peculiar velum of the Carybdeidæ among the Scyphomedusæ is a structure of the subumbrella, *not* of *both* subumbrella and exumbrella as in Hydromedusæ. It may be regarded as a parallelism, and not genetically related to the velum of Hydromedusæ. The exumbrella nerve-ring, found commonly in Hydromedusæ, does not exist in the Scyphomedusæ, but is replaced by a subumbrella plexus of fibers extending between the marginal sense-organs and also radially inward from these ganglionic centers. There is also a diffuse, nervous, epithelial, ectodermal network over the subumbrella. The subumbrella alone is sensitive to stimuli, the exumbrella being non-sensory, but covered with a nematocyst-bearing epithelium.

In the Scyphomedusæ the mature, sexual products are found in the entoderm, whereas they are usually in the ectoderm in Hydromedusæ. The velum which is universally present in Hydromedusæ is absent in Scyphomedusæ. The 4 interradial, gastric septa which are always seen in the *scyphostoma* larva of Scyphomedusæ are not found in the polyp stage of Hydromedusæ.

When we come to consider the relationships of the several orders constituting the Scyphomedusæ themselves we meet with difficulties which render our classification only tentative. The history of the attempts to classify the Scyphomedusæ have recently been reviewed by Maas, 1907 (Ergeb. und Fortschritte der Zool., Bd. 1, p. 189), and by Bigelow, 1909 (Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 13). Marked advances over Haeckel's artificial classification were made by Claus, 1878, 1883, who showed that the Carybdeidæ are a very aberrant group not closely related to other Scyphomedusæ, and not descended from the Stauromedusæ as Haeckel believed. As Claus showed, the interradial, gastric septa in Carybdeidæ may be newly arisen fusions of the entodermal walls of the exumbrella and subumbrella and not derived from the interradial tæniolæ of the scyphostoma. Unfortunately, however, no one has seen the late scyphostoma stage in Carybdeidæ, and hence our knowledge of their relationships must remain doubtful. Claus, 1883, and Vanhöffen, 1892, called attention to the supposed importance of the presence or absence of the interradial, gastric septa in the classification of sexually mature Scyphomedusæ but we must remember that these are absent in Semæostomæ and found in Coronatæ, yet these two orders are closely related. Moreover, interradial gastric septa are found both in Stauromedusæ and Carybdeidæ yet all modern students agree that these groups are widely divergent. The sessile Stauromedusæ certainly approach very closely in structure to the type of the scyphostoma, but this may be the result of degeneracy due to their sedentary habit.

Vanhöffen, 1892, in a masterly paper called attention to the importance of the annular furrow and marginal, exumbrella sculpturing of the bell in certain of Haeckel's Discomedusæ, and he grouped these under the designation Coronatæ. Claus, 1883, had previously shown that in *Nausithoë*, which is a typical member of the Coronatæ, the interradial septa of the central stomach are derived from the 4 tæniolæ of the scyphostoma. These septa are, however, absent in the medusa-stage in Semæostomeæ and Rhizostomæ, although they are found in the scyphostoma.

All evidence both anatomical and embryological shows that the Rhizostomæ are descended directly from the more simply organized Semæostomeæ. It is probable that the Coronatæ and Semæostomeæ are not descended one from the other, but are derived from some common ancestral stock which has disappeared. The Stauromedusæ may represent a highly specialized derivative from this common ancestral form, their specialization being due to their sessile, attached habit of life. The Carybdeidæ are so aberrant and our knowledge of their development is so imperfect that we have not yet been able to determine their relationships to other Scyphomedusæ.

The habits and distribution of the several orders of Scyphomedusæ are characteristic. The Stauromedusæ are found only in the Arctic and Antarctic regions and in cold seas, and are unknown from the tropics; thus furnishing us with an interesting problem in distribution. The planula is not pelagic but creeping and is devoid of cilia, and the medusæ are sessile or creeping, and do not pulsate rhythmically. They affix themselves to seaweeds and rocks and rarely move from their places of attachment. They are probably degenerate forms although their relationship to other Scyphomedusæ is uncertain. They are confined to the shores, but may be carried far from their normal habitats upon drifting seaweed.

The Orders of the Scyphomedusæ.

	Carybdeidæ.	Stauromedusæ.	Coronatæ.	Semæostomeæ.	Rhizostomæ.
Form of bell.	Cubical with interradial angles, and perradial sides.	Pyramidal, usually attached to objects by aboral apex.	Discoidal with annular furrow, and marginal zone of pedalia in exumbrella.	Discoidal without annular furrow or pedalia.	As in Semæostomeæ.
Margin of bell.	No lappets but with an annular membrane formed from the subumbrella and constituting a velum.	Usually with 8 adradial lobes which bear the tentacles.	Cleft into lappets.	Cleft into lappets.	Cleft into lappets.
Tentacles.	4 interradial, single or in clusters. Tentacles hollow, lash-like, and mounted upon spatula-shaped projections of the subumbrella.	Usually 8 adradial clusters of hollow, knobbed tentacles.	Arising from clefts between lappets.	Arising from subumbrella or from clefts between lappets.	Absent. In one genus (Lobonema) the marginal lappets have been metamorphosed into tentacle-like organs.
Sense-organs.	4 perradial clubs set in niches on sides of bell. Ocelli and lithocyst present.	When present 8 (4 perradial, 4 interradial) anchors without ocelli or lithocysts.	Arising from clefts between lappets. An entodermal mass of concretions always present.	As in Coronatæ.	As in Coronatæ.
Interradial septa in stomach.	Present.	Present.	Present.	Absent.	Absent.
Mouth.	Cruciform, simple.	Cruciform, simple.	Cruciform, simple.	Unitary. Cruciform, usually with veil-like lips.	Numerous mouths surrounded by motile tentacles and borne on 8 adradial, fleshy, arm-like processes.

The Carybdeidæ are highly specialized forms which are confined to tropical and warm seas. They live upon the bottom in shallow water along coasts, and are not commonly found upon the surface until nearly mature. Their developmental stages are practically unknown and their exact relationship to the other orders of Scyphomedusæ is problematical. In common with the Stauromedusæ and Coronatæ they have 4 perradial stomach-pouches. They bear a remarkable, but wholly superficial, resemblance to the Hydromedusæ in the shape of the bell and in the presence of an annular diaphragm which constricts the aperture of the bell-cavity. This velar diaphragm is, however, only an extended part of the subumbrella in Carybdeidæ whereas both exumbrella and subumbrella take part in its formation in Hydromedusæ.

The Coronatæ are deep-sea and pelagic forms and are therefore of world-wide distribution in common with other creatures of similar habits.

The Semæostomeæ are mainly coastal forms which develop through strobilization from scyphostoma larvæ. The genus *Pelagia* is peculiar, however, in that the larva is not attached, but remains free-swimming and develops directly into the medusa; and thus it is that medusæ of this genus are widely distributed, independently of the proximity of land and are found in all warm seas. Certain families, such as the Cyaneidæ, are practically confined to the Arctic and Antarctic, and to cold seas; whereas the Pelagidæ are found only in warm oceans. On the other hand the genus *Aurellia* is of world-wide distribution.

The Rhizostomæ form a well-defined order which are clearly descended from the Semæostomeæ. They are confined to tropical and warm seas and are most abundant in the Malay Archipelago. They develop through strobilization from scyphostoma larvæ, and are therefore confined to coastal waters of a depth suitable for the maturation of their attached larvæ.

In the Semæostomeæ and Rhizostomæ the egg develops into a pyriform, ciliated planula which is set free from the mouth-folds of its parent and swims freely through the water. Soon it attaches itself by means of its forward end. An ectodermal invagination is said by Goette to

occur at the non-attached, upper pole of the larva. 4 perradial stomach-pouches develop, 2 being partially ectodermal and derived in some measure at least from the invaginated ectoderm of the œsophagus, the other 2 pouches being entodermal and derived from the entoderm of the stomach of the larva. These perradial pouches are separated by 4 interradial septa which finally become perforated near the margin forming a peripheral ring-sinus. 4 funnel-like cavities lined by longitudinal muscle-fibers sink downward into these 4 interradial septa from the hypostome of the larva, and tentacles develop around the margin of the hypostome. Finally the larva splits by transverse clefts into a series of discoidal, free-swimming, ephyra larvæ, and the original corona of tentacles is cast off and dies while a new set of tentacles and a 4-cornered mouth may develop at the upper end of the remaining part of the larva. In some species, and under certain conditions, this strobilization may be monodiscus and give rise to but a single ephyra, while in others from 10 to 30 ephyræ may arise from a single scyphostoma. Details of this peculiar process of delamination and regeneration, and of the larval stages in general, will be found in Korschelt and Heider's text-book of the embryology of invertebrates, part 1, 1895, pages 102 to 122, and throughout the text of the present work. See especially *Cyanea arctica*, *Aurellia aurita*, *Pelagia*, *Chrysaora*, *Cotylorhiza tuberculata*, and *Cassiopea xamachana*.

With reference to the relationships between Hydromedusæ, Scyphomedusæ, and actinians, Goette's announcement that the œsophagus of the scyphostoma of Scyphomedusæ is formed of invaginated ectoderm seemed to suggest a close relationship between the scyphopolyp and the actinozoa. Hadzi, 1907, however, re-affirms the work of Claus and supports the view that the œsophagus of the scyphostoma is lined on the inside with entoderm and is not invaginated but evaginated from the primary stomach. All of the stomach-pouches are therefore entodermal according to Claus and Hadzi, whereas, 2 of the primary stomach-pouches are at least partially ectodermal and 2 wholly entodermal according to Goette.

We know, however, from Conklin's study of the development of *Linuche*, and Hyde's research upon *Aurellia*, that gastrulation in one and the same species may occur either through invagination or by ingression, and judging from the mass of evidence which has been accumulated we can not doubt but that the mouth of the scyphostoma of one and the same species may be formed either by invagination, or by a simple breaking through of both entoderm and ectoderm in which the entoderm takes the more active part, or even by an evagination of entoderm. The three processes may thus be closely related and the manner of operation dependent upon which layer takes the initiative and assumes the more active part. It is therefore misleading to attach any deep morphological significance or to draw any sweeping conclusions in respect to the phylogeny of the Scyphomedusæ from this process. Indeed, long ago our faith in the rigid application of the germ-layer theory has become so shaken that the discussion between the Goette and the Claus schools has lost most of its significance.

According to the Claus-Hadzi view the Scyphomedusæ are more closely related to the Hydromedusæ than they are to the actinians. Certainly the histological characters of the germ layers of the scyphostoma resemble the hydropolyps rather than the actinozoa, although both are so closely similar that no great weight can be attached to this fact. Hérouard, 1909 (Comptes Rendus, Paris, tome 148, page 1225), supports the opposite view from histological evidence, for he finds that the cellular investment of the pharynx of Scyphomedusæ and scyphostoma larvæ is similar in character to that of the gullet of Anthozoa, thus indicating a genetic relationship between the Anthozoa and Scyphomedusæ.

According to Goette the 4 primary stomach-pouches are actively *evaginated* from the central stomach-cavity and are of mixed ectodermal and entodermal origin. According to Claus-Hadzi, however, they are wholly entodermal, and are only passively separated one from another by the *infolding* of the 4 entodermal foldings in the stomach-wall which constitute the tæniolæ.

It is extraordinary that this contention should have persisted so long without a final settlement of views.

The table on the opposite page will serve to present the question more clearly.

The scyphostoma larva of *Nausithoë* bears a remarkable superficial resemblance to hydroids, being elongate, branched, and incased by a horny perisarc. It infests sponges.

In the majority of the Scyphomedusæ the sexes are separate, but in *Chrysaora* and in certain Rhizostomæ the medusæ are hermaphroditic.

	Hydropolyp (hydroids).	Scyphopolyp (Scyphostoma), according to Claus-Hadzi.	Scyphopolyp (Scyphostoma), according to Goette.	Anthopolyp (Actinozoa).
Inner lining of œsophagus.	Evaginated and entodermal.	Evaginated and entodermal.	Invaginated and ectodermal.	Invaginated and ectodermal.
Tæniolæ.	None.	4 wholly of entodermal origin, but with ectodermal muscle-strands.	4 of mixed ectodermal and entodermal origin, but with ectodermal muscle-strands.	Septa composed mainly of entoderm, with entodermal muscles.
Muscle-strands.	Formed from basal elongations of both ectoderm and entoderm cells.	Of ectodermal origin.	Of ectodermal origin.	Mainly entodermal but some ectodermal in origin.
Stomach-cavity.	Unitary, but often with irregular, longitudinal ridges of entodermal cells. (See Hamann, 1882, Jena. Zeitsch. Naturw.,Bd. 15, p. 509.)	With 4 primary pouches of purely entodermal origin simply separated one from another by 4 entodermal infoldings.	2 of the primary pouches are partially ectodermal and 2 of purely entodermal origin. They grow actively outward from sides of central stomach.	With lateral pouches.
Ripe sexual products.	In ectoderm.	In entoderm.	In entoderm.	In entoderm.
Intermediate lamella.	Structureless, free from cells.	Containing cells.	Containing cells.	Containing cells.
Mode of reproduction.	Medusæ develop by budding.	Medusæ develop by strobilization.	Medusæ develop by strobilization.	No medusæ developed.

Romanes and Eimer found that if the marginal sense-clubs of Scyphomedusæ be removed a more or less complete paralysis results, although the disk remains capable of responding temporarily to any stimulus. Bethe, 1903, found that in *Rhizostoma pulmo* and *Cotylorhiza tuberculata* the pulsation-stimulus is nervous in nature, and there are many analogies between the rhythmic movement of these medusæ and that of the vertebrate heart. For example the "all or none" principle applies to medusæ, as does also the phenomenon of the insensibility of the medusa to stimulation while in systole, and the extra systole and compensating period of rest. Mayer, working upon *Cassiopia xamachana*, finds that the sea-water is a balanced fluid, the stimulating tendency of its sodium being exactly counterbalanced by the inhibiting effects of its magnesium, calcium, and potassium. The pulsation stimulus arises in the marginal sense-clubs and is due to the constant formation of sodium oxalate in the entodermal cells at the distal end of each club. This precipitates the calcium chlorides and sulphates of the sea-water forming the insoluble calcic oxalate crystals of the sense-club, and setting free sodium chloride and sulphate the cations of which are powerful nervous stimulants, and produce the periodic response of the nervous elements which causes the rhythmic pulsation.

In the hydromedusæ on the other hand the function of the control of pulsation is not localized in the sense-organs for any part of the bell-rim will serve to maintain the bell in pulsation.

It is interesting to note that whatever the effect of the several cations, sodium, magnesium, calcium, and potassium, may be upon the neuromuscular system, their effects upon the movement of cilia is the exact opposite. Whatever stimulates muscles inhibits cilia, and *vice versa*.

The gastric tentacles, which arise from the subumbrella wall of the stomach on the sides of the interradial septa are very characteristic and constant structures in Scyphomedusæ. They are entodermal with solid cores of mesogloea, and are in no sense comparable with the marginal tentacles, but their function is unknown.

The marginal tentacles themselves are to be regarded as structures of the subumbrella. They are usually but not invariably hollow and consist of an axial core of entodermal cells encased outwardly by ectoderm which is richly besprinkled with nematocysts. The marginal sense-clubs are highly specialized tentacles which have been transformed into sensory centers. Ocelli may or may not be present and when found they may be of ectodermal or of entodermal structure; but concretions of crystalline nature are invariably found in the entodermal cells at the distal end of the club in all forms exhibiting rhythmical pulsation. The gonads are follicular foldings of the entodermal subumbrella floor of the stomach.

Order CARYBDEIDÆ Gegenbaur, 1856.

Carybdeidæ, GEGENBAUR, 1856, Zeit. für wissen. Zool., Bd. 8, p. 214.
Charybdea, CLAUS, 1886, Arbeit. Zool. Inst. Univ. Wien, Bd. 7, p. 110.—VANHÖFFEN, 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 21.
Marsupialidæ, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 174.
Cubomedusæ, HAECKEL, 1880, Syst. der Medusen, p. 423.—GOETTE, 1887, Abhandl. zur Entwickelungsgesch. der Thiere, p. 66, Leipzig.—SCHWEIKOFF, 1889, Morphol. Jahrb., Bd. 15, p. 25.—CONANT, 1898, Mem. Johns Hopkins Univ. Biol. Lab., vol. 4, No. 1, p. 3.—HAACKE, 1887, Jenaische Zeitschrift, Bd. 20, p. 590.—MAAS, 1907, Ergeb. und Fortschritte der Zool., Bd. 1, p. 197.

CHARACTERS OF THE ORDER.

Scyphomedusæ with 4 perradial, knob-shaped, marginal sense-organs which are situated within niches upon the sides of the bell. Each sense-organ contains an entodermal concretion, and one or more ectodermal ocelli. There are 4 interradial tentacles or groups of tentacles. 4 wide perradial sacs extend outward from the central stomach into the interstitial space of the bell. These sacs are incompletely separated one from another by 4 narrow interradial septa. There are 8 gonads each one of which is leaf-shaped and attached along one side to an interradial septum, from which it extends outward into the gastrovascular space of the bell. The bell-margin is not cleft into lappets. The subumbrella forms an annular diaphragm called the velarium which partially closes the opening of the bell-cavity.

The perradial sense-organs in the Carybdeidæ are knob-shaped, and are set within niches upon the sides of the bell. The stalk of each knob is hollow and connected with the gastrovascular system of the bell. The knobbed end of each club contains a large entodermal concretion and one or more ectodermal eyes (plate 56, fig. 6″). These eyes are placed on the inner or centripetal side of the club and look inward into the bell-cavity. The larger eyes are provided with a doubly convex lens, back of which is a cup-shaped space occupied by the lens-capsule and the retina. The retina is made up of a single layer of cells forming a hollow cup, into which the lens with its capsule fits. The central space of the retinal cup is clear and glassy. This transparent region is enveloped by a deeply pigmented part and back of this lies a muscular zone. The retina is made up of three kinds of cells, some long and prism-shaped, others short and pyramidal, and still others long and pyramidal. The deep-lying ends of these cells are more or less pigmented, while their outer parts are transparent, and being packed closely together, they form the vitreous center of the retinal cup. (See Conant, 1898; Berger, 1900; etc.)

The tentacles of the Carybdeidæ are interradial and arise at a level slightly above the apparent bell-margin, although they are actually structures of the subumbrella. Their proximal parts are developed into tough, gelatinous, wing-shaped or spatula-shaped structures (pedalia), which probably serve as keels to steer the animal in its course through the water. The long, distal ends of the tentacles are cylindrical and highly contractile, and their outer surface is covered with rings of nematocysts. The tentacles are hollow and their lumen is connected with the gastrovascular space of the bell. This is accomplished by the interradial septa being incomplete near the bases of the tentacles and thus the lumen of each tentacle is placed in direct connection with the gastrovascular spaces of the two adjacent perradial pouches. The flexible parts of the tentacles are armed with nematocysts, the stinging power of which is so great that the name "Sea Wasp" is commonly given to these medusæ.

The velarium is an annular membrane which extends inward from the bell-margin, forming a diaphragm which partially closes the cavity of the subumbrella; superficially it bears a close resemblance to the velum of the Hydromedusæ, but is separated from the exumbrella by means of a continuous sheet of entodermal tissue which penetrates the gelatinous substance of the bell all around the bell-margin, and connects the entoderm of the intermediate lamella with the ectoderm of the outer surface of the bell. It thus forms a ring of entoderm around the bell-margin which completely separates the ectoderm of the subumbrella side of the velarium from that of the exumbrella. At points other than those occupied by sense-organs or tentacles this vascular, entodermal lamella forms a simple, flat sheet, but when it comes to the tentacle-bases, or sense-organs, it makes a loop upward over them. Thus the tentacles and sense-clubs are structures of the subumbrella only, for they lie below the entodermal lamella which isolates them completely from the exumbrella. What the philogenetic significance of this lamella may be we do not know, and until this is discovered we can not be certain that the velarium of the Carybdeidæ is not strictly homologous with the velum of the

Hydromedusæ; for it constitutes the only important point of difference in the velar diaphragms of the two sorts of animals. The velarium is commonly bound to the wall of the subumbrella by 4 solid, bracket-like supports, the frenulæ, one of which is found in each perradius. There is also a more or less complicated system of entodermal canals or pouches which extend into the substance of the velarium from the gastrovascular space of the bell.

There has been a tendency among modern authors to regard the velarium as being composed of a series of fused lappets, the pouches being remnants of lappet-pouches. We have no proof, however, that this is the case, and the velarium in the youngest Charybdeidæ yet seen is as entire as in the adult.

There are 4 groups of gastric cirri, or phacelli, in the interradial corners of the central stomach, at the inner ends of the 4 interradial septa, and this feature alone would distinguish these forms from the Hydromedusæ in which no such structures have been observed. The gonads, also, are entodermal instead of ectodermal when mature as in Hydromedusæ. Both the gonads and gastric cirri are structures of the subumbrella, as is also the entire muscular system.

There is a well-developed nerve-ring on the bell-cavity side of the subumbrella near the margin. This ring forms 4 loops upward to the 4 perradial sense-organs (plate 57, fig. 2). There are 8 ganglia upon the nerve-ring, 4 perradial and 4 interradial. Each of the perradial ganglia sends off 2 nerve-roots, which pass through the gelatinous substance of the subumbrella and fuse as they extend down the inner (centripetal) side of the stalk of the sensory-club. The 4 interradial ganglia are situated at the bases of the tentacles into which they probably send nerve-fibers.

The Carybdeidæ are inhabitants of the warmer waters of all the oceans, and none of them has been found in the Polar seas. Most of them have been taken in the open ocean, but they are also found swarming in harbors and other places near land. When young they appear to be bottom forms, but they usually come to the surface when mature.

But little is known concerning the embryonic development of these forms. Conant, 1897, found that in *Tripedalia* the ovum develops into a free-swimming planula, which soon settles down upon the bottom and becomes a hydra-like polyp with a mouth and 4 tentacles. Haacke, 1887, found a very young individual of *Carybdea rastonii* in which a short style canal extended upward from the upper floor of the central stomach to the aboral apex of the bell, and he believes it possible that this structure may represent the remnant of some connection between the young medusa and some form of scyphopolyp nurse, but this is wholly problematical.

Haeckel, 1880, believed that the Carybdeidæ were descended from the Stauromedusæ, as, according to him, were also his Periphyllidæ and the Discomedusæ. He believes that morphologically the Carybdeidæ are intermediate between the Periphyllidæ and the Discomedusæ. All of this, however, is speculation unsupported by a single fact of any significance. We must first learn more of the early embryonic stages of the medusæ of the Carybdeidæ and Stauromedusæ before we venture to state how they may be related in philogeny to other Scyphomedusæ. They have perradial stomach-pouches which are partially separated by interradial septa as in the Stauromedusæ; indeed Goette, 1887, would consider the Carybdeidæ as an off-shoot of or cousins of the Stauromedusæ.

Most of our knowledge of the anatomy of the Carybdeidæ is due to the labors of Claus, 1878; Haeckel, 1880; Schewiakoff, 1889; Conant, 1898; and Berger, 1900.

Berger, 1900, reports upon a few physiological experiments upon the reactions of Carybdeidæ (see *C. xaymacana*). A synopsis of the genera of the Carybdeidæ follows:

(?) *Procharybdis Haeckel*, 1880. 4 simple pedalia. Velarium without velar canals or frenulæ. This is probably only a young *Charybdea*.

Carybdea Péron and Lesueur, 1809. 4 simple pedalia. Velarium with velar canals and with 4 perradial bracket-like supports (frenulæ). Stomach small, without hollow bracket-like sides arching over between it and the subumbrella. Stomach small and simple, with 4 horizontal clusters of gastric cirri.

Tamoya F. Müller, 1859. Similar to *Charybdea*, but with a large stomach which is bound to the subumbrella by 4 perradial, hollow arches and with 4 vertical, interradial clusters of gastric cirri.

Tripedalia Conant, 1897. Numerous, 8 to 12 or more, simple unbranched pedalia arranged in 4 interradial clusters. No hernia-like subumbrella sacs.

Chiropsalmus L. Agassiz, 1862. 4 branched, hand-shaped pedalia with tentacles arising from the tips of the fingers. With 8 simple, finger-shaped, hernia-like subumbrella gastric sacs. Free-margins of the 8 gonads entire and simple.

Chirodropus Haeckel, 1880. Pedalia hand-shaped as in Chiropsalmus. 8 branched, hernia-like sacs projecting into the subumbrella from the 4 perradial stomach-pouches. Free-margins of the gonads showing grape-like swellings.

Genus (?) PROCHARYBDIS Haeckel, 1880.

Procharybdis, HAECKEL, 1880, Syst. der Medusen, p. 437.

The type species is *P. tetraptera* Haeckel from the Sunda Islands, Indian Ocean. It may prove to be only a species of *Carybdea* which is regenerating its velum or is immature.

GENERIC CHARACTERS.

Carybdeidæ with 4 simple, interradial tentacles with pedalia. Velarium simple, without velar canals or frenulæ.

P. turricula and *P. flagellata* of Haeckel, *loc cit.*, p. 438, are both too inadequately known to be profitably retained in scientific literature. *P. cuboides* Haeckel, is, I believe, a young stage of the common *Carybdea rastonii*. The briefly described *Procharybdis securigera* Haeckel, *loc cit.*, p. 640, from the Pacific coast of Central America, may be *C. rastonii*, but it is said to have tentacles which terminate each in a knob. This character is seen in young individuals of *Carybdea*.

Procharybdis tetraptera Haeckel.

Procharybdis tetraptera, HAECKEL, 1880, Syst. der Medusen, p. 437, taf. 25, fign. 3, 4.

Bell dome-like with thick walls, 30 mm. high, 20 mm. wide. 4 very large, flat, expanded, simitar-shaped pedalia, with blunt outer ends; these pedalia are nearly as long as the bell-height and nearly one-third as wide as they are long; they are relatively larger than in any other known form of Carybdeidæ. The 4 perradial sense-clubs are set in niches nearly as far above the bell-margin as the width of the bases of the pedalia. Each sense-club is small and apparently contains only a single very large eye and an entodermal concretion. Each of the flexible, hollow tentacles tapers to a pointed end. They are ringed with nematocysts and are about 1.5 times as long as bell-height.

The velarium is without velar canals or bracket-like frenulæ, and its margin is entire. It is only about twice as wide as the tentacles and appears to be very rudimentary. It occurs to me that this velarium may be regenerating after having been lost through accident. Should the velarium have velar canals and frenulæ, the medusa would be one of the genus *Carybdea* which it resembles in all other respects.

The stomach is small, wide, flat, with 4 large, pointed lips. There are 4 pairs of gastric cirri in the interradial corners of the stomach, each consisting of an axial shaft which gives rise to 20 to 30 filaments on one side. The 8 gonads are developed as in other species of Carybdeidæ on both sides of the 4 interradial septa.

Haeckel describes this medusa from a single preserved specimen found in the Sunda Archipelago, Indian Ocean.

Genus CARYBDEA Péron and Lesueur, 1809.

Carybdea, PÉRON ET LESUEUR, 1809, Tableau des Méduses, Ann. Mus. Hist. Nat., tome 14, p. 332.—MILNE-EDWARDS, 1833, Annal. des Sci. Nat., tome 28, p. 248

Charybdea, CLAUS, 1878, Arbeit. Zool. Inst. Univ. Wien., Bd. 1, p. 221.—HAECKEL, 1880, Syst. der Medusen, p. 439; 1881, Deep-sea Medusæ *Challenger* Expedition, Zool., vol. 4, p. 91.—CONANT, 1898, Mem. Biol. Lab. Johns Hopkins Univ., vol. 4, No. 1, p. 3.—HAACKE, 1887, Jenaische Zeit. für Naturwissen., Bd. 20, p. 590.—BIGELOW, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 17.—MAAS, 1909, Abhandl. Aadk. Wissen., München, Suppl. Bd. 1, Ahandl. 8, p. 40.

The type species is *C. marsupialis* Péron and Lesueur, of the Mediterranean.

GENERIC CHARACTERS.

Carybdeidæ with 4 simple, interradial pedalia and tentacles. Velarium supported by 4 perradial, bracket-like frenulæ which bind it to the subumbrella. Velar canals present. Stomach small, without bracket-like mesenteries joining it to the subumbrella. Development unknown.

Péron and Lesueur spell this generic name *Carybdea;* Agassiz, 1862, Cont. Nat. Hist. U. S., vol. 4, p. 173, changed it to *Charybdea*.

All the species of this genus are inhabitants of warm seas. None have been taken north of Cape Cod on the North American coast, or north of the Mediterranean in Europe. Owing to the slight differences between them, it is exceedingly difficult to separate the species one

from another. The most characteristic features for specific distinction are the shape and size of the pedalia and the number and character (branched or unbranched) of the velar canals.

Carybdea marsupialis, *C. rastonii*, and *C. xaymacana* are very closely related, if not mere varieties, of one and the same medusa. They are found in the Mediterranean, tropical Atlantic, and Pacific.

C. pyramis, which appears to be identical with Haeckel's *C. obeliscus* and *C. alata* is distinguished by its long, simitar-shaped pedalia. It comes from the tropical Atlantic.

C. grandis and *C. moseri* are closely related tropical Pacific forms and may be mere local varieties, one of the other, indeed Bigelow, 1909, believes them to be mere growth stages of one and the same medusa, *C. moseri* being the younger. *C. grandis* is possibly identical with *Bursarius cythereæ* Lesson (=*Tamoya bursaria* Haeckel) but the descriptions of the last-named medusa are so vague that it must, I think, be dropped from our lists.

C. murrayana Haeckel is distinguished by its large number of profusely branched velar canals. In other respects it closely resembles *C. marsupialis*, of which form it may indeed be a mere variety.

Semper's Philippine Island *Carybdea*, called *C. philippina* by Haeckel, may be identical with *C. moseri*, but is too vaguely mentioned to be recognizable.

C. verrucosa Hargitt, 1903, is a very young form, too immature for identification.

C. aurifera Mayer is distinguished by its rosin-colored bell, being far darker in color than in any other species.

Haeckel's genus *Procharybdis* appears to be composed of immature or imperfectly known young specimens of *Carybdea*. It is not improbable also that future studies will show that Haeckel's *Procharagma* is actually *Carybdea*.

In some of the species of *Carybdea* the gastric cirri at the interradial corners of the stomach are in the form of branched tufts. The mature eggs are set free from the gonads and float in the gastric pouches, where they undergo a part of their development; but the larval stages remain practically unstudied.

A few physiological observations are reported of *C. xaymacana* by Berger and are discussed under the description of this species.

Carybdea marsupialis Péron and Lesueur.

Plate 58, figs. 1 to 5.

Medusa marsupialis, LINNÉ, 1758, Systema Naturæ, Ed. 10, p. 660; 1788 (Gmelin) tomus 1, pars 6, p. 3154.
Carybdea marsupialis, PÉRON ET LESUEUR, 1809, Annal. du Mus. Hist. Nat. Paris, tome 14, p. 333.
Charybdea marsupialis, CLAUS, 1878, Arbeit. Zool. Inst. Wien, Bd. 1, p. 221, 5 taf., fign. 1–48 (anatomy, histology).—HAECKEL, 1880, Syst. der Medusen, p. 442 (references to literature).

Bell prismatic, 4-sided, somewhat constricted near aboral apex, and with flat top. It is 40 mm. high and 30 mm. wide at level of velarium. The apex of bell, the pedalia, and the interradial ridges of the exumbrella are besprinkled with numerous, quite regularly spaced, oval nematocyst-warts of dull ocher-yellow color. The 4 interradial pedalia are each 17 mm. long and 10.5 mm. wide at their widest parts. The flexible, lash-like, filamentous parts of the tentacles are very contractile and range in length from 2 to 12 times as long as bell-height. These tentacles are hollow and regularly ringed with nematocysts.

The 4 perradially placed sense-clubs are each set in a niche almost covered by a gelatinous flap. These sense-clubs are 5 mm. above the velar margin of the bell. Each sense-club has a median pair of large eyes with a doubly convex lens, and also 4 small, lateral ocelli, which lack lenses. All 6 eyes are directed inward so as to look into the bell-cavity, and are of ectodermal structure. Besides the 6 eyes there is a large terminal mass of entodermal cystalline concretions.

The velarium is supported by 4 bracket-shaped buttresses (frenulæ) which bind it to the subumbrella in the radii of the sense-clubs. There are usually 3 (occasionally 4) branched, blindly-ending centripetal vessels in each octant of the velarium. These vessels branch quite complexly and irregularly, but do not anastomose. The base of the stomach is wide and flask-shaped, but the throat-tube is very narrow and with 4 simple, lanceolate lips. Altogether the manubrium is not more than one-third as long as the depth of the bell-cavity. There are 4 minute clusters of gastric cirri, one in each interradial corner of the stomach. These

*Synopsis of the Species of Carybdea.**

	C. marsupialis.	C. rastonii = a variety of C. marsupialis (?)	C. xaymacana = a variety of C. marsupialis.	C. murrayana = a variety of C. marsupialis (?)	C. alata.	C. pyramis = a variety of C. alata.	C. grandis = a variety of C. alata.	C. moseri = a variety or young stage of C. grandis.
Size of bell in mm.	4-sided, prismatic. 40 high, 30 wide.	4-sided, prismatic. 35 high, 30 wide.	Truncated pyramid above; prismatic below. 23 high, 15 wide.	Square-sided, flatly dome-like top. 60 high, 50 wide.	60 high, 50 wide. Sides pyramidal, apex rounded.	Truncated pyramid. 30 high, 20 wide.	Truncated pyramid. 230 high, 140 wide. Thick walls.	High-dome-shaped, thin walled. 80 high, 47 wide.
Form and size of pedalia in terms of height of bell.	Spatula-shaped, flat. One-third long, one-fourth wide.	Small, scalpel-shaped. One-third to one-fourth long, one-fifth to one-sixth wide.	Scalpel-shaped, flat, wider than in C. rastonii. One-third to one-half long, one-fourth to one-third wide.	As in C. rastonii. One-third long, one-sixth wide.	Spatula-shaped. One-half long, one-fifth wide.	Very long, narrow, curved, scythe-shaped. 1 long, one-eighth wide.	Wide, flat, spatula-shaped. One-sixth long, one-ninth wide.	Wide, flat as in C. grandis. One-third long, one-fifth wide.
Length of flexible tentacles in terms of height of bell.	2 to 12	1.5+	8±	2±	2+	1+	0.75 to 1	1 to 1.5
Number of eyes in each sense-club.	Six. 2 median; 4 lateral.	6	6	6	6	6	1 to 3 1 median; 2 lateral.	4 2 median; 2 lateral.
Form and number of velar canals in each octant of velarium.	3, occasionally 4, branched but not anastomosing.	2 branched but not anastomosing.	2 as in C. rastonii.	6 profusely branched, but not anastomosing.	3 branched complexly, but not anastomosing.	3 unbranched, or only some of them branched. Non-anastomosing.	3 branched, but not anastomosing.	3 unbranched.
Size and shape of stomach.	Base wide, throat-tube slender and small.	Wide, flat, less than half as long as bell-cavity.	Wide, flat, with large, lanceolate lips.	Wide, flat, with 4 short lips.	Short with 4 simple lips.	Small, with 4 large lips.	Small, with 4 simple lips.	As in C grandis.
Where found.	Mediterranean.	Tropical Pacific.	West Indies, tropical Atlantic.	Coast of Sierra Leone, West Africa. Depth of 200 fathoms.	Tropical Pacific.	Tropical Atlantic.	Tropical Pacific.	Tropical Pacific.

* For C. aurifera see text.

cirri are brush-like, and in each cluster about 8 to 10 primary branches arise, and each gives off 2 to 3 lateral branches, each of which terminates in a brush of 10 to 13 filaments. There are thus 100 to 150 of these terminal filaments in each interradial cluster of gastric cirri. The gonads are 8 leaf-like expansions on both sides of the 4 interradial septa. They extend not quite to the velar margin or to the interradial edges of the stomach.

Bell and pedalia dull milky-ocher, due to the color of the exumbrella nematocyst-warts. Flexible parts of tentacles dull pink. Ocelli very dark brown, nearly black; basal branches of gastric cirri dull horny-brown.

The medusa is common in the Mediterranean, but its development remains unknown. Claus, 1878, gives a detailed account of its anatomy and histology. When young it apparently remains in deep water probably at or near the bottom, but when mature it swims upward to the surface.

Carybdea rastonii Haacke.

Charybdea rastonii, Haacke, 1886, Zool. Anzeiger, Bd. 9, p. 554; 1887, Jena, Zeit. für Naturwissen., Bd. 20, p. 591, taf. 35, fign. 1–15; 1888, Biol. Centralblatt, Bd. 8, p. 357.—von Lendenfeld, 1888, Biolog. Centralblatt, Bd. 8, p. 218.—Mayer, 1906, Bull. U. S. Fish Commission, vol. 23, Part 3, 1903, p. 1134, plate 1, figs. 1–1c.—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 17, plates 1 and 10.—Maas, 1909, Abhandl. Akad. Wissen., München, Suppl. Bd. 1, Abhandl. 8, p. 41.

Charybdea arborifera (young medusa), Maas, 1897, Mem. Museum Comp. Zool. at Harvard College, vol. 23, p. 86, taf. 14, fign. 7–10.

Procharagma prototypus (young medusæ), Haeckel, 1880, Syst. der Medusen, p. 436, taf. 25, fign. 1, 2.—*Procharybdis cuboides*, *Ibid.*, p. 439.

Bell nearly cubical, with flatly rounded top and nearly plane vertical sides. 35 mm. high, 25 to 30 mm. wide. Pedalia small, only one-third to one-fourth as long as bell-height, and

three-fifths as wide as long. Flexible lashes of tentacles 1.5 times as long as bell-height. 4 sense-clubs in niches 5 mm. above velarium. Each club with 2 large median and 4 small lateral eyes, and an entodermal lithocyst. Velarium wide with 4 perradial, subumbrella frenulæ and 16 short, branched, non-anastomosing velar canals, 4 in each quadrant. Manubrium flat, wide, less than half as long as depth of bell-cavity. 4 simple lips. 4 very small, interradial tufts of branched gastric cirri as in *C. marsupialis*.

8 leaf-shaped gonads along entire sides of the 4 interradial septa. Each gonad is widest near the stomach and tapers toward both ends. Flexible parts of tentacles and gastric cirri dull pink. It swims toward a light at night.

Gulf of St. Vincent, South Australia; Honolulu Harbor, Hawaiian Islands; Subig Bay and Nasugbu, Luzon, and Mausalay, Mindoro, Philippine Islands, in January. Common on surface. Probably widely distributed over the tropical Pacific.

The medusa begins to develop its gonads when the bell is only 11 mm. high and they are large in medusæ 15 mm. high.

The youngest medusæ found by Haacke had a pyramidal bell and an axial-canal above the stomach-cavity as if it might have been attached at one time to a scyphostoma nurse. Each sense-club had but 2 eyes, the median ones; and the 16 velar canals were simple and unbranched. *C. arborifera* Maas, 1897, from Honolulu, is clearly the young of this species.

This small medusa may be distinguished by its cubical bell and small pedalia. It is closely related to the Mediterranean *C. marsupialis*.

The following are the dimensions (in millimeters) of a specimen obtained by the U. S. Bureau of Fisheries steamer *Albatross* in Subig Bay, Luzon, Philippine Islands, on the surface, January 6, 1908. Height of bell, 34; width of bell, 20; length of pedalium, 11; width of pedalium, 6.5; sense-clubs, 6 above the velar margin; flexible shafts of tentacles, contracted, 30 long. In this specimen the bell was unusually narrow.

Carybdea xaymacana Conant.

Plate 56, figs. 5 to 7; plate 57, fig. 1.

Charybdea xaymacana, CONANT, 1897, Johns Hopkins Univ. Circl., No. 132, p. 8, fig. 8; 1898, Mem. Biol. Lab. Johns Hopkins Univ., vol. 4, No. 1, pp. 4, 7–57; figs. 1–16, 31–34, 36–43, 57–67, 69, 70, 72.—BERGER, E. W., 1898, Jour. Comp. Neurology, Granville, vol. 8, p. 223, 5 figs. (structure of eyes); 1900, Mem. Biol. Lab. Johns Hopkins Univ., vol. 4, No. 4, p. 1–84, 3 plates.—MAYER, A. G., 1904, Mem. Nat. Sci. Museum Brooklyn Inst. Arts and Sci., vol. 1, plate 7, fig. 60.
Tamoya punctata (young medusa), FEWKES, J. W., 1883, Bull. Mus. Comp. Zool. at Harvard College, vol. 11, p. 84, plate 1, figs. 4–6.

Bell 18 to 23 mm. high, 15 mm. broad. Sides vertical for two-thirds their height, above which they slope slightly inward. A slight concavity at top of bell. Pedalia flat and scalpel-shaped and between one-third and half as long as bell-height. The 4 tentacles are at least 8 times as long as the bell-height. The 4 sensory-clubs are situated each within a niche about one-seventh or one-eighth the distance from bell-margin to apex. Each club contains an entodermal, crystalline concretion and 6 ectodermal eyes; 2 of these eyes are large and median, 4 are small and lateral. These eyes are all on the centripetal side of the club, so as to look inward into the bell-cavity. The median eyes are each provided with a prominent lens, whereas the lateral eyes have no lenses. Velarium about one-seventh as broad as bell-diameter. 16 velar canals, 4 in each quadrant; these canals are forked at their ends, at times with more than 2 branches. Stomach flat and shallow. The throat-tube, which is well developed. with 4 large oral lobes, hangs down into bell-cavity a distance between one-third and half the bell-height; it is very sensitive and contractile and can be inverted into the stomach, The 4 tufts of gastric cirri are epaulet-shaped and of small size. Each tuft arises from a stalk-like base which projects from the subumbrella floor of the stomach. There are 8 leaf-like gonads.

Bell translucent, slightly pink or milky with bluish-purple nettling warts near the aboral apex of the exumbrella and bluish-purple tentacles.

This species was found by Conant in Kingston Harbor, Jamaica. I have obtained it in Nassau Harbor, New Providence Island, Bahamas, in spring and summer.

Good figures of the mature medusa are given by Conant, 1897–98.

Berger, 1900, finds that strong light, or darkness, inhibits the pulsation of this medusa. A sudden change in the intensity of the light acts as a stimulus. Removal of all 4 sense-

clubs causes a short temporary "paralysis," but pulsation is soon resumed. Severance of the marginal nerve-ring in 8 places, so as to isolate the sense-organs from the tentacles, does not interfere with pulsation. The operation, however, causes the pedalia to bend inwardly by contraction. When the pedalia are cut off the medusa swims unnaturally, being unable to steer itself and turning in circles and somersaults. Removal of the perradial and interradial marginal ganglia produces paralysis of the pulsations.

When young the exumbrella of this medusa is regularly besprinkled with brown-colored, conspicuous clusters of nematocysts. When the bell is 4 mm. high it is pyriform, thin-walled, and the pedalia are merely short, flattened, swollen basal bulbs of the ringed tentacles. The velarium has no velar canals and there are no gastric cirri. The young medusa is abundant in Nassau Harbor, Bahamas, during the summer.

Carybdea aurifera Mayer.

Charybdea aurifera (young medusa), MAYER, 1900, Bull. Mus. Comp. Zool. at Harvard College, vol. 37, p. 70, plate 25, figs. 81–83.

A young medusa was described from the Tortugas, Florida, in 1900, but in 1909 a much larger but yet immature specimen was found. In this large specimen the bell is 7 mm. long, 5 mm. wide at the velar margin, thin walled, and tapering to a blunt apex. The exumbrella is besprinkled by large, wart-like clusters of nettle-cells. The 4 pedalia of the tentacles are 2 mm. long and the shafts of the tentacles about the same length. These tentacle-shafts are each ringed by 7 to 9 rings of nematocysts. The 4 rhopalia are set in niches about 1 mm. above the velar margin. Each club bears 1 large, median and 4 small, lateral eyes. The velarium is wide, has well-developed, circular muscles and is supported by 4 perradial frenulæ. There are 16 main velar

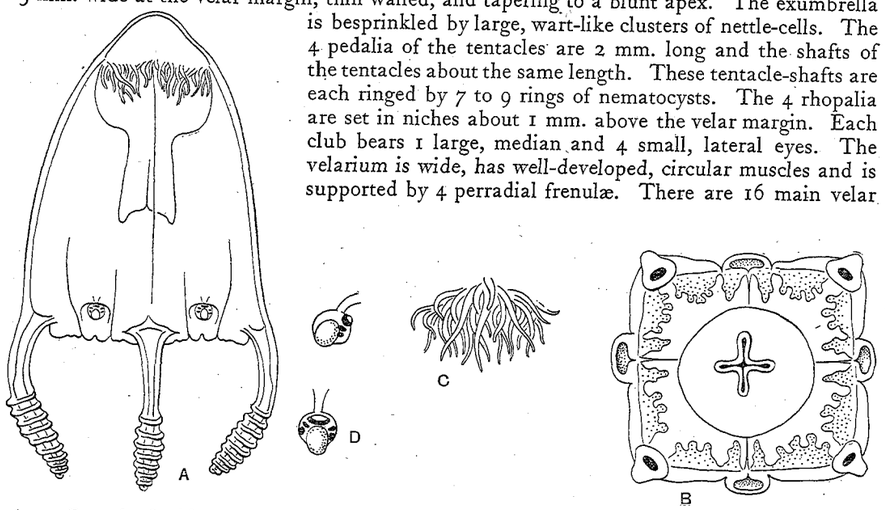


FIG. 328.—*Carybdea aurifera*, young medusa. From life, by the author, at Tortugas, Florida, July 11, 1909. A, side view. B, oral view showing velar canals. C, gastric cirri. D, side view, and inner side of sense-club.

canals; the 8 adjacent to the frenulæ are narrow and simple, but the 8 adjacent to the tentacles are wide and each gives off 3 or 4 finger-like processes. The manubrium is wide, 4-sided and nearly half as long as the height of the bell, with 4 simple lips. There are about 100 simple, tapering, unbranched gastric cirri. The most characteristic feature of this species is its uniform rich rosin or golden-brown color. It is a rare form and has been taken only twice in ten years in surface tows, in July, at Tortugas, Florida.

Carybdea alata Reynaud.

Carybdea alata, REYNAUD, 1830, Lesson's Centurie Zoologique, p. 95, planche 33, fig. 1.—VANHÖFFEN, 1908, Deutsche Südpolar Expedition, 1901–03, Bd. 10, Zool. 2, p. 34, fign. 3, 4.

See synoptic table of species of *Carybdea*.

Bell 55 mm. high, pyramidal, with a rounded apex and rounded angles. Bell 42 mm. wide at margin and 17 mm. wide at base of rounded apex. The 4 pedalia are each 27 mm. long and 12 mm. wide at widest part. The rhopalia are 13 mm. above bell-margin. When the bell is 55 mm. high there are 6 wide dichotomously forked velar canals in each quadrant between successive pairs of tentacles. In medusæ having a bell 60 mm. high, the forking of these canals becomes more complex and quite irregular, no two quadrants being alike. Thus

it is probable that *C. pyramis* from the West Indies, *C. obeliscus* from the Cape Verde Islands, *C. philippina* from the Philippine Islands, and *C. grandis* from the Paumotos Islands are only varieties or developmental phases of *C. alata*, the oldest species.

Carybdea alata var. pyramis Haeckel.

Charybdea pyramis, HAECKEL, 1880, Syst. der Medusen, p. 440, taf. 25, fign. 5–8.
(?) *Charybdea obeliscus*, HAECKEL, *Ibid.*, p. 441.
(?) *Carybdea alata*, REYNAUD, 1830, Lesson's Centurie Zoologique, p. 95, planche 33, fig. 1.

Bell about 30 mm. high and 20 mm. broad. A 4-sided truncated pyramid, the upper part being about one-third and the lower two-thirds as wide as the bell-height. A deep interradial furrow bordered by a pair of prominent ridges extends down the 4 sides of the exumbrella. The very long, narrow pedalia are lancet-shaped and about as long as the bell-height. The 4 perradial sense-clubs have each 6 eyes and are set in deep niches on the sides of the bell. Bell-margin displays 8 shallow lappets, the clefts being occupied by the 4 frenulæ and the 4 pedalia. The 4 frenulæ which support the wide velarium are 3-cornered and thick. 24 simple, 3-cornered velar canals, 6 in each quadrant. The stomach is not quite as wide as the bell-radius, and is shallow and quadratic. Neck large, 4-sided, pyramidal, and separated from the stomach by a deep stricture. 4 large, 3-cornered lips with folded edges. Gonads 8 wide leaves with irregular, crenulated, free margins. This form is found in the tropical regions of the Atlantic.

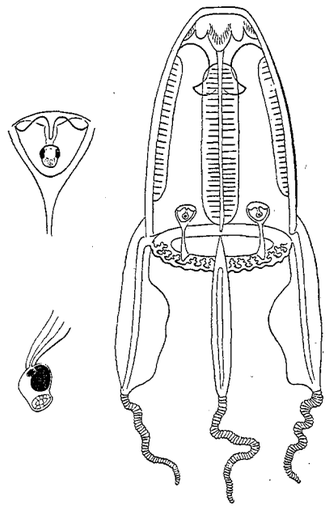


FIG. 329.—*Carybdea alata*, var. *grandis*. Young medusa, after Agassiz and Mayer, in Mem. Mus. Comp. Zool. at Harvard College.

Carybdea alata var. grandis Agassiz and Mayer

Charybdea grandis, AGASSIZ, A. and MAYER, 1902, Mem. Museum Comp. Zool. at Harvard College, vol. 26, p. 153, plate 6, figs. 26–31.—BIGELOW, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 17.
(?) *Charybdea grandis*, BROWNE, 1905, Report Pearl Oyster Fisheries, Gulf of Manaar, Suppl. Report No. 27, Roy. Soc. London, p. 157.
(?) *Bursarius cytherea*, LESSON, 1829, Voyage de la *Coquille* Zoophytes, p. 108, planche 14, fig. 1.
(?) *Tamoya bursaria*, MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 4.

This medusa may be identical with Lesson's *Bursarius cytherea* but the latter is so vaguely described and figured that I feel obliged to omit it from serious consideration.

Adult medusa.—Bell high, pyramidal, with blunt apex. 230 mm. high, and 140 mm. wide. Gelatinous substance quite thick and of remarkably tough consistency. There are 4 interradial, wing-like pedalia, the broad sides of which extend outward in a radial direction. These pedalia are each about 40 mm. long, and 25 mm. wide. A wide canal extends through the substance of each of them into the flexible portion of the tentacle, which arises from distal end of pedalium. The flexible part of the tentacle is about 140 mm. long and its surface is ringed with transverse rows of nematocyst-cells. Each of the 4 perradial sense-organs arises from a deep niche about 27 mm. above level of velarium.

The sense-organ is knob-shaped, mounted upon a short stem, and contains from 1 to 3 ectodermal ocelli and an entodermal concretion. In old medusæ there is usually a single, median ocellus in each sense-organ, but a young specimen 30 mm. in height had a large median and 2 small lateral ocelli. These ocelli are all directed as if to perceive objects within the bell-cavity. Velarium well developed and suspended by 4 mesenteries or frenulæ in the radii of the sense-organs. 24 short, tree-like, non-anastomosing velar canals extend centripetally inward into the substance of the velarium. Manubrium short, 4 slightly recurved lips. There are 4 interradial crescentic areas of numerous short, gastric cirri, the horns of each crescent pointing centripetally. 4 wide perradial pouches, extending outwardly from the stomach, are separated one from another by 4 narrow interradial partitions, but are placed in communication one with another by means of lateral canals leading into the lumen of the

pedalia. The gonads consist of 8 leaf-like folds attached to the sides of the interradial septa and hanging free in the radial pockets.

Gelatinous substance of bell is hyaline; entoderm translucent and milky-white; gastric cirri and flexible parts of tentacles pink or yellow-pink; sensory knobs of rhopalia dull ocher in color; ocelli deep brown, almost black.

This species is by far the largest *Carybdea* known.

Found at Fakarava and at Anaa Islands, Paumotos Islands, South Pacific by the *Albatross* in October, 1899. A large swarm upon the surface at Anaa Island.

This medusa may be identical with the vaguely described *Bursarius cythereæ* Lesson, from New Guinea, or with *Tamoya bursaria* briefly mentioned by Maas, from the Malay Archipelago. Bigelow, 1909, believes that *C. moseri* is only the young of this medusa.

Carybdea alata var. moseri Mayer.

(?) ————, Semper, 1860, Zeit. für wissen. Zool., Bd. 13, p. 561, taf. 39, fig. 9.
(?) *Charybdea philippina*, Haeckel, 1880, Syst. der Medusen, p. 440.
Charybdea moseri, Mayer, 1906, Bull. U. S. Fish Commission for 1903, vol. 23, part 3, p. 1135, plate 1, figs. 2–2c.

This common Hawaiian Island medusa may be only a small variety, or a young stage, of *Carybdea grandis*. (See table of synopsis of the species of *Carybdea*.) It is probably identical with a medusa briefly mentioned and inadequately figured by Semper, from the Philippine Islands.

Bell 80 mm. high, 47 mm. wide, dome-shaped, with flat top and thin, uniform walls. Each sense-club has 2 large median and 2 small lateral eyes. The sensory niches are long, transverse, narrow, and 14 mm. above the velar margin. Pedalia spatula-shaped, flat, expanded, 25 mm. long, 17 mm. wide, 24 simple, unbranched, velar canals. Tentacles ringed, tapering throughout their length, hollow, and about 1.5 times as long as bell-height. Gonads not quite as long as the septa on which they are developed. Stomach small, flat, 4 simple lips, gastric cirri simple and unbranched. Honolulu, Hawaiian Islands.

Carybdea murrayana Haeckel.

Charybdea murrayana, Haeckel, 1880, Syst. der Medusen, p. 442; 1881, Report Deep-sea Medusæ *Challenger* Expedition, Zool., vol. 4, p. 93, plate 26, figs. 1–10.

Bell 50 mm. wide, 60 mm. high, quadratic below, with flatly dome-like top. Pedalia narrow, tapering, flattened laterally, one-third as long as bell-height. Each sense-club has 2 large median and 4 small lateral eyes, as in *C. marsupialis*. Velarium wide, with 48 profusely branching, non-anastomosing canals. The 4 clusters of gastric cirri in the interradial corners of stomach are profusely branched, as in *C. marsupialis*.

Off coast of Sierra Leone, west coast of Africa. Depth of 200 fathoms.

Distinguished from *C. marsupialis* by its large number of velar canals.

Genus TAMOYA F. Müller, 1859.

Tamoya, Müller, F., 1859, Abhandl. Naturf. Ges. Halle, Bd. 5, p. 1.—Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 174.—Haeckel, 1880, Syst. der Medusen, p. 442.

The type species is *T. haplonema* F. Müller of the Atlantic coasts of North and South America, south of Cape Cod.

GENERIC CHARACTERS.

Charybdeidæ with 4 simple, interradial tentacles provided with pedalia. Stomach wide and deep; its 4 perradial sides flattened so as to present the superficial appearance of mesenteries binding the 4-sided œsophagus to the subumbrella. There are 4 vertical, interradial, thread-like or brush-like bands of gastric cirri in the middle of interradial sides of stomach.

The so-called mesenteries of Haeckel are merely the flattened, perradial sides of the cruciform stomach.

Haeckel's *Tamoya bursaria* and *T. gargantua* are too imperfectly known to be retained in scientific literature.

This genus is very closely related to, if not identical with, *Carybdea*, being distinguished only by its large stomach with its perradial mesenteries and its vertical clusters of gastric cirri. It may eventually prove necessary to unite this genus with *Carybdea*, for the differences between them are merely of an intergrading character.

Tamoya haplonema F. Müller.

Plate 57, figs. 2 to 2‴.

Tamoya haplonema, Müller, 1859, Abhandl. Naturf. Ges. Halle, Bd. 5, p. 1, taf. 1, 2.—Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 174.—Haeckel, 1880, Syst. der Medusen, p. 443.—Brooks, 1882, Studies Johns Hopkins Univ. Biol. Lab., vol. 2, p. 138.—von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 245.—Mayer, 1904, Memoirs Nat. Sci. Museum Brooklyn Inst. Arts and Sci., vol. 1, p. 28, plate 7, figs. 60–64.
Tamoya prismatica, Haeckel, *Ibid.*, p. 443.
Carybdea (Tamoya) haplonema, Fewkes, 1889, Report U. S. Commis. Fish and Fisheries for 1886, p. 526.

Bell 90 mm. high, 55 mm. wide, with vertical sides, and relatively flat top. Exumbrella surface thickly covered with white, wart-like clusters of nematocysts. 4 pedalia, 30 mm. long, flat, spatula-shaped, and sharp-edged. Tentacles 90 mm. long, hollow, very flexible and bearing regularly spaced rings of nematocysts that are capable of inflicting a severe sting to the hand. The sensory-clubs have 2 large median and 4 small lateral eyes, all being upon the inner side of the bulb. The large eyes are provided with prominent convex lenses and are ectodermal. There is a large terminal mass of concretions of entodermal origin.

The velarium is well developed and there are 10 dendritic velar canals in each quadrant, which terminate in numerous, non-anastomosing branches. The nerve-ring running from the base of each pedalium to the sensory-clubs is distinctly visible as a white-colored cord. The stomach extends about a third of the distance from inner apex to level of velarium, and there are 4 slightly recurved lips. Gastric cirri short and numerous.

The 8 genital organs are curtain-like sheets with frilled edges, which project from the 4 interradial septa into the perradial gastrovascular pouches of bell on either side. In old specimens the gonads are so large that their free edges overlap beyond the central line of each perradial stomach-pouch.

Gelatinous substance of bell transparent. The long, flexible tentacles are milky-yellow, often with a faint purple hue. There are large, white, wart-like clusters of nematocysts over the pedalia and velarium. The genital organs are milky-yellow, the eyes dark brown.

This medusa is exceedingly active, the gelatinous substance of its bell is tough and rigid.

Tamoya haplonema is widely distributed, having been found on the coast of Brazil, in the West Indies, at Beaufort in North Carolina, and in Great Peconic Bay, and Branford Harbor, Long Island Sound, New York, in the autumn. Our figures were obtained from a specimen captured at the last-named place early in September, 1902. None was found upon the surface in Great Peconic Bay, but all were brought up in dredges from the bottom at depths of a fathom or more.

Haeckel's *Tamoya prismatica* from the West Indies is apparently identical with *T. haplonema*. It is described as follows:

Bell 80 mm. high, 40 mm. broad, pyramidal, and 4-sided. The pedalia are longer and narrower than in *T. haplonema*. They are wedge-shaped, and 3 times as long as broad, and about half as long as bell-height. In their upper parts they are 3-sided, but below they are 2-sided with small meridional wings. Velarium very wide, with numerous, narrow, branching canals. Stomach large, occupying upper third of bell-cavity. Throat-tube about as large as stomach, 4 prominent lips. Color (?) Marginal sense-organs (?)

This form is found in the West Indies. It is probably only a variety of *T. haplonema*.

Genus TRIPEDALIA Conant, 1897.

Tripedalia, Conant, 1897, Johns Hopkins Univ. Circulars, No. 132, p. 9; 1898, Mem. Johns Hopkins Univ. Biol. Lab., vol. 4, No. 1, p. 5.

The type species is *T. cystophora*, described by Conant from Kingston Harbor, Jamaica.

GENERIC CHARACTERS.

Carybdeidæ with 4 interradial groups of tentacular pedalia, each tentacle being mounted upon a separate, unbranched pedalium which arises from the bell-margin. Velarium with canals and with 4 perradial frenulæ. No hernia-like sacs project into the bell-cavity from the main stomach-pouches of umbrella.

This genus is very closely related to *Chiropsalmus*, but the pedalia themselves do not branch, but each pedalium of each cluster arises *separately* from the interradial corner of the

bell-margin. In *Chiropsalmus*, on the other hand, each of the 4 pedalia gives rise to side branches which bear tentacles. Moreover, in *Tripedalia* there are no subumbrella, hernia-like, gastric diverticula as in *Chiropsalmus*.

Tripedalia cystophora Conant.

Tripedalia cystophora, CONANT, 1897, Johns Hopkins Univ. Circulars, No. 132, p. 9, fig. 9; 1898, Mem. Johns Hopkins Univ. Biol. Lab., vol. 4, No. 1, pp. 5, 22; figs. 17–30, plates 1, 2, 5, 7, figs. 44, 45, 53–56, 68, 71.

Bell cubical, with edges slightly rounded; 12 mm. high, and of about 15 mm. wide. There are 4 interradial groups of pedalia, each group consisting of 3 distinct, separate pedalia, each one of which arises from the bell-margin and gives rise to a single tentacle. The pedalia are flattened and resemble a slender knife-blade, and are about half as long as the bell-height. The 12 tentacles are each about 2.5 times as long as the pedalia. 4 sense-clubs are situated in niches at about one-fifth or one-fourth the height of bell above margin. Each sense-club has 2 large, median and 4 small, lateral eyes and a terminal lithocyst. The median eyes have doubly convex lenses. Velarium about one-sixth as broad as bell-diameter. There are 24 simple, unforked velar canals, 6 in each quadrant. These velar canals are triangular in outline, and the 8 adjacent to the 4 frenulæ are only half as wide as the others. Stomach wide and shallow, but the throat-tube is long and extends downward in some cases to bell-margin; cruciform in cross-section, with 4 well-developed, oral lobes in the radii of the sense-organs. There are 15 to 21 organs, resembling lithocysts, in the gelatinous walls of the manubrium; each consists of a round or oval sac lined with ciliated cells which keep in motion and bear up an irregular, coarsely granulated concretion. These organs are scattered irregularly through the gelatinous substance and are probably of entodermal origin. The small, tapering, gastric cirri are brush-shaped and spring from 4 short stalks in the interradial corners of the stomach. There are 4 wide, perradially situated, gastrovascular pouches in the umbrella, which are separated by 4 interradial septa; but these septa are incomplete in the regions of the pedalia, and thus the 4 stomach-pouches are placed in communication one with another, as in other Charybdeidæ. The gonads are 8 leaf-like sheets attached to the sides of the 4 interradial septa and projecting out into the 4 perradial stomach-pouches. The medusa is light yellowish-brown, the gonads being of the same color.

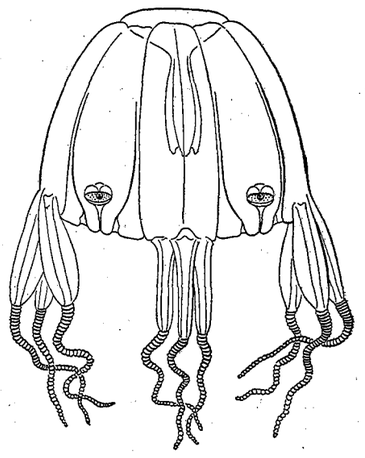


FIG. 330.—*Tripedalia cystophora.*

Figure 330 shows a mature female, 4 times natural size, drawn from nature, by the author. In order to illustrate their shape, the lips are shown twisted 45° from their natural position.

This species is found in Kingston Harbor, Jamaica, in great abundance during the summer among the mangrove roots of the islands in a shallow, muddy lagoon on the western side of the harbor, north of Port Henderson. It disappears in winter.

The dimensions of the mature specimen here figured are as follows: Bell 12 high, 15 mm. wide. Pedalia 5 mm. long, 2.1 mm. wide. Rhopalia 2.25 mm. above velarium margin. Stomach 5.5 mm. wide, 7 mm. long. The gonads were mature and the gastrovascular space filled with swimming planulæ. This medusa was captured on May 24, 1909.

Conant succeeded in obtaining females having embryos within their gastrovascular pouches. The embryos were thrown out into the water as free-swimming planulæ, which settled down on the bottom and sides of the aquarium in a day or two and quickly developed into small Scyphostomæ with mouth and typically with 4 tentacles and 4 tæniolæ, although 3 and 5 tentacled specimens were not uncommon. In this condition they lived for 3 weeks without essential change. I find that many, but not all of the planulæ, are besprinkled with dark brown pigment-spots which are scattered over the ectoderm of the narrow posterior end of the larva.

Genus CHIROPSALMUS L. Agassiz, 1862.

Chiropsalmus, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 174.—HAECKEL, 1880, Syst. der Medusen, p. 446.—VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 247.

GENERIC CHARACTERS.

With 4 interradial, branched pedalia which give rise to a number of tentacles. 4 wide perradially situated stomach-pockets in the subumbrella, and each of these gives rise to finger-shaped, unbranched, hernia-like pouches which project into the bell-cavity. Wide, marginal pouches and numerous canals in the velarium. 8 leaf-shaped gonads.

The type species of this genus is *Chiropsalmus quadrumanus*, described as *Tamoya quadrumanus* by F. Müller, 1859. This species is found in the warmer waters along the Atlantic coasts of North and South America south of Cape Hatteras.

Chiropsalmus quadrumanus L. Agassiz.

Plate 57, fig. 3.

Tamoya quadrumanus, MÜLLER, F., 1859, Abhandl. Naturf. Gesell, Halle, Bd. 5, pp. 1–11, taf. 2, 3, figs. 18–32.
Chiropsalmus quadrumanus, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 174.—HAECKEL, 1880, Syst. der Medusen, p. 447.—VON LENDENFELD, 1884, Proc. Linn. Soc. New South Wales, vol. 9, p. 248.—CONANT, 1898, Mem. Johns Hopkins Univ. Biol. Lab., vol. 4, No. 1, p. 4

Bell dome-shaped, about 140 mm. wide and 100 mm. high. 4 large, hand-shaped pedalia, the 7 to 9 finger-like branches of which give rise each to a single, long, slender tentacle. 7 to 9 tentacles thus arise from each pedalium. These tentacles are hollow and flexible, and are covered with numerous, closely set rings of nematocysts. A large axial-canal extends through the pedalium and gives off branches, one to each tentacle. The 4 sense-organs are situated within 4 covered niches upon sides of bell at about one-sixth the distance from margin to apex. There are 6 ectodermal eyes upon the sense-club, 2 large median and 4 small lateral. Velarium very wide with 16 large branched pouches which extend into it from the 4 main, gastrovascular spaces of the bell. The 16 velar pouches give rise in turn to numerous small, branching canals which ramify through the velarium. Stomach wide and globular, the mouth surrounded by 4 large, triangular lips. 4 wide, perradial pouches extend from stomach into wall of bell; each of these pouches gives rise to 2 finger-shaped, hollow, hernia-like sacs which project from the subumbrella side into the cavity of the bell; these 8 sacs are situated very near base of stomach. There are 4 interradial, crooked, crescent-shaped rows of gastric cirri on inner walls of stomach.

This species was found by Müller at Desterro, Santa Catharina, Brazil, and later it was obtained by H. V. Wilson at Beaufort, North Carolina, where it is quite abundant on the sea-bottom, about a mile off shore, though sometimes found within the harbor itself.

Chiropsalmus buitendijki Horst.

Chiropsalmus buitendijki, HORST, 1907, Notes from the Leyden Museum, vol. 29, No. 2, p. 101, plate 2, figs. 1–6.

This species from the harbor of Batavia, Java, is distinguished by its 8 long, simple, finger-shaped, subumbrella pocket-arms nearly as long as the depth of the bell-cavity, so that they almost touch the velarium. The pedalia also have 5 or 6 lateral branches arranged, judging from Horst's figure, in a linear series on the outer side of the main shaft, the largest branch being nearest the bell. In other species of *Chiropsalmus* the side branches of the pedalia are irregularly arranged.

In other respects the Javanese medusa resembles the other species of *Chiropsalmus*. Bell cubical, 65 to 70 mm. high and wide, with a slightly arched apex. Main shafts of pedalia sickle-shaped, about half as long as bell-height, and laterally compressed. The 5 or more lateral branches all arise from the abaxial side of the pedalium and form a decreasing series, the smallest being outermost. The rhopalia are in niches about one-fifth the distance between velarium and bell-apex. Each club has 2 large median and 4 small lateral eyes. The velarium is wide, has 4 frenulæ, and 16 dendritically branched velar canals. Bell transparent, flexible parts of tentacles of a rosy hue. In its simple finger-shaped processes of the subumbrella floor of the bell this species resembles the American *Chiropsalmus quadrumanus* to which it is closely related.

Chiropsalmus quadrigatus Haeckel.

Chiropsalmus quadrigatus, HAECKEL, 1880, Syst. der Medusen, p. 447.

The following description is based upon a study of six specimens obtained in a seine by the U. S. Bureau of Fisheries steamer *Albatross* among the Philippine Islands, from January to June, 1908.

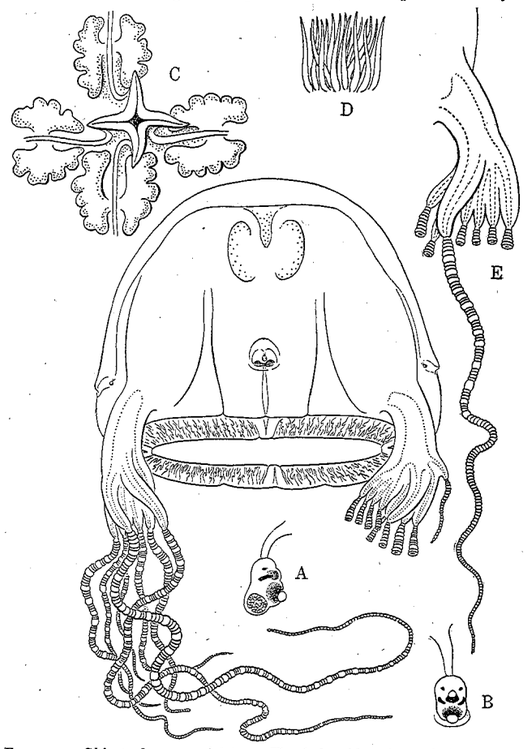


FIG. 331.—*Chiropsalmus quadrigatus* Haeckel, side view of half-grown medusa, half natural size. Drawn by the author, from a preserved specimen collected by the *Albatross*.
A, enlarged side view of sense-club. B, inner side of sense-club. C, oral view of stomach showing the 4 lips and 8 gastric sacs. D, enlarged view of gastric cirri. E, side view of a pedalium with all but one of the tentacles cut across.

Bell dome-like and 4-sided, with an evenly rounded, aboral apex. 70 to 100 mm. high, 80 to 100 mm. wide at level of velarium. There are 4 hand-shaped, interradial pedalia, laterally flattened, which arise from the sides of the bell at a short distance above the velar margin. These pedalia are about 30 mm. long and 11 mm. wide, and each bears 5 to 9 finger-shaped terminal projections which give rise to an equal number of long, flexible, hollow tentacles. These tentacles are thickly but somewhat irregularly ringed with nematocysts. They vary in length, but the longest when contracted are about 150 mm. long. The pedalia of a medusa 100 mm. wide were each 47 mm. long and 21 mm. wide.

The 4 perradial sense-clubs are set within covered niches in the sides of the bell about 14 mm. above the velar margin. Each sense-club contains an entodermal, terminal, abaxial mass of concretions and on its inner side are 6 eye-spots. The 2 median eyes have each a prominent convex lens, but the 4 smaller, lateral eyes are merely pigmented ocelli. The eyes are arranged so as to view objects within the bell-cavity.

The velarium is 13 mm. wide and supported by 4 bracket-like perradial frenulæ. There are about 50 dendritic, non-anastomosing velar canals, 12 to 15 in each quadrant. The velarium is diaphragm-like and does not hang downward beyond the velar margin but stretches flatly across tending to close the opening of the bell-cavity.

The wide central stomach is only about 20 mm. long and there are 4 lanceolate lips with entire, simple margins. The 4 perradial sides of the cruciform stomach are much flattened and form the so-called "mesenteries" of Haeckel, bridging across, bracket-like, between the subumbrella and the 4-sided œsophagus. 4 pairs of gastric saccules arise from the perradial sides of the stomach and project downward into the bell-cavity (c. fig. 331). Each saccule is laterally flattened, cock's-comb-shaped, with an irregularly notched margin, and is about 20 mm. long and 11 mm. wide. A solid, gelatinous projection extends downward so as to fill the greater part of the cavity of each gastric saccule.

There are 4 long, interradial bands of gastric cirri marking the borders of the central stomach. These cirri are fusiform, simple, sharp-pointed, and unbranched and arise in 4 or 5 rows. Each cirrus is about 3 mm. long.

The peripheral, gastrovascular system consists in the usual 4 wide, perradial stomach-pouches, separated by 4 narrow, interradial septa, which are interrupted at the point of origin of each pedalium where a canal extends downward from the adjacent stomach-pouches and branches in finger-like ramuli leading into the tentacles of the pedalium. The 50 or more velar canals have already been described. The 8 leaf-like gonads are well developed and resemble those of *Carybdea* but are not yet mature. They arise on both sides of each interradial septum and project into the wide, perradial stomach-pouches.

The bell is milky-yellow in formation and there are traces of a dull purple-pink coloration in the tentacles. The ocelli are dark brown.

I am informed that this medusa is abundant in Subig Bay, Luzon, Philippine Islands, where it is captured in seines. The natives are said to preserve it in vinegar, and when so prepared it is sold in the markets for food.

In the young medusa having a bell 18 mm. high and 20 mm. wide, there are only 4 or 5 tentacles on each pedalium and the subumbrella saccules have not begun to develop, nor is there any visible trace of the gonads. The abaxial finger of each pedalium is longest, and the 3 others are evidently of more recent development, are very short, and lie nearer the velar margin. The longest (abaxial) tentacles are about 7 mm. long when contracted, and the axially placed younger tentacles are shorter. The perradial brackets of the velarium are beginning to develop and there are about 7 irregularly but simply branched velar canals in each quadrant.

Haeckel, 1880, describes a somewhat larger young specimen from Rangoon, Indian Ocean. The medusa is common among the Philippine Islands.

I am told that this medusa grows to be about 150 mm. in diameter, although the largest specimen in the *Albatross* collection is only 100 mm. wide, but appears to be mature. It is found swimming in shallow water near the shore. It is very closely allied to the Atlantic *C. quadrumanus*, but may be distinguished by its laterally flattened cock's-comb-shaped gastric saccules, those of *C. quadrumanus* being finger-shaped.

The following is a record of specimens of *Chiropsalmus quadrigatus* obtained by the *Albatross* in 1908 in the Philippine Islands:

Locality.	Date.	Height of bell in mm.	Width of bell in mm.	Number of tentacles upon each pedalium.	Remarks.
Cataingan Bay, Masbate, near shore.	April 18	49	55	6, 6, 7, 7	Immature. The 8 gastric saccules only beginning to appear.
Do.	April 18	51	51	8, 6, 7, 5	Do.
Do.	April 18	40	20	6, 5, 6, 6	Do.
Subig Bay, Luzon. Caught in a seine.	January 7	18	20	4, 4, 4, 4	No gastric saccules and no gonads.
Do. See fig. 331	January 7	70	80	9, 5, 8, 8	With well-developed but immature gonads. With large cock's-comb-shaped gastric saccules.
Mausalay, Mindanao.	June 4	97	100	8, 8, 8, 8	Apparently mature.

Chiropsalmus zygonema Haeckel.

Chiropsalmus zygonema, HAECKEL, 1880, Syst. der Medusen, p. 641.

Bell 4-sided, pyramidal with a truncated apex, 60 mm. high and 40 mm. wide, including height of velarium. The 4 pedalia are leaf-shaped, each with only 2 short, asymmetrical, gelatinous, finger-shaped branches which give rise to long, lash-like tentacles. In all, therefore, there are but 8 tentacles. Stomach round and sac-like, œsophagus small with 4 lappets, though only half as long as stomach. 4 interradial bow-like areas of gastric cirri in stomach wall. The stomach gives rise to 4 perradially situated pouches, on both sides of the entrance to each of these pouches near the stomach are 2 very small, oval pouch-arms—8 in all.

This species is found off the Argentine coast, South America. It differs from all other species of *Chiropsalmus* in its simple, 2-pronged pedalia, and in the very *small* finger-like pouches of the stomach. The velarium and gonads are similar to those of *C. quadrumanus*.

Genus CHIRODROPUS Haeckel, 1880.

Chirodropus, HAECKEL, 1880, Syst. der Medusen, p. 447.

The type species is *Chirodropus gorilla* Haeckel, of the Atlantic coast of equatorial Africa.

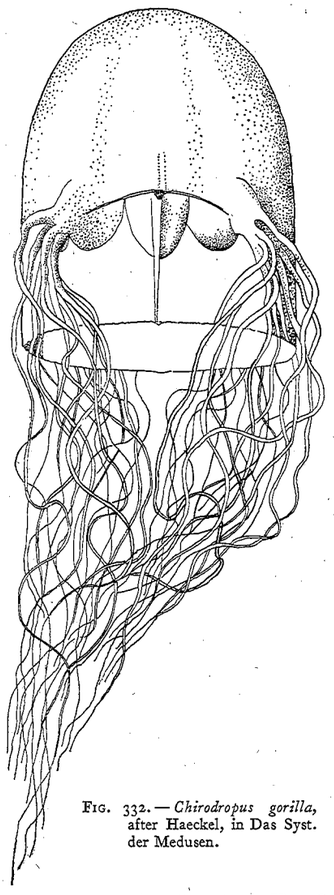


FIG. 332.—*Chirodropus gorilla*, after Haeckel, in Das Syst. der Medusen.

GENERIC CHARACTERS.

Carybdeidæ with 8 branched, or feathered, sac-like projections which extend from the 4 perradial stomach-pouches into the bell-cavity. The free margins of the gonads show grape-like swellings. With 4 hand-like pedalia.

This genus resembles *Chiropsalmus*, but is distinguished by its branched hernia-like pouches in the bell-cavity, whereas in *Chiropsalmus* these projections are unbranched; moreover, in *Chiropsalmus*, the free margins of the gonads are simple and entire, whereas in *Chirodropus* they are broken up into grape-like clusters of swellings.

Chirodropus gorilla Haeckel.

Chirodropus gorilla, HAECKEL, 1880, Syst. der Medusen, p. 448, taf. 26, fign. 1–8.

Bell dome-shaped, evenly rounded above and including the velarium, which hangs downward, 150 mm. high and 120 wide. Sides rounded; the sculptured angles usually seen on surface of exumbrella in Carybdeidæ are very poorly developed.

The 4 interradial pedalia are hand-like, asymmetrical and hardly one-fourth as long as bell-height. Each pedalium gives rise to 9 long, narrow, tapering gelatinous finger-like processes, each bearing a long, flexible, tapering tentacle longer than bell-height. Thus there are 36 tentacles in all.

The 4 perradial sensory niches are deep and heart-shaped. They are set in the sides of the bell at a somewhat higher level than the pedalia and are about 60 mm. above velar margin. The sense-club is mounted upon a slender stalk. Number of eyes (?)

Below the marginal nerve-ring are 16 gelatinous lappets which form an integral part of the wide velarium which projects downward. The 16 lappets are cleft in the 4 interradii and in the 8 adradii, and are divided by the 4 perradial frenulæ. The 8 lappets flanking the 4 frenulæ are about 1.5 times as long as the 8 which flank the 4 interradial pedalia. These lappets contain diverticula of the perradial stomach-pouches and each lappet-pouch gives rise to about 6 dendritically branched velar canals, which only occasionally anastomose and which extend outward nearly to margin of velarium, running mainly parallel one to another.

Each perradial stomach-pouch gives rise to a pair of elongate, tapering, hollow processes, which project downward into the bell-cavity and bear numerous finger-like side processes, all of which arise from inner (axial) side of main process. These processes are thus much more complex than the simple finger-shaped ones of *Chiropsalmus*. Central stomach large and urn-shaped, 4-sided, bound to subumbrella by 4 perradial mesenteries. There are 8 dendritic, digestive glands, a pair on either side of each perradial corner of stomach-cavity.

The 4 pairs of gonads are attached to the subumbrella sides of the 4 interradial septa, as in other Carybdeidæ. Their free outer margins bear grape-like clusters of swellings. The only specimen studied by Haeckel was a male, found at Chenchozo Loango, Lower Guinea, about 5° S. lat. West coast of Africa. Described in detail by Haeckel who is the only naturalist who has seen the medusa.

Chirodropus palmatus Haeckel.

Chirodropus palmatus, HAECKEL, 1880, Syst. der Medusen, p. 448.

This is possibly only the young of a variety of *C. gorilla* being smaller, and only 70 mm. wide and 100 mm. high, including the suspended velarium. The 2 pouch-arms which project into the bell-cavity from each perradial stomach-pouch are fused together in their upper two-thirds, leaving only their lower thirds free. They bear numerous filaments, as in *C. gorilla*. Finally, each pedalium bears 21 fingers instead of 9, as in *C. gorilla*.

A single specimen is described by Haeckel from preserved material found near St. Helena off the west coast of Africa.

We can not be sure that this form is distinct from *C. gorilla* until we know the normal limits of variability of the latter species, and it seems probable that there is but a single species which is somewhat variable in the number of tentacles, etc.

Order STAUROMEDUSÆ.

Lucernaridæ (in part), JOHNSTON, 1847, British Zooph., p. 244, 2d ed.
Stauromedusæ, HAECKEL, 1880, Syst. der Medusen, p. 363.—GOETTE, 1887, Abhandl. zur Entwickelungsgesch. der Thiere, Heft 4, p. 64.—MAAS, 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 499; 1907, Ergeb. Fortschitte der Zoologie, Bd. 1, pp. 194, 198.
Lucernaridæ, GROSS, 1900, Jena. Zeit. für Naturw., Bd. 33, p. 611.—KASSIANOW, 1901, Zeit. für wissen. Zool., Bd. 69, p. 287.
Lucernaria, CLARK, 1863, Boston Journ. of Nat. Hist., vol. 7, p. 531.

Neglecting for the moment to consider the family Tesseranthinæ Haeckel, the Stauromedusæ constitute a unitary group of sessile Scyphomedusæ which are attached to objects by means of an adhesive pad at the extremity of the aboral stalk of the bell. The bell-margin usually exhibits 8 adradial lobes, the pointed ends of which terminate in clusters of hollow knobbed tentacles; although in *Capria* we find that these tentacles are not knobbed, and in the genus *Stenoscyphus* there are no marginal lobes, while in *Lipkea* there are no tentacles and the lobes are perradial and interradial, not adradial.

In the 8 perradial and interradial notches between the marginal lobes we may find a knobbed tentacle, which may be metamorphosed into an adhesive organ serving as a sort of anchor. In the genera *Lucernaria*, *Kishinouyea*, *Craterlophus*, *Capria*, and *Lipkea*, however, these anchors are not found. The central stomach gives rise typically to 4 perradial pouches which are partially separated one from another by 4 interradial septa, but these pouches communicate one with another at the margin, thus forming a peripheral ring-sinus. The arms, or marginal lobes, are hollow, as are also their knobbed tentacles. There are 4 interradial septa in the central cavity of the aboral stalk or peduncle; and these partitions may fuse in the center, thus inclosing 4 separate perradial cavities in the stalk as in *Haliclystus*. The gonads, which are developed in the entoderm of the subumbrella, are typically interradial and more or less horse-shoe-shaped with the free ends of the horse-shoe directed outward; but often the horse-shoe is cleft in the middle, giving 8 adradial, crescentic gonads. There is a marginal ring-muscle in the subumbrella which may be entire or divided into 8 separate perradial and interradial sectors. Centripetal to this ring-muscle system are the radial muscles. The stalk also has a system of 4 interradial, longitudinal muscles. As in scyphostoma larvæ the 4 interradial septa of Stauromedusæ are not simple, solid-walled partitions, but each contains a funnel-like pit, livid with ectoderm, which dips downward from the subumbrella thus hollowing each partition. These funnel-cavities contain longitudinal muscles which extend downward even to the aboral end of the stalk itself.

Clark, 1863, and after him Gross, 1900, have made careful studies of the internal anatomy of the sessile Stauromedusæ. They conclude that we may divide these forms into 2 families, the Eleutherocarpidæ with 4 simple, perradial stomach-pouches, and the Cleistocarpidæ in which the neighboring halves of the adjacent gonads unite at their distal ends in the radii of the corners of the mouth. Thus the gonads become united by a transverse, circumferential membrane, which divides each of the 4 perradial stomach-pouches into 2 spaces, an outer and an inner, the oral or inner one of which forms a *cul de sac* or confined space which contains the gonads and opens at the axial end into the gastric cavity. The genera *Halimocyathus*, *Craterlophus*, and *Depastrum* are examples of the Cleistocarpidæ, while *Stenoscyphus*, *Kishinouyea*,

Capria, *Lipkea*, *Lucernaria* and *Haliclystus* represent the more simply organized Eleutherocarpidæ. A clear understanding of these relations can best be obtained from a study of the figures by Gross, 1900 (Jena. Zeitsch. für Naturwissen., Bd. 33, p. 613, taf. 23, 24). Being internal characters, I have not made use of them in the classification of the Stauromedusæ.

As one would expect in sessile animals the Stauromedusæ show evidences of degeneration, loss of marginal lobes or of tentacles; and in none of them do we find the lithocyst-bearing

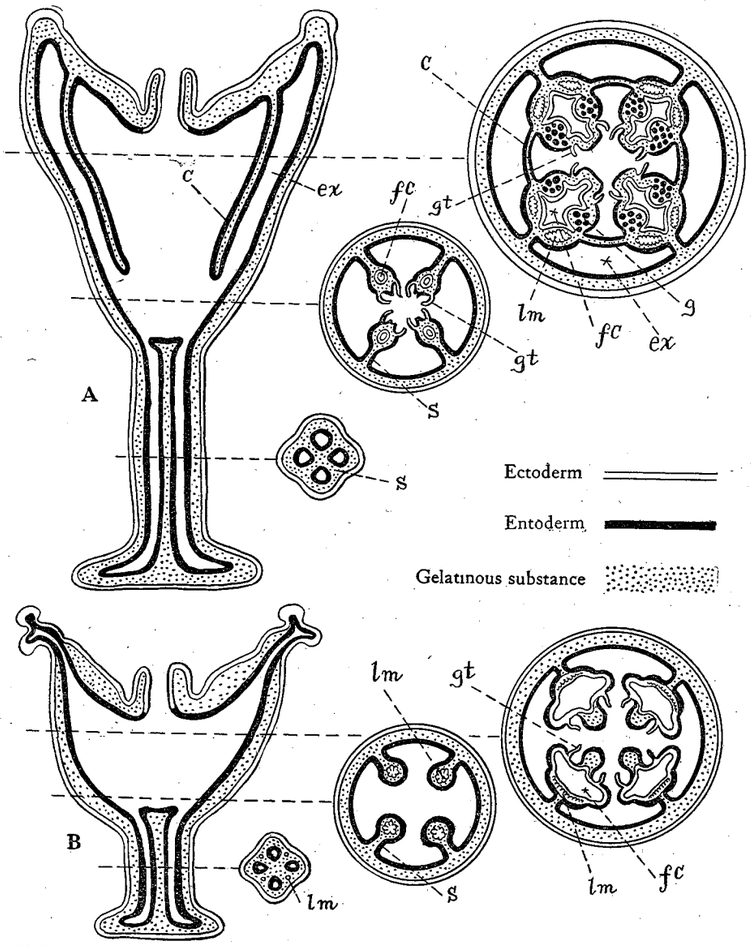


FIG. 332*a*.—Median longitudinal perradial sections and cross-sections of Stauromedusæ. Somewhat diagrammatic, after Gross.
A. The internal anatomy of the Cleistocarpidæ illustrated by *Craterlophus tethys*.
B. The internal anatomy of Eleutherocarpidæ illustrated by *Haliclystus*. The cross-partition, or claustrum (*C*), is found in the Cleistocarpidæ but is absent in the Eleutherocarpidæ.
In both figures: *C*, transverse partition spanning between gonads; *ex*, outer chamber; *fc*, funnel-pits containing longitudinal nucleus; *g*, gonads; *gt*, gastric cirri; *lm*, longitudinal muscles; *s*, interradial septa.

sense-organs seen in all other orders of Scyphomedusæ. Eyes and "otocysts" are absent in the Stauromedusæ, and pulsation is not exhibited by the sessile forms.

There is reason to believe that the Stauromedusæ are the most degenerate of all Scyphomedusæ and are to be regarded as sexually mature Scyphostomæ (see Kassianow, 1901; Goette, 1887). Their degeneracy is amply accounted for by their sessile mode of life; Hornell, 1883 (Natural Science, London, vol. 3, p. 204), and Hurst (*Ibid.*, p. 209) believe that they are

descended from some more highly organized forms of Scyphomedusæ. Their chief reasons for this belief lie in the facts that in the Lucernaridæ the marginal anchors (colletocystophores) are highly variable and may therefore be vestigial organs. Moreover, in *Lucernaria campanulata* the marginal anchors exist in the very young medusa but disappear as development proceeds and are not found in the adult. This evidence, although meager, supports the

Synopsis of the Genera of Stauromedusæ.

	Tesseranthinæ: Pelagic medusæ with solid, tapering, non-knobbed tentacles, and without marginal lobes.	Lucernarinæ: Attached medusæ, usually with hollow, knobbed tentacles, and typically with marginal lobes.			
	Tesseraria=Tessera+Tesserantha+Tesseraria Haeckel.	Depastrum=Depastrella+Depastrum Haeckel.	Stenoscyphus.	Lucernaria.	Kishinouyea.
Number and character of perradial and interradial tentacles.	8 solid, tapering, without terminal knobs.	Hollow, ending in nettling knob. 1 to 3 tentacles in each cluster.	An anchor in each interradius and perradius.	None.	None.
Character of adradial tentacles.	Similar to perradial tentacles.	Similar to perradial and interradial, but with more tentacles in each cluster.	A cluster of hollow, terminally-knobbed tentacles in each adradius.	8 clusters of hollow, terminally-knobbed tentacles.	As in Lucernaria.
Other tentacles.	Similar to perradial tentacles.	None.	None.	None.	None.
Cleistocarpidæ are indicated by C, Eleutherocarpidæ by E.		C	E.	E.	E.
Gonads.	4 interradial, horse-shoe-shaped.	As in Tesseraria.	Adradial.	8 adradial (4 cleft in interradii).	As in Lucernaria.
Stalk at aboral pole of bell, serving for attachment.	An aboral projection which does not serve for attachment Medusa pelagic.	An aboral stalk serving to attach the medusa.	A stalk with 4 perradial chambers.	Single-chambered.	With 4 perradial chambers.
Marginal lobes of bell.	None.	8 adradial sinuosities.	None.	8 adradial lobes.	8 adradial.

	Lucernarinæ: Attached medusæ, usually with hollow, knobbed tentacles, and typically with marginal lobes.				
	Haliclystus.	Halimocyathus.	Craterlophus Halimocyathus (?)	Capria.	Lipkea
Number and character of perradial tentacles.	8 anchors.	8 anchors.	None.	None.	None.
Character of adradial tentacles.	As in Lucernaria.	As in Lucernaria.	As in Lucernaria.	A row of basally webbed, finger-shaped, unknobbed tentacles.	None.
Other tentacles.	None.	None.	None.	None.	None.
Cleistocarpidæ are indicated by C, Eleutherocarpidæ by E.	E.	C.	C.	E.	E.
Gonads.	As in Lucernaria.	4 interradial.	8 adradial.	8 adradial.	4 interradial (?)
Stalk at aboral pole of bell serving for attachment.	With 4 perradial chambers.	With 4 perradial chambers.	With 4 perradial chambers.	Single-chambered.	Single-chambered.
Marginal lobes of the bell.	8 adradial.	8 adradial.	8 adradial.	8 adradial.	Eight; 4 perradial and 4 interradial.

also Thaumatoscyphus
b727

view that the Stauromedusæ are degenerate, and, indeed, degeneracy would very probably result from their sessile condition.

The Tesseranthinæ, known only through the works of Haeckel, who alone has observed them, appear to be pelagic and are said to differ from other Stauromedusæ in having solid, tapering, non-knobbed tentacles, and in lacking marginal lobes. Their relationship to the Stauromedusæ is uncertain. Only 4 specimens have ever been taken and these are described by Haeckel from preserved material. It will be well to suspend judgment in respect to their structure, relationship, and development until more specimens have been studied.

The sessile Stauromedusæ are creatures of cold seas. None is known from the tropics. They are littoral forms and attach themselves to *Fucus*, *Zostera*, and other seaweeds among the tidal eddies of the coast. They are generally rare and only locally abundant in any case.

Owing to their rarity many of the species of Stauromedusæ are imperfectly described, and it is probable that some of them should be reduced. Kassianow, 1901, has studied the nervous system of *Lucernaria*, *Haliclystus*, and *Craterlophus*, and the results of his studies are here reviewed in the discussion of the genus *Lucernaria*, wherein I have also reviewed the brief observations of Fol and of Kowalevsky, 1884, upon the early stages of the development of *Lucernaria*.

The sessile Stauromedusæ display no rhythmical pulsation in their bells, but no studies have been made to discover whether the larvæ at any stage possess this power. Hornell, 1893, and Browne, 1896, have studied the variations of *Haliclystus octoradiatus*. The results of their studies are referred to in the description of this species.

According to A. Meyer, 1865, the Lucernaridæ have great regenerative power. The bell may reproduce a new stalk and parts of the medusa may regenerate the whole (see genus *Haliclystus*). Kassianow, 1901 (Zeit. für wissen. Zool., Bd. 69, p. 371), reports upon somewhat similar experiments upon *Craterlophus*.

The relationship which may exist between the Stauromedusæ and the Carybdeidæ is discussed in the introduction to this volume.

Genera TESSERA, TESSERANTHA, and TESSERARIA Haeckel, 1880.

Tessera, Tesserantha, HAECKEL, 1880, Syst. der Medusen, pp. 373–375; 1881, Deep-Sea Medusæ *Challenger* Exped., vol. 4, p. 49.
Tesseraria, HAECKEL, 1880, Syst. der Medusen, p. 633.

Haeckel describes 4 specimens of these medusæ from preserved material, and is the only naturalist who has seen them. They are said to differ from other Stauromedusæ in their solid, non-knobbed tentacles, and in their being free-swimming, non-attached forms.

Haeckel states that these medusæ have a simple, uncleft, umbrella margin, no marginal anchors, but 8 to 16 simple, perradial, interradial, and adradial tentacles. The broad marginal ring-muscle of the subumbrella is entire, not divided into 8 isolated sectors. Centripetal to the ring-muscle there is a system of radial-muscles. The medusæ are pelagic and have no stalk of attachment, although a hollow apical projection is found at the aboral pole of the bell. The tentacles are solid and do not terminate in nematocyst-knobs.

The stomach gives rise to 4 wide, perradial, gastric pouches which are possibly divided one from another in the 4 interradii by 4 short, narrow septa. These septa extend centrifugally from the 4 gonads, but are so short that they do not reach the bell-margin, and thus there is a wide, marginal, gastral ring-sinus. There are 4 interradial, horse-shoe-shaped gonads with their free ends pointing outward. 4 simple lips and 4 interradial areas of gastric filaments in the stomach.

According to Haeckel these 3 genera are distinguished as follows:

Tessera, with 8 tentacles, 4 perradial and 4 interradial. Bell 4 to 8 mm. wide.
Tesserantha, with 16 tentacles, 4 perradial, and 4 interradial, and 8 adradial. Bell 6 mm. wide.
Tesseraria, with 32 tentacles. Bell 10 mm. wide.

In all respects these medusæ resemble one another so closely that I am lead to suspect that they may prove to be but stages in the growth of one and the same medusa. It will be observed that the larger medusæ have the greater number of tentacles.

The following is a brief diagnosis of the characters of these medusæ, according to Haeckel:

Tessera princeps Haeckel, 1880 (Syst. der Medusen, p. 347, taf. 21, fign. 1–6), is 5 mm. high and 4 mm. wide, with a pyriform bell and hollow apex. There are 4 perradial tentacles about as long as the bell height, and 4 shorter (undeveloped?) interradial tentacles. There

are only 4 simple, interradial, gastric cirri, one in each interradius of the central stomach above (centripetal to) the 4 horse-shoe-shaped gonads. A single specimen was found by the *Challenger* southeast of Kerguelen Island, Antarctic Ocean, on February 19, 1874.

Tessera typus Haeckel, 1880 (*Ibid.*, p. 638), bell 8 mm. wide, 12 mm. high, pyramidal, 4-sided, elongate. 8 tentacles, 4 perradial and 4 interradial, of equal lengths, each nearly twice as long as the bell-diameter. 6 to 8 gastric filaments in each interradius. 4 horse-shoe-shaped gonads in proximal half of subumbrella. A single specimen from the Indian Ocean, south of Madagascar.

Tesserantha connectens Haeckel, 1880 (Syst. der Medusen, p. 373; 1881, Deep-sea Medusæ *Challenger* Expedition, Zool., vol. 4, p. 50, plate 15, figs. 1 to 8) differs from "*Tessera princeps*" in being larger and in having 16 tentacles and numerous gastric cirri. The medusa is 9 mm. high and 6 mm. wide. The tentacles are perradial, interradial, and adradial, the largest being the first named, and the last quite short and apparently immature. There is an ectodermal pigment spot on the exumbrella side of the base of the 8 perradial and interradial tentacles. A ridge of nettle cells extends toward the apex of the bell from the base of each tentacle. These pigment spots and ridges are not seen in *Tessera princeps*. The numerous gastric cirri are arranged on both sides of the 4 interradial partial septa or tæniola of the central stomach. The 4 interradial pits of the subumbrella are deeper than in *Tessera*. Altogether all of the differences between *Tessera* and *Tesserantha* are such as one would expect to find in one and the same medusa in advancing stages of growth.

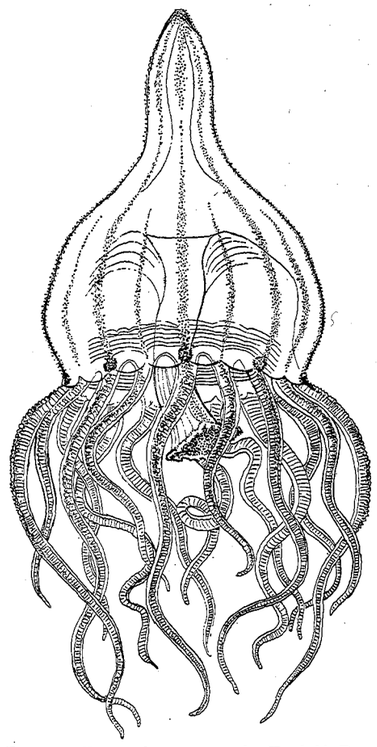


FIG. 333.—*Tesserantha connectens*, after Haeckel in Deep-sea Medusæ of *Challenger* Expedition.

Tesserantha connectens was found by the *Challenger* near the island of Juan Fernandez, South Pacific, at a depth of 2,160 fathoms. It is elaborately described by Haeckel, 1881.

Tesseraria scyphomeda Haeckel, 1880 (*Ibid.*, p. 638), has a goblet-shaped bell, 10 mm. wide, 15 mm. high. 32 tentacles equal each to each and not quite as long as the bell-diameter. 4 simple rows of gastric cirri. 4 horse-shoe-shaped gonads.

Found in Bass Straits between Australia and Tasmania. One specimen in Godeffroy Museum.

Genus DEPASTRUM Gosse, 1858.

Depastrum, GOSSE, 1858, Annals and Mag. Nat. Hist., vol. 1, ser. 3, p. 419.
Depastrum+Depastrella, HAECKEL, 1880, Syst. der Medusen, pp. 376, 378.
Depastrum, DIXON, G. Y. and A. F., 1893, Proc. Roy. Dublin Soc., vol. 8, p. 180.—BEAUMONT, 1894, Trans. Liverpool Biol. Soc., vol. 7, p. 254.—MAAS, 1906, Fauna Arctica, Bd. 4, p. 500.
Carduella, ALLMAN, 1860, Report British Association, p. 143.—Clark, 1863, Boston Journal Nat. Hist., vol. 7, p. 546.

The type species is *Depastrum cyathiforme* of the northern coasts of Europe, first described by M. Sars, 1846, as *Lucernaria cyathiforme*. Gosse, 1858, established for it the genus *Depastrum*.

GENERIC CHARACTERS.

Stauromedusæ with 16 clusters of tentacles, 4 perradial, 4 interradial, and 8 adradial, arranged in one or in several rows around the bell-margin. Tentacles are all similar each to each, and are hollow, and terminate each in a nematocyst-knob. There may be one or more tentacles in each perradius and interradius. No marginal anchors. With divided stomach-pouches as in the Cleistocarpidæ. An unbroken marginal, subumbrella ring-muscle. 4 small, interradial partial septa in the central stomach, leaving a wide, marginal ring-sinus. 4 interradial horse-shoe-shaped gonads with their convexities inward

and free ends directed centripetally. A 4-sided throat-tube. An aboral stalk serving for attachment. The adradial lobes are reduced to 8 barely discernible sinuosities.

Depastrella Haeckel, with 16 clusters of marginal tentacles arranged in a single row, is probably only the young of *Depastrum*. *Depastrella* appears to be intermediate between the Tesseranthinæ and the Lucernarinæ.

Depastrum cyathiforme Gosse.

Lucernaria cyathiforme, Sars, M., 1846, Fauna Littoral, Noweg., fasc. 1, p. 26, taf. 3, fign. 8–13.
Depastrum cyathiforme, Gosse, 1858, Annal. and Mag. Nat. Hist., vol. 1, p. 419; 1860, *Ibid.*, vol. 5, p. 481, figs. 1–3.
Lucernaria cyathiformis, Keferstein, 1862, Zeit. für wissen. Zool., Bd 12, p. 24.
Carduella cyathiformis, Allman, 1860, Trans. Microscop. Soc. London, vol. 8, p. 125, plate 5.—Clark, 1863, Boston Journal Nat. Hist., vol. 7, p. 546.
Calicinaria cyathiformis, Milne-Edwards, 1860, Hist. Nat. der Corall., tome 3, p. 459, Paris.
Depastrum cyathiforme, Haeckel, 1880, Syst. der Medusen, p. 378 (literature); *D. polare*, p. 639, and *Depastrella carduella*, p. 376.
Depastrum cyathiforme, Dixon, G. Y. and A. F., 1893, Proc. Roy. Dublin Soc., vol. 8, p. 180.—Beaumont, 1894, Trans. Liverpool Biol. Soc., vol. 7, p. 254.—Russell, 1904, Annals and Mag. Nat. Hist., ser. 7, vol. 13, p. 62, plate 5 (references to localities on the British coast).—Browne, 1905, Proc. Roy. Soc. Edinburgh, vol. 25, p. 774 (found in the Firth of Clyde at Little Cumbræ and near Keppel pier).—Maas, 1906, Fauna Arctica, Bd. 4, p. 500.

Medusa urn-shaped, about 6 to 10 mm. wide and of somewhat greater height. Stalk about as long as bell-height, flexible, contractile, and with an irregularly expanded adhesive foot. Bell-margin sinuous, subumbrella deeply concave. 36 to 100 tentacles arranged in 4 perradial and 4 interradial clusters of 1 to 3 tentacles each, and 8 adradial clusters, each consisting of about 9 tentacles. The tentacles bear each a terminal knob in adult specimens and are hollow and not retractile. Mouth 4-sided, cruciform, with 4 perradial buttresses, between which there are 4 interradial funnel-like pits in the floor of the subumbrella extending downward into the tissue of the 4 septa. The 4 gonads form each an interradial horse-shoe, the outer points of which do not extend to the bell-margin.

According to Clark, 1863, the perradial stomach-pouches are each bridged across by a cross-partition or claustrum extending over from the sides of adjacent gonads. Thus the gonads are confined within the 4 axial chambers adjacent to the mouth and are separated by cross-partitions from the outer parts of the perradial pouches.

Color is dirty chocolate-brown, the stalk paler.

This form grows permanently attached to rocks between tide-limits and does not reattach itself if torn from its anchorage.

Northern coasts of Europe. It is generally rare, and is found only locally in such places as the Firth of Clyde, Orkney Islands, near Bergen, Norway, Weymouth, England, etc.

Beaumont, 1894, Maas, 1906, and other recent observers have come to the conclusion that *Depastrella carduella* Haeckel, 1880 (p. 376, taf. 21, fign. 5 to 12), is only the young or an undeveloped stage of the *Depastrum cyathiforme*. Also *Depastrella allmani*, from Handa Island and the Orkneys, and *D. polare* from Spitzbergen, described by Haeckel, 1880, p. 639, appear to me to be identical with *D. cyathiforme*.

When young the tentacles are arranged in a single row around the margin and there is but one tentacle in each perradius and interradius, but when older the perradial and interradial tentacles become three times as many, and the adradial ones increase so as to be arranged in several rows.

It appears to me to be fruitless to attempt to separate species upon the length of the peduncle, its winged or unwinged (contracted or expanded) condition, as has been done by Haeckel, and until more detailed studies of living specimens have proven the contrary to be the case we had better venture to assume that all of the so-called Depastrellas and other forms of the North Atlantic are synonymous with *Depastrella cyathiforme*.

Genus STENOSCYPHUS Kishinouye, 1902.

Stenoscyphus, Kishinouye, 1902, Journal College Science, Tokyo, vol. 17, art. 7, p. 2, figs. 1, 2.
Stenoscyphus (?) Broch, 1907, Hydroiden und Medusen, Report Second Arctic Exped. *Fram*, No. 12, p. 9.

The type species is *Stenoscyphus inabai* Kishinouye, of Japan, which has 8 marginal anchors, 8 clusters of adradial tentacles, and a 4-chambered peduncle.

GENERIC CHARACTERS.

Stauromedusæ with simple, uncleft bell-margin without adradial lobes. With 8 (or 12 ?) perradial and interradial marginal "anchors," 8 (or 12 ?) adradial clusters of knobbed tentacles. With a ring-shaped, entire, coronal muscle. Stalk of attachment is 4 (or 6 ?) chambered. Stomach 4-chambered as in the Eleutherocarpidæ. Gonads interradial or on both sides of the interradii.

Kishinouye would constitute for *S. inabai* a new family, the Stenoscyphidæ, which would be intermediate between Haeckel's Tesseridæ and Lucernaridæ. *S. inabai* has a 4-chambered stalk and 8 separate, adradial gonads.

Broch, 1907, describes a medusa which may belong to the genus *Stenoscyphus* but which has 12 (6 perradial and 6 interradial) marginal anchors and 12 adradial clusters of tentacles. The mouth is 6-rayed instead of 4-rayed, as in *S. inabai*. A variation in the number of rays may be expected in these degenerate medusæ and it seems inexpedient at present to separate the 6-rayed from the 4-rayed form.

Stenoscyphus inabai Kishinouye.

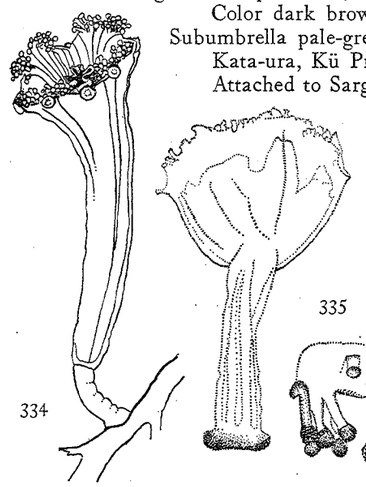
Depastrum inabai, Kishinouye, 1893, Zool. Mag. Tokyo, vol. 5, p. 416.
Stenoscyphus inabai, Kishinouye, 1902, Journal College Science, Tokyo, vol. 17, art. 7, p. 2, plate 1, figs. 1, 2.

About 25 mm. long, elongate, narrow, funnel-shaped, and quadratic in cross-section. Stalk with 4 interradial grooves. Exumbrella smooth; subumbrella beset with large, urn-shaped groups of nematocysts. The 8 principal tentacles are large, round, adhesive bodies (anchors). Secondary tentacles are short and knobbed, and arranged in 8 adradial clusters of about 25 each. There are neither arms nor lobes to the subumbrella. The ring-like coronal muscle is well developed and entire. 4 long, deep, interradial, gastrogenital pits extending to the aboral end of the bell. 8 gonads, in form of 4 pairs of bands along the interradial muscles. Each gonad composed of 40 sacs in 2 rows.

Color dark brown flecked with white, anchors red, gonads brown. Subumbrella pale-green, manubrium yellowish.

Kata-ura, Kü Province, and Misaki, Japan. In winter. Rare.

Attached to Sargassum. The animal can detach itself from the Sargassum "at will" and can crawl about, using its oral and aboral adhesive organs, thus effecting a locomotion resembling that of a leech. It can not swim by pulsations of the bell.



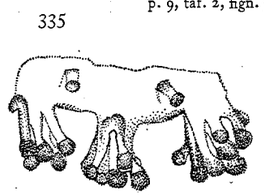


Fig. 334.—*Stenoscyphus inabia*, after Kishinouye, in Jour. College of Science Tokyo, Japan.
Fig. 335.—*Stenoscyphus hexaradiatus*, after Broch, in Report of the Second Norwegian Arctic Expedition in the "*Fram*."

Stenoscyphus (?) hexaradiatus Broch.

Stenoscyphus (?) *hexaradiatus*, Broch, 1907, Hydroiden und Medusen, Report Second Norwegian Arctic Expedition in the *Fram*, No. 12, p. 9, taf. 2, fign. 3-6.

Bell-shaped, with a cylindrical peduncle somewhat longer than height of bell. Bell about 6 mm. wide, total height of stalk together with bell 10 mm. Throat-tube short, 6-sided. Peduncle provided with 6 longitudinal muscles. 12 marginal anchors, 6 radial and 6 interradial. These are shaped very much as ordinary tentacles, but bent in the middle in a knee-like form, and each provided with an abaxial cushion. Tentacle-clusters arranged in 12 adradial groups, each composed of 7 to 10 tentacles which arise in several rows from the bell-margin. Among each cluster of suctorial tentacles there are one or more tentacles which resemble the marginal anchors. 6 horse-shoe-shaped, folded gonads with their convex sides abaxial. The two wings of each horse-shoe do not extend to the circular muscle. Color (?).

This medusa is distinguished by its 6-rayed structure, whereas in *S. inabai* the peduncle is 4-sided and there are 8 adradial tentacle-clusters instead of 12 as in *S. hexaradiatus*. It is possible, as Broch states, that *S. hexaradiatus* may be the type of a new genus, but we must await results of future studies before deciding this point. Unfortunately there is only one specimen, obtained by the *Fram* off Fosheims Peak, Arctic Ocean, on the second expedition.

A closely allied form from the Kurile Islands is described by Kishinouye, 1909, under the name *Thaumatoscyphus distinctus*. (See Appendix to this volume).

Genus LUCERNARIA O. F. Müller, 1776.

Lucernaria, Müller, O.F., 1776, Prodromus Zoolog. Dan., p. 227.—Sars, 1846, Fauna littoral. Norveg., fasc. 1, p. 20.—Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 175.—Clark, H. J., 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 551.—Agassiz, A., 1865, North Amer. Acal., p. 62.—Fol, 1873, Jena. Zeit. für Naturwissen., Bd. 7, p. 487.—Haeckel, 1880, Syst. der Medusen, p. 389; 1881, Deep-Sea Medusæ, *Challenger* Report, Zool., vol. 4, p. 53.—Hornell, 1893, Natural Science, vol. 3, p. 208.—Hurst, *Ibid.*, p. 209.

Lucernosa, Haeckel, 1881, *Ibid.*, p. 62.

Lucernaria, Kowalevsky, 1884, Zool. Anzeiger, Bd. 7, p. 712.—Kassianow, 1901, Zeit. für wissen. Zool., Bd. 69, p. 287, 11 fign., taf. 22–25.—Maas, 1906, Arktischen Medusen, Fauna Arctica, Bd. 4, Lfg. 3, p. 499.

Lucernaria+*Lucernosa*, Antipa, 1892, Zoolog. Jahrb., Abth. Syst., Bd. 6, pp. 378, 391.

The type species of this genus is *Lucernaria quadricornis* from the northern Atlantic coast of Europe, Greenland, and America.

GENERIC CHARACTERS.

Stauromedusæ with 4 simple perradial stomach-pouches as in Eleutherocarpidæ. Without marginal anchors or marginal papillæ. Peduncle single-chambered with 4 separate tæniola or partial septa. 8 adradial lobes which bear tentacles.

Antipa, 1892, would restrict *Lucernaria* to include forms with gonads of simple structure, whereas "*Lucernosa*" he would institute to define forms having complex gonads made up of numerous more or less separated sacs set side by side in a series of follicular ridges. In this respect he follows the suggestion of Haeckel, 1881, p. 62.

In all young medusæ of *Lucernaria* the gonads are simple, flat, leaf-like expansions in the entoderm of the subumbrella, and in many of the species they develop transverse ridges, and these may become so marked as to appear as deep foldings across the gonad, thus dividing it into a series of more or less sac-like corrugated pouches. This is, however, a relative matter and can not be safely used as a generic distinction; moreover, I think we should, if possible, avoid founding genera upon details of internal anatomy requiring dissection to determine their condition.

Kassianow, 1901, finds that in *Lucernaria*, *Craterlophus*, and *Haliclystus* there is a plexus of bipolar ganglion cells in the ectoderm of the exumbrella. These ganglion cells have each two nuclei. There is a motor center at the point of each arm, and the nervous epithelium spreads out from the bases of the tentacles. The perradial and interradial anchors are not motor centers as one would expect them to be were they derived from rhopalia.

The early development of *Lucernaria* has been studied by Kowalevsky, 1884 (Zool. Anzeiger, Jahrg. 7, p. 712), who found that the eggs and sperm were discharged in the Bay of Sebastopol near evening in August. The segmentation is total and equal, and the entoderm is apparently formed by delamination. A single, central, entoderm cell was seen, however, with a slender prolongation extending from between the ectoderm cells, and thus it is possible that the entoderm may originate from one of the ectoderm cells which withdraws into the interior. The larva elongates, the entoderm becoming a single linear row of cells, and the ectoderm becoming very thin at the ends. The ectoderm is not ciliated, but the larva creeps about. On the fourth day the larvæ attach themselves and become flat and rounded, and the entoderm forms a mass instead of a single layer, as previously. The larvæ then encyst themselves in a hard, secreted covering, within which they remain for about two weeks; after escaping they became lost to observation. Fol, 1873, found also that in *Lucernaria* the segmentation is complete and results in the formation of a single-layered blastosphere, which elongates, becomes ciliated and 2-layered. After this it becomes attached. 8 small, tentacle-like, marginal bodies, 4 perradial and 4 interradial, appear, but soon degenerate and disappear. Thus apparently *Lucernaria* is descended from a Haliclystus-like ancestor. Hornell, 1893, states that 8 marginal anchors are found in the young medusa, but disappear in the adult.

Synopsis of the Species of Lucernaria.

	L. quadricornis Müller.	L. pyramidalis Haeckel.	L. walteri Antipa.	L. kukenthali Antipa.	L. haeckeli Antipa.
Width of bell in mm.	50 to 60	40 to 50	55 to 60	55 to 60	27
Height of bell without peduncle in mm.	25 to 30	50±	70±	80±	45 to 50
Length of peduncle in mm.	25 to 40	40 to 50	80±	70±	15
Angular distance between arms.	The 4 perradial notches twice as wide and deep as the interradial.	As in L. quadricornis.	As in L. quadricornis.	The 4 perradial notches 3 times as wide and deep as the 4 interradial.	The 4 perradial notches only little wider and deeper than the 4 interradial
Number of tentacles on each arm.	100 to 120	130 to 140	700 to 750	800 to 850	80 to 90
Form and position of gonads.	8 from beginning of peduncle to ends of arms.	8 from base of peduncle only to crotch of each arm.	8 wide lancet-shaped extending to ends of 8 arms.	8 small, lancet-shaped, cross-folded bands reaching to ends of 8 arms.	8 very wide, overlapping; extending not quite to bases of 8 arms.
Color.	Very variable.	?	Light brown.	?	?
Where found.	North Atlantic coasts of Europe and America.	Labrador coast. Is this not L. quadricornus contracted through preservation in alcohol ?	East Spitzbergen, Arctic Ocean.	East Spitzbergen, Arctic Ocean.	East Spitzbergen, Arctic Ocean.

	L. infundibulum Haeckel.	L. campanulata Lamouroux.	L. bathyphila Haeckel.	L. australis Vanhöffen (immature).
Width of bell in mm.	24	20 to 30	50 to 60	9
Height of bell without peduncle in mm.	13	20 to 25	55 to 70	10
Length of peduncle in mm.	7	10 to 15	5 to 10	Absent or undeveloped.
Angular distance between arms.	As in L. haeckeli.	45° apart. Similar each to each.	As in L. kükenthali.	As in L. quadricornis.
Number of tentacles on each arm.	60 to 80	30 to 40	80 to 120	25 to 30
Form and position of gonads.	From middle of peduncle to bases of arms.	From point of juncture between bell and peduncle to tips of 8 arms.	Broad and short. Neither reaching to base of peduncle nor ends of arms. Each gonad has 200 sac-like foldings.	Not developed.
Color.	?	Very variable.	?	?
Where found.	Spitzbergen, Arctic Ocean.	Black Sea and Mediterranean to English coast. New Zealand (?)	Between Faröe and Shetland Islands, North Atlantic. From a depth of 540 fathoms.	Gauss Station, Antarctic Continent. From depth of 192 fathoms. November 3, 1902.

Lucernaria quadricornis O. F. Müller.

Lucernaria quadricornis, Müller, O. F., 1776, Prodrom. Zool. Dan., p. 227; 1788, Zool. Dan., vol. 1, p. 51, plate 39, figs. 1–6.—Lamarck, 1816, Syst. Anim. sans Vert., tom. 2, p. 354.—Cuvier, 1817, Règne Animal, tom. 4, p. 53.—Sars, M., 1829, Bidragtil Sodyrenes Natur., fasc. 1, p. 43, tab. 4, figs. 14–18; 1846, Fauna littoral. Norveg., fasc. 1, p. 20, plate 3, figs. 1–7.—Stimpson, 1853, Smithsonian Cont. to Knowledge, Marine Invert. Grand Manan, p. 8.—Carus, 1857, Icon., Zootom, taf. 4, fign. 1, 2.—Clark, H. J., 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 552, (good list of literature).—Agassiz, A. 1865, North Amer. Acal., p. 62.—Haeckel, 1880, Syst. der Medusen, p. 390.—Keferstein, 1863, Zeit. für wissen. Zool., Bd. 12, p. 20.—Taschenberg, 1877, Halle, Zeit. ges. Naturw., Bd. 49, p. 82, taf. 2, fig. 2.

Disk about 50 to 60 mm. in diameter and, together with the peduncle, 50 to 70 mm. in height. The bell is of the shape of a 4-sided funnel and about twice as wide as high. Peduncle

somewhat longer than the bell-height and with 4 longitudinal, interradial strands of muscle-fibers. Bell-margin divided by 8 clefts or notches, the 4 perradial ones being about twice as wide and deep as the 4 interradial; thus the 8 arms are brought quite close together in 4 separate pairs. Each arm bears 100 to 120 tentacles. The stomach gives rise to 4 wide, perradial pouches, which are lined on their edges by the 8 gonads.

Color variable, being either gray, green, yellow-brown, red-brown, or very dark brown.

Found on the northern coasts of Europe, on the Greenland coast, and on the coast of America, north of Cape Cod. It has never been taken south of Massachusetts Bay. Very rare on American coast.

Complete descriptions and good figures of this medusa have been given by Sars, 1846; Carus, 1857; and Taschenberg, 1877.

Lucernaria "pyramidalis" Haeckel = L. quadricornis (?)

Lucernaria pyramidalis, HAECKEL, 1880, Syst. der Medusen, p. 391, taf. 22, 10 fign.

Bell 4-sided and pyramidal, about 40 to 50 mm. wide and (with the style) 90 to 100 mm. high. The 8 arms grouped in 4 pairs, the 4 perradial notches of the bell-margin being twice as wide and deep as the 4 interradial. Each arm bears a large cluster of 130 to 140 tentacles.

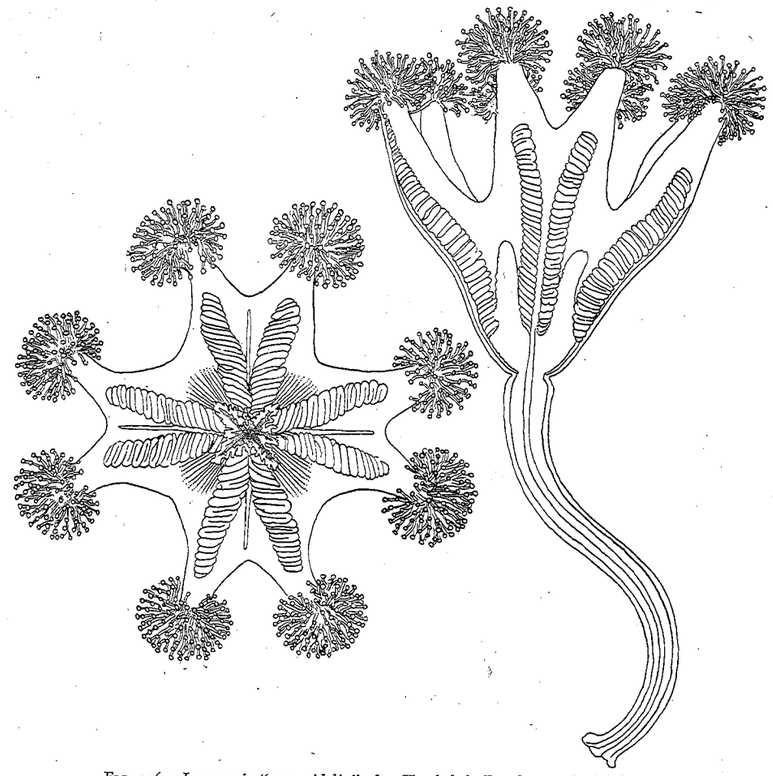


FIG. 336.—*Lucernaria "pyramidalis,"* after Haeckel, in Das System der Medusen.

Peduncle about 0.25 to 0.33 longer than bell-height. 4 short, blunt tæniola at its free distal end and a sharply marked pyloric stricture at its proximal end at base of bell. 4 linear, interradial strands of muscle-fibers traverse the length of the peduncle. Mouth cruciform, with 4 short, folded lips. The gonads are 8 blindly ending, transversely folded bands, grouped into 4 interradial pairs. They begin on the floor of the subumbrella at a short distance above the pyloric stricture and extend only to the crotch of the bell-arms. They diverge centrifugally outward, and the components of each pair are separated one from another by the 4 interradial septa. The gastric filaments in the regions of the gonads are small but very numerous.

This form is found on the Labrador coast. A good description of it is given by Haeckel, 1880. It is certainly closely related to, if not identical with *L. quadricornis*, but Haeckel states that the peduncle is separated from the bell by a pyloric stricture, or ring-furrow, which is not the case in *L. quadricornis*. Haeckel studied only preserved specimens and I strongly suspect that this so-called pyloric constriction may have been caused by unnatural contraction.

Lucernaria walteri Antipa.

Lucernosa walteri, ANTIPA, 1892, Zoolog. Jahrb., Abth. Syst., Bd. 6, p. 379, taf. 17, fign. 1–9.

150 to 160 mm. high and 55 to 60 mm. across the bell. Bell goblet-shaped; stalk round, single-chambered, somewhat higher than the bell. Stalk with 4 well-developed, linear, interradial, longitudinal muscles. 8 arms arranged in pairs with the 4 perradial concavities between the arms twice as wide at the 4 interradial notches of the margin. Each arm with a terminal, ball-like cluster of 700 to 750 short, knobbed tentacles. 8 wide, lancet-shaped, adradial gonads, extending to ends of the 8 arms; they are folded, band-like, and lie in the subumbrella wall of the perradial stomach-pouches. The cavity of the stalk extends directly into that of the bell, without a pyloric stricture. Color light brown. East Spitzbergen, Arctic Ocean. This is one of the largest known *Lucernarians*. Special description given by Antipa.

Lucernaria kükenthali Antipa.

Lucernosa kükenthali, ANTIPA, 1892, Zoolog. Jahrb., Abth. Syst., Bd. 6, p. 386, taf. 18, fign. 10, 11.

More than 150 to 160 mm. high, 55 to 60 mm. wide across the bell. Bell goblet-shaped, somewhat higher than wide. Stalk not quite as long as the bell itself, with no constriction or other sharp distinction between stalk and bell. Stalk round, single-chambered, with 4 well-developed, linear, longitudinal muscles. 8 arms arranged in pairs. The 4 perradial notches of the bell-margin are 3 times as wide and 3 times as deep as are the interradial. Each arm has a terminal, ball-like cluster of 800 to 850 short, knobbed tentacles. Gonads are 8 small, lancet-shaped, cross-folded bands extending to ends of the 8 arms. Color (?) East Spitzbergen, Arctic Ocean. Described in detail by Antipa, 1892. I am inclined to suspect that this is only a variety of, if not identical with, *Lucernaria walteri*. It appears to be distinguished only by its narrow lanceolate gonads and slightly wider perradial notches.

Lucernaria haeckeli Antipa.

Lucernosa haeckeli, ANTIPA, 1892, Zoolog. Jahrb., Abth. Syst., Bd. 6, p. 388, taf. 18, fign. 12–14.

60 to 65 mm. high and 27 mm. wide at widest part, which is below bell-margin. Bell oval, goblet-shaped, widest near middle. Stalk conical, wide, and hardly one-third as long as bell. Stalk single-chambered with 4 interradial, longitudinal muscles. 8 short arms arranged in pairs. The 4 perradial notches of the margin only a little wider and deeper than the 4 interradial notches. Each arm terminates in a ball-like cluster of 80 to 90 knobbed tentacles. 8 very wide gonads, so wide that they overlap one another. The gonads extend not quite to bases of arms, and quite fill the lower parts of the radial chambers of bell.

This species is distinguished from *L. bathyphila* by its short bell-stalk and the position and shape of its gonads. Color (?) East Spitzbergen, Arctic Ocean.

Lucernaria infundibulum Haeckel.

Lucernaria infundibulum, HAECKEL, 1880, Syst. der Medusen, pp. 392, 385.

Bell funnel-shaped, flat, not quite twice as wide as high, 24 mm. wide. Peduncle somewhat less than 10 mm. long, 4-sided, pyramidal, and single-chambered. The medusa is distinguished by having 4 hollow, interradial tæniolæ each with a funnel-like, central cavity extending to lower end of peduncle, recalling the condition seen in the aboral end of bell in *Periphylla*. Each hollow septum bears along the entire length of its side walls a pair of well-developed longitudinal muscles and 2 rows of gastric filaments. The 8 umbrella-arms are arranged in 4 pairs, the 4 perradial notches being wider than the 4 interradial. Each arm has

60 to 80 tentacles. 8 gonads extending from middle of peduncle to base of arm. Found at Spitzbergen. Described by Haeckel from a preserved specimen.

Lucernaria campanulata Lamouroux.

Lucernaria campanulata, Lamouroux, 1815, Mém. du Museum Hist. Nat., tome 2, p. 472, planche 16, figs. 1–7.—Keferstein, 1862, Zeit. für wissen. Zool., Bd. 12, p. 23, taf. 1, fig. 4.—Haeckel, 1880, Syst. der Medusen, p. 392 (list of literature).—Hutton, 1880, Trans. New Zealand Institute, vol. 12, p. 275.—Claus, 1883, Untersuch. über Organisation und Entwick. der Medusen, p. 35.—Graeffe, 1884, Arbeit. Zool. Inst. Wien., Bd. 5, p. 344.—Hornell, 1893, Nat. Sci., London, vol. 3, p. 208.—Beaumont, 1900, Proc. Roy. Irish Acad. Dublin, Ser. 3, vol. 5, p. 811.—Kassianow, 1901, Zeit. für wissen. Zool., Bd. 69, p. 370, fig. 11.
Lucernaria convolvulus, Johnston, 1835, London, Mag. Nat. Hist., vol. 8, p. 59, fig. 3.
Lucernaria, Kowalevsky, 1884, Zool. Anzeiger, Jahrg. 7, p. 712 (embryology).

This medusa is at once recognized by its symmetrically octagonal disk with its 8 arms 45° apart and with equally developed notches between them. There are no longitudinal muscles in the 4 interradial longitudinal ridges of the peduncle. The medusa is 20 to 30 mm. wide and 30 to 40 mm. high, including the peduncle. Color very variable, being yellowish, red, brownish, etc. Found along European coasts from the Black Sea and Mediterranean to southern England, Ireland, and Wales. Graeffe states that it is found only locally at Trieste, Adriatic Sea, in May and June, becoming mature at the end of the latter month. Hutton records it from Brighton near Dunedin, New Zealand, but he gives no description.

For an account of Kowalevsky's observations upon the early stages of the larva see genus *Lucernaria*.

Hornell, 1893 (Nat. Sci., vol. 3, p. 208), states that 8 marginal anchors are found in the young medusa, but they soon disappear and are not found in the adult. This leads one to conclude that *Lucernaria* is derived directly from *Haliclystus*. Indeed Horst, 1893, finds that the variations in number and development of the marginal anchors is so great that he is inclined to consider *Lucernaria* to be identical with *Haliclystus*. Kassianow, 1901, records the capture of an abnormal specimen having 2 medusa bells arising from one stalk.

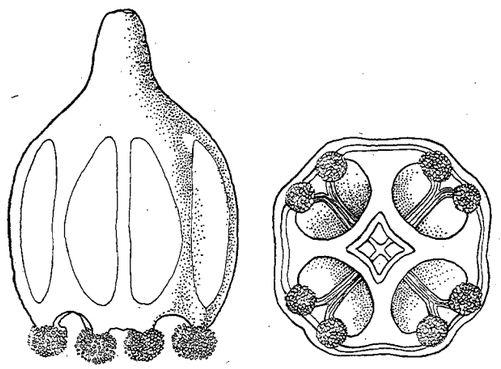


Fig. 337.—*Lucernaria bathyphila,* after Haeckel, in Deep-sea Medusæ *Challenger* Expedition.

Lucernaria bathyphila Haeckel.

Lucernaria bathyphila, Haeckel, 1880, Syst. der Medusen, p. 640; 1881, Report Deep-Sea Medusæ *Challenger* Expedition, Zool., vol. 4, p. 54, plates 16, 17, 21 figs.
Lucernosa bathyphila, Antipa, 1892, Zoolog. Jahrb., Abth. Syst., Bd. 6, p. 379.

For description, see synopsis of the species of *Lucernaria*. Haeckel, 1881, gives a very detailed and fully illustrated description of this species.

Lucernaria australis Vanhöffen.

Lucernaria australis, Vanhöffen, 1908, Deutsche Südpolar-Exped., 1901 to 1903, Bd. 10, Zool. 2, p. 32, fign. 1, 2.

Described by Vanhöffen from an immature specimen which had neither gonads nor peduncle.

Bell 10 mm. high, 9 mm. wide, thimble-shaped, with sloping sides. No basal stalk, but with a weakly developed ring-furrow at aboral end of bell, and an indication of the beginning of a single-chambered peduncle. 8 short arms, 2 to 2.5 mm. long, grouped in pairs somewhat closer in the interradii than in the perradii, and with the perradial concavities of margin deeper than the interradial. 25 to 30 short tentacles, with small terminal knobs on each arm. There were 7 very small, tentacle-like marginal bodies somewhat asymmetrically placed near the 4 perradial and 3 of the interradial points of the bell-margin. It is therefore possible that this medusa may be a young *Haliclystus*, but if the marginal bodies degenerate it is a *Lucernaria*, for such a course of development is known according to Hornell, 1893, in the European species of *Lucernaria*. The 4 perradial lips of the cruciform mouth are folded and are at about half the distance between the depth of bell-cavity and margin.

Wide ring muscle at margin of subumbrella and 8 strands of radial-muscles extending outward to the tentacles. These radial strands are one-third wider than the ring muscle. They inclose 4 narrow, triangular areas in the interradii and 4 wider, rectangular spaces in the perradii. These subumbrella areas between the muscle strands exhibit many large nettle-cells. There are about 12 simple, unbranched, gastric filaments in each of the 8 rows. Found at Gauss Station, Kaiser Wilhelm II Land, Antarctic Continent, at a depth of 192 fathoms, in November, 1902.

Genus KISHINOUYEA, nom. nov.

Schizodiscus, preoccupied by Kittl, 1891.
Schizodiscus, Kishinouye, 1902, Jour. College Sci., Tokyo, vol. 17, art. 7, p. 5.

The type species is *K. nagatensis* of Japan, first described by Oka under the name *Lucernaria nagatensis*.

GENERIC CHARACTERS.

Stauromedusæ with 4-chambered stomach as in the Eleutherocarpidæ, and without adhesive anchors. Umbrella deeply notched, with 8 adradial lobes. 8 adradial clusters of knobbed tentacles. Peduncle 4-chambered without muscle-fibers in the tæniola. Gonads 8 adradial bands of laterally oblong sacs.

This genus is very closely allied to *Lucernaria* and is distinguished only by its 4-chambered aboral stalk. In young medusæ, however, it is single-chambered, as in *Lucernaria*, but the 4 interradial septa, or tæniola, unite near the pyloric region as growth proceeds, and thus the peduncle comes to have 4 perradial, separate chambers.

Kishinouyea nagatensis.

Lucernaria nagatensis, Oka, 1897, Zool. Mag. Tokyo, vol. 9, p. 67, plate 1. Also; Annot. Zool. Jappon. Tokyo, vol. 1, p. 141, 4 figs.
Schizodiscus nagatensis, Kishinouye, 1902, Journ. Science College, Tokyo, vol. 17, art. 7, p. 6, plate 1, figs. 3–6.

The 8 adradial lobes are united in pairs, so that the 4 perradial notches are about twice as deep as the 4 interradial. These 8 adradial lobes are bent at right angles to the oral side. The disk has the shape of a Greek cross. Peduncle 4-chambered in adult. Well-developed, interradial, longitudinal muscles in the subumbrella. Marginal muscle divided into 8 U-shaped pieces. No primary tentacles. Adradial tentacles short, adhesive, in clusters of 5. Gastral filaments branched, few in number. Gonads, 8 broad, adradial bands of laterally oblong sacs. Color variable, matching its surroundings. Japan.

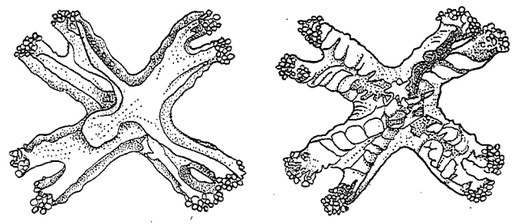


Fig. 338.—*Kishinouyea nagatensis,* after Kishinouye, in Jour. Col. of Science, Tokyo.

Genus HALICLYSTUS Clark, 1863.

Haliclystus, Clark, 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 559; 1878, Smithsonian Contributions to Knowledge, Article 2, Part. 2.—Agassiz, A., 1865, North Amer. Acal., p. 63.—Haeckel, 1880, Syst. der Medusen, p. 387.—Kishinouye, 1889, Proc. U. S. National Museum, vol. 22, pp. 125, 129.—Maas, 1904, Résult Camp. Sci. Prince de Monaco, fasc. 28, p. 43; 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 499.—Gross, 1900, Jena. Zeit. für Naturwissen, Bd. 33, p. 614 (anatomy).
Lucernaria, Bergh, 1888, Vidensk. Meddel. Naturhist. For. Kjöbenhavn, p. 214 (embryology).

The type species of this genus is *H. auricula* from the Atlantic coasts of Europe and of New England, United States.

GENERIC CHARACTERS.

Stauromedusæ similar to *Lucernaria* but with 8 perradial and interradial marginal anchors, and with a 4-chambered, aboral peduncle. The embryology has been studied by Bergh, 1888, and is similar to that of *Lucernaria*, excepting that in *Lucernaria* the 8 anchors become lost as growth proceeds.

The regeneration of *Haliclystus* has been studied by A. Meyer, 1865 (40 ste Versamml. deutsch. Naturforscher Aerzte, Hannover, p. 217), who gives a brief account of his experiments. It appears that the medusa possesses considerable regenerative capacity. The style is regenerated if it be removed, and if only the lower end of the style be cut off the medusa usually regenerates a new aboral end; but occasionally a bell is regenerated, thus giving an animal with 2 bells. Somewhat similar results were attained by Kassianow, 1901, on *Craterlophus*.

Characteristics of the So-called Species of Haliclystus.

	H. octoradiatus.	H. salpinx.	H. stejnegeri.	H. auricula.	H. antarcticus.	H. kerguelensis.
Umbrella.	Conical, surface flat, 2 to 3 times as broad as high.	Pyramidal, octangular, much broader than high.	Conical, surface flat, a little broader than high.	Pyramidal, octangular, almost as broad as high.	Flat, twice as wide as high, conical.	As in H. antarcticus.
Peduncle.	Cylindrical, almost as long as height of umbrella; no interradial longitudinal grooves.	Quadrangular, prismatic, considerably longer than height of umbrella.	About half as long as height of umbrella, with 4 interradial longitudinal grooves.	Almost as long as height of umbrella, with 4 deep longitudinal grooves.	4-sided, prismatic, half to two-thirds as long as height of umbrella. With 4 longitudinal grooves (contracted ?).	Twice as high as umbrella. Prismatic, 4-sided.
Eight arms.	45° apart. Each arm with 30 to 60 tentacles.	45° apart. Each arm with 60 to 70 tentacles.	45° apart. Each arm with 70 to 100 tentacles.	United in pairs. Each arm with 100 to 120 tentacles. Interradial clefts only half or two-thirds as wide as perradial.	45° apart and similar each to each. Each arm with more than 100 tentacles.	As in H. antarcticus, but with not more than 50 tentacles on each arm.
Eight marginal anchors.	Large, egg-shaped or nearly club-shaped, one-fourth as long as breadth of peduncle.	Very large, as long as arms, obliquely trumpet-shaped.	Large, egg-shaped, half as long as breadth of peduncle.	Large, shaped like coffee-beans, as long as breadth of peduncle.	Large, biscuit-shaped, about as long as width of peduncle.	Small, oval, only one-third as wide as width of peduncle.
Gonads.	In each gonad 20 to 30 large sacs in 2 longitudinal, alternate rows.	In each gonad 40 to 50 sacs in 4 longitudinal rows.	In each gonad 100 to 150 sacs, 6 to 8 sacs abreast in the broadest part.	In each gonad 100 to 150 sacs in 6 to 8 radial rows.	8 gonads, widely separated one from another, 100 to 150 sacs in 6 to 8 radial rows in each gonad.	8 widely separated, broad, lancet-shaped gonads.
Where found.	North Atlantic.	Coast of Maine, United States.	Bering Island, Commander Islands, North Pacific.	North Atlantic. Coasts of Europe and America.	Island of South Georgia, Antarctic Ocean.	Kerguelen Island, Antarctic Ocean

Haliclystus auricula Clark.

Lucernaria auricula, Rathke, 1806, Müller's Zool. Dan., Bd. 4, p. 35 (*exclus. synon*).
Haliclystus auricula, Clark, H. J., 1863, Jour. Boston Soc. Nat. Hist., vol. 7, p. 559.—Agassiz, A., 1865, North Amer. Acal., p. 63, figs. 88–90.—Clark, S. F., 1876, Exploration of Alaska, vol. 1, p. 235.—Clark, H. J., 1878, Smithsonian Contributions to Knowledge, pp. 1–130, plates 1–9, 145 figs.—Haeckel, 1879, Syst. der Medusen, p. 389.—Schlater, 1891, Zeit. wiss. Zool., Bd. 52, p. 580; Revue Sci. Nat. St. Pétersbourg, Anné. 2, p. 176 (sense-organs, structure of).—Beaumont, 1893, Trans. Liverpool Biol. Soc., vol. 7, p. 259; 1900, Proc. Roy. Irish Acad. Dublin, ser. 3, vol. 5, p. 806.—Bigelow, H. B., 1909, Proc. U. S. National Museum, Washington, vol. 37, p. 316.
(?) *Haliclystus tenuis*, Kishinouye, 1910, Journal College Sci., Tokyo, vol. 27, art. 9, p. 4, plate 1, fig. 3.

Disk about 20 to 30 mm. wide and (with the style) 20 to 30 mm. high. Bell-margin 8-sided. The 4 interradial notches between the arms being only half to two-thirds as wide as the 4 perradial clefts. Each arm terminates in a large cluster of 100 to 120 tentacles. These tentacles are each about quarter as long as bell-diameter. They are hollow and terminate in a globular tip thickly covered with nematocysts. There are 8 large, perradial and interradial, marginal anchors (colletocystophores), which are coffee-bean-shaped and mounted, each one, upon a short cylindrical base. These organs are much larger than in the European *H. octoradiatus*. The aboral peduncle, or stalk, is about as long as bell-height. It is cruciform in cross-section, there being 4 deep, interradial, longitudinal furrows beneath which are 4 well-

developed strands of longitudinal muscle-fibers. Alternating with these are 4 perradially situated, longitudinal chambers which communicate with the central stomach in the umbrella. There are 8 broad, adradial gonads, grouped into 4 interradial pairs. Each gonad is wide and triangular. These gonads begin a little above the point of junction of the stalk with the disk and extend to the ends of the 8 arms. Each gonad contains 100 to 150 out-folded sacs arranged in 6 to 8 radiating, longitudinal rows. Gastric cirri numerous.

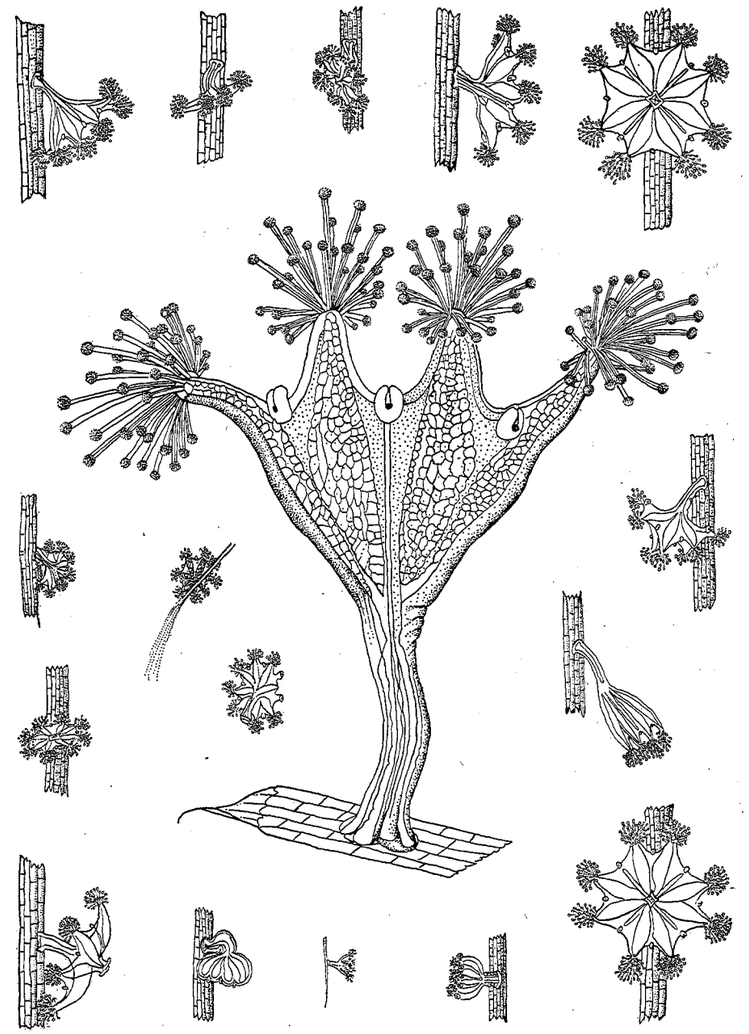


Fig. 339.—*Haliclystus auricula*, after Clark, in Smithsonian Contributions to Knowledge. The smaller figures are of natural size and illustrate characteristic attitudes.

Color very variable, but each medusa is commonly of one color, parti-colored individuals being very rare. Individuals are either blue, green, yellow, olive, orange, or very rarely red, pink, or violet. Medusæ of brownish and purple hues are also common.

This species is found in Massachusetts Bay and off the northern coasts of Europe from England to Norway. Clark reports it from Norton Sound, Alaska, and Bigelow from Labrador and Newfoundland. It is only locally common on the New England coast.

It may be distinguished from *H. octoradiatus* by its more slender bell and stalk, its large marginal anchors, and the greater number and smaller size of the genital sacs upon the gonads. Kishinouye, 1910, records a form from Japan which resembles *H. auricula* excepting that each gonad consists of only two rows of saccules. He calls this medusa *H. tenuis*.

Haliclystus octoradiatus Clark.

Lucernaria auricula, Montagu, 1808, Trans. Linn. Soc. London, vol. 9, p. 113, plate 7, fig. 5.—Sars, M., 1829, Bidragtil Södyr. Naturhist., p. 34, taf. 4, fign. 1 to 13.—Johnston, 1838, Hist. British Zoophytes, p. 229, fig. 35.—Agassiz, 1862, Cont. Nat. Hist. U. S., vol. 4, p. 176.

Lucernaria octoradiata, Lamarck, 1816, Hist. anim. sans vert., tom. 2, p. 474.—Steenstrup, 1859, Vidensk. Meddel. Nat. Foren. Kjöbenhavn, p. 108.—Sars, M., 1860, Forhandl. Vid. Selsk. Christiania, p. 145.—Keferstein, 1863, Zeit. wissen. Zool., Bd. 12, p. 22, taf. 1, fign. 1–3.—Taschenberg, 1877, Zeit. Ges. Naturw., Halle, p. 91, taf. 2, fig. 4.—Bergh, 1888, Vidensk. Meddel. Nat. For. Kjöbenhavn, p. 214, fign. 1–3.

Haliclystus octoradiatus, Clark, H. J., 1863, Jour. Boston Soc. Nat. Hist., vol. 7, p. 565.—Haeckel, 1880, Syst. der Medusen, p. 388.—Levinsen, 1893, Vid. Meddel. Nat. Foren. Kjöbenhavn, (5), Bd. 4, p. 146.—Browne, 1896, Quart. Journ. Mic. Sci., vol. 38, part. 1, pp. 1–8, plate 1, 22 figs.—Hornell, 1893, Natural Science, London, vol. 3, p. 33 (abnormalities).—Browne, 1895, Quart. Journ. Micros. Sci., ser. 2, vol. 38, p. 1, plate 1 (variations).—Gross, 1900, Jena. Zeit. Naturw., Bd. 33, p. 611, taf. 23, 24 (anatomical).—Beaumont, 1900, Proc. Roy. Irish Acad., Dublin, ser. 3, vol. 5, p. 808.—Maas, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 44.—Wietrzykowski, 1909, Comptes Rendus, Paris, tome 149, p. 746.

Disk 20 to 30 mm. wide and, with the stalk, 20 to 30 mm. high. Disk flat and about 2 to 3 times as broad as high. The 8 adradial arms are 45° apart, not grouped in 4 more or less approximated pairs, as in *H. auricula*. Arms very wide, concavities of bell-margin shallow. Each arm bears a terminal cluster of 30 to 60 tentacles, instead of 100 or more, as in *H. auricula*. The 8 perradial and interradial marginal anchors (colletocystophores) are egg-shaped, and about one-fourth as long as diameter of stalk. Stalk cylindrical, without longitudinal furrows, 4-chambered, and with 4 interradial, longitudinal strands of muscle-fibers. There are 8 separate gonads which do not extend quite to the end of the arms or to the aboral septa. Each gonad contains only 2 rows of alternately arranged, large, genital sacs.

Color quite variable, being either grayish-yellow, brownish-yellow, or grayish-brown.

Found on the North Atlantic coasts of Europe, on the Greenland coast, and at Spitzbergen.

The most complete descriptions of this species are given by Sars, 1829; Keferstein, 1863; Browne, 1895; and Gross, 1900. Its variations have been studied by Hornell, 1893, and by Browne, 1896. The abnormal forms are very irregular, symmetrical variations rarely appearing. The medusa is one of the most variable known. At Jersey, England, according to Hornell, 66 per cent of the specimens were abnormal in some respect; but at Plymouth, according to Browne, only 34 per cent were abnormal and the aberrations were quite different from those found at Jersey. We are unable to determine whether this difference is fostered by isolation or is due to the effect of local influences in the environments of Plymouth and Jersey. It may also be due to a difference in variative tendency in the medusæ of the two places. The development of *H. octoradiatus* has been studied by Bergh, 1888. The egg is fertilized after being discharged into the water and then it retracts somewhat from the vitelline membrane. 2 polar bodies are found; the segmentation is total and equal, and there is no cleavage cavity. The entoderm appears to be formed by polar ingression of cells into the center of the solid morula which is at first spherical but afterwards it elongates into a rod-like form, which becomes so long and narrow that the entodermal cells come to be arranged one after another in a single row as in the planula of *Solmundella*. The planula of *H. octoradiata* is not ciliated, however, but creeps about by means of worm-like movements. It then attaches itself by the anterior end as do other planulæ of Scyphomedusæ. At first the tentacles are not united into definite clusters but are distributed around the bell-margin, but 8 tentacles are more or less isolated and lie in the perradial and interradial radii. These form the marginal anchors.

The best description of the development of the planula is given by Wietrzykowski, 1909 (see Appendix to this Volume).

Bergh, 1888, describes an abnormal specimen of *H. octoradiatus* with a small bud arising from the side of its bell.

Haliclystus salpinx Clark.

Plate 56, figs. 1 to 4.

Haliclystus salpinx, Clark, H. J., 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 563.—Agassiz, A., 1865, North Amer. Acal., p. 64.—Haeckel, 1879, Syst. der Medusen, p. 388.

(?) *Lucernaria salpinx*, Graeffe, 1884, Arbeit. Zool. Inst. Wien., Bd. 5, p. 344.

Disk 25 mm. wide and (with the stalk) 20 mm. high. The 8 adradial arms are 45° apart, and their ends are rounded. Each arm bears 60 to 70 very slender tentacles, the globose tips of which are smaller than in *H. auricula*. The 8 marginal anchors are as long as the arms, slender, and obliquely trumpet-shaped. The edge of the trumpet is considerably thickened except at a narrow space on the proximal side, by the development of adhesive cells. The center of this terminal expansion is occupied by a single tentacular remnant about as long as half the breadth of the trumpet. Aboral stalk relatively longer and more slender than in *H. auricula*, 4-sided in cross-section, with 4 longitudinal rows of interradial muscle-fibers. The stalk is 4-chambered and about 12 mm. long. The 8 genital organs are not so widely separated as in *H. auricula;* their broader ends project only about half-way into the arms. The genital sacs of each gonad are arranged in 4 radiating rows, the marginal rows being shorter than the 2 middle rows. All of these sacs are of the same size and there are 40 to 45 of them in each row.

This species was obtained by Stimpson at Mount Desert Island, Maine. The best description of it is that of Clark, 1863. Our figures are drawn from specimens obtained upon eelgrass on the inner side of Ram Island near Manchester, Massachusetts, on September 7, 1905. Graeffe, 1884, appears to have found this species at Trieste, Adriatic Sea, in June and July.

Haliclystus stejnegeri Kishinouye.

Haliclystus stejnegeri, Kishinouye, 1899, Proc. U. S. National Museum, vol. 22, p. 126, figs. 1–3.

Bell conical, funnel-shaped, 1.33 to 1.5 times as broad as high. 18 mm. wide. Peduncle nearly quadrate in cross-section and about half as long as umbrella; its 4 interradial, longitudinal grooves are formed by the attachment of the tæniola. These septa meet at the longitudinal axis and divide the internal space of the peduncle into 4 perradial chambers which are continuous with the 4 perradial stomach-pouches. The surface of the exumbrella is smooth and the line of demarcation between the stalk and the umbrella is distinct, although there is no constriction at this point. There are a few small clusters of nematocysts at the radial sinuses of the umbrella margin. The radial muscle plates are, as in other species of *Haliclystus*, developed in the perradii and interradii of the subumbrella. The margin of the umbrella displays 8 equally spaced, adradial arms, all of the same size. The 8 incisions are about as deep as the width of the arms themselves.

There are 8 large, egg-shaped, perradial and interradial "anchors," which are about half as long as diameter of peduncle; these are situated in the concavities of the clefts, alternating with the tips of the 8 adradial arm-lobes. There are 8 adradial clusters of knobbed tentacles, one at the end of each of the 8 arms. Each cluster contains 70 to 100 tentacles of various sizes.

Manubrium short and quadrangular, the lips reflected outward. The 8 rows of well-developed gastric filaments extend from the base of the throat-tube to the proximal ends of the 8 gonads. The 8 gonads are broad, leaf-shaped, tapering at both ends, and touch each other along their proximal halves, so that the surface of the subumbrella is almost entirely occupied by them. There are 100 to 150 round sacs in each gonad; these sacs are not arranged in rows and those nearest to the 4 principal radii are the largest. There are 6 to 8 sacs abreast at the broadest part of each gonad. Each gonad is turned over in the 4 principal radii and is continuous with the mesentery.

Preserved specimens are grayish or pale brown, semi-transparent, with a dark-brown or nearly black streak at bell-margin.

A number of specimens were found at Bering Island, one of the Commander Islands, North Pacific, in summer.

The species is well described and figured by Kishinouye (see text-figure 340).

Haliclystus antarcticus Pfeffer.

Haliclystus antarcticus, Pfeffer, 1889, Mittheil. Naturhist. Museum Hamburg, Jahrg. 6, p. 16.

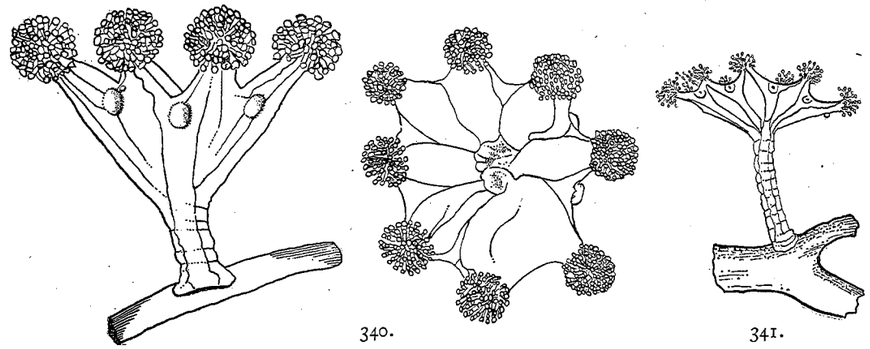
Bell flat, 17 mm. wide to bases and 27.5 mm. wide to ends of arms. Height 11.5 mm. to subumbrella disk and 15 mm. to ends of arms. The stalk is 8 mm. long, flexible, and when expanded it is about two-thirds as long as bell-height. It has 4 interradial, longitudinal muscles and is 4-sided in cross-section, the longitudinal muscles being in the 4 flat or grooved sides. The attached end of the stalk is swollen. There are 8 adradial arms 45° apart with the 8 clefts all of equal depth, and each arm has more than 100 tentacles; 8 large biscuit-shaped, marginal anchors about as long as width of stalk; 8 wide, lancet-shaped gonads, widely separated one from another and extending to ends of arms. The number of sacs in the gonads is not clearly defined in Pfeffer's specimens, but there appear to be at least 100 to 150 in 6 to 8 longitudinal rows. Stalk single-chambered thus illustrating the close relationship between *Haliclystus* and *Lucernaria*.

The medusa is a beautiful blue-violet in color, with lighter, somewhat reddish anchors and tentacles. Found at South Georgia, Antarctic Ocean.

Haliclystus kerguelensis Vanhöffen.

Haliclystus kerguelensis, Vanhöffen, 1908, Deutsche Südpolar-Expedition, 1901–1903, Bd. 10, Zool. 2, p. 31, taf. 2, fig. 1.

Bell 27 mm. wide across the outstretched arms exclusive of the tentacles, and 10 mm. high. Arms 45° apart, the concavities between them all similar each to each as in *H. antarcticus*. Peduncle prismatic, 20 mm. long and 3 mm. wide. Not quite 50 tentacles in each adradial cluster. Marginal anchors only one-third as wide as the peduncle in its expanded state. 8 wide, lancet-shaped gonads.



340. 341.

Fig. 340.—*Haliclystus stejnegeri*, after Kishinouye, in Proc. U. S. Nat. Mus.
Fig. 341.—*Haliclystus kerguelensis*, after Vanhöffen in Deutsch. Sudpolar Expedition.

Bell and peduncle sandy-brown with a play of green over the surface. Gonads dark olive-brown and plainly visible through the walls of the lighter colored bell. Terminal knobs of the tentacles rose-red.

Found at Observatory Bay, Kerguelen Island, Antarctic Ocean; in July, growing on the stems of *Macrocystis*.

This form is closely related to *H. antarcticus*, but has fewer tentacles, smaller anchors, and apparently a longer peduncle, although the stalk of *H. antarcticus* was probably contracted in Pfeffer's preserved specimens. There are also color differences between the two forms.

Genus HALIMOCYATHUS Clark, 1863.

Halimocyathus, Clark, 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 536.—Agassiz, A., 1865, North Amer. Acal., p. 61.
Halicyathus, Haeckel, 1880, Syst. der Medusen, p. 393.
Manania, Clark, 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 541.

The type species of this genus is *H. platypus* Clark, from Massachusetts Bay.

GENERIC CHARACTERS.

Stauromedusæ with 4 perradial, gastrogenital pockets in the subumbrella wall of the 4 stomach-pouches, as in Cleistocarpidæ. With 8 marginal anchors (4 perradial and 4 interradial). 8 adradial clusters of terminally knobbed tentacles. 4 interradial, horse-shoe-shaped gonads. 8 adradial arms.

This genus is very closely related to *Haliclystus*, but is distinguished by the partitions across its 4 perradial stomach-pouches, such as are found in all Cleistocarpidæ.

Halimocyathus platypus Clark.

Halimocyathus platypus, Clark, H. J., 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 537.—Agassiz, A., 1865, North Amer. Acal., p. 61.—Haeckel, 1880, Syst. der Medusen, p. 393.
Lucernaria platypus, Taschenberg, 1877, Zeit. Ges. Naturw., Halle, p. 92.

Disk deep funnel-shaped, about 6 mm. wide, and (with the peduncle) 10 mm. in height. The 8 arms are nearly twice as long as broad and one-third as long as bell-height from peduncle to margin. Each arm bears 17 to 20 thick, pistilliform tentacles, about as long as greatest breadth of arms; the tentacles upon each arm are arranged in 5 rows, there being about 7 tentacles in the middle row, 4 in each row on either side of the latter, and one in each of the outermost positions. The 8 marginal anchors are small and reverted, being only one-third as long as shortest tentacles, but proportionally broader; their length is a little less than 3 times their radial diameter. The peduncle is about half as high as the disk; at the narrowest part, where it joins the disk, its diameter is nearly half its length, and from there it broadens into a wide base having a width equal to the length of the peduncle; it is round, or very slightly furrowed at 4 points opposite the 4 interradial muscles. The 4 separate, longitudinal chambers of the peduncle are very voluminous and close together, but the longitudinal septa between them are complete. There are 4 horse-shoe-shaped gonads; the centripetal parts of each horse-shoe are united across the inner ends of the 4 interradial parts while the free, outer parts extend to the neighborhood of the marginal anchors. Each arm of the horse-shoe contains 15 to 17 genital sacs. The edges of adjacent gonads are joined by a cross partition as in other Cleistocarpidæ.

A single specimen of this species was found by Clark at Chelsea Beach, Massachusetts, where it was found attached to *Zostera*, along with *H. auricula*. It has not been seen since Clark's day, and indeed the contamination of the sea-water in this region has destroyed the Stauromedusæ which once abounded there, and which are now exceedingly rare along the entire New England coast.

Halimocyathus lagena Haeckel.

Holothuria lagenam referens, Müller, O. F., 1776, Prodromus Zool. Danica, p. 232.
Lucernaria auricula, Fabricius, 1780, Fauna Grœnlandica, p. 341.—Milne-Edwards, 1849, Cuvier, Règne Animal. Zoophytes, planche 63, 9 figs.—Sars, M., 1860, Forhandl. Vid. Selsk., Christiania, p. 145.—Keferstein, 1863, Zeit. für wissen. Zool., Bd. 12, p. 21.—Taschenberg, 1877, Zeit. Ges. Naturw., Halle, p. 89.
Lucernaria fabricii, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 176.
Lucernaria typica, Greene, 1858, Nat. Hist. Review, p. 132.
Manania auricula, Clark, H. J., 1863, Journ. Boston Soc. Nat. Hist., vol. 7, p. 542.—Agassiz, A., 1865, North Amer. Acal., p. 62.
Halicyathus lagena, Haeckel, 1880, Syst. der Medusen, p. 394.—Levinsen, 1893, Vid. Meddel. Nat. For. Kjöbenhavn (5), Bd. 4, p. 147.

Bell urn-shaped, much deeper than broad. It passes from a rounded base abruptly into the peduncle. Bell about 5 to 7 mm. wide, and (including the style) about 20 to 30 mm. long. A cluster of 60 to 70 slender tentacles upon the end of each of the 8 arms. Arms about as long as broad and grouped into 4 interradial pairs. 8 marginal anchors have the same form as the knobbed tentacles, but are somewhat smaller. 4 horse-shoe-shaped gonads, the distal ends of which extend radially outwards are separated from the bell-margin by a wide space. Each horn of the gonads exhibits 12 to 14 genital sacs.

Color black or dark brown, rarely reddish-brown or yellowish-brown.

Found upon the northern Atlantic coasts of Europe and upon the coast of Greenland. It occurs on the New England coast north of Cape Cod, but is very rare.

(?) Genus CRATERLOPHUS Clark, 1863.

Craterlophus, Clark, 1863, Journal Boston Soc. Nat. Hist., vol. 7, p. 539.—Haeckel, 1880, Syst. der Medusen, p. 394.—Gross, 1900, Jena Zeit. für Naturwissen, Bd. 33, p. 614.—Maas, 1906, Fauna Arctica, Arktischen Medusen, Bd. 4, Lfg. 3, p. 500.

The type species is *Craterlophus tethys* of Helgoland, German Ocean.

GENERIC CHARACTERS.

Stauromedusæ with 8 adradial lobes and with 4 perradial gastrogenital pouches in the subumbrella wall of the 4 perradial stomach-pouches as in the Cleistocarpidæ. Without perradial or interradial marginal anchors or marginal papillæ. The peduncle is 4-chambered.

According to Antipa, and Gross, this medusa may sometimes have 8 small tentacles, 4 perradial and 4 interradial, in the places of the anchors of other Stauromedusæ. It is probable, therefore, that *Craterlophus* is actually identical with *Halimocyathus*.

Craterlophus tethys Clark.

Lucernaria sp., Mettenheimer, 1854, Abhandl. Senckenberg, Naturf. Ges. Frankfurt, p. 15, taf. 1, fign. 5–11.
Craterlophus tethys, Clark, H. J., 1863, Journal Boston Soc. Nat. Hist., vol. 7, p. 540.—Kling, 1879, Morpholog. Jahrb., Bd. 5, p. 141, taf. 9–11.—Hertwig, 1879, Jena. Zeitschr. für Naturw., Bd. 13, p. 613, taf. 9, fign. 7–12.—Haeckel, 1880, Syst. der Medusen, p. 395.—Claus, 1883, Untersuch, über Organisation und Entwick. Medusen, p. 35.—Antipa, 1892, Zool. Jahrb., Abth. Syst., Bd. 6, p. 392 (aboral medusa).—Gross, 1900, Jena. Zeit. für Naturw., Bd. 33, p. 614, taf. 23, 24 (anatomy).—Kassianow, 1901, Zeit. für wissen. Zool., Bd. 69, pp. 299, 372, taf. 22, 24, 25.

Bell deep goblet-shaped, higher than wide, 15 to 25 mm. wide, and 25 to 30 mm. high, including peduncle. Peduncle short, 4-sided, prismatic, and 4-chambered, one-fourth to one-third as long as bell-height. Peduncle without longitudinal muscles. The 8 adradial arms are short, wide, and 45° apart. 60 to 80 knobbed tentacles upon each arm. There are normally no marginal anchors, although Antipa, 1892, and Gross, 1900, record abnormal specimens with 8 small tentacles, 4 perradial and 4 interradial.

The 8 gonads present the appearance of a 4-leaved cross, in the axes of which lie the 4 perradial, mesogonial pouches. The 8 arms of the gonads approach pair-wise and extend under the subumbrella from base of throat-tube to bell-margin with their proximal ends nearly touching. Each arm of the gonads has 10 to 16 feathery sinuosities and very numerous saccules.

Color variable, as in most of the Stauromedusæ, being olive-green, yellowish, reddish-brown, or dark brown.

This form is found at Helgoland, German Ocean, where it lives upon the west coast of the island upon *Ulva*, *Chorda*, or *Fucus*. Gross, 1900, gives the best description of its internal anatomy. Kassianow, 1901 (p. 371), finds that if *Craterlophus tethys* be cut longitudinally from the oral pole to the middle of the peduncle, each half regenerates a new individual. If, however, the cut be not so deep the edges grow together and restore the former individual although the scar remains as a constriction upon the bell and pharynx. He also reports the finding of specimens of this medusa with more than 8 marginal lobes.

Craterlophus is imperfectly separated from *Halimocyathus*, bearing the same relation to it that *Lucernaria* does to *Haliclystus*. We may, however, retain these generic names mainly as a matter of convenience. In both *Craterlophus* and *Lucernaria* the perradial and interradial tentacles or anchors are commonly absent, but occasionally they appear as an abnormality and in such cases the medusæ can not be separated from *Halimocyathus* and *Haliclystus* respectively.

Craterlophus macrocystis von Lendenfeld.

Craterlophus macrocystis, von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 165; 1887, Australian Museum Descript. Catalogue Medusæ Australian Seas, part 1, p. 13.

Umbrella deep and bell-shaped, 12 mm. high, 6 mm. wide. Stalk 8 mm. high and 3 mm. wide when extended. 8 short arms 45° apart, each with a cluster of about 30 tentacles. Gonads feathery, as in *C. tethys*. Color dark olive-green. East coast of New Zealand on *Macrocystis*. Rare.

The stalk of *C. macroscystis* is two-thirds as long as the bell, whereas in *C. tethys* it is only one-fourth to one-third of this length. In other respects it resembles the very closely allied *C. tethys* with which it may prove to be identical.

Genus CAPRIA Antipa, 1893.

Capria, Antipa, 1893, Mitth. Zool. Sta. Neapel, Bd. 10, p. 628.

The type species is *Capria sturdzii* Antipa, from the Island of Capri, Bay of Naples, Italy.

GENERIC CHARACTERS.

Stauromedusæ with 8 adradial, lappet-like arms which lack knobbed tentacles, but are each provided with a row of short, webbed, tooth-like or finger-shaped tentacles. Wart-like clusters of nematocysts on subumbrella side of each of the 8 arms. No perradial or interradial tentacles or "anchors." The circular muscle of the subumbrella is entire, not divided into 8 isolated marginal muscles. The radial-muscle is funnel-shaped and spreads over the entire surface of the subumbrella. The 4 septal edges of the perradial stomach-pouches extend nearly to the bell-margin, where they are pierced by the ring-canal. There is a long throat-tube, 8 adradial gonads, and an aboral stalk to the bell serving for attachment.

The genus *Capria* is the only representative of the family Capriidæ of Antipa, 1893, which may be defined as Stauromedusæ with 8 adradial arms which lack knobbed tentacles, but have each a row of rudimentary tentacles joined by a web, one to the other. No anchors. Ring-muscles of the subumbrella entire, not separated into 8 isolated sectors. Longitudinal muscles equally developed over the entire subumbrella. Bell provided with an aboral stalk for attachment. Stomach with 4 simple, perradial pouches as in Eleutherocarpidæ.

Capria sturdzii Antipa.

Capria sturdzii, Antipa, 1893, Mitth. Zool. Sta. Neapel, Bd. 10, p. 168, taf. 40, fign. 1–18.

Body 9 mm. long and 5.5 to 6 mm. wide; globular with a short, broad basal stalk or peduncle about as long as the bell-portion itself. Basal plate of peduncle or stalk of bell broad and flat and single-chambered, resembling a suctorial disk. There appear to be normally 8 short, thick, adradial, paddle-like arms, although the single specimen found had 10 arms; these are hollow and devoid of knobbed tentacles, but are provided with a row of 16 to 20 tooth-like, or short finger-shaped, rudimentary tentacles which are fused one to another by a web, thus giving the appearance of a multi-toed, bird-like web-foot. There are 5 to 8 large clusters of nematocysts on the subumbrella side of each of the 8 arms. There are no "anchors" or suctorial tentacles, but the spaces around the bell-margin between the 8 arms are open and somewhat less in width than are the arms themselves. The circular muscle of the subumbrella is entire, not cut into 8 isolated muscles, as in certain other Stauromedusæ. There are 4 rows of gastric filaments along the 4 interradial tæniolæ from the middle of the central stomach nearly to the foot-plate. Mouth-tube long, prismatic, 4-sided, with 4 interradial, longitudinal furrows. Mouth-opening cruciform and quadratic. 8 band-shaped gonads, above (aboral in reference to) the tæniolæ. Color yellowish-white.

Found attached to a *Serpula* tube dredged from a depth of 40 fathoms near the Blue Grotto, Island of Capri, Bay of Naples. It is described in detail by Antipa.

Genus LIPKEA Vogt, 1886.

Lipkea, Vogt, 1886, Archiv. Sci. Phys. et Nat. Génève, sér. 3, tome 16, p. 356.

The type species is *Lipkea ruspoliana* Vogt, from the coast of Sardinia, Mediterranean.

GENERIC CHARACTERS.

Stauromedusæ with 8 hollow (4 perradial and 4 interradial) arms. With a continuous circular muscle. Neither tentacles nor "anchors." There are well-developed mucous glands upon the subumbrella. The bell is attached by a sucker.

The only known species is described from a single specimen found attached to a *Gorgonian* at a depth of 50 fathoms off the Sardinian coast, Mediterranean. It is the only Stauromedusa having perradial and interradial marginal lobes, and Vogt places it in a new family, the Lipkeidæ.

Lipkea ruspoliana Vogt.

Lipkea ruspoliana, Vogt, 1887, Mém. Inst. Nat. Génèvois, tome 17, 53 pp., plates 10, 11, figs. 1-17; 1886, Arch. Sci. Physique et Naturelles, Génève, sér. 3, tome 16, p. 356.

Bell flat and soup-tureen-shaped with a very short basal stalk, by means of which the animal is attached. Bell 7 to 8 mm. wide, 4 mm. high, the basal stalk only 1.5 mm. long and 4 mm. wide. 8 short, blunt, hollow, marginal lappets, 4 perradial and 4 interradial in position. These lappets have plain, evenly rounded margins, and on their inner (centripetal) sides are about 15 to 20 large, oval mucous glands (containing nematocysts?), the openings of which are scattered over the inner surface of each lappet. Subumbrella concave, but the central mouth is elevated and bordered by 4 cruciform lips. The 4 deep, conical (subgenital?) ostia are interradial and alternate with the lips in position. Thus 4 of the 8 lappets are in the radii of the lips and 4 others are in the radii of the (subgenital?) ostia. Ring-muscle entire, not divided into sectors, and extends around margin of subumbrella at bases of the 8 lappets. Longitudinal muscle-fibers extend radially outward from this powerful ring-muscle along the subumbrella faces of the 8 lappets. There are also a few weak, longitudinal muscles in the exumbrella near the stalk. There are neither tentacles, "anchors," nor other marginal appendages.

There are conspicuous clusters of gland cells in the ectoderm of the subumbrella. 4 large clusters are perradial in position and lie at the base of the 4 angles of the cruciform mouth-tube. There are also 8 linear clusters of these glands at the bases of the 8 lappets on the inner side of the ring-muscle. Central stomach divided by 4 interradial septa into 4 perradial chambers. These septa do not extend into the cavities of the 4 interradial lappets, so that the perradial chambers of the stomach communicate one with another through the cavities of these lappets. Stalk single-chambered.

No genital products were observed in the folded, membranous floors of the 4 (subgenital?) interradial ostia, but 4 pairs of branched, gastric filaments arise from the edges of the 4 interradial septa at base of œsophagus. It would seem that the medusa was immature and that the folded, follicular organs under the 4 ostia in the 4 interradii of the stomach are destined to develop the sexual products.

Medusa translucent to milky in color and the clusters of nematocysts on the subumbrella are yellow.

A single (immature?) specimen was found by Vogt attached to a *Gorgonian* at a depth of 50 fathoms at Alghero on the northeast coast of Sardinia, Mediterranean. Vogt describes the specimen in detail.

Order CORONATÆ Vanhöffen, 1892.

Discomedusæ (in part), Haeckel, 1866, Generelle Morphologie, Bd. 2, p. 60; 1880, Syst. der Medusen, p. 450.
Coronatæ, Vanhöffen, 1892, Ergeb. der Plankton Exped., Bd. 2, K. c., p. 21; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., Dampfer *Valdivia*, Bd. 3, Lief. 1, p. 51; 1906, Nordisches Plankton, Acraspede Medusen, Nr. 11, p. 41.
Coronata, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 5; 1907, Ergeb. Fortschritte der Zool., Bd. 1, pp. 191, 199.—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 20.

CHARACTERS OF THE CORONATÆ.

Scyphomedusæ with marginal tentacles, a single central mouth-opening, and with the bell-margin cleft into lappets. The rhopalia arise from clefts between these lappets, and their entodermal cores contain a terminal mass of crystalline concretions of entodermal origin. Ocelli may or may not be present. The medusæ are free-swimming and have no aboral stalk for attachment.

With a circular, or coronal, furrow in the exumbrella, and peripheral to this there is a zone of gelatinous thickenings in the radii of the tentacles and sense-organs. These thickenings, or pedalia, are divided one from another by radiating clefts which alternate in position with the marginal sense-organs and the tentacles, and are in the middle (axial) lines of the marginal lappets. These marginal lappets project beyond the zone of the pedalia. The tentacles are solid, or not hollow, throughout their lengths. The throat-tube is simple, short, and provided with simple lips, without curtain-like appendages.

The families of the Coronatæ are as follows:

Periphyllidæ Claus, 1886. 4 interradial rhopalia and 4 or more tentacles.
Paraphyllinidæ Maas, 1903. 4 perradial rhopalia and 4 or more tentacles.
Ephyropsidæ Claus, 1883. 8 rhopalia (4 perradial and 4 interradial) and 8 or more tentacles.
Collaspidæ Haeckel, 1880. Numerous rhopalia, alternating with an equal number of tentacles.
Atorellidæ Vanhöffen, 1902. With 6 rhopalia and 6 tentacles.

Family PERIPHYLLIDÆ sensu Claus, 1886.

Peromedusæ (in part), Haeckel, 1880, Syst. der Medusen, p. 396.
Periphyllidæ, Claus, 1886, Class. der Medusen, Arbeit. Zool. Inst. Univ. Wien, Bd. 7, pp. 97-110.—Vanhöffen, 1892, Akalephen der Plankton Expedition, Bd. 2, K. d., p. 21.—Maas, 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, No. 1, p. 28; 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 501.—Vanhöffen, 1906, Nordisches Plankton, No. 11, Acraspede Medusen, p. 41.—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 23.
Peromedusæ, von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 166.

FAMILY CHARACTERS.

Coronatæ with 4 interradial pedalia which bear marginal sense-clubs, and with 4, or more, pedalia which bear tentacles.

The genera of the Periphyllidæ are as follows:

Pericolpa Haeckel, 1880, *sensu* Vanhöffen, 1902. With 4 perradial tentacles, 8 adradial lappets, 8 gonads.
Periphylla Steenstrup, 1837. With (4 × 3) 12 tentacles, 4 perradial, 8 adradial. 16 lappets, 8 gonads.
Periphyllopsis Vanhöffen, 1900. With (4 × 5) 20 tentacles, 24 lappets.
(?) *Nauphantopsis* Fewkes, 1885; *sensu* Vanhöffen, 1902. With (4 × 7) 28 tentacles, 32 lappets.

Genus PERICOLPA Haeckel sensu Vanhöffen.

Pericolpa+Pericrypta, Haeckel, 1880, Syst. der Medusen, pp. 413, 414, 640.
Pericolpa, Vanhöffen, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., *Valdivia*, Bd. 3, Lfg. 1, p. 50.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 12; 1906, Die Arktischen Medusen, Fauna Arctica, Bd. 4, p. 502.

GENERIC CHARACTERS.

Periphyllidæ with 4 interradial rhopalia, 4 perradial tentacles, 8 adradial lappets. The 8 gonads are adradial or on both sides of the 4 interradii.

Haeckel's *Pericrypta* is doubtless only a more advanced stage in the growth of *Pericolpa*. The interradial tæniolæ are solid in the young, but become hollowed by the development of 4 pits in the floor of the subumbrella, and the gastral filaments increase with age. In the structure of the gastrovascular system this genus resembles *Periphylla*, and were it not for the probability that the number of metameres apparently does not increase in the free ephyræ

of the Coronatæ we would be inclined to regard *Pericolpa* as being only the young of *Periphylla;* for the development of 8 adradial lappets and 8 corresponding tentacles would change the medusa to *Periphylla*.

The species founded by Haeckel are separated upon slight distinctions, some of which represent mere stages in growth. Probably there are but two forms, *P. quadrigata* with an elongate, pointed bell and *P. campana* with a flat, dome-like bell; but even this can not now be determined with any degree of certainty.

This genus includes the simplest and possibly most primitive of the Periphyllidæ.

Pericolpa quadrigata Haeckel.

Pericolpa quadrigata, HAECKEL, 1880, Syst. der Medusen, p. 413, taf. 23, fign. 1–12; *P. galea, Ibid.*, p. 414; (?) *P. tetralina*, p. 640.—MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 12.

Bell 40 mm. high and 30 mm. wide. The pointed, dome-like apical half of the exumbrella above the ring-furrow is as high as the width of the pedal and lappet-zone below. The 4 perradial tentacular pedalia are somewhat wider than the 4 interradial, rhopalar ones and somewhat longer than the 8 marginal lappets. The 4 tentacles are about as long as bell-height. Throat-tube and stomach wide, filling the greater part of bell-cavity. The basal part of the stomach leads into the gastrovascular space of bell by 4 perradial ostia, which are lined with gastral filaments. These ostia lead into a wide sinus which is interrupted by 4 short, partial septa in the interradii. Peripheral to these septa is another wide ring-sinus which sends out 8 canals in the radii of the sense-organs and tentacles. These radiating canals fork at their ends and extend around the edges of the lappets, forming a marginal ring-canal. The 8 gonads are grouped in 4 pairs on either sides of the interradii. Their inner ends are close together but they diverge outwardly. Color (?)

Found in the Antarctic, southeast of Kerguelen Island by the *Challenger*, and apparently identical with *P. galia* from the east coast of Australia.

Pericolpa campana Maas.

Pericrypta campana, HAECKEL, 1880, Syst. der Medusen, p. 414.
Pericolpa campana, MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 13, taf. 3, fign. 19–22.

Bell about 15 mm. high and 15 mm. wide, with thick gelatinous walls. A deep ring-furrow around exumbrella separates the evenly rounded dome-like center of bell from marginal zone of lappets. The 8 clefts between the 8 pedalia are also very deep. The 4 tentacular pedalia are nearly similar in size to the 4 pedalia of the sense-organs. The 4 tentacles are tapering and shorter than bell-radius. They are solid and their axial cores project into the gelatinous substance. These tentacles are situated in the perradii. Each of the 4 interradial marginal sense-clubs contains a terminal entodermal concretion and a ventral bulbular swelling, but no ocellus. The 8 marginal lappets are semicircular.

Stomach wide at base, and there are 4 interradial clusters, each with at least 30 gastric cirri. The stomach is connected with the gastrovascular space of the bell by 4 perradial openings. Peripheral to these there is a wide ring-sinus and this in turn gives rise to 8 radiating canals in the radii of the tentacles and sense-organs, and these fork and communicate one with another at their outer ends, forming a marginal ring-canal. The circular muscles of the subumbrella are well developed and there are radial-muscle strands near the bases of the tentacles. There appear to be 8 gonads. Maas records 7 of them irregularly arranged in a zone at middle of subumbrella, and Haeckel's specimen was so poorly preserved that he does not record the character of the gonads. Color (?)

Haeckel's specimen came from the region of New Zealand, while Maas records one from the Malay Archipelago, where it was obtained in a vertical net hauled from a depth of 500 fathoms in 17.6′ S. lat., 129° 14.5′ E. long.

This medusa is distinguished by its oval gonads.

Pericolpa tetralina Haeckel.

Pericolpa tetralina, HAECKEL, 1880, Syst. der Medusen, p. 640.

This medusa is probably identical with *P. quadrigata*, but both ends of the 8 gonads diverge from the 4 interradii, while in *P. quadrigata* only the outer ends diverge and the inner

ends approach one another closely. The medusa is very briefly mentioned by Haeckel and appears to be immature, being only 20 mm. high and 16 mm. wide. Found off the south coast of Australia. Described by Haeckel from a single preserved specimen.

Genus PERIPHYLLA Steenstrup, 1837.

Periphylla, STEENSTRUP, 1837, Acta et Cat. Mus. Hafniensis.—HAECKEL, 1880, Syst. der Medusen, p. 418; 1881, Deep-sea Medusæ *Challenger* Report, Zool., vol. 4, p. 63.—CLAUS, 1886, Arbeit. Zool. Inst. Univ. Wien, Bd. 7, p. 99.—VANHÖFFEN, 1892, Ergeb. der Plankton Exped., Bd. 2, K. d., pp. 4, 6, 21.—VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 168.—MAAS, 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, No. 1, pp. 28–64; 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 44; 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 5; 1907, Ergeb. Fortschritte der Zool., Bd. 1, pp. 199, 219, etc.—VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 21; 1906, Nordisches Plankton, Nr. 11, p. 41.—BIGELOW, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 24.
Periphema, HAECKEL, 1881, Deep-sea Medusæ *Challenger* Exped., p. 84.

GENERIC CHARACTERS.

Periphyllidæ with 4 interradial rhopalia, 12 tentacles, 4 perradial and 8 adradial. 16 marginal lappets grouped into 4 pairs of rhopalar and 4 pairs of tentacular lappets. A deep annular furrow separates the dome-like apex of the exumbrella from marginal zone of bell. Between this ring-furrow and the lappets is a zone of 16 pedalia, 12 in the tentacular and 4 in the rhopalar radii, and these are separated one from another by 16 deep, radiating clefts, which extend down the mid-axial lines of the lappets. There are 4 deep, interradial subgenital pits in the floor of the subumbrella, lined along their edges by rows of internal gastric cirri. The large central stomach extends peripherally outward into the subumbrella in the 4 perradii. These 4 openings lead into a wide ring-sinus in the subumbrella which in turn sends out a radiating vessel in the radius of each tentacle and rhopalium, 16 in all. These vessels fork before reaching the tentacles or rhopalia, and their diverging ends curve around the edges of the lappets and form a marginal ring-canal.

The 4 interradial septa are bordered by lines of gastric cirri and there are 8 U-shaped adradial gonads, one on either side of each septum. The free ends of each gonad are directed inward toward the stomach, and their convexities point outward toward the bell-margin. The rhopalia have no ocelli, but contain a proximal mass of entodermal pigment and a distal concretion.

The medusæ of *Periphylla* are deep-sea forms of very wide distribution. The so-called species are not well separated, being based on the relative height and width of the bell and on slight color distinctions. The bell appears to become relatively flatter as growth proceeds, and therefore its proportions would seem to afford a poor criterion for specific distinctions. Both Vanhöffen, 1902, and Maas, 1904, recognize but 3 species as follows:

P. hyacinthina with high, narrow bell, its height being to width as 44 to 23. The lappet pouches are dark-brown, so that the gonads can not be seen through them from the outside.
P. dodecabostrycha with bell flat, bluntly pointed, its height being to width as 27 to 18. Gonads visible through the lappets from the outside.
P. regina with dome-like rounded bell and light red-brown color.
Periphylla "mirabilis," Haeckel, appears to be identical with *P. regina;* and *P. "humilis,"* Fewkes, appears to be an imperfect *P. dodecabostrycha*. *P. peronii*, Haeckel=*Charybdea periphylla*, Péron et Lesueur, 1809, p. 332, is too imperfectly known to be classified.

I think it probable that there is but a single species of *Periphylla* (*P. hyacinthina*), and that *P. dodecabostrycha* and *P. regina* are only varieties or local races. It is impracticable to attempt to separate species upon slight differences of form or proportions in their bells especially when such characters are subject to constant changes due to growth or to state of contraction. Bigelow, 1909, who has studied many specimens of these medusæ, concludes that *P. hyacinthina* and *P. dodecabostrycha* are identical.

Peripalma corona of Haeckel, 1880 (Sitzungsber. Jena. Gesell. für Med. und Naturw. Jahrg. 1880, Feb. 20; Syst. der Medusen, p. 418), is probably a young *Periphylla*. Haeckel states that the genus is characterized by the absence of interradial pits or perradial concavities in the subumbrella, and that the 4 interradial tæniolæ of the basal stomach are solid ligaments without gastral filaments.

A single specimen was found by Haeckel at Algeciras in the Straits of Gibraltar. He states that owing to the general transparency of the specimen and to its smallness he is able to describe it only through reference to the larger species of *Periphylla* found by the *Challenger* expedition. He states that the bell is 30 mm. high, 20 mm. wide, helmet-shaped. The pedal zone nearly as wide as the lappet-zone. The 16 pedalia are of not quite equal size each to each. The 16 lappets tongue-shaped, sharp-pointed, the 8 tentacular more projecting than the 8 rhopalar lappets. 12 tentacles as long as the bell-height and one-third as wide as the lappets at their bases. Basal, central, and buccal stomachs of nearly equal length.

Color violet, bell more red, tentacles and throat-tube more blue, gonads dark-red.

Periphylla hyacinthina Steenstrup.

Periphylla hyacinthina, Steenstrup, 1837, Acta Mus. Hafniensis.—Haeckel, 1880, Syst. der Medusen, p. 419, taf. 24, fign. 11–16.—Fewkes, 1886, Report Commiss. Fish and Fisheries U. S. A., for 1884, p. 930.—Claus, 1886, Arbeit. Zool. Inst. der Univ. Wien., Bd. 7, p. 99, fig. 1, p. 100.—Agassiz, A., 1888, Bull. Mus. Comp. Zool. at Harvard College, vol. 15, p. 131, fig. 426.—Vanhöffen, 1891, Zool. Anzeiger, Jahrg. 14, p. 38; 1908, Deutsch. Südpolar Expedition, 1901–03, Bd. 10, Zool. 2, p. 36; 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 6, taf. 1, fign. 1–10; taf. 2, fign. 3–8; taf. 3, fign. 1–7; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 23; 1906, Nordisches Plankton, Nr. 11, p. 42, fig. 1.—Browne, 1903, Bergens Museums Aarbog, No. 4, p. 30.—Maas, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 47, plate 5, fig. 35; planche 6, figs. 45–46; 1906, Fauna Arctica, Bd. 4, Lfg. 3, pp. 502, 511 (review of literature).—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 26, plates 1 and 9.

Charybdea hyacinthina, Steenstrup, 1842, Acta Mus. Hafniensis.

The following description applies to the typical *P. hyacinthina*.

This so-called species is distinguished by its high, narrow bell, the ratio of height to width being usually about as 44 is to 23. The lappet-pouches are so densely pigmented with dark purple-brown that the gonads can not be seen through them from the outside.

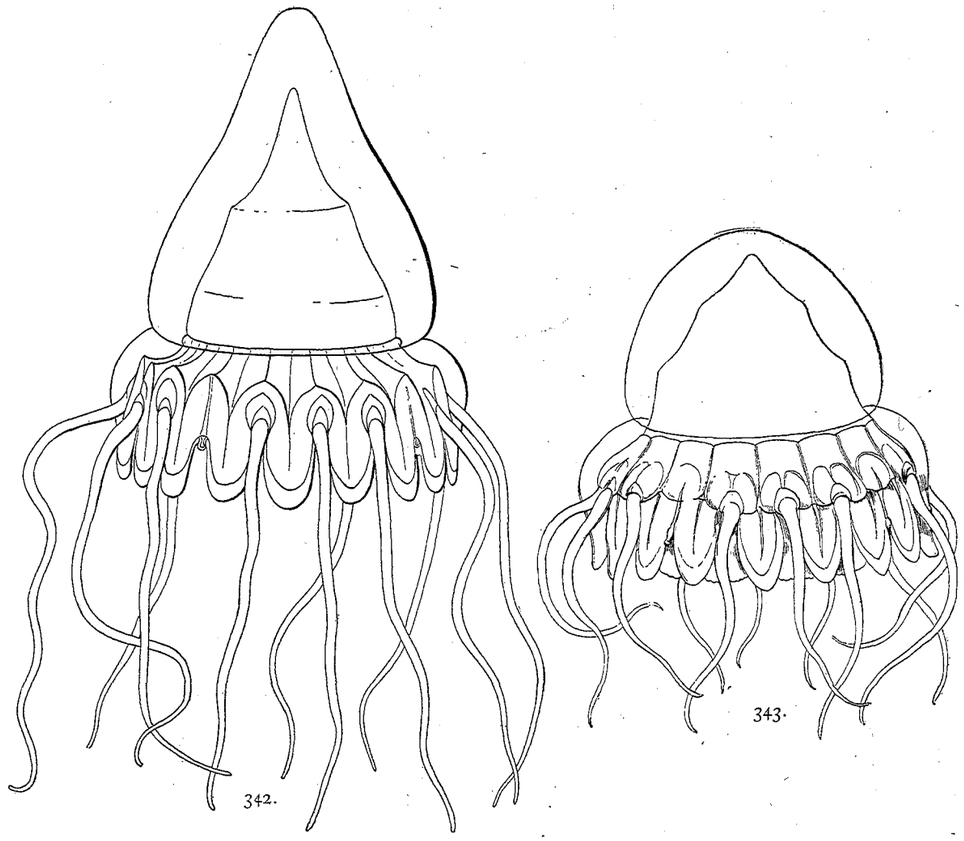
Bell 80 mm. high and about 42 mm. wide, but it may be much flatter and wider (see fig. 343). The upper, or aboral, half of the exumbrella is dome-shaped or pyriform with a smooth external surface. Just below this dome is a deep horizontal circular constriction which is occupied by circular muscle-fibers. Below this constriction the exumbrella flares slightly outward, and in this region we may distinguish an upper pedal-zone and a lower lappet-zone. The pedal-zone is divided by 16 deep, longitudinal furrows into the same number of projecting, wedge-like thickenings, the pedalia. The 4 interradial pedalia are smaller than the others and lie in the radii of the 4 marginal sense-organs; while the 12 perradial and adradial pedalia are situated in the radii of the tentacles.

There are 16 well-developed marginal lobes, arranged in 8 pairs. 16 deep longitudinal furrows lie in the mid-radial lines of the lappets and separate the 16 pedalia, so that a furrow extends about two-thirds the distance down the exumbrella surface of each marginal lappet. The 4 interradial rhopalar clefts between the lobes are only about two-thirds as deep as the 12 tentacular clefts. Each sense-organ contains a proximal mass of dark-brown entodermal pigment and a distal concretion, which is protected by an aboral fold forming a niche for its protection.

The 12 tentacles are equally developed and are each a little longer than the bell-height. They are solid and are provided with well-developed, longitudinal muscle-fibers. In the cavity of the subumbrella 4 long, funnel-shaped, interradial pits extend inwardly along the sides of the central stomach nearly to the aboral apex, where their points do not quite touch. There is a well-developed zone of circular muscle-fibers in the subumbrella just above the bases of the tentacles and sense-organs. This zone is divided by 16 longitudinal selvages into 16 distinct parts; each selvage extends down the middle of a lappet, and thus the adjoining halves of each pair of adjacent lappets are connected by the circular muscles. Besides the circular muscles, 8 well-developed, longitudinal muscle-strands lie in the inner, or proximal, part of the subumbrella wall; 4 of these are perradial and 4 interradial. They are deltoid in shape, their broad bases extending out into the distal part of the subumbrella, to the upper part of the zone of circular muscle-fibers. There are 8 U-shaped gonads which are on both sides of the 4 interradial septa, with their convexities directed outward; thus they appear to be adradial in position and alternate with the 8 longitudinal muscles of the inner part of the subumbrella.

The stomach extends from the inner apex of the subumbrella to about the level of bell-margin. Its cavity may be divided into 3 regions, which we may designate, respectively

as the basal, central, and buccal stomach. The central stomach is a 4-sided prism, the sides being interradial and the angles perradial in position. The lower or buccal part of the stomach hangs freely in the cavity of the bell, being joined to the subumbrella at 4 perradially situated points at its inner end. There are 4 longitudinal, interradial, thickened regions in the wall of the buccal stomach, which extend downward to the mouth-opening. The central stomach is a wide cavity which communicates by 4 perradial openings with the gastrovascular space of the subumbrella of the medusa. These 4 openings are narrow, elongate, longitudinal clefts, and their edges are lined with numerous gastric cirri which project into the space of



Periphylla hyacinthina.

Fig. 342.—After Vanhöffen, in *Valdivia* Expedition.
Fig. 343.—After Vanhöffen, in Nordisches Plankton.
Showing variation in shape of bell.

the stomach. The basal stomach is a 4-sided pyramid and 8 rows of gastric cirri extend up the 4 sides near the angles to the apex of the pyramid where they meet. These rows of cirri are continuous with those surrounding the 4 perradial side-openings of the central stomach. The gastrovascular coronal sinus of the subumbrella is thus connected with that of the stomach by the 4 perradially situated ostia of the central stomach. These open into this wide annular cavity which occupies the mid-region of the subumbrella above the zone of circular muscles. Below these, however, it appears as a broad, simple, annular space, which extends outward

into the 16 marginal lappets. A partial septum extends, however, down the midline of each lappet, and the gastrovascular space forms a marginal ring-canal around these septa. Diverticula of the annular space also extend for a short distance into the bases of the tentacles, but the main entodermal cores of the tentacles are solid. A good idea of the structure of the gastrovascular cavity of the bell may be obtained from Vanhöffen's figure 3, taf. 1, in "Ergeb. der Plankton Expedition," Bd. 2, K. d.

The inner surface of the subumbrella is purple, while the pedalia are copper-brown colored and the tentacles and lappets are of a milky-blue translucency. The gonads can not be seen through the densely pigmented bell-walls.

This deep-sea medusa is occasionally found upon the surface in the colder parts of the North Atlantic. It has been taken in the Bay of Biscay; at the Azores; off Cape Hatteras, North Carolina; at Martha's Vineyard; at Spitzbergen, and still more commonly off the coast of Greenland, but its true habitat is undoubtedly in the deep sea, at or near the bottom. Nearly all recent deep-sea expeditions record it, and the *Valdivia* found it in both the Atlantic and Indian Oceans. The best descriptions are those of Vanhöffen and Maas.

Haeckel states that the bell of this medusa may become 160 mm. high and 120 mm. wide, but later observers have not seen specimens of such great size.

Periphylla hyacinthina forma dodecabostrycha.

Chrysaora (dodecabostrycha) dubia, Brandt, 1838, Mém. Acad. Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 387, taf. 29, 30.
Periphylla dodecabostrycha, Haeckel, 1880, Syst. der Medusen, p. 421.—Vanhöffen, 1892, Ergeb. der Plankton Exped., Bd. 2, K. d., taf. 2, fign. 1, 2; 1908, deutsche Südpolar Expedition 1901–1903, Bd. 10, Zool. 2, p. 35; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., *Valdivia*, Bd. 3, pp. 21, 23.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 6, taf. 2, fig. 15; taf. 12, fig. 107 (figure of *rhopalium*); 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 47, planche 5, figs. 36, 37; 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, p. 64, taf. 11, fig. 1.—Mayer, 1906, Bull. U. S. Fish Commiss. for 1903, vol. 23, part 3, p. 1136, plate 3, figs. 5, 6.
non Periphylla dodecabostrycha, Lobianco, 1903, Mitth. Zool. Sta. Neapel, Bd. 16, p. 219, taf. 7, fig. 3 (this is a *Paraphyllina*).
(?) *Periphylla humilis*, Fewkes, 1886, Report Commiss. Fish and Fisheries U. S. A., for 1884, p. 931.

Bell higher than wide in young, wider than high in well-grown medusæ. Thus when the medusa is 50 mm. wide the bell is 55 mm. high; when 45 mm. wide it is 45 high; and when 100 mm. wide it is 70 mm. high.

The gonads may usually be seen through the gelatinous walls of the bell, but not so clearly in old as in young specimens. Thus the bell is said to be lower, flatter, and less pointed than in *P. hyacinthina*, and the bell-walls are more transparent.

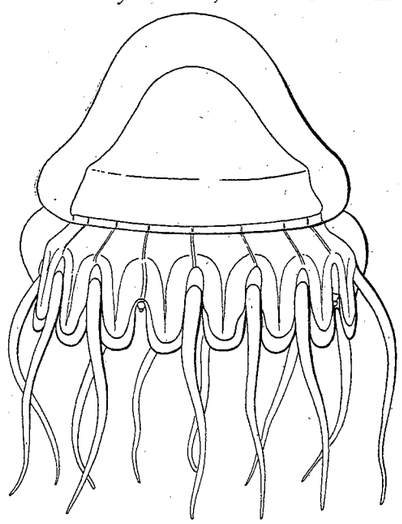


Fig. 344.—*Periphylla regina*, after Vanhöffen, in Tiefsee Expedition *Valdivia*.

Widely distributed over the floor of the great oceans, and especially in tropical parts of the Pacific, west coast of Mexico, coast of Chile, Hawaiian Islands, Philippine Islands, Indian Ocean, Malay Archipelago, Mediterranean, Guinea Stream off Atlantic coast of Africa.

It is probably only a variety of, or even only a growth-stage of, *P. hyacinthina*.

Periphylla hyacinthina forma regina.

Periphylla regina, Haeckel, 1880, Syst. der Medusen, p. 421; 1881, Deep-sea Medusæ *Challenger* Exped. Report, Zool., vol. 4, p. 85, plates 24, 25.—Maas, 1897, Mem. Museum. Comp. Zool. at Harvard College, vol. 21, pp. 29, 64, taf. 10, 1 fig.; 1903, Scyphomedusen *Siboga* Exped., p. 6.—Vanhöffen, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., *Valdivia*, Bd. 3, Lief. 1, pp. 21, 23; 1908, deutsche Südpolar Expedition, 1901–1903, Bd. 10, Zool. 2, p. 36.
Periphylla mirabilis, Haeckel, 1880, Syst. der Medusen, p. 442; 1881, *Challenger* Exped. Report, Zool., vol. 4, p. 64, plates 18–23, 40 figs.

This appears to be merely a light violet or rusty-reddish variety of *P. hyacinthina*. Bell usually low, dome-like, about 150 mm. wide, and nearly 1.5 times as wide as high, but Haeckel

records a specimen fully as high as wide. According to him, the pedalia are rectangular and longer than wide, but according to Maas, 1897, they are nearly circular in outline. The tentacles are said to be short and thick, and the stomach very large and wide, but these points as well as the proportions of the bell, are probably affected largely by growth and contraction.

Found on the bottom of the Pacific and Atlantic from the Antarctic regions to the tropics.

It is the largest form of *Periphylla* and may become 200 mm. wide.

Genus PERIPHYLLOPSIS Vanhöffen, 1900.

Periphyllopsis, Vanhöffen, 1900, Zool. Anzeiger, Bd. 23, p. 278; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., *Valdivia*, Bd. 3, Lfg. 1, p. 27.—Maas, 1907, Ergeb. und Fortschritte der Zool., Bd. 1, p. 195.—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 27.

The type species is *Periphyllopsis braueri* Vanhöffen, of the Indian Ocean; from a depth of 1,200 fathoms.

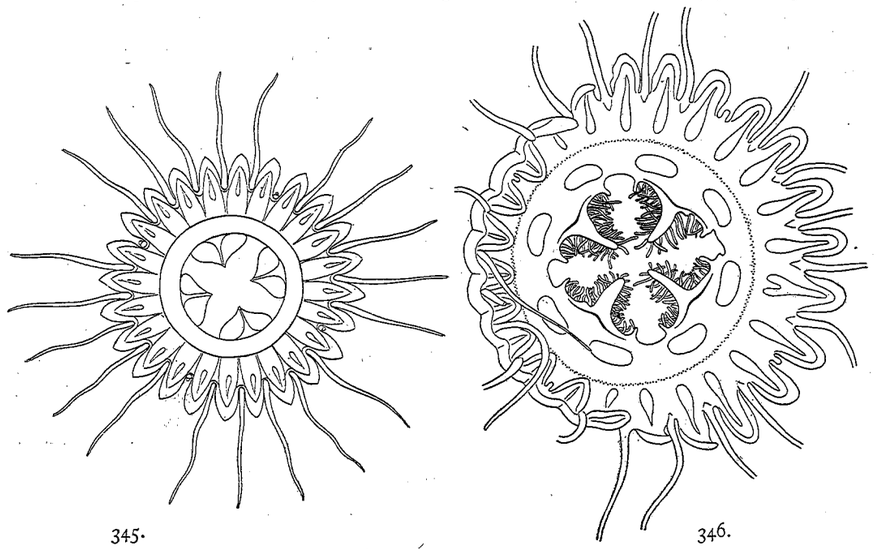
GENERIC CHARACTERS.

4 interradial rhopalia, 4×5 (20) tentacles, 4×6 (24) lappets.

Periphyllopsis braueri Vanhöffen.

Periphyllopsis braueri, Vanhöffen, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 27, taf. 2, fig. 7.—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 28, plates 9 and 12.

Vanhöffen's single specimen was so imperfect that he could not venture to present a detailed description of it. Recently, however, Bigelow describes a more nearly perfect specimen



345. 346.

Periphyllopsis braueri.

Fig. 345.—After Vanhöffen, in *Valdivia* Expedition. Aboral view of bell.
Fig. 346.—With the walls of the stomach torn away leaving only its base with the gastric cirri.
After H. B. Bigelow, in Mem. Museum Comp. Zool. at Harvard College, 1909.

from the collections of the *Albatross*, and the account here given is mainly derived from his description.

Bell flattened, 60 mm. wide and 25 mm. high, resembling an *Atolla* in shape. Central disk about 50 mm. wide; ring-furrow deep. 4 interradial rhopalia, 24 (4×6) ovate marginal lappets, and 20 (4×5) tapering tentacles, about as long as the bell-diameter. Thus the radial arrangement of the various organs is the same as is seen in *Periphylla*, only the numbers of lappets and tentacles being greater. The ring-muscle of the subumbrella is very weak as in

Atorella. The peripheral canal-system resembles that of *Periphylla*. The central stomach opens into a wide ring-sinus by 4 perradial ostia separated by 4 interradial septa. The ring-sinus is about 10 mm. broad and is at the zone of the gonads. On its outer side it gives off 24 broad, spoke-like radial-canals in the radii of the rhopalia and tentacles, and these canals are connected one with another by a festoon ring-canal at the margin, extending in loops around the lappet margins. There are 8 oval gonads, adradial in position and equidistant one from another. The mouth parts were lost in both Vanhöffen's and Bigelow's specimens, but there are about 80 to 100 simple gastric cirri arranged in a single linear row. There are 4 interradial ostia in the subumbrella. The entire entodermal system is chocolate-red.

The *Valdivia* specimen was dredged from between 1,200 fathoms and the surface in the Indian Ocean between New Amsterdam and Cocos Islands, and the *Albatross* specimen which was studied, while yet alive, by Bigelow was obtained in the Humboldt current off the coast of Peru between 400 fathoms and the surface.

Genus (?) NAUPHANTOPSIS Fewkes, 1885.

Nauphantopsis, Fewkes, 1885, Report Commiss. Fish and Fisheries U. S. A. for 1883, p. 596; 1886, Report Commiss. Fish and Fisheries U. S. A. for 1884, p. 944.—Vanhöffen, 1892, Ergeb. der Plankton Expedition, p. 21; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped. *Valdivia*, Bd. 3, Lfg. 1, p. 51.—Hargitt, 1904, Bulletin U. S. Bureau of Fisheries, vol. 24, p. 66.—Maas, 1907, Ergeb. und Fortschritte der Zool., Bd. 1, p. 199.

GENERIC CHARACTERS.

Coronatæ with 32 marginal lappets, 4 interradial sense-organs, and 28 tentacles. With an annular furrow and 32 radial ridges (or pedalia) upon the exumbrella in the radii of the tentacles and sense-organs.

Owing to the incompleteness of our knowledge of the only known species of this genus it must remain problematical.

Nauphantopsis diomedeæ Fewkes.

Nauphantopsis diomedeæ, Fewkes, 1885, Report Commiss. Fish and Fisheries U. S. A. for 1883, p. 596; 1886, Report Commiss. Fish and Fisheries U. S. A. for 1884, p. 946, plate 6, figs. 1, 2; 1888, Amer. Journ. Sci., ser. 3, vol. 35, p. 173; Ann. and Mag. Nat. Hist., ser. 6, vol. 1, p. 255.—Hargitt, C. W., 1904, Bull. U. S. Bureau of Fisheries, vol. 24, p. 66.

Fewkes gives an unsatisfactory account of this medusa owing to the poor preservation of his material. We are uncertain whether there are 4 or 8 marginal sense-organs.

Disk quite flat, 70 mm. in diameter. Central part of exumbrella flat and surrounded by an annular furrow; diameter of this region about 35 mm. Centrifugally from the annular furrow there is a zone about 10 mm. wide consisting of 32 radial elevations separated by 32 deep radial furrows; these elevations lie in the radii of the tentacles and sense-organs and alternate with the lappets. Each elevated ridge is bifurcated at its outer end by a deep median cleft. The 32 lappets are long and rectangular with rounded outer edges. They are each about 10 mm. long and 8 mm. wide. There are 4 or 8 (?) marginal sense-organs and 24 (?) or 28 tentacles. The sense-organs were not observed in the specimen studied by Fewkes. Tentacles slender and flexible and about 80 mm. in length. Subumbrella (?) Mouth (?) Gonads (?) Color (?)

A single specimen was dredged from a depth of 2,033 fathoms in N. lat. 38° 30′, W. long. 69° 8′.

Family PARAPHYLLINIDÆ Maas, 1903.

Paraphyllinidæ, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 6.

FAMILY CHARACTERS.

Medusæ Coronatæ with 4 perradial rhopalia and 4 or more tentacles.

This family differs from the Periphyllidæ only in having the marginal sense-organs *perradial* instead of *interradial*.

There is only one known genus among existing medusæ, this being *Paraphyllina*; but this is very closely related, if not identical, with *Paraphyllites*, a fossil medusa of the lithographic slate of Kelheim.

Maas records a *Paraphyllina* from the Malay Archipelago, and another specimen was taken by the Krupp yacht *Puritan* at a depth of 500 fathoms, near Capri, Bay of Naples.

Genus PARAPHYLLINA Maas, 1903.

Paraphyllina, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 6; 1907, Ergeb. und Fortschritte der Zool., Bd. 1, p. 195.

The type species is *Paraphyllina intermedia* Maas, 1903; from the Malay Archipelago, between 100 fathoms and the surface.

GENERIC CHARACTERS.

Coronatæ with 12 tentacles, 4 *perradial* marginal sense-organs, and 16 lappets. The 12 tentacles are interradial and adradial with reference to the stomach and lips. There are 4 pairs (8) of interradial gonads. The marginal sense-organs have a terminal lithocyst-sac and a ventral bulb-like swelling, just beyond which is an eye with ectodermal lens and ectodermal pigment.

The short 4-sided throat-tube and flat disk-like bell resemble the condition noted in *Nausithoë*, but in its 4 marginal sense-organs and 12 tentacles it recalls the condition seen in *Periphylla*, with the important difference that in *Periphylla* the sense-organs are interradial, whereas in *Paraphyllina* they are perradial in position.

Maas places this genus in a new family which he calls the Paraphyllinidæ. The characters of this family are those of its only genus, *Paraphyllina*. It is closely related to the fossil genus *Paraphyllites*, Maas, 1906 (Neuen Jahrbüch. für Mineralogie, Geol. und Paläontol., Bd. 12, p. 90, 4 fign.). This fossil medusa differs from recent *Paraphyllina* only in that its 8 gonads are adradial and placed 45° apart, whereas in *Paraphyllina* they are grouped in pairs on both sides of the 4 interradii.

Paraphyllites distinctus is described by Maas from a well-preserved specimen. It is 15 mm. wide and has a well-developed coronal furrow, 16 pedalia, 4 perradial marginal sense-organs, 12 tentacles, and 8 adradial gonads 45° apart. It is from the lithographic slate of Kelheim. The latest reference to this fossil is that of von Ammon, 1908, Geonostischen Jahrespeften, Jahrg. 19, p. 170.

Paraphyllina intermedia Maas.

Paraphyllina intermedia, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 8, taf. 2, fign. 10–14; taf. 11, fig. 106.
Periphylla dodecabostrycha, Lobianco, 1903, Mitth. Zool. Sta. Neapel, Bd. 16, p. 219, taf. 7, fig. 3. See also Maas, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 48, foot-note.

Bell flatly rounded, 8 mm. high and 15 mm. wide, without pointed apex. The coronal furrow around the exumbrella is deep and separates the smooth, central, flatly-rounded apex of exumbrella from the marginal zone of lappets. Lappet-zone about as wide as radius of central disk of exumbrella. The 16 pedalia of the marginal zone are rectangular with rounded angles and are separated one from another by deep radiating furrows. These pedalia are in the radii of the tentacles and sense-organs and alternate with the lappets. The 12 pedalia of the tentacles are of uniform width, while the 4 pedalia of the marginal sense-organs are only about half as wide as the former. The 16 marginal lappets are oval and bluntly pointed, and the 8 lappets flanking the 4 sense-organs are somewhat narrower than the others. The 12 tapering, hollow tentacles are all of equal length and are not quite as long as the diameter of the bell.

The 4 marginal sense-organs are each covered by a hood-like fold of the exumbrella. Each sense-club contains a small terminal sac-shaped entodermal concretion. On the ventral (subumbrella) side of the sense-club is a large ectodermal eye with a cup-like mass of pigment and a spherical lens. On the inner side of the eye and upon the ventral side of the sense-club is a bulb-like swelling. Altogether the sense-clubs resemble those of *Nausithoë*, but the eye is larger.

The throat-tube is short and 4-sided and the mouth is a simple cruciform opening. There are 4 interradial rows of gastric filaments. The coronal ring-canal gives rise to 16 peripheral pouches in the radii of the sense-organs and tentacles, and these are put into communication one with another by means of a marginal ring sinus, as in *Nausithoë*.

The gonads resemble those of *Palephyra* and are intermediate in character between those of *Periphylla* and those of *Nausithoë*. They consist of 4 pairs of bean-shaped or egg-shaped sacs. These 8 sacs project from the subumbrella floor on both sides of the 4 interradii near the sides of the throat-tube and centripetal to the ring-muscle.

There is a well-developed ring of circular muscle-fibers in the subumbrella, beyond the gonads and inside of the insertions of the tentacles. This zone of ring-muscles appears broken in the mid-radii of the lappets, thus forming 16 trapezoids in the radii of the sense-organs and tentacles. Radial-muscle strands extend outward in the tentacular radii and converge at the bases of the tentacles.

The medusa is colorless save for the pigment of the eyes in the marginal sense-organs and for 4 interradial masses of red-brown pigment in the central stomach, leaving a clear cruciform space between them.

Two specimens were taken by the *Siboga* in the Malay Archipelago, in vertical nets, from a depth of 100 fathoms, at 6° 2′ S. lat., 123° 57.7′ E. long.

Dr. Lobianco describes a similar medusa in the collection made by the Krupp yacht *Puritan*, from a depth of 500 fathoms, near Capri, Bay of Naples. He generously permitted me to study the very well-preserved specimen of the medusa in the Zoological Station at Naples. It resembles Maas's specimens from the Malay Archipelago except that the gonads

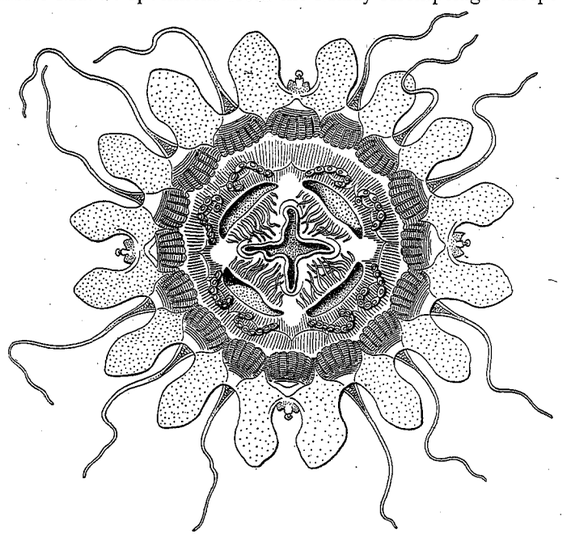


FIG. 347.—*Paraphyllina intermedia*. From a specimen in the Naples Zoological Station.

(female) are more slender and their outer ends somewhat longer than in the Malayan specimens. There are 4 deep interradial, crescentic pits in the floor of the subumbrella between the gonads and the gastric cirri. The medusa was 15 mm. wide and in all respects (save in the minor details mentioned above) it appears to be identical with the East Indian medusa. A figure of Dr. Lobianco's medusa drawn by me from his specimen is presented in fig. 347.

Family EPHYROPSIDÆ Claus, 1883.

Ephyropsidæ, CLAUS, 1883, Organisation und Entwick. Medusen, pp. 23, 24; 1886, Arbeit. Zool. Inst. Univ. Wien., Bd. 7, pp. 99, 110.—VANHÖFFEN, 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 21.—MAAS, 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, p. 65; 1907, Ergeb. und Fortschritte der Zool., Bd. 1, p. 211.—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, pp. 21, 33.
Ephyridæ+Linergidæ, HAECKEL, 1880, Syst. der Medusen, pp. 476, 490.

FAMILY CHARACTERS.

Coronatæ with 8 rhopalia (4 perradial and 4 interradial). 8 or more tentacles and 16 or more lappets. Mouth surrounded by 4 short, simple lips. 4 perradial ostia connect the central stomach with a wide ring-sinus. Peripherally this ring-sinus of the subumbrella gives rise to

16 radiating pouches in the radii of the sense-organs and tentacles; these pouches are separated one from another by 16 septa in the radii of the lappets. These septa may be complete or incomplete; and when incomplete there is a communication between adjacent pouches at the bell-margin forming a peripheral ring-canal.

The Ephyropsidæ are creatures of the open sea and are very widely distributed, but are especially abundant in the tropics. In the case of *Nausithoë* the scyphostoma larva bears a superficial resemblance to a branching hydroid, and it infests sponges. The ephyra is produced by strobilization.

The genera of the Ephyropsidæ are as follows:

Palephyra HAECKEL, 1880 (*sens. ampl.*)=*Ephyra*+*Palephyra*+*Zonephyra* Haeckel. 8 adradial tentacles, 16 lappets, 4 interradial gonads.
Nausithoë KÖLLIKER, 1853=*Nausicaa*+*Nausithoë*+*Nauphanta* Haeckel. 8 adradial tentacles, 16 lappets, 8 adradial gonads. No subumbrella saccules.
Linuche ESCHSCHOLTZ, 1829=*Linerges*+*Liniscus*+*Linuche* Haeckel. Similar to *Nausithoë*, but with sac-like gastric pouches upon the subumbrella.

Genus PALEPHYRA Haeckel, 1880.

Ephyra+*Palephyra*+*Zonephyra*, HAECKEL, 1880, Syst. der Medusen, pp. 482–484, 641.
Palephyra, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 31; 1908, deutsche Südpolar Expedition, Bd. 10, Zool. 2, p. 38.

The type species is *Palephyra antigua* Haeckel, from the Red Sea.

GENERIC CHARACTERS.

Coronatæ, with 8 adradial tentacles, 8 (4 perradial and 4 interradial) marginal sense-organs, 16 lappets, and 4 interradial gonads.

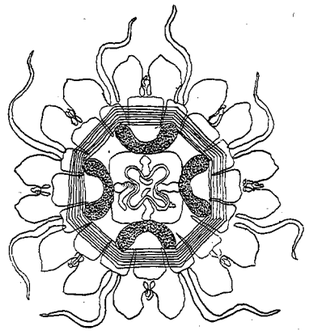


FIG. 348.—"*Ephyra prometor*." After Haeckel, in Das Syst. der Medusen.

This genus is related to *Nausithoë*, but is more primitive in that there are but 4 interradial instead of 8 adradial genital organs as in *Nausithoë*. Indeed, in *Nausithoë* itself the gonads begin to develop in the 4 interradii, but later they divide and migrate into the 8 adradii.

Haeckel distinguished three genera of medusæ with 8 tentacles, 8 sense-organs, 16 lappets and 4 interradial gonads: (1) *Ephyra*, without lappet-pouches; (2) *Palephyra*, with 8 cleft lappet-pouches in the ocular radii; (3) *Zonephyra*, with 16 cleft lappet-pouches in the rhopalar and tentacular radii. Haeckel, however, cut no sections and his ideas of the structure of the gastric cavity are probably erroneous. His *Ephyra* is apparently only an immature stage of *Palephyra*, which is in turn identical with *Zonephyra*.

"*Zonephyra corona*" Agassiz and Mayer, 1902 (Mem. Museum Comp. Zool. at Harvard College, vol. 26, p. 157), is apparently a young *Pelagia*.

Palephyra antiqua Haeckel.

Ephyra prometor (young medusa), HAECKEL, 1880, Syst. der Medusen, p. 482, taf. 27, fign. 1, 2.
Palephyra primigenia (half-grown medusa), HAECKEL, *Ibid.*, p. 483, taf. 27, fign. 3–6.
Pelephyra antiqua (adult [?] medusa), HAECKEL, *Ibid.*, p. 484.

Bell 20 mm. wide, 8 mm. high. Coronal furrow and pedalia (?), 8 adradial tentacles about half as long as bell-radius. 8 sense-organs; 16 spatula-shaped, sharply pointed lappets, half as long as bell-radius. A long 4-sided œsophagus with folded, recurved lips. 4 interradial gonads divided in the 4 perradii; each gonad crescent-shaped with the horns recurved. 6 to 8 slender gastric cirri in each interradius.

Tropical Indian Ocean near Madagascar.

Haeckel describes that which I take to be the young of this medusa as *Ephyra* (*Archephyra*) *prometor* from the coast of Australia. It is only 8 mm. wide and has 4 simple, interradial,

crescent-shaped gonads, each with only one gastric filament. His *Palephyra primigenia* appears to be the half-grown medusa. There are only 2 gastric cirri in each interradius, and the gonads and tentacles are said to be light-reddish, nearly colorless. It comes from the Red Sea, near Tur.

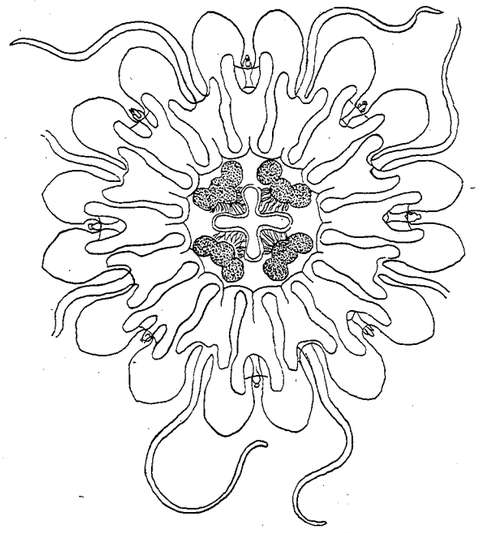


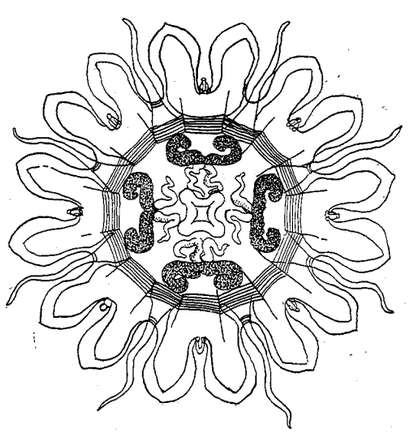
FIG. 349.—"*Zonephyra zonaria*," after Haeckel, in Das Syst. der Medusen.

Palephyra pelagica.

Zonephyra zonaria (young medusa), HAECKEL, 1880, Syst. der Medusen, p. 484, taf. 27, fign. 7, 8.
Zonephyra pelagica, HAECKEL, *Ibid.*, p. 485.

Bell 12 mm. wide, 2 mm. high, with a coronal furrow. Mouth-tube wide and short, hardly one-third as long as bell-diameter (contracted ?). 16 spatula-shaped, pointed lappets, half as long as bell-radius. 8 adradial tentacles not quite half as long as bell-radius. 4 half-moon-shaped interradial gonads with ends of crescent pointing outward. Each gonad consists of 3 swellings; the middle part being hardly half as large as the two lateral ones. 10 to 12 short, gastric cirri in each interradius. Color (?) Coast of Japan.

Haeckel describes that which may be a young stage of this medusa under the name of *Zonephyra zonaria*. It is only 8 mm. wide. The mouth tube and tentacles are longer than in *P. pelagica*, but this may be due to conditions of contraction. The median and terminal swellings of each gonad are all of the same size. Found off the coast of China. Haeckel's *Zonephyra connectens* (System der Medusen, p. 641), from the tropical Pacific is said to differ from those described above in having each gonad composed of 2 swollen regions instead of 3 as in his



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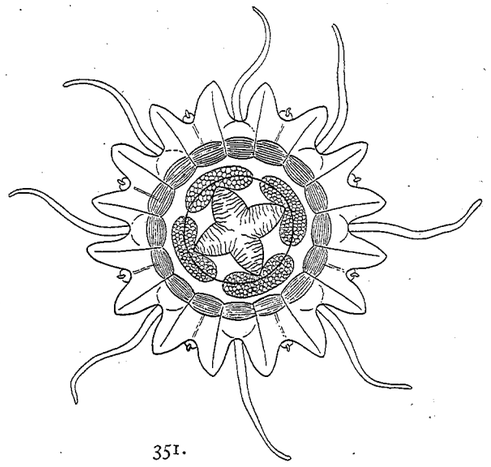

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FIG. 350.—*Palephyra "primigenia,"* after Haeckel in Das Syst. der Medusen.
FIG. 351.—*Palephyra indica,* after Vanhöffen, in *Valdivia* Expedition.

Z. pelagica. There are also 4 lanceolate, complexly folded lips. The medusa is only 10 mm. wide and is probably an immature stage.

Palephyra indica Vanhöffen.

Palephyra indica, VANHÖFFEN, E., 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, p. 32, taf. 3, fig. 10.

Bell 12 to 16 mm. wide. 8 adradial tentacles, 8 marginal sense-organs, 16 marginal lappets. 4 large, bean-shaped interradial gonads wider than the spaces between them. About 80 simple gastric filaments. Bell white, with faint brown, radial punctations in the radii of the sense-organs and axial lines of the lappets. Stomach brown. Gulf of Aden from a depth of about 500 fathoms.

Vanhöffen presents a beautiful figure of this medusa, drawn from life.

Genus NAUSITHOË Kölliker, 1853.

Nausithoë, KÖLLIKER, 1853, Zeit. für wissen. Zool., Bd. 4, p. 323.—GEGENBAUR, 1856, Zeit. für wissen. Zool., Bd. 8, p. 211.—HERTWIG, O., und R., 1878, Nervensyst. und Sinnesorg. der Medusen, p. 105.—CLAUS, 1883, Organisation Entwick. Medusen, p. 24.—VANHÖFFEN, 1892, Ergeb. der Plankton Expedition, p. 21; 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, pp. 28, 30; 1906, Nordisches Plankton, Nr. 11, p. 43.—MAAS, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 53; 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 18.—BIGELOW, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 33.
Octogonia, MÜLLER, J., 1854, Müller's Archiv. für Anat., etc., p. 97.
Ephyropsis, GEGENBAUR, 1856, Müller's Archiv. für Anat., etc., p. 239.
Nausicaa+Nausithoë+Nauphanta, HAECKEL, 1880, Syst. der Medusen, pp. 486, 487.
Scyphostoma larva:
Spongicola fistularis, SCHULTZE, F. E., 1877, Archiv. für Mikroscop. Anatomie, Bd. 13, p. 795.
Stephanoscyphus mirabilis, ALLMAN, 1874, Annals and Mag. Nat. Hist., ser. 4, vol. 14, p. 237.
Nausithoë, LOBIANCO, S., und MAYER, P., 1890, Zool. Anzeiger, Jahrg. 13, p. 687.

The type species is *N. punctata* of the Mediterranean, Atlantic, Pacific, Indian, and Arctic Oceans.

GENERIC CHARACTERS.

Ephyropsidæ with 8 (4 perradial and 4 interradial) marginal sense-organs and 8 adradial tentacles. There are 16 marginal lappets and 8 separate adradial gonads, the gonads isolated, not grouped in pairs. The central stomach communicates with a wide ring-sinus in the bell by means of 4 perradially situated ostia; the 4 interradial septa between these openings give rise to the entodermal gastric cirri. Peripherally, the ring-sinus gives forth 16 simple, unramified pouches in the radii of the sense-organs and tentacles. The partitions between these pouches are not complete, for there is a marginal ring-canal. No saccules on the subumbrella.

We may possibly distinguish the following "species" of *Nausithoë:*

N. punctata, with finely punctured, central disk without radiating furrows, large gonads, gastral filaments not grouped into clusters. All oceans.
N. clausi, with smooth central disk, small gonads. Caroline Islands, Pacific.
N. challengeri, central disk with radiating furrows. Tristan d' Acunha, South Atlantic.
N. albatrossi, smooth central disk, long, narrow marginal lappets. Gastral filaments grouped into clusters, with a number of separate clusters in each interradius. Gulf of Panama, Pacific Ocean.
N. rubra, red color. Pitted central disk. Simple gastral filaments which are not grouped into clusters. Indian and South Atlantic Oceans=*N. punctata* (?)
N. picta, similar to *N. punctata*, but with chocolate-brown or carmine gonads and blue gastric cirri=*N. punctata* (?).

It is apparent that there are only 4 well-marked forms of *Nausithöe:* (1) the *punctata, rubra, picta* group with pitted central lens which lacks radiating furrows, and with gastric filaments arising singly, not in clusters; (2) *N. clausi* with smooth central lens; (3) *N. albatrossi* with gastric filaments grouped in clusters; (4) *N. challengeri* with radial furrows upon the central lens.

The scyphostoma larva of *Nausithoë* infests sponges and bears a superficial resemblance to a branching hydroid. See *N. punctata.* The medusa of *Nausithoë* is peculiar in having clusters of small crystals scattered at intervals within the ectoderm of its umbrella.

Nausithoë punctata Kölliker.

Plate 60, figs. 4 and 5.

Nausithoë punctata, Kölliker, 1853, Zeit. für wissen. Zool., Bd. 4, p. 323.—Keferstein und Ehlers, 1861, Zool. Beitr. Neapel, Messina, p. 80, taf. 13, fign. 1–3.—Haeckel, 1880, Syst. der Medusen, p. 486.—Claus, 1883, Organ. und Entwick. der Medusen, pp. 24, 41, taf. 6, fign. 44–46b; taf. 7, fign. 47–53; taf. 8, fign. 54–55d.—Hamann, 1883, Zeit. für wissen. Zool., Bd. 38, p. 420, taf. 23.—Græffe, 1884, Arbeit. Zool. Inst. Wien., Bd. 5, p. 342 (at Trieste, Adriatic, June to Oct., rare).—Vanhöffen, 1892, Ergeb. der Plankton Expedition, Bd. II, K. d., p. 13, taf. 3, fign. 8, 9; 1892, Ergeb. der Plankton Expedition, Bd. 2, K. c., Nachtrag; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., Bd. 3, Lfg. 1, p. 29; 1906, Nordisches Plankton, Nr. 11, p. 43, fign. 2, 3 (North Atlantic 59° 39′ N. lat.); 1908, deutsche Südpolar Expedition, Bd. 10, Zool. 2, p. 37.—Mayer, 1900, Bull. Mus. Comp. Zool. at Harvard College, vol. 37, p. 67, figs. 67, 86; plate 23, figs. 87, 88; plate 26.—Agassiz, A. and Mayer, 1902, Mem. Museum Comp. Zool. at Harvard College, vol. 26, p. 155, plate 7, fig. 32.—Bigelow, H. B., 1904, Bull. Mus. Comp. Zool. at Harvard College, vol. 39, p. 263, plate 6, fig. 21 (Maldive Islands, Indian Ocean).—Maas, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 54.—Browne, 1905, Report Pearl Oyster Fisheries, Gulf of Manaar, p. 157.—Bigelow, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 35, plate 12.

Nausithoe albida, Gegenbaur, 1856, Zeit. für wissen. Zool., Bd. 8, p. 211.—Carus, 1857, Icones Zootom., taf. II, fign. 17, 22, 23.—Hertwig, O. und R., 1878, Nervensyst. und Sinnesorgane der Medusen, p. 105, taf. 9, figs. 2, 5, 10–13; taf. 10, fig. 17.

Nausithoë punctata, var. *polaris*, Maas, 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 511 = *Nauphanta polaris* Fewkes (review of literature).

Nauphanta vettoris pisani, Vanhöffen, 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 15, taf. 3, fig. 10.

Nauphanta polaris, Fewkes, 1888, Report Lady Franklin Bay Expedition, p. 40, plate 1, figs. 1, 2, Annals and Mag. Nat. Hist., ser. 6, vol. 1, p. 255.

Nausithoë marginata, Metschnikoff, 1886, Embryologische Studien an Medusen, Wien, p. 23 (egg); p. 37 (segmentation); p. 66 (formation of entoderm); taf. 10, fign. 1–22.

Larval Stage:

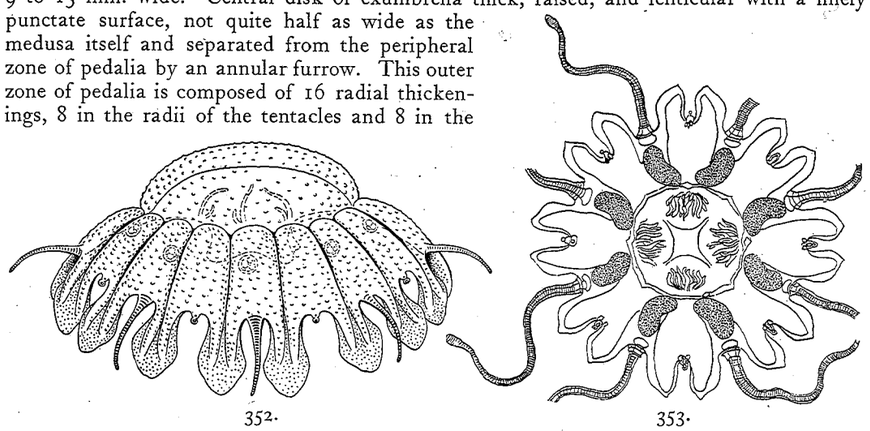
Nausithoë punctata = *Spongicola fistularis* = *Stephanoscyphus mirabilis*, Lobianco, S., and Mayer, P., 1890, Zool. Anzeiger, Jahrg. 13, p. 687.

Spongicola fistularis, Schulze, F. E., 1877, Archiv. für Mikroscop. Anat., Bd. 13, p. 795, taf. 45–47 (larval stage).

Stephanoscyphus mirabilis, Allman, 1874, Nature, vol. 10, 251; Annals and Mag. Nat. Hist., ser. 4, vol. 14, p. 237.

Parasitic scyphostoma upon *Esperia*, Kowalevsky, A., 1873, Mem. Imperial Soc. Lovers of Natural History, Moscow, vol. 10, part 2, p. 7 (Russian).

Adult medusa.—The umbrella is discoidal, flatter than a hemisphere, quite thick, and 9 to 15 mm. wide. Central disk of exumbrella thick, raised, and lenticular with a finely punctate surface, not quite half as wide as the medusa itself and separated from the peripheral zone of pedalia by an annular furrow. This outer zone of pedalia is composed of 16 radial thickenings, 8 in the radii of the tentacles and 8 in the radii of the sense-organs. They thus alternate in position with the 16 marginal lappets and are separated by deep radial clefts in the mid-axial radii of the lappets (fig. 5, plate 60). The 8 tentacles are adradial and arise from deep clefts between the lappets. The bases of these tentacles are set in thick, socket-like pedalia and arise from the subumbrella side of the bell. The tentacles are about three-fourths as long as bell-diameter. The entodermal core of each tentacle is solid and composed of highly vacuolated cells. There are 8 marginal sense-organs, 4 radial and 4 interradial; these sense-organs are set at the bottom of 8 clefts between the lappets, but the clefts of the sense-organs are not quite as deep as those of the tentacles. The Hertwigs (1878, fig. 2, plate 9) and Claus (1883, fig. 47, plate 7) have shown that each sense-organ contains a distal entodermal mass of cystalline concretions, and a ventral proximal, ectodermal eye provided with lens, retina, and nerve-fibers. The 16 marginal lappets are long, flexible, and spatula-shaped. The mouth is a simple, cruciform opening at center of



352. 353.

Fig. 352.—*Nausithoë punctata*, from life, by the author, at Naples Zoological Station, Jan. 15, 1908.
Fig. 353.—"*Nausicaa phæacum*," after Haeckel, in Das Syst. der Medusen.

subumbrella; the 4 lips are without prominent oral appendages or palps. The central stomach is connected with a wide annular sinus in the disk by means of 4 wide, perradial ostia, alternating with which there are 4 short interradial septa (see Claus, 1883, p. 27, taf. 7, fig. 48). The broad ring-sinus is interrupted near the bell-margin by 16 septa in the radii of the mid-axial lines of the lappets. These septa are not complete, however, but leave a marginal ring-canal. Thus the 16 peripheral stomach-pouches are in the radii of the sense-organs and tentacles, and are joined by the marginal ring-canal in the axial line of each lappet.

Four groups of simple, unbranched, gastric cirri are upon the interradial septa of the central stomach and project centripetally inward into the central stomach; altogether there are about 28 gastric cirri, about 7 in each group. The 8 adradial gonads occur in the 8 tentacular radii and are upon the floor of the subumbrella in the zone of the wide, inner ring-sinus of the bell. Each gonad is large and globular and consists of a pocket-like fold of the entoderm of the subumbrella (see Claus, 1883, p. 31). A zone of well-developed circular muscle-fibers is on the subumbrella between, and centrifugal to, the gonads. Centripetal to this, powerful strands of radiating muscle-fibers extend outward to the tentacles and marginal lappets; also, 8 poorly developed strands of radiating muscles extend outward in radial and interradial positions from the base of the œsophagus to the zone of circular muscles.

The color of this medusa is quite variable. The gelatinous substance of the bell is usually translucent-milky, greenish, or light brownish. The gonads are brownish or red or, in the case of the males, bright yellow. Rosin-colored spots in the ectoderm of the exumbrella, especially upon the lappets, are due to clusters of small crystals (see Claus, 1883, fig. 44, taf. 6).

A young ephyra of this species was found by us near Flamingo Key, Bahama Islands, February 9, 1893. It was 2 mm. in diameter, and there were as yet no marginal tentacles and only 4 gastric cirri A slightly older ephyra has been figured by Claus, 1883, fig. 48, taf. 7.

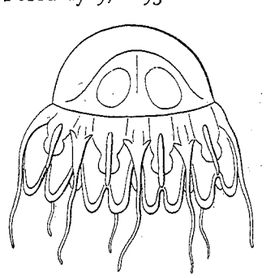


Fig. 354.—"*Nauphanta*" *albatrossi*, after Maas, in Mem. Mus. Comp. Zoology at Harvard College.

This medusa is a surface form, and is common in the Mediterranean, Atlantic, Pacific, and Indian Oceans, and in all tropical or warm seas. *Nausithoë polaris* (*Nauphanta polaris* Fewkes) from the Arctic Ocean, appears to be identical with *N. punctata*, and if this be true Vanhöffen is right in stating that *Nausithoë punctata* is found in all oceans. It is abundant in summer at Tortugas, Florida, and in the Bahamas, but has not been found on the Atlantic coast of the United States north of the Carolinas. Vanhöffen, 1906, describes a specimen 12 mm. wide from N. lat. 59° 39′, W. long. 8° 49′.

Hamann, 1883, studied the development of the ephyra of this species and finds that the gonads first appear as 4 interradial entodermal swellings in the subumbrella wall of the stomach, at a time when the ephyra has but one gastral filament in each interradius. Later the 4 original gonads divide and migrate so as to become 8 in the adradii of the subumbrella wall of the stomach. The genital products originate in the entoderm and migrate into a gelatinous space between two layers of entoderm. The spermaries appear as a series of follicles in this space.

According to Metschnikoff, 1886, who has studied the early development of *Nausithoë* "*marginata*" (which is apparently identical with *N. punctata*) the egg is citron-yellow, 0.23 mm. in diameter, and is laid in mid-day in December; segmentation is total but somewhat unequal, the cells of the vegetative pole being largest. A wide, central, cleavage cavity is formed and the gastrula results from invagination at the hinder end of the larva. The blastopore then closes over and the entoderm is entirely inclosed by a layer of ciliated ectoderm, and the free-swimming planula is thus formed.

The remarkable scyphostoma larva of *Nausithoë punctata* bears a striking superficial resemblance to a hydroid and it lives commensal within sponges such as *Suberites*, *Myxilla*, *Reneira*, *Esperia*, etc. It is especially abundant at Trieste and Naples. This hydroid-like larva forms a branching tree-like growth within the body of the sponge, the polyp-mouths and their tentacles projecting out of the oscula of the sponge. The branching, tree-like stock of the larva is covered with an irregularly annulated, chitinous perisarc, which terminates at a short distance below the zone of tentacles of each polypite. The mouth of the polypite

is at the extremity of a short, blunt-conical hypostome, which is surrounded by an annulus of about 40 solid filiform tentacles. 4 longitudinal partitions lined by entoderm extend throughout the cavity of the stem. These do not meet in the center, but form only partial septa, comparable with the mesenterial partitions of other scyphostomæ of Scyphomedusæ. There is no marginal ring-canal. There are external, longitudinal and internal (mesodermal) circular muscles. The polypites are translucent-white.

Lobianco and Paul Mayer, 1890, found that ephyræ of *Nausithoë* arise by strobilization from this larva. The young ephyra has only 4 gastric filaments and no tentacles. Kowalevski, 1873, also observed the giving off of the ephyræ, but did not determine that they were *Nausithoë*.

It is not surprising that this peculiar larva should have received various names: Allman calls it *Stephanoscyphus mirabilis;* F. E. Schulze describes it in detail under the name *Spongicola fistularis;* but its true nature was discovered by Lobianco and Paul Mayer, 1890.

Haeckel's *Nausicaa phæacum* from Corfu, Mediterranean, may be identical with *N. punctata*, but the 8 gonads tend to be grouped in 4 interradial pairs, forming a broken crescent in each interradius, with a wide separation between the outwardly directed horns of each crescent. It may have been described from an abnormal or young specimen of *N. punctata* (See Haeckel, 1880, Sitzungsber. Jena. Gesell. für Med. und Natur., Jahrg. 1880, Feb. 20.)

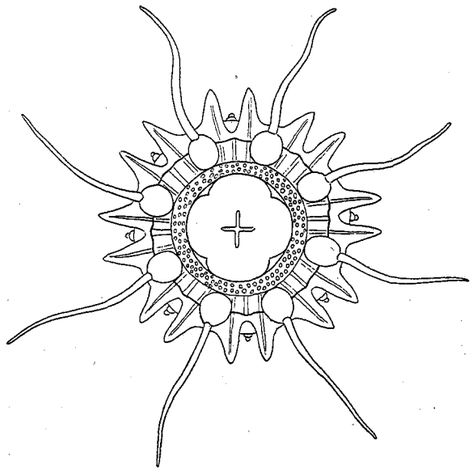


FIG. 355.—*Nausithoë rubra*, after Vanhöffen, in *Valdivia* Expedition.

Nausithoë clausi Vanhöffen.

Nausithoë clausi, VANHÖFFEN, 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 14, taf. 4, fign. 1, 2.

Disk about 9 mm. wide; central lens-shaped dome of exumbrella flat, smooth, unpitted, and without radial furrows; 5 mm. wide, 16 well-developed marginal pedalia. Medusa 3 times as wide as high. 16 very blunt, 3-cornered marginal lappets, three times as wide as long and hardly one-ninth as long as bell-radius. 8 adradial tentacles with well-developed, conical bases. Tentacles as long as bell-radius. 8 marginal sense-organs alternating with tentacles. 8 gonads in the tentacular radii, very small, spherical, only 1.3 as wide as the pedalia. Ring-muscle of subumbrella one-third as wide as bell-radius. Numerous, small, simple gastric cirri arising in a linear row in each interradius. Color (?)

Pacific Ocean east of the Caroline Islands. A single specimen appears to be *N. punctata* with poorly developed marginal-lappets and small gonads.

Nausithoë challengeri Vanhöffen.

Nauphanta challengeri, HAECKEL, 1880, Syst. der Medusen, p. 487; 1881, Report Deep-sea Medusæ, *Challenger* Exped., Zool., vol. 4, p. 103, plates 27, 28, 20 figs.
Nausithoë challengeri, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped. *Valdivia*, Bd. 3, Lfg. 1, pp. 28, 31.

Bell 12 mm. wide. Central lens of exumbrella separated by a deep annular furrow from zone of pedalia. Somewhat less in diameter than bell-radius, its margin cleft by 16 radiating furrows which do not extend to center of exumbrella. Marginal zone of pedalia well developed, the 8 ocular being narrower than the 8 tentacular. Tapering tentacles somewhat longer than bell-radius. The 8 large gonads are twice as long as wide and are elongated outwardly. They are somewhat wider than the intervals between them. 4 interradial clusters of simple gastric cirri which arise at equal spaces in a single row in each cluster and are not grouped into brushes as in *N. albatrossi*. Each cluster has about 24 cirri.

Found near the island of Tristan d'Acunha, South Atlantic, at a depth of 1,425 fathoms, in an open net, on March 16, 1876.

Nausithoë albatrossii Vanhöffen.

Nauphanta albatrossii, MAAS, 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, p. 83, taf. 14, fign. 1–3.
Nausithoë albatrissi, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Bd. 3, Lfg. 1, pp. 28, 30.

Disk 35 to 40 mm. wide, 35 mm. high. The marginal lappets are narrow and elongate with nearly parallel sides and rounded ends; not heart-shaped, as in *Nausithoë challengeri* or *N. vettoris pisani* (=*N. punctata*). Central disk smooth and without a notched margin, such as is seen in *N. challengeri*. Stomach, especially the lips, much shorter than in either *N. challengeri* or *N. vettoris pisani*. 8 gonads, elongate, oval, bladder-like organs. The gastric filaments arise in a row in each interradius, each row being composed of about 4 clusters, of 5 filaments each. All 5 filaments of each cluster arise close together, and with wide, free intervals between the groups. This species is remarkable for its large size.

Gulf of Panama, Pacific coast of Central America.

Nausithoë rubra Vanhöffen.

Nausithoe rubra, VANHOFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Bd. 3, Lfg. 1, p. 30, taf. 1, fign. 4, 5.—BIGELOW, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 36, plate 12, fig. 6.

Bell 15 mm. in diameter. With large pits over the exumbrella surface of the central disk. Simple gastral filaments arise separately, not in clusters. 8 large gonads. 16 short, pointed, marginal lappets. 8 tentacles longer than the bell-radius. Tentacles and bell red-purple, stomach blue. Indian and South Atlantic Oceans. It appears to be distinguished from *N. picta* by its deep color and large pits over the exumbrella surface of the central disk; moreover, according to Bigelow, 1909, the rhopalia in *N. rubra* lack ocelli, while there is a ventral ocellus in *N. punctata*. The septal nodes of *N. rubra* are broadly triangular and the 4 perradial gastric ostia are narrow. The marginal canal-system is as in *N. punctata*.

Nausithoë "picta" Agassiz and Mayer = N. punctata (?)

Nausithoë picta, AGASSIZ, A., and MAYER, 1902, Mem. Museum Comparative Zool. at Harvard College, vol. 26, p. 154, plate 7, fig. 33.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 19, taf. 1, figs. 5–8.

Bell 15 to 22 mm. wide, somewhat flatter than a hemisphere. Coronal furrow of exumbrella well-developed, central disk of exumbrella smooth-edged. 16 marginal lappets, wide and pointed. 8 tapering adradial tentacles, with wide bases, are somewhat shorter than bell-radius. 8 marginal sense-organs, radial and interradial in position with reference to the lips. 8 large, egg-shaped or oval gonads project from middle zone of subumbrella in the tentacular radii. Mouth cruciform, the lips being in the radii of 4 of the marginal sense-organs. 4 clusters of gastric cirri in the interradii, each cluster consisting of about 12 cirri.

The gonads are chocolate-brown to carmine and the gastric cirri are blue. The ocelli of the 8 sense-organs are dark-brown.

This medusa was found by the *Albatross* in the Paumotos Islands, South Pacific, in September, 1899. Later, 29 specimens were found by the *Siboga* in the Malay Archipelago. Maas, 1903, describes these specimens and fortunately corrects certain serious mistakes in the description written by me in the account published under the names of Agassiz and Mayer. I am inclined to regard this medusa as merely a large, highly-colored variety of *Nausithoë punctata*.

Genus LINUCHE Eschscholtz, 1829.

Linuche, ESCHSCHOLTZ, 1829, Syst. der Acal., p. 91.
Linerges+Liniscus+Linuche, HAECKEL, 1880, Syst. der Medusen, pp. 495, 496, 498, 642.

The type species is *Linuche unguiculata* Eschscholtz, 1829, of the West Indian region, tropical Atlantic.

GENERIC CHARACTERS.

Ephyropsidæ with 8 (4 perradial, 4 interradial) rhopalia. 8 adradial tentacles. 16 lappets. 8 gonads grouped in 4 pairs close to the 4 perradii. With zones of hernia-like sacs upon the floor of the subumbrella. The 16 peripheral stomach-pouches break up into branches in the lappets. A marginal ring-sinus may or may not be present.

There are, I believe, but two species, *L. unguiculata* of the tropical Atlantic and *L. aquila* of the Pacific and Indian Oceans. These are closely related, but in the Atlantic form there is no marginal ring-canal, whereas this is present in the Pacific species; moreover, the subumbrella warts of the Pacific form are arranged in 2 rows and in the Atlantic medusa in 3 rows.

Linuche unguiculata Eschscholtz.

Plate 59, figs. 1 to 10.

Medusa unguiculata, SCHWARTZ, 1788, Neue Abhandl. Schwed. Acad. Deutsche Uebers., 1789, p. 195, taf. 6, fig. 1.—LINNÉ (GMELIN), 1788, Syst. Naturæ, tomus 1, pas. 6, p. 3159.

Pelagia unguiculata, PÉRON ET LESSUER, 1809, Annal du Muséum Hist. Nat., Paris, tome 14, p. 349.

Linuche unguiculata, ESCHSCHOLTZ, 1829, Syst. der Acal., p. 91.—BLAINVILLE, 1834–1836, Manuel d' Actinologie, p. 289, planche 37, figs. 1–1c.

Linerges mercurius+L. pegasus+Liniscus ornithopterus (?) *+L. sandalopterus* (?) *+L. cyamopterus+Linuche unguiculata+ L. vesiculata*, HAECKEL, E., 1880, Syst. der Medusen, pp. 495, 497, 498, 499, taf. 29, fign. 4–6.

Linerges mercurius, FEWKES, 1882, Bull. Mus. Comp. Zool. at Harvard College, vol. 9, p. 259, plate 2, figs. 3–5; plate 3, figs. 4–8, 11, 13; plate 4, figs. 3–22; 1886, Report Commiss. Fish and Fisheries for 1884, p. 950.—AGASSIZ, A., 1888, Bull. Mus. Comp. Zool. at Harvard College, vol. 14, p. 186, fig. 93.—MAYER, 1900, Bull. Mus. Comp. Zool. at Harvard College, vol. 37, p. 68.—CONKLIN, 1906, Year Book of Carnegie Institution of Washington, No. 4, p. 115; 1908, Papers from Tortugas Laboratory Carnegie Institution of Washington, vol. 2, p. 153, 8 plates (development).

Bell about 13 mm. high and 16 mm. wide. Lenticular apex flat and horizontal, separated from the vertical sides by a distinct but shallow annular furrow. Occasionally a few irregularly arranged, radiating clefts are found in the margin of the lenticular apex of the bell, but this is usually plain. Sides of bell composed of 16 vertical pedalia, similar each to each, and separated one from another by 16 clefts in the radii of the mid-axial lines of the lappets. Thus the pedalia are in the radii of the tentacles and rhopalia and alternate with the lappets (plate 59, fig. 2).

The 16 lappets are bluntly oval with rounded edges and are all inclined inward at an angle such that when one observes the medusa by looking down upon the aboral end of the bell the animal rotates with the hands of the watch as it swims through the water, upon each contraction of its margin. The lappets being inclined as are the vanes of a wind-mill cause this peculiar spinning on its axis as the medusa progresses rapidly along. This was discovered by Prof. E. G. Conklin in 1905. 8 small, simple, marginal sense-organs, perradial and interradial in position, arise from clefts between the lappets and are not protected by covering scales. The entoderm of each rhopalium contains a spherical mass of concretions. No ocelli. The 8 adradial tentacles are small, neither very flexible nor contractile, and only about 1.5 times as long as lappets.

The 8 (4 double) gonads form 4 cleft crescents on both sides of the perradial lines of the subumbrella, the cleft being in the perradius itself and the horns of the crescents extending outward toward the margin of the bell. These gonads begin to develop as 8 separate sacs diverging outwardly on either side of the 4 perradii when the ephyra is about 5 mm. in diameter. The subumbrella sacs are not male gonads as was conjectured by Haeckel, and the medusa is not hermaphroditic, the sexes being separate.

The proboscis is urn-shaped, 4-sided, and with 4 slightly recurved lips with their perradial angles truncated so as to present a nearly octangular appearance when viewed upon looking into the bell-cavity. The mouth does not extend to level of bell-margin, but is usually at about two-thirds the distance down from the inner apex of the bell-cavity. There are 4 crescentic interradial rows of simple unbranched gastric cirri, about 15 to 20 in each row at the interradial septal nodes. Beyond these, and connected with the central stomach by 4 perradial ostia, is the broad bell-sinus, which in turn gives rise to 16 radiating pouches in the radii of the sense-organs and tentacles. The edges of these pouches break up into numerous, ragged-edged branches in the lappets, but I am unable to find any marginal ring-canal, for although I have often injected the lappet-pouches with air, carmine, or other stains, each pouch is evidently completely separated from the two adjacent to it. This appears the more remarkable from the fact that Maas has found a marginal ring-canal in the Pacific species; a fact which I am enabled to confirm in specimens from the Philippine Islands, and Claus, Vanhöffen and Bigelow have demonstrated that such a structure exists in other Ephyropsidæ.

Projecting from the floor of the subumbrella into the bell-cavity are 48 hollow sac-like or wart-shaped protuberances which arise from the radial stomach-pouches and are arranged

in 3 zones (text-fig. 356A). The 2 inner rows are each composed of 8 large perradial and interradial saccules which lie between the gonads, the 8 innermost saccules being partially cleft and bean-shaped (plate 59, fig. 7); a third row of 32 smaller saccules, 2 for each lappet-pouch, lies at the level of the outer ends of the horns of the crescentic gonads. In the subumbrella we find a broad, unitary, marginal area of ring-muscles, and centripetal to this are more or less isolated strands of radial muscle-fibers.

The entoderm of the gonads, of the wart-like saccules, and of numerous, separated, more or less polygonal areas of digestive cells in the gastric pouches is brown. 8 rows of dark-brown spots extend longitudinally down the inner surface of the lips.

Vast numbers of the ephyræ of this medusa appear among the Bahama Islands and West Indian region in February and March, and become mature from April until early June, usually disappearing at or about the middle of May. I have seen hundreds of such swarms, all composed of but one species. I have never seen any of the so-called "species" described by Haeckel from the West Indian region, and it appears to me that he has constituted species out of preserved material displaying various well-known characteristics of abnormal contraction and in various stages of growth. In fact I have seen Haeckel's "species" only in medusæ which I have myself preserved. They appear not to exist except in alcohol.

In the Bahama-Florida region in spring these medusæ form swarms, miles in extent, filling the water with myriads of brown thimbles, all actively spinning clockwise as they progress through the water.

Conklin, 1908, has studied the habits and early development of *Linuche unguiculata*. When mature the medusæ rise in vast swarms to the surface and the eggs are discharged and fertilized at 8 p. m. The female gonads are slaty or blue-gray in color while those of the male are brown. When the gonads have been emptied the medusæ sink down to the bottom and die. Each egg is closely invested by a very thin transparent membrane which persists to the gastrula stage. The eggs are laid near the surface but gradually sink downward. The newly laid egg is 0.24 mm. in diameter. It consists of a peripheral layer of clear protoplasm, an intermediate layer of densely packed yolk spherules, and a central sphere composed apparently of dissolved yolk. The peripheral layer becomes the peripheral layer of the blastula and gastrula, and gives rise to the cilia of the ectoderm. The intermediate "shell" of closely crowded yolk spherules constitutes the principal part of all of the cells of the gastrula and blastula, while the central mass of dissolved yolk is poured into the cleavage cavity and probably serves as a source of nourishment for the surrounding cells.

Two polar bodies are formed. The first two cleavages are meridional and cut downward from the animal (polar body) pole to the vegetative pole, and the third cleavage is equatorial. Up to the 64-cell state the divisions are wholly mitotic. Cleavage is total and practically equal. When the embryo consists of about 1,000 cells protoplasmic processes appear over the entire periphery, and these push off the egg membrane and form the vibratile cilia. Gastrulation usually takes place by invagination of the small, rounded cells of the vegetative pole of the embryo; but sometimes there is a unipolar ingression of cells at the vegetative pole and no invagination. The blastopore closes so that the entoderm becomes entirely incased within the ectoderm, and the larva elongates and becomes a free-swimming planula.

Isolated blastomeres, at least as late as the 4-cell stage, may give rise to apparently normal free-swimming larvæ.

The center of the egg is more nearly fluid than the peripheral layers, and this fact favors the cutting inward of the cleavage furrow from the animal pole to the vegetative during the first two divisions, and the unilateral constriction in the third (equatorial) division.

When the ephyra is 1.5 mm. in diameter, it has 16 lappets and 8 sense-organs, but neither tentacles nor gonads. 4 gastric cirri, one in each interradial side of stomach. Disk very flat, brown in color (fig. 3, plate 59). When 3 mm. wide the tentacles begin to develop, and the gonads appear when the medusa is about 5 mm. wide. The polygonal areas of pigmented digestive cells then develop in an inner ring of 16 large areas centrifugal to the gonads, and still farther out an outer annulus of 32 areas. There are also irregularly shaped and arranged areas of brown cells in the lappets (plate 59, fig. 5). The subumbrella saccules do not develop until later.

Linuche aquila.

Plate 59, fig. 11.

Linerges aquila, HAECKEL, 1880, Syst. der Medusen, p. 496.—GOETTE, 1886, Sitzungsber., Akad. Wissen., Berlin, Jahrg., p. 833.—AGASSIZ, and MAYER, 1899, Bull. Museum Comp. Zool. at Harvard College, vol. 32, p. 170, plate 10, figs. 33, 34; 1902, Mem. *Ibid.*, vol. 26, p. 156.
(?) *Linerges draco*, HAECKEL, *loc. cit.*, p. 496.
Linerges draco (young medusa), MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 24, taf. 1, fign. 1, 2.

This form is widely distributed over the tropical Pacific and is closely related to the tropical Atlantic *L. unguiculata*, with which it is identical in form and dimensions, being about 13 mm. high and 16 mm. wide. It has 48 wart-like protuberances upon the subumbrella arranged in 2 rows instead of in 3 as in the Atlantic medusa. 8 of the subumbrella sacs in *L. aquila* alternate with the gonads and 8 arise from the sides of the gonads themselves. Thus in the Pacific medusa we have two zones of protuberances, an inner zone of 16 large sacs, and an outer of 32 small subumbrella saccules. The 16 large sacs lie in the mid-regions of the gonads, while the 32 small saccules lie at the zone of the outer ends of the gonads. The areas of brown cells are developed only centrifugal to the zone of gonads in the Atlantic, while they occur *between* the gonads as well as beyond them in the Pacific medusa. A marginal ring-canal is present.

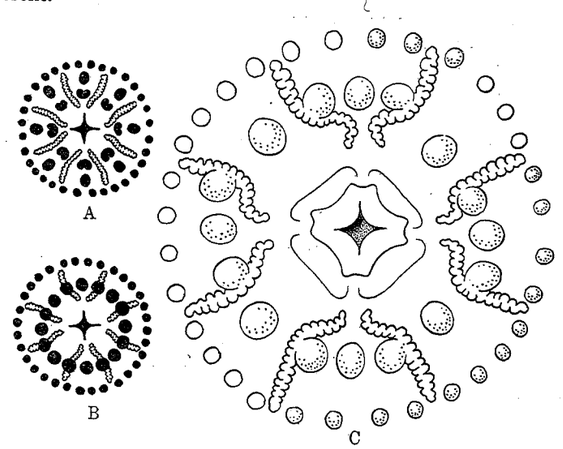


FIG. 356.—A, arrangement of subumbrella warts in *Linuche unguiculata* of the tropical Atlantic. B, arrangement of subumbrella warts of *Linuche aquila* of the tropical Pacific. C, enlarged view of central part of subumbrella of *Linuche aquila*, showing lips, gonads, and saccules.

Vast swarms of these medusæ are found among the atolls of the Fiji and Paumotos Islands, and they extend westward to the coast of Africa. They abound in the spring months, in Fiji in December and at Singapore in April. I have studied a large collection of these medusæ taken in the Philippine Islands at Mactau, near Sibu, on April 6, 1908, by the U. S. Bureau of Fisheries steamer *Albatross*. All were mature.

There appear to be no valid distinctions in Haeckel's descriptions between *L. aquila* and his "*L. draco*," the differences being such as one would expect to find in two contracted preserved specimens. Haeckel's *Linantha lunulata* (Syst. der Medusen, p. 494, taf. 29, fign. 1 to 3) is possibly the young of *L. aquila*. It is said to have 4 *interradial* horse-shoe-shaped gonads, but in all known species of *Linuche* the gonads are more nearly perradial than interradial. It is evidently an immature form, being only 10 mm. wide, and has no subumbrella saccules; indeed, the figure itself shows its ephyra-like condition. It comes from the Galapagos Islands, off the Pacific coast of South America.

Family COLLASPIDÆ Haeckel, 1880.

Collaspidæ, HAECKEL, 1880, Syst. der Medusen, p. 488.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 44.
Atollidæ, BIGELOW, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, pp. 21, 37.

FAMILY CHARACTERS.

Coronatæ with numerous (more than 8) marginal sense-organs which alternate with an equal number of tentacles. Marginal lappets twice as numerous as the tentacles.

Atolla is the only known genus.

Genus ATOLLA Haeckel, 1880, sensu Fewkes.

Atolla+*Collaspis*, HAECKEL, 1880, Syst. der Medusen, p. 488; 1881, Deep-Sea Medusæ, *Challenger* Report, Zool., vol. 4, p. 111.
Atolla, FEWKES, 1886, Report Commiss. Fish and Fisheries U. S. A. for 1884, p. 934; (?) Ephyroides, 1885; *Ibid.* for 1883, p. 597; and 1886, p. 948; 1889, p. 532.—VANHÖFFEN, 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 16; 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 5; 1906, Nordisches Plankton, Nr. 11, p. 44.—MAAS, 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, No. 1, pp. 78, 79; 1899, Bull. Soc. Zool. de France, p. 165; 1904, Résult Camp. Sci. Prince de Monaco, fasc. 28, p. 48; 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 14; 1907, Ergeb. und Fortschritte der Zool., Bd. 1, p. 195.—BROWNE, 1908, Trans. Roy. Soc. Edinburgh, vol. 46, p. 240.—BIGELOW, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 37.

GENERIC CHARACTERS.

Coronatæ with numerous (9 or more) tentacles and equally numerous marginal sense-organs. Twice as many marginal lappets as sense-organs. 8 adradial gonads and 4 interradial subgenital ostia. 4 lips. The tentacles and marginal sense-organs alternate regularly, but the insertions of the tentacles and their pedalia are higher up on the exumbrella than are the insertions of the pedalia of the sense-organs.

The type species is *wyvillei* Haeckel.

Haeckel distinguished "*Atolla*" with 8 gonads grouped in 4 pairs and "*Collaspis*" with 8 separate, equally spaced gonads. As was first shown by Fewkes, 1886, both of these conditions may exist upon one and the same medusa, some of the gonads being paired, others separated by equal spaces. The name "*Collaspis*" must therefore be dropped, being equivalent to *Atolla*.

The medusæ of this genus are deep-sea forms and are inhabitants of all oceans, and large numbers of them have been taken in open nets dragged at 350 to 2,500 fathoms. A few specimens have also been found upon the surface, but this is unusual. They are often brought up from depths of about 100 fathoms where the ocean is more than 2,000 fathoms deep.

In the sculpturing of the exumbrella, the structure of the tentacles, the general features of the anatomy of the gastrovascular system, and in the arrangement of the muscular system, these medusæ are strikingly similar to *Periphylla* but differ in the absence of funnel cavities in the floor of the subumbrella and in the flat, discoidal shape of the bell. The central stomach-cavity is thus less complex, but not essentially different from that of *Periphylla*.

The details of the structure of gastrovascular system, sense-organs, gonads, etc., are given in the description of *A. bairdii*.

Ephyroides rotaformis Fewkes, 1886 (Report U. S. Fish Commission for 1884, p. 949), may be closely related to *Atolla*. The 16 to 32, or more, pedalia are separated by wide intervals instead of by narrow clefts, as in *Atolla*. Several specimens are mentioned by Fewkes as having been dredged from depths of 389 to 1,555 fathoms in the Gulf Stream off the coast of the United States, but were not sufficiently well preserved to admit of description.

Vanhöffen, 1902, discovered in *Atolla*, a system of excretory openings which consists of 8 pores, 2 in each principal radius near the perradial angles of the stomach and centripetal to the zone of the gonads, with which this system has no connection. The position of these openings is marked by 8 oval spots upon the floor of the subumbrella. The closely allied *Ephyropsidæ* have numerous openings on the subumbrella at the place of connection between the tentacular canals and the ring-canal, but these have not been observed in *Atolla*.

Vanhöffen (1902), Maas (1904,) and Bigelow (1909), have given the best detailed description of the genus *Atolla*. The development is unknown.

Bigelow concludes that the sculpturing of the central lens of the exumbrella, the presence or absence of warts, etc., constitute the best criteria for the separation of species. The furrows of the central lens are, when present, always one less in number than the tentacles. Bigelow doubts the existence of *A. alexandri* and finds slight furrows on the central disk of the specimens which I described from Hawaii as *A. alexandri*. He therefore merges "*A. alexandri*" with *A. wyvillei*.

A study of the large number of specimens of *Atolla* in the National Museum at Washington convinces me that *A. bairdii* and *A. wyvillei* are very closely related if not mere individual variations of one and the same species. In some specimens the annular ridge in the outer side of the ring-furrow is so narrow and indistinctly separated from the marginal zone of pedalia that one hesitates to decide whether to consider it to be present or absent. Moreover the margin of the central lens in all Atollas is apt to be more or less notched with faint sinuosities in its outline, and thus *A. bairdii* and *A. wyvillei* may be only varieties of one and the same species.

8 so-called species of *Atolla* have been described, but I believe only three can be distinguished upon non-intergrading characters. These are:

A. bairdii Fewkes, with an annular ridge within the ring-furrow between the central lens and the marginal zone of pedalia. Exumbrella surface of lappets smooth. *A. valdiviæ* and *A. gigantea* are probably identical with *A. bairdii*.

A. chuni Vanhöffen has the exumbrella surface of lappets besprinkled with papillæ, very wide central lens, and an annular ridge in ring-furrow.

A. wyvillei Haeckel, with margin of central lens notched with radial furrows; no annular ridge in the ring-furrow. This is probably identical with *A. achillis* and *A. verrillii*.

A synopsis of the distinctive characters of the forms is presented in the following table:

Synopsis of the So-called Species of Atolla.

	A. bairdii.*	A. valdiviæ.*	A. gigantea.*	A. chuni.	A. wyvillei= A. achillis.†	A. verrillii.†
Width of bell in mm.	12 to 72	132	150	27 to 50	58 to 66	95
Width of central lens.	5 to 40, usually more than half as wide as medusa.	Half as wide as medusa.	70	22.5 to 38	About 29 to 33.	About 50.
Annular ridge on the outer side of the ring furrow.	Smooth with even margin.	As in A. bairdii.	Notched in outer margin. Contracted?	Hidden within the ring-furrow.	Hidden within the ring-furrow.	Hidden within ring-furrow.
Radical furrows of central lens.	None; but the margin is indented with 17 to 23 notches.	As in A. bairdii.	As in A. bairdii.	Notched with 23 shallow radial furrows.	Notched with 15 to 31 radial clefts or grooves.	Notched with 13 to 27 shallow radial clefts.
Number of tentacles.	18 to 24	20 to 29	?	24±	16 to 32	14 to 28
Exumbrella surface of lappet zone.	Smooth.	Smooth.	Smooth.	Covered with papillæ.	Smooth.	Smooth.
Where found.	North Atlantic.	Indian Ocean.	Gulf of Panama. Panama.	Cape of Good Hope, Africa.	Antarctic. Tropical Pacific.	Atlantic, Indian, and Pacific Oceans.

*These are probably all *A. bairdii*. †These are probably *A. wyvillei*.

To a great extent the conditions exhibited by these so-called species of *Atolla* intergrade. For example we can draw no sharp line of distinction throughout the series between a smooth, central lens with faint notches in its margin and as is seen in *A. bairdii*, and a lens deeply furrowed by radiating valleys as in *A. wyvillei*. Similarly the wide, annular ridge, which projects prominently on the outer side of the ring-furrow in *A. bairdii* grades insensibly to the condition seen in *A. wyvillei* wherein the ridge is so narrow that it is quite hidden by the ring-furrow which over-arches it. With the exception of *A. chuni*, which stands apart, all of the others may be mere local races or varieties of one variable species, *A. wyvillei*.

Atolla bairdii Fewkes.

Atolla bairdii, Fewkes, J. W., 1886, Report Commiss. Fish and Fisheries U. S. A. for 1884, p. 936, plates 1–3, 4 figs.; 1888, American Journ. Sci., ser. 3, vol. 35, p. 172; Ann. Mag. Nat. Hist., ser. 6, vol. 1, p. 253; 1889, Report Commiss. Fish and Fisheries U. S. A. for 1886, p. 530.—Agassiz, A., 1888, Bull. Mus. Comp. Zool. at Harvard College, vol. 15, p. 132, fig. 427.—Vanhöffen, 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 16, taf. 4, fign. 3–9; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., Dampfer *Valdivia*, Bd. 3, Lief. 1, p. 9; 1906, Nordisches Plankton, Nr. 11, p. 44, fign. 4, 5.—Maas, 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, p. 79; 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 49, planche 4, figs. 29–34; planche 5, figs. 38–43.—Browne, 1906, Trans. Linnean Soc. London, ser. 2, Zool., vol. 10, p. 179.

The medusa is 30 to 144 mm. in diameter, disk quite flat. Central lenticular part of exumbrella somewhat more than half as wide as entire medusa. It is flat aborally and surrounded by a recurved rim, the periphery of which displays about 20 to 22 slight notches, which are one less numerous than the tentacular pedalia in whose radii they tend to lie. Central lens separated from peripheral part of exumbrella by a deep, broad, annular groove, slightly over-arched by the recurved rim of the central lens itself. The peripheral zone of the exumbrella includes all that part of bell which lies centrifugal from the annular groove. It may in turn be divided into 4 zones: (1) The innermost zone is a simple, smooth-surfaced, annular ridge bounded on the inner side by the deep annular groove and on the outer by a very slight, reddish-colored groove which separates it from (2), the zone of the tentacular pedalia. There

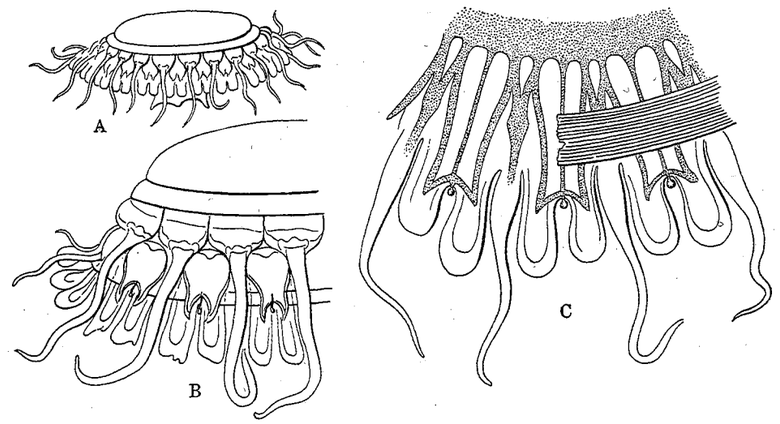


Fig. 357.—*Atolla bairdii*, after Maas in Résult. Camp. Sci. Albert 1er Prince de Monaco. A, and B, side views of the medusa; C, marginal canal-system and ring-muscle (cut across).

are about 18 to 24, usually 22, pedalia, one in the radius of each tentacle. These pedalia are thick ridges separated one from another by shallow radiating furrows, which do not cut very deeply into the gelatinous substance, so that the tentacular pedalia form a thick, continuous, gelatinous zone. Each pedalium bears a short, solid tentacle, usually carried recurved upward and provided with strong, longitudinal muscles upon its subumbrella side.

The third zone is that of the pedalia of the sense-organs and lies immediately centrifugal to the zone of the tentacular pedalia. These pedalia of the sense-organs alternate in position with the equally numerous, tentacular pedalia. They are lower than the tentacular pedalia and are separated from one another by deep, wide, radiating furrows which occupy the radii of the tentacles. Sense-organs very small with 2 swollen regions upon the ventral (subumbrella) side of the bulb where one finds thickened, sensory ectodermal epithelium. There is no ocellus and there are no pigment spots either in the ectoderm or the entoderm, but there is a terminal sac-like swelling which contains a crystalline mass of entodermal origin and which is protected by a wide, scale-like expansion on the exumbrella side of the sense-club. (See Vanhöffen, 1902; Maas, 1904.)

The fourth or outermost zone of the exumbrella consists of long, slender, marginal lappets supported by the pedalia of the sense-organs, and which are twice as numerous as the latter.

The center of the subumbrella is occupied by the shallow proboscis, the 4 lips of which are simple and cruciform. Surrounding the base of the proboscis is a zone in which are situated the 8 adradial gonads. The gonads vary considerably in size and shape, but normally appear to be composed of bean-shaped sectors, each genital ridge being constricted radially by one or more deep furrows (see Vanhöffen, 1892, taf. 4, fig. 4, *g*). 8 groups of radial-muscles lie in the floor of the subumbrella between the 8 gonads. Immediately centrifugal to the zone of the gonads lies a zone of circular muscle-fibers which is divided into separate parts by furrows which lie in the radii of the sense-organs. Beyond this zone lies the outermost ring of circular muscles developed so remarkably that it projects outward from the floor of the subumbrella as a thick annular mass, which is entire, not divided, as are the inner, circular muscles. The cavity of the central stomach communicates with a broad ring-sinus in the subumbrella by means of 4 perradially situated ostia. This ring-sinus corresponds in position to the zone of the gonads upon the subumbrella. Centrifugally it gives rise to a radiating vessel in each tentacular radius and also to an equal number of vessels to the sense-clubs. The tentacular vessels each give off a pair of side-branches which lead into the rhopalar vessels near the bases of the sense-clubs. At the point of origin of each tentacular vessel there is a region of fusion of the subumbrella and exumbrella walls of the gastrovascular cavity thus forming a small cathammal plate in the middle of each tentacular vessel (see fig. 359 C).

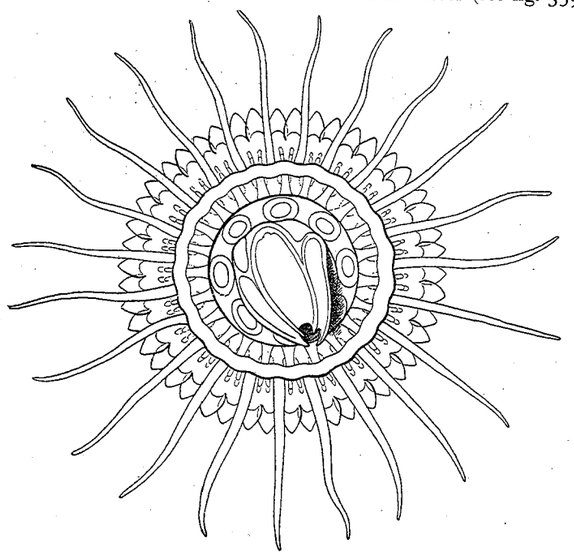


FIG. 358.—*Atolla valdiviæ*, after Vanhoffen, in *Valdivia* Expedition. View of subumbrella.

The excretory system of the exumbrella has been described under the genus *Atolla*.

In the corners of the central stomach are 4 interradial rows of gastric cirri forming a cross with perradial axes. Altogether the gastrovascular system, the pedalia of the exumbrella, and the structure of the muscular system, with the exception of the remarkable unitary ring-muscle of *Atolla*, are quite alike in both *Atolla* and *Periphylla* and indicate a genetic relationship between the two forms.

The gelatinous substance of the bell of *Atolla bairdii* is translucent and milky-blue in color. The central disk of the exumbrella is sprinkled over with rust-red colored patches which become more numerous in the region of the annular furrow, which is of a decided red-brown color. The powerful centrifugal circular-muscle band of the subumbrella is dark-red and a radial red streak extends inward on the subumbrella side from the base of each sense-organ to the band of circular muscles. Gonads and entoderm of central stomach red. The 8 adradial excretory pores near the 4 angles of the central stomach are dark-red of the hue so commonly seen in deep-sea medusæ of all ports.

This species is widely distributed over the North Atlantic. It has often been obtained in open nets dragged at depths from 900 to 2,000 fathoms, but has also been taken occasionally upon the surface, especially upon the Gulf Stream off the Carolina coast. It is a creature of the deep ocean, not found in bays or estuaries, but is evidently a deep-sea medusa that may only occasionally and under exceptional conditions come to the surface.

When young the 8 gonads are grouped in 4 interradial pairs, but in later life they swing into adradial positions. The number of antimeres does not alter with age; but in some specimens one finds some small tentacular pedalia inserted between larger rhopalar ones. Vanhöffen records 11 specimens ranging from 5.5 to 114 mm. in diameter and with 18 to 24 tentacles. These were found by the *Valdivia* in the Gulf of Guinea, west coast of Africa.

Atolla bairdii forma valdiviæ Vanhöffen.

Atolla valdiviæ, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lief. 1, p. 13, taf. 1, fig. 3; taf. 5, fig. 21; taf. 6, fign. 41–46; taf. 7.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 17, taf. 1, fign. 3, 4; taf. 3, fig. 23; taf. 12, fig. 108.

Medusa 132 mm. in diameter. Central disk only half as wide as bell, smooth, without radial furrows. 20 to 29 tentacles. The 4 interradial septal nodes of the subumbrella are wider than in the typical *A. bairdii*. 9 specimens were found by the *Valdivia* in the Indian Ocean. Maas records 9 specimens obtained by the *Siboga* in the Malay Archipelago. These ranged from 12 to 82 mm. in diameter, the central disks ranging from 6 to 42 mm. in width; and the antimeres range from 20 to 29 without reference to the size of the medusa. These medusæ were obtained from depths ranging from about 280 to 1,000 fathoms (see fig. 358).

This form is very closely related to *A. bairdii* but the central disk is only half as wide as the medusa, and the 4 septal nodes are wider than in *A. bairdii*.

The *Albatross* obtained 3 specimens of this medusa in the Philippine Islands on April 10, 1908, at dredging station No. 5202. The characters and dimensions, in mm., of these specimens are as follows:

	Specimen A.	Specimen B.	Specimen C.
Exumbrella:			
Diameter of bell	45.5	38	37
Diameter of central lens of exumbrella	21.5	19	18.5
Width of annulus between coronal furrow and tentacular pedalia	1.5	1.25	1
Width of tentacular pedalia	4	3.5	3.25
Length of tentacular pedalia (in radial direction)	3	2.75	3
Width of ocular pedalia	3.5	3	2.5
Length of ocular pedalia (in radial direction)	7.5	5	5.75
Subumbrella:			
Diameter to outer side of ring-muscle	43	35	34
Width of ring-muscle	2.25	3.5	2.5
Diameter to outer edge of gonads	31	20.5	23
Diameter of manubrium	15	13	14
Length (circumferential) of gonad	7	2.5	3.5
Width (radially) of gonad	6	3.5	3
General characters:			
Number of tentacles	24	22	24

Atolla gigantea Maas = A. bairdii (?)

Atolla gigantea, MAAS, 1897, Mem. Mus. Comp. Zool. at Harvard College, vol. 23, p. 80, taf. 12, fign. 2–4; taf. 13, fign. 7–9; taf. 14, fig. 6.

This form resembles *A. valdiviæ*, but the outer edge of the annular ridge in the ring-furrow is notched, not simple and entire as in *A. bairdii* and *A. valdiviæ*. Thus the central lens is half as wide as the bell, as in *A. valdiviæ*. Ring-furrow wide, and peripheral to it there is the notched, annular ridge, and beyond this is the zone of pedalia and lappets. Tentacular pedalia somewhat shorter and wider than the rhopalar pedalia. Medusa is 150 mm. wide. Number of tentacles (?) Gulf of Panama, Pacific coast of Central America (see fig. 359).

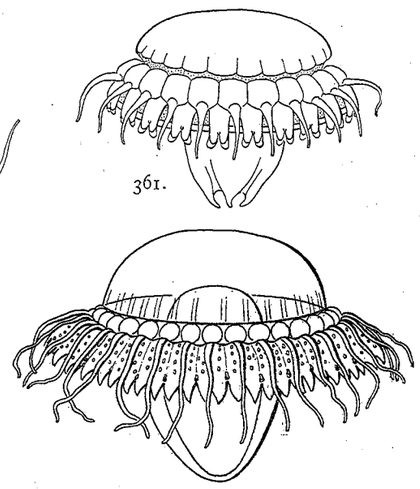
Maas is uncertain as to whether or not the margin of the central lens is plain or notched. Radial furrows of the ridge in the ring-furrow may be due to contraction in preservative fluids.

Atolla chuni Vanhöffen.

Atolla chuni, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lief. 1, p. 12, taf. 1, figs. 1, 2; taf. 5, fig. 26.—BROWNE, 1908, Trans. Roy. Soc. Edinburgh, vol. 46, p. 240.

Bell 27 to 50 mm. wide, 9 to 15 mm. high. Central lenticular disk 14 to 27.5 mm. wide with 23 faint radial furrows at the margin. Annular furrow 0.5 to 1.75 mm. wide. Zone of pedalia 2.25 to 3.5 mm. wide. 24 tentacles. Species distinguished by 7 to 9 small, pearl-colored, papilla-like protuberances over the exumbrella surfaces of each marginal lappet; commonly with one papilla in the center and the others in two lateral rows. 2 specimens found by the *Valdivia* off Cape of Good Hope, Africa, November 18, 1898; and 1 by the Scottish Antarctic Expedition, in a trawl at 1,332 fathoms, in the same region.

359.



360.

361.

FIG. 359.—*Atolla gigantea*, after Maas, in Mem. Mus. of Comp. Zool. at Harvard College.
FIG. 360.—*Atolla chuni*, after Vanhöffen in *Valdivia* Expedition.
FIG. 361.—*Atolla wyvillei*, 0.75 natural size, drawn by the author, from a specimen in the National Museum, Washington.

Atolla wyvillei Haeckel.

Atolla wyvillei, HAECKEL, 1880, Syst. der Medusen, p. 488; 1881, Report, *Challenger* Expedition, Zool., vol. 4, p. 113, plate 29, figs. 1–9.—ROULE, 1896, Résult. Scientifique Camp. *Caudan*, Tome 1, Lyon, p. 302 (Bay of Biscay, France, depth of 350 to 850 fathoms).—MAAS, 1897, Mem. Museum Comp. Zool. at Harvard College, vol. 23, p. 79.—VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition *Valdivia*, Bd. 3, Lfg. 1, p. 13, taf. 5, fig. 22; 1908, deutsch. Südpolar Expedition, Bd. 10, Zool. 2, p. 37.—BROWNE, 1908, Trans. Roy. Soc. Edinburgh, vol. 46, p. 241.—BIGELOW, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 39, plates 8–10.
(?) *Collaspis achillis*, HAECKEL, 1880, *loc. cit.*, p. 489.
Atolla alexandri, MAAS, 1897, Mem. Museum Comp. Zool. at Harvard College, vol. 23, p. 81, taf. 11, fig. 2; taf. 14, figs. 4, 5.—AGASSIZ, A., and MAYER, 1902, Mem. Museum Comp. Zool. at Harvard College, vol. 26, p. 156.—MAYER, 1906, Bull. U. S. Fish Commission, vol. 23, p. 1138, plate 2, fig. 7; plate 3, figs. 10, 11.

This species is characterized by the numerous, wide, radial notches or furrows in the margin of the central lens of the exumbrella. These are much wider and deeper than in *A. verrillii*. Exumbrella surface of lappets smooth, not beset with papillæ as in *A. chuni*. This medusa is probably identical with *Collaspis achillis* Haeckel, but in the latter the furrows of the central lens are represented as deep, narrow clefts, whereas in *A. wyvillei* they are shallow notches which vary greatly in prominence in individual medusæ. Moreover, in *A. wyvillei* the pedalia are short and broad, while in *A. achillis* they are long and narrow. The central lens and the pedalia are separated only by a ring-furrow and there is no prominent ridge peripheral to the ring-furrow such as is seen in *A. bairdii*. The medusa becomes 73 mm. wide and there are usually about 22 to 28 tentacles. The bell is flatter than a hemisphere. Found in the Antarctic and Southern Atlantic and Pacific. The *Albatross* obtained it in the Philippine Islands, tropical Pacific.

I am inclined to believe that *A. wyvillei*, *A. verrillii*, *A. alexandri*, and *A. achillis* are only varieties of one and the same species. "*A. alexandri*" is a form of *A. wyvillei* with indistinct notches in the margin of its central lens.

A specimen was dredged by the *Albatross* on April 10, 1908, dredging station No. 5201, off the south end of Leyi Island, Philippine Islands, from a depth of 554 fathoms. A side view is shown in fig. 361. There were 23 pedalia and tentacles, and 22 radial furrows in the margin of the central disk. The dimensions in millimeters are as follows:

Diameter of bell	55	Width of tentacular pedalia	6	Width of ring-muscle	3
Thickness of bell	26	Length of pedalia of lappets	6.5	Diameter across zone of gonads	28.5
Diameter of central lens	40	Width of pedalia of lappets	5	Diameter of manubrium	21
Depth of coronal furrow	3	Length of tentacles	13	Length of manubrium	22
Length of tentacular pedalia	6.5	Diameter to outer edge of ring-muscle	48	Gonads 7 long in the circumferential direction, 5 wide in the radial direction.	

Atolla wyvillei forma verrillii Verrill.

Atolla verrillii, VERRILL, 1885, Report Commiss. Fish and Fisheries U. S. A. for 1883, p. 594.—FEWKES, 1885, Report Commiss. Fish and Fisheries U. S. A. for 1883, p. 596; *Ibid.*, 1886, Report for 1884, p. 939, plates 4, 5, 4 figs.; *Ibid.*, 1889, Report for 1886, p. 530; 1888, American Journ. Sci., ser. 3, vol. 35, p. 172; 1888, Ann. Mag. Nat. Hist., ser. 6, vol. 1, p. 253.—MAAS, 1897, Mem. Museum Comp. Zool. at Harvard College, vol. 23, p. 79.—VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., *Valdivia*, Bd. 3, Lief. 1, p. 10, taf. 5, fig. 23; taf. 6, fig. 39; taf. 7; 1908, deutsche Südpolar Expedition, Bd. 10, Zool. 2, p. 36.

This form is distinguished from the typical *Atolla bairdii* and resembles *A. wyvillei* by the absence of a projecting annular ridge on the outer side of the ring-furrow, the numerous, fine, radial furrows of its central dome, the long, narrow pedalia of the sense-organs, and the smallness of its marginal lappets. The medusa becomes 95 mm. wide and has between 14 to 28, usually 22, tentacles and marginal sense-organs and 28 to 56 small lappets. Central lens of exumbrella wider than in *A. bairdii*. It is found in deep water in the Atlantic, Indian, and Pacific Oceans. Most of the specimens have been obtained in open nets dragged from depths of 373 to 2,369 fathoms; but several have been found upon the surface. It is probably only a variety of *A. wyvillei*.

Family ATORELLIDÆ Vanhoffen, 1902.

Atorellidæ, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition *Valdivia*, Bd. 3, Lfg. 1, p. 51.—BIGELOW, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, pp. 21, 30.

FAMILY CHARACTERS.

Coronatæ with 6 rhopalia.

There is but a single known genus, this being *Atorella*.

The relationship between the Atorellidæ and other Coronatæ is unknown; for in the Periphyllidæ, Paraphyllinidæ, and Ephyopsidæ there are 4 or 8 rhopalia, and in the Collaspidæ a large (more than 8) but indefinite number of these organs; and it is impossible at present to determine how the number 6 may have been derived in the Atorellidæ. It is probable, however, that its affinities are much closer to *Atolla* than to the other Coronatæ.

Genus ATORELLA Vanhöffen, 1902.

Atorella, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 33.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 10.—BIGELOW, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 30.

The type species is *Atorella subglobosa* Vanhöffen, of Dar es Salaam, Africa, and from the Malay Archipelago.

GENERIC CHARACTERS.

Coronatæ with 6 marginal sense-organs, 6 tentacles, 12 marginal lappets, and 12 pedalia. A coronal furrow is present, and the 12 pedalia alternate with the lappets. There is a poorly developed ring-muscle in the subumbrella. 4 lips, 4 interradial gonads.

Atorella subglobosa Vanhöffen.

Atorella subglobosa, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, *Valdivia*, Bd. 3, Lfg. 1, p. 33, taf. 3, fig. 11.—MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 10, taf. 3, fign. 16–18.—Bigelow, H. B., 1909, Mem. Mus. Comp. Zool. at Harvard College, vol. 37, p. 30.

Bell globular, 15 to 17 mm. in diameter. 6 mainly solid, tapering tentacles, about as long as the bell-radius. 6 marginal sense-clubs, each with a terminal mass of concretionary crystals, arise from very shallow niches in bell-margin. There are 12 wide, shallow, slighty cleft marginal lappets. Ring-furrow on exumbrella not very deep. Central disk of exumbrella more than twice as wide as zone of pedalia. The 12 pedalia alternate with the lappets and are separated one from another by shallow furrows. Throat tube 4-sided, mouth cruciform. There are 4 clusters of gastric filaments, each cluster consisting of about 20 filaments. The ring-sinus gives rise to 12 pouches in the radii of the tentacles and sense-organs and there is a marginal ring-canal as in *Atolla* or *Periphylla*. 4 interradial, sac-like, swollen gonads arise from floor of subumbrella beyond the zone of the gastric filaments. Muscular system of subumbrella quite similar to that of *Nausithoë*, but the ring-muscle is very poorly developed.

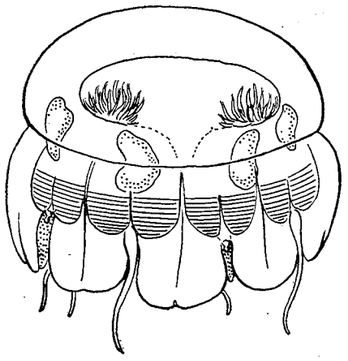


FIG. 362.—*Atorella subglobosa*, after Maas in *Siboga* Expedition.

Stomach and gastric filaments brown, gonads yellowish-brown. Subumbrella muscles white, all other parts translucent.

Vanhöffen describes a specimen from Dar es Salaam, east coast of Africa, and Maas describes another from the Malay Archipelago. Our description is derived mainly from that of Mass, his specimen being the more perfect. Vanhöffen's figure shows 6 gonads.

Atorella vanhoffeni Bigelow.

Atorella vanhoffeni, BIGELOW, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 30, plates 1, 11, and 12.

Bigelow had three specimens. In two of these the bell was 5 mm. high and 6 mm. wide, and one was 3 mm. high and 7 mm. in diameter. The ring furrow is a deep cleft. The entire exumbrella surface is besprinkled with wart-like, nematocyst-bearing prominences, thus being very different from the smooth surface of the bell of *Atorella subglobosa*. The 6 tentacles are each about as long as the bell-diameter. They taper outwardly but each terminates in a knob-like tip, instead of having simple, pointed ends as in *A. subglobosa*. The 6 rhopalia closely resemble those of *Atolla*, but the exumbrella surface of its covering scale is covered with thickened ectoderm, not with a thin layer as in *Atolla*. There is a large lithocyst and ventral bulb, but no ocellus. There are 12 long, oval, marginal

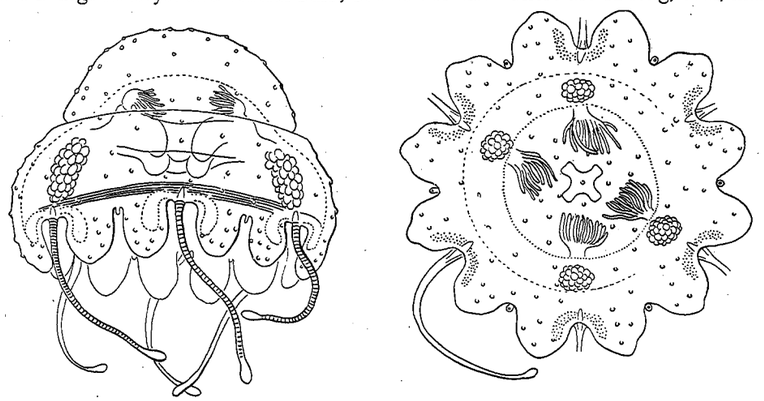


FIG. 363.—*Atorella vanhoffeni*, after H. B. Bigelow, in Mem. Mus. Comp. Zool. at Harvard College, 1909.

lappets. The stomach is flat and shallow and the 4 lips are short and thickened. The 4 interradial septal nodes are narrow and the perradial ostia wide. The gastric cirri are arranged in 4 interradial groups, each group arising from a stout gelatinous stalk, and consisting of 80 to 100 filaments. The canal-system of the bell resembles that of *Periphylla*. The 4 perradial ostia of the central stomach lead into a wide ring-sinus, which gives rise on its outer side to 12 broad radial-canals in the radii of the tentacles and sense-organs. These radial-canals branch at their ends and unite to form a marginal festoon canal. The ring-muscle of the subumbrella is very weak, but the subumbrella plates at the bases of the tentacles are very prominent.

There are 4 gonads, each being a leaf-shaped body folded so as to leave a deep groove along its middle line on the inner surface, and this groove causes the gonad to appear as if double, although this is not truly the case for each gonad is attached along a single line. The gonads are orange-yellow, all other parts colorless. This is a surface species. Bigelow records it from off the Pacific coast of Panama.

Order SEMAEOSTOMEÆ L. Agassiz, 1862.

Semaeostomeæ, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 9, 159.
Semostomæ, HAECKEL, 1880, Syst. der Medusen, p. 499.
Semæostomata, VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, pp. 6, 21; 1906, Nordisches Plankton, Nr. 11, Acraspedæ, p. 45.
Semaeostomæ, MAAS, 1907, Ergeb. und Fortschritte der Zool., Bd. 1, p. 200; 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 504.
Discomedusæ (in part), HAECKEL, 1880, Syst. der Medusen, p. 450.

CHARACTERS OF THE SEMAEOSTOMEÆ.

Scyphomedusæ without a coronal furrow and without pedalia. With a simple, central mouth-opening, the 4 perradial angles of which are developed into large curtain-like or gelatinous lips. With hollow tentacles and marginal rhopalia. The gonads are in sac-like folds of the entodermal wall of the subumbrella. Without interradial septal nodes in the stomach.

The families of the Semaeostomeæ are as follows:

(1) Pelagidæ GEGENBAUR, 1856. The central stomach gives rise to completely separated, unbranched radiating pouches. No ring-canal. Tentacles arise from the bell-margin between the clefts of the lappets.
(2) Cyaneidæ AGASSIZ, L., 1862. The central stomach gives rise to branched but completely separated radial-canals. No ring-canal. Tentacles arise from the floor of the subumbrella.
(3) Ulmaridæ HAECKEL, 1880, sens ampl. The central stomach gives rise to simple or branched radial-canals which are put into connection one with another by a marginal ring-canal.
A. Subfamily Umbrosidii. The tentacles arise singly from the clefts between the marginal lappets at the bell-margin. Protrusive, sac-like gonads, without subgenital pits.
B. Subfamily Sthenonidii. The tentacles arise in linear clusters from the floor of the subumbrella.
C. Subfamily Aurelidii. The tentacles and lappets arise from the sides of the exumbrella above the margin. Invaginated gonads with subgenital pits.

Family PELAGIDÆ Gegenbaur, 1856.

Pelagidæ, GEGENBAUR, 1856, Zeit. für wissen. Zool., Bd. 8, pp. 210, 267.—AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 121, 163.—AGASSIZ, A., 1865, North Amer. Acal., p. 47.—HAECKEL, 1880, Syst. der Medusen, p. 499.—VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 265.—CLAUS, 1886, Arbeit. Zool. Inst. Univ. Wein., Bd. 7, p. 110.—AGASSIZ AND MAYER, 1898, Bull. Mus. Comp. Zool. at Harvard College, vol. 32, p. 1.—CLAUS, 1883, Organisation und Entwick. Medusen, p. 24.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 45.

FAMILY CHARACTERS.

Scyphomedusæ with 8 or 16 marginal sense-organs, 4 perradial and 4 interradial, and, when present, 8 adradial. 8 or more tentacles which arise singly from the clefts between the marginal lappets. 16 to 64 marginal lappets. The mouth is simple and cruciform, and is situated at the extremity of an œsophagal tube, the 4 perradial corners of which are produced to form 4 long mouth-arms, the free edges of which are complexly crenulated. The simple, lenticular, central stomach gives rise to completely separated, radiating pouches the centrifugal ends of which give rise to simple, unbranched lappet-pouches. There is no ring-canal. The gonads occupy 4 interradial folds in the wall of the subumbrella. In some cases they project, but they are usually sunken, forming 4 pits in the floor of the subumbrella.

The medusæ of this family are readily distinguished from the Coronatæ by the absence of a coronal furrow and by the remarkable development of the 4 perradial corners of the mouth, which extend outward as 4 long palps or mouth-arms, carrying the free edge of the lips along with them in double curtain-like fringes. Also the exumbrella of the Pelagidæ is smooth and displays none of the complex sculpturing seen among the Coronatæ; finally, the gastrovascular system of the medusæ of the Pelagidæ is simpler than in the Coronatæ, for the central stomach is without interradial fusions of its upper and lower walls, and it consists merely in a wide, lenticular, central space which gives off completely separated, radiating pouches in the radii of the tentacles and sense-organs.

The Pelagidæ are also closely related to the Cyaneidæ. In the Cyaneidæ, however, the tentacles arise from the floor of the subumbrella at some distance in from the bell-margin, whereas in the Pelagidæ they arise from notches between the marginal lappets. Also the tentacles of the Cyaneidæ are usually grouped in clusters, while in the Pelagidæ they arise singly. A still further distinction lies in the fact that the radiating pouches of the stomach are simple in the Pelagidæ, while in the Cyaneidæ they give forth numerous blindly ending, non-anastomosing canals, which enter the marginal lappets.

Medusæ of the genus *Pelagia* develop directly from the planula without going through a sessile scyphostoma stage. The planulæ of *Chysaora* and *Dactylometra*, however, attach themselves and develop into Scyphostomæ, which in the case of *Chysaora* is known to strobilate and produce a number of ephyræ.

The Pelagidæ are of world-wide distribution, but are most abundant in the tropical regions. Many of them congregate in great swarms in bays and estuaries, and none are known to live permanently at great depths.

The development of *Pelagia* has been studied by L. Agassiz (Cont. Nat. Hist. U. S.) and by A. O. Kowalevsky, 1874 (Memoirs of the Imperial Society of the Friends of Natural History, Anthropology and Ethnography of Moscow, vol. 10, p. 7, plate 3 [Russian text]). A synopsis of the genera of the Pelagidæ follows:

Pelagia Péron and Lesueur, 1809. With 8 marginal sense-organs. 8 tentacles alternating with 8 marginal sense-organs, 16 marginal lappets.
Chrysaora Péron and Lesueur, 1809. With 8 marginal sense-organs. (3×8) 24 tentacles, 3 between each successive pair of marginal sense-organs. 32 marginal lappets.
Dactylometra L. Agassiz, 1862. With 8 marginal sense-organs. (5×8) 40 tentacles, 5 between each successive pair of sense-organs. 48 marginal lappets.
Kuragea Kishinouye, 1902. (7×8) 56 tentacles, (8×8) 64 lappets.
Sanderia Goette, 1886. 16 marginal sense-organs, 16 tentacles, 32 cleft lappets.

Genus PELAGIA Péron and Lesueur, 1809.

Pelagia, Péron et Lesueur, 1809, Ann. Mus. Hist. Nat. Paris, tome 14, p. 349.—Eschscholtz, 1829, Syst. der Acalephen, p. 72.—Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 163.—Haeckel, 1880, Syst. der Medusen, p. 504.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 6, 21; 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, *Valdivia*, Bd. 3, Lfg. 1, p. 34; 1906, Nordisches Plankton, Nr. 11, 14, 5.—Maas, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 56; 1906, Revue Suisse de Zool., tome 14, p. 100; 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 29.

GENERIC CHARACTERS.

Pelagidæ with 8 adradial tentacles, alternating with 8 rhopalia. With 16 marginal lappets. 16 radiating stomach-pouches in the rhopalar and tentacular radii, each of which ends in 2 side branches in the marginal lappets. No ring-canal.

The type species is *Pelagia noctiluca* of the Mediterranean, first described by Forskål, 1775, as *Medusa noctiluca*. At least 14 so-called "species" of *Pelagia* are known, 1 from the Mediterranean, 1 from the Mediterranean and Atlantic, 6 from the Atlantic, 5 from the Pacific, and 1 from the Indian Ocean. They are more abundant in warm or torrid regions, but one species is found in Behring Sea and another near the Cape of Good Hope. All of the Atlantic species are closely related one to another, and future researches may demonstrate that they are only geographical races. In fact the distinctions between "species" have been largely determined upon preserved material, and some of them may be separated upon unnatural conditions of contraction due to the effects of preservation; thus Vanhöffen, 1888, distinguishes a number of "species" upon the folding and wrinkling observed in the exumbrella warts of preserved medusæ. At present the "species" are in almost hopeless confusion, as will appear from the following table based largely upon Vanhöffen's work. Indeed it

seems probable that the foldings observed by Vanhöffen in the nettle-warts are largely due to shrinkage in alcohol.

The medusæ of *Pelagia*, being pelagic in all stages, are creatures of the high seas; and one would expect the species to be of world-wide distribution and at the same time to have developed many local varieties which are not very clearly differentiated from their parent stocks. I believe that all of the forms may be grouped into 4 cohorts as follows:

(1) *P. noctiluca, neglecta,* and *crassa,* of the Mediterranean and Atlantic, with large, elongate nettle-warts over the exumbrella.
(2) Allied to (1) in the Pacific, we find *P. flaveola, denticulata, tahitiana,* and *papillata* with large oval, erect nettle-warts.
(3) *P. cyanella, perla, discoidea, phosphora* and *minuta* of the Atlantic with small, rounded nettle-warts.
(4) *P. panopyra* and *placenta* of the Pacific with small, flatly dome-like nettle-warts.

Cohorts (1) and (2) are closely related; and (3) and (4) form another group.

As in *Cyanea* and *Aurellia* so in *Pelagia* we find that the Linnean system is inadequate to express the relationship of the numerous, closely related forms.

Synopsis of the Forms of Pelagia.

	P. noctiluca Péron et Lesueur.*	P. cyanella Péron et Lesueur.†	P. panopyra Péron et Lesueur.	P. flaveola Eschscholtz = P. tahitiana Agassiz and Mayer.	P. discoidea Eschscholtz‡.	P. denticulata Brandt. A variety of P. flaveola (?)
Width of disk in mm.	60	50	50	16 to 30	70 to 80	60
Height of disk in mm.	32	40	30	8 to 15	15 to 20	50
Character of nettle-warts on exumbrella.	Large, elongate, elliptical, with cross-foldings.	Small, roundish, thick-set. Found only in middle zone of disk.	Small, round, elliptical, with longitudinal furrow and cross-foldings.	Very large, thick-set, and egg-shaped.	No warts. Exumbrella smooth?	Large, elongate over entire exumbrella. Especially thick at apex.
Shape of marginal lappets.	Square-cornered, quadratic.	Twice as wide as high. Outer edge convex.	Quadratic.	Rounded, double, twice as wide as long.	Flat and cleft so as to be double.	Quadratic.
Length of mouth-tube in terms of disk radius.	r or r—	r	$2r$	r	r—	0.5 r
Length of mouth-arms in terms of disk-radius (r).	$2r$+	$2r$	$3r$	r	$3r$	$4r$
Where found.	Mediterranean.	Pernambuco, coast of Brazil and Florida to Cape Cod, in Gulf Stream.	Tropical Pacific.	Coast of Japan, Paumotos Islands, tropical Pacific.	Cape of Good Hope, Africa.	Behring's Sea, Aleutian Islands.
Color.	Variable. Yellow-brown to reddish-brown. Gonads and tentacles usually dark-red. Mouth-arms yellowish. Nettle-warts reddish-brown.	Variable. Usually blue-violet to pale blue. Nettle-warts reddish-brown. Tentacles reddish-purple.	Variable. Varying from light rose-red to violet-red. Mouth-arms more violet. Gonads more purple. Nettle-warts violet.	Light-yellowish. Tentacles citron-yellow. Gonads brownish-yellow. Nettle-warts tipped with orange.	Light-reddish. Palps rose-red. Tentacles purple-red. Gonads whitish.	Light violet-red. Tentacles red. Nettle-warts brown.

*Development without alternation of generations.
†Development through a pelagic larva without alternation of generations.
‡Too imperfectly known to be retained.

The remarkable development, which is direct, without a sessile larval stage, is described in detail under *P. noctiluca* and *P. cyanella.* The young medusa passes through a 4-tentacled stage, before acquiring its 8 adradial tentacles.

"*Zonephyra corona*," Agassiz and Mayer, 1902 (Mem. Museum Comp. Zool. at Harvard College, vol. 26, p. 157, pl. 4, figs. 19, 20), is probably a young *Pelagia.*

Synopsis of the Forms of Pelagia—Continued.

	P. perla Haeckel. A variety of P. cyanella (?)	P. phosphora Haeckel.*	P. placenta Haeckel. A variety of P. panopyra.	P. neglecta Vanhöffen=a variety of P. noctiluca.	P. crassa Vanhöffen.	P. minuta Vanhöffen. =P. phosphora (?)
Width of disk in mm.	50 to 60	40 to 50	40	53 to 60	35	12 to 25
Height of disk in mm.	40 to 50	25 to 30	12	23 to 28	13	3 to 6
Character of nettle-warts on exumbrella.	Numerous, rounded, small, and flat.	Small, rounded, with longitudinal furrow and cross-foldings. None on upper third of exumbrella.	Numerous, thick-set but flat and small. Surface nodular.	Large, rounded to elliptical. Without longitudinal furrow, but with cross-foldings.	Large, flat, elliptical with a longitudinal furrow and indistinct cross-foldings. None at bell-margin.	Rounded, small, thick-set, without longitudinal furrows, but with very thick cross-furrows.
Shape of marginal lappets.	Quadratic, with concave outer edge.	Rounded, almost semicircular.	Twice as wide as high. Flatly rounded.	Quadratic.	Twice as wide as high.	Wider than high.
Length of mouth-tube in terms of disk radius.	0.33*r*	0.5*r*	0.5*r*	*r*—	0.5*r*	0.66*r*
Length of mouth-arms in terms of disk-radius (*r*).	3*r*	2*r*	2*r*	2.5*r*	2*r*	2*r*
Where found.	Atlantic coast of Europe.	Tropical parts of the Atlantic. West coast of Africa.	Tropical Pacific, South America, Philippines.	Mediterranean and coast of Africa.	In middle of tropical Atlantic.	Coast of Brazil, Pernambuco.
Color.	Variable. Orange to rose-red or flesh-colored, or with rusty-yellow flecks. Nettle-warts orange. Tentacles and gonads red.	Variable. Rose-red to violet-red or purple. Arms, ribs, tentacles, and gonads usually darker red than the bell.	?	?	?	?

*Development through a pelagic larva without strobilization or alternation of generation, Haeckel, 1867.

Griffiths and Platt, 1895 (Nature, vol. 52, p. 564), find that the violet pigment of *Pelagia* has the composition $C_{20}H_{17}NO_7$. It is soluble in alcohol, ether, and acetic acid, and especially soluble in CS_2. Insoluble in water. It gives no characteristic absorption bands. It is thus quite distinct from the blue coloring matter of Hydromedusæ as determined by Colasanti, 1888 (Centralblatt für Physiol., Bd. 2, p. 10).

Pelagia noctiluca Péron and Lesueur.

Plate 60, figs. 1 to 3.

Medusa noctiluca, Forskål, 1775, Descript anim. itin. orient., p. 109.
Pelagia noctiluca, Péron et Lesueur, 1809, Annal. du Mus. Hist. Nat., tome 14, p. 350; *P. purpura, Aurellia phosphorica, loc. cit.,* pp. 350, 358.—Krohn, 1855, Müller's Archiv. Anat. Physiol., p. 491, taf. 20 (development).—Haeckel, 1880, Syst. der Medusen. p. 505 (list of authors and names).—Kowalevsky, 1873, Mem. Imp. Soc. Lovers of Nat. Hist., Moscow, vol. 10, part. 2, p. 7, plate 3 (development).—Hamann, 1883, Zeit. für wissen. Zool., Bd. 38, p. 422, taf. 32 (development and structure of gonads).—Metschnikoff, 1886, Embryol. Studien an Medusen, Wien., p. 24 (egg); 67 (segmentation); 100 (larva); taf. 10, fign. 23–28.—Monaco, Prince of, 1887, Comp. Rend. Paris, tome 104, p. 452 (swarming habits of the medusa).—Vanhöffen, 1888, Bibliotheca Zoologica, Heft. 3, p. 8, taf. 1, fign. 5, 6; taf. 6, fign. 1–5; 1908, Deutsch. Südpolar Expedition, 1901–1903, Bd. 10, Zool. 2, p. 38.—Goette, 1893, Zeit. für wissen. Zool., Bd. 55, p. 659, 11 fign., taf. 30–31; 1893, Sitzungsber. Akad. Wissen. Berlin, p. 853 (development).—Schaxel, 1910, Zool. Anzeiger, Bd. 35, p. 407 (histology of oögenesis).

The following is a description of a typical, adult specimen from the Bay of Naples: Disk somewhat higher than a hemisphere when contracted, but flatter than a hemisphere when expanded. In ordinary contraction it is about 49 to 55 mm. in diameter and 31 mm. high. Sides of bell relatively straight and sloping, the apex flat. Numerous nettle-warts over the exumbrella, arranged in more or less irregular lines radiating from aboral apex of exumbrella. These warts are rich orange-red in color and are elongate and linear, sometimes with, but more often without, cross-foldings. Near the bell-margin, however, they lose their linear shape and become small, simple, and more or less oval.

The 8 marginal sense-organs are set in deep niches in the perradii and interradii. The sense-club has no ocellus, but contains only a terminal mass of deeply pigmented orange-colored crystalline concretions of entodermal origin. There is no sensory pit in the exumbrella above the sense-club. The 8 hollow, tapering tentacles are each about twice (115 mm.) as long as the bell-diameter.

There are 16 subrectangular marginal lappets, with shallow median notches and rounded angles. The septum between the ultimate branches of the radiating stomach-pouches in the marginal lappets is twice as wide as the ultimate pouches themselves. The 4-sided throat-tube is as long as the bell-radius. The 4 lanceolate lips or palps, with their complexly folded margins are each about 1.33 as long as the bell-diameter. Thus in an adult medusa with a disk 49 mm. wide the palps were 68 mm. long.

The bell has a rich rose-purple tinge; the gonads, the entodermal cores and the tentacles being especially deep in this color. The warts upon the exumbrella and along the outer edges of the palps are orange-brownish red.

This medusa is abundant at times in the Mediterranean especially in summer, although large specimens are rarely seen in winter. It may be locally abundant during several successive seasons and then vanish for years. For many years it was all but unknown in the Bay of Naples but since 1900 it has been one of the commonest Scyphomedusæ in this region. It ranges widely over the warm regions of the Atlantic.

The development has been studied by Krohn, Kowalevsky, Hamann, Goette, Hyde, and Metschnikoff. Hamann, 1883, has made a detailed study of the development of the gonads, and their structure has been described by the brothers Hertwig, 1878. They appear as 4 interradial, elongate ridges in the entoderm of the subumbrella. The entoderm forms a series of follicles in which the sex-cells develop and then migrate into a gelatinous lamella between the layers of entoderm.

According to Metschnikoff, the egg is violet-brown and is laid between 12 and 2 in the afternoon, in December, in the Mediterranean. Segmentation is total and nearly equal, and a very large central segmentation-cavity is formed. The gastrula results from invagination at the hinder end of the body. The blastopore does not close, but forms the mouth of the larva. Thus, according to Goette, 1893, the mouth is ectodermal and forms by invagination at the hinder end of the larva, but the invaginated sac by no means fills the segmentation cavity. The first pair of stomach-pouches arise from the entoderm and are 180° apart, then follows an ectodermal pair 90° away from the first. The latter then develop 2 lateral pouches each, and at a later period the entodermal pair each gives rise to 2 lateral pouches, thus giving a larva with 6 ectodermal and 6 entodermal stomach-pouches; finally the ectodermal pouches give rise to 4 new adradial pouches and the larva has 16 stomach-pouches—10 ectodermal and 6 entodermal. There is thus a striking analogy between its development and that of the scyphostoma of *Aurellia*, according to Goette.

The external features of the transformation of the free-swimming larva into the medusa have been studied by Krohn (1855), Kowalevsky (1873), etc. The mouth-end of the larva becomes expanded and crater-like, with the mouth at summit of central cone of crater. The depressed region around the cone becomes the subumbrella. The lappets, into which the gastrovascular cavity is continued, grow out at intervals around the margin. The covering of cilia is lost from the body of the larva and it begins to swim by means of rhythmical contractions of its oral disk. Thus the free-swimming scyphostoma is converted into a medusa without strobilization (see Goette, 1893.)

Reasoning by analogy from the excellent work of Hyde, 1894 (Zeit. für wissen. Zool., Bd. 58, p. 531), upon *Aurellia*, it is probable that only the subumbrella floor of the second pair of evaginated gastric pouches is formed from ectoderm, their exumbrella sides being of entoderm. (See also Hadži's work upon *Chrysaora*.)

Pelagia noctiluca var. "neglecta."

Pelagia neglecta, VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, p. 9, taf. 6, fign. 6–12.

This variety is distinguished by the large, elliptical nematocyst-warts upon its exumbrella. These warts are usually about twice as long as they are wide and display cross-furrows. Specimens in which the bell is 53 to 60 mm. wide have a bell-height of 23 to 28 mm. Mouth-tube 15 to 25 mm. long and mouth-arms 68 to 85 mm. Color (?) This species is found at Naples and at the Canary Islands. Were it not for the very large, elliptical nettle-warts of the exumbrella, it would be identical with the typical *Pelagia noctiluca* Péron and Lesueur. It is so closely related to *P. noctiluca* that I believe in view of the ordinary variability of individuals of the same species in Scyphomedusæ, it had best be omitted from further consideration and merged with *P. noctiluca.*

Pelagia cyanella Péron and Lesueur.

Plate 61, fig. 1.

Medusa pelagica, LINNÉ, 1758, Systema Naturæ, Ed. 10, p. 660.
Medusa pelagica, LINNÉ, 1766, Systema Naturæ, Ed. 12, p. 1098.—1788 (Gmelin), tomus 1, pars 6, p. 3154.
Pelagia cyanella, PÉRON ET LESUEUR, 1809, Ann. Mus. Hist. Nat. Paris, tom. 14, p. 349, No. 66.
Dianaea cyanella, LAMARCK, 1816, Hist. Anim. sans vert., tome 2, p. 507.
Pelagia cyanella, ESCHSCHOLTZ, 1829, Syst. der Acalephen, p. 75, taf. 6, fig. 1.—BOSC, 1830, Hist. Nat. des Vers., Ed. 2, tome 2, p. 140, plate 17, fig. 3.—AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 128, 164; *Ibid.,* 1860, vol. 3, plate 12, figs. 1–16.—AGASSIZ, A., 1865, North Amer. Acal., p. 47, fig. 68.—HAECKEL, 1880, Syst. der Medusen, p. 507.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 22.—BIGELOW, 1890, Johns Hopkins Univ. Circ., vol. 9, No. 80, p. 66.—HARGITT, 1904, Bull. U. S. Bureau of Fisheries, vol. 24, p. 70, plate 7, fig. 1.

This American medusa is very closely related to the European *P. noctiluca*, of which it is apparently only a local variety.

Bell about 40 mm. high and 50 mm. broad; somewhat fuller than a hemisphere, being a little less broad at margin than a short distance above. Numerous small wart-like nematocyst capsules are sprinkled thickly over the exumbrella and are especially thick in a zone at about mid-height of bell; these protuberances are reddish in color and tend to be arranged in radiating lines. 8 very long, highly contractile, hollow tentacles alternate with 8 marginal sense-organs. Each sense-club is set within a niche between two adjacent lappets and is protected on the outer side by a partial web between the lappets. The club is hollow and has no ocellus, but contains a terminal, entodermal mass of crystalline concretions which are deeply pigmented. 16 marginal lappets, hemispherical in shape. There is a long, narrow, 4-sided proboscis, the radial corners of which extend downward as 4 long, flexible mouth-arms, the free edges of which are complexly crenulated. The proboscis, together with the mouth-arms, or palps, is about 3 times as long as bell-height. There are 4 complexly folded horse-shoe-shaped gonads in interradial positions upon the floor of the subumbrella, and immediately centripetal to them are 4 subgenital pits or cavities extending inward from the outer surface of the subumbrella. The quadrangular œsophagus leads into a circular, disk-shaped, central stomach which gives rise to 16 radial pouches extending outward in the radii of the sense-organs and tentacles. Each of these pouches gives off a pair of unbranched, curved canals which enter the lappets, but do not form a ring-sinus. There are 16 well-developed strands of radiating muscle fibers in the wall of the exumbrella adjacent to the gastrovascular cavity. These extend outward in the radii of the tentacles and sense-organs, and fork as they approach the bell-margin.

The color is quite variable, sometimes bluish, sometimes slightly yellowish. Exumbrella and mouth-arms sprinkled over with brownish-red nettling-warts, tentacles reddish-purple.

This species is found among the West Indies and Florida Reefs, and in summer it may drift northward in the Gulf Stream so as to appear off the southern coast of New England from July to September.

L. Agassiz, 1860 and 1862, found that the planulæ of this species, as in *P. noctiluca*, develop directly into medusæ without going through a sessile scyphostoma stage and without alternations of generations. The planulæ are set free into the water where each develops into a single medusa. The minute details of the development have been worked out upon *Pelagia noctiluca* by Metschnikoff, 1886 (Emb. Stud. an Medusen, Wien.), and by Goette, 1893 (Zeit. für wissen. Zool., Bd. 55, pp. 659–692). The gastrula is formed by invagination. The first pair of radial stomach-pouches appear, according to Goette, as outpocketings from the

entoderm and these are quickly followed by another pair from the ectoderm of the throat-tube, the two latter being 90° away from the former. The ectodermal pouches then give rise each to two side branches and soon thereafter the entodermal do the same. Thus the central stomach comes to have 12 radial pouches. 4 more radial pouches are soon formed from the ectodermal pouches, so that the young medusa finally possesses 16 radial pouches. It follows in adult medusa that the center of the exumbrella side of the central stomach is derived from entoderm. 2 diametrically opposed, perradial pouches are ectodermal in origin and the other 2 are entodermal. The 4 interradial pouches are ectodermal, and of the 8 adradial pouches, 4 are ectodermal and 4 entodermal. The wall of the œsophagus is of ectodermal origin. The young medusa soon develops 8 lobes which bifurcate, giving 16 marginal lappets. The 8 marginal sense-organs develop before the tentacles. The mouth is at first a simple, round opening at the center of the crater-like ectodermal depression. It soon acquires 4 lips, but the mouth-arms do not develop until a later stage. It is probable that the ectoderm does not take so large a share in the formation of the stomach-pouches as Goette supposes (see *Chrysaora* and *Aurellia*).

Pelagia panopyra Péron and Lesueur.

Medusa panopyra, Péron et Lesueur, 1807, Voyage aux Terres Australes, planche 31, fig. 2.
Pelagia panopyra, Péron et Lesueur, 1809, Annal. du Mus. Hist. Nat., tome 14, p. 349.—Eschscholtz, 1892, Syst. der Acal., p. 73, taf. 6, fig. 2.—Brandt, 1838, Mém. Acad. St. Pétersbourg, tome 4, sér. 6, Sci. Nat., p. 382, taf. 14, fig. 1; taf. 14 A, fign. 1–5.—Haeckel, 1880, Syst. der Medusen, p. 509 (literature).—Vanhöffen, 1888, Bibliotheca Zoologica, Heft. 3, p. 14.—Fewkes, 1889, American Naturalist, vol. 23, p. 592, fig. 1; 1889, Bull. Essex Inst. Salem, vol. 21, No. 7, p. 122, plate 5, fig. 1.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 29.—Mayer, 1906, Bull. U. S. Fish Commission, vol. 23, part 3, p. 1139, plate 2, figs. 3, 4.—Bigelow, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 43.—Maas, 1909, Abhandl. Akad. Wissen. München, Suppl. Bd., 1 Abhandl. 8, p. 43.—Kishinouye, 1910, Journal College Sci. Tokyo, vol. 27, art. 9, p. 9.

The characters of this widely distributed Pacific form are described in the table under the genus *Pelagia*. It is distinguished from the closely allied *P. flaveola* by its pink coloration, whereas *P. flaveola* is yellowish. Moreover the nettle-warts of *P. panopyra* are low and domelike, while in *P. flaveola* they are erect and bluntly pointed.

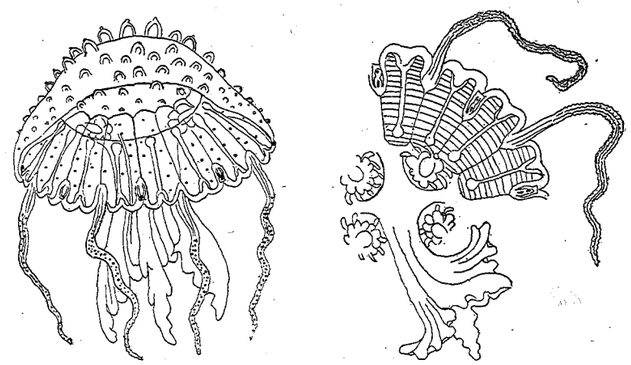


Fig. 364.—*Pelagia flaveola*, from Tahiti, after Agassiz and Mayer, in Mem. Mus. Comp. Zool. at Harvard College.

P. panopyra is common off the coast of California and extends across the Pacific to the Malay Archipelago, and northward to Japan.

Vanhöffen gives the dimensions of a specimen as follows: Bell 27 mm. wide, 6 mm. high; mouth-tube 15 mm. long; lips 27 mm. long.

When young the medusa has only 4 tentacles. When the bell is 15 mm. wide the gonads begin to develop.

Pelagia panopyra var. placenta.

Pelagia placenta, Haeckel, 1880, Syst. der Medusen, p. 510.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 12, taf. 6, fig. 20.

This appears to be a very close variety of *P. panopyra*. Both medusæ are widely distributed over the tropical Pacific. See synoptic table of forms of *Pelagia*. I believe that this

form can not be distinguished from *P. placenta* for I have found specimens which intergrade in one character or another. Many specimens of this medusa were found by the *Albatross* in the Philippine Islands in March and April, 1908. The dimensions in mm. of a mature specimen are as follows: Diameter of bell, 35; height of bell, 15; length of œsophagus, 14; length of lips, 30; length of tentacles, 50.

The largest exumbrella warts are near the center of the bell and they decrease in size toward the margin, where they are very small. The surface of these warts is nodular and lacks the cross-foldings seen in the typical *P. panopyra*, but this character intergrades.

Pelagia flaveola Eschscholtz.

Pelagia flaveola, Eschscholtz, 1829, Syst. der Acal., p. 76, taf. 6, fig. 3.—Goette, 1886, Sitzungsber. Akad. Wissen. Berlin, Jahrg. 1886, p. 883.
(?) *Pelagia denticulata*, Brandt, J. F., 1838, Mém. Acad. Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 383, taf. 14, fig. 2.
Pelagia tahitiana, Agassiz, A., and Mayer, 1902, Mem. Museum Comp. Zool. at Harvard College, vol. 26, p. 158, plate 8, figs. 34, 35.
Pelagia papillata, Haeckel, 1880, *loc. cit.*, p. 509.

For description see synoptic table of forms of *Pelagia*, and figure 364.

This form is distinguished by its yellow color and long, pointed nettle-warts which cluster thickly at the aboral apex of the bell. Tropical Pacific from South America to East Africa.

Pelagia perla Haeckel.

Medusa perla, Slabber, 1781, Physikal. Belust., p. 58, taf. 13, fign. 1, 2.
Pelagia cyanella, Forbes, 1847, Annals and Mag. Nat. Hist., vol. 19, p. 390, plate 9, fig. 5.
Pelagia perla, Haeckel, 1880, Syst. der Medusen, p. 506.—Maas, 1904, Résult Camp. Sci. Prince de Monaco, fasc. 28, p. 57.—Delap, M. S., 1906, Fisheries of Ireland, Sci. Invert., 1905, No. 7, p. 22, 1 plate.—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 45, fign. 6, 7.—Browne, 1908, Trans. Royal Soc. Edinburgh, vol. 46, p. 242.
Pelagia discoidea, Eschscholtz, 1829, Syst. der Acal., p. 76, taf. 7, fig. 1.

This appears to be a North Atlantic variety of *P. cyanella*. The nettle-warts of the exumbrella are more numerous and the outer margin of the lappets are concave instead of convex as in *P. cyanella*. For description see the synoptic table of the forms of *Pelagia*.

P. discoidea from the Cape of Good Hope is probably identical with *P. perla*.

Pelagia phosphora Haeckel.

Pelagia phosphora, Haeckel, 1880, Syst. der Medusen, p. 506.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 11, 22, taf. 6, fign. 18, 19; 1892, Ergeb. der Plankton Expedition, Bd. 2, K. d., p. 19; 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, *Valdivia*, Bd. 3, Lfg. 1, p. 36.

This form is closely related to *P. cyanella*, but may possibly be distinguished from it by the larger nettling-warts upon the exumbrella, which are round and 0.5 to 1 mm. in diameter and each gives rise to a longitudinal comb-like crest. Marginal lappets wider than long. Œsophagus about one-fourth as long as bell-diameter, mouth-arms about equal to bell-diameter in length. Bell hemispherical, 40 to 50 mm. in diameter. Color quite variable, either purple, violet, or reddish; gonads, tentacles, and median ribs of the mouth-arms of darker color than other parts of the animal.

Found in the eastern Atlantic from 58° N. to 42° S. lat.; also in the Indian Ocean, being especially abundant in the tropics.

Vanhöffen, 1902, gives the following dimensions for this species: Diameter of bell, 76 mm.; height of bell, 25 mm.; tentacles, 76 mm. long; nettling-warts on exumbrella, 2.5 mm. high.

Pelagia "minuta" Vanhöffen, 1888 (Bibliotheca Zoologica, Heft. 3, p. 12, taf. 6, fign. 16, 17), is a variety of, or possibly the young of, *P. phosphora*. The nettling-warts on the exumbrella, in specimens preserved in alcohol, are elongate with numerous transverse furrows (due to contraction?). No mature specimens were described by Vanhöffen. Found at Pernambuco, Brazil, early in July.

Pelagia crassa Vanhöffen.

Pelagia crassa, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 10, 22, taf. 1, fign. 1, 2; taf. 6, fign. 13, 14.
Pelagia crassa var. *sublaevis*, *Ibid.*, p. 11, taf. 6, fig. 15.

This appears to be a small variety of *P. noctiluca*.

Bell about 13 mm. high and about 35 mm. in diameter. Gelatinous substance of exumbrella thicker than in any other *Pelagia*. Marginal lappets about twice as wide as long.

Œsophagus shorter than in *P. cyanella*, only about one-quarter as long as bell-diameter. Mouth-arms also much shorter, only about as long as bell-diameter. Nettling-warts upon exumbrella larger and differently arranged than in either *P. cyanella* or *P. phosphora;* they are concentrated near apex of bell and not found near margin, elliptical in shape, sometimes quite flat, or with a well-developed longitudinal comb-like ridge crossed by corrugations. The largest warts are found at the apex of the exumbrella and they become smaller toward the periphery. In the variety *sublævis* the bell is arched and more hemispherical than in *P. crassa*. The gelatinous substance is thicker and the nettling-warts are larger and flatter than in *P. crassa*. These forms are found in the middle of the tropical Atlantic between Africa and South America.

Genus CHRYSAORA Péron and Lesueur, 1809.

Chrysaora, Péron et Lesueur, 1809, Ann. Mus. Hist. Nat. Paris, tome 14, p. 364.—Eschscholtz, 1829, Syst. der Acalephen, p. 78.—Brandt, 1838, Mém. Acad. des Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 384.—Haeckel, 1880, Syst. der Medusen, p. 510.—Claus, 1883, Untersuch. Organisation und Entwick. Medusen, pp. 1–22.—von Lendenfeld, 1884, Proc. Lin. Soc. New South Wales, vol. 9, p. 268.—Kishinouye, 1899, Zoolog. Anzeiger, Bd. 22, p. 44.—Vanhöffen, 1888, Bibliotheca Zoologica, Heft. 3, pp. 14, 22; 1906, Nordisches Plankton, Nr. 11, p. 47.—Hadži, 1907, Arbeit. Zool. Inst. Univ. Wien, Bd. 17, p. 17, fign. 1–15, taf. 3, 4.—Heric, *Ibid.*, p. 95, taf. 9.
Chrysaora+Melanaster, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 162.

The type species is *C. mediterranea* Péron and Lesueur, of the Mediterranean.

GENERIC CHARACTERS.

Pelagidæ with 8 marginal sense-organs, 24 tentacles (3 in each octant), and with 32 marginal lappets.

The medusæ of *Dactylometra* pass through a "*Chrysaora* stage" in their development, and there can be but little doubt that some of the so-called *Chrysaora* medusæ are only immature *Dactylometra*. The difficulty in distinguishing *Chrysaora* is still further complicated by the very variable, individual coloration of these medusæ, and by the fact that some species of *Dactylometra*, such as *D. quinquecirrha* itself, become sexually mature in the *Chrysaora* stage when living in brackish water. The *Chrysaora* and *Dactylometra* medusæ are widely distributed over the tropical and temperate seas and there are many local races. I believe that future study will reduce the species to two or three, with numerous local varieties, as in *Pelagia* or *Cyanea*.

Chrysaora hysoscella of the Mediterranean and Atlantic, and *C. melanaster* and *C. helvola* of the North Pacific appear to be distinct species, while the other so-called species may be varieties of the three above named or merely immature specimens of *Dactylometra*. *C. helvola* and *C. melanaster* finally develop small, lateral lappets upon the sides of their 16 ocular lappets and thus approach the *Dactylometra* condition in having 48 marginal lappets. The tentacles, however, remain 24 (3 in each octant) as in *Chrysaora*. L. Agassiz proposes the generic name *Melanaster* for Pelagidæ with 48 lappets and 24 tentacles, but as this appears to be but a transient stage in the process of growth of *Dactylometra*, or a late stage in the development of *Chrysaora*, we prefer not to adopt it.

Chrysaora hysoscella, which is probably identical with *C. mediterranea*, is often hermaphroditic; young individuals being male, middle-aged ones hermaphroditic, and old ones female. In other cases, however, the medusæ are throughout life of one sex; while in others male saccules develop among the old female gonads, and in other parts of the entodermal layer of the subumbrella.

The development of *Chrysaora* is through a sessile scyphostoma-stage, and the ephyra is produced by polydiscus strobilization. The ephyra passes through an 8-tentacled stage in which it recalls the condition seen in the adult of *Pelagia*.

The mode of origin of the 4 primary stomach-pouches of the scyphostoma, and their derivatives, has been the subject of a prolonged discussion between Claus and Goette, and others. The view of Goette that the œsophagus of the scyphostoma is derived from invaginated ectoderm received support from Hyde, and was generally accepted until 1907 when Hadži and also Heric (Arbeit. Zool. Inst. Wien, Bd. 17, Heft. 1) made further studies of the development of *Chrysaora*. It should also be remembered that R. P. Bigelow, 1900, in his study of the development of *Cassiopea* is in accord with the views which were later put forth by Hadži.

Hadži finds that some of the free-swimming planulæ of *Chrysaora* are 4 or 5 times as large as others. They swim with the broad end forward and soon settle upon *ulva*, etc., attaching by means of their forward ends. The entoderm, which was previously a solid mass, then hollows out and the larva becomes two-layered, and the uppermost (the former posterior) end becomes the widest. The mouth then breaks through, the oral pole flattens laterally, and 4 tentacles develop, 2 in the short and 2 at the ends of the long diameter. The stomach-pouches do not begin to form until after the mouth and 4 tentacles have developed.

The view of Claus has received strong support from Hadži who casts serious doubt upon Geotte's interpretation that the œsophagus of the scyphostoma is always composed of invaginated ectoderm.

Hadži, whose research upon *Chrysaora* appears to have been carefully studied, finds that the œsophagus of the scyphostoma is entodermal and that the mouth breaks through from the inside, the *entoderm* thus taking the active share in its formation, and no invagination of ectoderm occurring. Indeed Hadži finds that the cells lining the throat of the scyphostoma resemble ectodermal cells in having nematocyst capsules and glands, but they are nevertheless solely of entodermal origin. From this it follows that the 4 primary stomach-pouches are also entodermal, not 2 ectodermal and 2 entodermal as claimed by Goette. Hadži finds also that the 4 intertentacular tæniolæ are formed from 4 simple, longitudinal infoldings of the entoderm of the stomach wall, the ectoderm taking no part in their formation. The primary stomach-pouches are thus the passive result of the infoldings which form the tæniolæ, not of an active outgrowth of pouches as Goette believes.

Hadži's view appears to be the more reasonable, for if Goette were correct one half of the gonads would be ectodermal and one half entodermal, whereas according to Hadži they are all entodermal; moreover, according to Goette, the mouth of the first ephyra set free in strobilization has its œsophagus lined with ectoderm, while those ephyræ which follow it have their throats lined with entoderm, an anomalous condition. According to Hadži and Heric, however, all of the ephyræ have their throats lined with entoderm.

Heric finds in the strobilization of the scyphostoma of *Chrysaora* that with the exception of the terminal ephyra all of the mouth-tubes of the chain of ephyræ are formed from the connecting tube which joins all of the ephyræ together. The external wall of this connecting tube is ectodermal and its inner wall entodermal. 4 perradial clefts develop in the side wall of each tube near the upper end where it joins with the exumbrella of the overlying ephyra. The lower edges of these clefts grow outward and form the 4 lips of the ephyra, while the 4 connections are interradial and are in the radii of the tæniolæ which constitute their inner sides.

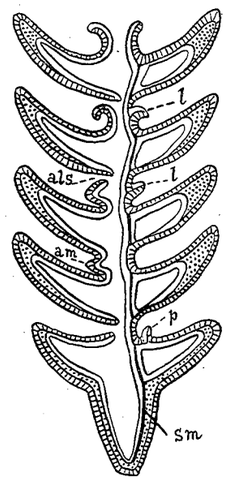


FIG. 365.—Diagrammatic section of a strobilla of *Chrysaora* after Heric, in Arbeit. Zool. Inst. Wien.
als, perradial cleft. *am*, beginning of the lip. *p*, *l*, *l*, stages in the growth of the throat-tube. *s m*, septal muscle. Ectoderm cross-hatched, entoderm plain, intermediate lamella dotted.

The 4 subgenital cavities of the ephyra are new formations and not derived from the 4 funnel-cavities of the scyphostoma. The 4 interradial septa of the stomach-cavity of the ephyra are, however, derived from the tæniolæ of the scyphostoma. These soon disappear, and the central stomach of the medusa is a simple lenticular space.

The forms of *Chrysaora* are so imperfectly separated one from another that were it not for the fact that many minute distinctions have been pointed out between them, I would greatly prefer to consider them all to be one variable species, *C. hysoscella*. However, we may possibly distinguish more or less vaguely:

C. hysoscella=*C. mediterranea* with its varieties *blossevillei* and *plocamia* (?) of the Atlantic, Mediterranean, and South Pacific.
C. helvola, with its varieties *calliparea*, and *chinensis* of the Pacific and Indian Oceans.
C. melanaster with its variety *gilberti* of the North Pacific.

I believe that a study of the following synoptic table will convince one that we have here only one species, the varieties of which defy classification in terms of the Linnean system.

Synopsis of the "Species" of Chrysaora.

	C. mediterranea Péron et Lesueur=C. hysoscella.*	C. hysoscella Eschscholtz.† Identical with C. mediterranea.	C. blossevillei Lesson, a variety of C. hysoscella.‡	C. fulgida Haeckel=Rhizostoma fulgidum Reynaud; a variety of C. hysoscella.
Shape of disk.	Flatly rounded.	Flatly rounded.	Nearly hemispherical.	Hemispherical.
Width of disk in mm.	100 to 300	100 to 200	100	300 to 400
Height of disk in mm.	40 to 80	40 to 60	40	100 to 200
Shape of marginal lappets.	Flatly rounded. The 16 ocular lappets only half as wide as the 16 tentacular lappets.	All semicircular and of equal width. The 16 ocular lappets project more than the 16 tentacular lappets.	All half-egg-shaped (oval). Ocular and interocular clefts about twice as deep as clefts which alternate with them.	All alike. Semicircular.
Shape of the 8 ocular stomach-pouches.	At periphery of central stomach as wide, in the middle three-fourths, at margin half as wide as tentacular pouches.	In middle, the 8 ocular pouches are same width as 8 interocular. At bell-margin, ocular pouches are only one-third as wide as tentacular pouches.	In middle, ocular pouches are equal to tentacular pouches in width. At margin, ocular pouches are only half as wide as the tentacular.	?
Shape of curtain-like lips.	Tapering from base to pointed ends. Edges are curtain-like and very complexly folded.	Tapering from base to pointed ends. Edges very much folded.	Lancet-shaped. Tapering with folded margins.	Lancet-shaped, widest in middle where they are as wide as 0.5*r*.
Length of mouth curtains (lips) in terms of disk-radius *r*.	3 to 4*r*	2*r*	2*r*	4 to 6*r*
Length of longest tentacles in terms of disk-radius *r*.	2*r*	2*r*	*r*	*r*. Reynaud figures only 16 tentacles.
Color.	Variable. Disk is whitish to yellow. Usually there is a reddish ring around apex, and radiating from this are 16 radial streaks.	Variable, and similar to C. mediterranea, but usually more intense.	Bell amber to rusty in color. Mouth-arms rusty-yellow.	Bell yellowish-brown. Radial streaks and marginal lappets reddish-brown. Mouth-arms reddish; gonads carmine.
Where found.	Mediterranean.	Atlantic coasts of Europe.	Coast of Brazil, Island of Santa Catharina to Pernambuco.	Cape of Good Hope, False Bay, Algoa Bay, Africa.

*Development through alternation of generations with strobilization (Claus).
†Development as in *C. mediterranea*. Haeckel found a specimen 160 mm. wide, with 40 tentacles, and 48 marginal lappets as in Dactylometra.
‡One of Vanhöffen's specimens had 4 tentacles in one octant. See also L. Agassiz, 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 127, 166.

Chrysaora hysoscella Eschscholtz.

Urtica marina, etc., BORLASE, 1758, Nat. Hist. Cornwall, p. 256, plate 25, figs. VII and VIII.
Medusa hysoscella, LINNÉ, 1766, Systema Naturæ, Ed. 12, p. 1097.
Chrysaora cyclonata, aspilonota, spilogona, spilhemigona, pleurophora, lesueurii, macrogona, heptanema, mediterranea, PÉRON ET LESUEUR, 1809, Annal. du Mus. Hist. Nat., tome 14, pp. 365, 366.
Chrysaora hysoscella, ESCHSCHOLTZ, 1829, Syst. der Acal., p. 79, taf. 7, fig. 2.—CLAUS, 1877, Denksch. Wien. Acad., p. 33, taf. 6, 7.—KRUKENBERG, 1880, Zool. Anzeiger, Jahrg. 3, p. 306 (the medusa contains 95.75 to 96.3 per cent of water).—GRAEFFE, 1884, Arbeit. Zool. Inst. Wien., Bd. 5, p. 342.—VANHÖFFEN, 1908, Deutsche Südpolar Expedition, Bd. 10, Zool. 2, p. 39.
Chrysaora mediterranea+*C. isosceles*, HAECKEL, 1880, Syst. der Medusen, pp. 511, 513, taf. 31, fign. 1–3 (list of literature).
Chrysaora mediterranea, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft 3, p. 14.
Chrysaora hysoscella=*C. mediterranea*, VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 47, fign. 9–10 *a*, *b*.
Chrysaora isosceles, DELAP, M. J., 1901, Irish Naturalist, vol. 10, p. 27 (rearing the larva in an aquarium).

For a synopsis of the characters of *C. hysoscella*, see table of characters of *Chrysaora*.

There appear to be no definite distinctions between *Chrysaora "mediterranea"* of the Mediterranean and *C. hysoscella* of the Atlantic coasts of France, England, Germany, and Holland, and in the entrance to the Baltic Sea. It is probable that the *Chrysaora* of the Chesapeake Bay, in America, is identical with that of Europe, but I believe the Chesapeake medusa to be only a brackish-water variety of *Dactylometra quinquecirrha*, which becomes mature in the 24 tentacle stage. Judging from Haeckel's figures the Mediterranean medusa is more highly colored than that of the northern shores of Europe. In the Chesapeake the

Synopsis of the "Species" of Chrysaora—Continued.

	C. plocamia Haeckel, a variety of C. blossevillei.	C. helvola Brandt.	C. calliparea Haeckel, a variety of C. helvola.	C. chinensis Vanhöffen, a variety of C. helvola.	C. melanaster.* See C. gilberti Kishinouye.
Shape of disk.	Hemispherical.	Hemispherical, or flatter. Exumbrella smooth.	Flatly rounded to hemispherical.	Flatly rounded to hemispherical.	Hemispherical or flatter.
Width of disk in mm.	85 to 100	100 to 300	160 to 200	70	200 to 300
Height of disk in mm.	40 to 50	50	50 to 100	30	100 to 150
Shape of marginal lappets.	All alike. Semicircular.	Oval. The adradial clefts between tentacular lobes are deeper than others, causing general outline of each octant to be convex.	Kidney-shaped, wider outward than at bases. The 16 ocular lappets wider and longer than the 16 tentacular lappets.	Lappets longer than wide, triangular with blunt points.	Tongue-shaped, narrower at base than beyond this point. All of equal size. When old, the 16 ocular lappets develop side lappets as in Dactylometra.
Shape of the 8 ocular stomach-pouches.	All 16 radial-pouches of equal width in middle. At margin ocular are only half as wide as tentacular pouches.	Ocular pouches are in middle twice as wide, at the margin half as wide, as tentacular pouches.	Ocular stomach-pouches spindle-shaped. In middle as wide as tentacular pouches.	Twice as wide in middle; at margin, half as wide as tentacular pouches.	Ocular and tentacular pouches of similar form and size.
Shape of curtain-like lips.	Curtain-like, folded. In middle as wide as radius of umbrella.	Lancet-shaped, in middle two-thirds as wide as disk-radius. Margin complexly folded.	Curtain-like, very wide and long.	Curtain-like. In middle as wide as radius of umbrella.	Tapering from a wide base to pointed ends. In middle one-third *r* wide. Margins much folded.
Length of mouth-curtains (lips) in terms of disk-radius *r*.	3*r*	4*r*	6 to 8*r*	7*r*	2*r*
Length of longest tentacles in terms of disk-radius *r*.	2*r*	Flat, ribbon-like. 4*r* long.	Ribbon-like at their bases 2*r*–	?	Ribbon-like *r*–
Color.	Bell rusty-yellow. Mouth-arms colorless, with yellow margins. Tentacles red.	Bell and lips light yellowish-brown, with marginal lappets and mouth-arms speckled with rusty-red. Tentacles dark rusty color.	Ground color of umbrella bright reddish-yellow, with a 32-rayed chestnut-brown star on exumbrella. Lappets brown. Mouth-arms yellow, spotted with brown. Gonads yellow.	?	Bell, mouth-arms, and tentacles light-bluish. 32 star-like brown rays on exumbrella. 16 dark-brownish to black radial streaks on subumbrella in radii of 16 lateral tentacles. Gonads reddish-brown.
Where found.	West Coast of South America. Cape Horn to Peru.	North Pacific Ocean. Asia to California.	Indian Ocean to east coast of Africa.	Southern parts of the China Sea.	North Pacific. Asia to California.

*This species shows a tendency to approach the *Dactylometra* stage in having 48 marginal lappets, but the tentacles remain 24 in number as in other species of *Chrysaora*. L. Agassiz, 1862, calls this *Melanaster mertensii*.

medusa is highly variable in color, sometimes pale, nearly uniform, milky ocher-yellow, and at other times with radiating streaks of rich red-brown.

The medusa is locally common but rare in many other places, such as Naples, where it is hardly ever seen.

According to Graeffe, *C. hysoscella* is found at Trieste, Adriatic Sea, from November to April, and is mature in winter. It is hermaphroditic, and the eggs segment in the ovaries and are set free as pear-shaped planulæ in March and April. At the end of 8 to 14 days they become attached by the broad anterior end and finally acquire 16 tentacles in the scyphostoma-stage. These strobilate in September and October and each gives rise to 8 to 12 ephyræ.

Miss M. J. Delap finds that the scyphostoma of *Chrysaora* does not eat copepods or small fish, but feeds voraciously upon hydromedusæ, siphonophoræ, ctenophoræ, and pelagic worms.

Claus, 1877, has studied the growth of the ephyra. At first the 8 ephyra lobes are very long and slender with deep, adradial clefts between them and with sharp-pointed, marginal lappets. There are 8 sense-organs but no tentacles. Later 4 and then 8 tentacles develop and the medusa is in the Pelagia-stage. The first 4 tentacles are in the 4 adradial clefts which precede the 4 perradii in the direction of the hands of the watch (see text-figure 372). The adradial stomach-pouches develop later than the perradial and interradial.

The hermaphroditism of *Chrysaora* was first observed by Derbés (1850, Annal. des Sci. Nat., tome 13, p. 377) and later by Wright (1861), Claus (1877), and Haeckel (1880). Young individuals are apt to be male, middle-aged ones hermaphroditic, older ones female. Some are, however, of one sex only throughout life. In other cases when the production of eggs in the entoderm of the gonads begins to decline, a number of sac-like cavities, of irregular size, develop not only in the gonads but in other parts of the subumbrella wall, and these give rise to spermatozoa.

Chrysaora hysoscella var. blossevillei.

Chrysaora blossevillei, Lesson, 1829, Voyage de la *Coquille* Zool., p. 115, planche 13, fig. 2; 1843, Hist. Zooph. Acalèphes, p. 401.—Haeckel, 1880, Syst. der Medusen, p. 514.—Lendenfeld, R. von, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 268.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 15, taf. 1, fig. 3.
Lobocrocis blossevillei, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 166.

This is closely allied to *C. hysoscella*, of which it is probably a local variety.

Disk 28 to 37 mm. wide, or larger, and about 7 to 9 mm. thick. Exumbrella covered with small, round, nettling warts. According to Vanhöffen there are 4 marginal lappets in each octant between successive sense-organs. The 8 interocular clefts are twice as deep as are the 16 clefts adjacent to them. The longest tentacles arise from the interocular clefts. These are about as long as bell-radius. The 2 other tentacles in each octant are only half as long as the interocular tentacles. There are thus 24 tentacles, 32 lappets, and 8 marginal sense-organs. 16 radial pouches extend out from the central stomach and these are twice as wide at margin in the interocular as in the ocular radii. The palps are shorter than bell-diameter. Bell and palps yellowish, speckled with rusty-red. Coast of Brazil. Best description by Vanhöffen.

Chrysaora hysoscella var. fulgida.

Rhizostoma fulgidum, Reynaud, 1830, Lesson's Centurie Zoologique, p. 79, plate 25.
Chrysaora fulgida, Haeckel, 1880, Syst. der Medusen, p. 514.—Vanhöffen, E., 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, *Valdivia*, Bd. 3, Lfg. 1, p. 38.

See synoptic table of forms of *Chrysaora*.

This form is very imperfectly known and may be identical with *C. hysoscella*. It is found off the Cape of Good Hope, Africa.

Chrysaora blossevillei var. plocamia.

Cyanea plocamia, Lesson, 1829, Voyage de la *Coquille* Zool., p. 116, plate 12, figs. 1, 2.
Chrysaora plocamia, Haeckel, E., 1880, Syst. der Medusen, p. 516.—Vanhöffen, 1888, Bibliotheca Zool. Bd. 1, Heft. 3, p. 16.

See synoptic table of forms of *Chrysaora*.

This form is found on the South Pacific coast of South America from Peru southward, and is allied to *C. blossevillei* of the Atlantic side. Its marginal lappets are said to be semicircular instead of oval as in *C. blossevillei*, and the contour of the bell-margin is circular, not octangular with concave inter-rhopalar sides. It is only misleading to attempt to separate species upon distinctions such as these.

Chrysaora helvola Brandt.

Chrysaora (*Polybostrycha*) *helvola*, Brandt, 1838, Mém. Acad. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 384, taf. 15, fign. 1–4.
Chrysaora helvola, Haeckel, 1880, Syst. der Medusen, p. 515.—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 48, fig. 11.
Chrysaora convoluta, Kishinouye, 1910, Journal College of Sci. University Tokyo, vol. 27, art. 9, p. 11, plate 2, figs. 11–14.

See synoptic table of the species of *Chrysaora*.

Distinguished by the considerable length of the 16 ocular lappets, which project beyond the zone of the velar ones, thus giving an octangular appearance to marginal outline of bell. The medusa is found in the North Pacific from Asia northward to Alaska and eastward to the coast of California. Kishinouye finds that young cod are often found under the bell of

this medusa. He gives good figures of it showing the considerable depth of the adradial clefts between the lappets.

Chrysaora helvola var. calliparea.

(?) *Cyanea calliparea*, REYNAUD, 1830, Lesson's Centurie Zoologique, p. 67, planche 20.
Chrysaora calliparea, HAECKEL, 1880, Syst. der Medusen, p. 516.

See synoptic table of forms of *Chrysaora*.

This medusa is reported from Pondichery and Zanzibar, and our knowledge of it is still imperfect.

Chrysaora helvola var. chinensis.

Chrysaora chinensis, VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, p. 16.

In the single specimen described by Vanhöffen the disk is 70 mm. wide and 30 mm. high. Exumbrella thickly covered with numerous, very small warts arranged in a scale-like manner from summit to margin. Ocular and tentacular marginal lappets of equal width and length, longer than wide, and each one ends in a blunt point; lappets overlap each other on their sides and this causes the ocular lappets to appear smaller and sharper than the tentacular lappets. The 16 radiating stomach-pouches are all of equal width at periphery of central stomach. The septa bordering the 8 ocular pouches trend so as to become wider apart for the proximal three-fourths of their lengths, so that the ocular pouches are about twice as wide as the tentacular ones at this zone. The septa then trend toward the ocular radii so that at the bell-margin the 8 ocular stomach-pouches are only half as wide as the 8 tentacular ones. The 4 lips, or palps, are each 7 times as long as the radius of the disk. Near the mouth-opening they are almost as wide as bell-radius and are curtain-like. Midrib of each mouth-arm well developed, the folded margins thin. Outer parts of palps about one-third as wide as bell-radius, not tapering outwards, but ending bluntly. Color (?) Gonads (?) Tentacles (?) Found near Hongkong, China, in October.

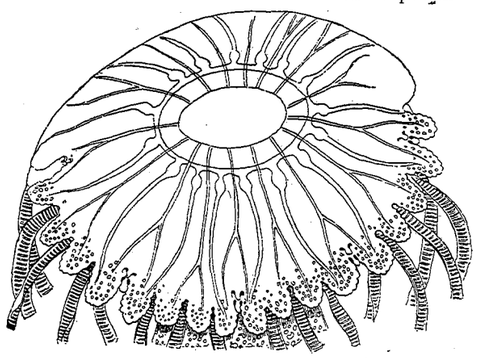


FIG. 366.—*Chrysaora helvola*, according to Brandt, after Vanhöffen, in Nordishes Plankton.

This form is distinguished by its peculiar exumbrella warts and its very long mouth-arms. It is separated from *Chrysaora calliparea* by its long, pointed, marginal lappets.

Chrysaora melanaster Brandt.

Chrysaora melanaster, BRANDT, 1838, Mém. Acad. Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 385, taf. 16, 17.—HAECKEL, 1880, Syst. der Medusen, p. 515.—FEWKES, 1889, Bull. Essex. Inst. Salem, vol. 21, No. 7, p. 121.—VANHÖFFEN, E., 1906, Nordisches Plankton, Nr. 11, p. 49, fig. 12.
Melanaster mertensii, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 126, 166.
Melanaster, sp., AGASSIZ, A., 1865, North Amer. Acal., p. 50.

See synoptic table of species of *Chrysaora*.

This abundant North Pacific form is found from Kamtschatka to California. Bell with reddish-brown radial lines extending from center to margin. Marginal sense-organs bright yellow and brown. Tips of tentacles are red. When old it develops 48 lappets, but the tentacles remain 32.

It is closely allied to *Dactylometra quinquecirrha* of the North Atlantic, and *C. gilberti* is one of its varieties.

Chrysaora melanaster var. "gilberti" Kishinouye.

Chrysaora gilberti, KISHINOUYE, 1899, Zool. Anzeiger, Bd. 22, p. 44, 1 fig.

Distinguished by its semicircular lappets all similar each to each and its relatively long tentacles. It is probably only a variety of *C. melanaster*.

Umbrella 70 to 100 mm. wide, 25 to 30 mm. high. Exumbrella thickly besprinkled with nematocyst-warts. 32 marginal lappets, all similar each to each and all nearly semicircular. 24 laterally compressed tentacles, all somewhat longer than bell-diameter. The 4 subgenital ostia are round to oval. The septa between the 16 radial stomach-pouches are nearly straight, but the ocular pouches are a little broader than the tentacular pouches at the annulus of the marginal sense-organs. The 4 oral curtains are as broad as the bell-radius near the mouth and are very long with finely frilled margins. In contraction they are coiled, screw-like; and in this condition are about as long as bell-radius. They taper to blunt points and their thick proximal parts are covered with nettle-warts.

Umbrella light brown, tentacles and midrib of mouth-arms darker brown. Common in Monterey Bay, California, in summer.

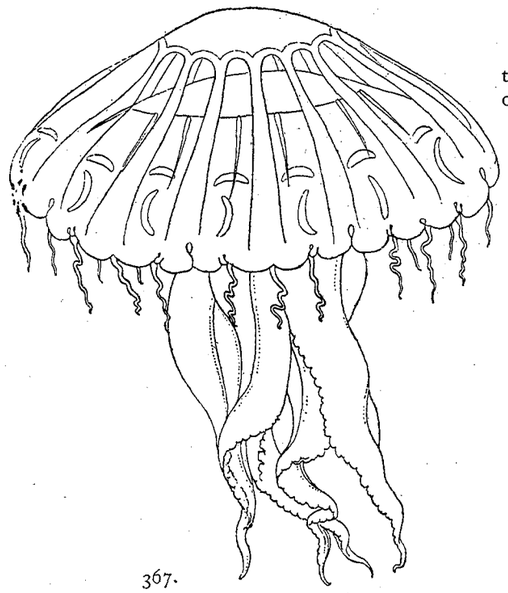
Genus DACTYLOMETRA L. Agassiz, 1862.

Dactylometra, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 166.—AGASSIZ, A., 1865, North Amer. Acal., p. 48.—HAECKEL, 1880, Syst. der Medusen, p. 517.—KISHINOUYE, 1892, Zoological Mag., Tokyo, vol. 4, p. 261.—AGASSIZ AND MAYER, 1898, Bull. Mus. Comp. Zool. at Harvard College, vol. 32, p. 1.—VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 39; 1906, Nordisches Plankton, Nr. 11, p. 50.

The type species is *D. lactea* L. Agassiz, of the West Indies and South American coast.

GENERIC CHARACTERS.

Pelagidæ with 40 tentacles, 5 between each successive pair of sense-organs, and with 48 marginal lappets.



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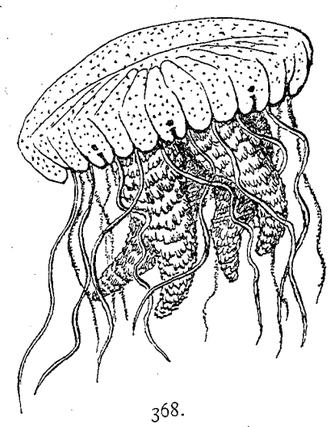

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FIG. 367.—*Chrysaora melanaster*, according to Brandt, after Vanhöffen, in Nordisches Plankton.
FIG. 368.—*Chrysaora gilberti*, after Kishinouye, in Zool. Anzeiger.

There is reason to believe that certain medusæ may become mature with 24 tentacles, while others, possibly better fed individuals of the same species, may develop 40 tentacles before becoming mature. Similarly *Dactylometra longicirra* of Japan may develop 40 or even 56 tentacles before becoming mature. The conditions characteristic of the genera *Chrysaora*, *Dactylometra*, and *Kuragea* may therefore be transitional stages in the growth of one and the same medusa.

Dactylometra lactea L. Agassiz.

Chrysaora lactea, ESCHSCHOLTZ, 1829, Syst. der Acal., p. 81, taf. 7, fig. 3.
Dactylometra lactea, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 125, 126, 166.—HAECKEL, 1880, Syst. der Medusen, p. 517.—LENDENFELD, R., VON, 1884, Proc. Linn. Soc. New South Wales, vol. 9, p. 271.—AGASSIZ, A., AND MAYER, 1898, Bull. Mus. Comp. Zool. at Harvard College, vol. 32, p. 7, plates 12, 13 and fig. 10, plate 7.

Mature medusa.—Bell hemispherical, smaller than in *D. quinquecirrha* being about 70 mm. in diameter. Clefts in lappets adjacent to sense-organs fully as deep as those between the remaining lappets instead of being mere shallow notches, as in *D. quinquecirrha.* The tertiary tentacles arise from clefts between the lappets, not from the floor of the subumbrella, as in *D. quinquecirrha.* The 8 primary tentacles are about 3 times as long as the bell-diameter. The 16 secondary tentacles, however, are only about half, and the 16 tertiary, one-quarter as long as the primary ones.

General color dull milky-white, exumbrella sprinkled over with ocher-yellow-colored spots, thickly clustered at aboral pole. Genital organs slightly yellowish, a delicate iridescence over the long, flexible mouth-arms.

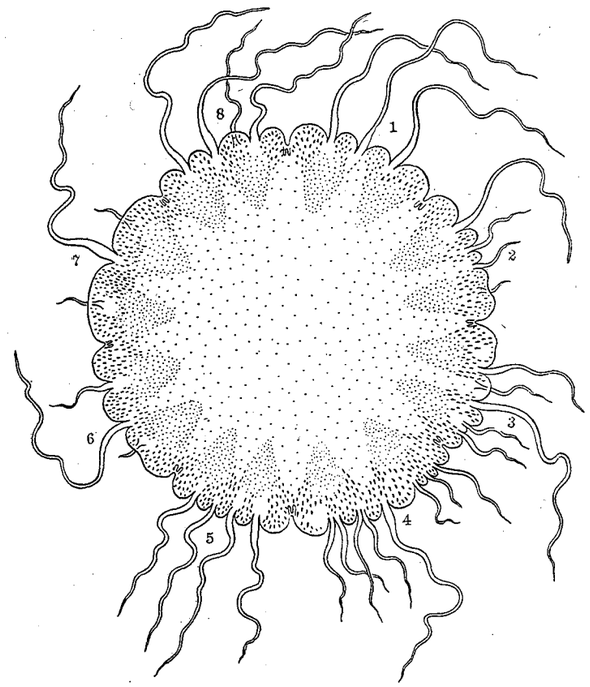


FIG 369.—*Dactylometra lactea,* aboral view, three-fourths natural size. From nature, by the author. Showing variable character of the lobes and tentacles.

This species is found at Rio Janeiro, Brazil, and at Jamaica and Cuba. In Havana Harbor it is abundant and mature in February.

Octant No.	No. of tentacles.	No. of lobes.
1	3	4
2	4	4
3	5	5
4	8	7
5	4	5
6	3	3
7	3	2
8	4	4

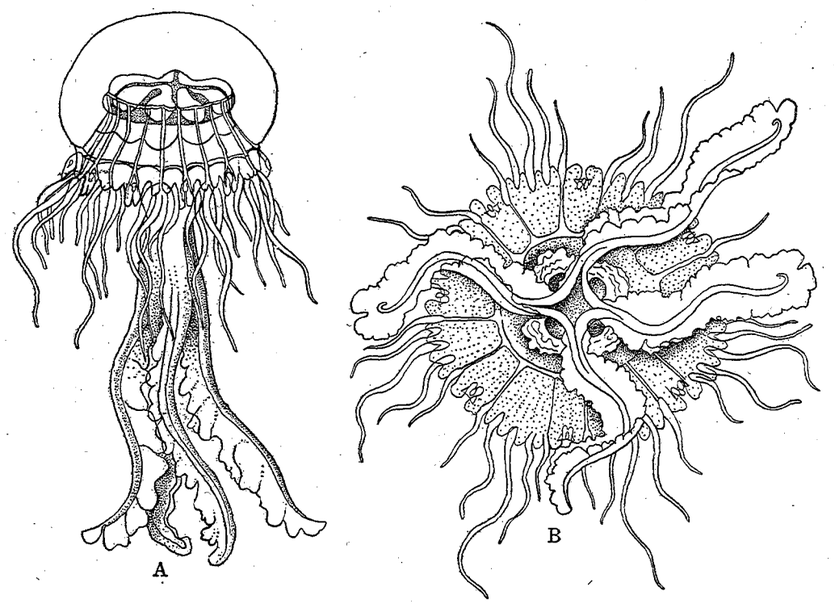
A mature specimen found by me off Port Royal, Kingston Harbor, Jamaica, on March 20, 1909, was of the following dimensions in millimeters: Bell 66 wide, somewhat flatter than a hemisphere, palps 50, longest tentacles 60 long. Exumbrella regularly and thickly besprinkled with very small, low-lying, milky-yellow colored nettling-warts. 16 spoke-like stripes of dull ocher color and numerous russet-brown nematocyst-warts at the margin of the exumbrella. Gelatinous substance and tentacles milky. Gonads dull milky-pink. This specimen was very irregular in the development of its tentacles and lobes, the 8 octants being as shown in the table (fig. 369).

Dactylometra quinquecirrha L. Agassiz.

Plates 62 to 64A.

Pelagia quinquecirrha, Desor, E., 1848, Proc. Boston Soc. Nat. Hist., vol. 3, p. 76.
Dactylometra quinquecirrha, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 125, 166.—Agassiz, A., 1865, North Amer. Acal., p. 48, fig. 69.—Haeckel, 1880, Syst. der Medusen, p. 518.—Fewkes, 1882, Bull. Mus. Comp. Zool. at Harvard College, vol. 9, No. 8, p. 293, plate 1, figs. 25–28, 38, 39.—Bigelow, 1890, Johns Hopkins Univ. Circulars, vol. 9, No. 80, p. 65.—Agassiz, A., and Mayer, 1898, Bull. Mus. Comp. Zool. at Harvard College, vol. 32, p. 1, plates 1–11, 33 figs.—Hargitt, 1904, Bull. U. S. Bureau of Fisheries, vol. 24, p. 69, plate 7, fig. 2.—Hargitt, 1905, Journal Exper. Zool., vol. 2, p. 575 (variations).—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 50, fign. 13–14.
Bathyluca solaris (damaged and regenerating specimen?), Mayer, 1900, Bull. Mus. Comp. Zool. at Harvard College, vol. 37, p. 2, plate 1.
Chrysaora, Bigelow, R. P., 1880, Johns Hopkins Univ. Circulars, vol. 9, No. 8, p. 66 (brackish-water variety from Chesapeake Bay).

Adult medusa.—Bell nearly hemispherical, 170 to 190 mm. in diameter. Numerous small, wart-like clusters of nematocysts thickly scattered over the exumbrella, especially abundant at aboral apex where they appear as little hemispherical projections above the general surface; near the margin they are elongate in shape, while at the margin itself they



Figs. 370.—*Dactylometra lactea* from Havana, Cuba; after Agassiz and Mayer in Bull. Mus. of Comp. Zool. A, side view; B, oral view.

are again hemispherical as at the apex. 8 marginal sense-organs, 40 tentacles, and 48 marginal lappets. The marginal sense-organs are set within niches between the lappets, 4 being perradial in position and 4 interradial; these niches are protected above by a small web between the lappets. A ciliated, pit-like depression extends downward from the surface of the exumbrella immediately above each sense-organ. The sensory-club projects slightly downward and contains a distal, entodermal mass of crystalline concretions but no ocellus. The entodermal core of the sense-club is hollow and its lumen is connected with the general gastrovascular space of the medusa.

There are 5 tentacles between each successive pair of sense-organs. 3 of these tentacles, the primary and secondary, arise from the clefts between the lappets, but the other 2 (tertiary) are generally found to spring from the under or subumbrella side of the ocular lappets; for even in very large medusæ the ocular lappets exhibit but a slight notch adjacent to the ter-

tiary tentacles; in fact, the tertiary tentacles do not usually make their appearance until the medusa is about 130 mm. in diameter and the lappets remain undivided until the medusa is mature, although Hargitt shows that this is subject to great individual variability. Thus in immature medusæ of large size there are usually but 24 tentacles and 32 marginal lappets, and the animal is in the "*Chrysaora* stage." I believe, also, that they often mature in this stage and never reach the *Dactylometra* condition.

The primary and secondary tentacles are very long and flexible while the tertiary tentacles are only a few millimeters in length. In like manner the lappet-clefts of the primary and secondary tentacles are deep and the lappets almost as long as they are broad; while the lappet clefts of the tertiary tentacles are mere shallow notches in the contour of the lappets adjacent to the sense-organs. Mouth-opening cruciform, in center of subumbrella, at extremity of a 4-cornered œsophagus and surrounded by 4 mouth-arms or palps, which when fully extended are about 3 or 4 times as long as the bell-diameter. The 8 free edges of the mouth-arms are complexly crinkled and highly flexible. The central stomach occupies a wide lenticular space in the midst of the bell and gives rise to 16 simple, radiating pockets, 8 in the tentacular and 8 in the rhopalar radii. These pockets are completely separated one from another by 16 radiating septa which join the upper and lower walls of the umbrella cavity together. The tentacles are hollow throughout the greater part of their length and their entoderm is ciliated as is that of the stomach itself.

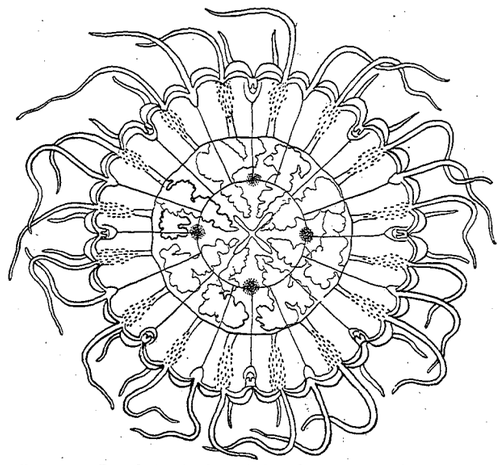


FIG. 371.—*Dactylometra quinquecirrha*, after Agassiz and Mayer, in Bull. Mus. of Comparative Zoology at Harvard College.

The gonads are contained in 4 interradially situated, entodermal infoldings of the wall of the subumbrella, and their position is marked by 4 deeply sunken, subgenital pits. The genital organs are provided with numerous, simple, unbranched gastric cirri which project inward into the stomach-cavity. There are two sets of radial muscle-fibers; the principal set is found in the 16 septa between the gastric pouches, and alternating with these in position are 16 strands in the exumbrella, 8 of which lead outward to the sense-organs and 8 to the primary tentacles.

Color quite variable. In some individuals the disk is pink, in others yellow with a bluish opalescence. The exumbrella is thickly sprinkled with yellow-ocher colored nettling-warts and there are 16 radiating stripes of reddish color upon the exumbrella in the radii of the septa of the peripheral stomach. These reddish stripes extend about half-way from the bell-margin toward the center of the exumbrella and are due to highly refractive, rosin-colored pigment granules within the epithelial cells of the disk. The male gonads are generally pink, while the ovaries are yellowish or ashy-gray. The radial muscle-strands of the subumbrella are of a glistening white and the entodermal cores of the tentacles are pink. The mouth-arms are pink or yellow and always sprinkled over with red-colored pigment spots. The marginal sense-organs contain each a mass of glistening white concretions, but no ocelli.

This species extends from the southern coast of New England to the tropics. In August it is abundant in Tampa Bay, Florida. It has been taken by Bickmore at the Bermudas, and by Drayton between the Bermudas and the Azores. "A well-marked southern variety" was found by Brooks at Beaufort, North Carolina, and is figured in plate 64A. It makes its appearance upon the surface along the coast of New England in August when large medusæ are found. The young rarely come to view, but remain in deep water.

Varieties and development.—The egg develops into a free-swimming planula which soon attaches itself to the bottom and develops into a scyphostoma having normally 4 ten-

tacles. R. P. Bigelow, 1880, states that the so-called "*Chrysaora*" of the Chesapeake, which is only a brackish-water, abortive variety of *Dactylometra*, develops from an ephyra through a *Pelagia* stage, wherein it has only 8 tentacles and 16 lappets, and Brooks has figured the ephyræ in the text figures here shown.

The present writer found considerable numbers of Chrysaora-like medusæ in Hampton Roads and Norfolk Harbor, Virginia, and in St. Mary's River, Maryland, early in Novem-

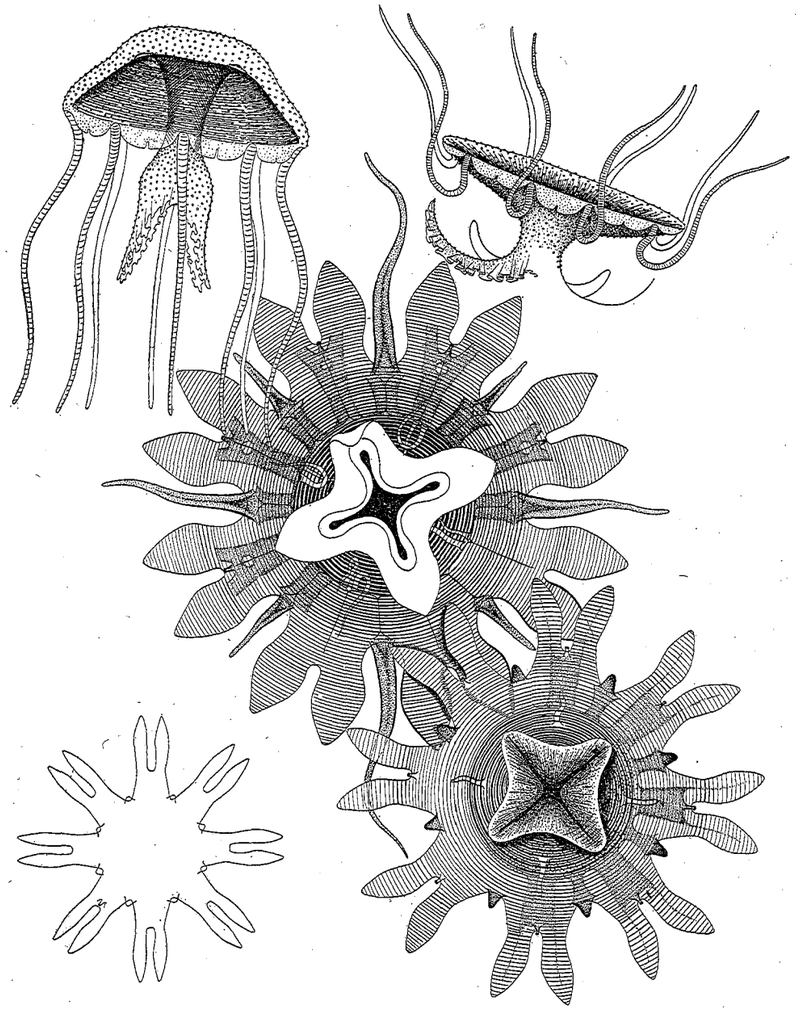


FIG. 372.—Young ephyræ of *Dactylometra quinquecirrha*. Figures drawn by the late Prof. William K. Brooks at the Chesapeake Bay Laboratory of the Johns Hopkins University. Presented by the Department of Biology of the Johns Hopkins University for publication in this work.

ber, 1904 and 1905. These were generally pale milky-yellow in color and lacked the rich brown pigment and the 16 pigmented, radial areas seen upon the exumbrella of *Dactylometra quinquecirrha*. Others had a red-brown spot at the apex of the exumbrella, and surrounding this was a star-like zone of red-brown streaks with pointed ends directed outward. The

axial ribs of the mouth-arms (palps) were red-brown. Although all were in the *Chrysaora* condition and had only 3 tentacles and 4 lappets in each octant, some appeared to be fully mature or with gonads nearly ripe. The exumbrella surface and the palps were covered with dull milky-yellow clusters of nematocysts. There were 8 marginal sense-organs as in *Dactylometra*, but only 24 tentacles and 32 marginal lappets. None of the medusæ were, however, as large as is commonly seen in full-grown *Dactylometra quinquecirrha*, the largest Chrysaora-like medusa seen in Norfolk harbor being only 105 mm. in diameter. It should be borne in mind that *D. quinquecirrha* does not usually attain 48 marginal lappets and 40 tentacles until the medusa is 120 mm. in diameter, and it seems therefore that the so-called *Chrysaora* of the Chesapeake is only a stunted *Dactylometra* which becomes mature in the *Chrysaora* stage, and its pale coloration may be a local peculiarity due to unfavorable conditions of confinement in brackish water. In the purer ocean water at the mouth of Chesapeake Bay the medusæ develop into the *Dactylometra* condition with 40 tentacles. These conditions are also found in Narragansett Bay, Rhode Island, where in relatively pure clean water the medusæ have 40 tentacles, but in brackish estuaries they often become mature with only 24 tentacles and are pale in color.

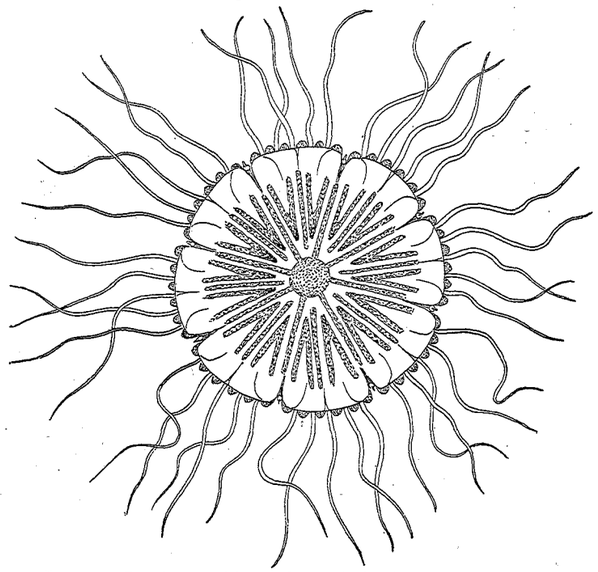


FIG. 373.—*Dactylometra africana*, after Vanhöffen, in *Valdivia* Expedition.

Dactylometra africana Vanhöffen.

Dactylometra africana, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 40, taf. 4, fig. 20.

Disk 100 to 130 mm. wide. 6 well-developed marginal lappets and 5 long tentacles in each octant. Lappets and tentacles red. Red radial streaks over exumbrella. Œsophagus, palps, and gonads not highly colored. Colors of large specimens duller than those of small medusæ and not unlike the coloration of *D. quinquecirrha*. Distinguished by its red lappets. Coast of German Southwest Africa. Common in the Great Fish Bay on October 10, 1898.

Dactylometra ferruginaster Kishinouye.

Dactylometra ferruginaster, KISHINOUYE, 1892, Zoological Magazine, Tokyo, vol. 4, p. 264, taf. 3.
Dactylometra pacifica var. *ferruginaster*, MAAS, 1909, Abhandl. Akad. Wissen. München, Suppl. Bd. 1, Abhandl. 8, p. 44, taf. 2, fig. 14.

Bell flatly rounded, 3 to 4 times as wide as high, 100 mm. in diameter. 48 oval, marginal lappets. The 8 primary tentacles longer than the others. The lappets next to the ocular

lappets are the smallest, and only about half as wide as the others. The 16 radial stomach-pouches of nearly similar form and size. Mouth-arms longer than bell-radius and tapering to pointed tips. Bell white with reddish-brown star on exumbrella. Inner sides of mouth-arms and tentacles brown. Found on the coast of Japan in autumn. This form is imperfectly separated from *D. quinquecirrha* of which it appears to be a variety, if, indeed, it be not identical with the American medusa.

"Dactylometra longicirra" Kishinouye.

Dactylometra quinquecirrha var. *pacifica*, GOETTE, 1886, Sitzungsber. Akad. Wissen. Berlin, Jahrgang 1886, p. 834.
Dactylometra longicirra, KISHINOUYE, 1892, Zoological Magazine, Tokyo, vol. 4, p. 261, taf. 2.

Bell flatly rounded, 3 times as wide as high and 75 mm. in diameter. 48 tongue-shaped marginal lappets, all similar each to each, somewhat narrower near their bases than near their outer ends. Accessory lappets sometimes seen on sides of ocular lappets. 40 tentacles of nearly equal length each to each, and 10 times as long as bell-diameter; these tentacles are wide, flat, and ribbon-like near their bases; sometimes one finds small accessory tentacles arising from between the ocular lobes and their accessory lateral lappets or from the sub-umbrella surface of the ocular lappets. The medusa then has 56 tentacles, 7 in each octant as in *Kuragea depressa* of Japan, and this illustrates the close genetic relationship which exists between the two forms. In the middle the ocular stomach-pouches are twice as wide and in their distal parts half as wide as the tentacular pouches. The mouth-curtains are very wide and much folded; they are about 5 times as long as bell-diameter.

Bell white with 32 reddish-yellow radiating streaks. Mouth-arms yellow. Gonads and tentacles reddish.

Found on the Pacific coast of Japan, in Owari Bay. Its common Japanese name is Aschinaga Kurage, or Akakurage. I am inclined to believe that this is only a growth-stage of *Kuragea depressa*, and that it is identical with *D. ferruginaster*.

Genus KURAGEA Kishinouye, 1902.

Kuragea, KISHINOUYE, 1902, Journ. College Sci. Tokyo, vol. 17, art. 7, p. 9, plate 1, fig. 7.

The type species is *K. depressa* of Japan.

GENERIC CHARACTERS.

Pelagidæ with 8 marginal sense-organs. 8×7 (56) tentacles. 8×8 (64) marginal lobes. 4 interradial gonads.

This genus bears the same relation to *Dactylometra* that the latter does to *Chrysaora*, being a stage wherein the lappets and tentacles have progressively increased by 16 in number.

Thus *Chrysaora* has 24 tentacles and 32 lappets, *Dactylometra* has 40 tentacles and 48 lappets, *Kuragea* has 56 tentacles and 64 lappets. I am inclined to look upon this form as an hypertrophic *Dactylometra* rather than as a separate genus.

Kuragea depressa Kishinouye.

Kuragea depressa, KISHINOUYE, 1902, Journ. College Sci. Tokyo, vol. 17, art. 7, p. 9, plate 1, fig. 7.

Umbrella 85 mm. wide and 30 mm. high. 8 marginal sense-organs. 8×7 (56) tentacles. 8×8 (64) marginal lobes. 4 gonads, each folded in the form of the Greek letter ω. Gastric filaments long and numerous. Color (?) Misaki, Japan. A single specimen.

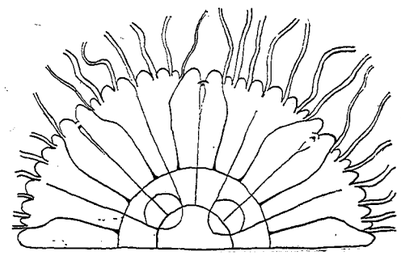


FIG. 374.—*Kuragea depressa*, after Kishinouye, in Journal College of Sci., Tokyo University.

The 16 ocular lobes and the lobes by the sides of the adradial tentacles are larger than the others, while those adjacent to the ocular lobes are the smallest. The lips are broad and complexly folded. The exumbrella exhibits a 16-rayed, star-shaped marking in the inter-radii, adradii, and perradii. The central stomach gives rise to 16 peripheral pouches as in *Dactylometra longicirra*. In the middle of their lengths the 8

rhopalar pouches are 1.5 times as wide as the 8 tentacular pouches, but at the bell-margin only half as wide.

This medusa is clearly derived from *Dactylometra longicirra* of Japan. *D. lactea* of America tends to attain to the *Kuragea* condition, but all of the octants do not usually develop equally (see text-fig. 369).

Genus SANDERIA Götte, 1886.

Sanderia, GOETTE, 1886, Sitzungsber. Akad. Wissen. Berlin, Jahrg. 1886, p. 835.—VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer, *Valdivia*, Bd. 3, Lfg. 1, p. 37.
Neopelagia (an aberration), KISHINOUYE, 1910, Journal College Sci. Tokyo, vol. 27, art. 9, p. 14.

The type species is *Sanderia malayensis* Goette, of the tropical Indian Ocean and Malay Archipelago.

GENERIC CHARACTERS.

Pelagidæ with 16 marginal sense-organs, 16 tentacles, and 32 cleft marginal lappets. 4 lips, 4 interradial gonads, and 32 peripheral stomach-pouches in the radii of the tentacles and sense-organs. No marginal ring-canal.

Sanderia malayensis Goette.

Sanderia malayensis, GOETTE, 1886, Sitzungsber. Akad. Wissen. Berlin, Jahrg. 1886, p. 835.—VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 38, taf. 3, fig. 12; taf. 8, fign. 69–74.
Neopelagia eximia, KISHINOUYE, 1910, Journal College of Sci. Tokyo, vol. 27, art. 9, p. 14, plate 3, fig. 15, text-fig. 1.

Bell flat, 90 mm. wide, large, rounded nettling-warts at the center of the exumbrella but diminishing in size outwardly so as to be absent at the bell-margin. 16 marginal sense-organs

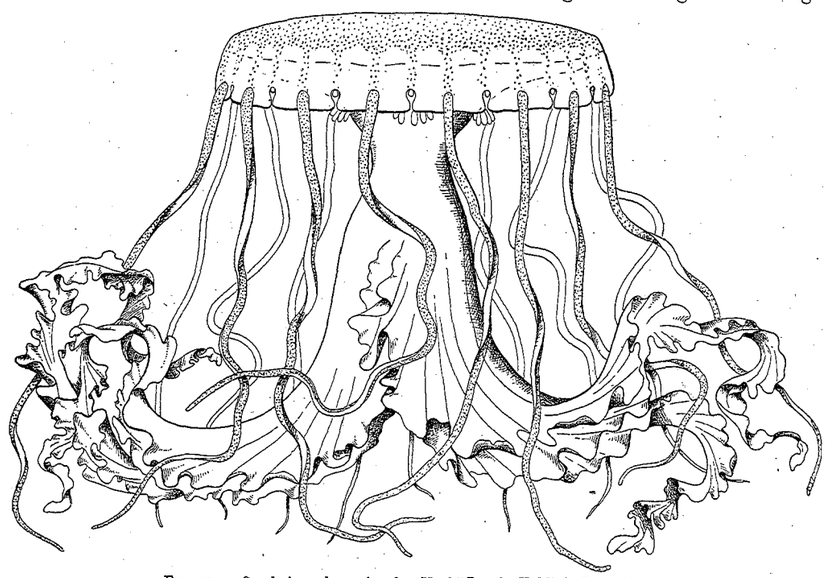


FIG. 375.—*Sanderia malayensis*, after Vanhöffen, in *Valdivia* Expedition.

alternating with 16 long, ribbon-like tentacles, 32 cleft lappets. A long, tubular œsophagus is bounded on the 4 perradial corners by long, complexly folded lips. The 4 interradial, heart-shaped, genital ostia are each bordered externally by about 24 to 30 finger-shaped papillæ. The central stomach gives rise to 32 peripheral pouches in the radii of the sense-organs and tentacles. These are completely separated one from another by straight, radiating septa which converge slightly near the bell-margin in the rhopolar radii. There is no marginal ring-canal. The general color is yellow with the aboral center of the bell dusted over with reddish flecks which extend outward, spoke-like, in the radii of the sense-organs and tentacles. The mouth-parts are also covered with reddish spots.

Found in the Indian Ocean, Gulf of Aden, at Singapore, and off the east coast of Africa. Some specimens of this medusa were found by the U. S. Fisheries Bureau Steamer *Albatross* in the Philippine Islands in March and April, 1908, and Kishinouye found it at Misaki, Japan.

A perfect specimen found by the *Albatross* on March 8, 1908, at station D 5175 in the Sulu Sea, southeast of Cagayanes Islands, Philippine Islands, had a bell 75 mm. wide, palps 46 long, central stomach 35 wide, contracted tentacles 65 long, and with 25 to 30 finger-shaped projections bordering each genital ostium.

Kishinouye, 1910, found an abnormal specimen with 13 tentacles, 13 rhopalia, 26 lappets and irregularly developed gonads. He found that a fish of the genus *Psenes* accompanied the medusa.

Family CYANEIDÆ L. Agassiz, 1862.

Cyaneidæ, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 114, 161.—AGASSIZ, A., 1865, North Amer. Acal., p. 44.—HAECKEL, 1880, Syst. der Medusen, p. 518; 1881, *Challenger* Report, Zool., Bd. 4, part. 2, p. 124.—CLAUS, 1883, Organ. und Entwick. Medusen, p. 24.—VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 271.—CLAUS, 1886, Arbeit. Zool. Inst. Univ. Wien., Bd. 7, p. 110.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 51.—MAAS, 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 505.

FAMILY CHARACTERS.

Semaeostomeæ with a single, 4-sided, central mouth surrounded by 4 perradially situated, curtain-like lips. The tentacles arise from the floor of the subumbrella, at some distance inward from the margin, and are usually in clusters. The gonads are situated in 4 complexly folded, interradial outpocketings of the wall of the subumbrella. The central stomach gives rise to radiating, peripheral pouches, which in turn give rise to numerous branching, non-anastomosing, blind canals in the lappets. There is no ring-canal. The tentacles are hollow.

The medusæ of this family are apparently descended from some such forms as the Pelagidæ. They resemble the Pelagidæ in the structure of the oral appendages, the general plan of the gastrovascular system, and in the lobulation of the bell-margin. They differ mainly in the complex branching of the peripheral edges of the radiating stomach-pouches, and above all in that the tentacles arise from the floor of the subumbrella, not from the notches between the lappets as in the Pelagidæ. The young medusæ are strikingly similar to the Pelagidæ in all respects, for their radiating stomach-pouches are simple and the tentacles first appear in the notches between the lappets. The margin grows beyond the bases of the tentacles as development proceeds, however, and thus they come secondarily to arise from the floor of the subumbrella. Indeed the tentacles of all Scyphomedusæ are structures of the subumbrella.

In *Cyanea* the development is known to be through a sessile scyphostoma which strobilates, giving off a number of ephyræ which develop into mature medusæ. The Cyaneidæ are of universal distribution, but the great majority of the species are found in the temperate regions and in the colder waters. Unlike the Pelagidæ the Cyaneidæ are creatures of the shallower waters along shores, not animals of the high seas.

A synopsis of the genera of the Cyaneidæ follows:

Desmonema L. AGASSIZ, 1862. 8 rhopalia, 8 adradial clusters of tentacles. No radial-muscle strands in the subumbrella.
Cyanea PÉRON ET LESUEUR, 1809=*Procyanea*+*Medora*+*Stenoptycha*+*Desmonema* (in part)+*Cyanea*, HAECKEL, 1880. 8 rhopalia, 8 adradial clusters of tentacles; each cluster contains several rows of tentacles. Both radial and circular muscles in the subumbrella.
Drymonema HAECKEL, 1880. 8 rhopalia. Tentacles not grouped in isolated clusters, but arising from a wide zone in the subumbrella.
(?) *Patera* LESSON, 1843 (doubtful). 16 rhopalia. 16 clusters of tentacles alternating with the radii of the rhopalia.

Genus DESMONEMA Agassiz, 1862.

Couthouyia, used for Mollusca by Adams, 1860, Annal. and Mag. Nat. Hist., vol. 5, p. 410.
Couthouyia, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 118, 163.
Couthouya, Maas, 1906, Fauna Arctica, Bd. 4, Lfg. 3, pp. 487, 505; 1908, Expédition Antarctique Française, Meduses, p. 3.
Desmonema, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 166.—HAECKEL, (in part), 1880, Syst. der Medusen, p. 526.—LENDENFELD R., VON., 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 273.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 17.—BROWNE, 1908, Trans. Royal Soc. Edinburgh, vol. 46, p. 242.—VANHÖFFEN, 1908, Deutsche Südpolar Exped., Bd. 10, Zool. 2, p. 40.
Medora (young stage), AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 118.
Medora, preoccupied for Mollusca by Adams, 1858, Genera of Mollusca, vol. 2, p. 183.

GENERIC CHARACTERS.

Cyaneidæ with 8 marginal sense-organs and with 8 adradial clusters of marginal tentacles. The tentacles of each cluster may arise in several rows from the subumbrella surface. There are 8 chief lobes and 16 to 32 secondary lappets. Without radial-muscles in the lobes.

The names *Couthouyia* and *Medora* are preoccupied, but Agassiz's *Desmonema* may be used.

The oldest species is the little-known "*Chrysaora*" *gaudichaudii* erroneously described by Lesson, 1829 (Voyage de la *Coquille*, Zooph., p. 114), from the region of Cape Horn, South America, and recently revealed through the studies of Maas, 1908.

Some of the medusæ which Haeckel included in his genus "*Desmonema*" represent only immature *Cyaneas* in which the tentacles of each cluster arise in a single row. Vanhöffen, 1888,

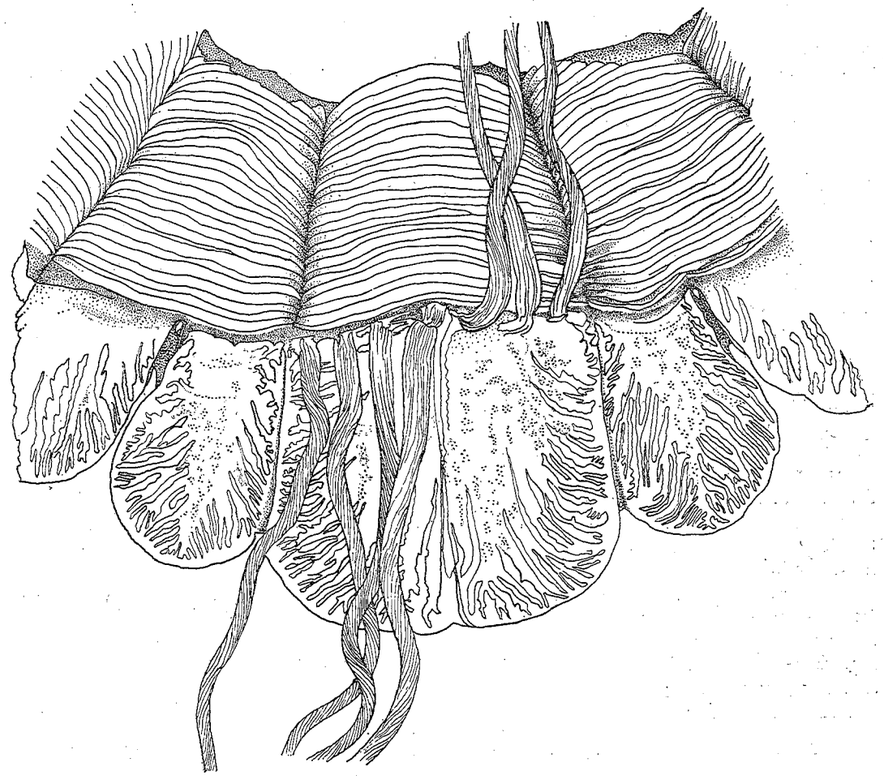


FIG. 376.—*Desmonema gaudichaudii*, after Maas, in Meduses Expédition Antarcticque Française.

shows, however, that there are considerable anatomical differences between *Cyanea* in any stage and *Desmonema*. In *Desmonema*, for example, the 8 clusters of tentacles arise in linear arcs concentric with the general contour of the bell-margin, whereas in *Cyanea* they arise in crescents, the horns of which are directed outward toward the margin. Moreover, there are no radial-muscle strands in the 8 velar lobes of *Desmonema*, but these are found in *Cyanea*.

Desmonema annasethe Haeckel is clearly a young *Cyanea*, as was pointed out by Vanhöffen, 1888.

The rediscovery of Lesson's, Cape Horn, medusa by Maas makes it practically certain that it is specifically referred to by Agassiz, 1862, p. 118, under the designation *Couthouyia pendula*.

Demonema gaudichaudii Agassiz.

Chrysaora gaudichaudii, LESSON, 1829, Voyage de la *Coquille*, Zooph., p. 114, Zoophytes planche 13, fig. 1.
Couthouyia pendula and *Medora capensis*, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 118, 163.
Desmonema gaudichaudi, AGASSIZ, L., 1862, Cont. Nat. Hist, U. S., vol. 4, p. 166.—HAECKEL, 1880, Syst. der Medusen, p. 527.
Couthouya gaudichaudi, MAAS, 1908, Expéd. Antarctique Française, Meduses, p. 5, planche 1, fig. 1.

Bell at least 500 or 600 mm. wide, only 5 to 7 tentacles in a single line, in each interrhopalar cluster. Thus when the medusa is of a greater size than *D. chierchiana*, it has fewer tentacles. Maas states that the color of the gastric cavity is brownish-purple, accentuated in the gonads, while the muscle-system is lighter and the gelatinous substance is bluish and transparent. The medusa is found in the Antarctic region in April. Future studies will probably demonstrate that *D. chierchiana* is only a variety of this medusa for they are alike in all respects excepting that in *Desmonema chierchiana* the tentacles arise in several rows, whereas in *D. gaudichaudii* they remain as a single row even when the medusa is much larger than *D. chierchiana*. This difference may be due to environmental causes, or may be of the nature of a variation such as one observes in the development of tentacles in *Dactylometra* and *Chrysaora*, but until further studies have been carried out it will be safer to keep the two forms specifically distinct one from the other. It is probable, however, that *D. gaudichaudii* is only a variety in which the tentacles remain in a single row, as in the young of *D. chierchiana* (see fig. 376).

Further details of the structure of *D. gaudichaudii* may be obtained from the description of *D. chierchiana* which follows.

Agassiz's *Medora capensis* is apparently a young stage of this medusa.

Desmonema chierchiana Vanhöffen.

Desmonema chierchiana, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft 3, p. 18, taf. 1, fig. 4; 1908, Deutsche Südpolar Expedition, 1901–1903, Bd. 10, Zool. 2, p. 41, taf. 2, fign. 2, 3; Abbild. 5–9.—BROWNE, 1908, Trans. Royal Soc. Edinburgh, vol. 46, p. 244, plate 2, fig. 2.
(??) *Chrysaora gaudichaudii*, LESSON, 1829, Voyage de la *Coquille*, Zooph., p. 114, planche 13, fig. 1.

Umbrella 310 mm. or more wide and 100 mm. high. Exumbrella smooth. The 8 pairs of ocular lappets are only about one-third as wide as the 8 tentacular lappets, which are flatter than a semicircle in outline. The 16 small, ocular lappets are bluntly rounded and sharply set off from the 8 tentacular lappets. The subumbrella is divided into 16 equal sectors corresponding to the 16 stomach-pouches. These sectors are areas in which the circular muscles are well developed and separated one from another by narrow septa. 8 of the 16 muscular sectors are in the radii of the 8 marginal sense-organs and 8 are intermediate. There are no radial-muscle strands.

There are 8 groups of tentacles, each of which, in old medusæ, arises in several rows from the subumbrella at some distance inward from the bell-margin. These tentacles are developed along the outer edges of the 8 interocular, circular muscle-sectors. There are about 60 tentacles in each cluster, the oldest and longest being along the innermost, and the shortest and youngest in the outermost rows. The rows are not U-shaped, as in *Cyanea*, but are nearly straight. The tentacles are hollow, their entoderm being thin and the ectoderm thick-walled. When young the tentacles are somewhat flattened and the ectodermal longitudinal muscle strands are set within infolded, gutter-like lines down the length of the tentacle. As growth proceeds these gutters sink deeper and deeper into the ectoderm and finally become inclosed tubes, sunken beneath the surface. Thus the longitudinal muscles become tubular strands of fibers. A full description of the tentacles is given by Vanhöffen, 1908. When expanded the tentacles of a large medusa may be at least 20 meters long.

The 4 mouth-curtains are well-developed and resemble those of *Chrysaora*. They are narrow near the mouth-opening but expand outwards and then taper gradually to a point. Each mouth-curtain is 1.5 times as long as the bell-radius and its margins are much folded.

The 4 sac-like, protrusive gonads are folded and resemble those of *Cyanea*, but are smaller.

There are 16 sectors of circular muscles in the subumbrella, 8 in the ocular and 8 in the interocular radii. These circular muscles do not extend beyond the zone of the clusters of tentacles and sense-organs and are not found in the subumbrella of the lappets. There are no strands of radial-muscles in the subumbrella, or in the lappets, such as are seen in *Cyanea*.

The 16 stomach-pouches break up into numerous forked, branched, radiating vessels in the marginal lappets, but their ultimate branches rarely anastomose. There are about 12 to 18 main branches from the outer edge of the stomach-pouch in each lappet and these branch dendritically so that about 100 ramuli reach the bell-margin. There is no marginal ring-canal.

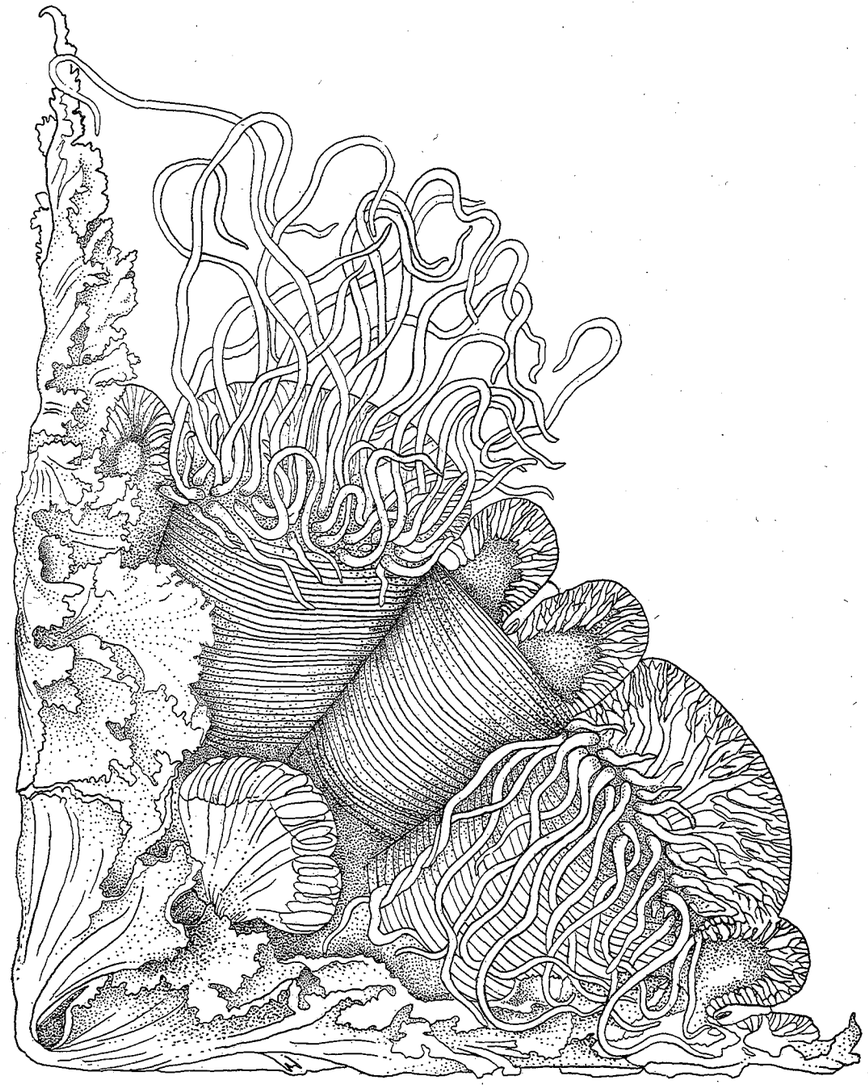


FIG. 377.—*Desmonema chierchiana*, after Vanhöffen, in deutsch. Südpolar Expedition.

The medusa is salmon-red or brownish-red, the canal-system being darker and the tentacles light in color. When young the bell and tentacles are bluish and the curtain-like lips salmon or brownish-red in color.

The medusa appears to be common from December to June in the Antarctic region, and is reported from both sides of the Straits of Magellan, Kerguelen, and the Falkland Islands; and from Kaiser Wilhelm Coast, South Victoria and Alexander I Land along the ice-edge of the Antarctic continent.

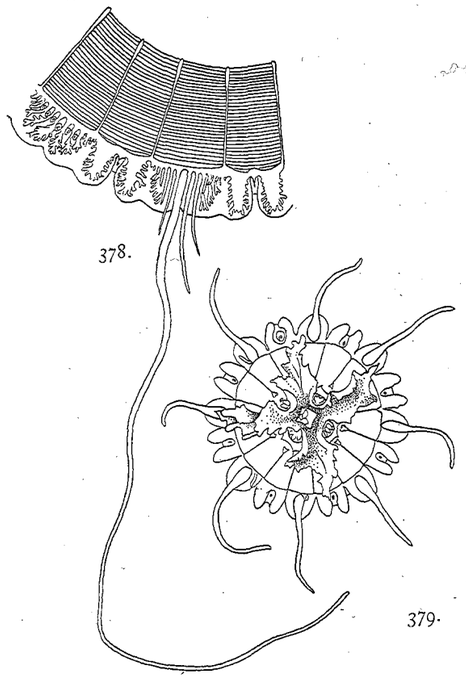
Ephyræ 3 to 10 mm. wide are found in January and February, and Vanhöffen records a young medusa in the *Medora* stage from Gauss Station, Kaiser Wilhelm Land on April 14. This medusa was 38 mm. in diameter, the mouth-arms 16 mm. long. There were 8 principal tentacles about two-thirds as long as bell-diameter, and 4 of these were bordered on one side by a small tentacle of recent development, figure 379. The lips and gastric cirri were brownish-red, other parts being translucent milky-blue. A later stage is described by Browne (see figure 378).

Genus CYANEA Péron and Lesueur, 1809.

Cyanea, PÉRON AND LESUEUR, 1809, Ann. Mus. Hist. Nat. Paris, tome 14, p. 363.—ESCHSCHOLTZ, 1829, Syst. der Acalephen, p. 67.—LESSON, 1843, Hist. Zooph. Acal., p. 379.—BRANDT, 1838, Mém. Acad. Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 77.—FORBES, 1848, British Naked-Eyed Medusæ, p. 77.—AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 115, 161.—AGASSIZ, A., 1865, North Amer. Acal., p. 44.—VON LENDENFELD, 1882, Zeit. für wissen. Zool., Bd. 37, p. 465; 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 275.—BIGELOW, R. P., 1900, Mem. Boston Soc. Nat. Hist., vol. 5, p. 211.—HARGITT, C. W., 1902, American Naturalist, vol. 36, p. 555.—MAAS, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 55; 1906, Fauna Arctica, Bd. 4, Lfg. 3, pp. 486, 505; 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 28.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 51.

Procyanea+*Medora*+*Stenoptycha*+*Desmonema* (in part)+*Cyanea*, HAECKEL, 1880, Syst. der Medusen, pp. 524–528.

The type species is *C. capillata* of the North Atlantic, Pacific, and Arctic Oceans. It is the largest of all known medusæ.



Desmonema chierchiana.

FIG. 378.—After Browne, in Trans. Royal. Soc. Edinburgh.
FIG. 379.—Young medusa, after Vanhöffen in deutsch. Südpolar Expedition.

GENERIC CHARACTERS.

Cyaneidæ with 8 marginal sense-organs and with 8 adradial crescentic groups of tentacles. Each group consists of several rows of tentacles. With radial muscle strands in the subumbrella.

When young only 8 simple tentacles arise in the adradial clefts between the ephyra lobes, but later the margin grows beyond them, leaving them to project from the floor of the subumbrella. In the meantime the tentacles increase in number, becoming a row in each adradius, but finally they come to lie in two or more rows. Haeckel has constituted a special genus for each of these growth-stages. He calls the 8-tentacled stage "*Procyanea*." The stage with 24 tentacles, 3 in each adradius, he names "*Medora*," and when there are 5 tentacles in each row the medusa becomes a "*Stenoptycha*"; then as long as the medusa remains with the tentacles of each cluster in a single row it is a "*Desmonema*," and finally when older and the tentacles begin to develop in two or more rows in each cluster the medusa is called a *Cyanea*. It is possible that some medusæ may become mature in, and never advance beyond, Haeckel's "*Desmonema* stage," but it is certain that others pass through this condition and become mature as *Cyanea*.

Medusæ of *Cyanea* are abundant in the Arctic and Antarctic, but are not found in the tropics. Being dependent upon a fixed scyphostoma-stage for development, they are confined to the proximity of coasts where the water is relatively shallow.

The early development of the planula takes place among the folds of the copious mouth-curtains of the adult medusa. Segmentation is total and regular but unequal, the cells of one pole being smallest. The gastrula results from simultaneous delamination and invagination at the small-cell pole. The blastopore closes. The planula attaches itself by its forward end and becomes a scyphostoma which acquires 15 to 20 tentacles and strobilates producing a number of ephyræ. The details of this development are given under *C. capillata*.

It appears that the numerous so-called species of *Cyanea* intergrade to such a degree that we can not maintain them, and I believe there are only two species:—*C. capillata* of the north temperate and Arctic regions and *C. annaskala* of the south temperate and Antarctic. In common with *Pelagia*, *Chrysaora*, *Dactylometra*, *Aurellia* and other world-wide forms of medusæ, growth-stages, color varieties and local races have frequently been described as separate species, but as our knowledge increases many intergrading forms come to light thus reducing the so-called species to a few dominant types with numerous, closely related offshoots. It is unfortunate that the aim of the old systematic zoology was mainly toward the emphasizing of distinctions rather than the indication of affinities and the discovery of relationships.

Cyanea is readily distinguished from *Desmonema* by its radiating muscle strands in the subumbrella, and its horse-shoe shaped clusters of tentacles.

Cyanea capillata Eschscholtz.

Plate 65, figs. 3 and 4.

Medusa capillata, Linné, 1746, Fauna Suecica, Ed. 1, p. 368, Nr. 1286; Systema Naturæ, Ed. 10, 1758, tome 1, p. 660; 1788, tomus 1, pars 6, p. 3154.—Fabricius, 1780, Fauna Groenlandica, p. 364.

Cyanea capillata, Eschscholtz, 1829, Syst. der Acalephen, p. 68.—Van Beneden, 1886, Fauna. littor, Belg., p. 77, taf. 1, 2.—Haeckel, 1880, Syst. der Medusen, p. 529.—Hamann, 1890, Internal. Monatsschrift Anat. Physiol., Bd. 7, p. 259, taf. 12.—Browne, 1905, Proc. Roy. Soc. Edinburgh, vol. 25, p. 775.—Maas, 1906, Fauna Arctica, Bd. 4, Lfg. 3, pp. 486, 511.—Holt, 1902, Report Fisheries of Ireland, part 2.

Cyanea artica, Péron et Lesueur, 1809, Ann. Mus. Hist. Nat. Paris, tome 14, p. 363.—Mörch, 1857, Beskriv. af Grönland, p. 95.—Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 87, 162; *Ibid.* 1860, vol. 3, plates 3–5*a*; plate 10, figs. 1–17, 19–21, 23–30, 33–35, 37, 38; plate 10*a*, figs. 1–4*a*, 5–12*a*, 14, 15, 17–40.—Packard, 1863, Canadian Naturalist and Geol., vol. 8.—Agassiz, A., 1865, North Amer. Acal., p. 44, fig. 67.—Haeckel, 1880, Syst. der Medusen, p. 530.—Fewkes, 1881, Bull. Mus. Comp. Zool. at Harvard College, vol. 8, No. 8, p. 166, plate 7, figs. 1, 4, 5, 8–14.—Wagner, 1885, Wirbellosen des Weissen Meeres, Bd. 1, p. 83, taf. 5, 6.—MacMurrich, 1891, Amer. Naturalist, vol. 25, p. 287.—Hargitt, 1902, Science, ser. 2, vol. 15, p. 571.—Macallum, 1903, Journal of Physiology, Cambridge, England, vol. 29, pp. 213–241.—Hyde, 1894, Zeit. für wissen. Zool., Bd. 58, p. 531, taf. 34, fign. 54–62; taf. 35, fign. 63–79; taf. 36, fign. 94–96.—Hargitt, 1904, Bull. U. S. Bureau of Fisheries, vol. 24, p. 68.—Maas, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 56.—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 53, fign. 16–19; *C. capillata*, p. 52, fig. 15; *C. lamarcki*, pp. 53, 64, fign. 35–37.—Hargitt, 1905, Journal Experimental Zool., vol. 2, p. 574 (variations).

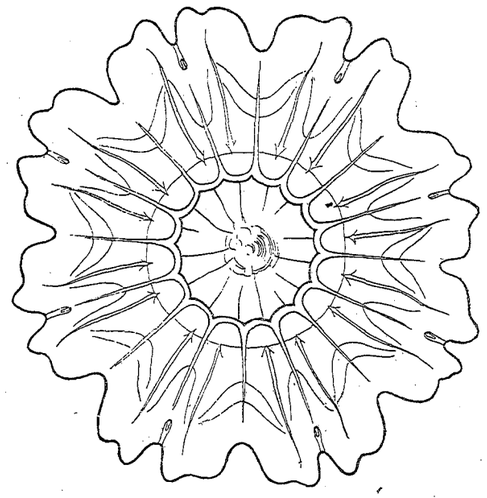


Fig. 380.—*Cyanea capillata*, after Vanhöffen, in Nordisches Plankton.

Cyanea lamarckii, Péron et Lesueur, 1809, Ann. Musée Hist. Nat., Paris, tome 14, p. 363.

Cyanea postelsii, Gould, A. A., 1841, (non Brandt) Report Invert. Massachusetts, p. 347.—Stimpson, 1853, Marine Invert. Grand Manan, p. 11.

Cyanea ———, M'Kendrick, J. G., 1881, Journal Anat. and Physiol., vol. 15, p. 261 (coloring matter).

Cyanea lamarcki, Delap, 1905, Annual Report Fisheries of Ireland 1902–03, part 2, Appendix 1 (reared from the egg in an aquarium).

Cyanea lamarckii, Haeckel, 1880, Syst. der Medusen, p. 530 (literature).—Joubin, 1906, Bull. Musée Oceanograph., Monaco, No. 66, p. 27, fig. 28 (after Delap).—Vanhöffen, 1908, Deutsche Südpolar Expedition, Zool. 2, Bd. 10, p. 39.

Cyanea lamarckii=*C. capillata*, M. Intosh, 1885, Annals and Mag. Nat. Hist., ser. 5, vol. 15, p. 148.

For literature of *C. fulva* and *C. versicola* see the detailed account of these varieties.

Cyanea ferruginea, Eschscholtz, 1829, Syst. der Acalephen, p. 70, taf. 5, fig. 1.

Cyaneopsis behringiana, Brandt, 1838, Mém. Acad. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 379, taf. 11, fig. 1.

Cyanea ferruginea, Haeckel, 1880, Syst. der Medusen, p. 531.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 28.—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 55, fig. 20.

(??) *Melusina formosa*, HAECKEL, 1881, Report Deep-Sea Medusæ *Challenger* Exped., Zool., vol. 4, p. 1.

Cyanea postelsii, BRANDT, 1838, Mém. Acad. Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 375, taf. 12, 13, 13*a*.—HAECKEL, 1880, Syst. der Medusen, p. 532.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 55, fig. 21.—MAAS, 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 506.

Cyanea imporcata, NORMAN, 1865, Nat. Hist. Trans., Northumberland and Durham, vol. 1, p. 11, 1 taf. (a young *Cyanea* from the British coast).

Cyanea citrea, KISHINOUYE, 1910, Journal College of Sci. University Tokyo, vol. 27, art. 9, p. 16, plate 4, figs. 16, 17 (this is *C. ferruginea*).

It is practically impossible to draw any fixed distinctions between the various forms of the great *Cyanea* of the North Atlantic. Intergrading forms are commonly met with and many of the races are separated only geographically or upon color distinctions which are neither wholly characteristic nor stable. *Medusa capillata* Linné, 1746, is the oldest name applied to any of these medusæ. The following are probably all varieties of one and the same species, *C. capillata:*

Cyanea capillata. Bell about 500 to 1,200 mm. wide. Ocular and interocular clefts of bell-margin not sharp and narrow, but with evenly rounded curves. Bell, palps, and tentacles reddish or yellowish-brown, with rose-colored or red gonads. Vanhöffen, 1906, states that when the bell is 13 mm. wide there are 7 tentacles in each adradial cluster, the middle one of each group being the longest. When 20 mm. wide there are 15 tentacles in each cluster with 3 long ones in the middle. When 41 mm. wide there are 35; and when 86 mm. there are 63 tentacles. This variety is not uncommon in the English channel, North Sea, and coast of Norway in summer and autumn.

Var. *lamarckii.* Distinguished by the decided blue color of the bell and palps, the color being lighter at the margin than at the center of the bell. Gonads and tentacles nearly white. In other respects this form resembles *C. capillata.* Vanhöffen states that when the medusa is 43 mm. wide there are only 20, and when 85 mm. wide only 31 tentacles in each group, thus being only about half as many as in the typical *C. capillata* of the same diameter. On the other hand the gonads in a medusa of *C. lamarcki* 43 mm. wide are about as long as the palps, thus being larger than in *C. capillata.* This form is found in the English channel along the coasts of France and Great Britain, at Helgoland, and in the entrances to the Baltic, but it does not extend into the Baltic. It becomes 300 mm. wide.

Var. *arctica.* Supposed to be distinguished from the first two forms by the indistinctness of its rhopalar lappets which do not project as far beyond the general contour of the bell-margin as in *C. capillata.* It is very large, though specimens over 800 mm. in diameter are rarely met with. The bell is very variable in color but is usually rich brown and yellow, with deeply colored gonads and rich rosin-yellow muscles and tentacles. It is found off the American coast north of Cape Cod, where it is abundant during the summer, becoming mature and disappearing in early autumn.

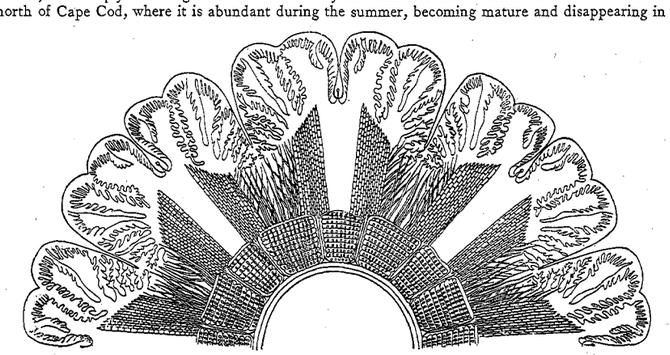


FIG. 381.—*Cyanea ferruginea*, according to Eschscholtz, after Vanhöffen, in Nordisches Plankton.

Var. *fulva.* A small yellowish-colored variety of *C. arctica* which ranges from Cape Cod southward to the Carolina coast. It is rarely over 200 mm. wide. At Newport, Rhode Island, it becomes mature early in June and is not seen in July, but on the coast of New Jersey it is found in August.

Var. *nozakii.* Similar to *C. fulva*, but milk-white in color. Found in the Inland Sea of Japan.

Var. *versicolor.* A pink-colored southern variety of *Cyanea fulva*, which is even smaller, rarely more than 110 mm. wide. It forms large swarms during the winter and spring off the coast of the United States between Cape Hatteras, North Carolina, and southern Florida.

Var. *ferruginea.* Of the North Pacific coasts of America and Asia. It is a variety of *C. capillata* and is apparently identical with the variety *C. "arctica."* It becomes about 450 mm. wide and is light-yellow or orange with the stomach and radial pouches light-brown. The gonads are yellow and the tentacles reddish, although these colors are probably somewhat variable as in other forms of *Cyanea.*

Var. *postelsii* appears to be only a local variety of *C. capillata.* It is found in the North Pacific from the Aleutian Islands to Oregon and is distinguished by the 16 well-developed clefts which flank the rhopalar lappets and are about half as deep as the adradial clefts; moreover, according to Mertens, the contours of the lappets are evenly rounded and even the clefts are not narrow, but widen inwardly with rounded contour. A modern study of this medusa is to be desired, for it is possible that Mertens over-emphasizes these peculiarities. The medusa is found between Sitka and the Aleutian Islands, Alaska.

The following is a detailed description of *Cyanea "arctica"* of the coast of North America:

Adult medusa.—The disk is quite flat and lenticular and attains a diameter of 2,300 mm. Medusæ of this size are very rare, however, and the majority are not over 800 mm. wide. The

umbrella margin is divided by 8 deep, adradial clefts into 8 principal lobes, which are about twice as broad as they are long. Each of these lobes is in turn divided by a median cleft, and there are also two slight notches upon the bell-margin on either side of the median cleft; the margin, therefore, displays 32 indentations, between which there are 32 lappets. The margin of the bell is sharp-edged for the gelatinous substance, which is quite thick at the center of the disk, becomes very thin as one approaches the periphery. The 8 marginal sense-organs are found at the bottom of the median niches of the 8 principal lobes of the disk. Each sense-organ is elongate and club-shaped, and protected above by a web which stretches between the adjacent lappets; proximal half of club quite thick, with a well-developed swelling upon its lower (subumbrella) side; this swelling is covered with wart-like elevations and provided with one or two papillæ. Distal to this swollen region the club extends outward as a cylindrical tube which terminates in a swollen knob-like part containing an entodermal mass of crystalline concretions, but no ocelli. Two open pits project downward from the floor of the exumbrella on either side of the base of the sensory-club. The structure of the sense-organ in *Cyanea* has been studied by L. Agassiz, 1862; Eimer, 1878; and Fewkes, 1881. About 800 long tentacles arise from 8 adradial, crescentic regions on the floor of the subumbrella, about midway between the periphery and the center. The horns of these crescentic areas point outward and the tentacles are arranged in about 5 concentric rows in each crescent, the oldest and longest tentacles being on the innermost row. The tentacles are hollow and highly contractile; when fully expanded they attain a length of about 25 times the bell-diameter; their surfaces are thickly covered with nematocysts. Mouth 4-cornered and situated at center of subumbrella; it is provided with 4 long perradial mouth-arms, the margins of which are greatly folded, forming the curtain-like lips or oral fringes which hang downward in the water. Mouth-arms about as long as bell-diameter, and with their fringes appear as a complexly folded, contractile mass of curtain-like appendages hanging from the oral floor of the bell.

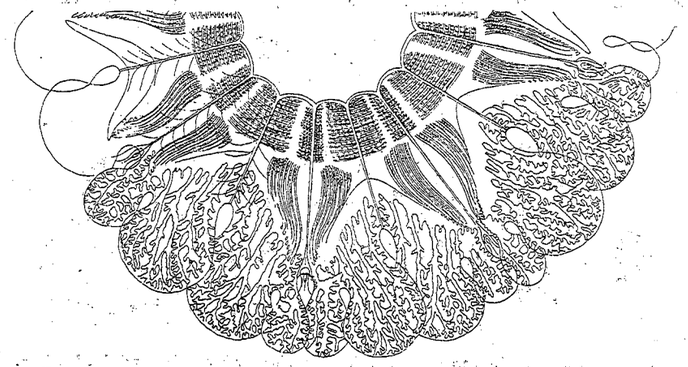


FIG. 382.—*Cyanea postelsi*, according to Brandt, after Vanhöffen, in Nordisches Plankton.

Gonads occupy 4 complexly-folded pouches which project from subumbrella floor at the 4 interradial sides of the stomach. Numerous clusters of small gastral cirri project from the bases of the gonads into the stomach-cavity; these are far more prominent in the young medusa than in the adult, for in the mature medusa they become hidden away at the bases of the pendant, pouch-like folds of the genital organs. There is a very powerful and conspicuous system of circular muscles in the subumbrella; these muscles occupy a zone about one-eighth as broad as bell-radius and which lies adjacent to and centrifugal from the gonads. This zone of muscles is composed of 16 trapezia, the 8 in the rhopalar radii being only half as wide as those in the adradii. 16 strands of radiating muscles extend from the outer side of the zone of circular muscles and pass outward on either side of the sense-organs.

The central stomach is a wide, lenticular space in the center of the disk; peripherally it gives rise to 16 radiating pouches, the outer edges giving numerous branched canals which ramify through the lappets without anastomosing. The 8 pouches in the radii of the sense-organs are less than half as wide as the 8 in the radii of the tentacles. The tentacles and the stalks of the sense-organs are hollow and in direct connection with the gastrovascular space of

the medusa. There is no ring-canal. The gonads are great hollow bags forming part of the gastric system of the animal. There are deep clefts in the aboral floor of the stomach giving it a reticulate appearance (see fig. 3, plate 65).

The gelatinous substance of the bell is translucent with a slightly bluish or yellowish tinge. The entoderm of the gastrovascular system is of a rich brownish-purple and the mouth-arms and oral curtains are chocolate-purple. The gonads and tentacles are either yellowish or reddish-brown, and the muscular system of the subumbrella is brown or yellow.

This species extends from the southern coast of New England northward to the Arctic Ocean. It thrives best in the colder waters, and specimens found south of Cape Cod are usually of small size. It is worthy of notice, also, that south of Cape Cod the medusæ disappear about the middle of June, while in the cold waters of the coast of Maine the mature ones are most abundant in August and September. In Europe it is abundant off the coasts from France to Northern Russia, and is found at Spitzbergen in August.

Cyanea arctica appears to be identical with the so-called *C. ferruginea* of the North Pacific; and *C. postelsii* of the Pacific is a closely allied form.

The embryonic and larval stages have been studied by L. Agassiz, 1862; Fewkes, 1881; Hamann, 1890; MacMurrich, 1891; and Ida Hyde, 1894. Agassiz gives a series of figures illustrating the general developmental stages of the planula and scyphostoma, while Hyde gives a very complete account of the histology of the early stages. The eggs are orange-colored and provided with a membrane, and are dehisced from the ovaries into the gastric cavity, where they undergo segmentation among the folds of the mouth-arms and finally escape through the mouth of the parent medusa as free-swimming planulæ. The segmentation is total but unequal, the cells at one pole being smaller than those at the opposite pole. A blastula is formed in which there is a large central blastocœl. The gastrula results from the rapid divisions of one or two small cells at the small-cell pole, which form a layer that invaginates. Hyde finds no wandering inward of free cells, but McMurrich records this condition. The blastopore then closes over and the entoderm becomes entirely enveloped by the ectoderm. In this condition the larva becomes a pear-shaped, ciliated planula and swims actively through the water, the posterior, narrow end being that at which the gastrula mouth had developed. One sometimes observes nematocysts in both ectoderm and entoderm at this narrow hinder end of the planula. The next stage in development is instituted by the formation of a shallow, crater-like, glandular invagination of the ectoderm at the broad, anterior pole of the pear-shaped planula, and then the animal sinks down and attaches itself to the bottom by this forward end. A cup-like depression of ectoderm then presses down upon the entodermal sac at the narrow posterior end and finally fuses with it, and eventually the mouth breaks through at this point.

The first pair of the radial pouches is formed from the entoderm, the second, in part at least, from the ectoderm of the crater. MacMurrich, 1891, and Hargitt, 1902, observed that planulæ in confinement encysted themselves during this stage, remaining thus for several days until the mouth is about to break through, when the embryos emerge from the cyst through a circular aperture at the center of its free, convex surface. Hyde, 1894, observed this, however, only in one embryo and it is possibly an abnormal condition due to unfavorable surroundings. Simultaneous with the formation of the mouth 4 tentacles make their appearance, and the scyphostoma finally acquires 15 to 20 tentacles. Hargitt, 1902, finds that lateral stolons are sometimes produced by the scyphostoma, and secondary scyphostomæ bud out from these stolons. A number of ephyræ result from strobilization of the scyphostoma, and this may occur in 18 to 20 days after the planula has attached itself but this period varies considerably.

The young ephyra 3.5 mm. in diameter (plate 65, fig. 4) has a simple 4-cornered mouth at the center of the subumbrella, and 4 smooth-edged, slightly raised lips. The 8 tentacular notches in the margin are much wider and deeper than the notches of the sense-organs. The tentacles arise from the bell-margin, but as the animal grows the margin extends beyond them and they thus come to project from the subumbrella floor of the disk. 4 short, entodermal gastric cirri (*gt* plate 67, figs. 2, 3) are found upon the oral floor of the subumbrella near the interradial corners of the mouth and project into the stomach-cavity. The gastric system in this stage consists of a wide, lenticular, central stomach from which there extend outward 16 simple, radiating pouches in the radii of the tentacles and sense-organs. In

later stages the young medusa develops an increasing number of tentacles and the lips form long curtain-like folds surrounding the 4-cornered mouth. When the young medusa is about 7 mm. in diameter there are a number of slender papillæ upon the exumbrella and these are clustered especially at the aboral apex. In this stage the medusa rarely comes to the surface, but frequently spreads its oral fringes out over the bottom or sides of the aquarium and remains sedentary. The same habit is exhibited by the closely allied "*Cyanea fulva*" which is represented in figs. 1 to 7, plate 66, and figs. 1 to 3, plate 67; and it is probably due to some such habit that the young are rarely to be found upon the surface while the large and mature medusæ are very abundant. The scyphostoma and young medusa feed upon protozoa, starfish, and mollusk larvæ.

Macallum, 1903, studied the composition of the body-juices of *Cyanea arctica* and found them to be as follows:

	Na.	Ca.	K.	Mg.
Content of sea-water	100	3.84	3.66	11.99
Content of body-juices of *Cyanea arctica*	100	3.86	7.67	11.31

The SO_3 is less in *Cyanea* than in sea-water by about 32 to 36 per cent and the medusa contains more iron and less iodine than does sea-water.

M'Kendrick, 1881, studied the chemical composition of the coloring matter of *Cyanea* and found that the blue pigment of *Cyanea* and *Aurellia* is in the form of granules surrounded by clear protoplasm. This pigment is soluble in acids, but is precipitated in neutral or acid solutions. Hence when the medusa becomes acid through decomposition after death the pigment dissolves out into the water, but during life it remains stable. This pigment matter of *Cyanea* shows two absorption bands in the spectrum, one in the red and one in the orange, very much as in *Stentor cæruleus*.

Holt, 1902, finds that in the North Sea this medusa is accompanied by young whiting.

Cyanea capillata var. fulva, L. Agassiz.

Plate 66, figs. 1 to 7; plate 67, figs. 1 to 3.

Cyanea fulva, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 119, 162.—Agassiz, A., 1865, North Amer. Acal., p. 46.

This southern variety is distinguished from the northern *C. arctica* by the light yellow or yellow-brown color of the entoderm of its gastrovascular system, which is never rich brown, as in the northern *C. arctica*. It is also much smaller, being rarely over 200 mm. in diameter. The lappet notches are more uniform than in *C. arctica* and the tentacles are much less numerous. The oral fringes, also, are less voluminous and by no means so complexly folded as in *C. arctica*. This variety appears in great numbers early in May on the southern coast of New England, and the medusæ arrive at maturity about the middle of June, after which they suddenly disappear. We have, however, met with swarms of them about 20 miles off Barnegat Bay, New Jersey, early in August. This variety has not been taken north of Cape Cod. The development is similar to that of the closely allied *C. arctica*.

We may regard this as a local race of *C. arctica*, which ranges from Cape Cod, Massachusetts, southward to the Carolinas; where it is replaced by a still more southerly variety, *C. arctica* var. *versicolor*.

Cyanea capillata var. versicolor L. Agassiz.

Plate 65, figs. 1 and 2.

Cyanea versicolor, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 119, 162.—Agassiz, A., 1865, North Amer. Acal., p. 46.

This form bears the same relation to *Cyanea arctica* var. *fulva* as *fulva* does to the northern *C. arctica*. It is smaller than *fulva*, but is distinguished especially by its pink coloration. Mature medusæ are about 110 mm. in diameter and are found in swarms off the coast between Cape Hatteras, North Carolina, and Cape Canaveral, Florida. They are practically confined to pure open water and do not frequent the harbors. The mature medusæ bear many ball-

like clusters of developing planulæ gathered into the peripheral canals of the gastric space. The gelatinous substance of the disk is translucent milky-blue in color, while the gastro-vascular space, gonads, radial and circular muscles of the subumbrella and the entodermal cores of the tentacles are purplish-pink. The outer parts of the veil-like folds of the palps are amber-brown, while the parts adjacent to the mouth are pink. The concretions of the 8 sense-organs are reddish-brown. The planulæ are yellow, but the ephyra is pink.

The curtain-like oral fringes are relatively smaller than in *Cyanea arctica*. However, the chief distinction of *C. versicolor* is its peculiar pink coloration. Even in the young *ephyra* only 2.5 mm. in diameter, the stomach-cavity displays a deep purplish-pink, very different from the pale yellow-colored ephyra of the southern *C. fulva*.

Mature medusæ of *C. versicolor* occur in the winter months along our southern coast.

Among thousands observed by the author during the winter of 1904–05 not more than a dozen lacked the pink coloration and these resembled the variety *C. capillata* var. *fulva*. They were, however, swimming among swarms of the typical pink *versicolor* medusæ. The variety *versicolor* appears to be a well-marked local race of *Cyanea capillata*.

Cyanea capillata var. nozakii Kishinouye.

Cyanæa nozakii, KISHINOUYE, 1891, In Japanese, 3 pp., 1 plate.

Kishinouye's paper upon this medusa is in Japanese, but with a German abstract, and accompanied by two clear figures of the animal. The bell is flat and shield-shaped, 5 times as wide as high, 160 to 260 mm. wide. The bell-radius is 3 times as wide as the radius of the central stomach. 16 rounded ephyra lappets, twice as wide as long. The ocular stomach-pouches are nearly rectangular. The tentacular stomach-pouches are twice as wide at their bases, and at the zone of the sense-organs 2.5 times as wide as the ocular pouches. Color, milk-white. Found in the Inland Sea of Japan.

This medusa is distinguished from *Cyanea capillata* var. *fulva* only by its color.

Cyanea annaskala von Lendenfeld.

Cyanea annaskala, VON LENDENFELD, 1882, Zeit. für wissen. Zool., Bd. 37, p. 465, taf. 27–33, 78 fign.; 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 275, var. *marginata, Ibid.*, p. 928, var. *purpura, Ibid.*, p. 928; 1883, Annals and Mag. Nat. Hist., ser. 5, vol. 12, p. 261 (nettling cells); 1887, Descript. Cat. Australian Mus. Sydney, Medusæ, part 1, pp. 20, 21.
Cyanea muellerianthe, HAACKE, 1887, Jena. Zeit. für Naturwissen., Bd. 20, p. 605, taf. 36, fign. 1–4; 1888, Biol. Centralblatt, Bd. 8, p. 358.
Desmonema rosea, AGASSIZ, A., and MAYER, 1898, Bull. Mus. Comp. Zool. at Harvard College, vol. 32, p. 15, plate 1, fig. 1 (young medusa in the *Desmonema* stage).
Cyanea mullerianthe=*C. annaskala*, VON LENDENFELD, 1888, Biol. Centralblatt, Bd. 8, p. 218.
Desmonema annasethe (? young medusa), HAECKEL, 1880, Syst. der Medusen, p. 526, taf. 30, fign. 1–4.
Cyanea rosea (? young medusa), QUOY ET GAIMARD, 1824, Voyage de l' *Uranie*, Zool., p. 570, planche 85, figs. 1, 2.
(?) *Cyanea purpura*, KISHINOUYE, 1910, Journal College Sci. Tokyo, vol. 27, art. 9, p. 18, plate 4, figs. 18, 19.

Umbrella flat, shield-shaped, 70 to 200 mm. wide and about 12 to 25 mm. thick, with a few protruding nettling-warts at the middle of the exumbrella; elsewhere smooth. 8 marginal sense-organs which lack ocelli, and with 32 marginal lappets divided into 8 main flaps of 4 lappets each. These lappets are evenly rounded and not wider at the end than at their bases; the 16 ocular lappets are about half as wide, as also are the 16 velar lappets adjacent to them. There are 8 U-shaped clusters of long tentacles arising from the floor of the subumbrella, with the concavity of each U directed outward. These tentacles are very numerous and are arranged in 3 to 4 crowded rows in each U; they are filiform and when extended are about 300 mm. long. The 4 complexly folded, curtain-like lips are about as long as the bell-radius. The 4 protrusive gonads are large and complexly folded. The 8 ocular, radial pouches of the central stomach are only about half as wide as the 8 velar pouches. All of the pouches break up into blindly-ending, branched, non-anastomosing vessels in the lappets. There is no ring-canal. The gelatinous substance of the disk and the tentacles are colorless. The entoderm of the gastral cavity is brown. Curtain-like lips intensely purple. Genital organs of the male are rose-colored; those of the female are orange-yellow. The medusa is distinguished from the Cyaneas of the northern hemisphere mainly by its brilliant coloration. It appears to be more closely related to *C. versicolor* than to any other form, and it is interesting to observe that *C. versicolor* is the most southerly in its range of any of the northern Cyaneas.

This species is abundant along the temperate coasts of Australia and is found in Port Philip, Victoria, in large numbers from January to March. It is described in great detail by von Lendenfeld, who finds that the embryos remain attached to the mouth-arms until "they are nearly matured to young scyphostomæ"; they then affix themselves to bodies in the water and produce a long stalk with a chitinous perisarc and 8 arms (tentacles?). According to von Lendenfeld the ephyra develops into an adult medusa by a complicated metamorphosis. The lappets of the umbrella are said to be produced by fission, but this statement probably applies only to the ocular lappets, not to the 8 primary ephyra lobes.

In the variety *purpura* from Melbourne Harbor, Australia, the mouth-curtains are rich purple throughout, and in the variety *marginata* from Sydney their free-margins are purple, but elsewhere they are colorless.

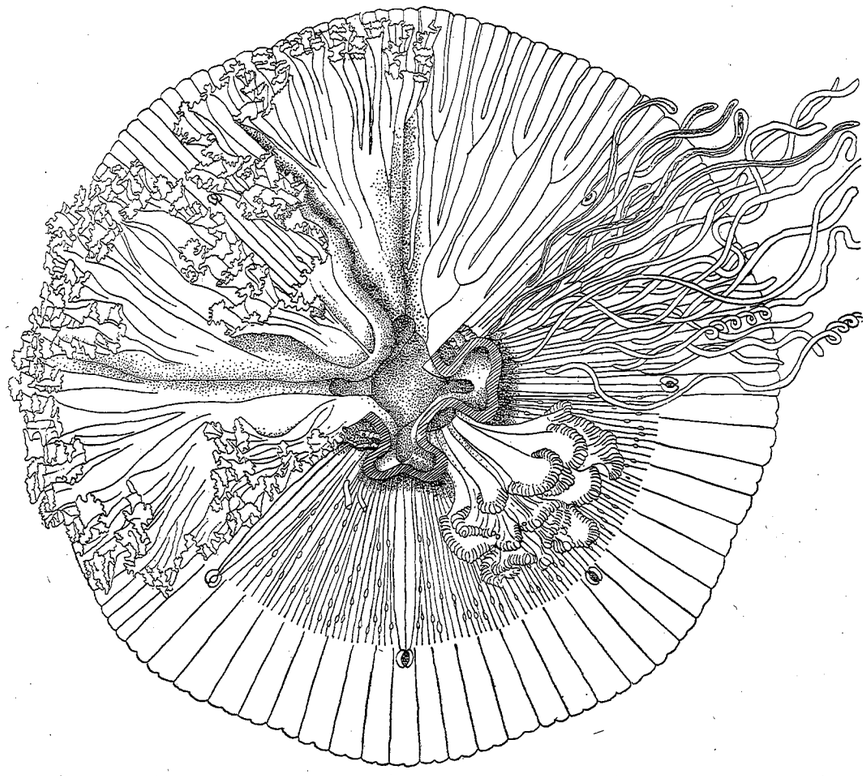


FIG. 383.—*Drymonena "victoria,"* after Haeckel, in Deep-sea Medusæ of the *Challenger* Expedition.

Cyanea mullerianthe Haacke, from St. Vincent Gulf, South Australia, is a delicately pink-colored variety of this medusa, and *Desmonema rosea* Agassiz and Mayer is the same medusa when young and in the stage wherein the tentacles of each cluster arise in a single row.

Desmonema annasethe Haeckel, 1880, may be a young contracted specimen of this medusa. The 16 so-called feathered, radiating ribs of the exumbrella present the appearance of being due to unnatural contraction. The tentacles arise in 8 U-shaped groups with 13 to 17 tentacles in each crescent. This form is described by Haeckel from a preserved specimen found off the west coast of South Africa. Color (?)

Dendy, 1889 (Proc. Royal Soc. Victoria, p. 112), describes parasitic actinian larvæ found upon the mouth-curtains of the *Cyanea* of Port Phillip, Victoria.

Genus DRYMONEMA Haeckel, 1880.

Drymonema, HAECKEL, 1880, Sitzungsber. Jena. Gesell. für Med. und Natürw., Jahrg. 1880, Feb. 20; 1880, Syst. der Medusen, p. 633; 1881, Report on Deep-sea Medusæ, *Challenger* Expedition, Zool., vol. 4, p. 124.—MÜLLER, F., 1883, Zool Anzeiger, Jahrg. 6, p. 220.

The type species is *Drymonema dalmatina* Haeckel, 1880, of the Mediterranean. The same species was renamed *D. "victoria"* by Haeckel in 1881. *D. gorgo* is a closely related form from the coast of Brazil.

GENERIC CHARACTERS.

Cyaneidæ with 8 marginal sense-organs. The tentacles are not grouped in separated clusters, but arise diffusely in a wide annulus from the subumbrella. The central stomach gives rise to 16 radial pouches (8 ocular and 8 interocular) which branch dichotomously, but do not anastomose. No ring-canal. Marginal lappets numerous. Development unknown.

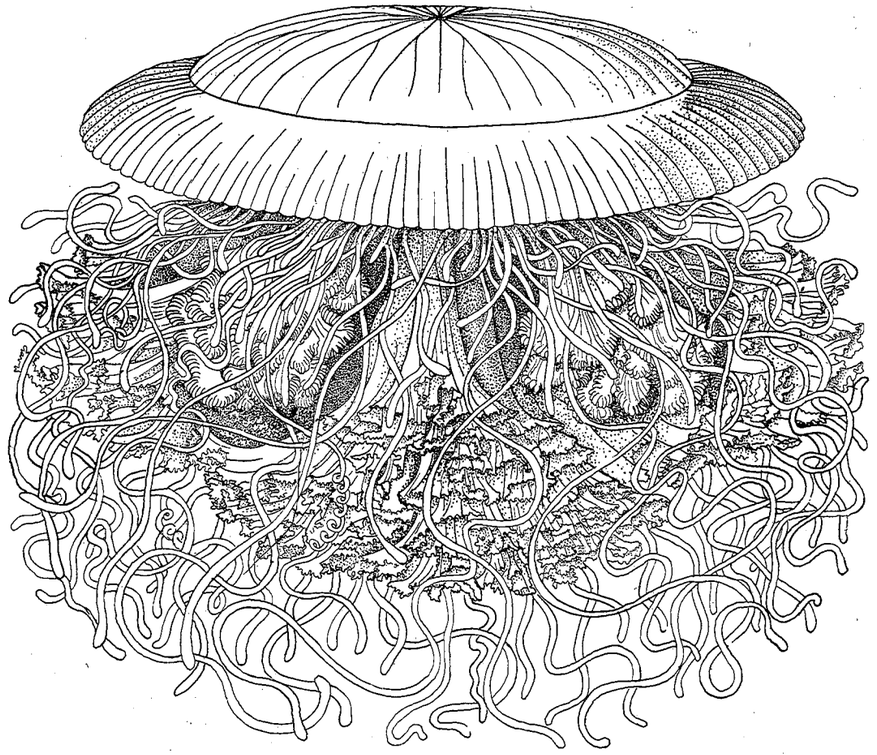


FIG. 384.—*Drymonema "victoria,"* after Haeckel, in Deep-sea Medusæ of the *Challenger* Expedition.

This genus is distinguished from *Cyanea* and *Desmonema* by the fact that its tentacles arise not in 8 separate clusters, but from a wide annular zone in the subumbrella. Moreover, the 16 dichotomously branched radial-canals, numerous velar lappets, and the radial furrows of the exumbrella are all distinctive of *Drymonema*.

Drymonema dalmatina Haeckel.

Drymonema dalmatina, HAECKEL, 1880, Syst. der Medusen, p. 642=*D. victoria*, 1881, Report Deep-sea Medusæ *Challenger* Exped., Zool., vol. 4, p. 125, plates 30, 31.—GRAEFFE, 1884, Arbeit. Zool. Inst. Wien, Bd. 5, p. 342.
Drymonema cordelio, ANTIPA, 1892, Jena. Zeitsch. für Naturwissen, Bd. 27, p. 339, taf. 9, fign. 1–3.

Haeckel, 1880, had four small specimens of this medusa from the Dalmatian coast, Mediterranean. They ranged from 120 to 160 mm. in width and had only 64 radial furrows

upon the exumbrella and 9 double lappets per octant, 144 in all. In Antipa's specimens from the Gulf of Smyrna, Mediterranean, the radial furrows had increased to be 144 and thus corresponded in number with the lappets. Haeckel's specimens had only 80 terminal gastric canals, while Antipa's specimens had 144.

The following is a description of Antipa's specimens, these being the more mature:

Bell flatly rounded, shield-shaped, 500 to 1,000 mm. wide, 144 radial furrows on the exumbrella, and between them 144 marginal lappets. 8 marginal sense-organs in deep niches. 4 perradial, veil-like oral palps, each ending in 2 points, and thus the palps have 8 adradial points. These palps are more than 1.5 times as long as the disk-radius and their outer edges are complexly folded. The numerous tentacles arise from the middle zone of the subumbrella, halfway between the center and margin line, and are 3 to 6 times as long as diameter of the bell. There are 4 interradial protruding horseshoe-shaped gonads. Mouth-opening wide. Wall of mouth-tube thickened at 8 subradial places. The 16 stomach-pouches terminate in 144 dichotomous ramuli (128 tentacular and 16 ocular). Color reddish-white (pink ?). Gulf of Smyrna, coast of Asia Minor, Mediterranean; Trieste, Adriatic Sea, Graeffe; Straits of Gibralter (?) Haeckel.

Drymonema gorgo F. Müller.

Drymonema gorgo, MÜLLER, F., 1883, Zool. Anzeiger, Jahrg. 6, p. 220.

The disk is 20 to 500 (usually 300) mm. wide. "Mouth-arms" or palps longer than diameter of umbrella, whereas they are only about half as long as this in *D. dalmatina*. The 8 ocular stomach-pouches fork once, thus giving 16 marginal diverticula as in *D. dalmatina*. The 8 velar stomach-pouches branch dichotomously 4 times, as in the mature *D. dalmatina*, but the fifth, sixth, eleventh, and twelfth branches in *D. gorgo* branch dichotomously a fifth time, and thus each of the 8 ocular stomach-pouches gives rise to 20 terminal branches in the lappets. There are thus $8\times20+16=176$ dichotomous terminal gastrovascular canals in *D. gorgo* and only $8\times16+16=144$ in *D. dalmatina*.

Found at St. Catharina Island, coast of Brazil. Rare.

This may prove to be a variety of *D. dalmatina*.

Genus (?) PATERA Lesson, 1843; DONACOSTOMA L. Agassiz, 1862.

Patera, LESSON, 1843, Hist. Zooph. Acalèphes, p. 322.—HAECKEL, 1880, Syst. der Medusen, p. 533.
(?) *Melusina*, HAECKEL, 1880, *loc. cit.*, p. 534; 1881, Report Deep-sea Medusæ *Challenger* Expedition, Zool., vol. 4, p. 1 (abandoned by Haeckel himself).
(?) *Donacostoma*, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 118, 163.

The type species of this problematic genus is *Patera cerebriformis*, first described as *Dianæa cerebriformis* by Lesson, 1829, Voyage de la *Coquille*, Zooph., p. 124, planche 10. The description and figure are evidently so inaccurate as to be all but worthless. *Dianæa*, Lamarck, 1816 (Hist. Anim. sans Vert., tome 2, p. 504), is a synonym of *Geryonia*.

GENERIC CHARACTERS.

Cyaneidæ which are said to have 16 rhopalia. 16 clusters of tentacles arise from the subumbrella alternating in position with the sense-organs. Agassiz's *Donacostoma* has only 8 rhopalia, but 16 rows of tentacles.

Patera cerebriformis is said to come from near the Cape Verde Islands, tropical Atlantic; and another species *Donacostoma woodii* L. Agassiz, 1862 (Cont. Nat. Hist. U. S., vol. 4, pp. 118, 163), is from the China Sea, and is said to have 8 "eyes," but with 16 branches of tentacles like *Patera*, arranged in a single row in each lobe. Neither is well enough known to be worthy of description here, and indeed it is possible that both belong to the genus *Drymonema* or even to *Cyanea* itself.

Family ULMARIDÆ Haeckel, 1880, sens. ampl.

Flosculidæ+Ulmaridæ, HAECKEL, 1880, Syst. der Medusen, pp. 535, 539.
Ulmaridæ, VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 56.

FAMILY CHARACTERS.

Semæostomeæ with simple or branched radial-canals and a ring-canal. With hollow tentacles. 4 interradial gonads. 4 mouth-arms with folded, curtain-like margins.

The medusæ of this family are closely related to the Cyaneidæ, but differ in that their radial-canals are placed in intercommunication by means of a marginal circular canal; moreover, th radial-canals anastomose in some of the genera, and this is never the case in the Cyaneidæ.

The genera of the Ulmaridæ are as follows:

1. SUBFAMILY UMBROSINÆ.
   The tentacles arise singly from the margin in the clefts between the lappets. 4 evaginated, sac-like gonads without subgenital pits. 8 or 16 marginal sense-organs. 4 unbranched mouth-arms.
   (?) *Floresca* (immature ?)=*Floscula*+*Floresca* HAECKEL, 1880. 8 rhopalia, 24 tentacles, 32 lappets 16 simple unbranched radial-canals.
   Discomedusa, CLAUS, 1877=*Ulmaris*+*Umbrosa* HAECKEL, 1880. 8 rhopalia, 24 tentacles, 32 lappets. The 8 perradial and interradial canals are branched, the 8 adradial canals are simple. 4 gonads.
   Parumbrosa, KISHINOUYE, 1910. Similar to Discomedusa but with 64 instead of 32 lappets. (See Appendix to this volume.)
   Undosa HAECKEL, 1880. 8 rhopalia, 40 tentacles, 48 lappets. Radial-canals as in *Discomedusa*.
   Diplulmaris, MAAS, 1908=*Ulmaropsis*, VANHÖFFEN, 1908. 16 rhopalia, 16 tentacles, 64 lappets, 32 radial-canals arise from stomach. The 16 rhopalar canals branch and the 16 tentacular canals are simple. All canals are merged in a marginal network of anastomosing vessels.
2. SUBFAMILY STHENONINÆ.
   Tentacles arise from floor of subumbrella. Evaginated, sac-like gonads without subgenital pits. 8 to 16 marginal sense-organs. 4 unbranched mouth-arms.
   Sthenonia, ESCHSCHOLTZ, 1829. 8 marginal sense-organs. 8 adradial linear clusters of tentacles. Perradial and interradial canals branched. Adradial canals some simple and some branched.
   Phacellophora, BRANDT, 1835. 16 marginal sense-organs alternating with 16 clusters of tentacles. Radial-canals in the rhopalar radii are branched, in the tentacular radii simple. 4 gonads.
   Poralia, VANHÖFFEN, 1902. Numerous straight, unbranched radial-canals. Numerous gonads in a ring around the stomach-margin.
3. SUBFAMILY AURELINÆ.
   The tentacles and lappets arise from the sides of the disk above the margin. Invaginated gonads with external subgenital pits. 8 marginal sense-organs. 4 simple or bifurcated mouth-arms. Numerous tentacles and lappets.
   Aurellia, PÉRON AND LESUEUR, 1809. 4 simple *non*-bifurcated mouth-arms. Some or all of the radial-canals give rise to anastomosing branches. 4 gonads.
   Aurosa, HAECKEL, 1880. Similar to *Aurellia* but with 4 bifurcated mouth-arms.

Subfamily UMBROSINÆ.

SUBFAMILY CHARACTERS.

The tentacles arise singly from the bell-margin in clefts between lappets. 4 protrusive, bag-like gonads without subgenital pits. 4 unbranched mouth-arms.

(?) Genus FLORESCA Haeckel, 1880, sens. ampl.

Floscula + *Floresca*, HAECKEL, 1880, Syst. der Medusen, p. 537, 538, 643.

GENERIC CHARACTERS.

Haeckel's genera *Floscula* and *Floresca* may possibly be the young stages of some medusæ of the Ulmaridæ. In these forms we find that the central stomach gives rise to simple radial-canals which connect with one another by means of a marginal ring-canal. The tentacles arise from the clefts between the lappets, not from the floor of the subumbrella. We must bear in mind, however, that in the young of *Cyanea* the tentacles first appear in the clefts between the lappets and later the margin grows outward, leaving them to project from the subumbrella. Indeed all tentacles in Scyphomedusæ are structures of the subumbrella.

Floscula has 8 tentacles and 16 marginal lappets; *Floresca* has 24 tentacles and 32 marginal lappets. Indeed *Floresca* presents every appearance of being immature and only an advanced stage of "*Floscula*," both being one and the same species. Both come from the tropical Indian and Pacific Oceans.

A brief description of these medusæ may be of service should they prove to be mature forms. Haeckel is the only naturalist who has seen them.

"Floresca parthenia" Haeckel.

Floresca parthenia+*F. pallada*, HAECKEL, 1880, Syst. der Medusen, pp. 538, 539, taf. 32, fign. 5–8.
Floscula promethea (younger stage), HAECKEL, *loc. cit.*, p. 537, taf. 32, fign. 1–4. *F. pandora*, *Ibid.*, *p.* 643.

Bell rounded, 50 mm. wide, 30 high, with a 16-rayed pigmented star-like marking in the perradii, interradii, and adradii of the exumbrella. 8 rhopalia, (8×4) 32 tongue-shaped

lappets. 24 (8×3) hollow tentacles 2 to 3 times as long as the bell-diameter. Throat-tube 1.5 times as long as the bell-radius and as the 4 complexly folded, leaf-shaped lips. The central stomach gives rise to 16 unbranched radial-canals which are joined one to another by a marginal ring-canal. 4 interradial crescentic gonads with their convexities outward. These project from the floor of the subumbrella. There are no subgenital pits. The gonads are lined on their inner, concave sides by a row of gastric cirri. Color (?) Found at New Caledonia, New Guinea, and the Cocos Islands in the tropical Pacific and Indian Oceans.

Another specimen called "*Floscula pandora*" by Haeckel, 1880 (p. 643), is from the tropical Pacific. The bell is 30 mm. wide, without a star-like marking upon the exumbrella, and with a short throat-tube hardly one-fourth as long as the long, narrow mouth-arms. Tentacles as long as the bell-radius. Lappets oval, sharp pointed, 1.5 times as long as broad.

These medusæ appear to be immature, although Haeckel states that the gonads contained ripe eggs, but he studied only preserved specimens and cut no sections.

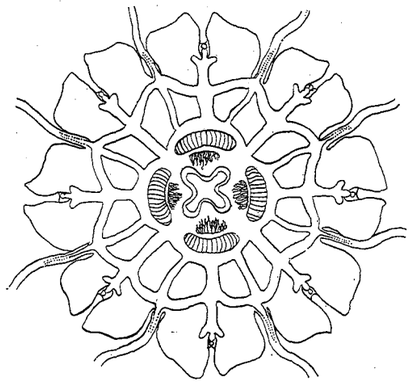


FIG. 385.—"*Floscula promethea?*"

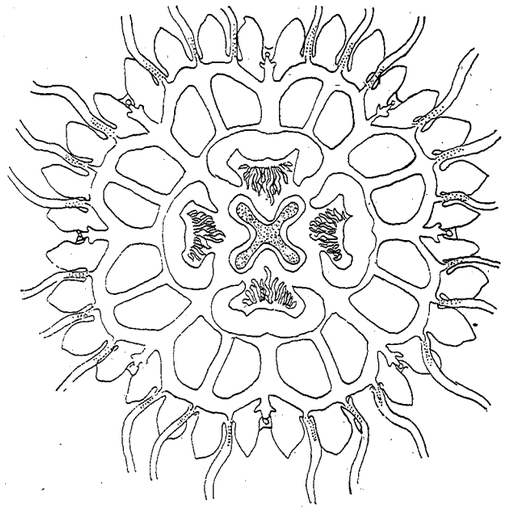


FIG. 386.—"*Floresca parthenia.*"

After Haeckel, in Das Syst. der Medusen.

Genus DISCOMEDUSA Claus, 1877.

Discomedusa, CLAUS, 1877, Denkschrift, Wien. Acad., Bd. 38, p. 42.
Ulmaris+Umbrosa, HAECKEL, 1880, Syst. der Medusen, p. 545.
Umbrosa, MAAS, 1908, Expédition Antarctique Française, Meduses, p. 9.

The type species is *Discomedusa lobata* Claus, 1877, of the Mediterranean. This may prove to be an arrested variety of Haeckel's *Undosa undulata* of the west coast of tropical Africa. In *Undosa*, however, there are 40 tentacles and 48 lappets, whereas in *Discomedusa* there are 24 tentacles and 32 lappets.

GENERIC CHARACTERS.

Ulmaridæ with 24 (3×8) tentacles, 32 (4×8) lappets, and 8 sense-organs. The tentacles arise from the clefts between the marginal lappets. There are 8 simple, unbranched adradial canals, 8 branched, perradial and interradial canals, and a marginal ring-canal.

Haeckel's genus *Ulmaris* is apparently only the young of *Discomedusa* in a stage wherein there are only 8 tentacles and 16 lappets. His genus *Undosa* bears the same relation to *Discomedusa* that *Dactylometra* does to *Chrysaora*, the tentacles and lappets having increased from

24 and 32 to 40 and 48, respectively. Thus *Discomedusa* is a growth-stage in the development of *Undosa*. The medusa of Trieste, Adriatic, appears to become mature, however, with only 24 tentacles, and it is interesting to observe that under unfavorable conditions in brackish water *Dactylometra* also becomes mature with 24 instead of 40 tentacles.

Discomedusa lobata Claus.

(?) *Medusa stelligera* EHRENBERG, 1835, Abhandl. Acad. Berlin, p. 260.—1836, Akalephen des Rothen Meeres, p. 82.
Discomedusa lobata, CLAUS, 1877, Denkschr. Wien. Acad., Bd. 38, p. 42, taf. 8, 9.—GRAEFFE, 1884, Arbeit. Zool. Inst. Wien., Bd. 5, p. 343.
Umbrosa lobata, HAECKEL, 1880, Syst. der Medusen, p. 546.
Ulmaris prototypus (? young medusa), HAECKEL, 1880, *loc. cit.*, p. 545, taf. 33, fign. 1–4.

Bell shield-shaped, flatter than a hemisphere, 150 mm. wide, 40 mm. high. The 16 ocular lappets are as wide as, but somewhat longer than, the 16 tentacular lappets. There are 24 tentacles, and 8 adradial ones are about as long as bell-diameter and twice as long and thick as the 16 secondary tentacles. The 4 mouth-arms are wide, tapering, somewhat longer than bell-radius and with curtain-like, folded margins provided with numerous tentaculæ. Mouth cruciform. Genital radius somewhat wider than half the bell-radius. The 4 crescentic gonads are convex outwardly and their ends nearly touch in the 4 perradii. Centripetal to these gonads are 4 lines of long, numerous, gastric cirri, one row for each gonad.

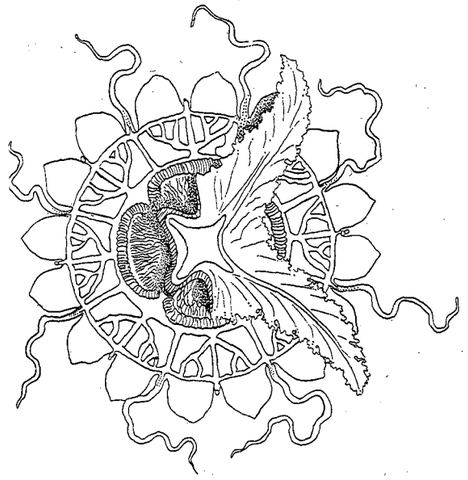


FIG. 387.—"*Ulmaris prototypus*," after Haeckel, in Das Syst. der Medusen.

The central stomach gives rise to 8 unbranched, adradial canals and to 8 perradial and interradial vessels, each of which gives rise to a pair of branched and anastomosing side-branches, the terminal ramifications of which fuse with the adradial canals and with the marginal ring-canal.

This medusa is found at Trieste, Adriatic Sea, from December to March, the young being common in January and the adult in February and March. Claus gives the best description of it. It may be identical with the imperfectly described *Medusa stelligera* Ehrenberg, from the harbor of Alexandria, Egypt, in October. Ehrenberg's medusa, however, appears to have about 40 short tentacles, all of equal length, and may therefore belong to Haeckel's genus *Undosa*.

The young medusa of *Discomedusa lobata* passes through a stage wherein there are only 16 lappets and 8 adradial tentacles. The 8 adradial canals are simple and the 8 perradial and interradial ones branched.

Discomedusa philippina, sp. nov.

This form is allied to *D. lobata* of the Mediterranean, but it appears to be smaller and to differ in the bluntness of its lappets, in having no fusions between the adradial and perradial and interradial canals, and above all by the blind branches on the outer side of the ring-canal.

Bell 29 mm. wide, flatter than a hemisphere, evenly rounded, exumbrella thickly besprinkled with prominent wart-like projections. Gelatinous substance fairly thick at center, thin at bell-margin. 8 rhopalia. 32 oval lappets all similar each to each, thus differing from *D. lobata*. 24 tentacles, the 8 adradial being longer and stouter than the 16 intermediate tentacles. The tentacles were all broken off in the specimens obtained by the *Albatross* so that their lengths could not be determined. 4 simple, crenulated lips at the end of a 4-cornered

manubrium about as long as the bell-radius. 4 interradial, crescentic gonads with their convexities outward and with a single row of simple unbranched gastric cirri along their inner sides. These gonads are about 5 times as wide as the perradial interspaces between them. Central stomach 15 mm. wide. 8 simple, unbranched, adradial canals arise from central stomach and proceed straight outward to ring-canal. Trident-like, pitch-fork-shaped, anastomosing canals arise from the 8 (perradial and interradial) sides of the stomach and break up into a network of vessels which fuse with the ring-canal. These networks, however, do not fuse with the 8 adradial canals, in this differing from *D. lobata*. On its outer side the ring-canal gives rise to 64 simple, unbranched, blindly-ending diverticula; a pair in each lappet. In formalin the gelatinous substance is transparent and the entodermal canal-system dull milky. The gonads appear to be mature, but the preservation is such that I can not be

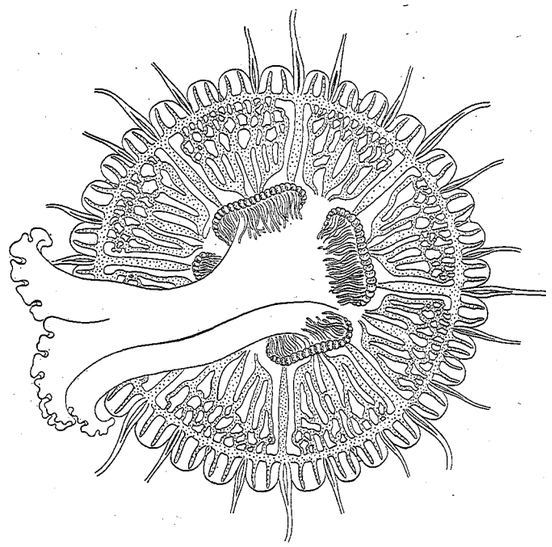


FIG. 388.—*Discomedusa philippina*, sp. nov. Drawn by the author, from specimens obtained by the U. S. Fisheries Bureau steamer *Albatross* in Catingan Bay, Philippine Islands, April 20, 1908.

certain that this is the case. Six specimens were found by the U. S. Fisheries Bureau steamer *Albatross*, in Catingan Bay, Philippine Islands, on April 20, 1908. This medusa may possibly be the young of *Parumbrosa polylobata* (see Appendix) but the large size of its gonads and complexly branched canals renders this improbable.

Genus UNDOSA Haeckel, 1880.

Undosa, HAECKEL, 1880, Syst. der Medusen, p. 546.—MAAS, 1908, Expédition Antarctique Française, Meduses, p. 9.
Ulmaris (young medusa), *loc. cit.*, p. 545.

The type species is *Undosa undulata* Haeckel, of the tropical Atlantic coast of Africa. It is possible that Ehrenberg's *Medusa stelligera* of the Mediterranean may be identical with this species, but it is so imperfectly described that it is unrecognizable.

GENERIC CHARACTERS.

Ulmaridæ with 8 sense-organs, 48 (8×6) marginal lappets, and 40 (5×8) tentacles which arise from the clefts between the lappets. 4 interradial protrusive gonads without subgenital ostia. 8 simple adradial canals, 8 branched perradial and interradial canals, and a ring-canal.

The genus is derived from *Discomedusa* through the multiplication of lappets and tentacles. During the growth of the medusæ they pass through a "*Discomedusa*" stage.

Undosa undulata Haeckel.

Undosa undulata, HAECKEL, 1880, Syst. der Medusen, p. 546, taf. 33, fign. 5, 6.

Bell 120 mm. wide, 40 mm. high, flatly rounded. A brown, 16-rayed, star-like figure on exumbrella composed of pigmented nettling ridges. 48 (6×8) sharp-pointed, oval lappets, somewhat longer than wide and projecting prominently; the 16 ocular lappets are somewhat longer than the others. Of the 40 tentacles, the 8 adradial are 2 to 3 times as long as bell-radius, twice as long as the 16 secondary, and 3 times as long as the 16 tertiary tentacles. All tentacles are hollow. The 4 mouth-arms resemble those of *Aurellia aurita*, but their margins are more curtain-like and more folded and provided with numerous tentacular filaments. The 4 gutters of the mouth-arms are very deep. The 4 folded, interradial, bag-like gonads project from the floor of the subumbrella. There are no subgenital ostia. The genital radius is about half that of the bell itself. Margin of central stomach circular. 8 simple, unbranched, adradial canals and 8 (perradial and interradial) canals, which give rise to numerous side branches which in turn anastomose, forming a network of vessels connecting all 16 canals one with another and with the marginal ring-canal.

The general color is bluish, and the star-like marking on the exumbrella dark-brown. Found at Fernando Po, coast of Guinea, Africa.

Haeckel's "*Ulmaris prototypus*" from St. Helena is probably the young of this species (*loc. cit.*, 1880, p. 545, taf. 33, fign. 1–4).

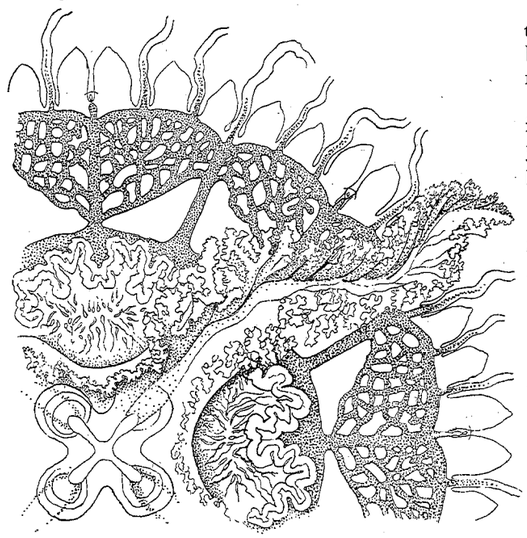


FIG. 389.—*Undosa undulata*, after Haeckel is Das Syst. der Medusen.

Genus DIPLULMARIS MAAS, 1908.

Diplulmaris, MAAS, 1908, Expédition Antarctique Française, Meduses, p. 9.
Ulmaropsis, VANHÖFFEN, 1908, Deutsche Südpolar Expedition, Bd. 10, Zool. 2, p. 45.

The type species is *Diplulmaris antarctica*, Maas, 1908, from the Antarctic Ocean.

GENERIC CHARACTERS.

Ulmaridæ with 16 tentacles, 64 marginal lappets, and 16 marginal sense-organs. 16 branched radial-canals in the radii of the sense-organs and 16 simple straight radial-canals in the tentacular radii. All 32 of the canals are joined by an anastomosing network of vessels near the bell-margin.

This medusa bears the same relation to *Undosa* that *Sanderia* does to *Dactylometra*. Indeed, there is a remarkable case of parallelism of mutation in the Pelagidæ and Ulmaridæ as is shown in the accompanying table.

	Family Pelagidæ.	Family Ulmaridæ.
8 rhopalia, 8 tentacles, 16 lappets	Pelagia	Ulmaris (immature?)
8 rhopalia, (8×3) tentacles, 32 lappets	Chrysaora	Discomedusa
8 rhopalia, (8×5) tentacles, 48 lappets	Dactylometra	Undosa
16 rhopalia, (8×2) tentacles, 64 lappets	Sanderia	Diplulmaris

Diplulmaris is a connecting link between the subfamilies *Umbrosidii*, in which the tentacles arise from clefts between the lappets, and *Sthenonidii*, in which they arise from the subumbrella floor; for in the young *Diplulmaris* the tentacles arise from the subumbrella,

but later the bell-margin becomes cleft so that the tentacles project from the clefts. *Diplulmaris* resembles the genus *Phacellophora* in having 16 rhopalia.

Vanhöffen, 1908, describes this medusa under the name *Ulmaropsis drygalskii*. Some of his specimens were more advanced than those seen by Maas, and they had 64 marginal lappets instead of only 32, as in those of Maas.

Diplulmaris antarctica Maas.

Diplulmaris antarctica, Maas, 1908, Expéd. Antarctique Française, Meduses, p. 12, 1 taf.
Ulmaropsis drygalskii, Vanhöffen, 1908, Deutsche Südpolar Expédition, 1901–03, Bd. 10, Zool. 2, p. 45, fign. 10–12.
Ulmaropsis antartica, Vanhöffen, 1909, *Ibid.*, Bd. 10, Zool. 2, p. VI.

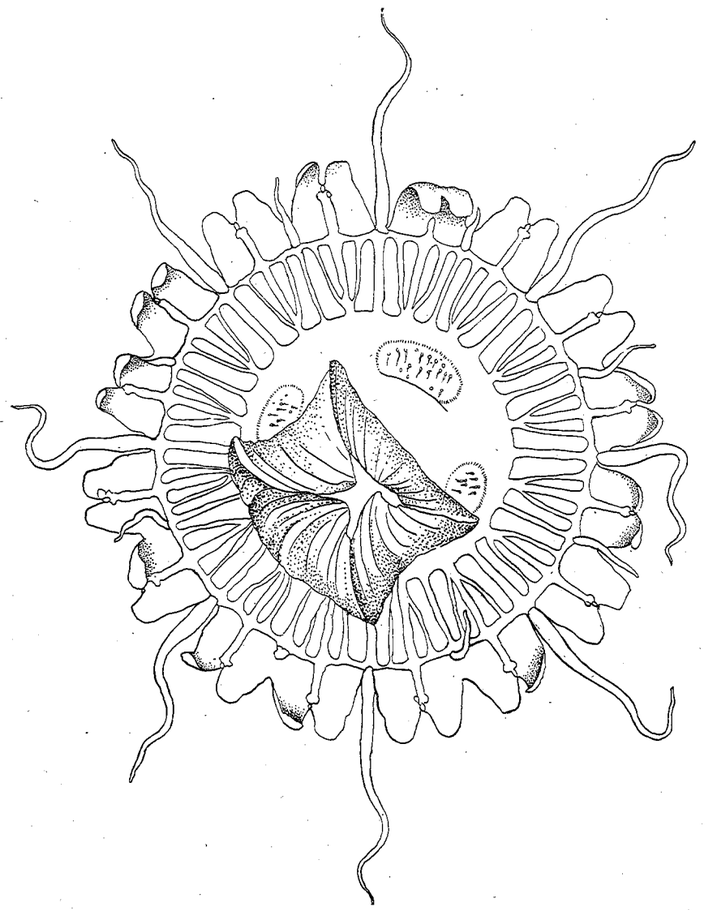


Fig. 390.—*Diplulmaris antarctica*, young medusa, after Maas, in Meduses Expédition Antarctique Française.

The largest specimen is described by Vanhöffen, whose publication appeared only a few weeks after that of Maas, and is as follows:

Bell 42 mm. wide, 16 marginal sense-organs alternating with 16 simple, hollow tentacles. The sense-organs and tentacles are flanked by 64 slender, pointed lappets, the 32 lappets flanking the sense-organs being wider and longer than those flanking the tentacles. 32 radial-canals arise from the central stomach these being in the tentacular and ocular radii. The tentacular canals are simple and unbranched, but each of the ocular canals gives off 2 pairs

of side branches and thus 96 canals radiate outward toward the margin, before reaching which they are all connected by a network of anastomosing vessels. There are 4 lips and 4 gonads. 9 ephyræ and young medusæ of this species were found by the German Antarctic Expedition between January and March. They ranged from 4 to 22 mm. in diameter. The species appears to be quite variable, for only 6 of them were 16-rayed, while the 3 others were 12, 15, and 17 rayed respectively.

Two immature specimens were studied by Maas. The bell of larger was 35 to 40 mm. wide. 16 marginal sense-organs flanked by only 32 bluntly-pointed lappets. 16 hollow, tapering tentacles, somewhat shorter than the bell-radius. These tentacles arise from the inter-rhopalar clefts between the lappets. The rhopalar clefts are only half as deep as the inter-rhopalar. Ventral stomach circular, nearly as wide as bell-radius. 16 trident-shaped radial-canals arise from the stomach-margin in the rhopalar radii and alternate with 16 straight, narrower, unforked canals in the tentacular radii. All the radial-canals give off anastomosing side branches in the outer parts of their lengths near the ring-canal. The ring-canal is at the zone of the origins of the tentacles, and 16 slightly branched radiating diverticula extend outward from it to the sense-organs. The 4 lips are bordered by curtain-like fringes. 4 interradial gonads with clusters of gastric cirri. Canal system yellowish-brown, the tentacles dull purple. The specimen was immature.

Maas also describes a smaller specimen only 15 mm. in diameter (fig. 390). This had 8 long tentacles alternating with 8 short. The short tentacles project from the floor of the subumbrella at some distance inward from the clefts between the lappets, and it appears that during growth the clefts extend inward until they meet the tentacles at the zone of the ring-canal. There are 16 simple, unbranched radial-canals in the radii of the tentacles and 16 trident-like canals in the rhopalar radii. None of these canals gives off side-branches close to the ring-canal, as in later life. 4 interradial oval gonads are now visible, and the short throat-tube expands into 4 pointed lips with folded margins. Central stomach circular, about as wide as bell-radius.

This medusa is found in the Antarctic Ocean from January to March where it lives along the edge of the Antarctic continent having been taken at Cape Adare, off Kaiser Wilhelm II Land, and at other places.

Subfamily STHENONINÆ.

SUBFAMILY CHARACTERS.

The tentacles arise in linear clusters from the floor of the subumbrella. 8 to 16 marginal sense-organs. 4 protrusive, bag-like gonads without subgenital pits. 4 unbranched mouth-arms. Some single and some branched radial-canals.

Genus STHENONIA Eschscholtz, 1829.

Sthenonia, Eschscholtz, 1829, Syst. der Acalephen, p. 59.—Haeckel, 1880, Syst. der Medusen, p. 548.—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 56.

The type species and only known form is *Sthenonia albida* of Awatscha Bay, coast of Kamtschatka.

GENERIC CHARACTERS.

Ulmaridæ with 8 rhopalia, 16 ocular lappets, 8 bifurcated velar lappets, and 8 adradial clusters of tentacles which arise from the subumbrella. 8 branched radial-canals in the rhopalar radii. Numerous simple or branched radial-canals in the radii of the velar lappets and a ring-canal. No subgenital pits.

Sthenonia albida Eschscholtz.

Sthenonia albida, Eschscholtz, 1829, Syst. der Acalephen, p. 59, taf. 4.—de Blainville, 1834, Man. d'Actinologie, p. 291, planche 36, fig. 1.—Haeckel, 1880, Syst. der Medusen, p. 548.—Vanhöffen, E., 1906, Nordisches Plankton, Nr. 11, p. 56, fig. 2.

This form has not been seen since Eschscholtz described it.

Bell about 300 mm. wide, flat, and shield-shaped. 8 marginal sense-organs. 16 ocular and 8 velar lappets with evenly rounded, reentrant markings. Each ocular lappet has a small pointed projection into which the gastrovascular system extends, and each velar lappet has

a pair of these projections. 8 adradial rows of tentacles arise from the subumbrella in the intervals between the sense-organs; these rows being somewhat shorter than the intervals between them. The 4 mouth-arms are only one-third as long as bell-radius. The central stomach is less than one-fifth as wide as the bell, and there are 4 interradial clusters of gastric cirri. 8 radial-canals, each of which gives rise to several side branches, arise from the central stomach in the radii of the sense-organs. A simple and a forked canal arise in each of the 8 radii of the velar lappets. These radial-canals anastomose to some extent and fuse with a wide ring-canal in the zone of the sense-organs. On its outer side the ring-canal

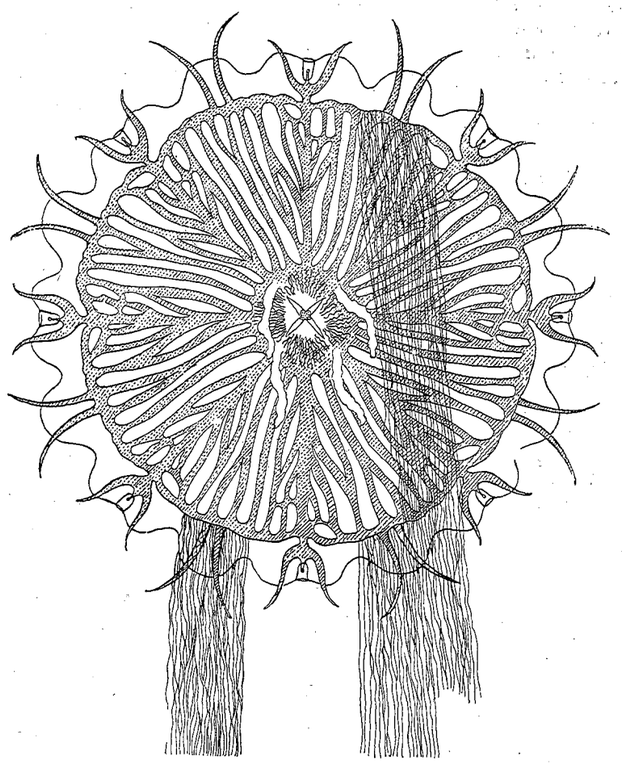


FIG. 391.—*Sthenonia albida*, according to Eschscholtz, after Vanhöffen in Nordisches Plankton.

gives off a trident-shaped vessel in each rhopalar-radius and a pair of vessels in each velar lappet-radius. Bell whitish, gonads and canals milk-white.

Found by Eschscholtz in Awatscha Bay, coast of Kamtschatka, Siberia.

Genus PHACELLOPHORA Brandt, 1835.

Phacellophora, BRANDT, 1835, Mém. Acad. Impériale des Sci. St. Pétersbourg, sér 4, tome 2, p. 224; 1838, Mém. Acad. Impériale des Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 365.—HAECKEL, 1880, Syst. der Medusen, p. 549.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 58.—BROWNE, 1908, Trans. Royal Soc. Edinburgh, vol. 46, p. 247.
Heccædecomma, BRANDT, *Ibid.*, p. 380.
Callinema, VERRILL, 1869, American Journ. Sci., ser. 2, vol. 48, p. 117; Ann. and Mag. Nat. Hist., vol. 4, p. 161.—FEWKES, 1888, Bull. Mus. Comp. Zool. at Harvard College, vol. 13, p. 235.
Phacellophora=*Heccædecomma*, MAAS, 1906, Fauna Arctica, Bd. 4, Lfg. 3, pp. 506, 512, Jena.

The type species is *P. camtschatica*, described by Brandt, 1838, from the North Pacific.

GENERIC CHARACTERS.

Ulmaridæ with 16 marginal sense-organs and numerous marginal lappets. The tentacles arise in 16 simple, linear clusters from the floor of the subumbrella, centripetal to the margin. Central mouth surrounded by 4 mouth-arms bearing curtain-like lips. Gonads are 4 complexly folded sacs which project outward in the 4 interradii from the floor of the subumbrella. No subgenital pits. The central stomach gives rise to numerous radiating canals, some of which anastomose. There is a ring-canal at the bases of the marginal lappets. Tentacles hollow.

Synopsis of the Species of Phacellophora.

Name.	P. camtschatica.	P. sicula.*	P. ambigua.†	P. ornata.†
Diameter of disk in mm.	500 to 600	155	150 to 200	350
Shape and number of marginal lappets.	16 trident-shaped lappets in rhopalar radii. 7 small lappets in each of 16 semicircular, velar lobes.	32 narrow, rounded rhopalar lappets. 16 simple velar lobes.	(4×16) 64 lappets, all similar each to each, and evenly rounded.	(4×16) to (6×16) lappets all similar each to each and evenly rounded.
Shape of mouth-arms.	Long, narrow, resembling those of Aurelia.	As in P. ambigua.	Wide, curtain-like, and resembling those of Cyanea.	As in P. ambigua.
Number of radial-canals.	16 branched rhopalar canals, and 5×16 simple unbranched radial-canals.	As in P. ambigua.	16 branched, rhopalar and 3 to 5×16 simple, unbranched canals.	16 branched rhopalar and (2×16) to (5×16) simple canals.
Number of tentacles in each cluster.	20 to 24	9 to 15	9	5 to 9
Where found.	North Pacific, Siberia to California.	Mediterranean, Naples, Messina, and off the coast of Japan.	Pacific coast of North America, Washington.	North Atlantic, northern coast of Maine. Montevideo, South America.

*Intermediate in character between *P. camtschatica* and *P. ornata*.
†Closely allied, probably identical.

Phacellophora camtschatica Brandt.

Phacellophora camtschatica, BRANDT, 1838, Mém. Acad. Sci. St. Pétersbourg, tome 4, Sci. Nat., sér. 6, p. 366, taf. 8.—AGASSIZ, A., 1865, North Amer. Acal., p. 44.—HAECKEL, 1880, Syst. der Medusen, p. 549.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 58, fig. 23.

Bell flat, 500 to 600 mm. wide. 16 marginal sense-organs each beneath a large, projecting, covering scale, which is flanked by 2 narrow, rhopalar lappets, each about half as wide as the covering-scale itself. 16 wide, nearly semicircular, velar lappets, each cleft into 7 marginal lappets. 16 crescent-shaped linear clusters of tentacles arise from subumbrella floor of velar lappets; the convexities of these crescents are inward and their horns outward, and each consists of 20 to 24 tentacles. Tentacles about as long as bell-radius. The 4 mouth-arms are wide, tapering, and thick, and about 1.5 times as long as bell-radius; their lips are folded in a curtain-like manner. There are 4 interradial, sac-like gonads with narrow, perradial interspaces between them. The central stomach gives rise to 16 rhopalar canals which send out lateral branches, and also to 80 (5×16) simple unbranched velar canals. There is a ring-canal at the zone of the tentacles, on the outer margin of which there arise 7 blindly ending, simple diverticula in each velar lappet and a trident-shaped branch in the radius of each sense-organ.

Bell colorless to bluish, gonads reddish-brown, canals yellow, tentacles light-violet.

This medusa ranges along the shores of the North Pacific from Kamtschatka to San Francisco, California. It has not been figured since Mertens studied it.

Phacellophora sicula Haeckel.

Phacellophora camtschatica, HERTWIG, O. UND R., 1878, Nervensyst. und Sinnesorgane Medusen, pp. 113, 114, taf. 9, fig. 15; taf. 10, fig. 16.—HAECKEL, 1880, Syst. der Medusen, p. 551.
Phacellophora ambigua, KISHINOUYE, 1910, Journal College of Sci. Tokyo, vol. 27, art. 9, p. 21, 1 fig.

The brothers Hertwig describe the marginal sense-organs of this exceedingly rare medusa and give a very diagrammatic figure of a part of the bell-margin. They were appar-

ently under the impression that it was identical with *P. ornata* Brandt, from the Pacific, but Haeckel rightly distinguished it as a distinct species.

The following description is based upon my study of a single good specimen of this medusa collected by Dr. S. Lobianco at Naples, Italy, on January 11, 1901, and now preserved in formalin at the Naples Zoological Station.

Disk 155 mm. in diameter, flatter than a hemisphere, being only 55 mm. high. Exumbrella surface finely granular, being covered with small, thickly clustered nematocyst-warts. 16 marginal sense-organs, 4 perradial, 4 interradial, and 8 adradial. Sense-organs set at bottom of deep, narrow clefts in bell-margin. The sense-club has no ocellus, merely a terminal mass of entodermal concretions. No sensory pit in exumbrella above the sense-club. 32 narrow, rhopalar lappets are separated by shallow clefts from the 16 wide, velar, simple lappets.

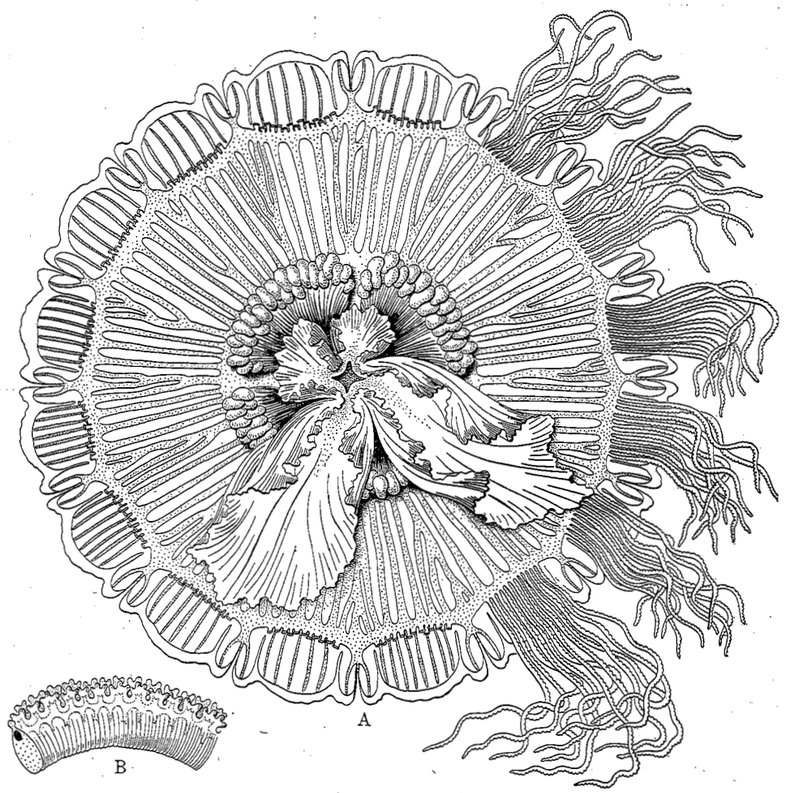


FIG. 392.—*Phacellophora sicula*, drawn by the author, from a specimen found at Naples by Dr. S. Lobianco, January 11, 1901. B, enlarged view of part of one of the tentacles.

The tentacles are arranged in 16 clusters and arise in a single row from the inwardly-arched outer margin of the ring-canal, on the subumbrella side of the 16 velar lappets. Each cluster consists of about 9 to 15 tentacles. In the Naples specimen these tentacles are about half (75 mm.) as long as diameter of disk and are set inward at a maximum distance of 17.5 mm. from the bell-margin. A narrow canal extends throughout the length of each tentacle on the inner (centripetal) side to its tip. A double row of mammiform, nematocyst-bearing papillæ extends along the inner side of each tentacle close to the tentacular canal, which sends off lateral diverticula into the papillæ. The outer (centrifugal) side of each tentacle is provided with circular muscle-fibers, which are interrupted along the line of the papillæ.

The genital cross is about one-third (55 mm.) as wide as the bell itself. The 4 extruded, pouch-like gonads with their swollen, folded, wart-like genital-sacs resemble those of *Cyanea*. The 4 gonads are separated by very narrow intervals in the 4 perradii. The 4 wide, curtain-like lips also resemble those of *Cyanea* and are not quite as long as the radius of the bell. The central stomach gives rise to 16 rhopalar radial vessels which fork outwardly; and also to 48 (3×16) inter-rhopalar radial-canals which are simple and do not fork. Lateral anastomoses between these radial-canals are very rare. Ring-canal very well developed, about 3 mm. wide, while the radial-canals are each about 2.5 mm. wide, being about as wide as the spaces between them. The ring-canal gives rise to from 5 to 8 straight, simple, blindly-ending, centrifugal vessels in each velar lappet.

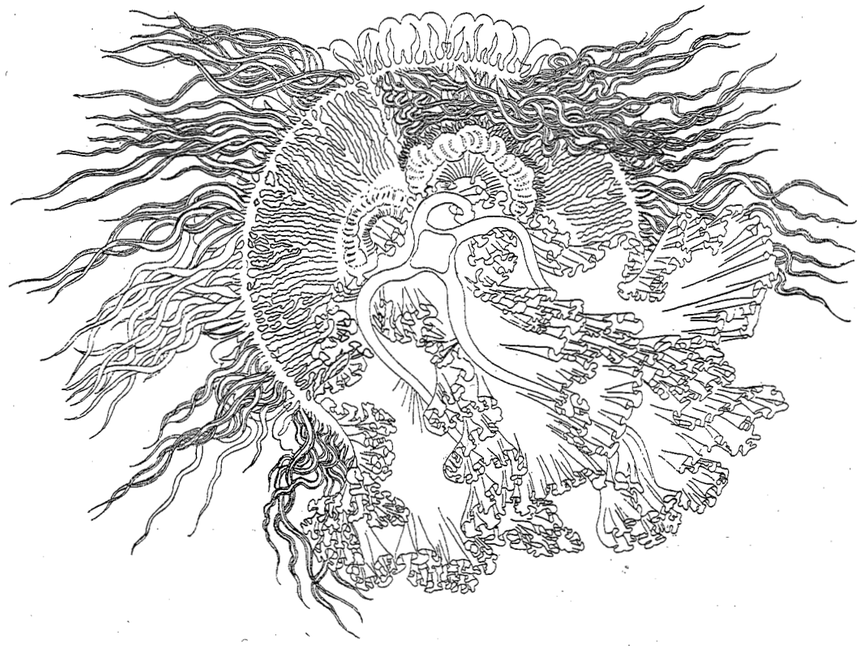


FIG. 393.—*Phacellophora ambigua*, according to Brandt, after Vanhöffen, in Nordisches Plankton.

In formalin the exumbrella is yellowish-milky in color, the canal-system milky and translucent, the gonads dull orange to ocher, and the lips of a lighter hue of the same color.

Found at Naples and Messina, Mediterranean, and off the coast of Japan (Kishinouye).

This species is closely related to *P. ambigua*, but is distinguished by having only 16 wide, simple, velar lappets instead of 32 narrow ones, as in *P. ambigua*. *P. sicula* is probably only an arrested variety of *P. ambigua* in which the velar lobes remain entire and uncleft.

Phacellophora ambigua Haeckel.

Haccædecomma ambiguum, BRANDT, 1838, Mém. Acad. Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 380, taf. 27, 28.—AGASSIZ, A., 1865, North Amer. Acal., p. 43.
Phacellophora ambigua, HAECKEL, 1880, Syst. der Medusen, p. 550.—VANHÖFFEN, 1906, Nordisches Plankton, Nr. 11, p. 58, fig. 24.

Bell flatter than a hemisphere, 150 to 200 mm. wide. There are 64 (4×16) evenly rounded, marginal lappets all similar each to each. The sense-organs are sunken within deep, narrow clefts. Mouth-arms broad, curtain-like, similiar to those of *Cyanea* instead of being *Aurellia*-like, as in *P. camtschatica*. About 9 tentacles in each of the 16 linear clusters. The 16 rhopalar canals are forked and between them are 48 (3×16) simple, unbranched, radial

vessels. The ring-canal gives rise centripetally to a short diverticulum in the radius of each sense-organ and to 8×16 inter-rhopalar diverticula. The gonads are 4 interradial, sac-like, protruding pouches separated by narrow intervals in the perradii.

This species is closely related to *P. sicula* of the Mediterranean and Pacific, but is distinguished by having 32 instead of 16 velar lappets. It is found along the Pacific coast of North America, Port Townsend and Straits of Fuca, Washington.

Phacellophora ornata Haeckel.

Callinema ornata, Verrill, 1869, American Journ. Sci., ser. 2, vol. 48, p. 117; Ann. and Mag. Nat. Hist., vol. 4, p. 161.—Fewkes, 1888, Bull. Mus. Comp. Zool. at Harvard College, vol. 13, No. 7, p. 235, plate 6, 4 figs.; 1888, Report U. S. Expedition to Lady Franklin Bay, vol. 2, p. 40.
Phacellophora ornata, Haeckel, 1880, Syst. der Medusen, p. 643.—Hargitt, 1904, Bull. U. S. Bureau of Fisheries, vol. 24, p. 68.—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 59, fign. 25–26.—Browne, 1908, Trans. Royal Soc. Edinburgh, vol. 46, p. 247, plate 2, figs. 3, 4.

Disk quite flat, with a slight dome-shaped aboral apex; it is about 350 mm. in diameter, and the marginal lappets droop vertically. The surface of the exumbrella is covered with small nematocyst-warts. Gelatinous substance of disk quite thick and rigid. 16 marginal sense-organs are set within niches between the 32 ocular lappets. Ocular lappets about twice as long as velar ones, but not so numerous, there being 2 to 4 velar between each successive pair of ocular lappets. The clefts separating the ocular lappets are deeper and more distinct than those separating the velar lappets. Over 100 long tentacles arise from the floor of the subumbrella in a broken circle in 16 inter-rhopalar clusters at a short distance inward from the bases of the marginal lappets. The 5 to 9 tentacles between each successive pair of sense-organs vary considerably in size, the longest being about equal to bell-diameter; they are hollow and flat, and there is a wavy double thickening along the centripetal narrow edge, which is covered with nematocysts. Mouth simple and 4-cornered, situated at center of subumbrella. The 4 mouth-arms are each about as long as bell-diameter, their free edges much folded. They are highly flexible and contractile. The gonads are found in 4 interradial, crumpled sacs which project outward from the floor of the subumbrella at the sides of the mouth. Central stomach 4-lobed, being extended outward in the radii of the 4 genital organs, very much as is the case in *Aurellia*. A large number of radiating canals run outward from the periphery of the central stomach to the circular canal, which lies at a considerable distance inward from bell-margin. The radiating canals in the radii of the sense-organs branch and anastomose, while those in the tentacular radii are simple and slender. There are about 2 to 5 of these simple canals between each successive pair of anastomosing canals. Circular canal broad, somewhat sinuous, and it lies under the insertions of the ring of tentacles. Outwardly it gives rise to a blind canal

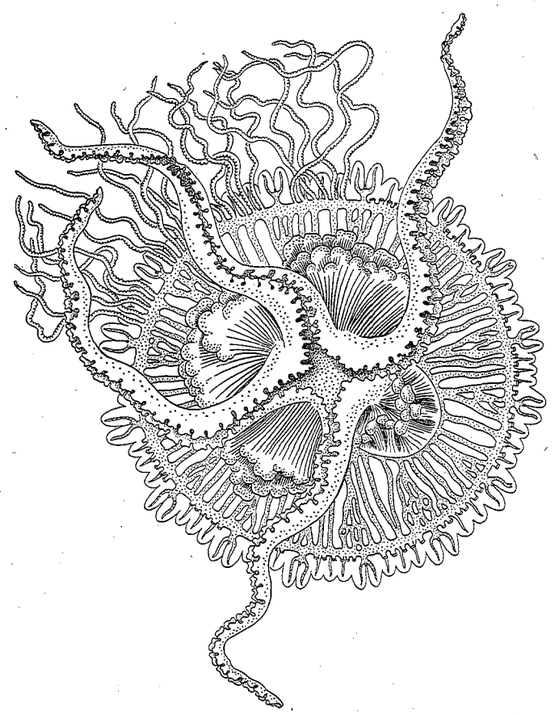


Fig. 394.—*Phacellophora ornata.*

in each velar lappet and a trident-shaped canal to each sense-organ and its adjacent lappets. Usually the outer ends of these blind canals are simple, but occasionally they bifurcate (fig. 395).

Disk transparent, the radiating and circular canals slightly brown in color. Sense-organs glistening white. Nematocyst-bearing edges of tentacles white. Central stomach orange-yellow, the mouth-arms citron-yellow, the gonads yellowish-brown.

This species is found at Eastport, Maine, and in the Bay of Fundy. It is very rare, and has been taken there only by Verrill and Fewkes. In 1908 Browne describes a closely allied or identical species from the South Atlantic about 200 miles east of Montevideo, South America.

I am gratefully indebted to Professor Verrill for permitting me to make drawings (figs. 394, 395) of the type specimen preserved in the Peabody Museum at Yale University.

This species is closely related to *P. ambigua*, but is distinguished by its greater number of velar lappets and radial-canals. The velar lappets are also shorter than in *P. ambigua*.

Genus PORALIA Vanhöffen, 1902.

Poralia, Vanhöffen, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 40.—Bigelow, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 45, plate 13, figs. 1–5.

GENERIC CHARACTERS.

Ulmaridæ closely related to *Phacellophora*. With numerous simple radial-canals, and a ring-canal, which on its outer side gives rise to blindly-ending vessels. The gonads form a ring

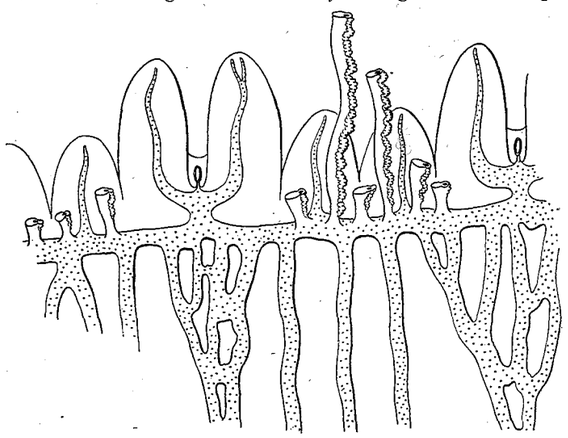


Fig. 395.—*Phacellophora ornata.* Portion of bell-rim.

of outpocketings in the lateral wall of the stomach extending entirely around the base of the stomach, but interrupted at frequent intervals by vertical thickenings of the stomach wall. Tentacles (?) There are no subgenital pits in the floor of the subumbrella. The mouth parts are imperfectly preserved but appear to resemble those of *Cyanea* or *Phacellophora*.

This genus was founded by Vanhöffen, but his single specimen was imperfect and immature, and our knowledge of it is chiefly due to the studies of Bigelow upon the more perfect specimens found by the *Albatross* in the eastern part of the tropical Pacific.

The type species is *Poralia rufescens* Vanhöffen, from the Indian Ocean and tropical Pacific.

Poralia rufescens Vanhöffen.

Poralia rufescens, Vanhöffen, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 41, taf. 4, fign. 15–16; 1908, Deutsche Südpolar Expedition, Bd. 10, Zool. 2, p. 47.—Bigelow, H. B., 1909, Mem. Museum Comp. Zool. at Harvard College, vol. 37, p. 45, plate 13.

In Bigelow's largest specimen the bell was 250 mm. in diameter. There were apparently 16 rhopalia, although some of these were destroyed so that the exact number was not determined with certainty. The rhopalia resemble those of *Phacellophora* and are set within deep

niches. The sense-club is covered by a prominent scale, beneath which it stands in an almost vertical position. There is a deep exumbrella sensory-pit above each sense-club. There appear to be no distinct velar lappets, the bell-margins being only slightly wavy, excepting for the deep, rhopalar clefts. In Bigelow's large medusa 41 radial-canals arise from the periphery of the circular central stomach, but two of these anastomose so that only 40 extend to the ring-canal centripetal to the zone of the rhopalia. The ring-canal gives rise to a trident-shaped diverticulum in the radius of each sense-club and to one or two simple, blindly-ending diverticula in the inter-rhopalar spaces. The canal-system, like the rhopalia, bears a striking resemblance to *Phacellophora*. The mouth parts appear also to be similar to those of *Phacellophora* but are not well preserved in any specimen yet captured. The gonads form a nearly continuous ring around the periphery of the subumbrella floor of the stomach. This ring is not truly con-

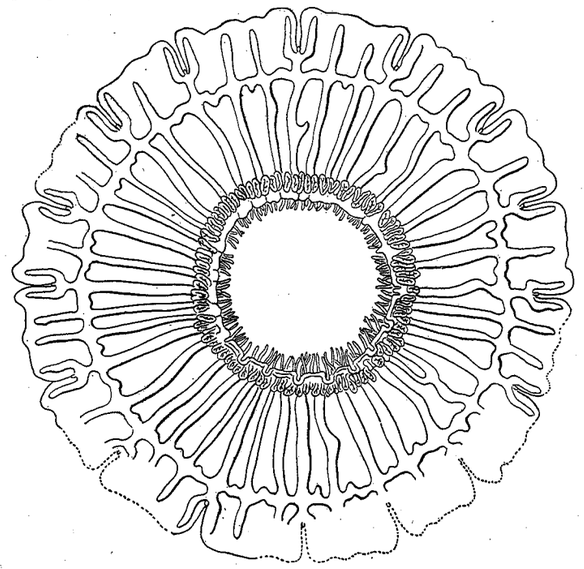


FIG. 396.—*Poralia rufescens*, after H. B. Bigelow, in Mem. Mus. Comp. Zool. at Harvard College.

tinuous, however, but is interrupted by 18 or 19 thickened, vertical ridges in the stomach-wall. The gonads themselves thus consist of 18 or 19 outpocketings of the stomach-wall projecting outward. The numerous, simple, gastric cirri are arranged in a single line arising from the stomach-wall on the inner side of the genital organs. The subumbrella is reddish-brown, the gonads being paler. The tentacles were lost in all of the specimens so that we know nothing of them.

Vanhöffen's specimen came from a depth of about 350 fathoms between Queen Emma Harbor and Siberut Island, Indian Ocean, and the two described by Bigelow were found by the *Albatross* in the eastern part of the tropical Pacific.

The radial-canals in this medusa appear to increase in number with growth, for Vanhöffen's specimen which was only about 60 mm. wide had 21 canals, while Bigelow's 250 mm. wide specimen had 41. Vanhöffen's medusa had 7 or 8 (?) gonads, and both he and Bigelow believe that the young medusa is probably octoradial.

Subfamily AURELINÆ L. Agassiz, 1862.

The numerous tentacles and lappets arise from the sides of the exumbrella above the margin. Gonads are invaginated sacs with external subgenital cavities. 4 simple or bifurcated mouth-arms.

Genus AURELLIA Péron and Lesueur, 1809.

(?) *Evagora*, PÉRON ET LESUEUR, 1809, Ann. du Mus. Hist. Nat., Paris, tome 14, p. 343.
Aurellia, *Ibid.*, p. 357.
Ocyroë, *Ibid.*, p. 355.
Orythia, LAMARCK, 1816, Hist. Anim. sans. Vert., tome 2, p. 502. *Aurelia*, *Ibid. p.* 512.
Medusa, ESCHSCHOLTZ, 1829, Syst. der Acalephen, p. 61.
Monocraspedon+*Diplocraspedon*, BRANDT, 1838, Mém. Acad. Impèriale des Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, pp. 370, 372.
Biblis, LESSON, 1843, Hist. Nat. des Zoophytes, p. 339.
Claustra, *Ibid.*, p. 378.
Aurelia, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 11, 72, 78, 159.—AGASSIZ, A., 1865, North Amer. Acal., p. 41.—CLAUS, 1877, Denks. Akad. Math. Naturwiss., Wien., Bd. 38, p. 19.—HAECKEL, 1880, Syst. der Medusen, pp. 551, 644; 1881, Metagenesis und Hypogenesis von *Aurelia aurita*, Jena, 36 pp., 2 taf.
Aurelia, VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 279.—GOETTE, A., 1887, Abhandl. zur Entwickelungsgesch. Thiere, Heft 4, Leipzig (embryology).—AGASSIZ AND MAYER, 1899, Bull. Mus. Comp. Zool. at Harvard College, vol. 32, p. 171.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft 3, p. 23.—BATESON, 1895, Materials for the Study of Variation, p. 428 (variations).—BROWNE, 1894, Quart. Journ. Micros. Sci., vol. 37, p. 245.—HYDE, 1894, Zeit. für wissen. Zool., Bd. 58, p. 535.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft 3, p. 19; 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 41; 1906, Nordisches Plankton, Nr. 11, p. 60.—MAAS, 1906, Fauna Arctica, Bd. 4, Lfg. 3, p. 507 (discussion of literature); 1903, Scyphomedusen der *Sibega* Expedition, Monog 11, p. 26.—FRIEDMANN, 1902, Zeit. für wissen. Zool., Bd. 71, p. 227.—HARGITT, 1905, Journ. Exper. Zool., vol. 2, p. 548.
Auricoma, HAECKEL, 1880, *loc. cit.*, pp. 633, 644 (an abnormal *Aurellia* with 16 sense-organs).

GENERIC CHARACTERS.

Ulmaridæ with a simple, central mouth-opening which is surrounded by 4 well-developed, radially situated, unbranched mouth-arms or palps. 8 marginal sense-organs. The tentacles are small and alternate with an equal number of short lappets. Both tentacles and lappets arise from the sides of the exumbrella a short distance above bell-margin. The bell-margin is divided into 8 or 16 broad, velar lobes. The central stomach gives rise to a number of branched, radiating canals which anastomose and are connected by a marginal ring-canal. There are 4 interradial gonads and 4 well-developed, subgenital pits.

The name "*Evagora*" which takes precedence over "*Aurellia*" was applied to Forskål's *medusa persea* which is wholly unrecognizable, as is also "*Ocyroë*," and these names must therefore yield to "*Aurellia*," which was first proposed by Péron and Lesueur for *Aurellia aurita* of Europe. They spell the generic name *Aurellia*.

The species of this genus are among the most widely distributed of Scyphomedusæ, being found in all oceans and all latitudes. They are most abundant along the shores of continents and large islands and are comparatively rare in the open ocean far from land. It is possible that the fossil *Medusina costata* from the lower Cambrian of Sweden is an *Aurellia*.

Although fully a dozen species of *Aurellia* have been described I believe that there are but 3 reasonably well-defined types. Of these *A. aurita* is of world-wide distribution. *A. labiata* is found in the Pacific, and a third fairly well-defined species is *A. maldivensis*, described by H. B. Bigelow from the atolls of the Maldive Islands in the Indian Ocean. The distinctions between many of the "species" are not well ascertained, and there are numerous varieties or local races. *A. aurita* is subject to great individual variation and some of these chance variations have been described as species.

The species of *Aurellia* display much individual variability, and studies upon this subject have been carried out by Ehrenberg (1835), Romanes (1876–77), Browne (1894–95), Duncker, Sorby, Herdman, Unthank (1894), Ballowitz (1898), and Hargitt (1905). Good reviews of the results of the earlier of these investigations are given by Bateson, 1895 (Materials for the Study of Variations, p. 426), and by Agassiz and Woodworth, 1896 (Bull. Mus. Comp. Zool. at Harvard College, vol. 30, No. 2). The abnormal individuals of *Aurellia aurita* are peculiar in that they generally preserve the radial symmetry of the disk, even though the number of segments be changed. Radially symmetrical abnormalities appear to be about twice as numerous as are irregular ones. This law applies also to the variations of the Leptomedusa *Pseudoclytia pentata* (see vol. II, p. 278).

Browne, 1894 and 1895, discovered that congenitally abnormal ephyræ of *Aurellia* survived fully as well as normal ones, and also that the abnormal ephyræ were no more abundant in 1892 than they were when Ehrenberg studied them at the same place in 1834. Evidently the abnormal individuals do not acquire any fixed tendency to perpetuate their own peculiarities

rather than those of their normal parents, and thus the race as a whole maintains itself unchanged. About 22 per cent of the ephyræ and of adult *Aurellia* have either more or less than 8 marginal sense-organs.

Most interesting physiological studies have been carried out upon *Aurellia* by Romanes, 1885 (International Scientific Series, vol. 49, etc.), and also by Eimer, 1878. These studies show that the marginal sense-organs of *Aurellia* are locomotor centers which control the rhythmical pulsation. These marginal sense-organs tend to send out impulses to pulsation at various rates, but the fastest working sense-organ controls all the others and forces them to beat at its own rate. Parts of the subumbrella deprived of marginal sense-organs will still

Synopsis of the Races or Species of Aurellia.

	Aurellia aurita and its varieties.				
	A. aurita Péron et Lesueur.	A. cruciata Haeckel. (This is only a variety of A. aurita.)	A. colpota Brandt =A. coerulea von Lendenfeld.	A. flavidula Péron et Lesueur (this is only a variety of A. aurita)=A. habanensis Mayer.	A. hyalina Brandt.
Shape of umbrella.	Flatly rounded to hemispherical.	Flatly rounded to hemispherical.	Flatly rounded to hemispherical.	Flatter than a hemisphere.	Flatter than a hemisphere.
Width in mm.	50 to 400	50 to 400	100 to 120	140 to 250	60 to 80
Height in mm.	20 to 125	20 to 125	40 to 50	50 to 90	20 to 30
Form of margin of umbrella.	The 8 marginal sense-organs set in shallow clefts, 8 simple entire, velar lobes.	Sense-organs set in deep clefts.	Sense-organs set in shallow clefts.	Sense-organs set in clefts which may either be deep or shallow, being very variable.	Sense-organs set in wide, deep clefts.
Number of velar lobes.	8 simple.	8 simple.	8 slightly notched in middle.	8 simple.	8 simple.
Form of mouth-arms.	Small, lancet-shaped, with complexly folded margins, but without lateral lappets.	Small, lancet-shaped, with complexly folded margins, but without lateral lappets.	Large, complexly folded, with lateral lappets. Very wide at their bases.	Thick, lancet-shaped, with complexly folded edges.	Similar to A. aurita.
Length of mouth-arms in terms of radius of umbrella (r).	$r-$	Only a little longer than $0.5r$.	$r+$	$r+$	$r+$
Length of genital-radius in terms of radius of umbrella.	One-third r.	Half r.	Half r.	One-third to half r.	One-third to one-fourth r.
Number of primary branches arising from each interradial genital sinus.	5 to 7, quite wide.	5 to 7	5	7	5
Character of adradial canals.	Simple, unbranched.	Simple, unbranched.	Anastomosing with other canals, or simple and unbranched.	Simple, unbranched.	All canals branched.
Color.	Very variable. Milky to light-violet, rose-red, or almost colorless.	Very variable. Milky to light-violet rose-red, or almost colorless.	Light rose-red tentacles and gonads deeper in color.	Variable as in A. aurita.	Variable. Transparent to reddish.
Where found.	Atlantic coast of Europe and in Mediterranean. Vast swarms.	Atlantic coast of Spain and Mediterranean.	Indian Ocean to Pacific.	Atlantic coast of North America, Greenland to Florida and West Indies.	North Pacific.
Remarks.	Development through alternations by strobilization.			Development as in A. aurita.	

respond momentarily by contractions to all sorts of stimuli, electrical, chemical, thermal, or mechanical. Small parts of the disk with sense-organs attached pulsate somewhat more slowly than large ones. Romanes succeeded in maintaining the rhythmical movement of the medusa in parts of the disk without marginal sense-organs by stimulating weakly with a constant or alternating current of electricity.

Romanes also found that a stimulus too weak to cause a response would if repeated eventually give rise to a contraction. This phenomenon is known as the summation of stimuli, and it is interesting to see that Lee and Morse, 1910 (Proc. Soc. Experimental Biology and Medicine, New York, vol. 7, p. 38), find that this effect may be due to a rise in irritability, brought about by the action on the living substance of small quantities of certain products of metabolism, especially carbon dioxide and lactic acid, the same substances which in greater concentration are important factors in fatigue.

Synopsis of the Races or Species of Aurellia—Continued.

	Aurellia aurita and its varieties.			
	A. dubia Vanhöffen.	A. vitiana Agassiz and Mayer (immature).	A. marginalis L. Agassiz. (This is only a variety of A. flavidula.)	A. solida Browne.
Shape of umbrella.	Flatter than a hemisphere.	Hemispherical.	Flatter than a hemisphere.	Hemispherical.
Width in mm.	130	80	160 to 300	80
Height in mm.	43	40	60 to 120	40
Form of margin of umbrella.	As in A. flavidula.	As in A. flavidula.	As in A. flavidula.	As in A. aurita but sense-organs are set in deep clefts and point upward toward exumbrella, not toward bell-margin. The 8 sense-clubs are thus directed 90° away from direction assumed by A. aurita.
Number of velar lobes.	8 simple.	8 simple.	8 simple.	8 simple.
Form of mouth-arms.	Mouth-arms give rise to lateral lappets.	Simple lancet-shaped.	As in A. flavidula.	Closely similar to those of A. aurita. The subgenital ostia are very small circular openings only 2 mm. wide.
Length of mouth-arms in terms of radius of umbrella (r)	Two-thirds r.	Half to two-thirds r.	$r-$	$r+$
Length of genital-radius in terms of radius of umbrella.	One-third r.	One-fourth to one-third r.	Half $r+$.	Four-fifths r.
Number of primary branches arising from each interradial genital sinus.	7	5 to 7, all very slender.	7. As in A. flavidula.	As in A. aurita.
Character of adradial canals.	All canals branched.	Simple, unbranched.	Simple, unbranched.	As in A. aurita.
Color.	?	Gonads, mouth-arms, and tentacles lilac. Other parts colorless.	Gonads often light rose-red, or blue, but colors variable as in A. flavidula.	Gonads salmon-colored, other parts translucent whitish.
Where found.	Persian Gulf.	Fiji and Tonga Islands, South Pacific.	Florida Keys, Key West, Havana to coast of Maine.	Maldive Islands, Indian Ocean.
Remarks.	Described from a single specimen.	Swarms in harbors.	(?) Development slightly different from that of A. flavidula (see Hyde 1894).	Distinguished by its peculiar sense-organs.

Krukenberg, 1880, finds that *Aurellia aurita* contains 95.34 per cent of water and only 4.66 per cent of solid matter.

The planula larva commonly develops into a scyphostoma which gives rise to a number of ephyræ through strobilization. In aquaria, however, Haeckel, 1881, finds that the planula may develop directly into a single medusa without passing through the scyphostoma-stage. In this case the ocular lobes and tentacles grow outward around the gastrula mouth, and the gelatinous substance of the planula becomes that of the medusa. In other cases the scyphostoma develops into a single medusa which remains attached by a pedicel formed of the basal part of the scyphostoma, recalling the condition observed in the Stauromedusæ.

Hérouard, 1907 (Comptes Rendus, Paris, tome 145, p. 601, *Ibid.*, 1908, tome 147, p. 1336), finds a peculiar scyphostoma in an aquarium at Roscoff, which may possibly be that of *Aurellia* affected by adverse conditions of confinement, although he calls it *Taeniolhydra roscoffensis*. It develops lateral buds, and in addition to these peculiar cysts on its pedal zone.

Synopsis of the Races or Species of Aurellia—Continued.

	Aurellia labiata and its varieties.			
	A. labiata Chamisso and Eysenhardt.*	A. "clausa" Lesson = young of A. labiata.*	A. limbata Brandt.	A. maldivensis Bigelow.*
Shape of umbrella.	Hemispherical or flatter.	Hemispherical or flatter.	Hemispherical or flatter.	Flatter than a hemisphere.
Width in mm.	200 to 300	80 to 100	200 to 300	250
Height in mm.	100 to 200	40 to 50	100 to 150	90
Form of margin of umbrella.	Margin with 16 deep clefts, 8 ocular, 8 interocular, 2 velar lobes in each octant.	Margin with 16 clefts, 2 velar lobes in each octant.	Margin with 16 deep clefts, 2 velar lobes in each octant.	16 velar lobes with very shallow interocular clefts.
Number of velar lobes.	16, two in each octant.	16, two in each octant.	16, two in each octant.	16, two in each octant. Very shallow clefts between lappets.
Form of mouth-arms.	Thick, pyramidal, short, folded when mature, but slender and simple, as in A. aurita when young.	Small, thin, folded.	Triangular.	Lips large, wide, flexible, curtain-like and folded with their free edges lined by small tentacles.
Length of mouth-arms in terms of radius of umbrella (*r*).	Two-thirds to three-fourths *r*.	?	*r*—	*r*—
Length of genital-radius in terms of radius of umbrella (*r*)	One-fourth *r*.	?	Half *r*.	One-fourth to one-third *r*—.
Number of primary branches arising from each interradial genital sinus.	As in A. aurita.	?	9	8 to 10 branched and anastomosing. Altogether about 48 canals arise from central stomach.
Character of adradial canals.	Usually simple, but may branch dendritically (without anastomosing).	?	All canals anastomose.	Simple, unbranched.
Color.	Light violet, gonads darker in color.	Ovaries, canals, tentacles rose-red to wine-red.	Umbrella bluish, tentacles and margin orange-brown. Velar lappets brownish-black.	Variable. Bell delicate lilac. Canals and tentacles violet-pink. Gonads violet or blue.
Where found.	Pacific coast of North America to Malay Archipelago.	South Pacific coast, New Ireland, Australia.	North Pacific coast of Siberia.	Maldive Islands, Indian Ocean, in January.
Remarks.		Too imperfectly known for determination. Probably identical with A. limbata or A. labiata.		This form is chiefly distinguished by its curtain-like lips recalling those of Cyanea.

*These are probably one and the same species and should be called *Aurellia labiata*

These cysts or statoblasts are formed during resting periods in about 15 days and are incased in a chitinous envelope. After one of these statoblasts is formed the scyphostoma moves a short distance and leaves it behind. The chitinous envelope may then burst and the cyst develops into a polyp with tentacles. When fed upon ovary of the sea-urchin this scyphostoma strobilated.

The early development of the planula and scyphostoma has been elaborately studied by Goette, Claus, Hyde, Smith, Friedmann, and others and the results of these researches will be reviewed under *Aurellia aurita*.

Friedmann, 1902, finds that in the scyphostoma the tentacles develop in the order of 4, 8, 16, 24; and that the 12 and 20-tentacle conditions are intermediate phases.

Aurellia aurita Lamarck.

Plate 67, fig. 4; plate 68, figs. 1 to 4.

Medusa aurita, Linné, 1746, Fauna suecica, No. 1287; 1747, Westgöta Resa, tab. 3, fig. 2; 1758, Syst. Nat., Ed. 10, tomus 1 p. 660.—Gmelin, 1788, Linne's Syst. Naturæ, tomus 1, pars 6, p. 3153.

Medusa, sp., Borlase, 1758, Nat. Hist. of Cornwall, p. 257, plate 25, figs. IX and X.

Aurelia aurita, Lamarck, 1816, Hist. Anim. sans. Vert., tome 2, p. 513.—Ehrenberg, 1834, Abhandl. Kgl. Akad. Wissen., Berlin, p. 99 (variations).—Delle Chiaje, 1841, Animali senza Vert., tome 7, Napoli, tav. 144, fig. 1; tav. 145, fig. 2.—Romanes, G. J., 1875, Nature, vol. 2, p. 29; 1876, Journal Linnean Soc.-London, Zool., vol. 12, p. 528; vol. 13, p. 190, plates 15, 16 (variations); 1885, Jellyfish, Star-fish and Sea-urchins, etc., International Scientific Series, vol. 49 (physiology of pulsation).—Haeckel, 1880, Syst. der Medusen, p. 552 (important list of literature).—Mobius, 1880, Zool. Anzeiger, Jahrg. 3, p. 67 (medusa killed by freezing).—Krukenberg, 1880, Zool. Anzeiger, Jahrg. 3, p. 306 (water content of body).—Haeckel, 1881, Metagenesis und Hypogenesis von *Aurelia aurita*, Jena, 36 pp., 2 taf; Kosmos, Bd. 5, p. 29.—M'Kendrick, 1881, Journ. Anat. and Physiol., vol. 15, p. 261 (coloring matter).—Mobius, 1882, Zool. Anzeiger, Jahrg 5, p. 586. (*Aurellia* from Kiel contains 97.92 per cent of water.)—Claus, 1883, Untersuch. über Organization und Entwicklung Medusen, Prag. Leipzig, pp. 1–23, taf. 1, fign. 1–20 (development).—Graeffe, 1884, Arbeit Zool. Inst. Wien, Bd. 5, p. 343.—Götte, 1885, Zool. Anzeiger, Jahrg. 8, p. 554 (development); 1887, Abhandl. Entwickelungsgeschichte der Thiere, Heft 4, Leipzig. (development).—Marshall, 1888, Quart. Journal Microscop. Sci., vol. 28, p. 84, (striped muscles).—Schewiakoff, 1889, Morphol., Jahrb., Bd. 15, H, 1 (structure of sense-club).—Minchin, 1889, Proc. Zool. Soc. London, p. 583, 2 plates (brood-pouches of the oral arms).—Claus, 1890, Arbeit. Zool. Inst. Wien, Bd. 9, p. 85 (development).—Götte, 1891, Claus und die Entwicklung der Scyphomedusen, Leipzig. 64 pp., 24 fign. (controversy over the manner of development).—Claus, 1892, Arbeit. Zool. Inst. Wien., Bd. 10, p. 20 (development of the scyphostoma).—Duncker, 1895, Archiv. für Naturgesch., Jahrg. 60, p. 7, plate 1 (variations).—Browne, 1894, Nature, vol. 50, p. 524 (variations).—Sorby, 1894, Nature, vol. 50, p. 476 (variations).—Herdman, 1894, Nature, vol. 50, p. 426 (variations).—Browne, 1895, Quart. Journal Microscop. Sci., vol. 37, p. 245, plate 25, figs. 1–7; 1901, Journal of Biometrica, vol. 1, p. 90, 3 diagrams (comparative variability of ephyræ and of adult medusæ).—Haacke, 1897, Zool. Garten, Jahrg. 37, p. 357.—Ballowitz, 1899, Archiv. Entwickelungsmech., Bd. 8, p. 239, taf. 5 (variations).—Hein, 1900, Zeit. für wissen. Zool., Bd. 67, p. 401, 5 text-figs., taf. 24, 25 (development).—Götte, 1900, Zool. Anzeiger, Bd. 23, p. 559 (development).—Friedmann, 1902, Zeit. für wissen. Zool., Bd. 71, p. 227, taf. 12, 13 (development of tentacles in scyphostoma).—Hein, 1902, Zool. Anzeiger., Bd. 25, p. 637 (development).—Vanhöffen, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., Dampfer *Valdivia*, Bd. 3, Lfg. 1, pp. 43, 44 (world-wide distribution of *A. aurita*); 1906, Nordisches Plankton, Nr. 11, p. 60, fign. 27–31.—Delap, 1906, Fisheries Ireland, Sci. Invert., 1905, No. 7, p. 22, 1 plate (development).—Goodey, 1909, Proc. Zool. Soc. London, part 1, p. 78, plate 24.—Hanstein, 1907, Naturgesch. des Tierreichs., p. 332, fig. 446.

Aurelia cærulea, von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 280.

Aurelia colpota, Götte, 1886, Sitzungsber. Akad. Wissen. Berlin, Jahrg. 1886, p. 836.

Aurelia aurita var. *colpota*, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 26, taf. 1, fig. 9.—Browne, 1905, Fauna and Geog. Maldive and Laccadive Archipelagoes, vol. 2, p. 959.

Aurelia japonica, Kishinouye, 1891, Zool. Magazine, Tokyo, vol. 3, No. 33, p. 289, plate 7.

Aurelia vitiana, Agassiz, A., and Mayer, 1899, Bull. Museum Comp. Zool. at Harvard College, vol. 32, p. 171, plate 10, fig. 35; 1902, Memoirs, *Ibid.*, vol. 26, p. 159.

Aurelia dubia, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 20, 24.

Aurelia cærulea, von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 280.

Aurelia cruciata, Haeckel, 1880, *loc. cit.*, p. 644.

Aurellia aurita from America.

Plate 67, fig. 4; plate 68, figs. 1 to 4.

Medusa aurita, Fabricius, 1780, Fauna Groenlandica, p. 363, Nr. 356.

Aurellia flavidula, Péron et Lesueur, 1809, Ann. du Mus. Hist. Nat. Paris, tome 14, p. 359, No. 92.

Aurelia flavidula, Lesson, 1843, Hist. Zooph. Acal., p. 376.—Agassiz, L., 1860–62, Cont. Nat. Hist. U. S., vol. 4, pp. 10, 12, 51, 160; vol. 3, plates 6–9, 11*a*, 12*b*; plate 10, figs. 18, 22, 31, 32, 36; plate 10*a*, figs. 4*b*, 13, 15*a*, 16–41; plate 11*c*, figs. 1–13 (development).—Packard, 1863, Canadian Nat. and Geol., vol. 8.—Agassiz, A., 1865, North Amer. Acal., p. 42, figs. 65, 66.—Haeckel, 1880, Syst. der Medusen, p. 555.—Fewkes, 1881, Bull. Mus. Comp. Zool. at Harvard College, vol. 8, p. 172, plate 7, figs. 2–4, 6; 1884, Mem. Mus. Comp. Zool. at Harvard College, vol. 10, No. 3, plate 8.—Smith, 1891, Bull. Mus. Comp. Zool. at Harvard College, vol. 22, p. 115, plates 1, 2, figs. 1–12 (development).—Hyde, 1894, Zeit. für wissen. Zool., Bd. 58, p. 535, taf. 24, figs. 36–53 (development).—Verrill, 1873, Report U. S. Commiss. Fish and Fisheries for 1871–72, p. 723.—Macallum, 1903, Journal of Physiology, Cambridge, England, vol. 29, pp. 213–241 (inorganic composition).—Hargitt, 1904, Bull. U. S. Bureau of Fisheries, vol. 24, p. 67 (scyphostomæ with stolons).—1905, Journal Exper. Zool., vol. 2, p. 548, figs. and plate (variations).

Medusa aurita, Eschscholtz, 1829, Syst. der Acal., p. 61.

Aurelia flavidula, *A. aurita*, *Ephyra octolobata*, Gould, 1841, Report Invert. Massachusetts, p. 348.

Aurelia sex-ovalis, Mörch, 1857, Beskriv. af Grönland, p. 95.

Aurelia aurita, Mörch, 1857, Beskriv. af Grönland, p. 95.—Stimpson, 1853, Marine Invert. Grand Manan, p. 11.

Aurelia habanensis, Mayer, 1900, Bull. Mus. Comp. Zool. at Harvard College, vol. 37, p. 69, plate 24, figs. 73, 74; plate 26, fig. 86 (Cuba to Tortugas).

Dimensions in mm. of a mature specimen of *Aurellia aurita* from Naples, Italy, captured May 30, 1900. Bell-radius, 85; length of mouth-arms, 75; width of genital cross, 51. (See text-figure 397.)

The following is a description of the American form of *Aurellia aurita*, which has been commonly called "*A. flavidula*":

Adult medusa.—Disk 140 to 250 mm. wide, 50 to 90 mm. high. When expanded it is flatter than a hemisphere, but when contracted it becomes hemispherical. Gelatinous substance tough, thick at center, but thin at edge of disk. 8 marginal sense-organs at the bottom of shallow niches between the 8 broad velar lappets. Each sense-club is blunt and contains an ectodermal, proximal ocellus on the exumbrella side, a cup-like pigmented eye composed of both ectoderm and entoderm on the subumbrella side, and a distal entodermal mass of crystalline concretions. It is partially protected above by a bridge-like web stretching between the adjacent lappets. Lappets of considerable size on both sides of the club.

A single median pit projects downward from exumbrella surface just above the sense-club. Small and numerous tentacles arise from sides of disk at a slight distance above margin and alternate with an equal number of small, elongate, marginal lappets which similarly arise from the sides of the disk above the projecting margin. Tentacles hollow, with longitudinal strands of muscles down their subumbrella sides, and with broken rings of nematocyst-cells on their exumbrella sides. Margin of disk entire and simple except at places of the 8 sense-organs, where it is broken by notches. It forms a narrow, velum-like structure lying below the tentacles and marginal lappets. Central mouth-opening 4-sided, surrounded by 4 thick, stiff, gelatinous mouth-arms, the 8 free edges of which are much convoluted and provided with a row of numerous, small tentacles. These free edges inclose a median trough or gutter, which extends down the middle of the lower side of each mouth-arm. These mouth-arms are each about as long as the radius of the disk; at their bases they are broad and their free margins are here greatly indented and folded in sinuous lines bordered by small tentacles. The 4 interradial gonads are horseshoe-shaped and alternate with the mouth-arms, and their position is marked on the floor of the subumbrella by 4 thick, horseshoe-shaped thickenings of the gelatinous substance, in the center of each of which there is a deeply sunken, subgenital pit. The radius of each of these horseshoe-like regions is about one-third that of the disk itself.

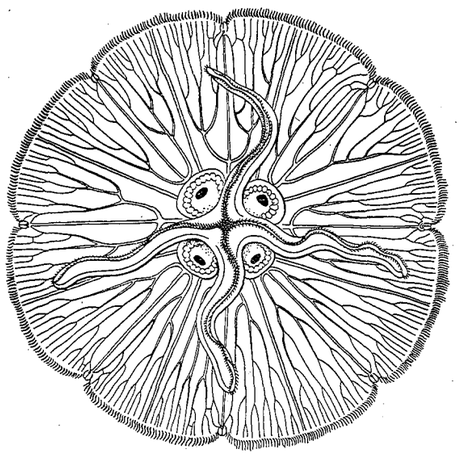


FIG. 397.—*Aurellia aurita*. Drawn by the author, from a specimen found at Naples, Italy, by Dr. S. Lobianco at the Naples Zoological Station, May 30, 1900.

Goodey, 1909, finds 4 interrradial, canal-like grooves in the subumbrella floor of the stomach leading from the gonads to the folds of the oral arms and serving to conduct the genital products away from the gonads.

The central stomach occupies a 4-lobed space, its outline being determined by the peripheral edges of the 4 horseshoe-like genital cavities, and it gives rise to a complex system of radiating canals extending from edges of stomach to circular canal at bases of marginal tentacles. 8 separate, straight, non-anastomosing, adradial canals and 4 radial and 4 interradial, pitchfork-shaped systems of anastomosing canals; each of these systems consists of a single, straight, median canal and a pair of branching, lateral canals, which arise on either side of the median canal very near the periphery of the central stomach-cavity. The lateral canals each give rise to 3 to 5 radiating branches which anastomose sparingly and extend outward to the circular canal. These branches decrease in caliber and anastomose more frequently as they approach the circular canal. The gonads are found in 4 horseshoe-shaped

convoluted ridges on the subumbrella floor of the 4 genital cavities. The bases of the genital ridges are beset with numerous, small, gastric cirri.

The gelatinous substance of the disk is of a translucent milky-white or yellowish-brown; spermaries usually slightly pink. In old individuals the gonads in both sexes are white.

Common from Greenland to the West Indies. At Eastport, Maine, it is mature in September, and at Tortugas, Florida, in May.

The American medusa is closely allied to *Aurellia aurita* of Europe and is at most merely a variety of the latter. It may possibly differ from its European representative in the thickness and rigidity of the mouth-arms, which are very broad at their bases and often complexly convoluted at their free edges, but I have seen these same characters in *Aurellia* at Naples and consider the American and European medusæ to be identical.

A very complete description and numerous figures of the American medusa are given by L. Agassiz, 1860-62, Cont. Nat. Hist. U. S., vols. 3 and 4.

Development.—The ova are dehisced from the gonads into the interradial grooves from which they enter the median gutter of the mouth-arms and are here retained in small pouches near margins of free edges of mouth-arms and finally set free in the planula stage. Minchin, 1889, gives a good description of these brood-pouches. Segmentation total and unequal, and a blastula is formed which has a large, central blastocœl. According to Hyde, 1894, the gastrula may be formed in either one of two different ways: (1) by the invagination of a small part of the blastula wall combined with the ingression of numerous cells from various parts of the wall of the blastula; (2) by invagination of the wall of the blastula, aided only occasionally by the ingression of cells from the blastula wall. According to Smith, 1891, however, the gastrula is formed from a small invaginated region in the wall of the blastula, from which there develops a single, continuous layer of cells, which layer finally completely fills the cleavage cavity, thus giving rise to a 2-layered embryo with an open blastopore. Smith denies that this process is aided in the least by the ingression of cells from the wall of the blastula into the blastocœl. He finds, indeed, that a few cells are occasionally seen to wander into the blastula cavity, but these always degenerate without taking any share in the formation of the entoderm. These variations in the mode of forming the gastrula have been seen in other Scyphomedusæ, having been observed by Conklin in *Linuche*, and Hyde and McMurrich in *Cyanea*. The blastopore then closes and the entoderm becomes a closed sac entirely enveloped by the ectoderm. The larva then becomes ciliated and swims actively about as a pear-shaped planula, which soon attaches itself to the bottom by the wide anterior end. A crater-like depression (œsophagus) formed of ectodermal cells then appears at the narrow (now the upper) end of the animal, and this presses down upon the entodermal sac. The first pair of radial stomach-pouches is formed from the entodermal sac, while the second pair is formed, at least partially, from the ectoderm of the cup-like depression. The mouth breaks through and 4 tentacles appear. The larva then has 4 interradial, longitudinal, partial septa each formed of a fold of the entoderm supported by a central shelf of gelatinous substance. These septa extend from the margin of the mouth to the lower end of the stomach-cavity. They form the 4 primary, gastric filaments of the future ephyra, and there are no septa in the central stomach of the medusa.

As we have stated, it appears from the researches of Götte and of Hyde that the two original pairs of stomach-pouches are derived alternately from the ectoderm of the œsophagus and from the entoderm of the primitive stomach, although Hyde shows that the lower aboral floor of the 2 œsophagus pouches is formed at least partially from entoderm. Through division of the 4 original stomach-pouches we have finally 24 pouches, 10 entodermal and 14 mainly ectodermal, as follows: 6 diammetrically opposite perradial, 4 interradial, and the 4 connecting adradial pouches are ectodermal. 90° apart from these the 6 perradial and their 4 adjacent adradial pouches are entodermal. (See Götte, 1887.)

One must remember that R. P. Bigelow, 1900, finds that the 4 primary stomach-pouches of *Cassiopea xamachana* are wholly entodermal, and Hadži, 1907, finds that this is also the case in *Chrysaora*. Moreover, according to Hadži there is no ectodermal invagination in *Chrysaora* to form the mouth, but on the contrary the throat is *evaginated* and lined with entoderm.

The larva of *Aurellia* becomes a scyphostoma which finally attains a height of about 5 mm. and acquires 8, 16, and finally 24 long tentacles. The ephyræ are developed through strobilization of the scyphostoma. As many as 13 annular constrictions may develop below the zone of

oral tentacles, and then an additional set of tentacles usually develops below the last constriction. As many as 12 disk-like ephyræ may be cast off one by one, and finally the scyphostoma is left greatly reduced in size, but still provided with a corona of tentacles. After all of the ephyræ have been cast off through this terminal budding the scyphostoma frequently develops irregular stolons from its sides and base. Haeckel's observations of other modes of development are discussed in the description of the genus *Aurellia*.

The young ephyra has 8 marginal sense-organs flanked by 16 lappets, the ocular clefts of which are only about half as wide and deep as the 8 alternating clefts. The throat is at first a simple 4-cornered tube and the lenticular central stomach gives rise to 16 simple, separate, radiating canals which extend outward in the radii of the tentacles and sense-organs. The tentacles then begin to develop (first one, then others laterally) in the 8 adradial spaces. The lips elongate at the 4 perradial corners and form the mouth-arms, and a peripheral ring-canal is formed by the radial-canals becoming T-shaped at their free, distal ends, and the sides of each adjacent T fusing. As the animal increases in size, blind canals travel centripetally inward from the ring-canal even before the ring-canal is complete, and fuse with the 8 perradial and interradial canals, which thus become pitchfork-shaped. (See fig. 4, plate 67.)

Full descriptions and very complete figures of the development of the various stages in *Aurellia flavidula* are given by L. Agassiz, 1860–62. Hyde, 1894, gives a detailed and careful account of the development of the planula and of the early stages of the scyphostoma, and Smith has investigated the process of formation of the gastrula. Claus and Götte, whose views are at variance, studied the development of the scyphostoma and its gastral pouches.

Macallum, 1903, finds that, in *Aurellia flavidula* living in brackish water, the salinity of the water may undergo considerable change during the day and yet the amount of NaCl within the body of the *Aurellia* remain practically constant. The medusa contains slightly less sodium and considerably more potassium than does normal sea-water. It contains also about the same amount of calcium as is found in sea-water, but less magnesium and 32 to 36 per cent less SO. He gives the composition of *Aurellia*, *Cyanea* and of sea-water as follows:

	Na.	Ca.	K.	Mg.
Contents of sea-water	100	3.84	3.66	11.99
Contents of body-juice of *Aurellia*	100	4.13	5.18	11.43
Contents of *Cyanea arctica*	100	3.86	7.67	11.31

27 mature specimens of *Aurellia* from Tortugas, Florida, all collected at random from a single swarm on May 4, 1906, were of dimensions and proportions as follows:

Among 27 specimens—	Radius of umbrella.	Length of mouth-arms.	Radius of genital cross.
Largest specimen	92 mm.	90 mm.	32 mm.
Smallest specimen	59 mm.	61 mm.	25 mm.
Average specimen	78 mm.	74 mm.	33 mm.
Proportions of specimen with longest mouth-arms	*r*	1.04 *r*	
With smallest mouth-arms	*r*	.89 *r*	
Average length of mouth-arms	*r*	.95 *r*	
Proportions of specimen with largest gonads	*r*		0.51 *r*
Smallest gonads	*r*		0.36 *r*
Average gonads	*r*		0.42 *r*

Thus individuals among these 27 specimens displayed all of the characteristics of *Aurellia aurita*, "*A. flavidula*," "*A. marginalis*," and "*A. habanensis*"; and all should be called *A. aurita* Lamarck, this name being the oldest. I wholly agree with Vanhöffen, 1902, that *A. aurita* is distributed over all warm and temperate oceans.

Aurellia aurita forma "marginalis."

Aurelia marginalis, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 86, 160.—Agassiz, A., 1865, North Amer. Acal., p. 43.—Haeckel, 1880, Syst. der Medusen, p. 556.—Hyde, 1894, Zeit. für wissen. Zool., Bd. 58, pp. 532, 544, taf. 32, 33, fign. 1–35.

This variety is larger than *A. flavidula*, being often more than 300 mm. in diameter. Mouth-arms smaller than in *A. flavidula*, being less than bell-radius in length. Genital pouches fully half as wide as bell-radius, instead of being about one-third this width as in *A. flavidula*. The gonads are of a pale rose color in both sexes.

Professor Hyde has made a careful study of the development up to the scyphostoma stage. The gastrula results from a peculiar process of delamination. Some of the cells of the one-layered blastula divide and their inner halves thus become free and wander into the blastula cavity where they eventually form the entodermal layer.

According to Hyde, however, the development of *A. flavidula* is itself subject to much variation and the gastrula in this form also results in some cases from delamination. Hence the peculiar features of the development in *A. marginalis* are different only *in degree* from those observed by Hyde in *A. flavidula* and are not of specific importance. Moreover, we must bear in mind that Smith finds that the gastrula of *Aurellia flavidula* is formed by invagination, and according to Götte and to Hein, 1900, the gastrula of *A. aurita* is also formed by invagination. Staleness of the water in ordinary aquaria may profoundly alter the normal course of development.

I am convinced that "*Aurellia marginalis*" is only a variety of "*A. flavidula*," which is itself specifically identical with *A. aurita*. For example, among 27 mature specimens of *Aurellia* found in a single swarm at Tortugas, Florida, on May 4, 1906, if we call *r* the radius of the umbrella, the length of the mouth-arms ranged from 0.89 to 1.04 *r*, the average being 0.95 *r*; also the radius of the genital cross ranged from 0.36 to 0.51 *r*, the average being 0.42 *r*. Agassiz called specimens of *Aurellia* with arms longer than *r* and the genital radii less than 0.5 *r* "*A. flavidula*"; those having arms less than *r* and genital radii more than 0.5 *r* he would call "*A. marginalis*." It is evident, however, that the two forms intergrade, and this is true not only along the Florida reef, but also in the harbor of Eastport, Maine, where I found some individual Aurellias that conform to the proportions of "*A. marginalis*." It is safe to conclude that "*A. marginalis*" is merely a manuscript species and should disappear henceforth. L. Agassiz described it from the Florida reefs.

Aurellia aurita = "Aurellia dubia" Vanhöffen.

Aurelia dubia, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 20, 24.

The disk is 130 mm. wide and 43 mm. thick. The 8 marginal sense-organs are set in deep niches, as in *A. flavidula*, and there are 8 broad, marginal lappets. The 8 mouth-arms are only two-thirds as long as the disk-radius. Genital-radius one-third of disk-radius; 7 radiating canals extend outward from each genital sinus. All of the canals fork; their branches are narrow and elongate in the middle and small and numerous at the margin. Color (?) Persian Gulf, March.

Described from a single specimen by Vanhöffen. Distinguished by its short mouth-arms and its having only 8 velar lobes instead of 16 as in *A. labiata*.

Aurellia solida Browne.

Aurelia solida, Browne, 1905, Fauna and Geog. Maldive and Laccadive Archipelagoes, vol. 2, plate 960, plate 94, figs. 1, 2; 1908, Trans. Royal Soc. Edinburgh, vol. 46, p. 249.

This medusa differs from *Aurellia aurita* in its marginal sense-organs, but in all other respects the characters of *A. solida* are well within the common ranges seen in *A. aurita*. In *Aurellia solida* each marginal sense-organ arises from the inner end of a deep groove which is open on the exumbrella side and bordered by the lateral lappets, but closed on the subumbrella side. In *Aurellia aurita* the sense-club points outward toward the umbrella margin. In *Aurellia solida*, however, the sense-club points upward toward the exumbrella and therefore at right angles to the position assumed by the sense-club in *Aurellia aurita*.

In *Aurellia aurita* there is a well-developed covering membrane or "hood" which extends over and above the sense-club on the exumbrella side, but in *Aurellia solida* the "hood" is a

mere ridge or ledge-like mass of tissue covering the concavity in which lies the sense-club. The dorsal sensory-pit in *Aurellia solida* is a deep triangular funnel with a long, narrow mouth, and is quite unlike the shallow exumbrella sensory-pit of *Aurellia aurita*.

The bell is 80 mm. wide and 40 mm. high. Canal-system similar to that of *Aurellia aurita*, but the 4 circular, subgenital ostia are each only 2 mm. in diameter, whereas in *A. aurita* they are usually much larger. The oral arms are not quite as long as the radius of the umbrella. The genital radius is about 0.4 that of the umbrella.

Maldive Islands, Indian Ocean, and 15° west of Madeira in the North Atlantic.

Aurellia labiata Chamisso and Eysenhardt.

Aurelia labiata, Chamisso und Eysenhardt, 1820, Nova Acta phys. med. Leop. Car., tome 10, p. 358, planche 28, figs. 1 *A*, *B*.
Aurellia labiata, de Blainville, 1834, Manuel d'Actinologie, p. 294, planche 42, figs. 1, 2.—Fewkes, 1889, American Naturalist., vol. 23, p. 592, fig. 2; Bull. Essex. Institute, Salem, vol. 21, No. 7, p. 122, plate 5, fig. 2.
Diplocraspedon limbata, Brandt, 1838, Mém. Acad. Sci. St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 372, taf. 10.
Aurelia clausa (young medusa), Lesson, 1829, Voyage de la *Coquille*, Zool., p. 119.
Aurelia labiata+*A. clausa*+*A. limbata*, Haeckel, 1880, Syst. der Medusen, pp. 557, 558.
Aurelia limbata, Götte, 1886, Sitzungsber. Akad. Wissen. Berlin, Jahrg. 1886, p. 836.—Vanhöffen, 1906, Nordisches Plankton, Nr. 11, p. 61, fig. 32.—Kishinouye, 1910, Journal College of Sci. Tokyo, vol. 27, art. 9, p. 22.

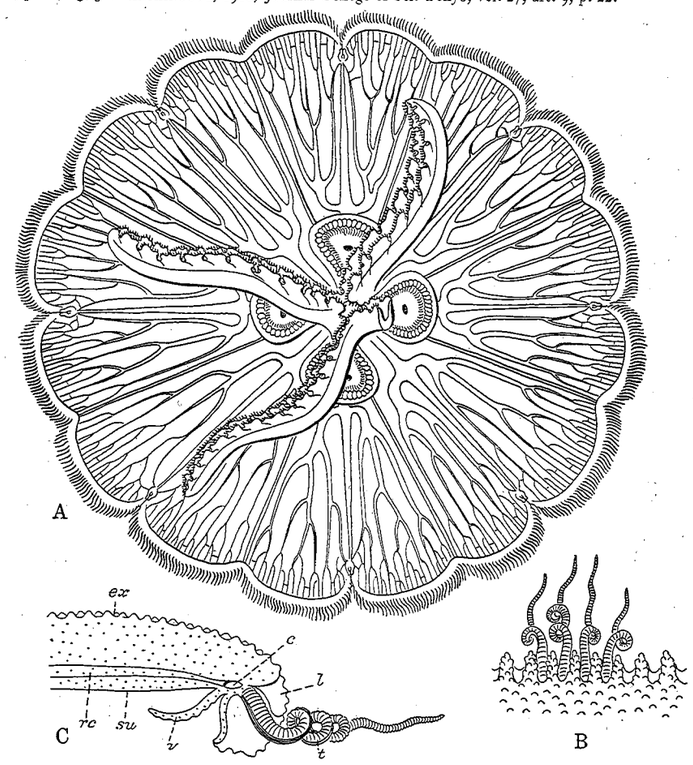


Fig. 398.—*Aurellia labiata*. Drawn by the author, from specimens collected by the U. S. Bureau of Fisheries steamer *Albatross* at Masbate Anchorage, Philippine Islands, April 21, 1908.
A, oral view of medusa with one mouth-arm cut off. B, bell-margin seen from exumbrella side showing dorsalward migration of lappets and tentacles. C, section of bell-margin, the areas cut across being dotted. *c*, circular vessel; *ex*, exumbrella; *l*, marginal lappet; *rc*, radial-canal; *su*, subumbrella; *v*, velum-like bell-margin of bell; *t*, tentacle.

This species is distinguished by having 16 velar lobes separated by deep median clefts instead of 8 simple lobes as in *A. aurita*. The canal-system is similar to that of *Aurellia aurita*, but there is probably a greater tendency for fusions to occur between the adradial and other canals than in *A. aurita*. The bell-margin projects downward from the subumbrella side as

8 plain-edged, velum-like folds spanning between the sense-organs. The tentacles and marginal lappets have migrated a considerable distance up the sides of the exumbrella, above the velar margin. A longitudinal strand of muscle-fibers extends down the subumbrella side of each tentacle and interrupts the rings of nematocysts which trend across its exumbrella side. When the medusa is old the mouth-arms become much thickened and folded as in *Aurellia aurita*.

The dimensions of three specimens obtained by the U. S. Fisheries Bureau steamer *Albatross* at Masbate Anchorage, Philippine Islands, on April 21, 1908, are as follows:

	Mm.	Mm.	Mm.
Diameter of umbrella	174	189	128
Diameter across zone of gonads	57	53	42
Length of each mouth-arm	74	75	52

Aurellia labiata is distinguished from *A. aurita* by having 16 notches in its bell-margin, by its peculiar velum-like, inter-rhopolar, subumbrella membranes representing the true bell-margin, and by the very small size of its subgenital ostia. The mouth-arms are also shorter than one commonly observes them to be in *A. aurita*.

Aurellia maldivensis H. B. Bigelow.

Aurelia maldivensis, Bigelow, H. B., 1904, Bull. Mus. Comp. Zool. at Harvard College, vol. 39, p. 261, plates 6, 8, figs. 22, 23, 27.

Bell 250 mm. wide and about one-third as high. 8 marginal sense-organs, flanked by small, pointed, ocular lappets. 8 wide interocular or velar lobes are each divided into 2 by

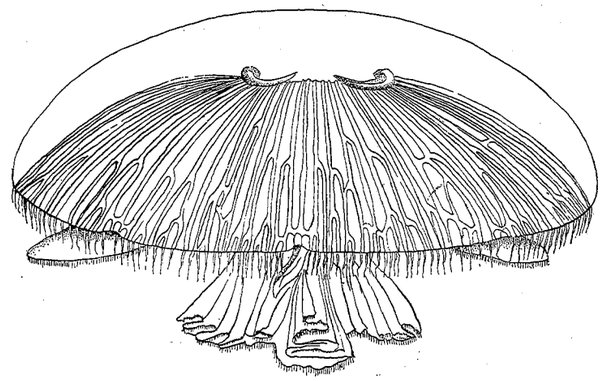


Fig. 399.—*Aurellia maldivensis*, after H. B. Bigelow, in Bull. Mus. Comp. Zool. at Harvard College.

a very slight, central depression, thus forming 16 lobes as in *A. labiata*. About 500 small tentacles alternate with an equal number of small, dorsal lappets as in *Aurellia aurita*. The 4 mouth-arms, or palps, are large and curtain-like, recalling those of *Cyanea;* their lips are complexly folded and bear numerous, short tentacles. About 48 radial-canals arise from the central stomach, the 8 canals to the marginal sense-organs and the 8 adradial ones do not branch, but all of the others branch, and occasionally anastomose, so that about 175 canals reach the circular vessel at the margin. The 8 canals to the sense-organs each give off 2 side-branches in the immediate neighborhood of the sense-organ. These side branches extend to the circular vessel. The 4 gonads are small and horseshoe-shaped and have wide subgenital pits.

The bell is of a delicate lilac, the canals and tentacles pinkish-violet, and the mature gonads bright violet. The color is, however, variable, some specimens being blue.

Abundant in the lagoons of the atolls of the Maldives, Indian Ocean, in January.

The comparative dimensions and other details are stated in the table giving a synopsis of the species of *Aurellia*.

In its cleft, velar lobes it recalls *A. labiata*, while in its wide, curtain-like mouth-arms it stands alone among Aurellias. Indeed its peculiar mouth-curtains are all that separate it from *A. labiata*.

Genus AUROSA Haeckel, 1880.

Aurosa, Haeckel, 1880, Syst. der Medusen, p. 559.

The type species and only known form is *Aurosa furcata* Haeckel, from the tropical Indian Ocean.

GENERIC CHARACTERS.

The medusa is similar to *Aurellia* but the 4 mouth-arms are bifurcated at their outer ends. There are 24 anastomosing radial-canals and a marginal ring-canal. 4 interradial gonads, 8 rhopalia, 8 velar lobes, and numerous small tentacles as in *Aurellia*.

Aurosa furcata Haeckel.

Aurosa furcata, Haeckel, 1880, Syst. der Medusen, p. 559, taf. 33, fign. 7, 8.

Bell flat, shield-shaped, 80 mm. wide, 30 mm. high, 8 velar lappets as in *Aurellia aurita*. 8 marginal sense-organs. Tentacles small, numerous, arising from exumbrella side of margin

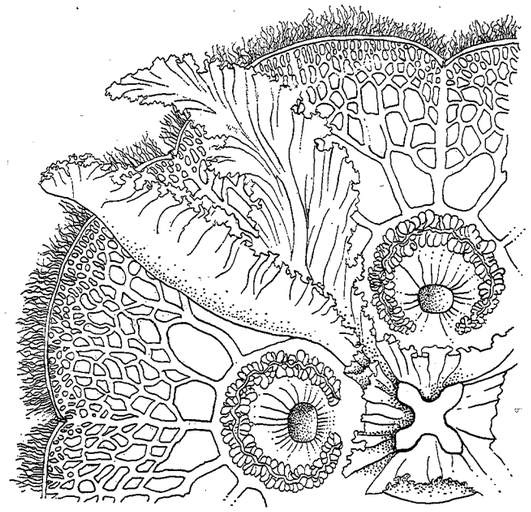


Fig. 400.—*Aurosa furcata*, after Haeckel, in Das Syst. der Medusen.

as in *A. aurita*. Gonads as in *A. aurita*. Genital radius half the bell-radius. Central stomach gives rise to 24 radial-canals, all of which give forth anastomosing side-branches. There are 4 perradial, 4 interradial, and 16 adradial canals. Thus each genital pouch gives rise to 5 radial-canals, and the perradial canals arise from the angles between the genital pouches. The peripheral network of anastomosing canals becomes narrower in its mesh the nearer the vessels are to the marginal ring-canal. The 4 mouth-arms resemble those of *Aurellia aurita*, but each one bifurcates near its outer end. Their curtain-like margins are much folded.

Found near Cocos Islands, Indian Ocean, southwest of Sumatra.

Order RHIZOSTOMÆ Cuvier, 1799.

Rhizostomæ, Cuvier, 1799, Journal de Phys., tome 49, p. 436.—Haeckel, 1880, Syst. der Medusen, p. 560.—Hamann, 1881, Jena. Zeit. für Naturwissen., Bd. 15, p. 243.—Claus, 1883, Untersuch. über Organisation und Entwick. der Medusen, Leipzig, p. 60; 1886, Arbeit. Zool. Inst. Wien, Bd. 7, p. 110.—von Lendenfeld, 1888, Zeit. für wissen. Zool., Bd. 47, p. 208.
Rhizostomeæ, Agassiz, L., 1862, p. 208, Cont. Nat. Hist. U. S., vol. 4, p. 149.
Rhizostomata, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 39.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 88; 1906, Revue Suisse de Zool., tome 14, p. 100; 1907, Ergeb. und Fortschritte der Zoologie, Bd. 1, p. 201.
Rhizostomidæ, Eschscholtz, 1829, Syst. der Acalephen, p. 42.

CHARACTERS OF THE ORDER.

Scyphomedusæ without marginal tentacles*, and with numerous mouths which are borne upon 8 adradial, fleshy, branched arm-like appendages which arise from the center of the subumbrella. The lips of the numerous mouths are bordered by minute, constantly moving tentacles.

The rhopalia and marginal lappets of the Rhizostomæ are similar to those of Semæostomeæ. The Rhizostomæ are the most highly differentiated Scyphomedusæ, and owing to the generally tough consistency of their gelatinous substance and their large size they have often been found preserved as fossils, especially in the lithographic slates of Solenhofen and Eischstädt. They are tropical forms and none are known from the polar regions. The genus *Rhizostoma* is the only one which extends far into temperate regions, and the majority of the genera are confined to the warm waters of the Indo-Pacific region. A few are found in the tropical Atlantic and the Mediterranean. The Rhizostomæ develop, in so far as we know, through strobilization from scyphostomæ. Phylogenetically they are derived from the more simply organized Semæostomeæ, but they have lost their marginal tentacles, though in *Lobonema* the marginal lappets have become greatly elongated and may in some respects function as tentacles. The ephyra of the Rhizostomæ has a simple cruciform, central mouth, as in the Semæostomeæ, but the 4 rays of the cross soon fork at their outer ends and then grow outward in the form of 8 adradial, fleshy, mouth-bearing appendages, which branch in a characteristic manner and constitute the so-called "mouth-arms." The primitive central mouth may then be obliterated by the coalescence of its lips, but numerous other mouth-openings remain in the gutter-like grooves which extend down the ventral sides of the mouth-arms; and these mouths may also extend over parts of the dorsal sides of the mouth-arms. The semæostomous genus *Aurosa* with its 4 bifurcated mouth-arms, which in other respects resemble those of *Aurellia*, appears to be a connecting link between the Semæostomeæ and the Rhizostomæ.

The gonads of the Rhizostomæ are invaginated as are those of *Aurellia*, not protrusive as in *Cyanea*. In the young medusæ of all Rhizostomæ and in the mature medusæ of some genera such as *Cassiopea* there are 4 separate genital sacs which project into the central stomach-cavity of the medusa. In many Rhizostomæ such as in *Cotylorhiza*, *Mastigias*, etc., the inner ends of the 4 primitive, genital bags may coalesce and their walls break down, forming a cruciform cavity beneath the stomach of the medusa and not connected with the gastrovascular cavity, but opening to the surrounding ocean through the 4 interradial genital ostia. The formation of this cruciform, genital cavity, or subgenital porticus of Haeckel, is illustrated in the 3 diagrams of figure 401. In A, we see 4 separate, interradial, genital sacs (*G*) projecting into the stomach-cavity (*S*), as in *Rhizostoma* and *Cassiopea*. In B we see these 4 sacs fused at their inner ends as in some species of *Cephea* (*Netrostoma*); and in C we find the walls broken down in the fused regions forming a cruciform genital space lying *beneath* the stomach as in *Cotylorhiza*, *Crambessa*, *Mastigias*, etc.

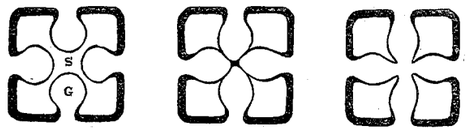


Fig. 401.—Diagrams illustrating the fusion of the 4 primitive genital cavities (A) to form a single cruciform cavity (C).

The umbrella of the *Rhizostomæ* resembles that of their more simply organized ancestors the Semæostomeæ. It is usually dome-shaped and covered with nematocyst-warts. The bell-

*Excepting in *Lobonema*, gen. nov., wherein the marginal lobes are converted into long, tapering tentacle-like organs.

lappets and rhopalia are in all respects similar to those of the Semæostomeæ. The muscular system of the subumbrella is well-developed and these forms are usually vigorous swimmers, although in *Cassiopea* we find that the medusæ commonly remain upon the bottom with their oral sides uppermost, and the pulsations of the umbrella serve mainly to stir up currents which may bring food to the mouths.

At the center of the subumbrella we find a thick, disk-shaped, gelatinous projection called the arm-disk, for the 8 adradial mouth-arms arise from its lower side. This arm-disk is merely the lower wall of the stomach which has become thickened in order to give support to the heavy gelatinous mouth-arms. In all forms, however, having a unitary, cruciform, genital cavity, an open space lies between the arm-disk and the stomach so that the arm-disk is suspended from the subumbrella by 4 thick perradial columns which are separated one from another by the 4-rayed genital porticus, which opens to the outer world by 4 interradial ostia which alternate with the columns.

The cruciform, central stomach dips downward into these perradial columns and 4 bifurcated or 8 simple canals arise from the stomach and extend downward into the 8 adradial mouth-arms, giving off numerous branches to the mouths. The 16 canals to the scapulets, when these are present, arise from these 8 mouth-arm ducts, as do also the canals to the arm-disk, which fuse into 4 and finally into a single, central duct at center of arm-disk. The central stomach also gives rise to canals which radiate outward through the subumbrella of the bell. These may be connected by one or more ring-canals, or by networks of anastomosing vessels.

The facility with which some of these medusæ may be maintained alive in aquaria has permitted certain physiological work to be performed upon them. Bethe, 1903, 08, 09, studied the rhythmical pulsation of *Cotylorhiza* and *Rhizostoma*, and Mayer, 1906, 08, carried out experiments upon *Cassiopea*. Bethe finds that the pulsation resembles that of the vertebrate heart in all important respects. The pulsation-stimulus is nervous in nature, and the "all or none" principle applies to medusæ as it does to the vertebrate heart, as does also the phenomenon of the refractory stage of Marey, 1876. A definite interval of time elapses between the passage of the nervous stimulus and the response of the muscles, and the pulsation is a reflex due to a constantly present stimulus, the response to which is periodic, because after the nerves have responded to the stimulus they become incapable of reacting to it until after a definite interval of rest, this resting period being called the refractory stage.

Bethe, 1908, 09, in his study of *Rhizostoma pulmo* comes to conclusions in respect to the effects of the ions of sea-water upon pulsation, which are in accord with those of Mayer, 1906. (See *Rhizostoma pulmo*.)

Mayer, 1906, 1908, working upon *Cassiopea*, found that the sea-water is a balanced fluid, neither stimulating nor inhibiting pulsation. This is due to the fact that the stimulating effect of the sodium ion of sea-water is counterbalanced by the inhibiting influences of the calcium, potassium, and magnesium. The stimulus which produces pulsation is due to the constant maintenance of a slight excess of the sodium cation in the marginal sense-clubs, over and above its concentration in the surrounding sea-water. This excess of sodium is maintained by the constant production of sodium oxalate in the terminal entoderm of the sense-clubs. This oxalate precipitates calcium to form the calcic oxalate crystals of the sense-club and sets free sodium chloride the sodium ion of which acts as a nervous stimulant. Details of these researches upon pulsation are given in the accounts of *Cotylorhiza tuberculata*, *Rhizostoma pulmo*, and *Cassiopea xamachana*.

Hargitt, Zeleny, and Stockard have studied regeneration in *Rhizostomæ*. Zeleny stated that in *Cassiopea* the greater the number of arms removed up to 6 the more rapidly does each and every arm regenerate, but this is refuted by Stockard, who further shows that the regenerating tissue has a greater ability to absorb nutriment than have the normal, somatic body tissues, and that in consequence of this the body shrinks in size in direct proportion to the growth of the regenerating arms, the growing arms reducing the body as do cancer cells in their proliferation. Stockard also shows that cuts near the center regenerate more rapidly than those near the margin of the disk, this being in accord with Morgan's law that the deeper the level of the cut the more rapid the rate of regeneration. In *Rhizostoma pulmo* Hargitt found that two rhopalia sometimes regenerate in the place of one which he had removed, and I have observed

the same thing in *Cassiopea*. In *Cassiopea xamachana* R. P. Bigelow showed that the rhopalia are derived from every alternate tentacle of the scyphostoma, the other tentacles degenerating wholly. I find that in this medusa when the rhopalium regenerates it gives rise to a short lateral branch thus tending in an abortive manner to regenerate the tentacle, from which it originally came.

Many observations have been carried out upon the embryology of Rhizostomæ, and reviews of these researches will be found in the descriptions of *Cassiopea xamachana*, *Cotylorhiza tuberculata*, *Rhizostoma pulmo*, *Mastigias papua*, *Phyllorhiza punctata*, and *Stomolophus meleagris*. Claus, Goette, R. P. Bigelow, Kowalevsky, von Lendenfeld, and Vanhöffen have been especially active in these researches.

Haeckel, 1880, considered the presence or absence of a unitary, cruciform, genital cavity to be of great systematic importance and sought to separate families upon this distinction; but Claus, von Lendenfield, Vanhöffen, Maas, and Browne have demonstrated that this is a matter of no great import, for in different individuals of the same species we may find in some cases 4 separate genital sacs, while others have a cruciform genital cavity, and still others may have a more or less complete coalescence and breaking apart of the partitions in some quadrants and not in others. It is therefore evident, as was first clearly shown by Claus, 1883 (Organisation und Entwick. Medusen), that the conditions exhibited by the genital sacs afford no criteria for the distinction even of genera, much less of families. Indeed, Haeckel's system leads to the separation of closely related forms and the close approximation of remotely related forms, and is quite artificial.

Claus, 1883, 1886, and Vanhöffen, 1888, have attempted to separate the families of Rhizostomæ upon the distinctions afforded by the manner of branching of their mouth-arms. Claus's system somewhat modified by von Lendenfeld, 1888 (Zeit. für wissen. Zool., Bd. 47, p. 208), distinguished nine families as follows:

RHIZOSTOMÆ: Scyphomedusæ without marginal tentacles and with 8 adradial mouth-arms.
- *Archirhizidæ:* Mouth-arms unbranched. Gastrovascular network simple. No central mouth.
- *Cassiopeidæ:* Arm-disk flat. Arms long, irregularly branched with appendages. Radial-canals numerous. No central mouth.
- *Craunostomidæ:* Arm-disk wide, style-shaped, arms dichotomously forked. Arm-margins free, with clubs. Centripetal canals end blindly. Subgenital porticus unitary. Central mouth-opening present.
- *Cepheidæ:* Arm-disk wide and flat. Arms dichotomously forked, with 2 of the axial, terminal wings turned outwards. With clubs. No direct central mouth-opening.
- *Lychnorhizidæ:* Arms 3-leaved or distally 3-winged. 8 or 16 radial-canals. Gastrovascular network simple. No central mouth.
- *Stomolophidæ:* Arm-disk style-shaped, elongate, with 8 pairs of lateral "shoulder ruffles" or "scapulets." Proximal parts of the arms fused into a tube, distal parts branched. 16 radial-canals, with well-developed net-work of connecting vessels. No central mouth.
- *Rhizostomidæ:* Arm-disk style-shaped, elongate, with 8 pairs of lateral "scapulets" with clubs. Lower-arm three-winged, with dorsal mouths. 16 radial-canals. Centripetal network of canals well-developed. No central mouth.
- *Catostylidæ:* Arm-disk very wide, elongate, and style-shaped. Lower arm 3-winged with dorsal mouths. No centripetal networks of canals. Subgenital porticus unitary. No central mouth.
- *Leptobrachidæ:* Arm-disk wide and fused with the upper arms. Lower arms long, ribbon-shaped, and 3-winged. Simple canal net spread over the entire subumbrella. Subgenital porticus unitary. No central mouth.

A simpler system is proposed by Vanhöffen, 1888 (Bibliotheca Zoologica, Heft 3), who divides the *Rhizostomæ* into 7 families:

- *Rhizostomata simplicia:* Mouth-arms simple and unbranched. All of these are apocryphal, having been seen only by Haeckel and Fewkes.
- *Dichotoma:* Mouth-arms dichotomously forked, with lateral expansions.
- *Pinnata:* Elongate mouth-arms pinnately or irregularly branched.
- *Triptera:* Mouth-arms 3-winged. Each mouth-arm with a ventral and 2 dorsal lamellæ which meet at a point at the lower end of the arm.
- *Trigona:* Identical with the *Rhizostomata triptera*.
- *Lorifera:* Mouth-arms elongate, lash-like, and triangular in cross-section; with mouths developed along the 3 angles of the arms.
- *Scapulata:* Mouth-arms with simitar-shaped "scapulets" or "ruffles" projecting from their dorsal sides.

As was pointed out by Maas, 1903, Vanhöffen's *Triptera* and *Trigona* are identical and should be united, thus reducing his families to six. Schultze, 1898, showed that the mouth-arms of the "*Dichotoma*" of Vanhöffen are not forked at their outer ends, but give rise to 2 broad, longitudinal, *lateral* lamellæ, which may branch secondarily. With these modifications Vanhöffen's system affords the readiest means of classifying the Rhizostomæ, being based upon the mutations of the most conspicuous organs, the mouth-arms.

Maas, 1903 (Syphomedusen der *Siboga* Expedition, p. 89), proposes another system based upon the character of the muscle-system of the subumbrella, the presence or absence of ocelli on the sense-clubs, the character of the canal-system and of the mouth-arms. Maas's system is as follows:

Arcadomyaria: The subumbrella muscles are arranged in feather-like arcs. Mouth-arms elongate and irregularly pinnate in their branching. Rhopalia with ocellus and without an exumbrella sensory pit. Radial-canals twice as numerous as the rhopalia and connected by an anastomosing network of vessels. One or more ring-canals may or may not be present. 4 separate genital sacs, with small, round, interradial ostia. There is only one family, the *Cassiopeidæ*.

Radiomyaria: Radial-muscles of the subumbrella better developed than the circular muscles. Mouth-arms bifurcated. Rhopalia without ocelli and without exumbrella, sensory pits. 8 principal and other secondary radial-canals, all connected by a marginal network. No definite ring-canal. Funnel-shaped genital ostia. A unitary subgenital cavity may or may not be present. There is one family, the *Cepheidæ*.

Cyclomyaria: Circular muscles of the subumbrella better developed than the radial-muscles, the latter being often absent. Mouth-arms 3-winged, or derived from this type. There are 3 groups of the *Cyclomyaria*, as follows:

(*A*) 16 radial-canals which extend from the stomach to the bell-margin, and between them a blindly-ending, anastomosing network of vessels. Mouth-arms with scapulets. Genital ostia slit-like and divided by a median flap. Rhopalia without ocelli, but with sensory pits with radiating furrows. Group *A* is equivalent to the *Rhizostomidæ*+*Stomolophidæ* of Claus, or to the *Rhizostomata scapulata* of Vanhöffen.

(*B*) 8 rhopalar canals extend to the bell-margin and 8 in the inter-rhopalar radii end in the ring-canal. On its outer side, the ring-canal gives off a network of anastomosing vessels, and on its inner side it gives rise to another network which ends blindly without connecting with the stomach.

(1) Mouth-arms 3-winged, usually with pinnate lateral branches. Genital ostia slit-like. Rhopalia with pigment spots, and sensory pits with radiating furrows. This contains the family *Lychnorhizidæ* of Claus; including the genera *Lychnorhiza*, *Crambione*, and *Crambessa*.

(2) Mouth-arms very elongate, triangular in cross-section. Genital ostia wide openings. Rhopalia with pigment spots and furrowed sensory pits. This contains a part of Claus's family *Leptobrachidæ*.

(*C*) The 8 rhopalar extend to the bell-margin, and ($8 \times n$) canals extend only to the ring-canal. On its outer side the ring-canal gives off a narrow network and on its inner side is a network of wider mesh.

(1) Mouth-arms very elongate, triangular, file-shaped. Genital ostia wide slits. Genera: *Thysanostoma*, *Leptobrachia*, and *Himanostoma* of Claus's Leptobrachidæ.

(2) Arms 3-winged, not elongate. Ostia wide. Rhopalia with ocelli and small sensory pits without furrows. This is equivalent to Claus' family *Catostylidæ* containing the genera *Loborhiza*, *Crossostoma*, and *Mastigias*.

The *Arcadomyaria* of Maas is only a new name for Vanhöffen's *Rhizostomata pinnata*, the *Radiomyaria* are equivalent to Vanhöffen's *Rhizostomata dichotoma*, and the *Cyclomyaria* includes rather confusedly the *triptera*+*trigona*+*scapulata*+*lorifera* of Vanhöffen. Maas's system is erroneous in some respects; for example the rhopalia of *Cassiopea xamachana* have pigment spots while those of *Cassiopea frondosa* have none; similarly *Crambessa tagi* has ("ocelli") pigment spots but *Crambessa mosaica* has none. It is therefore evident that the presence or absence of "ocelli" does not afford a suitable criterion for the separation even of genera. The exumbrella sensory pits may have furrows in one species of a genus and be simple in another, as in *Rhopilema esculenta* and *R. verillii*. In my opinion the older and simpler system of Vanhöffen is to be preferred to this complex scheme proposed by Maas.

In view of the observations of Schultze and of Maas, we may amend Vanhöffen's system as follows:

Rhizostomata pinnata: Rhizostomæ with 8 separate, elongate, linear mouth-arms which give rise to pinnately or complexly arranged side branches (figs. 4, 5, and 7, plate 69). The circular muscles of the subumbrella tend to be bowed outward in a series of arcs on both sides of each radial-canal, the convexities alternating with the canals. The genera are as follows: *Toreuma* Haeckel, 1880, with 8 rhopalia.

Cassiopea Péron and Lesueur, 1809, with more than 8 rhopalia.

Rhizostomata dichotoma: 8 separate mouth-arms, the lower parts of each one of which is V-shaped in cross-section, the apex of the V being centrad, and the rays directed outward (fig. 404, p. 650) The mouths are developed upon the ventral sides of the mouth-arms. The radial-muscles are powerfully, and the ring-muscles weakly, developed. The radial-canals are all connected by a marginal network of vessels, without a definite ring-canal. The genera are as follows:

Cephea Péron and Lesueur, 1809. Exumbrella with a central dome bearing solid, wart-shaped protuberances.

Cotylorhiza L. Agassiz, 1862. With a smooth, simple dome at the center of the exumbrella.

Polyrhiza L. Agassiz, 1862. Exumbrella with a central depression and with radiating furrows.

Rhizostomata triptera: 8 separate mouth-arms the lower parts of each of which is Y-shaped in cross-section, due to the development of 2 lateral, dorsal, and a median ventral, longitudinal lamella, all 3 of which taper to a point at the lower end of the arm. The mouths are developed upon the free edges and partially over the sides of the 3 lamellæ or wings of the mouth-arms (fig. 411, p. 664) The ring-muscles are powerfully and the radial-muscles weakly, developed. A ring-canal with a network of anastomosing vessels arising from its inner and outer sides is usually present. Mouth arms without scapulets. The genera are very closely related and are as follows:

Catostylus L. Agassiz, 1862=*Toxoclytus*+*Crambessa* Haeckel. Mouth-arms without filaments, clubs, or other appendages. The network of vessels arising from the inner side of the ring-canal *ends blindly, without* connecting with the stomach.

Lychnorhiza Haeckel, 1880. With filaments but without clubs upon the mouth-arms. In other respects similar to *Crambessa*.

Rhizostomata triptera, continued—

Crambioné Maas, 1903. Similar to *Crambessa*, but with both clubs and filaments upon the mouth-arms.

Mastigias L. Agassiz, 1862=*Mastigias*+*Eucrambessa* Haeckel. Each mouth-arm terminates in a naked club. Numerous clubs or filaments among the mouths. The network of vessels which arises from the inner side of the ring-canal *connects* with the stomach.

Pseudorhiza von Lendenfeld, 1882. Similar to *Mastigias* but without lateral clubs or filaments upon the mouth-arms. A terminal club present. The canals which arise from the circular vessel, between the radial-canals end blindly without reaching the stomach.

Phyllorhiza L. Agassiz, 1862. Mouth-arms with lateral filaments, but without clubs as in *Lychnorhiza*. Canal-system as in *Mastigias*.

Vessura, Haeckel, 1880. Mouth-arms with clubs and filaments as in *Crambione*. 4 perradial canals arise directly from the stomach, but the 4 interradial canals result from the fusion of a network of vessels which arise from each interradial side of the stomach. An outer and an inner zone of circular muscles with an annular separation between them.

Lobonema, gen. nov. Marginal lappets elongated to form tentacles-like organs. Mouth-arm membranes perforated by window-like openings. Exumbrella covered profusely with papillæ.

Rhizostomata lorifera: 8 mouth-arms, very elongate, whip-like, and triangular in cross-section, with frilled mouths developed along the angular edges of the arms (fig. 419, p. 691) The cylindrical upper parts of the arms are rudimentary and partially fused one to another by gelatinous arches spanning between them and connecting them with the arm-disk. The genera are as follows:

Thysanostoma L. Agassiz, 1862. No terminal clubs on the mouth-arms. Mouths along the 3 angles throughout length of arms.

Lorifera, Haeckel, 1880. Similar to *Thysanostoma*, but with a naked club at lower end of each arm.

Leptobrachia Brandt, 1838=*Leptobrachia*+*Leonura* Haeckel. Mouths confined to the upper and lower ends of the mouth-arms, leaving the middle part of the arm naked.

Rhizostomata scapulata: Each mouth-arm bears a pair of simitar-shaped appendages (scapulets) which arise from the outer side near the base of the arm and bear frilled mouths (fig. 421, p. 697). The circular muscles of the subumbrella are powerfully, and the radial-muscles weakly, developed, or even absent. The genera are as follows:

Rhizostoma Cuvier, 1800=*Pilema* Haeckel, 1880. 8 free mouth-arms, the lower parts of which are Y-shaped, or 3-winged, in cross-section. Each arm terminates in a naked club. There are no other clubs or filaments.

Rhopilema Haeckel, 1880. Similar to *Rhizostoma* but with numerous clubs or filaments upon the mouth-arms.

Eupilema Haeckel, 1880. Similar to *Rhizostoma*, but the arms have neither clubs nor filaments.

Stomolophus L. Agassiz, 1862=*Brachiolophus*+*Stomolophus*, Haeckel, 1880. The 8 mouth-arms are fused along their sides leaving only the lower ends free and forming an elongate throat-tube for the central mouth which remains open.

Rhizostomata simplicia: Rhizostomæ with unbranched mouth-arms. These apocryphal forms are described by Haeckel and by Fewkes from alcoholic specimens of small size. They are apparently immature or injured specimens. No naturalist has seen any of these forms since Fewkes described his "*Stomotonema reticulatum*" in 1884. It is probable that we should drop these medusæ from further consideration, but in the faint hope that some may be discovered I have given descriptions of them based upon the statements of Haeckel and Fewkes.

RHIZOSTOMATA PINNATA Vanhöffen.

Rhizostomata pinnata, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 40.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 38.

Cassiopeidæ, Claus, 1883, Organisation und Entwick, Medusen, Leipzig.—von Lendenfeld, 1888, Zeit. für wissen. Zool., Bd. 47, p. 211.

Arcadomyaria, Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 88; 1907, Ergeb. Fortschritte der Zool., Bd. 1, p. 201; 1906, Revue Suisse de Zool., tome 14, p. 100.

Rhizostomous medusæ with 8 linear, pinnately, or complexly branching mouth-arms.

GENERA.

Toreuma Haeckel, 1880. 8 rhopalia.
Cassiopea Péron and Lesueur, 1809. More than 8 rhopalia.

Genus TOREUMA Haeckel, 1880.

Toreuma, Haeckel, 1880, Syst. der Medusen, p. 566.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 40.—Maas, 1903, Scyphomedusen, *Siboga* Exped., Monog. 11, p. 43.

The type species is *Toreuma dieuphila*, described by Péron and Lesueur from the Indian Ocean.

GENERIC CHARACTERS.

Rhizostomata pinnata with 8 adradial, linear mouth-arms which branch pinnately or complexly, and the main side branches also branch. 8 marginal sense-organs.

This genus is closely related to *Cassiopea* and is distinguished only by having 8 rhopalia, whereas *Cassiopea* has more than 8. Haeckel is the only modern naturalist who has seen any of these forms. They all come from the Indian Ocean.

Toreuma dieuphila.

Cassiopea dieuphila, Péron et Lesueur, 1809, Annal du Mus. Hist. Nat. Paris, tome 14, p. 356.
Cassiopea theophila, de Lamarck, 1816, Hist. Nat. Anim. sans Vert., tome 2, p. 511.
Rhizostoma theophila, Eschscholtz, 1829, Syst. der Acalephen, p. 53.
Polyclomia theophila, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 159.
Toreuma theophila+T. thamnostoma+T. gegenbauri, Haeckel, 1880, Syst. der Medusen, pp. 566, 567, 645.

It is probable that Haeckel's *T.* "*thamnostoma*" and "*T. gegenbauri*" are only growth-stages of Péron and Lesueur's "*Cassiopea*" *dieuphila*. I therefore present the descriptions of the three forms side by side in order that they may readily be compared. Haeckel enjoyed the opportunity of studying Péron and Lesueur's original specimen preserved in Paris.

	Toreuma dieuphila=Cassiopea dieuphila Péron and Lesueur.	Toreuma "gegenbauri" Haeckel.	Toreuma "thamnostoma" Haeckel.
Diameter of bell in mm.	60 to 80	60	90
Shape of bell.	Hemispherical (contracted?) Exumbrella with coarse warts.	Flatter than a hemisphere, without papillæ.	Flatter than a hemisphere. Exumbrella with small warts.
Number of marginal lappets.	96. In each octant 10 short, rectangular, velar, and 2 very small, ocular lappets.	80. In each octant 8 short, rectangular, velar, and 2 very small, ocular lappets.	120 to 160. In each octant 14 to 18 short, rectangular, velar, and 2 very small ocular lappets.
Length of mouth-arms in terms of bell-radius (*r*).	Less than *r* long (contracted?)	1 to 0.5 *r* long.	Nearly 2 *r* long.
Number of branches of each mouth-arm.	6 to 8 wide, flat, main side-branches.	8 to 12 flattened main side-branches.	12 to 16 cylindrical, main side-branches.
Appendages upon mouth-arms, between mouths.	Numerous small, and 10 to 20 large, club-shaped vesicles.	Numerous small clubs and a very large one at base of each arm, half as long as arm itself.	Numerous club-shaped vesicles. Smoother than in T. dieuphila, and not longer than width of marginal lappets. (Large clubs lost?)
Color.	Bell brownish-red, with white spots on the lappets. Gonads and clubs white.	Bell brown (?) An elongated, white spot upon lappet.	Bell dark-brown with numerous white spots. Abaxial surface of arms yellowish-brown. Clubs white.
Where found.	Northwest coast of Australia, in the Indian Ocean.	Tropical Indian Ocean.	Indian Ocean.

Genus CASSIOPEA Péron and Lesueur, 1809.

Cassiopea, Péron et Lesueur, 1809, Ann. du Mus. Hist. Nat. Paris, tome 14, genre 24, p. 356.—Eschscholtz, 1829, Syst. der Acal., p. 42.—Tilesius, 1834, Acad. Caes. Leop. Nova. Acta., tom. 15, p. 256.—Brandt, 1838, Mém. Acad. Impériale des Sci., St. Pétersbourg, Sci. Nat., sér. 6, tome 4, p. 396.—Guppy, 1883, Nature, vol. 27, p. 31 (habits).—von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 284.—Claus, 1883, Organisation und Entwick. der Medusen, p. 60.—Colasanti, 1886, Atti Acad. Med. Roma, Anno. 12, 18 pp. (blue color).—Agassiz and Mayer, 1899, Bull. Mus. Comp. Zool. at Harvard College, vol. 32, p. 175.—Keller, C., 1883, Zeit. für wissen. Zool., Bd. 38, p. 632.—Browne, 1905, Fauna and Geog. Maldive and Laccadive Archipelagoes, vol. 2, p. 966.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, pp. 38, 80.—Schultze, L. S., 1898, Abhandl. Senckenberg. Gesell., Bd. 24, Heft. 2, p. 163.
Cassiopea+polyclonia, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 139, 155, 159.—Perkins, 1908, Papers from Tortugas Laboratory of Carnegie Inst. of Washington, Publication 102, p. 150.
Polyclonia+Cassiopea, Haeckel, 1880, Syst. der Medusen, pp. 567, 568.

The type species is *Medusa andromeda* Forskål, called *C. forskalca* by Péron and Lesueur (=*C. andromeda*, Eschscholtz) of the Red Sea and Indian Ocean. The first species described by Péron and Lesueur, 1809, is called *Cassiopea dieuphila*. Haeckel, 1880, however, places this in the genus *Toreuma*.

GENERIC CHARACTERS.

Rhizostomata pinnata with 8 (4 pairs of) adradial, complexly branched mouth-arms the lower or ventral surfaces of which bear numerous mouth-openings and vesicles. There are 4 gonads and 4 separate subgenital cavities. There are more than 8 marginal sense-organs and twice as many radial-canals as sense-organs. The radial-canals are placed in communication one with another by means of an anastomosing network of vessels. A definite ring-canal may or may not be present.

Tilesius, 1834, figured 4 species of *Cassiopea* and represented each of them as having 8 subgenital cavities. Relying upon the figures of Tilesius, L. Agassiz, 1862, separated the genus *Polyclonia*, having but 4 subgenital cavities. Later researches have demonstrated that all the known species of these medusæ have normally but 4 subgenital cavities, and should therefore be placed in the genus *Cassiopea*. Haeckel, 1880, attempts to separate *Cassiopea* from *Polyclonia* by calling medusæ with 16 marginal sense-organs *Cassiopea*, while those with 12 of these organs are called *Polyclonia*. The *number* of marginal sense-organs is, however, very variable, not only among different species of these medusæ but also among individuals of the same species, and therefore can not be used as a means of establishing generic distinctions.

The medusæ of this genus are all inhabitants of warm oceans, and are found in greatest abundance in the tropical coral regions of the East Indies and Red Sea. R. P. Bigelow finds that *C. xamachana* from the West Indies develops through the monodiscus strobilization of a scyphostoma and the young ephyræ of this species and of *C. frondosa* have a simple, central, 4-cornered mouth, thus recalling the adult condition in the Semæostomeæ, from which forms the Rhizostomæ have evidently been derived. The rhopalia of the ephyra are derived from the bases of each alternate tentacle of the scyphostoma, the other tentacles degenerating.

The number of "species" of *Cassiopea* has been multiplied greatly, owing to the remarkable color-range and variability in other respects of these medusæ. These color types appear to be local, and the *Cassiopea* medusæ of almost every new region of the tropics are nearly certain to be described as "new species" based on color peculiarities. It is therefore impossible, at present, to classify the forms of *Cassiopea* with any degree of certainty.

The blue and amber-green coloration of these medusæ is due to the presence of commensal plant organisms. Colasanti, 1886, describes the blue pigment matter as zoocyanin.

Maas, 1903, attempts to separate the genus into two cohorts; one, consisting of *C. mertensi*; *C. mertensi* var. *ndrosia*, *polypoides*, *xamachana*, *ornata*, and *ornata* var. *digitata*, distinguished by its long, cylindrical, pinnately branched mouth-arms. The other group consists of *C. andromeda* and its varieties: *C. depressa* and *C. depressa* var. *picta*. This latter cohort has irregularly branched, short, flat mouth-arms. An idea of the range in color-patterns of these medusæ may be obtained from an inspection of plates 70 to 72 which exhibit photographs of a few of the varieties of *Cassiopea xamachana*, all taken in the course of an hour from the moat of Fort Jefferson, Tortugas, Florida.

Stockard demonstrated that in *C. xamachana* the nearer the injury is made to the center of the disk the more rapid the rate of regeneration. He also found that the more arms we remove, the more does the central disk shrink during the growth of the regenerating arms, and he thus finds that the regenerating tissue absorbs nutriment at the expense of the normal body tissue as do cancerous tissues in their growth.

Mayer finds that the rhythmical pulsation in *C. xamachana* is due to a nervous stimulus, and this stimulus is caused by the presence of a slight excess of sodium in the rhopalia over and above the concentration of this ion in the surrounding sea-water. This excess of the sodium ion is due to the constant formation of sodium oxalate in the sense-club, and this oxalate precipitates the calcium chloride of the sea-water to form the calcium oxalate crystals of the sense-club and sets free sodium chloride.

R. P. Bigelow finds that the vesicles between the mouths of *C. frondosa* serve to capture prey and to thrust the food into the mouths.

Cassiopea andromeda Eschscholtz.

Medusa andromeda, Forskål, 1775, Descript. que in Itinere Orientali Observavit, Hauniæ, p. 107, tab 31, 3 fign.
Cassiopea andromeda, Eschscholtz, 1829, Syst. der Acalephen, p. 43.—Tilesius, 1829, Nova Acta Phys. Men. N. C., tome 15, p. 266, taf. 69, 70.—Milne-Edwards, 1849, Cuvier's Règne Animal Illustré, Zooph., plate 51, fig. 1.—Haeckel, 1880, Syst. der Medusen, p. 569.—Keller, 1888, Zool. Anzeiger, Bd. 11, pp. 359, 389.—Hartlaub, 1909, Zoolog. Jahrbücher, Abth. Syst., Bd. 27, p. 467, taf. 23, fign. 1-8.
Cassiopea forskalca, Péron et Lesueur, 1809, Annal. du Mus. Hist. Nat., Paris, tome 14, p. 356.

Bell flat, shield-shaped, 100 to 120 mm. wide, 20 to 30 mm. high. 15 to 18, usually 16, marginal sense-organs. A variable number of short, blunt lappets. In each paramere are 1 to 6, usually 3, velar flanked by 2 ocular lappets. 8 mouth-arms, wide, flat, and hardly as long as

Synopsis of the Described Forms of Cassiopea.

	C. andromeda.	C. andromeda var. zanzibarica.	C. andromeda var. malayensis.	C. andromeda var. maldivensis.	C. andromeda var. acyclobia.	C. polypoides.	C. xamachana.
Shape of bell.	Flat.	Flat.	Flat.	Exumbrella concave.	With low central dome.	Sucker-like concavity on exumbrella.	Exumbrella concave.
Number of rhopalia.	12 to 18, usually 16.	16	16	12 to 19, usually 16.	16	16	11 to 23, usually about 16.
Number of marginal lappets in each paramere.	5, occasionally 1 to 6.	8	3, 5, 7, or 9	7o to 10	5	5	5
Length of mouth-arms in terms of bell-radius(r).	Less than r.	Less than r.	Less than r.	Less than r.	0.6 r	r+	1 to 0.25 r
Vesicles and filaments among mouths.	Many small; 5 or more large, club-shaped vesicles.	Many small, 5 large clubs. Longer than in C. andromeda.	Many small, 2 to 3 large clubs.	Linear, hand-shaped, and ribbon-shaped appendages. Some very large.	8 large, many small filaments.	Large and small clubs and filaments.	Large and small ribbon-like filaments.
Where found.	East coast of Africa, Red Sea to the Malay Archipelago.	Zanzibar coast, East Africa.	Malay Archipelago.	Maldive Islands, Indian Ocean.	Amboina, Malay Archipelago.	Coral flats of Red Sea.	West Indies to Florida.

	C. frondosa.	C. ornata.	C. ornata var. digitata.	C. depressa.	C. depressa var. picta.	C. mertensii.	C. ndrosia.
Shape of bell.	Flat.	Flat.	Flat.	Flat.	Flat.	Rounded without a concavity on exumbrella.	Exumbrella concave.
Number of rhopalia.	12	16	16	16	14 to 16	16	18 to 22
Number of marginal lappets in each paramere.	5	5	Variable, about 5.	9	Variable, 5 to 12 usually.	8	4
Length of mouth-arms in terms of bell-radius(r).	0.75 r to r.	r+	1 to 0.5	Less than r.	Less than r.	1 to 0.5 r	1 to 0.5 r
Vesicles and filaments among mouths.	Only flat leaf-shaped vesicles.	Very small clubs.	Very small clubs.	Very small clubs.	Very small clubs.	Very large clubs.	Small leaf-shaped vesicles.
Where found.	West Indies to Florida.	Pelew Islands, New Guinea.	Malay Archipelago.	Coast of Mozambique, East Africa, Madagascar.	Red Sea.	Caroline Islands.	Fiji Islands.

bell-radius. 4 to 6 flat, short side branches arise from each arm in a tree-like manner and these in turn give off side branchlets. Numerous small and 5 or more large, club-shaped vesicles on each arm between the mouths. The largest 2 to 3 times as long as width of main branches of arms. 4 small subgenital ostia.

Color very brilliant and variable. Exumbrella is reddish-brown to violet-brown, with milk-white spots, between which are dark, radial stripes. Bell-margin usually bluish or violet. The milk-white spots on the exumbrella are disposed as follows: A large oval spot above each sense-organ and a small, white spot upon each lappet. Thus there are 80 (5×16) small

spots and 16 large ones, 96 in all. Mouth-arms olive-green to reddish-brown, spotted with white.

This East Indian species ranges from the Red Sea to Sumatra, giving rise to a number of color varieties and local races, many of which have been described as distinct species. Keller, 1888, records its having wandered into the Suez Canal from the Red Sea. Hartlaub gives a good description of this species from Djibuti, East Africa.

Cassiopea andromeda var. zanzibarica Chun.

Cassiopea andromeda var. *zanzibarica*, CHUN, 1896, Mittheil, Naturhistorischen Museum, Hamburg, Bd. 13, p. 17.

This resembles *C. andromeda* in most respects, being 40 to 90 mm. in diameter and with a flat disk. But it is said to be distinguished from *C. andromeda* by having 6 velar and 2 ocular lappets between each successive pair of sense-organs instead of 5 lappets as in the typical *C. andromeda*. The 5 large clubs or filaments of the arm-disk are also larger than in *C. andromeda*, being 10 mm. long. The color is also different, but quite variable. The exumbrella is usually brownish-red with 16 to 17 smoky-gray or white radial streaks, which commence at the outer edge of the central concavity of the exumbrella and fork over the lappets. Some specimens have 3 white spots over the velar lappets between each successive pair of sense-organs. Mouth-arms light whitish-red beset with small brownish-white clubs. The large central filaments are black. Zanzibar coast, July to August. This is certainly identical with *C. andromeda*.

Cassiopea andromeda var. malayensis Maas.

Cassiopeja andromeda var. *malayensis*, MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, pp. 40, 43; taf. 4, fign. 24–25, 27–29, 31–34; taf. 11, fign. 98, 102; taf. 12, fig. 112.

This medusa is said to be distinguished by having 1, 3, 5, 7, or more velar lappets between each pair of ocular lappets. Mouth-arms are slightly shorter than bell-radius and compressed dorso-ventrally. A few large, isolated, club-shaped appendages are between the frilled mouths, but these are not commonly found upon all of the mouth-arms. Indeed, there are usually only 2 to 3 of these large clubs upon the mouth-arms of any individual medusa. The umbrella may become more than 200 mm. in diameter, although such large specimens are rare. There are normally 16 small, marginal sense-organs, each containing an entodermal concretion and a distal pigment spot. Young medusæ have about 32 ocular and 16 velar lappets, but as growth proceeds the velar lappets increase by division so as to become 3, 5, 7, or more times as many as in the young medusa. The mouth-arms are compressed dorso-ventrally, those of *C. acyclobbia* laterally. They branch quite irregularly, in a tree-like manner.

Both male and female medusæ are described by Maas, who records numerous examples ranging from 10 to 200 or more millimeters in diameter. The medusa appears to be widely distributed among the islands of the Malay Archipelago. Color (?) It is evidently identical with *C. andromeda*.

Cassiopea andromeda var. maldivensis.

Cassiopea andromeda var. *maldivensis*, BROWNE, 1905, Fauna and Geog. Maldive and Laccadive Archipelagoes, vol. 2, p. 962.

The disk is about 75 mm. wide with a central concavity on the exumbrella. The marginal sense-organs range from 12 to 19 but are usually about 16. The marginal lappets are very indistinct and range from about 7 to 10 between each successive pair of sense-organs.

There are 4 pairs of complexly branching mouth-arms which project slightly beyond the umbrella margin. The proximal branches of the mouth-arms are generally alternate in position, while those of the outer branches are generally dichotomous. There are numerous disk-shaped, flat, spatula-like appendages over the mouth-arms. These are adjacent to the oscula. There are also cylindrical or somewhat flattened linear appendages and hand-shaped appendages, which are almost leaf-like and may be 25 mm. long and 9 mm. wide. There are not more than 5 to 6 of these cylindrical or hand-shaped appendages on each of the 8 mouth-arms. At the center of the mouth-arm disk there is a single long appendage which may either be cylindrical or hand-shaped.

The 4 subgenital ostia are very small and triangular in shape, about 3 mm. wide. The gonads are similar to those of *Cassiopea xamachana*. The peripheral canal-system consists

of a radial-canal to each sense-organ and an equal number of intermediate radial-canals. These radial-canals are put into communication one with another by means of an anastomosing network of vessels, without any distinct ring-canal.

The medusa is dark-green without spots or pattern of any sort. This green color is due to an infesting alga, one of the *Zooxanthellæ*. The chlorophyl is readily dissolved out in alcohol.

This medusa is abundant in muddy bottoms in shallow bays and back waters at Febidu, Maldive Islands, Indian Ocean. It is a well-marked variety of *C. andromeda* being distinguished by the hand-shaped appendages on its mouth-arms.

Cassiopea andromeda var. acycloblia Schultze.

Cassiopeja acycloblia, Schultze, L. S., 1898, Denkschrift. Med. Nat. Ges. Jena., Bd. 8, p. 459, taf. 33, fign. 2, 4, 6; taf. 34, fig. 15.
Cassiopeja andromeda var. *cyclobalia*, Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 40.

Bell flat with low central dome (?) at middle of the exumbrella. 16 marginal sense-organs and 80 (5×16) marginal lappets. Exumbrella flecked with 16 large, oval, radially placed, white spots above the sense-organs. A wide ring of white binds these spots together. There is also a small, white fleck on the exumbrella side of each lappet. Those of the interradial lappets fuse with the white ring. Mouth-arms only three-fifths as long as bell-radius. Diameter of arm-disk less than disk-radius. The mouth-arms branch dichotomously each with one large and many small filaments. Amboina, Molucca Islands.

Cassiopea polypoides Keller.

Cassiopea polypoides, Keller, 1883, Zeit. für wissen. Zool., Bd. 38, p. 632, taf. 36, 37, fign. 6–23.

Disk flat, shield-shaped, 100 to 150 mm. wide. A well-developed, sucker-like depression at center of exumbrella, the thickened, outer edge of which is 15 to 20 mm. inward from bell-margin. Margin of umbrella is thin, but at the center there is a disk-like thickening of the gelatinous substance of the exumbrella. There are 16 marginal sense-organs each with a red-brown ectodermal pigment spot and a terminal entodermal mass of concretions. 80 short, rounded, marginal lappets, 3 velar and 2 ocular in each of the 16 parameres. The thick mouth-arm disk is octagonal with 8 equal sides. The 8 mouth-arms are about as long as radius of umbrella and project beyond the bell-margin; they are somewhat higher than wide at their distal ends. Each arm usually gives rise to 3 pairs of alternately arranged, pinnate branches, with frilled mouths on their under sides. There are numerous clubs and filaments on the under sides of the mouth-arms, the largest filaments being over 30 mm. long. The 4 subgenital ostia are small, oval, and elongated in a radial direction. Central stomach 4-sided. 32 radiating canals extend outward from the stomach, 16 to the sense-organs and 16 to intermediate parts of the margin; these 32 vessels connect one with another by an anastomosing network of vessels, but there are no specialized ring-canals.

Exumbrella light-brown with a broad, white ring which gives out 16 cog-wheel-like, forked branches on its outer edge in the radii of the 16 sense-organs. There is also a short, white, radial spot on the exumbrella side of each marginal lappet. 16 dull white, spoke-like pigment areas in the gelatinous substance of the exumbrella extend outward from the edges of the central thickening to near the margin in the radii of the sense-organs. The suctorial mouths are intense brown. Appendages and filaments of mouth-arms very variable in color, being sky-blue, greenish-blue, horny-yellow, translucent white, or rose-red. In one variety the exumbrella is olive colored with indistinct radiating spots.

Keller distinguishes five varieties based on color and differences in number of the mouth-arm filaments as follows:

Cyanea. With 5 or 6 large, sky-blue or green-blue filaments on each mouth-arm. The white oral tufts are numerous, the clubs rarer. This is the commonest form.
Flava. The large filaments are twisted, never flattened, their color is horny-yellow or translucent. Common.
Albida. The large filaments are twisted and white in color. Rare.
Rosea. Exumbrella olive colored, radial spots indistinct. Some of the filaments are round, some flat, and of rose-red color. Club-shaped vesicles rare. Rare variety.
Herbacea. The mouth-arm appendages poorly developed. No filaments. The mouths of the arms large. Rare variety.

This medusa was found in large swarms by Keller on the shallow coral flats of the southern parts of the Red Sea. It differs from the typical *C. andromeda* in the thick-rimmed sucker of the exumbrella, and the long, laterally compressed arms. Keller describes it in detail with good figures. In common with other Cassiopeidæ it lies upon the bottom with its oral surface uppermost. Keller draws comparisons between its habits and structure and those of actinians, etc. This medusa is probably only a local variety of *C. andromeda*, but the thick, sucker-like disk at the middle of the exumbrella appears to distinguish it.

Cassiopea xamachana R. P. Bigelow.

Plate 69, figs. 4 to 8; plates 70 and 71; plate 72, the seven lower figures.

Cassiopea xamachana, Bigelow, R. P., 1892, Zoolog. Anzeiger, Bd. 15, p. 212; Johns Hopkins University Circulars, 1892, vol. 11, pp. 71, 84; 1893, Journal Institute of Jamaica, vol. 1, p. 301, 1 plate; 1900, Memoirs Boston Soc. Nat. Hist., vol. 5, No. 6, p. 191, figs. A to L, plates 31 to 38, 66 figs.—Perkins, 1905, Year Book of the Carnegie Institution, No. 4, p. 118. Publication, No. 102, p. 150, plate 4.—Mayer, 1906, Year Book of the Carnegie Institution, No. 4, p. 117; Publication of the Carnegie Institution, No. 47, 62 pp. (rhythmical pulsation); 1907, Year Book Carnegie Institution, No. 6, p. 121; *Ibid.*, 1908, No. 7, p. 123.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 40.—Stockard, 1907, Year Book Carnegie Institution of Washington, No. 6, p. 119 (regeneration); *Ibid.*, No. 7, 1908, p. 130.—Papers from Tortugas Laboratory of Carnegie Institution of Washington, vol. 2, p. 61, figs. 1–29; Journal of Experimental Zoology, 1909, vol. 6, p. 433, 8 figs.—Zeleny, C., 1907, Journal Experimental Zoology, vol. 5, p. 265, 4 text-figs. (regeneration)—Dahlgren and Kepner, 1908, Text-Book of Principles of Animal Histology, p. 88, fig. 85 (histology of muscles).—Mayer, 1908, Papers from the Tortugas Laboratory of the Carnegie Institution of Washington Publication, No. 102, p. 113 (the cause of rhythmical pulsation); Popular Science Monthly, vol. 73, pp. 481–487, 4 figs.; 1909, Report of 7th International Zoological Congress, 4 pp.—Harvey 1909, Year Book of the Carnegie Institution of Washington, No. 8, p. 129.

Cassiopea frondosa, Fewkes, 1882, Bull. Museum Comp. Zool. at Harvard College, vol. 9, p. 254, plate 1, figs. 7–19; plate 2, figs. 1, 2; plate 3, figs. 1–3, 9, 10; *Ibid.*, 1883, p. 80, plate 1, fig. 16.

The disk is usually about 150 mm. in diameter, although Bigelow records one from Jamaica 240 mm. wide. It is flat and with rounded edges. There is a well-marked concavity at the middle of the exumbrella, the diameter of which is about equal to the disk-radius. It enables the medusa to cling firmly to any smooth surface as by a sucker.

The number of the marginal sense-organs ranges from 11 to 23, although there are usually about 16. For example, in 25 medusæ taken at random and ranging in size from 23 to 149 mm., one had 13 marginal sense-organs, 1 had 14, 1 had 15, 12 had 16, 5 had 17, 1 had 18, 2 had 19, 2 had 20. I have seen one medusa with 11 and one with 23 sense-organs. The number is independent of the size of medusa, being determined at time of strobilization.

The sense-organs are short, blunt, and club-shaped, and are set within niches protected above by a shelf-like membrane spanning the cleft between the adjacent lappets. There is no exumbrella pit above the club. Each sense-organ contains a terminal mass of entodermal crystals and an aboral cup-shaped ectodermal ocellus having reddish-brown pigment. There are 5 short, blunt, rounded lappets between each successive pair of sense-organs; the 2 lappets adjacent to the sense-organs are only about half as wide as the others. The mouth-arm disk, which projects as a flat plate from the center of the subumbrella, is only about two-thirds as wide as the disk-radius. 4 pairs of adradial mouth-arms arise from this disk. Each of these 8 mouth-arms is about 1.25 times as long as radius of bell and projects somewhat beyond bell-margin. These mouth-arms are triangular in cross-section, their aboral surface being broad and flat; they each give rise to 10 to 15 alternate, primary branches, which in turn give rise to secondary branches. These branches are commonly longer than in *C. frondosa* and are also longer and stouter than in *C. andromeda* Eschscholtz and more slender and have more primary branches than in *C. polypoides* Keller. In the axil of each primary branch of the mouth-arms is a single, flat, ribbon-like filament, which varies in length with the size of the adjacent branch. There are also 5 to 13 large, ribbon-shaped filaments upon the oral surface of the mouth-arm disk. The largest filament is at the center and is fully one-fourth as long as the bell-diameter. The filaments decrease successively in length out over the mouth-arms; those at the tips of the arms being only about one-seventh as long as those at the center. In addition to the filaments there are numerous short club-shaped, nematocyst-bearing vesicles scattered among the mouths.

The mouths are found upon the oral (uppermost as the medusa lies upon the bottom) sides of the primary and secondary branches of the mouth-arms, and to some extent upon the oral sides of the 8 basal trunks of the arms. There are no mouths at the center of the

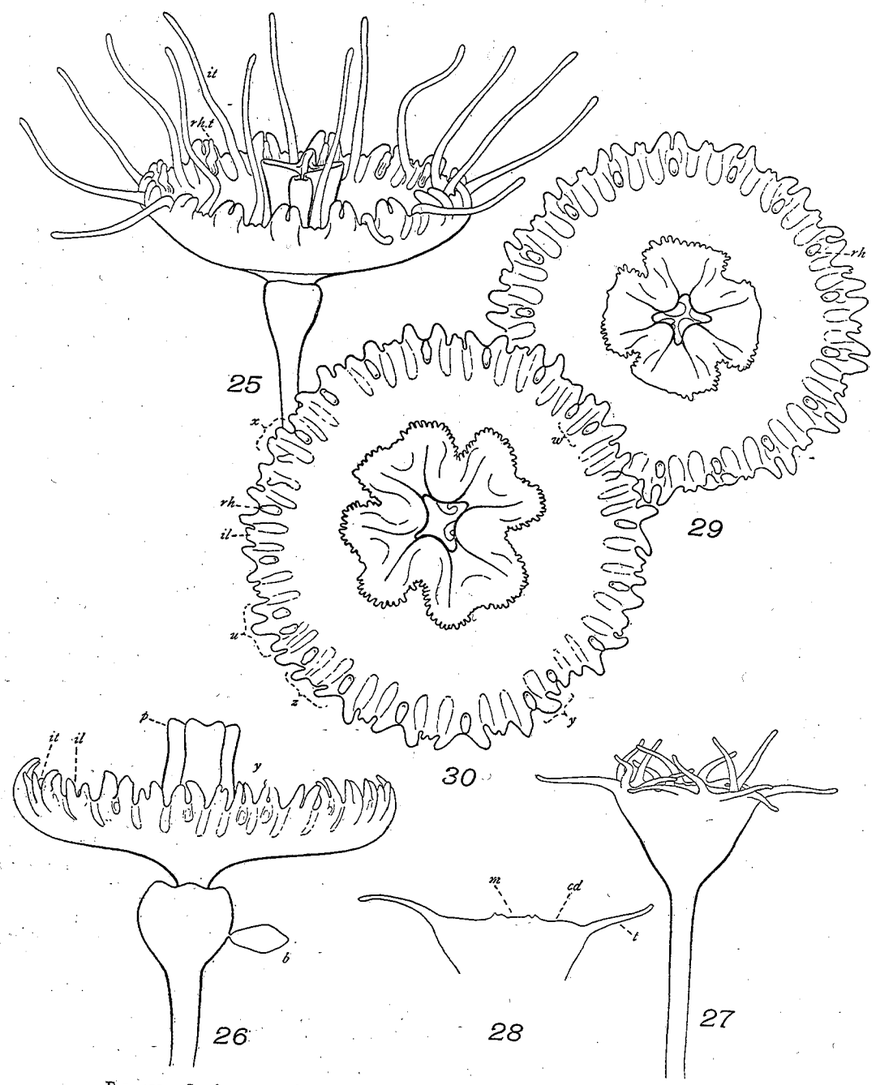


FIG. 402.—*Cassiopea xamachana*, after R. P. Bigelow, in Mem. Boston Soc. Natural History.

b, bud growing from side of scyphostoma; *cd*, circum-oral disk or peristome; *il*, interrhopalial lobe; *it*, interrhopalial tentacle; *m*, mouth; *p*, proboscis; *rht*, rhopalial tentacle; *t*, tentacle. 25, strobila, in which the degeneration of the rhopalial tentacles is nearly complete and the interrhopalial tentacles have begun to degenerate. 26, a complete strobila. The basal polyp bears a bud which broke off and swam away while the drawing was being made. The ephyrula was detached during the following night. The rhopalia are visible through the umbrella. At *y* is a pair of twin rhopalia (compare *y*, fig. 30). 27, basal polyp of same specimen, a few hours after separation of the ephyrula. 28, optical section of same. 29, an ephyrula recently set free; oral aspect, gastric filaments visible through mouth; × 31. 30, specimen of about same age, showing variations of margin at *u*, *w*, *y* and *z*; × 31.

mouth-arm disk in the full-grown medusa, although they are commonly found near the edges of the disk. The mouths are fringed with a multitude of fine, waving tentacles.

There are 4 small, deep, oval-shaped, interradial subgenital pits, and 4 separate invaginated genital sacs. Central stomach is cruciform, being encroached upon at the interradial sides by the 4 sac-like gonads. The axial ducts of the 8 mouth-arms empty into this central stomach at the 4 principal radii. The central stomach also gives rise to twice as many radial vessels in the subumbrella as there are marginal sense-organs. Every alternate vessel extends to a sense-organ, the others going to intermediate parts of the rim. All of these radial vessels are put into communication one with the other by numerous anastomosing branches; but there is no well-defined circular vessel such as is figured by Haeckel in *Cassiopea ornata*.

There is a well-developed zone of circular muscle-fibers in the outer half-radius of the subumbrella. These have a more and more cuspate trend as we near the center of the disk, there being twice as many cusps as there are radial vessels, the outward convexities of the cusps being between the vessels.

The general color of the medusa is greenish-gray-blue, the greenish color being due to clusters of commensal plant-cells within the gelatinous substance of the disk near the surface. If the medusa be maintained in darkness for a month this green color disappears, leaving the animal a pale, translucent blue-gray. Around the outer edge of the central concavity of the exumbrella is a wide, dull white circle, edged on its inner side with faint gray-brown. A more or less Y-shaped, radial, white stripe extends outward from the broad ring in the radii of the sense-organs, the sense-organ being in the center of the crotch of the Y. In addition a single, radial stripe extends outward down the middle of the exumbrella side of each marginal lappet. Occasionally these radial stripes are more or less separated from the broad, white circle. Conspicuous spoke-like, white stripes extend outward in the radii of the sense-organs. These are white regions found in the gelatinous substance of the bell and extend half-way through the gelatinous substance from the subumbrella toward the exumbrella surface. The mouths, filaments, and vesicles are olive or olive-brown, the vesicles and filaments being of a decided green. Among the many color varieties there is a rare one in which the spoke-like, dull white spots are diamond-shaped, and there is no broad, white ring on the exumbrella. The whole medusa is more translucent than are the more abundant medusæ with the white ring. They are also smaller than the common form. Curiously enough this color variety bears a striking resemblance to *Cassiopea ndrosia* Agassiz and Mayer, from the Fiji Islands, South Pacific. Various forms of its color patterns are shown in the photographs in plates 70 to 72 taken from life by the author.

I find that *Cassiopea* can thrive well in darkness for more than a month, hence the medusa is not dependent upon its commensal plant cells for the oxygen it requires. In this connection Whitney, 1907 (Biol. Bulletin, vol. 13, No. 6, p. 291), finds that if green *hydra* be placed temporarily in a 0.5 to 1.5 per cent solution of glycerin, the green algæ (*Chlorella vulgaris*) pass out through the mouth. Then if the *hydra* be replaced in water it will grow normally, but remains clear and does not regain the green bodies even when placed in an aquarium with algæ.

This medusa was discovered in great abundance by Dr. R. P. Bigelow in a salt-water lagoon called the Great Salt Pond, near Port Henderson, Kingston Harbor, Jamaica. It is also exceedingly common in the salt-water moat of Fort Jefferson, Tortugas, Florida, where it is found upon the weedy bottom throughout the summer; and it occurs in many semi-stagnant, salt lagoons along the Florida Reef as far north as Miami.

The early stages of the development of the egg into the scyphostoma are as yet unobserved, but the process of the formation of asexual buds by the scyphostoma has been elaborately studied by Bigelow and observed also by Perkins. The buds arise from the perradial sides of the calyx of the scyphostoma near the point of origin of the stem. Scyphostomæ are never found with more than two buds attached. When two are present the older is always attached to the apex of the younger bud. The bud is at first hemispherical, hernia-like; then elongated, and finally spindle-shaped. The ectoderm, entoderm, and mesoglœa of the bud are produced from the corresponding layers of the parent scyphostoma, and the 4 ectodermal, septal muscles of the bud are derived from out-growths of one or both of the septal muscles of the parent which lie in the interradii adjoining the perradial area of bud formation. The

bud is set free as a spindle-shaped larva which swims by means of cilia. After 2 or 3 days the mouth breaks through at the pole which was at the proximal end of the bud while it was attached to the parent, thus resembling the case of budding in *Cotylorhiza*. The mouth is not formed by an invagination of the ectoderm, but breaks through by the local disappearance of the mesoglœa and the fusion of ectoderm and entoderm at the posterior end of the larva. The anterior end then elongates to form the stem of attachment, and in about 4 or 5 days after being set free the larva fastens itself to some solid object.

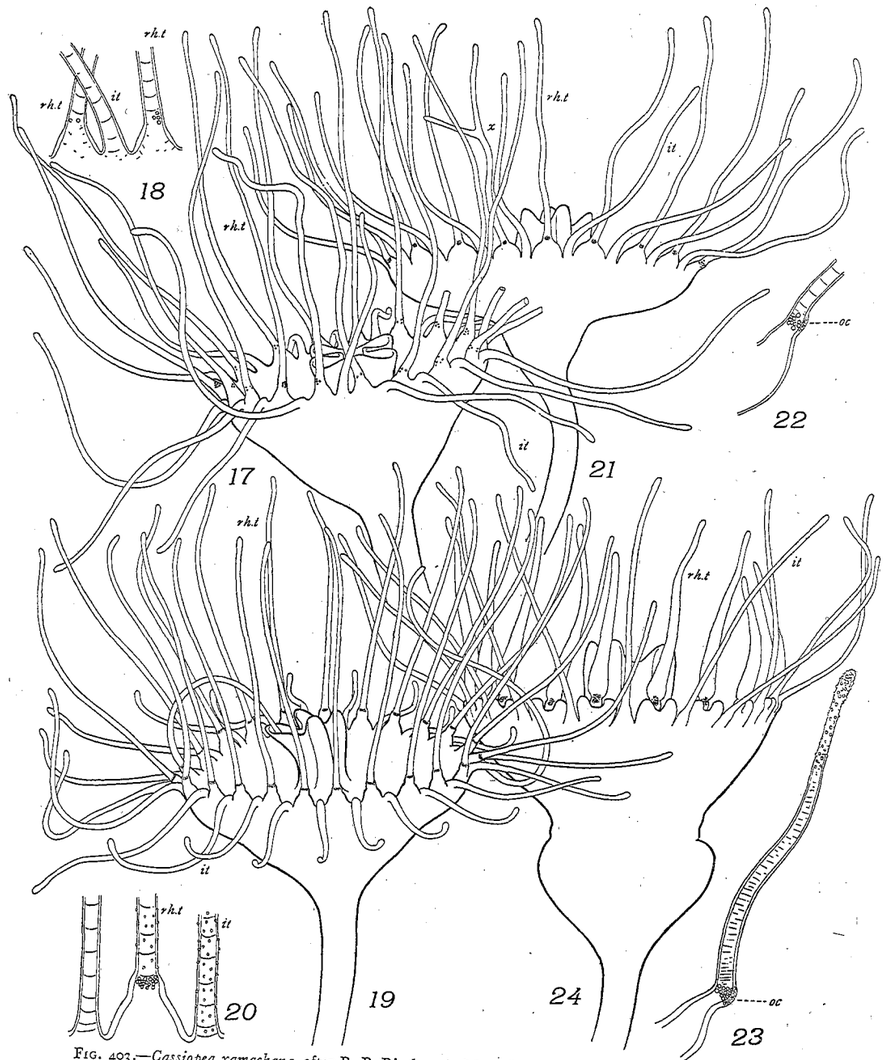


FIG. 403.—*Cassiopea xamachana*, after R. P. Bigelow, in Mem. Boston Soc. Natural History.
it, interrhopalial tentacle; *oc*, ocellus; *rht*, rhopalial tentacle; *x*, abnormal branched tentacle. 17, scyphostoma showing first traces of rhopalial structure. 18, small part of margin, more highly magnified. 19, scyphostoma at slightly older stage. 20, small part of margin of similar larva. 21, early stage in strobilization. 22, rhopalial tentacle of same specimen seen from side. 23, older rhopalial tentacle. 24, strobila in which rhopalial tentacles have begun to degenerate.

Usually the 4 perradial tentacles are soon supplemented by the 4 interradial ones, and in about 3 days after they first appear the 8 tentacles are as long as the proboscis of the scyphostoma. 8 adradial tentacles then develop. The number and arrangement of the tentacles is, however, very variable but finally there are about 32. In any case there are twice as many tentacles as there are to be rhopalia. The full-grown tentacles are tapering, slender, and about 3 times as long as the body of the scyphostoma. Half of them are erect, and the alternate half stretch more horizontally outward.

The 4 primary, gastric pouches are not formed by evagination from ectoderm and entoderm alternately, as in the sexually produced scyphostoma of *Aurellia*, etc., according to Goette, but are wholly entodermal as Hadži finds them to be in *Chrysaora*, and simply separated one from another by the ingrowth of the 4 interradial septa. At first the septa are simple, entire buttresses of entoderm with an axial sheet of mesoglœa, but later each septum becomes perforated immediately under the interradial tentacles, thus forming a ring-sinus. There are 4 longitudinal strands of septal muscles, 1 in the mesoglœa of each septum.

The septa bear no definite relation to the exact position of the interradial tentacles, for these may arise on either side of or in the plane of a septum. In this respect the scyphostomæ resemble those of *Aurellia* and *Cotylorhiza* according to Claus, and differ from the *Anthozoa*, in which the tentacles are invariably interseptal. Every alternate tentacle stands erect while the others extend outwardly. When the scyphostoma disk is about 2 mm. wide, conical enlargements which contain crystalline concretions are observed in the entoderm at the bases of the erect tentacles. An ectodermal ocellus develops upon the aboral (lower) side of each conical enlargement and the tentacle itself begins to degenerate, becoming finally absorbed, leaving only the sense-club with its ectodermal ocellus and terminal mass of entodermal concretions. When the tentacles begin to degenerate, slight pulsating movements of the disk commence. The marginal lobes grow out while the rhopalia are being formed, and finally the interrhopalial tentacles are also absorbed.

Strobilization is monodiscus, but the scyphostoma after setting free the ephyra develops new tentacles and gastric pouches, and may strobilate a second time.

The young ephyra has the same number of marginal sense-organs as the adult medusa. It has 4 simple lips and a central mouth-opening. Then the angles of the lips become extended to form 8 oral arms, very much as in the adult *Aurosa*. Then there is a stage wherein the œsophagus is divided into 4 tubes with 3 osculæ and an oral vesicle on each arm. *Rhizostoma* and *Cotylorhiza* go through a similar stage. The septal muscles and their funnel-cavities disappear wholly in the ephyra, as do also the 4 interradial septa.

Mayer, 1906, 1907, 1908, finds that the stimulus which produces pulsation in *Cassiopea* is nervous in nature and will pass over newly regenerated tissue which contains nervous, but no muscular elements. Moreover, if the muscles be paralyzed by magnesium the pulsation-stimulus still travels through the nervous network of the subumbrella, even though the muscles can not respond to its presence by contraction.

If an annulus, or strip of any shape constituting a closed circuit, be cut from the subumbrella and stimulated momentarily at any one point, 2 waves of contraction start in opposite directions around the strip from this stimulated point. By pressing upon one side of the ring we dampen and reduce the strength of the initial wave passing over that side, and when the two waves meet the stronger wave overpowers and annuls the weak one. Thus a single contraction-wave is entrapped in the ring-circuit and travels constantly around it at a uniform rate. The mechanical arrangement of the pulsating medusa in nature is such as to prevent the formation of such continuous pulsation-waves—the pulsations are recurrent and each contraction-wave is annulled as soon as it has produced a single contraction of the medusa.

The sea-water is a balanced fluid for the medusa, neither stimulating nor inhibiting its pulsations. This balance is due to the fact that the ionic *sodium* of sea-water is a powerful nervous and muscular stimulant, but the *magnesium*, *calcium*, and *potassium* are inhibitors and annul the stimulus produced by the *sodium*. If *calcium* be absent the *magnesium* quickly checks all pulsation. On the other hand, a slight increase in the *sodium* serves as a nervous stimulus which overcomes the inhibiting tendency of the *magnesium*, *calcium*, and *potassium* and produces contraction.

The pulsation-stimulus is engendered in the marginal sense-organs. A uric oxalate of sodium is developed constantly in the entodermal cells of the outer end of each sense-club. This oxalate precipitates calcium, thus forming the crystalline concretions which consist of calcium uric oxalate, and at the same time it sets free such soluble stimulants as NaCl and Na_2So_4. Thus we find that the sense-clubs are engaged in the maintenance of a slight concentration of *sodium* over and above that found in the sea-water itself. This slight excess of the *sodium* ion is a stimulant to the nervous elements within the sense-club and the nervous elements respond to it recurrently, producing the rhythmical contractions of the muscles.

If a disk without marginal sense-organs be set into pulsation and then disturbed by a sudden current in the sea-water, etc., it displays excitement by markedly increasing the amplitude of its pulsations. Hence its ability to display excitement is not dependent upon the sense-organs, but upon the general nervous tissues of the subumbrella.

When the marginal sense-organs regenerate, each one appears with a short, hernia-like side branch, which disappears later. In this connection it is interesting to see that the sense-organs are normally formed as side buds from the bases of each alternate tentacle of the scyphostoma, and then the tentacles themselves are absorbed. Thus when they regenerate they display a tendency to replace the *tentacle* as well as the sense-club.

In 1909 I succeeded in grafting two individuals of *C. xamachana*, side by side, so that their subumbrellas joined. The double-medusa then pulsated constantly at the rate of the faster individual which initiated and controlled all of the rhythmical movements; but if one pinched the controlled medusa its rate increased and it then assumed a temporary control of the double animal. Hence the complex always pulsated at the rate of its fastest member. Hargitt attained a similar result with 2 individuals of *Gonionemus murbachii*, but in this case the rims were attached around nearly their entire edges so that any movement of one medusa must necessarily cause a corresponding movement of the other. In the two Cassiopeas, however, the contact was at a single narrow bridge of tissue only, and indeed the medusæ pulsated independently until the nerve-nets of their subumbrellas joined in the process of regeneration.

The color of the umbrella of *C. xamachana* is mainly due to the presence of numerous symbiotic algæ, *Zooxanthellæ*, which Bigelow finds contain starch, cellulose, and chlorophyl. These plant cells are globular and occur in small clusters imbedded in the mesoglœa and are greenish-brown in color.

A well-marked, conical, pit-like depression is occasionally seen upon the aboral side of each mouth-arm near its point of origin from the arm-disk, but more commonly in male than in female medusæ. The female medusæ greatly outnumber the males. Perkins believes that the medusæ may be hermaphroditic, but of this we have no evidence. *Pseudorhiza haeckelii* is, however, known to be hermaphroditic, the spermaries being in the gutters of the mouth-arms.

Zeleny, 1907, finds that medusæ maintained in pulsation appear to regenerate at about the same rate as if the disk were at rest. Certainly the functional activity of pulsation seems to be of no aid in accelerating regeneration, for Stockard also finds that the medusa regenerates at practically the same rate whether it be pulsating or at rest.

Stockard, 1907, discovered that tissues removed from various parts of the subumbrella regenerate more rapidly the nearer they are to the disk-center, and less rapidly as the periphery is approached, thus according with the rule discovered by Morgan in the regenerating fish's fin—the deeper the level of the cut the more rapid the regeneration.

In 1908, Stockard made the interesting discovery that if the medusæ be starved while they regenerate lost arms the disk of the medusa shrinks during the process of regeneration, and its rate of decrease is greater the greater the number of removed arms. The regenerating tissue evidently possesses a greater capacity for absorbing nutriment than does the somatic tissue of the disk itself, and in this respect the regenerating tissue behaves as does that of cancer which grows rapidly even when the normal tissues surrounding it are wasting away. (See Year Book of the Carnegie Institution of Washington, No. 7, p. 131, 1908.)

Cassiopea frondosa Lamarck.

Plate 69, figs. 1 to 3; plate 72, the 3 upper figures.

Medusa frondosa, Pallas, 1774, Spicilegia Zoolog., fasc. 10, pp. 29, 30, plate 2, figs. 1–3.—Gmelin, 1788, Linné's Syst. Naturæ, tomus 1, pars 6, p. 3157.—Bosc, 1802, Hist. Nat. d Vers., tome 2, p. 170.

Cassiopea frondosa, Lamarck, 1816, Hist. Nat. Anim. sans Vert., tome 2, p. 512.—Eschscholtz, 1829, Syst. der Acalephen, p. 43.—Tilesius, 1834, Acad. Caes. Leop. Nova. Acta., tom. 15, pp. 263, 278, tab. 72, fign. 1–5.—Lesson, 1843, Zooph. Acal., p. 405.—Milne-Edwards, 1849, Cuvier's Règne Animal, Zooph., plate 51, fig. 3.—Perkins, 1906, Year Book, Carnegie Institution of Washington, No. 4, p. 115; 1908, Publication No. 102, Carnegie Institution of Washington, p. 152, plate 4.

Cassiopea pallasii, Péron et Lesueur, 1808, Annal. der Mus. Hist. Nat., Paris, tome 14, p. 357, Nr. 85.

Polyclonia frondosa, Agassiz, L., 1860, Cont. Nat. Hist. U. S., vol. 3, plates 13, 13*a*; 1862, *Ibid.*, vol. 4, pp. 139–148, 159.—Agassiz, A., 1865, North Amer. Acal., p. 41; 1881, Nature, vol. 24, p. 509. See also Archer, H., *Ibid.*, p. 307.—Haeckel, 1880, Syst. der Medusen, p. 568; 1881, Report H. M. S. *Challenger*, Zool., vol. 4, p. xviii.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 40.—Bigelow, R. P., 1893, Johns Hopkins University Circulars, vol. 2, No. 106, p. 106 (habits, physiology).—Perkins, 1906, Year Book, Carnegie Institution of Washington, No. 4, p. 115; 1908, Publication No. 102, Carnegie Institution of Washington, p. 152.

Disk flat, with rounded edge, and about 120 to 260 mm. in diameter. There is no concavity at the center of the exumbrella, such as is seen in *Cassiopea xamachana*. There are *constantly* 12 marginal sense-organs in *C. frondosa*, 4 perradial, 8 adradial, each of which contains a terminal entodermal mass of crystalline concretions. There are no ocelli. There are 60 short, subrectangular, nearly straight-edged, marginal lappets, 5 between each successive pair of marginal sense-organs. The lappets flanking the sense-organs are only half as wide as the other lappets. The 4 pairs of mouth-arms arise from a shallow, flat, mouth-arm-disk at the center of the subumbrella; this arm-disk is not quite as wide as the semi-diameter of the medusa. The mouth-arms, which are about three-fourths as long as bell-radius, usually bifurcate at their free ends and give rise to short, pinnate side branches from their oral sides; but occasionally the branches are quite long as in *Cassiopea xamachana*. The numerous frilled mouths are found exclusively upon their lower sides, the upper sides of the mouth-arms being smooth and without mouths. Scattered quite uniformly between the mouths are 30 to 40 small, expanded, flat, leaf-shaped vesicles. There are 4 small, round, interradial, subgenital pits, and 4 separate, invaginated genital sacs which project into the stomach-cavity. A duct extends from each of the 8 mouth-arms into the central stomach, and 24 radial-canals pass outward from the stomach into the subumbrella and are put into communication one with another by a network of anastomosing vessels. 12 radial-canals go to the marginal sense-organs and 12 are intermediate in position.

General color of gelatinous substance amber-yellow, slightly olive, or greenish. Just above each of the 12 marginal sense-organs is usually a single, large, bilateral, bean-shaped white spot in the gelatinous substance of the exumbrella. There is also a smaller white spot in each marginal lappet, and above this an irregular line of 3 to 5 smaller white spots between each successive pair of marginal sense-organs. A more or less broken, axial, white line extends through the length of each mouth-arm in the gelatinous substance. The frilled mouths are of a cinnamon color and the leaf-like vesicles are opaque, dull white. The spots upon the bell are very variable in number and arrangement (see plates 69 and 72).

Cassiopea frondosa is found throughout the West Indian region and the Florida Reefs. Perkins observes that it lives upon sandy rather than weedy bottoms. In common with other species of the genus it lies upon the bottom with the oral surface and mouth-arms uppermost. In this position it remains for long intervals of time, slowly contracting its disk in a sluggish rhythm. This movement serves not only to maintain the disk upon the bottom, but to create a water-current over the mouth-arms. It prefers purer water than *C. xamachana*, and is usually found in protected places among the mangroves in the cuts between the Florida Keys.

In Kingston Harbor, Jamaica, this medusa is found upon the muddy bottoms of protected lagoons, especially in those surrounded by mangroves, near the harbor entrance where the water is quite pure. In Jamaica it attains to a far greater size than in Florida. A specimen which I found in a mangrove lagoon near Port Royal in March, 1909, was of the following dimensions in mm.: Bell 259 wide, arm-disk 95 wide, mouth-arms 129 long, pinnately and complexly branched, and projecting beyond the rim of the bell. Color as in the Florida specimens. I am told that the medusa becomes even larger in Jamaica.

L. Agassiz (1862, p. 147) showed that the young ephyra of this species possesses a central mouth-opening which disappears in the adult.

C. frondosa can at once be distinguished from *C. xamachana* by its amber color, the absence of ocelli on its rhopalia, the absence of a sucker-like concavity upon its exumbrella, and by the fact that it has constantly 12 marginal sense-organs, whereas *C. xamachana* has 11 to 23 (see plate 69). It is far less hardy in aquaria than *C. xamachana*.

According to Bigelow, 1893, in the adult female the mouths disappear from the oral disk while at the same time the oral vesicles increase in number until they are closely crowded together and completely cover it. The eggs are discharged from the ovaries into the stomach, where cleavage begins; they then pass out on to the oral disk and are to be found there in large numbers, cemented together in small, reticulated clusters at the bases of the vesicles; they remain there until some time after they have become ciliated planulæ. Bigelow reared the scyphostomæ of this species to the 8-tentacle stage. The young scyphostoma appears to be entirely similar to those of other species of *Cassiopea*.

Dr. R. P. Bigelow has shown that while the vesicles on the oral surface of the disk serve to protect the young, those of the mouth-arms serve to capture food. These vesicles usually stand upright, but upon being struck by an unwary copepod they bend down and close the mouth of the nearest funnel in the manner of a lid. The prey thus finds itself within one of the mouths, tightly shut in by the overlying vesicle.

Cassiopea ornata Haeckel.

Cassiopea ornata, HAECKEL, 1880, Syst. der Medusen, p. 570, taf. 37, fign. 1–8.—HAMANN, 1881, Jena. Zeit. für Naturw., Bd. 15, p. 248 (structure of the mouth-arms).

Bell 100 to 120 mm. wide, 30 to 40 mm. high, flat and shield-shaped. 16 rhopalia, 80 lappets, 96 white spots, as in *C. andromeda*. Mouth-arms cylindrical, slender, and somewhat longer than bell-radius, not broad and flat as in the typical *C. andromeda*. There are only small, club-shaped vesicles between the mouths. The characteristic feature of this species is said to be the presence of 2 distinct ring-canals. The inner ring-canal connects the 16 principal radial-canals at an annulus some distance inward from the margin, while the outer ring-canal is at the margin. The 16 inter-rhopalar radial-canals are narrower than the rhopalar, and soon lose themselves in the network of anastomosing vessels of the subumbrella, whereas the 16 rhopalar canals extend straight out to the sense-organs. The network of vessels becomes fine-meshed on the inner side of the ring-canal, but on its outer side it gives off a wide-meshed network, the meshes of which become finer as they near the bell-margin, where there is a marginal ring-canal. These hypothetical ring-canals are so peculiar and unlike the simple network seen in other species of *Cassiopea* that the fact of their existence requires confirmation. Haeckel alone has observed them. The medusa is from the Pelew Islands and New Guinea.

I find among the collections of the U. S. Fisheries Bureau steamer *Albatross* seven specimens of a medusa which appears to be a closely related variety of, if not identical with, *C. ornata*. None of these has the remarkable ring-canals figured by Haeckel, and this leads me to doubt their existence in Haeckel's medusa. The dimensions in mm. of the largest of these medusæ are as follows: Bell 76 wide; exumbrella flat, smooth and without an aboral sucker-cavity; arm-disk 39 wide; mouth-arms 31 long, stout and flattened laterally, with 9 to 12 short, stout, blunt, dentritically arranged side branches. A few very small, flat, club-like appendages less than 1 mm. long scattered among the mouths of the mouth-arms; but these become larger near the arm-disk. The arm-disk itself is thickly covered with irregularly shaped tuber-like, or truffle-shaped, appendages, the largest being 3 to 4 mm. long. There are 16 rhopalia. 5×16 blunt, square-edged, marginal lappets. 32 tree-like radial-canals which give off an anastomosing network, but no distinctly differentiated ring-canal. These medusæ were obtained in the following localities in the Philippine Islands in 1908: 3 large specimens from near shore at Tataan, Simaluc Islands, February 19 and 20; 3 from Subic Bay, January 7, in a seine, and 1 from Catbalogan, Samar, on April 16.

Cassiopea ornata var. digitata Maas.

Cassiopea ornata var. *digitata*, MAAS, 1093, Scyphomedusen der *Siboga* Expedition, Monog. 11, pp. 40, 45, taf. 4, fign. 26, 30.

Bell about 100 mm. wide, very flat, without an aboral concavity or a dome. 16 marginal sense-organs, 32 rhopalar and 3×16, or more, velar lappets which are, however, quite irregularly arranged. 16 long, violet-colored, radial stripes upon the subumbrella. The mouth-arms branch in a hand-shaped manner, the terminal branches resembling fingers in shape. These mouth-arms are 1.5 times as long as the disk-radius. There are no large club-shaped appendages between the mouths, all being very small. The mouths are brown to violet.

This variety is distinguished from the typical *C. ornata* by its color and by its finger-shaped mouth-arms. It is found among the islands of the Malay Archipelago, at Saleyer, and elsewhere.

Cassiopea depressa Haeckel.

Cassiopea depressa, HAECKEL, 1880, Syst. der Medusen, p. 572.

Bell flat, shield-shaped, 100 to 120 mm. wide, 15 to 20 mm. high. Exumbrella smooth, without aboral concavity or dome. 16 rhopalia, 144 wide, pointed, but not prominent lappets. In each paramere 7 velar between 2 ocular lappets. 8 very wide, flat mouth-arms shorter than the bell-radius and with 6 to 8 short, wide-spreading main-branches. Numerous very small club-shaped vesicles between the mouths, hardly larger than the rhopalia, only 0.4 to 0.8 mm. long. No radial spots on the exumbrella.

Found at Madagascar and at the Querimba Islands off Mosambique, East Africa. Described in detail by Haeckel.

Cassiopea depressa var. picta Vanhöffen.

Cassiopeia picta, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 26, taf. 2, fign. 1, 2.
Cassiopea depressa, var. *picta*, MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 43.

Disk flat, 60 to 85 mm. wide. 14 (?) to 16 marginal sense-organs. 112 (7×16) velar and 32 ocular lappets, all similar each to each, and blunt and small. The lappets are irregularly developed in the two specimens described by Vanhöffen, and while there are usually 5 velar lappets between each successive pair of ocular lappets, in some parameres there are 0, 3, 8, or even 10 velar lappets. Arm-disk octagonal with 8 equal sides and half as wide as bell-diameter. The free, projecting parts of the 8 mouth-arms are somewhat shorter than the radius of the disk and project about one-third of their length beyond the bell-margin. These mouth-arms are pinnately branched with short branches as in *C. xamachana*, and have no appendages excepting small lancet-shaped ones, as in *C. ndrosia* and *C. depressa*. The musculature is similar to that of *C. ornata*. The 32 radial-canals give off anastomosing side branches which place them all in connection one with another. There are no distinctly differentiated ring-canals.

Ground color of disk translucent opal. There are 16 large white spots over the 16 marginal sense-organs, and in the large medusa these are fused into a ring of varying width, being widest in the radii of the sense-organs and narrowest in intermediate positions. Peripheral to this white ring are 144 white, linear-oval streaks, one over each lappet; those over the 32 ocular lappets smallest, those over the interocular lappets the longest. The 32 small spots over the ocular lappets are fused with the 16 large, white, radial spots. 16 white rays in the subumbrella appear as large egg-shaped spots, their blunt ends inwards. They are in the radii of the sense-organs and extend from the outer edges of the central stomach and gonads outwards with their radial edges almost touching.

This species was described by Vanhöffen from two specimens found near Beibul in the Red Sea, in December, 1884. It differs from other species of *Cassiopea* in the large number of its marginal lappets and its very wide arm-disk. There is no raised central sucker on the exumbrella and no large club-shaped vesicles on the mouth-arms, such as are seen in *C. polypoides*.

Cassiopea mertensii Brandt.

Cassiopea mertensii, BRANDT, 1838, Mém. Acad. Sci. St. Petersbourg., Sci. Nat., sér. 6, tome 4, p. 396, taf. 20–23.—HAECKEL, 1880, Syst. der Medusen, p. 572.
Cassiopeja mertensii, MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 40.

Bell evenly rounded without an aboral concavity, 100 to 120 mm. wide, 30 to 40 mm. high. 16 rhopalia. 128 small, tongue-shaped, prominently projecting lappets. In each paramere 6 velar between 2 ocular lappets. 8 cylindrical mouth-arms 1.5 times as long as

bell-radius give off 8 to 12 main branches each, which also branch in a tree-like manner. Numerous large club-shaped vesicles between the mouths, some half as long as bell-radius.

Bell yellowish, rusty-brown, lighter in the center. Radial streaks reddish-brown. There are 2 white, half-moon-shaped spots over each rhopalium. Upper surfaces of mouth-arms light-yellow. Mouths dark rusty-yellow. Vesicles white.

Found at Ualan, Caroline Islands, tropical Pacific.

Cassiopea ndrosia Agassiz and Mayer.

Cassiopea ndrosia, AGASSIZ AND MAYER, 1899, Bull. Museum Comp. Zool. at Harvard College, vol. 32, p. 175, plate 14, figs. 45, 46.
Cassiopeja mertensii var. *ndrosia*, MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 40, 43.

Bell 50 mm. in diameter with a shallow concavity at the center of the exumbrella, similar to that of *C. xamachana*. Rhopalia variable in number, 18 to 22. Marginal lappets very indistinct but there are 2 velar flanked by 2 ocular lappets in each paramere. Mouth-arms cylindrical, 1.5 times as long as bell-radius, and branched in a tree-like manner. Each arm gives off 6 to 12 main side branches. There are numerous small, flattened, expanded leaf-shaped vesicles between the mouths, most numerous at center of arm-disk. No ribbon-shaped filaments. 4 small, round, subgenital ostia. 4 separate genital sacs.

General color of bell grayish-brown, with bluish, inter-rhopalar, radiating streaks and white radiations in the subumbrella in the rhopalar radii. A large, spearhead-shaped white spot with its pointed end outward is found near the margin of the exumbrella above each sense-organ; there are also 4 small, radially elongated, white spots near the margin in each paramere—one above each of the rudimentary lappets. The aboral surfaces of the mouth-arms are grayish-white, the mouths deep brown, and the vesicles olive-green.

Found upon muddy bottoms in Suva Harbor and at Komo Island, Fiji Islands, South Pacific, in November.

C. ndrosia lacks the large vesicles of *C. mertensii* and has an aboral exumbrella concavity, whereas the bell of *C. mertensii* is, apparently, evenly rounded. It is most closely related to *C. xamachana* of the West Indies, and resembles one of its color varieties, but lacks the ribbon-like filaments of *C. xamachana*.

RHIZOSTOMATA DICHOTOMA Vanhöffen 1888.

Rhizostomata dichotoma, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 39.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition., Monog. 11, p. 31.
Chaunostomidæ+Cepheidæ, CLAUS, 1883, Organisation und Entwick. Medusen, Leipzig.—VON LENDENFELD, 1888, Zeit. für wissen. Zool., Bd. 47, p. 211.
Radiomyaria, MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 89; 1907, Ergeb. und Fort. Zool., Bd. 1, p. 201.

CHARACTERS OF THE GROUP.

8 separate mouth-arms the lower ends of each one of which gives rise to 2 expanded, leaf-like side-walls, or lateral membranes, the outer edges of which give rise to secondary branches and bear the frilled mouths. Thus each arm is V-shaped in cross-section (fig. 404).

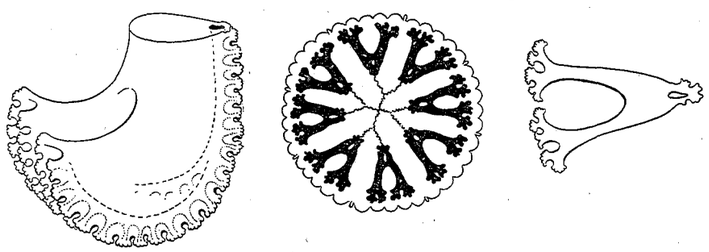


FIG. 404.—Diagrammatic representation of the shape and position of the mouth-arms in the *Rhizostomata dichotoma*. The figure on the right hand shows a section of one of the mouth-arms. The middle figure is an oral view of the bell.

There are no scapulets upon the mouth-arms. The radial-muscles are powerfully and the ring muscles weakly developed. A description of the genera follows:

Cephea PÉRON AND LESUEUR, 1809. Exumbrella with a central area bearing wart-shaped projections.
Cotylorhiza L. AGASSIZ, 1862. Exumbrella with a smooth central dome without wart-like elevations. Radial-canals of the bell all similar each to each.
Polyrhiza L. AGASSIZ, 1862. Exumbrella with a central concavity and with radiating furrows.

Genus CEPHEA Péron and Lesueur, 1809.

Cephea, PÉRON ET LESUEUR, 1809, Annal du Mus. Hist. Nat., tome 14, p. 360.—ESCHSCHOLTZ, 1829, Syst. der Acalephen, p. 55.—LESSON, 1843, Hist. Zooph. Acal., p. 410.—AGASSIZ, 1862, Cont. Nat. Hist. U. S., vol. 4, p. 155.—HAECKEL, 1880, Syst. der Medusen, p. 573.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, p. 39; 1902, Wissen. Ergeb. deutsch. Tiefsee Exped. *Valdivia*, Bd. 3, Lfg. 1, p. 45.
Cephea+Netrostoma, MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 31, 32, 35, 81, 89.
Netrostoma, SCHULTZE, L. S., 1898, Denkschr. Med. Nat. Gesell. Jena., Bd. 8, p. 457.
Microstylus+Perirhiza, KISHINOUYE, 1902, Journal College Sci. Tokyo, Japan, vol. 17, Art. 7, pp. 11, 13.
Stylorhiza, HAECKEL, 1880, Syst. der Medusen, p. 612.
Halipetasus, SCHULTZE, 1898, Denkschr. Med. Nat. Gesell. Jena, Bd. 8, p. 458.

The oldest known species is "*Medusa octostyla*" of Forskål, and this may serve as the type of the genus *Cephea*.

GENERIC CHARACTERS.

Rhizostomata dichotoma in which the 8 mouth-arms fork once dichotomously and each fork gives rise to short dichotomous or dendritic branches. Solid, wart-shaped tubercles at the center of the exumbrella. The central stomach gives rise to 8 rhopalar and numerous inter-rhopalar radial-canals, all of which connect with a network of anastomosing vessels in a wide zone near the margin. Rhopalia without ocelli and without exumbrella, sensory pits. There is no definite ring-canal. Development unknown.

The described species of *Cephea* are all found in the tropical Indian Ocean and Pacific region. *Cephea cephea* (*Medusa cephea*, Forskål) is apparently widely distributed over the Indo-Pacific region and is distinguished by its numerous, long, tapering, conical, pointed filaments; its deep rhopalar clefts in the bell-margin; oval velar lappets fused one to another by a thin web, and its brown coloration. *C. octostyla* of the Red Sea—Malay Archipelago—is distinguished by its very low exumbrella dome with very small tubercles. The marginal lappets are indistinct. Also in *C. conifera*, *C. dumokuroa*, and *C. cærulea* the lappets are so indistinct that the bell-margin is entire, save for the deep niches of the 8 rhopalia. In *C. dumokuroa* and *C. cærulescens* the central dome bears warts only on its sides, leaving its apex bare. *C. cærulea* has only 16 long filaments, whereas *C. conifera* has more than 100 and *C. dumokuroa* none. In *Cephea cærulescens* we find very small tubular and somewhat large spindle-shaped filaments between the mouths, and the subgenital porticus is only partially differentiated. In some quadrants the primitive genital sacs may have fused and the fused wall broken down to form an opening, so that one may pass a probe into one subgenital ostia and out through another without penetrating any tissue, the passage being continuous and actually a part of the outside world. In other quadrants, however, the gonads may be quite separate one from another or merely fused without any break in the area of fusion. In *C. conifera* and *C. dumokuroa*, on the other hand, the subgenital porticus is unitary and cruciform, whereas in C. *setouchiana* the 4 genital sacs are fused along their inner walls, but the walls remain unbroken. In *Cephea typhlodendrium* the filaments are small and spindle-shaped, and confined to the arm-disk.

It is evident that we have in the Red Sea, Indian Ocean, and western parts of the tropical Pacific a large number of closely related forms of *Cephea* displaying many local variations. I think there are only 2 well-marked forms and these are but the extremes of an intergrading series: C. *octostyla* with low dome or flat exumbrella and small warts, and *C. cephea* with a high dome and large warts.

L. S. Schultz, 1898, proposes a genus *Netrostoma* to include *Rhizostoma dichotoma* with mouth-arms laterally compressed and several times dichotomously branched; no large filaments between the mouths on the mouth-arms, although filaments may be found on the mouth-arm-disk.

As a matter of fact the mouth-arms of all known species of *Cephea* give rise to secondary dichotomous, or dendritic, branches, and all are laterally compressed. Moreover, we can not separate genera merely upon the relative size of the mouth-arm-filaments, for confusion is certain to result.

"*Microstylus*" of Kishinouye is evidently a *Cephea* closely allied to *C. typhlodendrium*.

I have therefore broadened the definition of the genus *Cephea* to include all *Rhizostomata dichotoma* with a wart-bearing central area upon the exumbrella and with 8 forked mouth-arms, the forms of which are themselves still further branched.

In the collection of Cepheas made by the U. S. Fish Commission steamer *Albatross* in 1908, I find an intergrading series among specimens of *Cephea* collected all at the same time on the surface at Jolo, Philippine Islands. In some there is no central dome, the exumbrella being quite flat, and in others there is a low but well defined dome. In some the exumbrella warts are large and mammiform, while in others they are mere granules, often absent over wide areas or leaving the center smooth. The filaments upon the mouth-arms and arm-disk may be absent or long and filiform. Thus among these intergrading individuals (evidently all of one and the same species) some are identical with Forskål's "*Medusa octostyla*," others are similar to Schultze's "*Halipetasus scaber*."

Cephea octostyla L. Agassiz.

Medusa octostyla, Forskål, 1775, Descrip-Anim. Itin. Orient, p. 106, No. 18, Icon., tab. 29.
Medusa cephea, Linné, (Gmelin) 1788, Systema Naturæ, Ed. 13, p. 3158. *Non Medusa cephea*, Forskål.
Cephea cyclophora, Milne-Edwards, 1849, Cuvièr's Règne animal illustré Zooph., planche 51, fig. 4.
Cephea octostyla, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 156.
Stylorhiza octostyla, Haeckel, 1880, Syst. der Medusen, p. 613.
(?) *Stylorhiza polystyla*, Haeckel, 1880, Syst. der Medusen, p. 613.
Halipetasus scaber, Schultze, L. E., 1898, Denkschrift. Med. Nat. Gesell., Jena, Bd. 8, p. 458, taf. 33, fign. 5 und 7.

According to Haeckel and Forskål the bell is 300 mm. wide, flatter than a hemisphere. Surface of exumbrella smooth, without a central dome, and without radiating furrows. 8 rhopalia 50 to 60 (?) wide, flatly-rounded, marginal lappets. Rhopalar clefts shallow. Arm-disk wider than bell-radius. 4 small subgenital ostia. 8 bifurcated mouth-arms 1.25 times as long as bell-radius; the forks of each arm as long as undivided upper part of arm. 9 long, stout filaments of uniform caliber arise apparently from the arm-disk. These are 1.5 times as long as diameter of bell and end simply, without terminal knobs. In addition to these filaments there are about 12 short, stout, swollen, club-shaped appendages between the mouths on the lower sides of the arms. The color is blue and hyaline. Arabian coast of the Red Sea.

Forskål's description evidently refers to the medusa figured on his plate 29, not that of plate 30 as stated by Niebuhr, who edited the plates of his work in 1776. While Forskål's figure is remarkably good for its period, his description is too brief and vague to be of value. The description given above has therefore been mainly derived from a study of his figure.

Haeckel's "*Stylorhiza polystyla*" from Singapore is described from a preserved and damaged specimen. It is said to be 100 mm. wide with flatly rounded bell and 80 marginal lappets. In each octant are 8 rectangular velar and 2 small oval ocular lappets. 4 subgenital ostia hardly as wide as the columns between them. Mouth-arms nearly twice as long as bell-radius; many times dichotomously branched, with 16 very long tubular appendages and numerous vesicles upon long pedicels. 8 of the long appendages arise from the bases of the arms and 8 from the crotches of the primary forks. This is probably identical with Forskål's medusa.

Many well-preserved specimens of *Cephea octostyla* were obtained by the U. S. Fisheries Bureau steamer *Albatross* at Jolo Anchorage, Philippine Islands, tropical Pacific, in February and March, 1908.

The bell of the large specimens is 90 mm. wide, exumbrella flat; rim vertical, 20 mm. high. Neither central dome nor coronal furrow, but there is a zone of numerous, low, wart-like protuberances upon the exumbrella, leaving the center free. This wart-covered zone is about 40 mm. in diameter and 15 mm. wide, leaving a circular area about 10 mm. in diameter free of warts at the center of the exumbrella. Other parts of the exumbrella are smooth. There are 8 rhopalia set within fairly deep niches. These lack ocelli and have no exumbrella sensory pits. There are about 72 indistinct lappets, 7 velar and 2 ocular lappets in each octant. These

lappets are similar each to each and are rectangular in outline, being separated by very slight indentations which are spanned by a web. Fairly deep grooves extend up the vertical rim of the exumbrella surface of the bell, between the lappets.

The arm-disk is as wide as the bell-radius and is 18 mm. thick. The free parts, upper, of the 8 bifurcated mouth-arms are each about 20 mm. long. At the center of the arm-disk we find 4 to 12 or more tapering, somewhat flattened, wart-covered filaments which are about 25 mm. long and terminate each in a simple, pointed end. There are also numerous shorter filaments, ranging from about 15 to 5 mm. in length, all near the center of the arm-disk, and many still shorter ones between the numerous frilled mouths of the 8 mouth-arms.

There are 4 small, oval, subgenital ostia only about 2 mm. wide. The ring-muscles of the subumbrella are entire, but are very weakly developed. The central stomach gives rise to 8 large rhopalar and about 56 (7×8) somewhat narrower radial-canals, all connected one with another by a network of anastomosing vessels. The rhopalar canals proceed straight through this network, giving off small side branches to the adjacent radial-canals, but the inter-rhopalar canals tend to lose their identity in the network. There is no distinctly differentiated ring-canal. There is a unitary, cruciform, genital cavity opening to the outer world by the 4 genital ostia. There are many fairly large, reddish-brown dots over the outer surface of the arm-disk and reddish-brown streaks around the exumbrella warts. The color of the bell

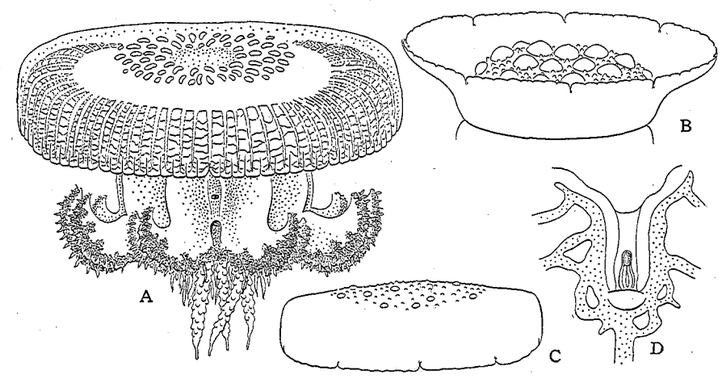


Fig. 405.—*Cephea octostyla*. Drawn by the author, from specimens taken by the *Albatross* at Jolo Anchorage, Philippine Islands, in February and March, 1908.
A, B, and C, side views of exumbrella, showing variations in development of warts; D, rhopalium seen from subumbrella side.

is faded in formalin, but a color note states that the exumbrella bore numerous small, round, ocherous spots. When the bell is 15 mm. wide there are a few, small, scattered warts near the center of the exumbrella. There are 8 rhopalia set within shallow niches. The bell-margin between the sense-clubs is entire and there are no lappets. There are 8 quite wide rhopalar and 8×3 somewhat narrower inter-rhopalar canals, all set into communication by side branches forming a marginal network. The 4 genital cavities are separate. The 8 bifurcated mouth-arms lack appendages either upon the arm-disk or between the frilled mouths. This young specimen was caught upon the surface under an electric light in Jolo Anchorage, Philippine Islands, on February 13, 1908.

Cephea octostyla var. cœrulescens Maas.

Netrostoma cærulescens, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 35, taf. 5, fign. 37, 46; taf. 11, fign. 97, 103; taf. 12, fig. 109; 1906, Revue Suisse de Zool., tome 14, p. 101.—Browne, 1905, Fauna and Geog. Maldive and Laccadive Archipelagoes, vol. 2, p. 967.

The bell becomes at least 200 mm. wide. There are 8 marginal sense-clubs, each with a terminal entodermal concretion-mass and without an exumbrella sensory pit. No ocelli (?) In other respects the bell resembles that of *Cephea octostyla* having a central dome which bears about 10 wart-like projections. There are 6 to 8 round-edged, marginal lappets in each octant. The 8 mouth-arms are short, massive, laterally compressed, and curved outwards.

Each mouth-arm bifurcates at its outer end and also gives rise to numerous very short, lateral branches upon its lower side. These side branches themselves branch somewhat dichotomously, giving a complex system of mouth-bearing ramuli upon the lower side of the mouth-arm. There are two sorts of appendages between the mouths: small, thin, tubular appendages with prominent nettling-warts and larger, spindle-shaped appendages. These are, however, very small in comparison with the size of the branches of the arms themselves.

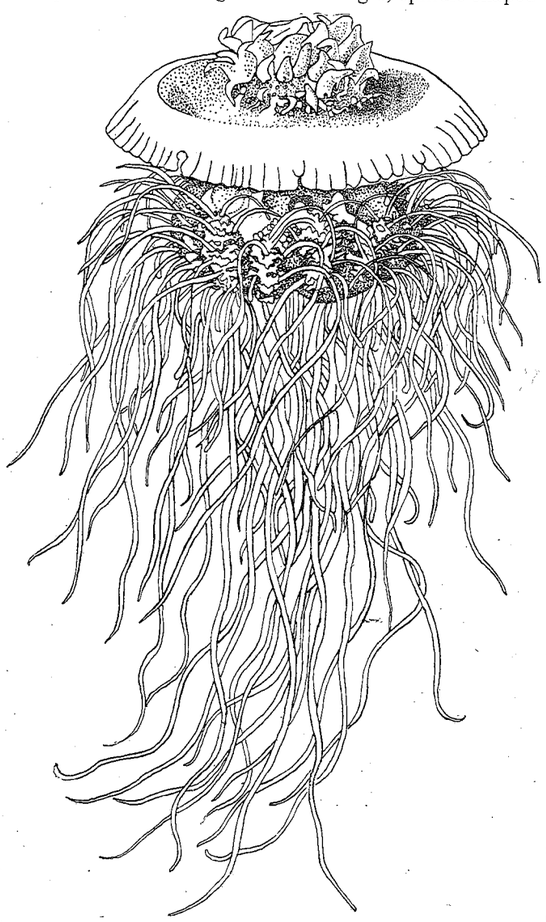


FIG. 406.—"*Perirhiza nematophora*" = *Cephea cephea*, after Kishinouye, in Journal College of Science Tokyo.

In young medusæ there are 4 separate, subgenital cavities with 4 small, external ostia in the interradial sides of the arm-disk. In older individuals we find a very variable condition, the different quadrants of the same medusa being unlike; but it seems that a *completely* separated, subgenital porticus, such as that found in *Crambessa* or *Cotylorhiza*, is never formed in *Cephea cærulescens*. The canal-system of the umbrella consists of 8 radial-canals in the radii of the 8 marginal sense-organs and 24 intermediate canals which give rise to numerous side branches, forming a network of canals which place all 32 vessels in communication one with another. There is no distinctly differentiated, annular ring-canal. The muscular system of the subumbrella resembles *Cotylorhiza* in the form of the radial-muscle strands. The marginal ring-muscles are, however, very poorly developed.

The general color appears to be blue. A narrow zigzag band of fiery red, around the outer side of the arm-disk, lies above the subgenital ostia and bends downward (outward) at each interradius toward the subgenital ostium. Clusters of small, brown, oval spots are found near the side of each subgenital ostium.

This medusa is found in the Malay Archipelago and Maldive Islands, Indian Ocean. The reddish dots found in the typical *C. octostyla* around the sides of the arm-disk have, in this variety, fused into a solid band of color.

Cephea cephea.

Medusa cephea, FORSKÅL, 1775, Descript. Anim. Itin. Orient., p. 108, No. 22, Icon., tab. 30 (*Non*. Tabl. 29).
Medusa octostyla, LINNÉ, (Gmelin), 1788, Systema Naturæ, Ed. 13, Pars. 6, p. 3157.
Cephea rhizostomoidea, PÉRON ET LESUEUR, 1809, Annal. du Mus. Hist. Nat. Paris, tome 14, p. 361, No. 100.
Polyrhiza cephea+Diplopilus couthouyi, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 156, 158.
Cephea forskalea+C. conifera, HAECKEL, 1880, Syst. der Medusen, pp. 574, 576, taf. 36, fign. 3–6.
(?) *Cephea fusca*, PÉRON ET LESUEUR, 1809, *loc. cit.*, p. 361, No. 99.
(?) *Cassiopea fusca*, DUSIMUER, 1835, Musée du Jardin des Plantes, No. 111.
Perirhiza nematophora, KISHINOUYE, 1902, Journal College Sci. Tokyo, vol. 17, Art. 7, p. 14, plate 2, figs. 11–13.

Forskål gives a good, clear drawing of this medusa, which bears so close a resemblance to the figures of "*Perirhiza nematophora*" of Kishinouye that I am convinced the two are identical. The medusa is distinguished by the very deep rhopalar clefts in the bell-margin, its long tapering mouth-arm-filaments, and brown color. Gmelin erred in calling this *M. octostyla*, when he quoted from Forskål, for the latter's *Medusa octostyla* is very different.

Bell 100 to 140 mm. in diameter. A large dome at apex of exumbrella, nearly as wide as bell-radius and covered completely with about 30 large, conical, pointed warts, many of which are bent near their pointed ends. The dome is surrounded by a wide, shallow ring-furrow, which separates it from the nearly equally wide, flexible marginal zone of the bell. The 8 sense-organs are set within deep niches in the bell-margin, as is well shown in Forskål's figure. There are 80 to 90 marginal lappets; in each octant 8 or 9 large, oval, velar between 2 very small, pointed, ocular lappets; the velar lappets are united by a web, so that the bell-margin appears to be nearly entire. The small ocular lappets are deeply set inward centripetal to the margin.

On the subumbrella a radiating inner zone of folded ridges contains the radial muscles, and near the bell-margin is an unbroken zone of circular muscles. Arm-disk octagonal, nearly as wide as bell-radius. The 4 subgenital ostia are very small, compressed clefts. There is a unitary, cruciform, subgenital cavity. The arm-disk has no canal-system of its own, and there are no mouths upon its central parts. The 8 laterally compressed, stout, adradial mouth-arms are somewhat shorter than the bell-radius. Their upper halves are nearly coalesced where they arise from the arm-disk, but below they fork and each main branch branches profusely and curves upward. The numerous, frilled mouths are found on the lower, ventral sides of these mouth-arms and their branches. There are more than 100 long, tapering, hollow filaments with pointed ends. The largest of these arise from the arm-disk at the points of origin of the 8 mouth-arms, and they are as long as the diameter of the umbrella and hollow. Forskål figures 16 such filaments all apparently arising from the arm-disk and numerous smaller ones arising from between the mouth-frills on the arms, very much as does Kishinouye 127 years later.

The nearly circular, central stomach gives rise to 8 ocular and about 40 to 48 interocular radial-canals. The ocular canals are not wider than the others, but they extend straight out to the rhopalia, giving off numerous side branches into the network-zone of the bell; whereas the interocular canals lose themselves in this wide network of anastomosing vessels which form a broad zone extending from near the outer edge of the stomach-cavity to the bell-margin. There is no differentiated ring-canal. The network gives off many blindly-ending branches which extend downward into the radiating muscular ridges of the subumbrella.

The margins of the velar lobes are brown, but Kishinouye finds that other parts are colorless, although Forskål's medusa displayed some reddish-brown on its bell. Forskål describes this medusa from the Red Sea, and Kishinouye from Misaki, Japan, where it is found in winter. Péron and Lesueur's *C. fusca*, from Malabar and northwestern Australia, is probably the same medusa; as is also *Diplopilus couthouyi* Agassiz, 1862 (Cont. Nat. Hist. U. S., vol. 4, p. 158), from Hawaii. The medusa appears to be widely distributed over the Indo-Pacific region. Haeckel's *Cephea conifera* from Samoa may be another name for the same medusa, but its color is not stated and its marginal lappets appear to be indistinct, and the bell-margin to be practically entire, as in *C. cærulea*. The decided resemblance, in other respects, between Haeckel's *C. conifera* and Forskål's medusa will appear in the following description.

"Cephea cephea var. conifera" Haeckel.

Cephea conifera, HAECKEL, 1880, Syst. der Medusen, p. 576, taf. 36, fign. 3–6.—HAMANN, 1881, Jena. Zeit. für Naturw., Bd. 15, p. 246 (anatomy of mouth-arms).

This is probably identical with *Cephea cephea*.

Bell 100 to 120 mm. wide, 30 to 40 mm. high. A thick-walled, flatly rounded, central dome upon the exumbrella bears 20 to 30 large and numerous small protuberances and is separated from the marginal zone of the exumbrella by a deep annular furrow. These solid, wart-like protuberances of the central dome are scattered irregularly over its entire surface, as in *C. cærulea*, not arranged in 2 rows, as in *C. dumokuroa*. 8 rhopalia are set within deep niches. 80 indistinctly developed, marginal lappets. In each octant 8 wide, flat, velar lappets,

flanked by 2 very small, rhopalar lappets. The lappets are so poorly developed that the bell-margin is practically entire and without notches, in this respect resembling *C. cærulea*. The octangular arm-disk is about as wide as the bell-radius, and the 4 subgenital ostia on its interradial sides are very short, narrow clefts.

The 8 mouth-arms arise in 4 pairs from the perradial angles of the central part of the arm-disk, but separate widely, one from another, so as to project from the 8 adradial corners of the sides of the disk. The 8 mouth-arms are each about as long as the bell-radius and each one bifurcates near its outer end. Numerous short branches arise from the ventral sides of the mouth-arms and these bear the mouths. A single long, stout filament arises from each of the 4 perradial corners of the ventral side of the arm-disk at the points of bifurcation of the 4 primary mouth-arm canals. In this respect the medusa differs from *C. cærulea*, wherein there are 4 filaments in each perradius of the arm-disk. There are also more than 100 long, slender filaments between the mouths. These filaments are longer than the bell-diameter. In the closely allied *C. cærulea* the mouth-arm filaments are very short and inconspicuous. The radial-muscles of the subumbrella are well-developed and form radiating, lamella-like ridges as in *C. cærulea*. There are numerous, fine, anastomosing radial-canals and a wide network of vessels near the margin. Color (?)

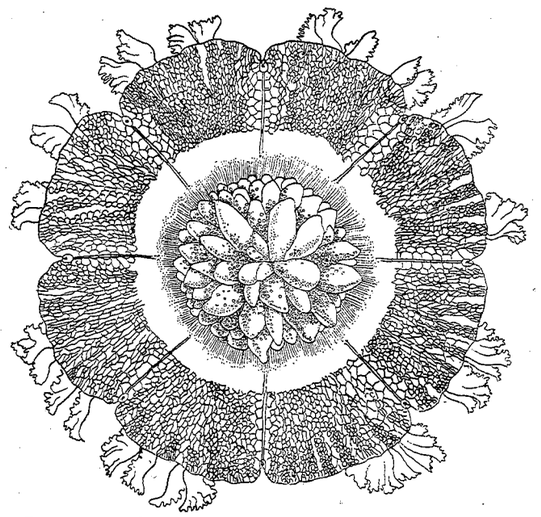


FIG. 407.—"*Cephea conifera*," after Haeckel, in Das Syst. der Medusen.

Found at the Caroline and Samoan Islands, tropical Pacific. This description is presented to show that there are no appreciable differences between this medusa and Forskål's *Medusa cephea*.

Cephea cephea var. dumokuroa Agassiz and Mayer.

Cephea dumokuroa, AGASSIZ AND MAYER, 1899, Bull. Museum Comp. Zool. at Harvard College, vol. 32, p. 172, plates 11, 12, figs. 36–39.
Netrostoma dumokuroa, MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 38.

Bell 300 mm. wide, flat, and disk-shaped with sides vertical near the margin. A large prominent dome at center of exumbrella. The apex of this dome is smooth and without the wart-like protuberances seen in *C. cærulea* and *C. conifera;* instead of which the protuberances of *C. dumokuroa* are arranged in two verticels, confined to the sides of the dome. The upper row of protuberances consists of about 8 large, solid, wart-like, bluntly-pointed projections, and below them is a zone of about 12 smaller warts not more than half as large as those of the upper row. There is a wide, shallow furrow around the dome. 8 rhopalia are deeply sunken within marginal niches. Each sense-organ contains a terminal mass of white, entodermal concretions. There is no ocellus and no exumbrella sensory pit.

The marginal lappets are so shallow that one can barely distinguish them, but there are 8 scarcely perceptible, velar lappets in each octant, as in *C. cærulea* and *C. conifera*. The arm-disk is about as wide as the bell-radius and there are 4 very small, round, subgenital ostia, with a unitary subgenital porticus. 8 short, bifurcated mouth-arms, each about as long as bell-radius; their free outer ends curve upward and the mouths are confined to the ventral sides of the arms, the frilled mouths being placed upon short branches which arise from the lower side of each arm. There are neither filaments nor club-shaped appendages, and in this respect the medusa differs from *C. cærulea* and *C. conifera*. The central stomach is a wide cruciform space above the subgenital porticus. 32 radial-canals arise from its margin and diverge into the subumbrella. 8 of these canals lead to the rhopalia and 3 are in each inter-rhopalar octant, instead of 7 as in *C. cærulea*. There is a wide zone of anastomosing vessels near the margin. The central stomach also sends 8 canals downward into the arm-disk and this in turn to the 8 mouth-arms.

General color of medusa blue, as in *C. cærulea*. The bare apex of the central dome is streaked longitudinally with blue, and a deep blue entodermal band of color extends around the sides of the arm-disk above the subgenital ostia. This blue band is especially wide in the adradii above the bases of the 8 mouth-arms. The unbranched portions of the radial-canals adjacent to the stomach and the canals of the arm-disk and arms are blue. The broad network of anastomosing vessels near the bell-margin is dull coffee-colored and the frilled mouths are of a deeper hue of the same color.

A large swarm of these medusæ was found upon the surface off Vanua Mbalavu Island, Fiji Islands, on November 25, 1897.

Cephea cephea var. cœrulea Vanhöffen.

Cephea cærulea, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped. *Valdivia*, Bd. 3 Lfg. 1, p. 75, taf. 4, fign. 13, 14.

Bell 57 mm. wide. A dome-like apex 14 mm. wide at the center of the exumbrella is surrounded by an annular furrow 9 mm. wide. The dome itself bears 6 large and about 30 small, rounded, wart-like protuberances, the largest of which are 2.4 to 5 mm. wide; numerous fine punctations between the warts. There are 8 rhopalia. No marginal lappets, but 8 radial thickenings of the gelatinous substance at the margin in each octant. The 4 subgenital ostia are very small. The dichotomous mouth-arms are each 16 mm. long and bear frilled mouths on their ventral sides. There are 4 long filaments at the point of bifurcation of each of the 4 primary arm-canals, 16 in all; of these, the second and third are 2 to 3 times longer and much stouter than the first and fourth. Numerous very small filaments are among the mouths. The central stomach gives rise to 64 radial-canals, which break up into a wide, anastomosing network zone near the bell-margin. There are 8 rhopalar radial-canals and 7 inter-rhopalar canals in each octant thus differing from *C. dumokuroa*, wherein there are only 3 radial-canals in each inter-rhopalar sector. There is a broad, marginal annulus of ring-muscles in the subumbrella, and centripetal to this is a wide zone of radial-muscles extending from the supports of the arm-disk to the zone of ring-muscles.

The disk, arms, and filaments are blue and the frilled-mouths are chocolate-brown. Found at Dar es Salaam, east coast of Africa (see fig. 408).

Cephea cephea var. setouchiana.

Microstylus setouchianus, KISHINOUYE, 1902, Journal College Sci. Tokyo, vol. 17, Art. 7, p. 11, plates 1, 2, figs. 8–10.
Netrostoma setouchianus, BROWNE, 1905, Fauna and Geog. Maldive and Laccadive Archipelagoes, vol. 2, p. 967.

Disk 100 to 200 mm. wide with a prominent central dome nearly as wide as bell-radius and covered completely by 50 or more solid, pointed, wart-like projections of various sizes. This central dome is surrounded by a wide, annular furrow which separates it from the thin, flexible, outer zone of the exumbrella. 8 rhopalia. 6 to 8 flatly rounded, velar lappets flanked by 2 smaller, rounded, rhopalar lappets in each octant. 50 to 60 lappets, in all, upon the bell-margin. The 8 mouth-arms curve outwardly and upwardly in their lower halves. They are a little longer than the bell-radius and each one is forked, each of the main forks being nearly as long as the upper, undivided part of the arm. The forks give rise in turn to numerous pinnate branchlets. There are numerous small, short appendages among the frilled mouths, and those on the arm-disk at the ends of the perradial oral suture are longer, triangular in cross-section, and prickly in appearance. The 4 subgenital ostia are circular and much narrower than the spaces between them. The subgenital cavity is unitary and 4-lobed, as in *Cotylorhiza*.

The central stomach gives rise to 8 large rhopalar and 24 inter-rhopalar radial-canals, all of which extend straight outward to the bell-margin. All of the canals give off side branches which form a wide, anastomosing network of vessels, the meshes of which are mainly polygonal near the center, but rectangular near margin of disk. 8 canals arise from the stomach at depressed areas near the sides of the perradial septa of the subgenital cavity. These canals

extend downward into the 8 mouth-arms and each give off a horizontal branch which extends into the center of the arm-disk where they unite in a single short duct.

Each wart of the central dome is pigmented with lines of numerous, minute, brown dots converging toward the pointed apex of the wart. There are also brown dots on the sides of the arm-disk. The oral frills are brown and the gonads pinkish.

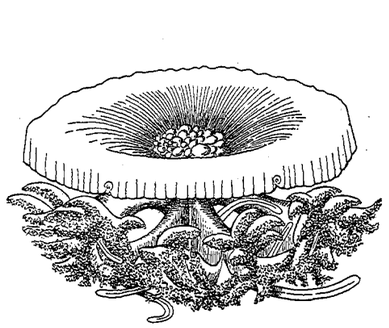
Found in August and September in the Inland Sea, and at Misaki and Senzaki, Japan.

A shrimp is commensal with the medusa, hence its popular Japanese name "Yebi-kuragé" (shrimp medusa).

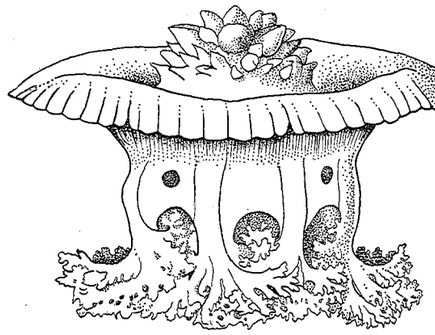
Cephea typhlodendrium.

Netrostoma typhlodendrium, SCHULTZE, L. S., 1898, Denkschr. Med. Nat. Ges. Jena., Bd. 8, p. 457, taf. 34, fign. 10–12a.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 38.

Bell flatly rounded, 110 mm. wide. The center of the exumbrella is occupied by a low dome completely covered with about 80 rounded warts of various sizes. There is no ring-furrow around the dome. The outer parts of the exumbrella are smooth. 8 marginal sense-organs. 80 marginal lappets composed of 64 rounded or cleft, velar lappets and 16 narrow sharp-pointed ocular lappets. The 8 mouth-arms arise from a thick arm-disk. The mouth-arms branch dichotomously and are laterally compressed. Small, spindle-shaped, sharp-pointed filaments are found only on the arm-disk. There are 4 very small, round, subgenital



408.



409.

FIG. 408.—*Cephea cærulea*, after Vanhöffen in *Valdivia* Expedition.
FIG. 409.—*Cephea setouchiana*, Kishinouye, in Journal College of Science, Tokyo.

ostia and a unitary, subgenital porticus. The stomach gives rise to 32 radial-canals: 8 ocular, 24 interocular. The interocular canals give rise, distally, to blindly-ending side branches, peripherally to anastomosing branches; but the 8 ocular canals give off only the peripheral, anastomosing vessels. These ocular canals are wider than the interocular and extend straight through the marginal network to the 8 rhopalia, whereas the interocular vessels become lost in the peripheral network. There is no definite ring-canal.

Found at Amboina, Molluccas, Malay Archipelago.

This may be a well-defined species, for it appears to be distinguished from other members of the genus by its small, sharp-pointed, ocular lappets.

Genus COTYLORHIZA L. Agassiz, 1862.

Cotylorhiza, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 158.—HAECKEL, 1880, Syst. der Medusen, p. 609.—CLAUS, 1883, Untersuch. Organisation und Entwick. Medusen, p. 60, Leipzig.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 27, 40.—MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 32, 80, 89.

The type species is the well-known *Cotylorhiza tuberculata* (*Medusa tuberculata* Macri) of the Mediterranean.

GENERIC CHARACTERS.

Rhizostomata dichotoma with 8 simple, bifurcated mouth-arms, the terminal branches of which branch pinnately. The 4 subgenital ostia are simple and funnel-shaped, and there

is a single subgenital porticus. The appendages upon the mouth-arms are mounted upon pedunculated filaments. There are 8 marginal sense-organs and numerous radial-canals which anastomose laterally without any definite ring-canal in the adult. The sense-clubs have no ocelli and no exumbrella sensory pit. There is a unitary peripheral zone of circular muscles and an inner zone of radial-muscles in the subumbrella. The exumbrella is smooth and without an aboral "sucker-like" depression, but with a prominent central dome without wart-shaped elevations upon it.

This genus is sharply separated from *Cassiopea*, with which it has often been confused, by its single, unitary, subgenital porticus, its relatively simple bifurcated mouth-arms, and by having constantly 8 instead of an indefinite number of marginal sense-organs. Also there is no aboral "sucker" upon the exumbrella, such as is commonly seen in *Cassiopea*.

Cotylorhiza tuberculata L. Agassiz.

Plate 73, fig. 2.

Medusa tuberculata, MACRI, G., 1778, Osservazioni Int. Polmone Marino, p. 20.—LINNÉ, (Gmelin), 1788, Systema Naturæ, Ed. 13, Pars. 6, p. 3155.
Medusa tuber, MACRI, S., 1825, Atti Reale Acad. Sci. Napoli, vol. 2, Parte 2, p. 74, tav. 4, figs. 1, 2.
Cephea polychroma, PÉRON ET LESUEUR, 1809, Annal. du Mus. Hist. Nat. Paris, tome 14, p. 361.—LAMARCK, 1816, Hist. Anim. sans Vert., tome 2, p. 516.
Cassiopea borbonica, DELLE CHIAJE, 1823, Memorie sulla storia e notomia degli animali senza vertebre, Napoli, Mem. 3, p. 75, tav. 3, 4, figs. 1–6; 1841, Animali senza vert., Napoli, tome 7, tav. 140–141.—KOWALEVSKY, 1873, Mem. Imp. Soc. Friends of Nat. Hist., Moscow, vol. 10, part 2, p. 3, plate 2 (Russian).—DU PLESSIS, 1881, Bull. Soc. Vaud. Sci. Nat., vol. 17, No. 86, p. 633, plate 31 (development of egg-scyphostoma).—DE MEREJKOWSKY, 1882, Archiv. Zool. Exper. et Générale, tome 10, p. 577, planche 29*B*, figs. 14–20 (development of spermatozoa).—CLAUS, 1883, Arbeit. Zool. Inst. Wien, Bd. 5, p. 169, 2 taf., fign. 1–11 (development of the ephyra); 1883, Organisation und Entwick. der Medusen, pp. 43, 53, taf. 15, fign. 106–111 (ephyra); 1890, Arbeit. Zool. Inst. Wien, Bd. 9, p. 85, taf. 4–6; 1890, Verhandl. Zool. Botan. Gesell. Wien, Bd. 40, pp. 54–55 (development of the scyphostoma larva); 1892, Arbeit. Zool. Inst. Wien., Bd. 10, p. 1 (scyphostoma).—GRAEFFE, 1884, Arbeit. Zool. Inst. Wien, Bd. 5, p. 343 (seasonal distribution).—KELLER, 1884, Recueil Zool. Suisse, tome 1, p. 403 (breeding habits of the medusa, and nature of the "yellow cells").—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft 3, pp. 27, 40 (in the Red Sea).—HESSE, 1895, Zeit. für wissen. Zool., Bd. 60, p. 441, taf. 21, fign. 17–19; taf. 22, fign. 27, 28 (nervous system of the subumbrella).—BIGELOW, R. P., 1900, Mem. Boston Soc. Nat. Hist., vol. 5, No. 6, p. 209.—HEIN, 1902, Zool. Anzeiger, Bd. 25, p. 637; 1902, Zeit. für wissen. Zool., Bd. 73, p. 302, taf. 20, 21 (development of the gastrula).—BETHE, 1903, Allgemeine Anat. und Physiol. Nervensystem, pp. 410, 414, 448, etc., fig. 83, 84, 88, 91, etc. (physiology of the nervous system and of pulsation).—MAAS, 1904, Résult. Camp. Sci. Prince de Monaco, fasc. 28, p. 58, planche 2, figs. 16–19; plate 6, fig. 47; 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 32, taf. 8, fign. 69, 70.—BOUVIER, 1907, Bull. Instit. Océanograph, Prince de Monoco, No. 93.
(?) *Cassiopea corolliflora* + *C. canariensis*, TILESIUS, 1829, Nova Acta. phys. med. N. C., tome 15, pp. 265, 285, tab. 73.
Cephea tuberculata, ESCHSCHOLTZ, 1829, Syst. der Acal., p. 56.
Cephea wageneri, WILL, 1884, Horæ Tergestinæ, p. 58.—BUSCH, 1851, Anat. Entwickl. wirbell. Seeth., p. 30, taf. 2, 3.—FRANTZIUS, 1852, Zeit. für wissen. Zool., Bd. 4, p. 118, taf. 8, fign. 1–4 (siphostoma larva).
Cassiopea borbonica, GEGENBAUR, 1854, Generationswechsel Medusen, p. 2, taf. 2, fign. 32–35.
Cotylorhiza tuberculata, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 158.—HAMANN, 1881, Jena. Zeit. für Naturwissen, Bd. 15, p. 254, taf. 9, fign. 8, 9; taf. 10, fign. 19–23, 34, 35; taf. 11, fign. 24–28 (structure of the mouth-arms).
Cotylorhiza tuberculata, and *C. ambulacrata* (?) HAECKEL, 1880, Syst. der Medusen, pp. 610, 611.
Cotylorhiza borbonica, GÖTTE, 1885, Zool. Anzeiger, Bd. 8, p. 554; 1887, Abhandl. Entwick. der Thiere, Heft. 4, Leipzig, 79 pp.; 1893, Zeit. für wissen. Zool., Bd. 55, p. 645, taf. 28, 29 (embryology).

Bell usually not more than 150 to 170 mm. in diameter, though according to Will it may become 300 mm. wide. The dimensions of a large medusa found at Naples on December 28, 1907, were as follows: Bell 168 mm. wide, arm-disk 88 mm. wide, each mouth-arm 46 mm. long and 54 mm. thick (dorso-ventrally). The gelatinous substance is very rigid. The exumbrella surface is smooth and without wart-like projections.

The center of the exumbrella is occupied by a smooth, elevated dome, somewhat flatter than a hemisphere and about as wide as radius of disk. Around the outer edge of this dome is a depressed region forming a gutter-like ring, somewhat lower than the parts of the bell nearer the margin. There are 8 marginal sense-organs, which lack an exumbrella sensory pit and have no ocelli. The sense-club has a very large, bag-like ventral bulb and contains a terminal mass of orange-colored entodermal concretions.

The marginal sense-organs are flanked by 16 short, blunt, oval rhopalar lappets. There are typically 10 velar lappets in each octant, the middle 6 of which are sometimes, but not always, cleft. The outer edges of these lappets are subrectangular with bluntly-rounded angles. The primary clefts between the lappets are fully twice as long as the secondary clefts of the 6 middle lappets; but all the clefts are bridged over by a web of subumbrella tissue, so that they are not complete cuts, but mere grooves upon the exumbrella. The 16 velar

lappets adjacent to the 16 rhopalar lappets are fully twice as wide as the others and are rarely cleft. The actual number of marginal lappets is quite variable, but we may say that there are typically 96 primary lappets, of which 48 are typically cleft. Counting these clefts we would then have 18 lappets per octant or 144 in all. The bell-margin usually bends at right angles to the general surface of the exumbrella; subumbrella surface convex.

Arm-disk octangular with re-entrant angles and sharply set off from subumbrella. It is thick and about as wide as radius of bell. Thus in a medusa 168 mm. in diameter the arm-disk was 88 mm. wide. 4 simple, small, oval, subgenital ostia on interradial sides of arm-disk are not much wider than the width of a marginal lappet. The 8 adradial mouth-arms are bluntly simitar-shaped in general outline, are laterally compressed, and only about half as

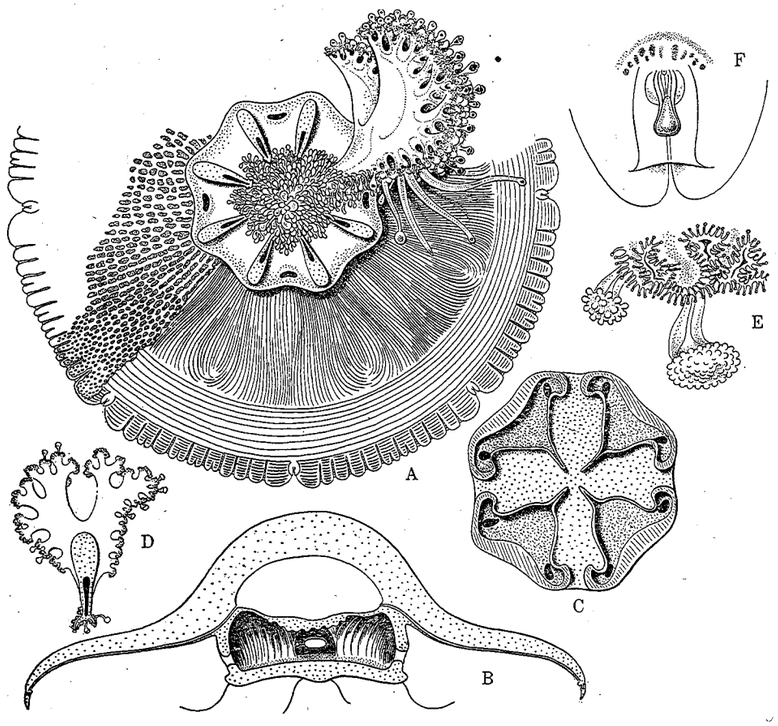


FIG. 410.—*Cotylorhiza tuberculata*, from life, by the author, at Naples Zoological Station, December, 1907.

A, oral view with all but one of the mouth-arms removed. The muscular layer is also removed over the area on to left side of the figure in order to show the canal-system. B, section through medusa showing central stomach and unitary subgenital space below it. C, cross-section through subgenital space (sparsely dotted) and stomach (with thickly placed linear dots); showing the 8 ostia of the mouth-arm canals. D, mouth-arm cut off from arm-disk and viewed from cut end. E, club-like appendages among the frilled mouths. F, sense-organ seen from exumbrella side.

long as bell-radius. They are somewhat thicker (downward) than wide and arise from the arm-disk at 45° apart. Thus in a medusa 168 mm. in diameter the mouth-arms were each 46 mm. long and 54 mm. thick. Each mouth-arm bifurcates near its base and each of the two main branches gives rise to about 10 to 14 side branches, which in turn give off 30 to 40 smaller branches, and these again to 100 to 150 smaller branches, which branch still further dendritically. The farther out the branches the more *dendritic* and the less dichotomous is their mode of branching.

A large number of short, club-shaped appendages between the frilled mouths terminate in bluntly conical to flatly expanded, disk-like ends covered with small, wart-like tubercles.

Besides these short appendages, less numerous but somewhat larger ones terminate in a flattened ball-like to disk-like end set in a socket. At the point of bifurcation of each of the 8 main mouth-arms is a filament which is circular in cross-section and nearly half as long as the mouth-arm itself. This filament tapers gradually from base to tip, but usually terminates in a swollen end. Centripetal to these 8 main filaments are 3 to 5 other, somewhat shorter filaments arising between the frilled mouths of each mouth-arm. Near and at the center of the arm-disk there are numerous slender filaments, about one-third as long as the main filament, which terminate in expanded disk-like conical ends.

A unitary, cruciform, subgenital space opens outwardly at the 4 subgenital ostia. Thus it is possible to pass a probe into any one of the subgenital ostia and out through the one on the opposite side of the arm-disk without penetrating any tissues of the medusa; the subgenital space being actually outer world (C, fig. 410). The complexly folded, genital membrane is developed upon the sides and upper floor of this subgenital space, and thus upon the lower floor of the central stomach.

The central stomach is large, occupying the spacious cavity of the central dome of the exumbrella (B, fig. 401). 11 to 13 radial-canals per octant (88 to 124 in all) arise from the margin of this central stomach and extend outward to the bell-margin. There is no distinct ring-canal, but instead there are numerous, lateral anastomoses between the radiating canals, forming a complex network of vessels under the floor of the subumbrella. The main canals of the 8 mouth-arms empty by 8 adradial openings into the central stomach. Each of these mouth-arm canals bifurcates, and the two main branches give rise to numerous, lateral diverticula which lead to the gutters of the frilled mouths.

There is a well-developed unitary, marginal ring of circular muscles and an inner zone of radial-muscles in the subumbrella. Bethe, 1903, has shown that when the medusa pulsates these inner-lying radial-muscles contract *before* the ring-muscles, though the latter lie nearer to the sense-organs, from which the contraction-impulse arises. This more rapid response of the radial-muscles is due to the fact that *their* latent interval between the reception of the stimulus and their response is less than in the case of the circular muscles. Bethe also finds that the normal pulsation consists of 80 to 100 contractions at fairly regular intervals with periods of total rest between them. These are then followed by a pause which lasts as long as 3 to 20 of the normal pulsations. For further details of the character of the pulsation, the reader should refer to *Rhizostoma pulmo*.

The bell of this medusa is rich olive, tending to orange, or to brownish-yellow, being especially dark and brownish on dome-like apex of the exumbrella. The rich yellow color is found on both exumbrella and subumbrella, and is due to the presence of numerous yellow to brown plant cells (*Zoochlorellæ*) which float in the canal-system and infest the entoderm of the medusa. Claus, 1883, finds these cells in the 8 lobed ephyra when only 1.5 to 2 mm. wide.

The arm-disk and mouth-arms are usually pale milky-white tinged with delicate creamy-yellow. The free outer edges of the mouths are tinged with purple varying to blue or violet. The terminal portions of the appendages, which arise between the frilled mouths, are deep blue tending to purple, or violet.

This medusa is found in the Mediterranean, but is quite capricious in its appearance, being at times very rare. According to Graeffe it is not seen every year in the Adriatic at Trieste, but adult medusæ are usually seen from July to September, while small ones are found in July and August. At Naples adult medusæ are commoner from August to October than in winter, when they become very rare, being only occasionally found in mid-winter. Keller is of the opinion that this medusa is a deep-water species which only occasionally comes to the surface when sexually mature, and that the young remain near the bottom of the sea. Vanhöffen, 1888, records the capture of a young individual of this medusa at Assab in the Red Sea on June 10, 1885. The medusa must have been introduced into the Red Sea through the Suez Canal. It has also been found in the Atlantic, near the Canary Islands. (See *C. ambulacrata* Haeckel.)

The development of this medusa has been studied by Busch, Frantzius, Gegenbaur, Kowalevsky, Claus, Goette, du Plessis, Hein, and others, and has furnished some of the evidence for a controversy between Claus and Goette concerning the development of the gastrovascular cavity of the scyphostoma.

The young larvæ are set free from the mouths of the mother medusa as planulæ or young gastrulæ. Segmentation is total and nearly equal. The gastrula is formed by invagination as in the case of *Aurellia*. The free-swimming planula is pyriform to oval, flattened laterally, and ciliated externally. The entoderm of the planula is entirely encased by the ectoderm through the closure of the blastopore, and thus the planula is a two-layered sac which attaches itself to the bottom by means of its broad anterior end, and then loses its cilia.

An invagination of the ectoderm takes place at the posterior (now uppermost) end of the planula. According to Goette the entoderm is also evaginated at the same time in such manner that two backwardly projecting pouches remain in the plane of the wide lateral diameter, while these pouches are absent on the flat sides of the larva. The ectodermal invagination forms the mouth and œsophagus; while the entodermal evaginations form the first pair of lateral stomach-pouches. An opening is soon formed where the invaginated ectoderm has fused with the entoderm, and thus the throat-tube is placed in communication with the central stomach. The second pair of gastric pouches now arise 90° apart from the first and, according to Goette, are produced by evagination entirely from the *ectoderm* of the lower end of the throat-tube.

Hyde, 1894 (Zeit. für wissen. Zool., Bd. 58, p. 521), finds, however, that in the case of *Aurellia* only the upper floor of the second pair of stomach-pouches is formed from the ectoderm of the throat-tube, their lower (aboral) floor being of entodermal origin and derived from the wall of the primitive stomach. Hyde's research appears to be very carefully prepared, and it is probable that the second pair of stomach-pouches in *Cotylorhiza* is of mixed (ectodermal and entodermal) origin as in *Aurellia*. The apparent analogy between the ectodermal œsophagus of the young scyphostoma and that of the *Anthozoa* is very interesting, for it may imply a close generic relationship between the *Anthozoa* and the Scyphomedusæ.

In this connection we must, however, give due weight to the work of the Claus-Hadži school (see Genus *Chrysaora*) who find that the 4 primary stomach-pouches and the lining of the throat are wholly of entodermal origin, and that therefore the scyphostoma resembles the hydropolyps more closely than the Anthozoa.

The scyphostoma develops 16 tentacles and then gives rise to buds which grow out from the sides of the body. The wider end of the pyriform bud is adjacent to the parent scyphostoma, and the mouth is at this broad end. The bud is set free and swims, rotating through the water with its narrow posterior end directed forward. Soon, however, the bud attaches itself to the bottom by means of its narrow aboral end and then develops into a new scyphostoma.

This asexual development of lateral buds by the scyphostoma of *Cotylorhiza* seems to be a normal process and is described by Goette, 1887, p. 24, and Claus, 1892. Claus, 1892, reared *Cotylorhiza* in an aquarium and found that eggs laid at Trieste in September developed into scyphostomæ with 16 tentacles and then began to produce lateral buds in the following July. They strobilated in August. The strobilization is monodiscus, the scyphostoma giving rise to one ephyra. The 8 marginal sense-organs are apparently developed out of the bases of the 8 perradial and interradial tentacles, while the 8 adradial tentacles degenerate and are absorbed. A similar process takes place in *Cassiopea xamachana*, according to R. P. Bigelow, 1900. The gelatinous substance is secreted by the entoderm.

Claus, 1883, has studied the young ephyræ of *Cotylorhiza tuberculata*. When only 1.75 mm. wide the ephyra has a simple 4-cornered mouth similar to that of the single-mouthed Scyphomedusæ. There are 8 long, slender, cleft lobes in the radii of the 8 marginal sense-organs. The central stomach gives rise to 16 blindly ending radiating diverticula, 8 in the radii of the marginal sense-organs and 8 adradial in position. There is no ring-canal. These canals are lined by unicellular yellow-brown algæ (*Zoochlorellæ*). There are 4 gastric cirri, one in each interradius. The 4 lips are simple and cruciform and devoid of a marginal fringe of tentacles. When about 2.25 mm. in diameter the oral fringe of tentacles begins to develop around the edges of the still cruciform mouth. When 2.5 to 3 mm. wide the ring-canal develops by fusions between the adjacent edges of the 16 radiating canals, and 8 adradial velar lappets begin to grow out from the deep notches between the 8 primitive ephyra-lobes.

When 3 mm. wide each quadrant of the cruciform mouth is bifurcated twice, giving 16 terminal forks to the entire mouth. The central mouth, however, still remains open. At this

stage there are still only 24 lappets, 16 rhopalar and 8 velar. When 4.5 to 5 mm. in diameter the ephyra has 8 (4 pairs) of cleft mouth-arms and the ring-canal has become unrecognizable, owing to the fusion into a network of numerous, lateral vessels which arise from the 16 radial-canals. It is evident that at first the ephyra is like that of the single-mouthed Scyphomedusæ and that only later it acquires the characters of the multi-mouthed Rhizostomæ. This is true of all known ephyræ of the Rhizostomæ, and it furnishes the strongest argument for the theory that the Rhizostomæ have been derived from the more simply organized, single-mouthed Scyphomedusæ.

For further details of the development of *Cotylorhiza* the reader should consult the papers of Claus, Goette, Hein, and Kowalevsky.

Bouvier, 1907, finds *Trachurus* to be commensal with this medusa.

Haeckel's *Cotylorhiza ambulacrata* described from a preserved specimen from Lessona, Canary Islands, Atlantic Ocean, appears to me to be identical with *C. tuberculata*, being well within the limits of variation of the typical medusæ found at Naples.

Genus POLYRHIZA L. Agassiz, 1862.

Polyrhiza, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 156.—Haeckel, 1880, Syst. der Medusen, p. 576.—Vanhöffen, 1888, Bibliotheca Zoologica, Heft. 3, p. 40.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, pp. 32, 81.

GENERIC CHARACTERS.

Rhizostomata dichotoma with mouth-arms bifurcated two or more times. Exumbrella without a dome but with a central concavity and with radiating furrows. Numerous simple filaments between the mouths. 8 rhopalia. Numerous radial-canals and a wide marginal network of vessels.

Homopneusis frondosa Lesson and *Orythia incolor* Quoy and Gaimard are believed by Haeckel to belong to the genus *Polyrhiza*, but the descriptions and figures of these medusæ are so vague, fanciful, and evidently inaccurate that we can not consider them. One should consult Lesson, R. P., 1829, Voyage de la *Coquille*, Mollusques, plate 12; and Quoy et Gaimard, 1833, Voyage d l'*Astrolabe*, Zoophytes, tome 4, p. 297 (not plate 25, figs. 6 to 10; these are mollusca).

Polyrhiza vesiculosa L. Agassiz.

Cephea vesiculosa, Ehrenberg, 1835, Abhandl. Berlin Acad., p. 260.
Polyrhiza vesiculosa, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 156.—Hamann, O., 1881, Jena. Zeit. für Naturw., Bd. 15, p. 247, taf. 9, fig. 7 (anatomy of mouth-arms).

Bell 50 to 60 mm. wide, flat, with a pit at center of exumbrella. 32 dichotomous, radiating furrows are separated by a deep annular furrow from the equally wide marginal zone of the exumbrella. 8 rhopalia. 80 lappets. In each octant are 8 rectangular velar and 2 small rhopalar lappets. The mouth-arms branch dichotomously 4 to 6 times. There is a large cluster of long, simple filaments at the center of the arm-disk. 32 radial-canals, 8 large rhopalar and 24 narrower canals, all connected one with another by a wide-meshed network of anastomosing vessels. There is no definite ring-canal.

Bell rose-red, knobs of mouth-tentacles brownish-black. Filaments transparent. Found in the Red Sea, at Tur and Suez.

RHIZOSTOMATA TRIPTERA Vanhöffen, sensu Maas, 1903.

Rhizostomata triptera+R. trigona, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 41, 44.
Rhizostomata triptera, Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 46.

Rhizostomæ in which the lower parts of the 8 separate mouth-arms are 3-winged or Y-shaped in cross-section, being expanded in a ventral and 2 dorsal lamellæ. The 3 lamellæ narrow outwardly and meet in a point at the lower end of the arm. The frilled mouths are borne upon the 3 lamellæ, especially along their free edges. The mouth-arms do not bear scapulets. The ring-muscles of the subumbrella are powerful and the radial-muscles weak.

There is no sharp line of demarkation between the *Rhizostomata dichotoma* with mouth-arms V-like in cross-section and the *Rhizostomata triptera* wherein the arms are Y-shaped in

cross-section. The two groups may, however, be maintained apart more for convenience of classification than because of any non-intergrading distinction between them.

Indeed the chief distinction between them is that in the *Rhizostomata dichotoma* the radial muscles are powerfully and the circular muscles weakly developed whereas in the *Rhizostomata triptera* the reverse is the case, the circular muscles being the more powerful.

Another distinction is that in the *Rhizostomata dichotoma* the axial duct of each mouth-arm simply bifurcates sending a branch to each arm of the V-shaped lower part of the mouth-arm. In the *Rhizostomata triptera*, however, each axial duct gives off 3 lateral branches which extend downward along the lines of the 3 rows of frilled mouths and usually rejoin the axial duct at the lower end of the arm. This may be made clearer by saying that in the *Rhizostomata triptera* the arm is Y-shaped in cross-section, and the axial duct passes down through the middle of the Y while its 3 lateral branches extend down near the 3 ends of the Y. In the *Rhizostomata dichotoma*, however, a single duct extends down in the angle of the V and sends off 2 branches into the arms of the V (see text-figures 404 and 411).

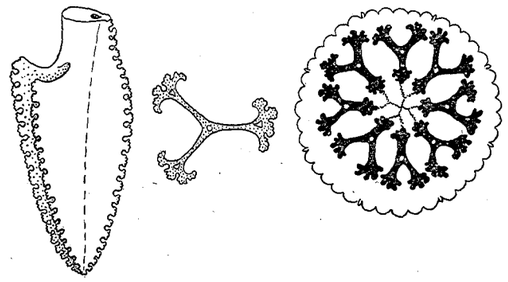


FIG. 411.—Diagrammatic representation of the shape and position of the mouth-arms in the *Rhizostomata triptera*.

The genera are very closely related, being distinguished by the presence or absence of appendages upon the mouth-arms and by the arrangement of the canal-system. A description of the genera follows:

Catostylus L. AGASSIZ, 1862. Neither clubs, filaments, nor other appendages upon the mouth-arms. The network of canals on the inner side of the ring-canal *ends blindly without* connecting with the stomach.

Lychnorhiza HAECKEL, 1880. Similar to *Catostylus* but with filaments, and no clubs upon the mouth-arms.

Crambione MAAS, 1903. Similar to *Catostylus* but with clubs and filaments upon the mouth-arms.

Mastigias L. AGASSIZ. Each mouth-arm terminates in a naked club-shaped extremity. Numerous clubs or filaments among the mouths. The network of canals arising from the inner side of the ring-canal *connects* with the stomach.

Pseudorhiza VON LENDENFELD, 1882. Similar to *Mastigias*, but without lateral clubs or filaments among the mouths. A terminal club present. The canals which arise from the inner side of the ring-canal between the radial-canals end blindly without connecting with the stomach.

Phyllorhiza L. AGASSIZ, 1862. Mouth-arms with lateral filaments, but without clubs, as in *Lychnorhiza*. Canal system as in *Mastigias*.

Versura HAECKEL, 1880. Mouth-arms with clubs and filaments as in *Crambione*. 4 perradial canals arise directly from the stomach, but the 4 interradial canals result from the fusion of a network of vessels which arise from each interradial side of the stomach. No ring-canal, but a marginal network of vessels. An outer and an inner zone of ring-muscles with an annular separation between them.

Lobonema, gen. nov. Marginal lappets of the bell elongated so as to resemble tentacles. Mouth-arm membranes perforated. Exumbrella covered with papillæ.

Genus CATOSTYLUS L. Agassiz, 1862.

Catostylus+*Toxoclytus*+*Rhacopilus*, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 152, 153.
Crambessa, HAECKEL, 1869, Zeit. für wissen. Zool., Bd. 19, p. 509.—VON LENDENFELD, 1888, Zeit. für wissen. Zool., Bd. 47, p. 231.—BROWNE, 1905, Report Pearl Oyster Fisheries, Gulf of Manaar, p. 519.
Toxoclytus+*Crambessa*, HAECKEL, 1880, Syst. der Medusen, pp. 585, 619.
Crambessa+*Loborhiza*, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 28, 41, 44; 1902, Wissen. Ergeb. *Valdivia* Exped., Bd. 3, Lfg. 1, p. 52.
Toxoclytus+*Crambessa*+*Loborhiza*, MAAS, 1903, Scyphomedusen *Siboga* Exped., Monog. 11, pp. 47, 61, 80, 81.

The type species is *Catostylus mosaicus* of Australia, first described as *Cephea mosaica* by Quoy and Gaimard, 1824. Agassiz designates this as the type of the genus.

GENERIC CHARACTERS.

Rhizostomata triptera the mouth-arms of which bear neither clubs, filaments, nor other appendages. 16 radial-canals, 8 rhopalar, and 8 adradial. The rhopalar canals extend to the bell-margin, but the adradial canals end in the ring-canal. On both its inner and outer sides the ring-canal gives off anastomosing vessels which may join with the radial-canals, but which do not connect directly with the central stomach.

Among characters of minor importance, the marginal zone of circular muscles in the subumbrella is only partially interrupted in the 8 principal radii. There is an exumbrella pit with radiating furrows above each sense-club.

Vanhöffen, 1902, shows that Haeckel's *Crambessa* and *Toxoclytus* are identical and must be merged. The only possible distinction appears to be that in *Toxoclytus* there are 4 separate genital sacs, whereas in *Crambessa* there is a unitary, cruciform genital cavity.

Catostylus is very closely allied to *Lychnorhiza* and *Crambione*, being distinguished solely by having neither filaments nor clubs upon the mouth-arms.

Haeckel's *Crambessa* is equivalent to the genera *Catostylus*, *Toxoclytus*, and *Rhacopilus* of L. Agassiz, 1862. The name *Catostylus* takes precedence over all of the others, and Haeckel should have used this name instead of inventing a new one.

The lower ends of the mouth-arms of *C. orsini* and *C. stuhlmanni* are devoid of frilled mouths and the extremity is blunt, triangular, and naked.

Medusæ of *Catostylus* are often found in brackish or muddy harbors. They are often infested with commensal plant-cells which may give them a peculiar opaque yellow-brown coloration as in *C. mosaicus* in certain parts of Australia; for von Lendenfeld finds that in the harbor of Melbourne the medusa is not infested with plant-cells and is deep cobalt-blue in color, whereas in the harbor of Sydney it is infested and is opaque, light yellow-brown. I have also seen a swarm of these cobalt-blue medusæ in Brisbane Harbor, Queensland.

It is possible, as Vanhöffen surmises, that "*Cephea*" *dubreuillii* Reynaud (1830, Lesson's Centurie Zoologique, p. 75, planche 23) may be a *Catostylus*, but the description and plate are so unsatisfactory that I think knowledge will be advanced by dropping the species. It comes from Pondichery, Indian Ocean.

Catostylus is abundant in the Indo-Pacific region, but only 2 or 3 species are known from the Atlantic coasts of Africa and southern Europe, and not one has been found in North

Synopsis of the Forms of Catostylus.

	C. cruciatus.	C. palmipes.	C. tagi.	C. pictonum C. tagi (?).	C. mosaicus.
Diameter of bell in mm.	120 to 150	64	500	400	350
Shape of bell, and character of exumbrella surface.	Hemispherical, with deep radiating furrows.	Hemispherical, with fine granulations.	Flatter than a hemisphere with dendritically branching furrows.	With regularly rectangular elevations bordered by furrows.	Nearly hemispherical, covered with coarse granulations.
Number of lappets in each octant of bell-margin.	Six; 4 large triangular velar, 2 very small ocular.	Eight; 6 large square velar, and 2 oval ocular.	Ten; 4 pairs of large, triangular velar, and 2 small, pointed ocular.	Ten; 4 pairs of large triangular velar, and 2 small, pointed ocular.	Variable, about 16 oval, long, all similar each to each.
Length of mouth-arms in terms of bell-radius (r)	1 to 0.5	$r\pm$	$2r$	$-2r$	1 to 0.5
Length of 3-winged, pointed, lower end of each arm in terms of length of simple, cylindrical, upper part of arm.	4	6	3 to 4	3 to 4?	6
Color.	Bell yellowish-white. Gonads and ring-canal rose-red, or with bluish-white bell, deep blue lappets, and red mouth-frills.	?	Opalescent yellow or bluish-white. Sometimes brown. Ridges of exumbrella purple-brown. Gonads yellowish.	Yellowish or opalescent greenish-white, rarely reddish-yellow. Gonads greenish or yellow.	Bell and arms yellowish-white. Opaque. Sometimes cobalt-blue.
Where found.	Coast of Brazil, harbor of Rio de Janeiro.	Northern coast of Australia to Amboina.	In harbors from Portugal to Senegambia, Africa.	Brittany, Atlantic coast of France, August.	East coast of Australia, Brisbane to Melbourne. In large swarms in harbors.

Synopsis of the Forms of Catostylus—Continued.

	C. stuhlmanni.	C. orsini.	C. stiphropterus.	C. viridescens.	C. ornatellus.	C. tripterus.	C. purpurus.
Diameter of bell in mm.	200	65	100	80	?	50	115
Shape of bell and character of surface of exumbrella.	Hemispherical, surface granular with sharp pointed projections on lappets.	Flatly rounded, smooth.	Flat, with smooth surface.	Hemispherical, with smooth surface.	Flatly rounded, granular surface with lines over lappets.	Hemispherical.	Flatly rounded, smooth surface.
Number of lappets in each octant of bell-margin.	Fourteen; 12 long, rounded velar, 2 short, small ocular.	Eighteen; 16 long, sharp-pointed velar, and 2 smaller ocular.	Seven; 5 large cleft velar, and 2 slender, sharp-pointed ocular.	? lost.	Ten; 4 pairs of large, bluntly pointed velar, and 2 small, sharp pointed ocular.	Six; 4 wide quadratic velar, and 2 narrow, long, projecting ocular.	4 cleft, and 2 simple velar, and 2 rhopalar lappets in each octant.
Length of mouth-arms in terms of bell-radius(*r*).	1 to 0.5 *r*	*r*	—*r*	*r*	0.66 *r*.	*r*	0.75 *r*.
Length of 3-winged, pointed, lower end of each arm in terms of length of simple cylindrical upper part of arm.	6	3	5	5	1	0.5	5 to 7
Color.	Bell yellowish-brown, milky-yellow with purple-brown blotches and streaks. Arms colorless. Mouths brownish-purple.	?	Exumbrella with 4 perradial areas of brown spots.	Bell sea-green. Arms colorless. Mouths dark-violet.	?	?	Uniform dark brownish-purple.
Where found.	4 miles above mouth of Quilimane River, East Africa, February to March.	Assab, Red Sea.	Ternate, Malay Archipelago.	Mouth of Pengami River, East Africa, in November.	Near Puna Island, Guayaquil, Equador.	Fernando Po Island, coast of Guinea, West Africa.	Manila Bay, Philippine Islands. Common.

American waters. There are a number of local races, as is the case with *Cassiopea*, which also thrives in harbors.

Catostylus mosaicus L. Agassiz.

Cephea mosaica, Quoy et Gaimard, 1824, Voyage de *l'Uranie*, Zoologie, p. 569, planche 85, fig. 3.
Rhizostoma mosaica, Huxley, 1849, Philosoph. Trans. Roy. Soc. London, pp. 422, 432, plate 38, figs. 26, 27; plate 39, figs. 28–34.
Catostylus mosaicus+C. wilkesii, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 152.
Crambessa mosaica, Haeckel, 1880, Syst. der Medusen, p. 622.—von Lendenfeld, 1883, Annals and Mag. Nat. Hist., ser. 5, vol. 12, p. 259 (nematocysts in the gelatinous substance); 1884, Proc. Linnean Soc. New South Wales, vol. 9, pp. 428, 926; 1888, Zeit. für wissen. Zool., Bd. 47, p. 231, taf. 19, fign. 10, 13; taf. 21, fign. 21, 23; taf. 23, fign. 44–46, 51, 58, 59; taf. 24, fign. 63–65; taf. 25, fign. 66–78; taf. 26, fign. 82, 83, 93, 96, 97; taf. 27, fign. 108, 109, 111–113, 115–119 (detailed description).—Agassiz, A., and Mayer, 1898, Bull. Museum Comp. Zool. at Harvard College, vol. 32, p. 16, plates 2, 3, 5 figs.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 47.

Bell fully 250 to 350 mm. wide, somewhat flatter than a hemisphere when expanded. Exumbrella covered with coarse granulations. 8 rhopalia without an ocellus, but with an exumbrella sensory pit having radiating furrows in its floor. There are about 128 long, oval, marginal lappets, about 16 in each octant, all similar each to each and with smooth exumbrella surfaces. Arm-disk somewhat wider than bell-radius. There is a unitary subgenital cavity.

A gelatinous papilla is found upon the subumbrella on the outer side of the opening of each subgenital ostium. The 8 mouth-arms are about 1.5 times as long as bell-radius. The laterally compressed, simple, upper part of each arm is only about one-sixth as long as the 3-winged, tapering lower part. The 3 expanded membranous lamellæ of the lower parts of the arms are 120° apart, and their free, outer edges branch profusely and bear the frilled mouths. The mouth-arms taper to a pointed end below. No clubs, filaments, or other appendages. The mouths are bordered by small knobbed tentacles, which wave incessantly. 16 radial-canals leave the cruciform central stomach and are connected by a ring-canal which gives off, both on its outer and inner sides, an anastomosing network of vessels which fuse with the radial-canals, but do not extend inward to the margin of the stomach.

This medusa is normally cobalt-blue, but in Port Jackson, New South Wales, Australia, it is infested with plant cells (*Zoöxanthellæ*), which give it a uniform creamy or brownish-yellow color except along the upper edges of the wing-like folds of the mouth-arms, where the deep blue color appears. In Brisbane Harbor and at Melbourne, Australia, the medusa is not commonly infested with plant cells and is deep cobalt in color.

C. mosaicus occurs in vast swarms in the harbors and estuaries of the Australian coast from Brisbane to Melbourne during the Australian summer and autumn.

It swims by an incessant series of pulsations of its bell-rim and tends to oppose the current. It is the most abundant medusa along the Australian coast, and is often cast up on the beaches in long wind-rows during storms.

A small fish, *Trichinurus declivis*, is often seen living commensally with the medusa.

Catostylus cruciatus.

Rhizostoma cruciata, Lesson, 1829, Voyage de la *Coquille*, Zooph., p. 121, planche 11, fig. 1.
Rhacopilus cruciatus, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 153.
(?) Rhacopilus cyanolobatus, Agassiz, L., *Ibid.*, p. 152. After *mss.* of Couthouy.
Crambessa cruciata, Haeckel, 1880, Syst. der Medusen, p. 620.

Bell hemispherical, 120 to 150 mm. in diameter. 8 marginal sense-organs and 48 lappets. 4 large triangular velar and 2 very small ocular lappets in each octant. There are about 32 deep, radial furrows in the exumbrella. Arm-disk as wide as bell-radius. The 8 mouth-arms are 1.5 times as long as bell-radius. The simple, cylindrical, upper part of each arm is short, while the lower part is about 4 times as long and tapers to a point. These lower parts of the mouth-arms are 3-winged in cross-section and thickly covered with frilled mouths.

The medusa is yellowish-white with rose-red gonads and ring-canal, according to Lesson; but according to Agassiz's note from Couthouy's manuscript, the bell is bluish-white with deep-blue marginal lappets and with carmine mouths upon the arms. It should be borne in mind that *Crambessa mosaica* of Australia is sometimes yellowish-white while other individuals are deep cobalt-blue. This yellowish-white is caused by unicellular, commensal plant cells which sometimes infest the medusa.

Found at Santa Catharina Island and at Rio de Janeiro, Brazil.

Catostylus palmipes.

Crambessa palmipes, Haeckel, 1880, Syst. der Medusen, p. 620.—Lunel, 1883, Annals and Mag. Nat. Hist., ser. 5, vol. 12, p. 268.—Schultz, L. S., 1898, Denkschr. Med. Nat. Gesell., Jena, Bd. 8, p. 453, taf. 33, fig. 1; taf. 34, fig. 11.

Bell 64 mm. wide, hemispherical. Exumbrella covered with fine granulations. 64 marginal lappets. In each octant 6 quadratic, truncated velar lappets, flanked by 2 oval ocular lappets only half as large as the velar ones. Mouth-arms thick, somewhat shorter than the bell-radius. The cylindrical, upper shaft of the arm is only about one-sixth as long as the pointed, 3-winged, lower part. These short, upper shafts of the 8 arms are bound one to another along their sides by 8 membranes, leaving only the pyramidal lower parts of the arms free. Neither clubs nor filaments. Subgenital ostia 3 to 4 times as wide as the columns between them. Color (?) Found from northern Australia to Amboina, Malay Archipelago. Most fully described by Schultze.

Lunel, 1893, observes that this medusa is often found commensal with a fish *Carnex melampygus*.

A variety of this medusa, in which the webs spanning between the basal parts of the mouth-arms and the arm-disk are not so well developed as in the typical *C. palmipes*, was found by the U. S. Fisheries Bureau steamer *Albatross* at a depth of 150 feet in Manila Harbor, Philippine Islands, on January 13, 1908. Bell 56 mm. wide, flatter and more conical than a hemisphere. Exumbrella finely granular without furrows. 64 lappets. 2 small, oval ocular and 6 indistinct, rectangular, sometimes cleft, velar lappets in each octant. Arm-disk 35 mm. wide where it arises from subumbrella, and 27 mm. wide at level of origin of 8 mouth-arms. 4 subgenital ostia slightly wider than perradial columns. A unitary cruciform subgenital cavity. Free parts of upper arms 5.5 mm. long, lower 3-winged parts of arms 30 mm. long, 19 mm. wide, without appendages. Mouths extend to blunt tips of mouth-arms without naked areas. Canal-system as in *C. purpurus*. General color in formalin dull ocher-violet, gelatinous substance milky.

Catostylus tagi.

Crambessa tagi, HAECKEL, 1869, Zeitschrift für wissen. Zool., Bd. 19, p. 509, taf. 38, 39, 8 fign; 1880, Syst. der Medusen, p. 621.—GRENACHER UND NOLL, 1876, Abhandl. Senckenberg Naturf. Gesell., Frankfurt, Bd. 10, p. 123, taf. 1–7, 17 fign.—GREEF, R., 1881, Zool. Anzeiger, Bd. 4, p. 564.
(?) *Crambessa pictonum*, HAECKEL, *loc. cit.*, p. 621.

Bell hemispherical, 500 mm. wide. Exumbrella covered with dendritically branched ridges which extend upward from the outer, pointed ends of the lappets toward the apex of the bell. 8 rhopalia, with an ocellus on the aboral side and an exumbrella sensory pit, the floor of the pit covered with radiating, branching furrows. 80 marginal lappets; in each octant 4 pairs of oval, pointed, velar between 2 small, pointed, ocular lappets, not half as wide or as long as the velar lappets. Arm-disk somewhat wider than bell-radius. The 4 subgenital ostia are wider than the columns between them, and there is a unitary subgenital porticus.

The 8 mouth-arms are as long as the bell-diameter. The simple, laterally compressed, upper part of each arm is less than one-third as long as the 3-winged, lower part. These lower parts bear 2 lateral, outwardly projecting wings which are about 60° apart, and a ventral (inner) wing which is 150° from the lateral wings. The wings taper to a point at the lower end of the mouth-arm. The free edges of the 3 membranous, leaf-like expansions of the arms are complexly folded and bear numerous mouths which are bordered by a row of small tentacles. There are neither clubs, filaments, nor other appendages upon the mouth-arms. The circular muscles of the marginal zone of the subumbrella are interrupted in the 8 principal radii.

The cruciform central stomach gives rise to 16 radial-canals, 8 of which extend to the sense-organs and 8 are intermediate and adradial in position. All are connected by a ring-canal. Centripetal to the ring-canal the 16 radial-canals give off an anastomosing network of vessels which fuse with the ring-canal, and on its outer side the ring-canal gives off a network which extends into the lappets and fuses with the outer ends of the 16 radial-canals. Each of the 8 principal mouth-arm-canals gives off 3 side branches which extend down the 3 membranous leaves of the arm and send branches off to the mouths. These 3 branches then fuse again with the central canal at lower end of mouth-arm.

The medusa is opalescent yellowish or milky bluish-white, sometimes brown. The dendritic ridges of the exumbrella are reddish or brownish-purple. Gonads yellowish.

This medusa is found in brackish waters near the mouths of rivers from Senegambia, Africa, to France. It is well described and figured by Grenacher and Noll.

"*Crambessa pictonum*" of Haeckel, from the mouth of the Loire and in le Croisic harbor, France, is closely related to, if not identical with, *C. tagi*. It is distinguished, according to Haeckel, by the peculiar rectangular elevations separated by furrows upon the exumbrella. These rectangles are not quite as wide as the largest velar lappets and are all of the same size. They are arranged in a 4-sided, cruciform system upon the exumbrella and are separated one from another by deep, parallel furrows. The velar lappets are said to be somewhat wider than they are long, and the mouth-arms are shorter than in *C. tagi*. Haeckel found this medusa in August on the southern coast of Brittany. He states that when the medusa's bell is 30 mm. wide, the mouth-arms have only a single row of mouth-frills on their ventral sides, as in his genus *Haplorhiza*, and the lateral, leaf-like wings develop later.

Catostylus stuhlmanni.

Crambessa stuhlmanni, CHUN, 1896, Mittheil. Naturhistor. Museum, Hamburg, Bd. 13, p. 10, taf. 1, 2 fign.

Bell hemispherical, 80 to 200 mm. wide. 8 marginal sense-organs, set within deep clefts in the bell-margin. 112 marginal lappets. The ocular lappets are short, pointed and small, but the 12 velar lappets in each octant project farther outward and have rounded margins. They are separated one from another by long, deep grooves extending up the sides of the exumbrella. Each of these lappets is provided with a median longitudinal row of sharp-pointed projections on the exumbrella side. The 8 mouth-arms are bluntly pointed and are shorter than the bell-diameter. The subgenital ostia are one-third to one-fourth as wide as the columns between them. A unitary, subgenital porticus.

The bell is yellowish-brown or milky-yellow, besprinkled with purple-brown blotches, which are most numerous near the margin. The marginal lappets have rusty-brown, longitudinal median streaks. The arms are colorless and the mouths are usually spotted with brownish-purple.

8 specimens found 4 miles above the mouth of Quilimane River, East Africa, in February and March. Described in detail by Chun, 1896.

This species resembles *C. orsini* in that the mouths are not developed upon the lower, pointed, knob-shaped ends of the mouth-arms. The outer zone of circular muscles of the subumbrella is interrupted near the margin in the 8 principal radii, but centripetal to this they are unbroken and form a complete annulus.

Catostylus orsini.

Mastigias orsini, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 34, 44, taf. 4, fign. 2–4; 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, pp. 48, 49.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, pp. 63–66.

Umbrella 65 mm. wide, with smooth, exumbrella surface flatly rounded with incurved margin. 8 marginal sense-organs. 144 small, sharp-pointed, marginal lappets. 16 velar lappets between 2 somewhat smaller, ocular lappets in each octant. A radial furrow extends up the side of the exumbrella in the line of the cleft between each adjacent pair of lappets. The 8 sense-organs are set within deep niches and there is an exumbrella sensory pit with radiating furrows above each sense-club. The subumbrella displays a deep annular furrow on the inner side of which lies the ring-canal. Centrifugal to this furrow is a zone of powerful circular muscles, which are not interrupted in the 8 principal radii.

The arm-disk is nearly as wide as the radius of the bell and the 4 arm-disk pillars are wider than the ostia of the subgenital porticus. The simple upper part of each of the 8 mouth-arms is very short and only one-third as long as the 3-winged lower part of the arm. It is also thin and ribbon-like, and in this respect is in marked contrast to the large, 3-cornered lower part of the arm. The upper part of the arm bears no dorsal mouths, but only a single row of frilled mouths along its ventral side. The large, 3-sided, lower part of the arm is elongate, prismatic, with a short gelatinous, pyramidal, bluntly pointed, 3-cornered knob at its end. Altogether the entire mouth-arm is about as long as the bell-radius. The lower part of the arm bears frilled mouths, but neither filaments nor other appendages. The lower end of the arm is naked and devoid of mouths, as in *Catostylus stuhlmanni*, and forms a blunt, triangular knob which on the outer side is nearly half as long as the upper part of the arm itself, but only one-third of this length on the two radial sides.

8 canals extend down the middle of the 8 mouth-arms and send ramifying branches to the frilled mouths. These 8 arm-canals enter the small, central stomach, from which arise 16 straight radial-canals, 8 ocular and 8 adradial, connected one with another by a wide, circular vessel. An anastomosing network of vessels arises on the inner side of the ring-canal between the radial-canals, although this network does not fuse with the radial-canals themselves, but arises solely from the ring-canal. The radial-canals are about twice as wide as the ring-canal. The unitary, subgenital porticus is very small. Color (?) Found at Assab, Red Sea, in June.

Catostylus stiphropterus.

Crambessa stiphroptera, SCHULTZE, L. S., 1897, Abhandl. Senckenberg, Naturforsch. Gesell. Frankfurt a. M., Bd. 24, Heft 2, p. 159, taf. 15, fign. 4, 5, 5*a*.

Bell flatly rounded, 100 mm. wide, with a smooth, exumbrella surface which lacks the protuberances found in *C. mosaicus*. There are 8 marginal sense-organs. The rhopalar, marginal lappets are slender and sharp-pointed, and in each octant there are at least 5 larger, cleft, velar lappets about 10 mm. long and 6 mm. wide at their bases. The arm-disk is about 38 mm. in diameter, somewhat less in width than the bell-radius. The 4 arm-disk-columns are nearly as wide as the 4 narrow, subgenital ostia. Lower arm 5 times as long as upper, the total length of both not quite equal to that of the bell-radius. Upper arm wholly free, differing in this respect in the number of its marginal lappets and in its narrow subgenital ostia from *C. palmipes*.

The exumbrella displays 4 perradial areas of indistinct, round, brown spots which do not extend to the bell-margin.

Found at Ternate, Malay Archipelago.

Catostylus viridescens.

Crambessa viridescens, CHUN, 1896, Mittheil. Naturhist. Museum, Hamburg, Jahrg. 13, p. 12, taf. 1, fig. 2.

Bell 80 mm. wide, hemispherical. Marginal lappets (?) Arm-disk wider than the bell-radius. Subgenital ostia wider than the spaces between them. 8 short mouth-arms, not longer than bell-radius. Upper arm about one-fifth as long as the lower part. Bell sea-green, mouth-arms colorless. Frilled mouths dark-violet. Two specimens found at the mouth of the Pangani River, East Africa, late in November. The marginal lappets were lost in both specimens. Characterized chiefly by its sea-green color.

Catostylus ornatellus.

Loborhiza ornatella, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 28, 41, taf. 2, fign. 3–6.

Disk flatly rounded, the gelatinous substance thick. Size (?) The exumbrella is finely and evenly granulated, but these granules fuse into rows upon the marginal lappets. 8 marginal sense-organs and 80 marginal lappets. In each octant there are 4 pairs of bluntly pointed, nearly rounded, velar lappets, and 2 very small, sharp-pointed, lancet-shaped ocular lappets. The velar lappets adjacent to the ocular lappets project farther outward and are sharper-pointed than the remaining velar lappets. There is a powerfully developed zone of ring-muscles in the subumbrella, but these are relatively indistinct and somewhat interrupted in the radii of the 8 ocular radial-canals.

The arm-disk is supported by 4 thick arm-pillars, which flare outward at their subumbrella bases so as to recall a Maltese cross when viewed looking toward the subumbrella surface. The 4 perradial columns of the arm-disk are about as wide as the 4 genital ostia, but they appear wider than the genital ostia, for their flaring bases curve around in 8 hook-like lateral projections so as to partially close the openings of the genital ostia. The opening of each genital ostium is still further blocked by a triangular pointed flap of the arm-disk which projects over the middle of the ostium, so that each ostium appears as if constricted into 2 side-openings (see figures by Vanhöffen, 1888, taf. 2). The arm-disk is octagonal, and there is a unitary subgenital porticus with 4 folded, U-shaped gonads.

The 4 pairs of mouth-arms are very thick, but only about two-thirds as long as bell-radius. The simple upper half of each arm is short, but the lower half gives rise to 2 dorsal, wall-like lamellæ which bear the mouths on their free outer edges. The ventral side of each mouth-arm also gives rise to a similar lamella; and thus the lower parts of the mouth-arms are 3-rayed in cross-section. The 2 dorsal lamellæ are set off one from another at an angle of about 60°, while the ventral lamella is at an angle of 150° from the 2 dorsal lamellæ. The outer edges of these 3 wing-like lamellæ fold in and out and give rise to short, lateral branches, along the edges of which the numerous mouths are placed. There are neither filaments nor other appendages among the mouths. The 3 wings of the mouth-arms end in a blunt point at the lower extremity of the mouth-arms.

The 8 ocular radial-canals are joined one to another by a thick, irregularly anastomosing, network of canals. The ring-canal is not clearly defined. Other radial-canals (?) Color (?)

Found at Puna Island, near Guayaquil, coast of Equador, South America.

Catostylus tripterus.

Toxoclytus tripterus, HAECKEL, 1880, Syst. der Medusen, p. 586.
Crambessa triptera, VANHÖFFEN, 1902, Wissen. Ergeb. deutschen Tiefsee Exped. *Valdivia*., Bd. 3, Lfg. 1, p. 52.

Bell 50 mm. wide, hemispherical. 8 rhopalia, 48 lappets. In each octant 4 wide, nearly quadratic, velar lappets between 2 smaller, but longer, conspicuously projecting, ocular lappets. 8 arms, somewhat longer than bell-radius, are grouped in 4 pairs, and each consists of a stout, long, nearly cylindrical upper part of the arm which is twice as long as the 3-cornered pyramidal, lower part of the arm. There are 3 wide, leaf-like projections on this lower part of the arm, and the mouths on their edges are only slightly folded. There are no appendages between the mouths. 4 horseshoe-shaped gonads.

Found on the west coast of tropical Africa at Fernando Po Island, on the coast of Guinea. Color (?)

Catostylus turgescens.

Toxoclytus turgescens, SCHULTZE, L. S., 1898, Denkschr. Med. Nat. Ges. Jena., Bd. 8, p. 455, taf. 34, figs. 13, 14.

This is described by Schultze from a single specimen which appears to be quite abnormal—so much so that I have but little faith in its value.

Bell flatly rounded, 90 mm. wide. Exumbrella smooth. 9 marginal sense-organs. Marginal lappets narrow and sharp-pointed. Number (?) Arrangement (?) 6 subgenital ostia wider than the arm-shafts which separate them. Arm-disk flat. The 6 upper arms are thick, arrowhead-shaped and curve outward; they are about 19 mm. long and 17 mm. wide. Lower arm sharply pointed, only about 12 mm. long. There are thin filaments upon the arm-disk between the mouths, but no other appendages. The canal-system consists of a fine anastomosing network on the inner and outer sides of the ring-canal. This network does not reach the margin. There are also unbranched radial-canals and blindly-ending centripetal canals. Amboina, Moluccas. Color (?)

Catostylus purpurus, sp. nov.

This form is closely related to *Catostylus stiphropterus*, from Ternate, but differs in the number and arrangement of its marginal lappets and in its deep, uniform dark brownish-purple coloration.

Disk flatter than a hemisphere, 88 to 115 mm. wide, 26 to 35 mm. high. Exumbrella smooth. 8 rhopalia flanked by short, narrow, bluntly rounded lappets. A furrowed exumbrella sensory pit above each rhopalium Rhopalar lappets somewhat narrower than the velar. In each octant there are 4 cleft and 2 simple velar lappets arranged in a definite manner, see A and B, fig. 412. In the middle of each octant there are a pair of cleft velar lappets, and these are flanked on their outer sides by 2 simple velar lappets, which are in turn bordered by 2 cleft velar lappets. Thus the lappets of each octant are arranged in sequence as follows: (1) a small, simple, rhopalar lappet adjacent to the sensory-club; (2) a cleft velar lappet; (3) a simple velar lappet; (4 and 5) 2 cleft velar lappets; (6) a simple velar lappet; (7) a cleft velar lappet; (8) a small rhopalar lappet. Thus the bell-margin displays 96 nearly equally spaced notches, there being 16 rhopalar and 80 velar terminal lappets.

The arm-disk is about as wide as the bell-radius at its origin from the subumbrella, but at the level of the origins of the 8 mouth-arms it is somewhat less than three-eighths as wide as the bell-radius. There are 4 long, narrow, genital ostia nearly as wide as the 4 perradial columns of the arm-disk. Each ostium is constricted by a thick, wide, median gelatinous projection from the arm-disk. A long, finger-shaped papilla arises from the subumbrella surface in the median line on the outer side of and close to the opening of each genital ostium, and this is in some specimens flanked by a pair of cocks-comb shaped, gelatinous projections from the floor of the subumbrella as is shown in c in text-figure 412. The arm-disk is notched in each perradius. The unitary subgenital cavity is wide and cruciform.

There are 8 separate mouth-arms, each three-eighths as long as the bell-diameter. The lower, 3-winged, expanded part of each arm is about 5 times as long as the simple, flattened, upper part of the arm. Each mouth-arm is bluntly pointed and its frilled mouths lack filaments or other appendages. The mouth-frills extend to the extreme tip of the arm and there is no naked, terminal portion.

A zone of powerfully developed, unbroken, circular, subumbrella muscles extends from the outer edge of the arm-disk to the bell-margin. The gelatinous substance of the bell is very tough and of a leathery consistency.

16 radial-canals leave the central stomach: 8 rhopalar and 8 adradial. These are connected by a ring-canal on the outer side of which there is a fine-meshed and on the inner side a coarse-meshed network of anastomosing vessels.

The medusa is dull, uniform dark brownish-purple, resembling old leather soaked in water. It is abundant in Manila Bay, Philippine Islands, where it occurs over the bottom in shallow water.

Seven specimens found in Manila Bay on December 9, 1907, are in the collection made by the U. S. Fisheries Bureau steamer *Albatross*, and a larger one on March 11, 1908. This largest specimen serves as the type of the species in the National Museum at Washington. Its dimensions in mm. are as follows: Bell 115 wide, evenly rounded, 35 high; arm-disk 75 wide where it arises from the subumbrella, 52 wide at level of origin of mouth-arms; mouth-arms 58 long, upper arm 7 long, lower arm 51 long and 30 wide.

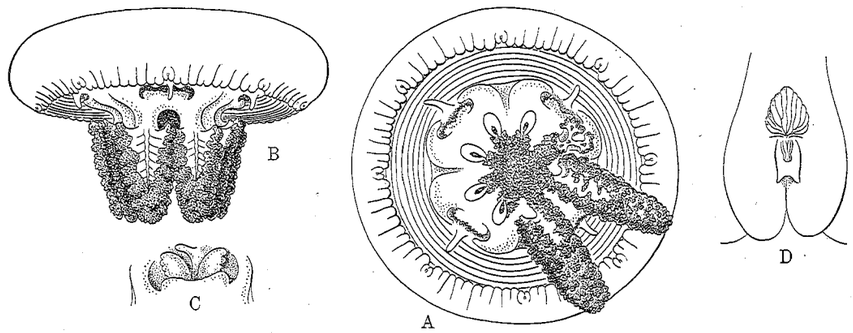


FIG. 412.—*Catostylus purpurus*, sp. nov. Drawn by the author, from specimens obtained by the U. S. Bureau of Fisheries steamer *Albatross* in Manila Harbor.
A, oral view, half natural size. Only two of the mouth-arms are shown; 5 others are cut off close to their points of origin, and one is shown cut across in its expanded 3-winged part. *B*, side view. *C*, genital ostium showing subumbrella papilla flanked by a pair of cocks-comb-shaped subumbrella projections. *D*, exumbrella view of rhopalium showing furrowed sensory pit.

Genus LYCHNORHIZA Haeckel, 1880.

Lychnorhiza+*Cramborhiza*, HAECKEL, 1880, Syst. der Medusen, pp. 587, 633.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft 3, pp. 28, 41.
Lychnorhiza, MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 48, 80; 1906, Revue Suisse de Zool., tome 14, p. 102.

The type species is *Lychnorhiza lucerna* Haeckel, from the coast of Brazil, Rio de Janeiro to Pernambuco.

GENERIC CHARACTERS.

Rhizostomata triptera with filaments, but without clubs, upon the 3-winged mouth-arms. No axial terminal club at the end of each arm, and no club-shaped appendages between the mouths. The stomach gives rise to 16 radial-canals: 8 rhopalar and 8 adradial. The rhopalar canals extend to the bell-margin, but the adradial ones end in the ring-canal. Blindly ending centripetal vessels arise from the inner side of the ring-canal and may anastomose to some extent. On its outer side the ring-canal gives off a network of anastomosing vessels which extend into the lappets.

Among characters of minor importance the circular muscles of the subumbrella are entire and not broken in the 8 principal radii. The sense-clubs have each a sensory pit with radiating furrows over its floor. The subgenital ostia are wider than the columns between them.

This genus is so closely allied to *Crambione* that the two might readily be merged. It may, however, be distinguished by having no club-like appendages between the mouth-frills.

Lychnorhiza lucerna Haeckel.

Lychnorhiza lucerna, HAECKEL, 1880, Syst. der Medusen, p. 587, taf. 34, 8 fign.—HAMANN, 1881, Jena. Zeit. für Naturw., Bd. 15, p. 249 (anatomy of mouth-arms).
Cramborhiza flagellata (young medusa), HAECKEL, *Ibid.*, p. 646.
Lychnorhiza flagellata, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft 3, pp. 29, 42, taf. 2, fig. 7; taf. 3, fign. 1–3.

The bell is flatter than a hemisphere, 120 to 150 mm. in diameter, and its exumbrella surface is besprinkled with fine granules and minute, sharp-pointed projections. There are 8 marginal sense-organs and 48 marginal lappets. The 16 lappets flanking the 8 marginal sense-organs are small, sharply pointed, and triangular, while the 4 velar lappets of each octant are 3 times as broad and 3 to 4 times as long as those flanking the sense-organs. These velar lappets are more nearly oval in outline and not quite so sharply pointed as are the ocular. The 8 stout, adradial mouth-arms arise from a large, gelatinous base which projects from the center of subumbrella. These 8 mouth-arms are laterally compressed, separate one from another, and about as long as the bell-diameter. The outer sides of the upper halves of the mouth-arms are smooth and bear no mouths, but below this the arm is developed into a ventral median and 2 large lateral wing-like membranes, all 3 of which meet at a point below. The edges of these 3 membranes are much folded and are lined by numerous mouths which are surrounded by minute, clubbed tentacles. In addition, the edges adjacent to the mouths bear numerous long filaments, 120 to 160 upon each mouth-arm. Near their bases these filaments are conical, but they expand beyond into a ribbon-like shape, each of the narrow edges of the ribbon being lined by a row of small, club-like nematocyst-organs. Each mouth-arm bears a pair of very long filaments and 15 to 20 somewhat shorter filaments, the remainder being still shorter. The longest filaments exceed the length of the mouth-arms themselves.

There is a well-developed, unbroken zone of circular muscles in the outer part of the subumbrella. The central stomach is cross-shaped, the arms of the cross being in the diameters of the principal radii, while the 4 subgenital pits lie in intermediate positions. 16 radial-canals extend out from the central stomach: 4 in the principal radii, 4 in the secondary, and 8 in the tertiary (adradial) radii. The 8 principal radial-canals extend to the sense-organs, but the 8 adradial ones end in the ring-canal, which is at some distance inward from the margin. The ring-canal gives off 32 blindly-ending, centripetal vessels, 2 between each pair of radial-canals. On its outer side the circular vessel gives rise to about 160 radiating vessels (20 in each octant) which extend into the lappets and are connected by numerous, anastomosing vessels forming a marginal network. Each of the 8 mouth-arms sends a canal into the central stomach. This main canal of each mouth-arm gives rise to 2 side branches, each of which extends down a lateral wing of the mouth-arm under the mouths, while the central canal extends down the center of the lower side of the mouth-arm. The gonads are much-folded membranes lining the inner walls of the 4 subgenital pits. They fill the greater part of the stomach cavity and according to Haeckel, they project outward through the subgenital pits. This is, however, unknown in any other rhizostomous medusa and is, I believe, merely a result of shrinkage, etc., in the preservative fluid.

Haeckel studied a single specimen of this medusa from Rio de Janeiro, Brazil. He gives a detailed description accompanied by figures.

I am inclined to believe that "*L. flagellata*" is only the young of *L. lucerna*. In order the more readily to aid future students in settling this question, we present a detailed description of "*L. flagellata*:" The disk is 80 mm. wide, about 30 mm. high, and evenly rounded. It is very tough with thick gelatinous walls. The exumbrella is covered with fine granules, which become larger near the marginal lappets and set themselves in elongate lines over the lappets. There are 8 marginal sense-organs and 48 marginal lappets. In each octant 4 large, bluntly triangular, velar lappets between 2 very small, sharp-pointed, lancet-shaped, ocular lappets

which are hardly half as long and one-fifth as wide as the velar lappets. The marginal sense-organs are similar to those of *Catostylus*. The ring-muscles of the subumbrella are very powerfully developed, but are partially interrupted over the 8 ocular radial-canals. The arm-disk is about as wide as the radius of the umbrella. It is 8-sided, the narrow sides being in the radii of the arm-pillars; and the wide sides, which are 3 times as wide as the others, are in the radii of the 4 subgenital ostia. The subgenital ostia are thus 3 times as wide as the arm-pillars between them.

8 thick mouth-arms arise from the arm-disk, and these are about as long as the bell-radius. The lower part of the arm is somewhat longer than the upper. There are 2 well-developed, thick, dorsal mouth-lamellæ or "wings" which project from the lower arm and these fuse with the ventral mouth-lamella at the pointed end of the arm. The ventral side of the mouth-arm is complexly folded and gives rise to lateral lappets. The filaments, which arise at the ends of these lappets between the mouths, are shorter than in the mature *L. lucerna*. The 4 sides of the genital organs are bent at right angles, thus forming a cross of 4 right-angled membranes which are very much folded. The gastrogenital cavity and subgenital porticus are small and much reduced.

16 radial-canals (8 ocular and 8 interocular) emerge from the cruciform, central stomach. These 16 radial-canals are put into connection one with another by a wide ring-canal which is about half-way between the center and the margin. Peripheral to this ring-canal there is a network of vessels, although the 8 ocular canals run through and fuse with this network. 32 blindly-ending, centripetal vessels extend inward from the ring-canal toward the center of the disk, but they end blindly before reaching the edges of the stomach. There are 2 of these blindly-ending diverticula between each successive pair of radial-canals, and in some cases they fuse one with another. Color (?)

Found at Pernambuco and at Contigeriba on the coast of Brazil. The most complete description is that of Vanhöffen, 1888, from which the above has been mainly derived.

I am inclined to believe that this medusa will prove to be only a young stage of *Lychnorhiza lucerna* Haeckel. The marginal lappets, mouth-arms, and canal-system are similar in both. According to Haeckel the bell is flatter and thinner in *L. lucerna* than in *L. flagellata*; also in the mature *L. lucerna* the gonads protrude through the subgenital ostia, but this may be due to defects in preservation or to the general breaking up of these organs which commonly occurs in medusæ when the genital products are set free. Vanhöffen did not compare his specimen of *L. flagellata* with Haeckel's type in the Berlin Museum. The only distinguishing features according to the accounts of Haeckel and Vanhöffen are as follows:

Lychnorhiza lucerna:	*Lychnorhiza flagellata:*
Disk flat, gelatinous substance thin. Umbrella 120 to 150 mm. wide.	Disk nearly hemispherical, gelatinous substance thick. Umbrella 80 mm. wide?*
Mouth-arms are twice as long as the radius of the umbrella.	Mouth-arms are only a little longer than the radius of the umbrella.
Mouth-arm filaments longer than the mouth-arms.	Mouth-arm filaments very short (broken off?).
4 separate, subgenital cavities. Gonads protrusive.	Subgenital porticus present. Gonads do not protrude through the subgenital ostia.

*Vanhöffen does not state the size of his specimen.

The presence of a unitary subgenital porticus in "*L. flagellata*" is its only really distinctive character, but this is often highly variable in development in different specimens of the same medusa. See Maas, 1903, Scyphomedusen *Siboga* Exped., p. 36.

Lychnorhiza bartschi, sp. nov.

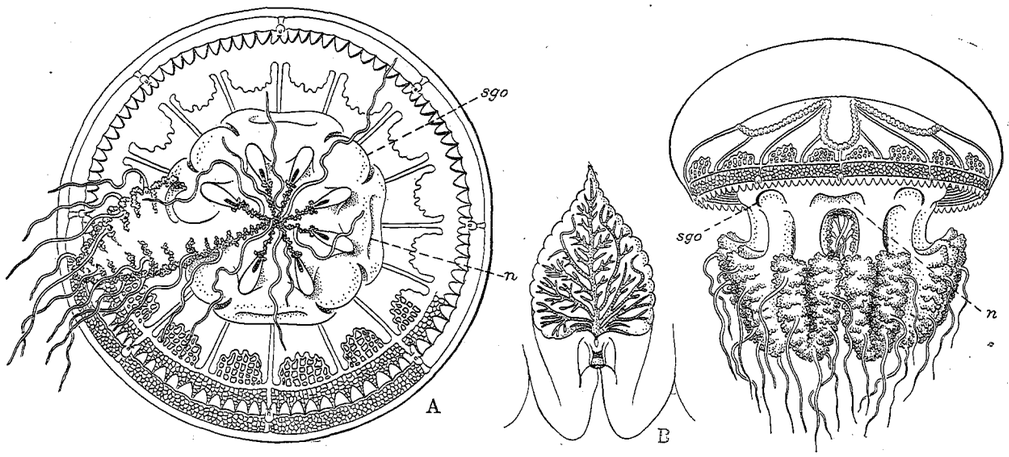
Named in honor of Dr. Paul Bartsch to whose care and skill the excellent preservation of the medusæ upon the Philippine expedition of the *Albatross* is due.

Bell 74 mm. wide, flatter than a hemisphere and with smooth exumbrella surface. Gelatinous substance thick but not very rigid. 8 rhopalia, each with an ocellus and an exumbrella

sensory pit with dendritic furrows over its floor. 96 (8×12) lappets, 10 bluntly pointed velar lappets between 2 somewhat smaller ocular lappets in each octant. Arm-disk 48 mm. wide where it arises from the subumbrella, but only 40 mm. wide at the level of origin of the 8 mouth-arms. The 4 subgenital ostia (*s g o*) are crescent-shaped and each is covered above by a gelatinous flap. They are only half as wide as the perradial columns between them. Each perradial column exhibits a niche, *n*, figs. 413 and 414, on its outer side which bears a superficial resemblance to the subgenital ostia. The subgenital cavity is unitary.

The 8 mouth-arms are laterally compressed and 36 mm. long, the lower 3-winged parts of the arms being 24 long and 23 wide. Numerous simple, laterally flattened, tapering filaments arise from between the frilled mouths on all sides of the mouth-arms and from the arm-disk. The filaments upon the arm-disk are about 30 mm. long, but those from the outer parts of the mouth-arms are shorter.

The central stomach is cruciform and about 40 mm. wide. 16 simple radial-canals, 8 rhopalar and 8 adradial. These are all put into intercommunication with a wide ring-canal which is at some distance inward from the margin. The adradial canals terminate in this ring-canal, but the rhopalar canals extend onward to the sense-organs. On its inner side the



413. 413. 414.

FIG. 413.—*Lychnorhiza bartschi*. Drawn by the author. A, Oral view. B, sense-organ seen from exumbrella side.
FIG. 414.—*Lychnorhiza bartschi*, sp. nov. Natural size, drawn by the author. *sgo*, subgenital ostium. *n*, niche in perradial column of arm-disk.

ring-canal gives rise to 16 blindly ending networks of vessels which do not connect either with the stomach or with the radial-canals. On its outer side a fine-meshed network of vessels arises from the ring-canal and fuses with the rhopalar vessels. Around the margin at the bases of the lappets there is a marginal ring-canal of fine caliber. There is a unitary uninterrupted system of ring-muscles in the marginal zone of the subumbrella, but there are no radial muscles.

The gelatinous substance is translucent and milky in formalin, and the gonads, mouth-frills, and canal-system are milky-yellow. I am told by Dr. Bartsch that these colors in the living animal were nearly as they appear in the formalin specimen.

A single specimen was found by the U. S. Fisheries Bureau steamer, *Albatross*, at Jolo Anchorage, Philippine Islands, on February 13, 1908 (text-figs. 413 and 414).

Genus CRAMBIONE Maas, 1903.

Crambione, Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 48, 81; 1906, Révue Suisse de Zool., tome 14, p. 103.

The type species is *Crambione mastigophora*, Maas, from the Malay Archipelago.

GENERIC CHARACTERS.

Rhizostomata triptera in which each mouth-arm is 3-winged and the wings bear secondary branches. All 3 of these wing-like expansions and their branches bear mouths, among which there are clubs and filaments. No terminal club at the end of each arm. With a unitary, subgenital porticus and with 4 slit-like, subgenital ostia.

The canal-system consists of 8 vessels which extend outward to the bell-margin in the perradii and interradii, and 8 adradial canals which end in the ring-canal at some distance inward from the bell-margin. On the outer side of the ring-canal is a network of vessels, and on the inner side the ring-canal gives off a network between each 2 radial-canals, which does not connect with the radial-canals themselves. The circular muscles are unitary, being unbroken by radial strands. The marginal sense-organs have a pair of eye-spots and a sensory pit with large radial furrows.

This genus is closely related to *Catostylus*, but is distinguished by having clubs and filaments upon its mouth-arms, these being absent in *Catostylus*. It is also very closely allied to *Lychnorhiza*, but has *both* clubs and filaments upon its mouth-arms, whereas *Lychnorhiza* has filaments only.

Crambione mastigophora Maas.

Crambione mastigophora, Maas, O., 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 49, taf. 6, fign. 47–53; taf. 8, figs. 71–74; taf. 11, fign. 100, 104; taf. 12, fig. 113; 1906, Revue Suisse de Zool., tome 14, p. 103.

The bell may become 400 mm. wide and is highly arched and rounded. The gelatinous substance of the center is thick, while the margin is sharply set off from the center and is thin-edged. The exumbrella is smooth. There are 8 marginal sense-organs. These sense-clubs have each a bulbular swelling on the subumbrella side and 2 lateral ocelli near the outer end of the club. There is also an entodermal lithocyst mass. There is a large, heart-shaped sensory pit on the exumbrella side above each sense-organ, and prominent radiating furrows spread out from the center of the pit-cavity just above the base of the sense-club. 2 small, pointed, lanceolate, ocular lappets flank each of the 8 sense-organs, and in each octant are also 8 to 10 velar lappets which are elongate, with rounded outer edges and deep clefts between them, and which increase in number with age.

The arm-disk is very wide and 8-sided. The 4 interradial, subgenital ostia are narrow, elongate, and slit-like, but not as long as the arm pillars between them. 4 perradial, slit-like depressions or fossæ in the arm-disk are somewhat higher than the subgenital ostia to which they bear a close superficial resemblance; they are not to be confused with subgenital ostia, however, for they are mere depressions in the surface of the arm-disk. The 8 adradial mouth-arms alternate in position with the subgenital ostia and the perradial fossæ. In the young medusa they are grouped in 4 pairs, but in the adult they arise at equal intervals from the sides of the arm-disk. Basal parts of mouth-arms massive, nearly circular in cross-section; in their lower halves each gives rise to 3 projecting, lateral expansions or "wings" which meet at the lower end of each arm, giving a pyramidal general outline to the outer half of each mouth-arm. There are numerous mouths along the lower inner lamella of each mouth-arm and along the edges of the 2 lateral wings, as in *Catostylus*. But unlike *Catostylus* many small, club-shaped and some long, tapering, filamentous appendages arise from both the lower and upper sides of the mouth-arms between the mouths.

The central stomach is cruciform, the axes of the cross being in the perradii. 4 perradial, 4 interradial, and 8 adradial canals arise from the stomach. The perradial and interradial canals extend to the bell-margin, but the 8 adradial vessels end in the ring-canal, which lies some distance inward from the margin of the bell. On its outer side the ring-canal gives off a network of vessels which anastomose with the perradial and interradial canals. Centripetal to the ring-canal and arising from it, between the 16 radial-canals, are 16 open networks of vessels. The ring-canal and the 16 radial-canals are of uniform and moderate width. The peripheral network of vessels is of finer caliber and the 16 networks on the inner side of the ring-canal are of wider caliber than the outer network, but not as wide as the radiating vessels. These inner networks do not fuse with the radial-canals.

The 4 interradial gonads form a cross following the lines of the cruciform stomach of the medusa but interior to the border. The adjacent gonads lie so close one to another that the genital cross is extremely narrow and elongate. There is a unitary, subgenital porticus or chamber which serves as a brood-sac for the planula larvæ. There is a well-developed, peripheral ring-muscle in the subumbrella, and this is not broken by radial muscle-strands, such as are found in *Mastigias*.

The gelatinous substance is translucent and milky. The frilled mouths are whitish and the clubs reddish. The gonads are flesh-colored, pinkish, or reddish.

This medusa is found at Amboina and at other places among the islands of the Malay Archipelago. It is described and figured in detail by Maas, 1903.

Crambione cookii, sp. nov.

Plate 74, fig. 2.

Bell hemispherical, 110 mm. wide, gelatinous substance tough. Exumbrella smooth in the flexible zone above the margin, but the inflexible central part of the dome is reticulated by a network of deep furrows trending more or less radially outward from the apex. 8 rhopalia. 88 large, pointed, marginal lappets, equal in size each to each. Mouth-arms 1.5 times as long as bell-radius. The lower two-thirds of each arm is 3-winged and the outer edges of these lamellæ are complexly folded and bear the mouths. 4 slender, uniform filaments, as long as the bell-radius, arise from the arm-disk. There are about 2 to 6 globular, gelatinous appendages on the outer sides of each mouth-arm. These are about 6 mm. long.

The gelatinous substance of the bell is opaque, horny, milky-yellow. The marginal ring-muscles of the subumbrella are brown and the valleys of the exumbrella furrows are of a lighter shade of the same color. Mouth-arms and vesicles translucent milky-blue. Mouth-frills brown.

Found by me on the surface along Great Barrier Reef, off Cooktown, Queensland, Australia, May 4, 1896, during Dr. Alexander Agassiz's exploration of the reefs. Named in honor of the distinguished navigator, Captain James Cook, whose voyage first made the Queensland coast known to the world, and whose ship, the *Endeavour*, met with misfortune in June, 1770, near the place wherein this medusa was found.

Genus MASTIGIAS L. Agassiz, 1862.

Mastigias, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 152.—Claus, 1883, Organisation und Entwick. der Medusen, p. 61.—von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 300.—Kishinouye, 1895, Zoological Mag. Tokyo, vol. 7, No. 78.—Chun, 1896, Mittheil, Nat. Mus. in Hamburg, Jahrg. 13, p. 13.—Maas, 1909, Abhandl. Akad. Wissen., München, Suppl. Bd. 1, Abhandl. 8, p. 46.
Mastigias + *Eucrambessa*, Haeckel, 1880, Syst. der Medusen, pp. 622, 624.
Mastigias + *Desmostoma*, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 33, 35, 44, 45.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 62, 66, 81.
Mastygias, Vanhöffen, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., *Valdivia*, Bd. 3, Lfg. 1, p. 46.

The type species is the widely distributed *M. papua* of the Indo-Pacific region. It was first described as *Cephea papua* by Lesson, 1829.

GENERIC CHARACTERS.

Rhizostomata triptera with 3-winged mouth-arms which terminate in a naked, club-shaped extremity. There are also smaller clubs and filaments between the frilled mouths. The mouths are developed not only along the edges of the 3 leaf-like wings of the lower parts of the mouth-arms, but also over parts of their flat, expanded sides. The central stomach gives rise to 8 rhopalar canals and numerous, interocular radial-canals all of which anastomose and finally connect with the ring-canal. The rhopalar canals extend straight to the sense-clubs, but the inter-rhopalar canals end in the ring-canal. On its outer side the ring-canal gives off a network of vessels which extend into the lappet-zone and fuse with the outer ends of the rhopalar canals. The ring-muscles of the subumbrella are interrupted in the 8 rhopalar radii. A unitary subgenital porticus. No furrows in the exumbrella sensory pits.

The genus *Desmostoma* of Vanhöffen, 1888, conforms in all respects to Agassiz's *Mastigias* except that there are clusters of filaments upon its arm-disk at the bases of the mouth-arms, whereas the other species of *Mastigias* lack filaments and have only small clubs on the sides

of the mouth-arms in addition to the terminal club, I have merged it with *Mastigias* for the genera among *Rhizostomata triptera* are already too numerous, and are distinguished upon differences of such slight importance that the distinctions threaten to confuse rather than to clarify the system of classification.

Mastigias is closely allied to *Pseudorhiza*, but may be distinguished by its numerous, complete, interocular radial-canals; whereas the converging vessels on the inner side of the ring-canal between the 16 radial-canals in *Pseudorhiza* end blindly without reaching the stomach.

The canal-system of von Lendenfeld's *Phyllorhiza punctata* is similar to that of *Mastigias*, but the mouth-arms bear numerous very long filaments without any definite terminal club.

The following synopsis of the forms of *Mastigias* may be of service. *r* is the length of the radius of the exumbrella.

Tabular Synopsis of the Forms of Mastigias.

	M. papua.	M. papua var. siderea.	M. papua var. sibogæ.	M. ocellata.	M. pantherina.	M. gracile.
Number of velar lappets.	8×8. Rounded.	8×8. Rounded.	9×8. Rectangular.	6×8 or 12×8 truncated. Rectangular.	16×8. Rectangular.	5×8 or 10×8.
Length of mouth-arms.	*r*	2*r*	*r*	*r*	2*r*	—*r*
Length of terminal clubs.	2*r*	*r*	2*r*	*r*	4 to 6*r*	One-sixth *r*.
Color.	Bell blue, greenish, olive, or brown; with white, brown, or yellowish spots.	Bell blue, greenish, olive or brown; with white, brown, or yellowish spots.	Bell yellow (?) with orange (?) spots. Canals and clubs violet to rose-colored.	Bell reddish-brown with ring-like spots of white and brown.	Bell brown with darker margin. White spots ringed with black.	?
Where found and remarks.	Fiji Islands, Japan, Malay Archipelago, Indian Ocean.	Zanzibar, East Africa.	Malay Archipelago.	Indian Ocean, Hongkong, Cocos Islands.	Samoa.	Red Sea. Distinguished by long filaments on arm-disk.

Mastigias papua L. Agassiz.

Cephea papua, LESSON, 1829, Voyage de la *Coquille*, Zooph., p. 122, planche 11, figs. 2, 3.
Cephea papuensis, GRIFFITH, 1832, Cuvier's Animal Kingdom, plate 3, fig. 3.
Mastigias papua, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 152.—HAECKEL, 1880, Syst. der Medusen, p. 623.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, pp. 66, 69, taf. 7, fign. 60, 62, 63; taf. 12, fig. 111.
Pseudorhiza thocambaui, AGASSIZ, A., and MAYER, 1899, Bull. Museum. Comp. Zool. at Harvard College, vol. 32, p. 173, plate 13, figs. 40–44 (young stages).
Mastygias papua, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, *Valdivia*, Bd. 3, Lfg. 1, p. 47, taf. 4, fign. 17–19.
Mastigias physophora, KISHINOUYE, 1895, Zoolog. Magazine, Tokyo, vol. 7, No. 78, 3 pp., plate 13, figs. 1–13.—SCHULTZE, L. S., 1898, Denkschr. Med. Nat. Gesell. Jena, Bd. 8, p. 443.
Mastigias physophora, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 49.
Mastigias papua var. *physophora*, MAAS, 1909, Abhandl. Akad. Wissen. München, Suppl. Bd. 1, Abhandl. 8, p. 46.

Bell 30 to 80 mm. wide, usually hemispherical, sometimes flatter and sometimes fuller than a hemisphere. Gelatinous substance firm. Exumbrella surface with very fine granulations. 8 rhopalia, each with a pigmented mass of crystalline concretions and a shallow, exumbrella, sensory pit without furrows. 80 marginal lappets. In each octant 2 small, pointed, ocular and 8 larger, rounded velar lappets with deep furrows between them extending a short distance up the sides of the exumbrella. Arm-disk somewhat wider than bell-radius. The 4 subgenital ostia are about twice as wide as the columns between them and are each somewhat constricted in the middle. Subgenital porticus unitary. 8 mouth-arms, each about as long as bell-radius. The simple upper part 1.5 times as long as the 3-winged lower portion of the arm. The frilled mouths are developed not only along the edges of the 3 wings, but also for some distance inward along the sides of each leaf. Each mouth-arm usually terminates at its lower end in a club-like filament which may be as long as the diameter of the bell, but is sometimes reduced in size or even wholly absent. This club is triangular in cross-section and contains an axial canal. A large number of small, club-shaped vesicles arise from between

the mouths on the outer sides of the mouth-arms. The central canal of each mouth-arm gives off 3 side branches which lead to the 3 rows of frilled mouths of the winged, lower part of the arm. All 3 of these canals fuse again with the axial-canal at the base of the terminal club and extend onward as the axial-canal of the club.

The central stomach is cruciform and gives off 8 straight radial-canals which extend to the sense-organs. These canals are all connected by a wide ring-canal in a zone at a considerable distance inward from the margin. About 7 to 9 anastomosing radial-canals arise from the stomach in each octant between the rhopalar canals and fuse with the ring-canal. On its outer side the ring-canal gives off a fine-meshed network of anastomosing vessels which extend into the lappets and fuse with the outer ends of the 8 rhopalar canals. The circular muscles of the marginal zone of the subumbrella are widely interrupted in the 8 principal (rhopalar) radii. The gonads are 4 folded walls forming cruciform sides of the subgenital porticus.

Color quite variable. Bell and mouth-arms usually greenish-blue, or olive-green to olive-brown, and there are a number of yellow, white, or occasionally brown, blue, or green oval spots over the exumbrella, especially near the margin. The frills of the mouths may be olive, greenish-blue, yellowish-green, or brown. The 8 rhopalar radial-canals are darker.

This medusa is widely distributed over the Malay Archipelago, Indian Ocean, and China Sea to Japan, and outward over the Pacific to the Fiji Islands.

Agassiz and Mayer found an ephyra of the medusa in Suva Harbor, Fiji Islands, in January, 1898. It was 5 mm. in diameter and quite flat and disk-shaped. There were 8 marginal sense-organs. The central mass of dark-brown entodermal pigment granules of the sense-organ was developed, but the peripheral shell of transparent granules had not yet made its appearance. There were 24 marginal lappets, the 16 ocular lappets being about twice as long as the 8 velar lappets. There were 16 radial-pouches from the stomach, of which 8 went to the sense-organs and 8 to the velar lappets. The subgenital porticus was already unitary and the brachial disk was suspended from the floor of the subumbrella by means of 4 gelatinous pillars, exactly as in the adult. The ephyra possessed only a simple, central mouth opening, having 4 cruciform lips. The margins of the lips were lined with a row of short, slender tentacles with knob-like ends exactly like those that surround the mouths on the mouth-arms of the adult medusa. No trace of the genital organs could be detected, but the gastric cirri were represented by 12 short filaments (3 in each quadrant). The color of the ephyra was very similar to that of the adult. The ring-canal had not yet begun to develop.

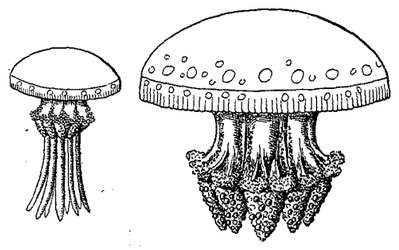


FIG. 415.—*Mastigias papua*, after Vanhöffen, in *Valdivia* Expedition.

Mastigias papua swims very rapidly by an incessant contraction and expansion of the bell-rim. Being an abundant and variable form, it has given rise to many nearly related varieties, such as *M. papua* var. *sibogæ* of the Malay Archipelago and *M. siderea* of the east coast of Africa. *M. physophora* Kishinouye is another variety found abundantly off the coasts of Shima and Sagami, Japan, during summer and autumn. Its bell is at least 100 mm. in diameter and is light-brown with numerous, round, dark-brown spots near the margin.

Schultze finds this medusa at Amboina, Moluccas, in January and February, and it is evidently only a large, dark-colored variety of *M. papua*. Kishinouye gives an excellent series of drawings of this medusa.

Mastigias papua var. siderea.

Mastigias siderea, CHUN, 1896, Jahrb. Wissen. Anstalten Hamburg, Jahrg. 13, p. 13, taf. 1, fig. 3.
Mastigias, sp., (young medusa ?), SCHULTZE, 1898, Abhandl. Senckenberg, Gesell., Bd. 24, Heft. 2, p. 161, taf. 15, fig. 2.
Mastygias siderea, VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Exped., Dampfer *Valdivia*, Bd. 3, Lfg. 1, p. 49.
(?) *Mastigias siderea*, SCHULTZE, L. S., 1898, Abhandl. Senckenberg. Gesell. Naturf., Bd. 24, p. 161, taf. 15, fig. 2.
(?) *Eucrambessa mülleri*, HAECKEL, 1880, Syst. der Medusen, p. 624.
(?) *Mastygias mülleri*, VANHÖFFEN, 1902, Wissen. Ergeb. *Valdivia* Exped., Bd. 3, Lfg. 1, p. 49.

Bell flatly rounded, 70 mm. wide. 8 marginal sense-organs and 80 marginal lappets. Ocular lappets narrow, but the 8 intermediate lappets in each octant are semicircular in outline.

Arm-disk wider than bell-radius, and the subgenital ostia are twice as wide as the radial supports between them. 8 wide, ocular radial-canals and 7 anastomosing, radial vessels in each octant. Mouth-arms are twice as long as bell-radius, the simple upper part of the arm being somewhat shorter than the lower, 3-winged part. Each arm terminates in a single club as long as the bell-radius.

Bell light yellowish-brown with round white spots, which are largest over the ring-canal and smaller near the margin, where they are arranged in 3 or 4 radiating rows between each successive pair of marginal sense-organs. 8 blackish streaks along the 8 ocular radial-canals on the subumbrella, and also white specks in each octant of the subumbrella between the stomach-pouches and the circular furrow. Arms brown with small white spots. Filaments yellowish.

Found along the Zanzibar coast, East Africa, in August and September, and in the western parts of the Indian Ocean.

Chun, 1896, gives a detailed description of the adult and the young of this species.

Haeckel's *Eucrambessa mülleri* from Madagascar is probably identical with this species, but is so imperfectly described that we will never be able to determine it with certainty.

Mastigias papua var. sibogæ Maas.

Mastigias papua var. *sibogæ*, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 66, taf. 6, fign. 54–57; taf. 7, fign. 58, 59, 61, 64; taf. 8, fign. 75–77; taf. 9, fign. 84, 85; taf. 12, fig. 110.

Bell massive, rounded, and when mature 120 mm. in diameter. There are about 9 rectangular velar lappets with rounded angles in each octant between sense-organs. The 4 interradial ostia of the subgenital porticus are 3 times as wide as the columns between them. There are 7 to 10 anastomosing radial-canals between each successive pair of rhopalar canals. Mouth-arms as long as the bell-radius. There are numerous small, rounded clubs upon each of the mouth-arms and also a terminal appendage, which is triangular in cross-section and nearly as long as the bell-diameter.

The ground color is yellowish (?) with orange (?) spots. There are no ring-shaped spots upon the exumbrella. There are 8 violet radial bands upon the rhopalar canals. The terminal appendages of the mouth-arms are sprinkled over with violet spots. The canal-system is rose-colored and the gonads are orange.

This variety is found in the Malay Archipelago, and is described in detail by Maas, 1903. It is distinguished from the typical *M. papua* by the absence of "eye spots" upon the exumbrella, by its yellow or orange color, and by its nearly rectangular velar lappets.

Mastigias ocellata Haeckel.

Medusa ocellata, Modeer, 1791, Nova. Acta. Phys. Med., N. C., tome 8, Append., p. 27.
Cephea ocellata, Péron et Lesueur, 1809, Annal. du Mus. Hist. Nat. Paris, tome 14, p. 361.
Cephea ocellata+*Hidroticus rufus*, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 156, 158.
Mastigias ocellata, Haeckel, 1880, Syst. der Medusen, p. 623.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 33, 44, taf. 5, fign. 3–6; 1902, Wissen. Ergeb. *Valdivia* Exped., Bd. 3, Lfg. 1, p. 49.—Maas, 1902, Scyphomedusen *Siboga* Exped., Monog. 11, p. 63.

This medusa is distinguished from *M. papua* by the peculiar "eye spots" on the exumbrella. These may be described as white circles with a brown center and brown rim. There are also other simple brown spots on the exumbrella. The mouth-arms are shorter than in *M. papua*, being shorter than the bell-radius, and the terminal clubs are not longer than the bell-radius. Velar lappets more numerous than *M. papua*, there being about 12 rounded velar lappets between 2 narrow, pointed, prominently projecting, ocular lappets in each octant. There are 15 to 20 anastomosing radial-canals in each octant between the rhopalar canals, instead of about 7 to 9 as in *M. papua*.

General color reddish, with numerous white, brown-rimmed, and centered "eye spots" on the exumbrella. Tips of terminal club blue.

The medusa becomes about 50 to 60 mm. wide and is found in the eastern parts of the Indian Ocean and in the China Sea. Straits of Sunda, Hongkong in October, Cocos, and Philippine Islands. The *Albatross* found small medusæ in March and April, and a mature one in January in the Philippines, in 1908.

Mastigias pantherina Haeckel.

Mastigias pantherina, Haeckel, 1880, Syst. der Medusen, p. 624.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 44; 1902, Wissen. Ergeb. *Valdivia* Exped., Bd. 3, Lfg. 1, p. 49.
Mastigias papua, Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 63.

This is known only from a preserved specimen, briefly described by Haeckel. It appears to be related to, if not identical with, *M. ocellata*, having the same peculiar "eye spots" on the exumbrella. The velar lappets are said to be truncated and rectangular and to be more numerous than in *M. ocellata*, there being 16 in each octant instead of about 12, as in *M. ocellata*. Mouth-arms are much longer than in *M. ocellata*, being nearly as long as bell-diameter. The simple upper part of the arm is hardly half as long as the 3-winged lower part, whereas in *M. ocellata* and *M. papua* the upper part is longer than the lowest part of the arm. Terminal club very much longer than in other forms of *Mastigias*, being 2 or 3 times as long as the bell-diameter.

Bell dark-brown with white spots ringed with black. Bell-margin black.

Found at Samoa, tropical Pacific.

Mastigias gracile.

Desmostoma gracile, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft 3, pp. 35, 45, taf. 4, fign. 5–7.

Disk flatly rounded or hat-shaped, 35 mm. wide, thin at margin, but very thick at apex. Exumbrella besprinkled with irregularly placed clusters of small warts. 8 marginal sense-organs, the marginal lappets irregularly arranged, there being 5 or 10 rectangular velar lappets in various octants; thus some marginal sense-organs may be close together, while others are far apart. There is a wide, well-developed zone of ring-muscles, confined, however, to the peripheral parts of the subumbrella, its inner edge being beyond the periphery of the arm-pillars. The subgenital ostia are twice as wide as pillars of the arm-disk. These ostia appear double, thus giving the false appearance of 8 instead of 4 genital pits. This is due to the fact that each of the 4 interradial gonads is separated into 2 lateral rays by means of a central gelatinous flap which divides the subgenital ostium into 2 side-openings.

The 8 mouth-arms are hardly as long as the bell-radius and consist of a simple, short, thick, upper part of the arm and an expanded 3-winged, lower part, which is 3 to 4 times as long as the upper. The lower part is thickly beset with frilled mouths, there being short, isolated, gelatinous knobs strewn between the mouths and a short, rounded terminal knob at the free end of each arm, about one-sixth as long as the arm itself. There is also a large cluster of about 8 to 20 linear filaments upon the arm-disk at the bases of the 8 mouth-arms. These are about 1.5 times as long as the diameter of the bell.

Central stomach large and cruciform, 8 radial-canals arise from it and extend outward to the marginal sense-organs; of these the 4 interradial canals are long and the 4 perradial ones short. Between these 8 main canals are numerous, slender canals which arise from the periphery of the stomach and anastomose with themselves and with the main radial-canals. All of these canals are set into communication one with another by means of the circular canal near the bell-margin. On its outer side the ring-canal gives off a network of slender vessels which anastomose over the lappets. The subgenital porticus is very small. Color (?)

Vanhöffen describes 3 examples of this medusa from Assab, on the Red Sea. They were found in September. He gives it the generic name *Desmostoma*, defining the genus as being similar to *Mastigias*, but with a large cluster of filaments upon the arm-disk between the mouth-arms. The distinction appears to me to be too slight for generic, although important for specific, differentiation.

Mastigias (?) rosea Vanhöffen.

Rhizostoma rosea, Reynaud, 1830, in Lesson's "Centurie zoologique," p. 97, planche 34.
Toxoclytus roseus, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 153.—Haeckel, 1880, Syst. der Medusen, p. 586.—Lendenfeld, von, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 288.
Mastigias roseus, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 45.

Disk flat and hat-shaped, short, deep radial furrows on the exumbrella surface between the lappets; 56 to 64 (?) small, elongate, marginal lappets, all of the same size and shape. 8 separate mouth-arms, hardly as long as the bell-radius; upper part of each arm cylindrical,

lower half pyramidal and 3-winged, one wing centripetal, the other two centrifugal; outer surfaces of all 3 wings covered with deep furrows which are complexly folded and contain the frilled mouths. A club-shaped, gelatinous appendage arises from the free lower end of each arm and numerous other appendages spring from the sides of the arms between the furrows. No scapulets. 4 horseshoe-shaped gonads.

The bell-margin and frills of the mouth-arms are deep rose color, while the gonads are paler. This species is found in the tropical Atlantic.

Size (?) Exact locality (?) A more accurate and modern figure of this form is greatly to be desired for we can not now be certain even of the generic position of this medusa.

Genus PSEUDORHIZA von Lendenfeld, 1882.

Pseudorhiza, von Lendenfeld, 1882, Zool. Anzeiger, Bd. 5, p. 380; 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 293; 1887, Descriptive Catalogue Australian Museum, Sydney, part 1, p. 23.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, pp. 53, 71, 80.
Monorhiza, Haacke, 1887, Jena Zeit. für Naturw., Bd. 20, p. 614.

The type species is *Pseudorhiza aurosa* von Lendenfeld, of Victoria and South Australia.

GENERIC CHARACTERS.

Rhizostomata triptera with eight 3-leaved mouth-arms, one or all of which terminates in a single large club. No other clubs or filaments among the mouths. 8 rhopalia. 16 radial-canals, 8 rhopalar and 8 adradial. The rhopalar canals extend to the bell-margin, but the adradial ones only to the ring-canal which connects with all of the 16 radial-canals. On the outer side the ring-canal gives off an anastomosing network, and on its inner side a number of blindly-ending, centripetal vessels which may anastomose. The wide, circular muscle of the subumbrella is only partially interrupted in the radii of the radial-canals. The sense-club bears an ocellus and there is a shallow, exumbrella sensory pit without radiating furrows. The central mouth persists at the center of the arm-disk.

Haacke's genus *Monorhiza* is similar to *Pseudorhiza*, but in *Monorhiza* only one mouth-arm bears a terminal club, whereas all 8 bear each a terminal club in *Pseudorhiza*. The distinction may be deemed to be of specific rather than of generic value.

Pseudorhiza is so closely allied to *Mastigias* that we might readily merge the two genera into one, designating it by the older name *Mastigias*. In *Mastigias*, however, one finds small clubs or filaments arising from the sides of the mouth-arms between the mouths, and these are wholly absent in *Pseudorhiza*; also in *Mastigias* the inter-rhopalar canals which arise from the inner side of the ring-canal *connect* with the stomach, whereas in *Pseudorhiza* they end blindly. These blindly-ending, centripetal canals on the inner side of the ring-canal in *Pseudorhiza* may or may not anastomose. They appear not to anastomose in Haacke's *P. haeckelii*, but in von Lendenfeld's *P. aurosa* they are said to form a network; yet von Lendenfeld believes these medusæ to be identical, and they are certainly closely related.

The terminal club in all *Rhizostomata* is merely the naked extension of the axial shaft of the mouth-arm. It is triangular in cross-section as is the arm itself, and the axial duct of the arm extends onward into it. Thus it is not homologous with the club-like appendages and filaments which arise *between* the mouth-arms.

Pseudorhiza aurosa von Lendenfeld.

Pseudorhiza aurosa, von Lendenfeld, 1882, Zool. Anzeiger, Bd. 5, p. 380; 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 293, plate 3, 1 fig.; *Ibid.*, p. 426.—1887, Descriptive Catalogue Australian Museum, Sydney, Part 1, p. 23; 1888, Zeit. für wissen Zool., Bd. 47, p. 218, taf. 18, fig. 1; taf. 19, fign. 3–7; taf. 20, fign. 14–16; taf. 23, fign. 39, 42, 43, 49–52, 57; taf. 24, fign. 60, 62; taf. 26, fign. 84, 87–92, 94, 95; taf. 27, fign. 98–107, 114 (detailed description).

Umbrella 400 mm. wide, flatly rounded, about 130 mm. high. Exumbrella rough and reticulate. 8 marginal sense-organs and in each octant there are 2 long, narrow, pointed, ocular lappets and 6 velar lappets. Each of the velar lobes consists of 3 secondary lappets. The arm-disk is about as wide as the radius of the umbrella and gives rise to 8 mouth-arms which are about as long as the diameter of the umbrella. There is a central mouth on the (lower) subumbrella side of the arm-disk and 4 pairs (8) of deep gutters extend out from this

mouth along the lower side of the 8 mouth-arms. These arms are 3-leaved and the free edges of these leaf-like expansions branch profusely and complexly. The 8 club-shaped axial appendages which arise from the lower ends of the 8 arms are each about as long as the diameter of the disk.

The 4 subgenital ostia are somewhat wider than the supports between them. There is a single subgenital cavity. The cruciform, central stomach gives rise to 16 radiating canals, 8 to the sense-organs and 8 to the intermediate positions. These 16 canals are put into connection one with another by a ring-canal. On the outer side of this ring-canal is an anastomozing network of vessels, and extending inward from the ring-canal are 160 blindly-ending, centripetal vessels, 10 between each pair of adjacent radial-canals.

Umbrella colorless, the valleys of the reticulate elevations of the exumbrella violet. The entoderm of gastrovascular cavity brown. Upper parts of mouth-arm grooves rose-colored. Arms colorless and transparent. Mouth-frills along the margins of the grooves and distal ends of the long axial mouth-arm clubs rich violet.

Found at Port Philip, Victoria, and at Adelaide, South Australia.

Described in detail by von Lendenfeld, in Zeit. wissen. Zool. It differs from Haacke's "*Monorhiza*" in that there are 8 moderately long, mouth-arm filaments, instead of only one very long filament, and the centripetal canals anastomose into a network on the inner side of the ring-canal instead of remaining separate, as in Haacke's medusa.

Pseudorhiza haeckelii Haacke.

Pseudorhiza haeckelii, Haacke, 1884, Biol. Centralbl., Bd. 4, p. 291.
Monorhiza haeckelii, Haacke, 1887, Jena. Zeit. für Naturwissen, Bd. 20, p. 614, taf. 37, fign. 1–9.

Disk hemispherical to hat-shaped, 200 to 250 mm. wide and 50 to 100 mm. high. Exumbrella roughened with polygonal, wart-like reticulations. 4 elongate, wart-like protuberances upon the subumbrella in the 4 interradii beyond the 4 subgenital ostia. 8 marginal sense-organs flanked by 16 short, narrow, sharp-pointed lappets. The 48 velar lappets are wide, short, and rounded. There are thus 8 marginal sense-organs and 64 lappets. The central mouth opening is 4-cornered, and the central disk gives rise to 4 pairs of laterally compressed 3-leaved mouth-arms. Each leaf of these mouth-arms gives rise to many flat, fern-like expansions. A single filament, 300 mm. long, arises from the lower end of one of the mouth-arms; it is spindle-shaped and 3-cornered in cross-section. The 4 subgenital ostia are wider than the gelatinous columns between them. The central stomach is Maltese-cross-shaped and gives rise to 16 canals, 8 extending outward in the radii of the marginal sense-organs, and 8 being adradial. These 8 ocular canals extend outward to the rhopalia, but the adradial canals end in the ring-canal near the middle zone of the subumbrella. This ring-canal gives rise in each octant to about 18 narrow, unbranched, non-anastomosing, centripetal canals which end blindly. On the outer side of the ring-canal is a network of anastomosing vessels which fuse with the 8 rhopalar radial-canals. The circular muscles of the subumbrella are well-developed over the peripheral half of the under side of the bell and are only partially interrupted in the 8 principal radii.

The gonads form 4 U-shaped walls of the subgenital porticus and are much folded. The gastric filaments are so inconspicuous that Haacke failed to find them, although according to von Lendenfeld they are present. Like *Chrysaora*, *Pseudorhiza haeckelii* is hermaphroditic, for in addition to the central gonads there are sporadic spermaries situated in root-like entodermal filaments in the "gutters" or food crevices of the mouth-arms.

The furrowed network of the exumbrella is violet-brown and the entoderm of the gutters of the mouth-arms dark-red. The large filament glistens in metallic copper-color, and in young specimens it is blue-violet at the base, with a dark-colored, blue and red, spiral, entodermal band of color extending throughout its central cavity. The peripheral canal-system of the subumbrella is brownish-red.

Found in the Gulf of St. Vincent, South Australia, and described in detail by Haacke, 1887. Von Lendenfeld regards this medusa as being identical with, or only a variety of, his *Pseudorhiza aurosa*.

Genus PHYLLORHIZA L. Agassiz, 1862.

Phyllorhiza, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 158.—HAECKEL, 1880, Syst. der Medusen, p. 588.—VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 296.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 41.

Phyllorhiza chinensis L. Agassiz and *P. trifolium* Haeckel are too imperfectly described to be recognizable, and *P. punctata* von Lendenfeld, from Australia, is the type species and the only adequately determined form.

Phyllorhiza chinensis is probably *Cephea cephea*, and *P. trifolium* is, according to Haeckel, described from a preserved and mutilated specimen. It has 96 marginal lappets. Exumbrella finely granular. Arms with 3 semicircular, pinnately-branched, separated lappets or wings, with 24 long and numerous, short filaments, the largest being equal to the bell-diameter. Bell 75 mm. wide. Japanese Sea.

GENERIC CHARACTERS.

Similar to the closely allied *Lychnorhiza* but the centripetal vessels which arise from the inner side of the ring-canal join with the central stomach, as in *Mastigias*, instead of ending blindly as in *Lychnorhiza*. Also the ring-muscle of the subumbrella is interrupted in the 8 principal radii. The canal-system resembles that of *Mastigias*, but the mouth-arms have no terminal clubs.

Phyllorhiza punctata von Lendenfeld.

Phyllorhiza punctata, VON LENDENFELD, 1884, Zool. Anzeiger, Bd. 7, p. 429 (development).—1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 296, plate 4, 1 fig.; p. 307, plate 5, figs. 1–4; 1888, Zeit. für wissen. Zool., Bd. 47, p. 223, taf. 18, fig. 2; taf. 19, fign. 8, 9, 11, 12; taf. 21, fign. 17–20, 22; taf. 22, fign. 27–35, taf. 23, fign. 40, 53–55; taf. 26, fign. 79, 80, 86; taf. 27, fign. 110, 117 (detailed description).—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 60.

Umbrella somewhat flatter than a hemisphere, 500 mm. wide. Exumbrella 50 mm. thick, with a finely granular surface. 8 marginal sense-organs. In each octant there are 2 sickle-shaped ocular lappets, 4 simple lappets near the ocular lappets, and 4 double lappets near the middle of each octant. There are thus 14 lappets in each octant, considering each double-lappet as two. The large, double lappets are partially fused by a basal web, and the ocular lappets are only half as wide as the others and are sharp-pointed, while the others are rounded. Radial furrows extend centripetally over the exumbrella between the lappets. The arm-disk is thick and a little wider than the bell-radius, octagonal in shape and has a canal-system of its own. It is thickly beset with filaments on its ventral side, to which young embryos in the gastrula stage adhere. The 4 subgenital ostia are oval and more than twice as wide as the pillars between them. The eight 3-leaved mouth-arms are two-thirds as long as diameter of umbrella. Their 3 mouth-bearing edges branch pinnately, but the pinnæ are only rudimentary. The lower parts of the mouth-arms bear numerous, tapering, bluntly-ending filaments, some of which are two-thirds as long as the mouth-arms themselves. The circular muscles of the subumbrella are interrupted in the 8 principal radii.

8 radial-canals, 4 perradial and 4 interradial, arise from the cruciform, central stomach and extend to the 8 marginal sense-clubs. A wide ring-canal, at some distance inward from the margin, connects all 8 radial-canals. On its outer side the ring-canal gives rise to a fine-meshed network of vessels (which fuse also with the radial-canals) extending into the lappet zone. On its inner side the ring-canal also gives off a similar network of vessels which connects with the central stomach and with the 4 interradial, but not with the 4 perradial, canals.

The arm-disk, main stems, branches of the mouth-arms, and gelatinous substance of the umbrella are colorless. In the gelatinous substance of the umbrella, close to the surface, are groups of unicellular, yellow, plant cells which give the whole surface a brown color. Also in the gelatinous substance, close to the surface of the exumbrella, there are cloud-like masses of minute, highly refractive bodies which give the medusa a spotted appearance, the spots being whitish. The frilled mouths are brown and the filaments colorless.

This medusa is found in Port Jackson, New South Wales, Australia, and is described in elaborate detail by von Lendenfeld (Zeit. für wissen. Zool.). He finds that during development the marginal sense-organs decrease from 24 to 16, and finally to 8.

When the medusa is 15 mm. wide there are 24 marginal sense-organs and 48 marginal lappets. The 2 ocular lappets of each octant are sharp-pointed, narrow, and elongate, while

the 4 intermediate marginal lappets are broad and bluntly rounded. The 2 intermediate sense-organs of each octant lie in the clefts of the 2 lappets on both sides of the central fissure of each octant.

When the medusæ are about 30 mm. wide the 16 intermediate sense-organs disappear and a new set of 8 sense-organs develops in the middle cleft of each octant. The medusa now has 64 lappets and 16 marginal sense-organs. The 2 lappets on both sides of the 8 velar sense-organs are now double and finally divide completely. When 50 mm. wide the medusæ lose their 8 intermediate sense-organs, and there are then 8 radial and interradial rhopalia and 80 marginal lappets. von Lendenfeld's observations of this remarkable process of development await confirmation.

Genus VERSURA Haeckel, 1880.

Crossostoma, used for Mollusca by MORRIS and LYCETT, 1850.
Crossostoma, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 155.—MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 54, 81.
Versura+*Crossostoma*, HAECKEL, 1880, Syst. der Medusen, pp. 606, 607.

The older species are inadequately described and we may designate *V. palmata* Haeckel, from the Malay Archipelago, as the type of the genus.

GENERIC CHARACTERS.

Rhizostomata triptera with clubs and filaments upon the mouth-arms. The 4 perradial canals arise directly from the stomach, but the 4 interradial canals result from the fusion of a number of anastomosing vessels which arise from the interradial sides of the stomach. There is no definite ring-canal, but merely a marginal network of vessels. There are no radial-muscles in the subumbrella, but the ring-muscles are well-developed.

Among characters of minor importance, the subgenital ostia are wide openings, wider than the columns between them, and the sense-organs have a simple, exumbrella pit without radiating furrows. At the center of the arm-disk is a prominent, raised cluster of frilled mouths having filaments between them.

The older species are so imperfectly described that it will be hopeless to attempt to determine them and they had best be omitted from further consideration. For example: "*Crossostoma corolliflora*" Haeckel is probably a *Cotylorhiza;* "*C. dubreuillii*" may be a *Catostylus*, and "*C. frondifera*" may be a *Cassiopea* (see Haeckel, Syst. der Medusen, pp. 608, 609).

Versura palmata Haeckel.

Versura palmata, HAECKEL, 1880, Syst. der Medusen, p. 606, taf. 40, fign. 9–12.—GOETTE, 1886, Sitzungsber. Akad. Wissen. Berlin, Jahrg. 1886, p. 836.—VANHÖFFEN, 1888, Bibliotheca, Bd. 1, Heft. 3, p. 42.—HAMANN, 1881, Jena. Zeit. fur Naturwissen., Bd. 15, p. 253.

Bell flat, shield-shaped, 60 mm. in diameter, 20 mm. high. 8 rhopalia set within very shallow niches in the bell-margin. Ocular lappets very small and sharply pointed; the velar lappets vary greatly in number, ranging from about 4 double ones to 12 in each octant. They are barely discernible, being separated by very short, narrow clefts. Arm-disk about two-thirds as wide as bell-radius; the 4 subgenital ostia are twice as wide as the perradial columns between them. There is a unitary, narrow, cruciform subgenital cavity. The 8 mouth-arms are somewhat shorter than the bell-radius. The simple upper axial shaft of each arm is not quite half as long as the 3-winged lower part, which is Y-shaped in cross-section and nearly as wide as long. The free edges of the Y are complexly branched and folded and bear the frilled mouths. Each lamella of the mouth-arm displays 6 to 7 very deep clefts. There are numerous, small, club-shaped vesicles scattered among the mouths and a larger terminal club at the lower end of each arm.

The central stomach is Maltese-cross-shaped. Canal-system of bell (?) There is a marginal zone of circular muscles which are only partially interrupted in the 8 principal radii. Centripetal to this zone is another muscular zone which is interrupted in the 8 principal radii, the fibers of which are bowed outward toward the areas of interruption. Color (?)

Haeckel records this medusa from the Malay Archipelago, and Goette studied specimens from Zanzibar, Singapore, and Nagasaki, Japan. It is distinguished only by its indistinct velar lappets and the terminal club of its mouth-arms.

Versura vesicata.

Versura vesicata, HAECKEL, 1880, Syst. der Medusen, p. 645.

This is very briefly mentioned by Haeckel. It is closely related to, if not identical with, *V. palmata*, but has twice as many velar lappets. The ocular clefts in the margin are deep and the subgenital ostia are only half as wide as the pillars between them. The vesicular club at the end of each arm is larger than in *V. palmata*, being one-fourth as long as the bell-radius. Northwestern coast (?) of Australia. Size, etc. (?)

Versura pinnata Haeckel.

Versura pinnata, HAECKEL, 1880, Syst. der Medusen, p. 607.

This Cocos Island medusa is very briefly described by Haeckel. Bell flat, 80 mm. wide. 8 deeply-cleft rhopalar niches. 144 lappets. In each octant 16 indistinct quadratic velar, between 12 small, pointed, ocular lappets. Subgenital ostia as wide as the columns between them. Mouth-arms somewhat longer than bell-radius and twice as long as wide. It may be identical with *V. palmata*, being described only from a preserved and presumably contracted specimen.

Versura anadyomene.

Crossostoma anadyomene, MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 56, taf. 7, fign. 65–68.
Crossostoma, sp., GOETTE, 1886, Sitzungsber. Akad. Wissen., Berlin, Jahrg. 1886, p. 837.

Bell about 200 mm. in diameter and quite flat. Exumbrella covered with a network of anastomosing furrows, leaving polygonal elevations between them. This network is wide at the center and finer-meshed at the margin, and the general trend of the furrows is mainly outward from the center. Gelatinous substance of bell very thin, being only a few millimeters thick even at center. The canal-system can be seen by looking through the bell from the exumbrella side. There are 8 marginal sense-organs, 4 perradial and 4 interradial. These are small and probably lack ocelli, and on the exumbrella side above each sense-organ there is a small, simple sensory pit without radiating furrows. The 16 ocular lappets which flank the 8 marginal sense-organs are small and lanceolate. In each octant between sense-organs are 8 large, semicircular velar lappets, which alternate somewhat irregularly with about 8 small, narrow, tongue-shaped lappets. The arm-disk is rectangular to cruciform, with long interradial slit-like, subgenital ostia and 4 narrow, perradial pillars between them. The subgenital sinus is a flat, narrow, cruciform space and the genital cross is very narrow. The medusa is very delicately formed, the lower parts of the mouth-arms being thin and leaf-like.

Each of the 8 mouth-arms is about as long as the bell-radius and very strongly compressed laterally. The upper part of the arm has the form of a knife blade, the sharp edge being inwards (axial) and the thick, rounded side being abaxial. Two rhomboidal, expanded, leaf-like wings arise from the abaxial side of each arm. The lower sides of the two lateral wings and the inner (axial) part of each arm gives rise to numerous, flat, membranous side branches which expand outwardly. These side branches bear the frilled mouths. Small club-shaped vesicles arise from between the mouths of the two lateral, abaxial wings of each mouth-arm, while the ventral side of each mouth-arm gives rise solely to tapering filaments between the mouths. The rows of frilled mouths on the inner (axial) sides of the mouth-arms extend to the center of the arm-disk, where they form a projecting rosette.

A main canal arises from each of the 4 perradial corners of the stomach and sends branches into the mouth-arms. It is remarkable that each of the lateral, abaxial wings of the lower arms contain 2 separate axial-canals, each of which sends off side branches to the mouths. These side branches do not anastomose and thus there is a double canal-system in each of the lateral wings of the lower arms.

The central stomach is cruciform, the arms of the cross being perradial. 4 perradial canals extend uninterruptedly from the 4 angles of the central stomach to the 4 perradial sense-organs. The 4 canals to the interradial sense-organs do not arise directly from the stomach, but from 4 areas of anastomosing vessels which form a network on the interradial sides of the central stomach. These network-like areas of vessels arise in numerous canals from the entire interradial sides of the stomach. They send out a few branches which join

the 4 perradial canals. There is no true ring-canal, although all 8 of the radial-canals are placed in communication one with another by a marginal zone of anastomosing vessels which extend into the lappets. There are no radial-muscles in the subumbrella, but there are 2 separate concentric ring-muscles, which are further divided into 8 sectors, the lines of separation being in the radii of the 8 radial-canals. The outer zone of ring-muscles lies close to the bases of the marginal lappets. The inner zone is not a true circle but is widest in the 4 interradii and narrowest in the 4 perradial lines. The gonads and canal-system appear to be reddish.

This medusa is described by Maas from a single specimen found in the Malay Archipelago by the *Siboga* expedition. It may be identical with the *Versura* briefly described by Goette, 1886 (Sitzungsber. Akad. Wissen. Berlin, Jahrg. 1886, p. 837), from the east coast of Africa. Maas gives a detailed description of the medusa. The species is distinguished by its prominent velar lappets, its very thin, delicately formed bell and mouth-arms, and the furrowed surface of its exumbrella.

Versura maasi, sp. nov.

Named in honor of Prof. Dr. Otto Maas in recognition of his notable researches upon medusæ.

Bell 90 mm. wide, flatter than a hemisphere and evenly rounded. Exumbrella finely granular, without furrows. Gelatinous substance fairly thick but not very rigid. 8 rhopalia, each with a pigment mass and an exumbrella pit with smooth floor. 112 marginal lappets.

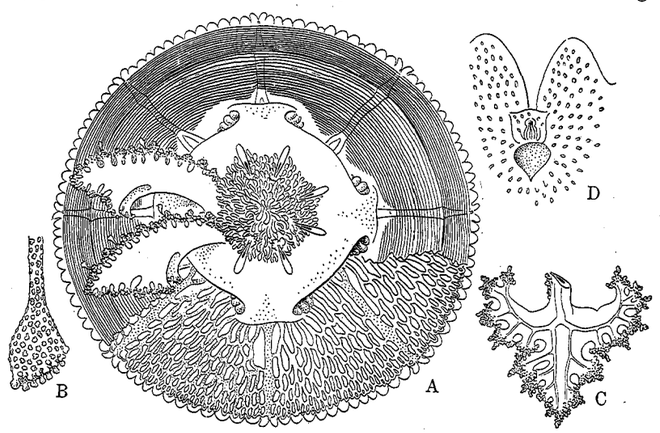


FIG. 416.—*Versura maasii*. Drawn by the author, from a specimen obtained by the U. S. Fisheries Bureau steamer *Albatross* in the Philippine Islands.
A, oral view showing 6 of the mouth-arms cut off close to the arm-disk. In the lower sector the circular muscles are removed exposing the canal-system. B, magnified view of one of the clubs from between mouths of the mouth-arms. C, mouth-arm seen from the outer (abaxial) side. D, exumbrella view of one of the marginal sense-organs.

The 16 rhopalar lappets are only slightly narrower than the velar lappets. There are usually 12 velar lappets in each octant. The outer edges of all lappets are bluntly rounded. The arm-disk is five-ninths as wide as the bell-diameter in the perradius where it arises from the subumbrella, but is only one-fourth as wide as the bell-diameter at the level of the origin of the 8 mouth-arms. The 4 interradial subgenital ostia are twice as wide as the perradial arm-disk columns. There is a wide unitary subgenital porticus. The 8 mouth-arms are each one-third as wide as the bell-diameter. The 3-winged lower part of each arm is somewhat more than twice as long as the unbranched proximal shaft of the arm. The 2 lateral, outer wings of each arm are deeply cleft (fig. 416, C). There are a very few, small, club-like appendages (fig. B) among the mouths of the mouth-arms, but the center of the mouth-arm disk bears a great number of clubs. These clubs are laterally flattened, the largest being only 10 mm. long and besprinkled with nematocyst-bearing warts which are especially numerous upon

their outer ends. The mouth-arms are strongly compressed laterally, being only 3 mm. in circumferential and 11 mm. in radial width at their points of origin from the mouth-arm disk. A single duct extends into each mouth-arm, but this soon sends off a pair of side branches to the lateral wings, and a pair of secondary branches arises from these and extends down the main shaft of the mouth-arm (fig. 416, c).

There are 8 wide rhopalar canals of which the 4 perradial ones arise directly from the stomach, but the 4 interradial arise from the confluence of a pair of forks. 7 to 9 narrow vessels arise from each inter-rhopalar octant of the stomach and extend outward toward the bell-margin, giving off numerous, anastomosing side branches which form a network connecting all the canals. There is no definite ring-canal.

Near the bell-margin there is a sharp, angular bend in the subumbrella surface so that the outer annulus of the subumbrella extends downward vertically and at right angles with the inner zone of the subumbrella. There is a wide annulus of circular muscles in the subumbrella. These muscle-fibers are unbroken but somewhat thinned in the 8 rhopalar radii, and the muscular-zone is wider in the interradii than in the perradii, but does not extend to the edges of the arm-disk.

In formalin the rhopalar radial-canals and the proximal parts of all other canals adjacent to the stomach are bluish-purple. The mouth frills are brownish to brownish-purple. The bell is milky and the muscles and gonads dull brownish-yellow.

A single perfect specimen was obtained by the U. S. Fisheries Bureau steamer *Albatross* on April 8, 1908, along the shore at Mantocao Island, west coast of Bohol, Philippine Islands.

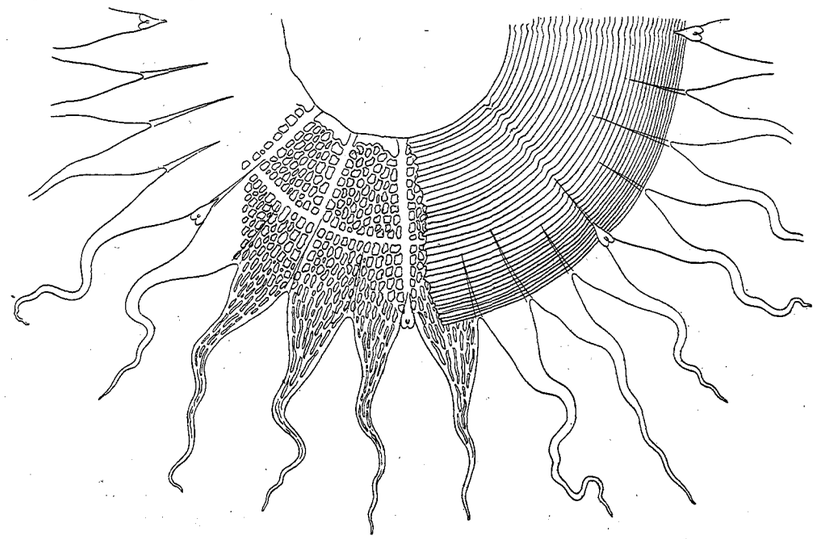


FIG. 417.—*Lobonema smithii*. Drawn by the author, from a preserved specimen. View of subumbrella. Muscular system shown on right and vascular system on left.

Genus LOBONEMA, gen. nov.

The type species and only known form is *Lobonema smithii* from Manila Bay, Philippine Islands.

GENERIC CHARACTERS.

Rhizostomata triptera in which the marginal lappets are greatly extended, tapering to pointed ends. Mouth-arms with numerous filaments. Mouth-arm membranes perforated by window-like openings. 8 rhopalia, 16 radial-canals, and a ring-canal which gives off anastomosing vessels on both its inner and outer sides. The inner network does not connect

with the stomach. The subumbrella exhibits a well-developed system of entire ring muscles. There are numerous prominent, tapering, nematocyst-bearing papillæ upon the exumbrella. All 16 of the radial-canals extend to the bell-margin. There is a sensory pit on the exumbrella side above each rhopalium and the floor of this pit is furrowed.

Lobonema smithii, gen. et sp. nov.

This species is named in honor of Dr. Hugh M. Smith, Deputy United States Fish Commissioner, who found it in Manila Bay, Philipine Islands. The *Albatross* found a perfect specimen of this medusa, and a quadrant of its disk and all of its mouth-arms were preserved. There were also two other imperfect specimens, so that all three taken together afford data for a partial description of the medusa.

Bell flatter than a hemisphere, 236 mm. across from each sense-club to the one 180° from it. Gelatinous substance thick, tough, and rigid. Exumbrella regularly besprinkled with erect, gelatinous papillæ which are largest and most abundant at the center of the exumbrella but disappear near the margin and are not seen over the lappets. Near the center of the exumbrella these papillæ are about 6 to 10 mm. apart and each is about 35 to 40 mm. long and 3 to 5 mm. wide at the base; they are conical, usually more or less curved, and taper to pointed ends. Their surfaces are thickly covered with nematocysts, which give a bristling appearance to the disk of the medusa. 8 rhopalia which lack ocelli in specimens preserved in formalin or alcohol. On the exumbrella side above each sense-club there is a shallow, heart-shaped, sensory pit with dendritic ridges over its floor. The rhopalia are flanked by very small, oval, ocular lappets only 3 mm. long and 2.5 mm. wide. There are 32 (4×8) velar lappets which are most extraordinary, each being 90 to 100 mm. long and tapering gradually from base to tip. They are modified so as to resemble superficially tentacles of semæostomous Scyphomedusæ and trail downward from bell-margin, waving flexibly to and fro as do veritable tentacles; I can find no muscles in these lappets, however, and do not believe that they can contract and elongate. There are deep clefts in the exumbrella surface between the lappets, but these clefts are bridged over by a thin subumbrella membrane spanning between the lappets. The 8 inter-rhopalar grooves are 35 mm., the 8 rhopalar 16 mm. and the 16 intermediate clefts 31 mm. long. The 8 rhopalar clefts are ʌ shaped and the exumbrella sensory pit is at the middle of the crotch of the ʌ with the divided groove on either side of it (see text-figure 418, c). The grooves between the velar lappets are simple, undivided, linear clefts.

16 radial-canals, 8 rhopalar and 8 inter-rhopalar, leave the central stomach and all extend to the bell-margin. There is a fairly distinct ring-canal about 30 mm. inward from the sense-clubs, and this ring-canal gives rise on both its inner and outer sides to an anastomosing network of vessels which connect with the 16 radial-canals, but not directly with the stomach. This network of vessels extends downward throughout the length of the tapering lappets trending mainly longitudinally but with frequent anastomoses.

The muscular system forms an annulus about 68 mm. wide in the subumbrella from the margin of the arm-disk to the zone of the rhopalia. The circular muscles are powerfully developed, and are only thinned but not broken in the rhopalar radii. There are no radial muscles and no muscles in the lappets.

The arm-disk is 100 mm. wide but as it was cut off, I can make no statements in reference to the size or form of the subgenital ostia or of the gonads.

The 8 mouth-arms are separate, 150 mm. long, and each is 3-winged below. The upper shaft of each arm is 60 mm. and the 3-winged lower part 90 mm. long. It is remarkable that each of the 3 lateral membranes is perforated by 3 windows or openings (see diagram A, text-figure 418). The axial duct of the arm extends down the center and gives off side branches in the tissue between the windows to the mouths. These side branches are joined one to another by longitudinal canals near the frilled mouths (see text-figure 418, B).

There are numerous appendages upon the mouth-arms arising between the mouths. Those near the lower pointed ends of the mouth-arms are large, spindle-shaped, more or less triangular in cross-section and taper to pointed ends. Those arising higher up are more slender, and above these there are mere thread-like filaments. The appendages are usually 70 to 100 mm. long, and the large ones contain an axial duct. The general color of the medusa in formalin is milky-gray. The mouths and gonads being darker than other parts.

The U. S. Fisheries Bureau steamer *Albatross* found this medusa in Manila Bay at the ship's anchorage on April 25, 1908, and again at station D, 5222, between Marinduque and Luzon, 9 miles off San Andreas Island, on the surface on April 24, 1908.

Dr. Hugh M. Smith tells me that this medusa inflicts a very severe sting upon persons who may venture to handle it, and he believes it to have been the species which stung nine bathers

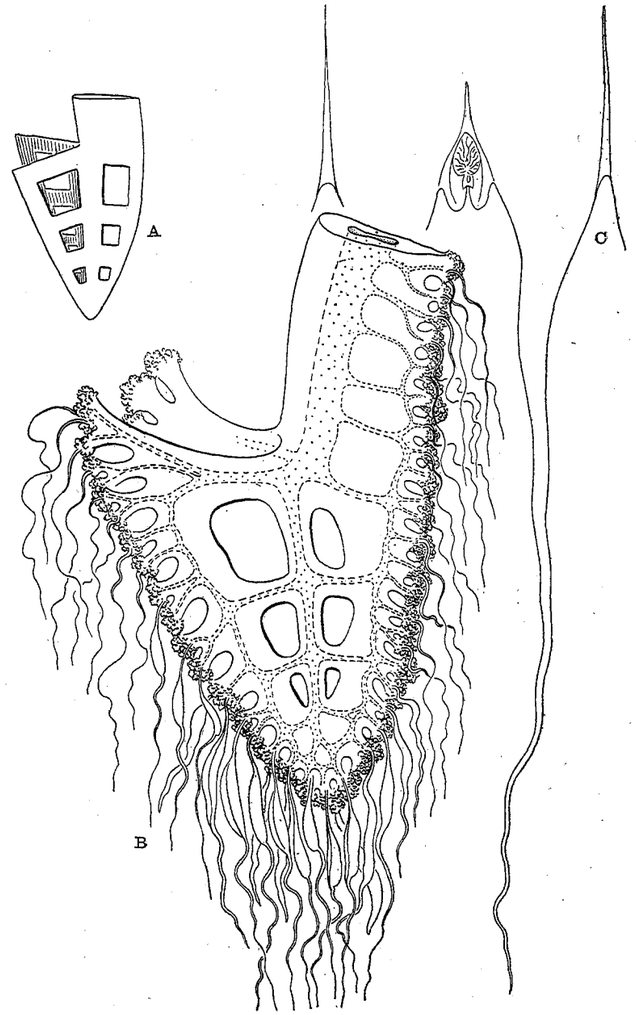


FIG. 418.—*Lobonema smithii*. Drawn by the author, from a preserved specimen.
A, diagrammatic illustration of one of the mouth-arms, to show the window-like openings in side walls of arms. B, side view of a mouth-arm, showing canal-system (dotted). C, rhopalium and one of the marginal lobes.

in Manila Bay whose cases were reported upon by Edward H. H. Old, Asst. Surgeon, U. S. Navy. One of these cases proved fatal, and they all occurred during the summer months of 1906-07. The skin where the sting occurs becomes red and vesiculated and "weeps" as does an eczema. Soon general pains develop throughout the body, especially in the lumbar region.

The mucous membranes give rise to a thin copious secretion. The patient becomes hysterical, coughs almost incessantly and throws himself about the bed, nauseated, weeping, and with an anxious congested face. The pulse becomes rapid and some degree of fever usually develops. The general symptoms develop in from 10 to 15 minutes after the infliction of the sting.

The most efficient remedy was found to be a hypodermic injection of one-sixth to one-eighth grain of morphine sulphate and an external application of an alkaline solution such as bicarbonate of soda. A report upon these cases is presented by Dr. Old in the Philippine Journal of Science, vol. 3, p. 329, 1908.

RHIZOSTOMATA LORIFERA Vanhöffen.

Rhizostomata lorifera, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 45.—MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 75.
Leptobrachidæ, CLAUS, 1883, Organisation und Entwick. Medusen, Leipzig.—VON LENDENFELD, 1888, Zeit. für wissen. Zool., Bd. 47, p. 211.—MAAS, 1906, Revue Suisse de Zool., tome 14, p. 104.

CHARACTERS OF THE GROUP.

Rhizostomæ with very elongate, narrow, lash-like mouth-arms. The lower parts of the arms are 3-winged in cross-section, the mouths being developed upon and near the angles. The upper parts of the mouth-arms are very short and partially fused to the arm-disk by a series of arches spanning from one arm to another. The ring-muscles of the subumbrella are powerfully and the radial muscles weakly developed.

FIG. 419.—Diagrammatic representation of the form and position of the mouth-arms in the *Rhizostomata lorifera*.

The *Rhizostomata lorifera* are only a subordinate group of the *Rhizostomata triptera* from which they have been derived by the elongation of the mouth-arms and the reduction of the lateral expansions of the arms. A description of the genera follows:

Thysanostoma L. AGASSIZ, 1862. Mouth-arms without terminal clubs. 3 rows of frilled mouths extend down the angles throughout the entire length of the lower arm.
Lorifera HAECKEL, 1880. Similar to *Thysanostoma* but with a naked knob at the lower end of each arm.
Leptobrachia BRANDT, 1838=*Leptobrachia*+*Leonura* HAECKEL. Mouths confined to the lower and upper ends of the mouth-arms, so that the mouth-arms are devoid of mouths in the mid-regions of their lengths.

Genus THYSANOSTOMA L. Agassiz, 1862.

Thysanostoma, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 153.—HAECKEL, 1880, Syst. der Medusen, p. 625.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 45.—KISHINOUYE, 1895, Zool. Magazine, Tokyo, vol. 7, p. 133.—SCHULTZE, 1898, Denkschr. Med. Nat. Gesell., Jena, Bd. 8, p. 448.—MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, pp. 75, 81; 1906, Revue Suisse de Zool., tome 14, p. 105.

The type species is *Thysanostoma thysanura* from the Indo-Pacific region. It is possible that Lesson's inadequately described *Rhizostoma brachyura* may be the same medusa.

GENERIC CHARACTERS.

Rhizostomata lorifera having mouth-arms bearing 3 rows of frilled mouths from base to lower end, without a terminal club.

Among characters of minor importance, the 4 interradial, subgenital ostia are wider than the perradial columns between them. There are 8 rhopalar canals, and a ring-canal which gives off a network of vessels on both its inner and outer sides. This network connects with all the radial-canals and also at numerous points with the central stomach. The well-developed circular muscles are only partially interrupted in the 8 principal radii. There is a small, shallow, exumbrella pit above each sense-organ, without furrows in the floor of the pit.

The only difference between this genus and the closely allied *Lorifera* is that the frilled mouths are developed even to the tips of the lower ends of the mouth-arm and there is no terminal club, whereas *Lorifera* has a naked terminal club.

Thysanostoma thysanura Haeckel.

(?) *Rhizostoma brachyura*, Lesson, R. P., 1829, Voyage de la *Coquille*, Zoophyt., tome 2, p. 153; 1830, Centurie Zoologique, p. 227, planche 80.

Thysanostoma thysanura, Haeckel, 1880, Syst. der Medusen, p. 625, taf. 39, fign. 1–9.—Schultze, L. S., 1898, Denkschr. Med. Nat. Gesell., Jena., Bd. 8, p. 448, taf. 33, fig. 3; taf. 34, fig. 8.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 75, taf. 10, fign. 93, 94; 1906, Revue Suisse de Zool., tome 14, p. 105.—Kishinouye, 1910, Journal College of Sci., University of Tokyo, vol. 27, art. 9, p. 23.

Thysanostoma denscrispum, Kishinouye, 1895, Zoological Magazine, Tokyo, vol. 7, No. 83, p. 133, plate 18, figs. 1–13.

The bell is 90 to 120 mm. wide. The exumbrella exhibits polygonal facets or granular elevations which are larger at the center than at the margin. Its outline is dome-like and flatter than a hemisphere, recalling the appearance of a shield. There are 8 marginal sense-

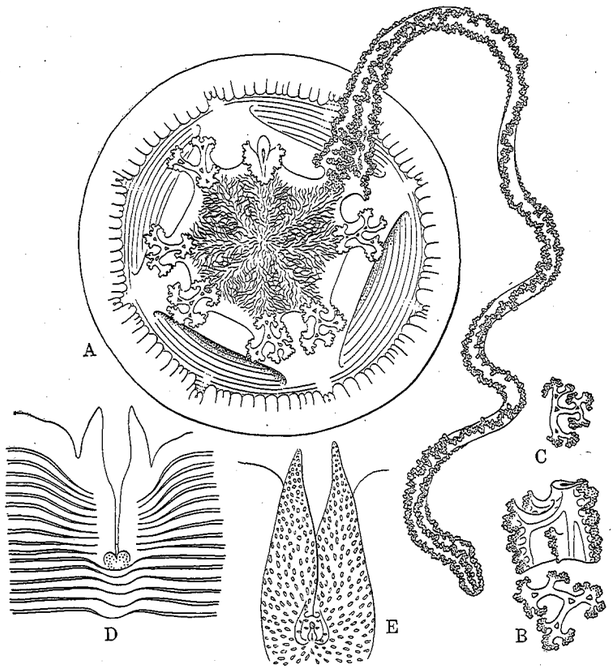


Fig. 420.—*Thysanostoma thysanura*. Drawn by the author, from a specimen taken in a seine by the U. S. Fisheries Bureau steamer *Albatross* at Panabutan Bay, Philippine Islands, Feb. 6, 1908.

A, oral view showing all but one of the mouth-arms cut off. One mouth-arm is cut off close to its point of origin, but the other 6 are cut off at their widest, Y-shaped regions. B, side view of basal part of mouth-arm, with section of same. C, section near distal end of mouth-arm, somewhat enlarged, showing T-shape of cross-section of arm the and 4 arm-canals. D and E, rhopalar lappets from subumbrella and exumbrella sides respectively.

organs which are flanked by 16 small, pointed lappets and between each successive pair of sense-organs are 6 to 12 bluntly rhomboidal lappets which are very variable in size even in different parts of the same octant. The sense-clubs have a pigmented mass of lithocysts and there is a very small, shallow, simple, exumbrella pit.

The 8 mouth-arms are each about 1.5 to 3 times as long as the bell-diameter; upper arm only about one-twelfth as long as the lower arm. Lower arm delicately formed, 3-winged and Y-shaped or T-shaped in cross-section throughout its length; in its upper part it tapers

slightly and then continues throughout the greater part of its length of nearly uniform width, ending in a blunt, distal extremity, covered with frilled mouths. The wings are thin, longitudinal lamellæ, one being inward (axial) and two flaring outward (lateral). The 2 lateral wings give rise each to short, small, secondary wings near their upper, outermost end. In the upper third of the lower arm the frilled mouths are developed upon the outer sides as well as along the edges of the 3 wings. In the middle third they are confined to the edges of the 3 wings; and in the lower (distal) third, they are developed upon the sides and edges as in the upper third of the arm. Thus in the proximal and the distal thirds of the lower arms the mouths recall the condition seen in the mouth-arms of *Mastigias* and *Crambione*. There are neither terminal knobs nor other appendages upon the mouth-arms, but there are numerous short, slender, filiform, tubular appendages upon the arm-disk.

The arm-disk is quadrangular with rounded angles, with its sides about three-eighths as long as the bell-diameter. The subgenital ostia are large and gaping, 4 times as wide as the perradial columns of the disk, and are not narrowed by median flaps. There is a single, large, but low, subgenital porticus.

There are only ring-muscles in the subumbrella. These are strongest near the margin and the muscle-mass is widest in the 4 interradii. The muscles are only partially interrupted in the 8 principal radii. The canal-system of the subumbrella is characterized by the considerable width of the 8 rhopalar canals, which are somewhat wider than the others. The ring-canal is at some distance inward from the bell-margin and the anastomozing network of vessels extends on both sides of the ring-canal, fusing with the 8 radial-canals and with the central stomach. 4 canals arise from the perradial sides of the cruciform stomach and extend downward through the 4 pillars into the arm-disk. Here each canal divides into 4 branches, 2 horizontal ones leading into the center of the arm-disk and 2 vertical leading down into 2 of the oral arms. Each arm-canal gives off 3 side branches which together with the axial-canal extend down the mouth-arms, the side branches giving off branchlets to the 3 rows of mouths.

This medusa is found in the Malay Archipelago, from Amboina, Philippines, and Moluccas to Japan. It is described in detail by Haeckel, L. S. Schultze, and Kishinouye. The exumbrella is violet or mauve colored at its center, grading into russet at its margin. Subumbrella flesh-colored. Gonads and mouth russet or hazel-brown. Mouth-arms and arm-disk violet.

Kishinouye's *Thysanostoma denscrispum*, from Japan, is, I believe, only the young of *T. thysanura*. Lesson's *Rhizostoma brachyura*, from New Guinea, has a whitish bell with rusty-colored margin and yellowish-red mouth-frills, the general color pattern being very similar to that of the more highly colored Japanese medusa.

The dimensions in mm. of a specimen obtained at Mindanao, Philippine Islands, by the U. S. Bureau of Fisheries steamer *Albatross* are as follows: Bell, 100 wide; perradial diameter of arm-disk, 74; diameter of arm-disk at level of origin of mouth-arms, 48; genital ostium, 40 wide; mouth-arms, 220 long, 24 wide at widest part, 12 wide at their blunt tips; 8 to 12 velar lappets in each octant; filamentary appendages on the arm-disk, 10 to 15 long; exumbrella finely granular.

In another large medusa from Mausalay, Mindoro, Philippine Islands, taken by the *Albatross* on June 4, 1908, from a depth of 150 feet, the bell is 120 mm. wide and the mouth-arms 190 long. In a half-grown medusa obtained on the surface at the same time and place the bell is 59 mm. wide with finely granular exumbrella. Mouth-arms 67 long. Arm-disk 41 mm. wide at its origin from the subumbrella and 33 mm. wide at the level of the origins of the mouth-arms.

Genus LORIFERA Haeckel, 1880.

Himantostoma, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 152.—Haeckel, 1880, Syst. der Medusen, p. 627.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 45.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11. pp. 77, 81.

Lorifera, Haeckel, 1880, *Ibid.*, p. 628.

The type species is *L. lorifera* of the Indo-Pacific region. This genus is distinguished from the closely allied *Thysanostoma* only by the naked, club-shaped extremities of its mouth-arms.

The name *Himantostoma* is preoccupied, having been used by Loew, 1853, for Diptera. We must therefore use Haeckel's alternative name *Lorifera*.

GENERIC CHARACTERS.

Rhizostomata lorifera in which the 8 mouth-arms bear rows of three continuous frilled mouths, but terminate each in a naked knob.

Among characters of minor importance the subgenital ostia are usually wider than the perradial disk-columns. The circular muscles of the subumbrella are practically entire. The sense-clubs have each an ocellus and a well-developed, exumbrella pit with radiating furrows.

All the species are from the Indo-Pacific region.

Tabular Description of the Species of Lorifera.

	H. lorifera:	H. flagellata:
Diameter of bell in mm.	150 to 160. Exumbrella smooth.	200. Exumbrella granular.
Number of velar lappets in each octant.	6 double.	8 rounded.
Length of mouth-arms in terms of bell-radius (*r*).	3 to 4 *r*	2 *r*
Length of terminal knob in terms of length of mouth-arms.	One-sixtieth; a very small, swollen, oval bulb.	Two-thirds; slender and tapering.
Color.	Bell amethyst. Margin white with dark-violet spots. Mouths dark-violet.	?
Where found.	Red Sea to Pacific Ocean.	Malay Archipelago to Hawaiian Islands.

Lorifera lorifera Haeckel.

Rhizostoma lorifera, EHRENBERG, 1835, Abhandl. Berlin. Acad., p. 260.
Leptobrachia lorifera, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 154.
Himantostoma lorifera, HAECKEL, 1880, Syst. der Medusen, p. 628, taf. 38, fign. 1–6.
(?) *Himantostoma sueurii*, AGASSIZ, *loc. cit.* p. 152.
Lorifera arabica, HAECKEL, *loc. cit.*, p. 628.

Bell 150 to 160 mm. wide with very thin walls and smooth exumbrella surface. 8 rhopalia. 64 marginal lappets. In each octant 6 short, wide, bluntly-rounded, double, velar lappets between 2 rudimentary, oval, ocular lappets. The 4-sided arm-disk is somewhat wider than the bell-radius. The 4 subgenital ostia are 3 to 4 times as wide as the perradial columns between them. There is a narrow, cruciform, subgenital cavity. The 8 long, tapering, whip-like mouth-arms are twice as long as the bell-diameter. Near the arm-disk they are only 5 to 6 mm. wide and taper outwardly, being only 2 to 3 mm. at their ends where they terminate in a naked, oval knob 5 to 6 mm. long. A ventral and dorsal row of complexly folded, frilled mouths is found in the upper half of each mouth-arm, and thus the upper half of the arm is triangular in cross-section, with a double row of mouth-frills at each of the 3 angles. The ventral (inner) ridge of mouths disappears about the middle of each arm, the lower halves of the arms being thus ribbon-like with only the 2 lateral rows of mouth-frills persisting to the base of the terminal knob. Neither clubs nor filaments between the mouths. There is a wide unitary zone of circular muscles in the subumbrella and apparently no radiating muscle-fibers.

Stomach cruciform, the 4 perradial oral rays of the cross being 60 mm. long and twice as wide (30 mm.) in their outer half as they are near the center of the bell. 8 rhopalar radial-canals arise from the stomach and extend to the marginal sense-organs. These 8 canals are put into connection one with another by a ring-canal at some distance inward from the margin. On its outer side the ring-canal gives off a network of vessels which fuse with the rhopalar canals, and on its inner side there is a wider-meshed network of vessels which fuse with the radial-canals and with the central stomach. There are traces of 8 narrow, adradial canals in the network.

The bell is amethyst-color with a white margin and with a dark-violet spot upon each lappet. The frills of the mouths are dark-violet and the gonads reddish-yellow.

Found at Tur, near Saini, Red Sea, in November.

This medusa may be identical with Agassiz's "*Himantostoma sueurii*" from the China Sea; but in this form there are only 5 velar lappets in each octant instead of 6 as in *L. lorifera*.

Lorifera lorifera "var." pacifica.

Himantostoma loriferum, var. *pacifica* SCHULTZE, L. S., 1897, Ablandlung. Senckenberg. Naturf. Gesell., Bd. 24, Heft 2, p. 153, taf. 15, fign. 1, 1*a*, 6; 1898, Denkschrift. Med. Nat. Gesell. Jena, Bd. 8, p. 446, taf. 34, fig. 9 (young medusa).

This variety is described by Schultze from Ternate and from Amboina, Malay Archipelago.

Bell flatly rounded, 200 mm. wide and 50 to 60 mm. high. 8 marginal sense-organs. 64 marginal lappets; each octant has 2 sharp-pointed rhopalar lappets and 6 velar lappets separated one from another by long, deep furrows; the outer edges of these velar lappets are rounded and each lappet usually displays a median cleft, as in *L. lorifera*, or is even further divided; outer edges of velar lappets evenly rounded. The 4 subgenital ostia are 3 to 4 times as wide as the arm-columns between them. The 8 mouth-arms are 1.5 times as long as diameter of disk. Thus in a medusa 200 mm. in diameter the arms are each 290 mm. long. The simple upper arm is only 10 mm. long; below this each arm expands into a 3-winged appendage, with two outer and one inner wing. This 3-winged part of mouth-arm is very short and extends below in a very long, slender, 3-sided lash, the angles of which bear frilled mouths. This lash terminates below in a small, vesicular, naked knob. The gastric canal which enters each lower mouth-arm sends out a longitudinal branch into each of the 2 dorsal wings. These branches are put into communication with the central canal of the arm by frequent cross-branches, and the side branches into the mouth-grooves often anastomose.

In the middle of the bell is a dark blue-violet area. Near the bell-margin the color is brownish or white. The marginal lappets are violet. The smooth, outer side of the upper arm is transparent. The thick, proximal parts of the lower arms are light-brown in their basal parts, but throughout the greater portion of their lengths they are violet.

This "variety" is probably identical with Haeckel's *L. lorifera* from the Red Sea. The slight differences mentioned by Schultze may readily be due to individual variation. For example, in the medusa from the Malay Archipelago the lower side of the arm-disk along the lines of the 8 axial rows of mouth-openings is beset with a felt-like mass of long, thin filaments. These are absent, however, in Haeckel's medusa from the Red Sea. Schultze has seen Haeckel's original specimen in Berlin and finds that it is a male, whereas the medusa from the Malay Archipelago is a female. It is possible, therefore, that this difference in the condition of the lower surface of the arm-disk may be sexual.

Lorifera flagellata.

Himantostoma flagellata, HAECKEL, 1880, Syst. der Medusen, p. 629.—MAAS, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 77, taf. 10, fign. 87–92; taf. 11, fig. 101.

The bell is flatly rounded and may be 200 mm. in width. The gelatinous substance is thick, tough, and of a porcelain-like whiteness. The exumbrella bears fine granulations, and near the margin are light-brown punctations, especially numerous over the marginal lappets, where they are rendered especially conspicuous owing to the white color of the underlying gelatinous substance.

There are 8 marginal sense-clubs each with a large swollen end containing a concretion and a pigment-spot of horseshoe shape. The covering scale over each sense-club is wider than it is long, and there is a well-developed sensory pit upon the exumbrella side. The bottom of this pit exhibits radiating furrows. The 8 sense-clubs are flanked by 16 short, pointed, ocular lappets, and between each successive pair of sense-organs are typically 8 large, rounded, velar lappets. Thus there are in all 80 marginal lappets.

The arm-disk is 8-sided and the 4 interradial, subgenital ostia are nearly twice as wide as the pillars between them. These pillars of the arm-disk are peculiar. Near their points of origin from the subumbrella each pillar is divided so that 2 arches of gelatinous substance extend downward to the base of the upper arm. Spanning these arches is a well-developed, gelatinous membrane which also spans the 4 interradial spaces between the arm-disk-pillars and overlaps the 4 subgenital ostia. This peculiar arrangement is well described by L. S. Schultz, 1898, in *L. lorifera* var. *pacifica* (see Denkschr. Med. Nat. Gesell., Jena, Bd. 8, p. 447). The arches and the cross-spanning membrane extend so far down the length of the upper arm that only a small portion of the latter is free.

The 8 mouth-arms when contracted are hardly longer than the bell-diameter. The lower arms are free and taper to their pointed lower ends. They are about 6 times as long as the upper arms. At the upper end of each of these lower arms there are 2 abaxial wings so that the arm is here 3-winged in cross-section and the frilled mouths are developed only along the thin edges of the 3 membranous wings. The main shaft of the lower arm is, however, triangular in cross-section and the mouths are developed upon the sides as well as upon the angular edges of the arm. Each lower arm terminates at its pointed lower end in a long, tapering filament which is about two-thirds as long as the lower arm itself. Numerous, short, slender filaments arise from between the mouths, especially along the lines of the angular edges of the lower arm. There are no club-shaped appendages.

Stomach cruciform, the arms of the cross wide and not quite as long as the center, wherein the arms come together. Thus the stomach is relatively wider than in other species of *Lorifera*. The canal-system of the bell consists of 8 canals in the radii of the sense-organs, which are put into communication one with another by a network of anastomosing vessels which arise not only from the 8 radial-canals but from the edges of the stomach. There is no clearly developed ring-canal and it is difficult to determine the number of canals which arise from the stomach between each successive pair of rhopalar canals. There is a very wide zone of circular muscle-fibers in the subumbrella. This muscle is only somewhat thinned but not actually interrupted in the 8 principal radii. The 4 gonads are horseshoe-shaped and complexly folded. This medusa is found at the Hawaiian Islands and in the Malay Archipelago.

In a small specimen found by the U. S. Fisheries Bureau steamer *Albatross* at station D 5226, in the Philippine Islands on May 4, 1908, the bell is 50 mm. wide and mouth-arms 56 mm. long, the slender, tapering filaments at the ends of the arms being 18 mm. and the mouth-bearing parts of the arms 38 mm. long.

Genus LEPTOBRACHIA Brandt, 1838.

Leptobrachia, Brandt, 1838, Bull. Acad. Sci. St. Pétersbourg, tome 1, p. 191.—Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 154.—Maas, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 81.
Leptobrachia+*Leonura*, Haeckel, 1880, Syst. der Medusen, pp. 630, 631.
Leonura, Haeckel, 1881, Deep-Sea Medusæ *Challenger* Expedition, Zool., vol. 4, p. 133.
Leptobrachia+*Leonura*, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 45.

GENERIC CHARACTERS.

Rhizostomata lorifera in which the long, linear mouth-arms bear no frilled mouths near the middle of their lengths; but near their points of origin from the arm-disk there is a ventral row of mouths, and below the naked mid-region there are 3 lines of mouths, 1 ventral and 2 dorsal. The mouth-arms terminate below in a naked pointed end, free of mouths.

Among characters of minor importance, the slit-like subgenital ostia are wider than the columns between them. 16 radial-canals extend to the bell-margin and a well-developed ring-canal gives off a network of vessels on both its inner and outer sides; these networks fuse with the radial-canals. A unitary, circular muscle is in the marginal zone of the subumbrella.

Leptobrachia leptopus Brandt.

Rhizostoma leptopus, Chamisso et Eysenhardt, 1821, Nova Acta Phys. Med. Naturæ Curios., tome 10, p. 356, taf. 27, fign. 1, *A* and *D*.
Leptobrachia leptopus, Brandt, 1838, Bulletin Acad. Sci. St. Pétersbourg, tome 1, p. 191.
Leonura terminalis, Haeckel, E., 1880, Syst. der Medusen, p. 646; 1881, Deep-sea Medusæ *Challenger* Expedition, Zool., vol. 4, p. 133, plate 32, figs. 1–8.
Leonura leptura, Haeckel, 1880, *loc. cit.*, p. 631.

The following description is derived from Haeckel's account of his "*Leonura terminalis*" which is only a modern name for Brandt's *Leptobrachia leptopus*=*Rhizostoma leptopus* Chamisso and Eysenhardt.

Bell flatter than a hemisphere, 80 mm. wide. Exumbrella covered with regularly arranged, polygonal elevations bordered by furrows. 8 rhopalia. 80 marginal lappets. All of the lappets are sharply pointed and are largest at the middle of each octant, the smallest being adjacent to the rhopalia, the lappets increasing successively in size and being largest midway

between the rhopalia. Converging furrows extend up the sides of the exumbrella from the clefts between the lappets. Arm-disk 4-sided, rarely as wide as the bell-radius, with subgenital ostia 3 times as wide as the columns between them. A unitary, cruciform, subgenital cavity. The 8 slender mouth-arms are about as long as the bell-diameter. The arms are triangular in cross-section and end below in a triangular, pointed, naked extremity nearly one-fourth as long as the entire arm itself. 8 rows of frilled mouths radiate outward from a raised rosette of frills at the center of the arm-disk and extend down the ventral angle of each mouth-arm for a distance about one-fourth the length of the arm. Below this the arm is naked, triangular, and devoid of all mouths for about one-fourth of its length. Below this naked region are 3 double rows of frilled mouths, 1 on the ventral and 2 on the dorsal angles of the arm covering a length equal to about one-fourth the arm; below this region is the naked terminal club. Thus from base to lower end we find: (1) a length wherein there are only ventral mouths; (2) a mid-region devoid of mouths; (3) a part wherein there are 3 double rows of frilled mouths, 1 ventral, 2 dorsal; (4) the pointed, naked, terminal club. There is a unitary marginal zone of ring-muscles in the subumbrella.

The cruciform, central stomach gives rise to 16 radial-canals, 4 perradial, 4 interradial, and 8 adradial. All extend to the bell-margin and are connected by the ring-canal at some distance inward from the margin. A network of anastomosing vessels connects the ring-canal with the radial-canals on the inner side. On its outer side the ring-canal gives off a forked canal into each velar lappet and a network of anastomosing vessels which connects with all of the canals in the lappets.

Found by the *Challenger* expedition near Juan Fernandez Island, off the Pacific coast of South America.

Haeckel's "*Leonura leptura*," from near New Zealand, is probably another name for *L. terminalis*. It differs only in having rectangular instead of pointed velar lappets and the mouth-arms are 3 times as long as the bell-diameter, whereas the arms of *L. terminalis* are said to be only about as long as the diameter of the bell. The "quadratic" marginal lappets of *L. "leptura"* are probably due to the loss of their originally pointed ends, an accident which frequently occurs to Scyphomedusæ.

It seems probable that *Rhizostoma leptopus* of Chamisso and Eysenhardt, 1821, is the same medusa. It is described from the Radack Islands, tropical Pacific. The mouth-arms are not quite twice as long as the bell-diameter, thus resembling Haeckel's *L. terminalis*.

The bell is light-violet, the margin and frilled mouths being darker. 32 reddish-violet spots on the exumbrella near the margin. Gonads yellow.

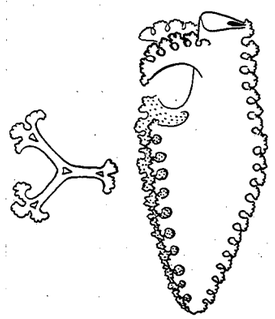


Fig. 421.—Diagrammatic representation of shape of mouth-arm in *Rhizostomata scapulata*.

RHIZOSTOMATA SCAPULATA Vanhöffen.

Rhizostomata scapulata, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 42.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 72.
Stomolophidæ+*Rhizostomidæ*, Claus, 1883, Untersuch. über Organisation und Entwick. Medusen.—von Lendenfeld, 1888, Zeit. für wissen. Zool., Bd. 47, p. 208.

Rhizostomæ in which each of the 8 mouth-arms bears a pair of wing-shaped outgrowths, called scapulets, or shoulder ruffles which arise from the dorsal side of each arm near its point of origin from the arm-disk. Frilled mouths are developed upon the upper and outer sides of these scapulets as well as upon the lower parts of the mouth-arms. The circular muscles of the subumbrella are powerfully and the radial-muscles weakly developed or absent. A description of the genera follows:

Rhizostoma Cuvier, 1800. 8 free mouth-arms, the lower parts of which are Y-shaped or 3-winged in cross-section. These 3 wings meet at a point at the lower end of the arm, and a naked, 3-cornered, club-like appendage arises from this point. There are neither secondary clubs nor filaments upon the mouth-arms.
Rhopilema Haeckel, 1880. Similar to *Rhizostoma*, but with numerous clubs or filaments upon the mouth-arms.
Eupilema Haeckel, 1880. Similar to *Rhizostoma* but there are neither clubs nor filaments upon the mouth-arms.
Stomolophus L. Agassiz, 1862=*Brachiolophus*+*Stomolophus* Haeckel, 1880. 8 laterally coalesced mouth-arms forming an 8-sided throat-tube for the central mouth. Lower ends of mouth-arms are free and branch complexly.

Genus RHIZOSTOMA Cuvier, 1799, sens. restr.

Rhizostome, Cuvier, 1800, Bull. des Sci. Soc. Philomathique de Paris, tome 2, p. 69, planche 4.
Rhizostoma, Peron et Lesueur, 1809, Annal du Muséum Hist. Nat. Paris, tome 14, p. 362.—Eschscholtz, 1829, (in part), Syst. der Acal., p. 45.—de Blainville, 1834, Manuel d'Actinologie, Paris, p. 297.—Lesson, 1843, Hist. Nat. Zooph. Acalephes, p. 411.—Gegenbaur, 1856, Zeit. für wissen. Zool., Bd. 8, p. 210.—Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 150.
Pilema, Haeckel, 1880, Syst. der Medusen, p. 591.
Rhizostoma, Claus, 1883, Organisation und Entwick. Medusen, p. 60, Leipzig.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 31, 43.—Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 80.

The type species is *Rhizostoma pulmo* of the Mediterranean.

GENERIC CHARACTERS.

Rhizostomata scapulata with 16 scapulets upon the outer sides of the 8 mouth-arms. The 8 mouth-arms are free, not fused together. Lower arms 3-winged, each terminating in a single, club-like, gelatinous appendage. There are no other clubs, nor filaments among the mouths. The 4 subgenital ostia are narrow cross-slits, each constricted by a wart-like papilla upon the subumbrella. 16 radial canals, 8 rhopalar and 8 adradial, all of which extend to the bell-margin. A network of anastomosing vessels arises from the outer halves of these 16 radial-canals, and this network gives rise centripetally to 16 blindly-ending areas in the sectors between the radial-canals. There is no marginal ring-canal, but the most direct and widest connection between the radial-canals is through the middle of the zone of anastomosing vessels. 16 triangular areas of circular muscle-fibers alternate with the 16 radial-canals. The marginal sense-clubs lack ocelli. There is an exumbrella pit above the sense-club and the bottom of this depression is furrowed with radiating ridges.

This genus is distinguished from *Eupilema* Haeckel by having 8 terminal clubs upon its mouth-arms whereas these are absent in *Eupilema*. It is distinguished from *Rhopilema* by

Synopsis of the varieties of Rhizostoma pulmo.

	R. pulmo.	R. lutea.	R. octopus.	R. corona.	R. capensis.
Diameter of bell in mm.	150 to 600	200 to 300	As in R. pulmo.	200 to 400	200 to 300 (?)
Character of exumbrella surface.	Finely granular.	Rough with oval warts.	As in R. pulmo.	Smooth (?)	Smooth or finely granular.
Number of marginal lappets.	80	80	96 to 112	140 to 180	?
Shape of velar lappets.	Semicircular.	Short, oval.	Short, pointed.	Small, truncated.	Semicircular.
Length of upper arm.	Longer than lower arm.	As in R. pulmo.	Shorter than lower arm.	Nearly twice as long as lower arm.	Not as long as lower arm.
Length and shape of terminal club.	Shorter than, or equal to, upper arm. Widest near base. Constricted at base. No basal stalk.	Longer than entire arm. With long slender basal stalk and swollen club-like outer end.	Longer than upper arm with a slender basal stalk and swollen club-shaped outer end.	Somewhat shorter than upper arm. Width nearly uniform throughout. Terminal knob with toothed angle.	Half as long as upper arm. Pyramidal, 3-cornered with toothed angles and bluntly pointed end.
Color.	Bell milky-yellow, occasionally reddish. Marginal lappets blue or violet. Mouth-frills orange-yellow to brownish-red or violet.	Warts of exumbrella reddish-brown. Frilled mouths yellowish. Terminal club deep purple-brown.	As in R. pulmo.	?	Bell and clubs bluish. Mouth-frills brownish-red.
Where found.	Mediterranean.	Straits of Gibralter.	Atlantic coasts of Europe, France to Scotland.	Red Sea at Suez and Tur.	Cape of Good Hope, South Africa.
Remarks.		Described in detail by Grenacher and Noll.	Closely related to R. pulmo, but distinguished by its swollen, club-like, terminal appendages.	Imperfectly known. Apparently closely related to R. pulmo.	So imperfectly known that it can not be determined.

having but a single filament (a terminal one) on each mouth-arm, while in *Rhopilema* there are, in addition to the terminal knob, many lateral appendages between the frilled mouths.

The varieties of *Rhizostoma* are known only from the Mediterranean, Red Sea, and Atlantic coasts of Europe and Africa, and are closely related to *R. pulmo* of the Mediterranean; distinguished one from another only by the relative lengths, and the various shapes of the terminal clubs.

Rhizostoma pulmo Agassiz.

Plate 73, fig. 1.

Potta marina, ALDROVANDI, 1642, Zoophyt. Lib., tome 4, pp. 73, 76. Also; *Pulmo marinus*, pp. 75, 77.
Medusa pulmo, MACRI, 1778, Atti Real. Acad. Sci. Napoli, vol. 2, p. 45, tav. 1.—LINNÉ, (Gmelin), 1788, Systema Naturæ, Ed. 13, Pars. 6, p. 3155.
Rhizostoma aldrovandi, PÉRON ET LESUEUR, 1809, Annal. du Mus. Hist. Nat. Paris, tome 14, p. 362, No. 102.—DELLE CHIAJE, 1822, Mém. Anim. senza Vert., Regno Napoli, tav. 74, fig. 10; tav. 75, figs. 1–10; *Ibid.*, 1841, vol. 7, tav. 142, 143.
Cephea aldrovandi, DE LAMARCK, 1816, Syst. Anim. sans. Vert., tome 2, p. 517.
Rhizostoma cuvieri, CHAMISSO ET EYSENHARDT, 1821, Nova Acta Acad. Nat. Cur., Leop. C., tome 10, p. 377, plate 34.—DE BLAINVILLE, 1834, Manuel d'Actinologie, p. 297, planche 44, fig. 1.
Rhizostoma pulmo, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 150.—CLAUS, 1883, Untersuch über Organisation und Entwick. der Medusen, p. 43, taf. 12–15, fign. 86, 105 (development of the ephyra).—GRAEFFE, 1884, Arbeit. Zool. Inst. Wien, Bd. 5, p. 343 (seasonal distribution).—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 31.—DE VESCOVI, 1895, Zool. Results, vol. 1, p. 37.—VON UEXKÜLL, 1901, Mitth. Zool. Sta. Neapel, Bd. 14, p. 620 (rhythmical pulsation).—BETHE, 1903, Allgemeine Anat. and Physiol. Nervensyst., pp. 87, 90, 108, 410, 426, 432, etc., fign. 33–35, 83, 87, etc. (rhythmical pulsation); 1908, Archiv für Ges. Physiologie, Bd. 124, p. 541; *Ibid.*, 1909, Bd. 127, p. 219.—HARGITT, 1904, Journal of Exper. Zool., Baltimore, vol. 1, p. 73, figs. 1–6 (regeneration).
Rhizostoma cuvieri, BRANDT, A., 1870, Mém. Acad. Sci. St. Pétersbourg, tome 16, No. 6, 29 pp., 1 taf. (detailed description).—CLAUS, 1877, Denkschrift. Wien Acad., Bd. 38, p. 47, plate 10, 11; 1881, Zool. Anzeiger, Bd. 4, p. 79 (young ephyra), 1883, Arbeit. Zool. Inst. Wien, Bd. 5, p. 9, taf. 2, fig. 12 (young ephyra); 1884, Arbeit. Zool. Inst. Wien, Bd. 5, p. 169; taf. 2, fig. 12 (ephyra).—BLANCHARD, 1883, Zool. Anzeiger, Bd. 6, p. 67 (the blue coloring matter is not cyanein).—HESSE, 1895, Zeit. für wissen. Zool., Bd. 60, p. 411, taf. 20–22 (nervous system and sense-organs).
Pilema pulmo, HAECKEL, 1880, Syst. der Medusen, p. 591 (record of literature).—HAMANN, 1881, Jena. Zeit. für Naturwissen, Bd. 15, p. 250, taf. 10, fig. 13 (structure of mouth-arms).

Bell pyriform, somewhat higher than a hemisphere, usually not more than 150 mm. in diameter, though specimens 600 mm. wide may occasionally be found. Surface of exumbrella finely granular, being covered with small nettling-warts. 8 marginal sense-organs, each containing an orange-colored mass of concretions of entodermal origin; no ocellus. Above each sense-organ on the exumbrella side is a wide triangular pit, the bottom of which exhibits diverging furrows. Each sense-organ is flanked by a pair of narrow, elongate, lanceolate, sharp-pointed rhopalar lappets. 8 evenly rounded, velar lappets, all similar each to each in size and shape in each octant. Thus there are in all 80 marginal lappets (16 rhopalar + 64 velar).

The total length of the mouth-arms, including their terminal clubs, is about equal to the bell-diameter. In its upper part the arm-disk is 4-sided and narrow, but below it widens out, becomes 8 to 16-sided and gives rise to the 16 (8 pairs) short, simitar-shaped scapulets having fringed mouths upon their upper, convex sides. The 8 mouth-arms are each 3-winged, or Y-shaped in cross-section, two of the wings being directed outward, one being centripetal. These wing-like expansions bear numerous mouths, the lips of which are fringed by a row of short, flexible, knobbed tentacles.

The terminal knobs are triangular in cross-section, somewhat contracted in the middle of their lengths and with a simple, central canal. They are usually a little shorter than the upper arms, but may equal or slightly exceed them in length. The mouth-bearing, lower arms are somewhat shorter than the free upper arms between the zone of the 16 scapulets and the winged portion of the arms. Ordinarily the scapulets are hidden away under the concavity of the subumbrella. The 4 subgenital pits are narrow, slit-like and with their openings constricted in the middle by a knob-shaped protuberance upon the floor of the subumbrella. The 4 invaginated, genital sacs are small and separated completely one from another.

The cruciform central stomach gives rise to 16 radiating canals, 8 of which extend to the sense-organs and 8 are intermediate in position; all reach the bell-margin. A network of anastomosing vessels places the outer halves of the radial-canals in connection one with another, and extending inward between the 16 radial-canals are 16 blindly ending areas composed of a network of vessels. There is no distinct ring-canal at the bell-margin, but the connections between the radial-canals are wider along the inner edge of the zone of anastomosing vessels than elsewhere. 16 deltoid areas of circular muscles alternate with the radial-canals and are more or less completely separated in the radii of the canals themselves.

The canal-system of the mouth-arms is as follows: 4 vessels arise from the perradial angles of the lower side of the central stomach and extend downward into the arm-disk in the 4 perradii. These 4 primary canals bifurcate and the 8 branches extend down the 8 mouth-arms. The 16 lateral vessels which go into the scapulets arise from these 8 mouth-arm canals.

The central mouth is always present in very young medusæ but it usually disappears in the adult. When this mouth is present, or more or less vestigial, we often find a corresponding complexity in the mouth-arm canals, for in this case the 4 perradial canals from the corners of the lower part of the central stomach extend downward beyond the points of origin of the

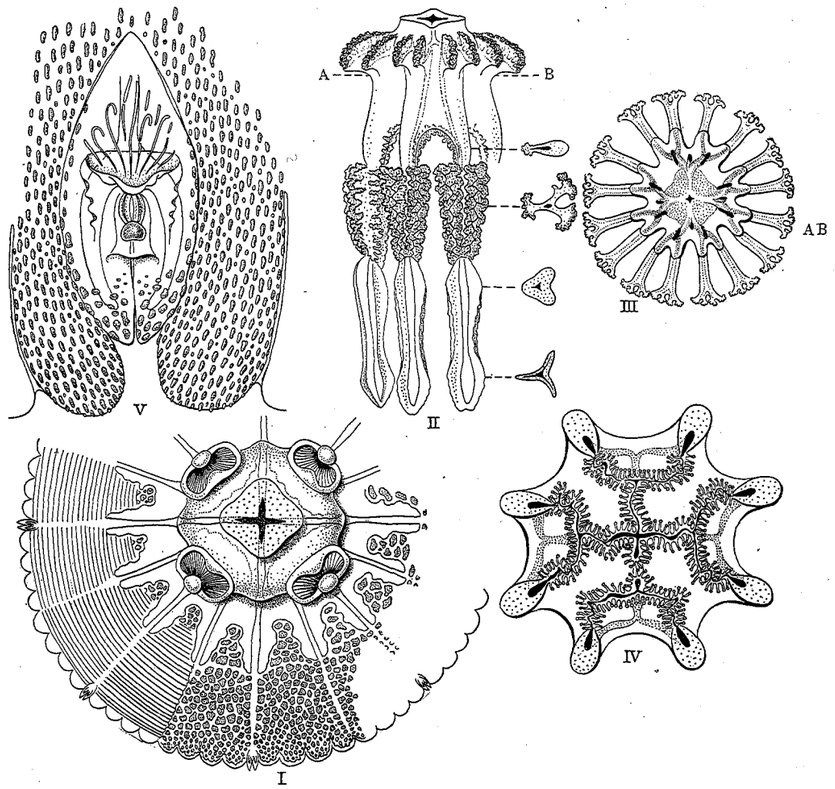


FIG. 422.—*Rhizostoma pulmo*. From life, by the author, at Naples Zoological Station, December, 1907. I, oral view of bell with mouth-arm removed. One half of the surface shows sector of circular muscles, and the other half shows the muscles removed to reveal the canal-system. II, side view of mouth-arms with sections of same. III, section of arm-disk immediately below scapulets. IV, oral view of arm-disk showing persistent central mouth opening. V, sense-organ from exumbrella side.

8 mouth-arm canals; upon reaching the cruciform, central mouth, each of these 4 canals forks and the 8 branches extend outward along the 8 lines of the frilled mouths, becoming confluent with the 8 main, mouth-arm canals in the 3-winged parts of the mouth-arms. A detailed description of the canal-system is given by A. Brandt, 1870.

The gelatinous substance of the disk is creamy-yellow to milky, or rusty-yellowish and translucent. Marginal lappets dark cobalt or violet to blue. The sensory-clubs are tipped with orange, which colors the concretions. The frilled mouths are dull orange, yellow, or brownish-yellow, and the outer parts of the terminal knobs are tinged with the same color. Gonads yellowish, all other parts translucent.

This medusa is common in the Mediterranean. It is found throughout the year, but is most abundant from June until August, becoming ripe in August and September. Very small medusæ are often found in June. Mature individuals are occasionally seen in midwinter.

Claus has studied the development of the pelagic ephyra. When 3.5 mm. in diameter the ephyra has a central, cruciform mouth, the 4 lips of which are lined by a row of knobbed tentacles as in *Aurellia*. There are 8 pairs (16) of velar lappets and 8 pairs (16) rhopalar lappets. 16 radial-canals and a simple, circular canal. In this stage the 8 adradial canals end in the ring-canal, but the 8 others go to the bell-margin. The velar lappets develop in pairs, as in the Discomedusæ and in *Stomolophus*, not singly as in *Aurellia* or *Cotylorhiza*. The 8 mouth-arms arise from paired, terminal folds of the 4 primary rays of the cruciform, central mouth. A detailed description of the young ephyra is given by Claus, 1883.

The rhythmical pulsation of this medusa has been studied by von Uexküll, who found that if the marginal sense-organs be mechanically confined the pulsation is hindered. His conclusion, however, that the stimulus which produces pulsation is mechanical in nature and may be likened to that produced by the clapper of a bell in striking against the margin seems to me improbable. Pressure upon the nerve-center might readily interfere with the activity of the sense-club, and any confinement which cuts off the supply of soluble calcium from the sea-water would soon cause pulsation to cease.

A very suggestive and important series of studies of the nature of the pulsation stimulus in this medusa and in *Cotylorhiza tuberculata* was carried out by Bethe, 1903–1909. He finds, in 1903, that under normal conditions hundreds of pulsations follow quite regularly one after another, with only an occasional pause of brief duration. The medusa pulsates almost incessantly. According to Bethe there are many analogies between the pulsation of this medusa and that of the vertebrate heart. For example, the "all or none" principle applies to medusæ, as does also the phenomena of the extra systole and corresponding compensation-period of rest. The medusæ also show a refractory stage during systole in which they are insensible to stimuli, as was demonstrated by Marey, 1876 (Travaux du lab., p. 73), for the vertebrate heart.

There is an increase in the time that elapses between stimulation and response, and also in the duration of the pulsation itself as the temperature is lowered from 25° to 13° C. The pulsation-stimulus is nervous in nature, being transmitted by the diffuse, nervous network of the subumbrella. Indeed, there are areas of the subumbrella which are wholly without muscles; nevertheless the pulsation-stimulus passes freely over these to the muscular areas beyond. Bethe gives a good series of figures showing the histological character of the nerve plexus which forms a network between the epithelium and the deep-lying, muscular layer of the subumbrella. The sense-organs are physiologically speaking only highly differentiated parts of the nerve-plexus of the subumbrella.

Under normal conditions the pulsation-stimulus originates in the marginal sense-organs, yet in medusæ (such as *Cotylorhiza*) which have an inner zone of radial and an outer zone of circular muscles in the subumbrella the radial-muscles contract *before* the circular, although they are farther away from the sense-organs. This is due, as Bethe shows, to the fact that the latent period (*i. e.*, the time that elapses between stimulus and response) is longer for the circular than for the radial muscles.

The pulsation is a reflex due to a constantly present stimulus, and the refractory stage produces periodicity (rhythm) in the responses. The nerves can not send forth a new contraction-stimulus until a definite period of rest has elapsed.

Bethe, 1908, 09 (Pflüger's Archiv. für ges. Physiologie, Bdn. 124 and 127), has continued his studies of the rhythmical pulsation of *Rhizostoma pulmo* at Naples. He finds that artificial sea-water will not sustain life and pulsation as well as does natural sea-water unless a small amount of $CaCo_3$ be added to the solution. This improvement of the artificial sea-water is not due he believes to the addition of Ca or to the neutralization of an acid, but is caused by the presence of the undissociated molecules of $CaCo_3$. It will be recalled that Rogers, 1905 (Journal Experimental Zool., vol. 2, p. 249), found that the addition of small amounts of $CaCo_3$ to solutions containing the pulsating heart of the crab *Brachynotus* had a beneficial effect. He attributed this, however, to the neutralization of free acid in the solutions.

NaCl in the absence of the other salts of sea-water at first stimulates and later retards pulsation, and this effect is commonly reversible. According to Bethe, the absence of calcium in the presence of the other salts of sea-water causes all movement to cease but normal pulsation is restored by restoring the calcium to its normal amount. In a slight excess in from 2 to 5 c.c. of $\frac{1}{2}$ molecular $CaCl_2$ in 100 sea-water calcium operates for a long time to accelerate and strengthen pulsation. In larger excess such as 10 $CaCl_2$ in 100 sea-water it retards pulsation and produces an abnormal duration of systole. Magnesium chloride and sulphate produce a marked primary retardation, without any final acceleration. Potassium tends primarily to stimulate the rhythmical movement in *Rhizostoma*. Thus, according to Bethe, Na, K, and Ca of the sea-water are primarily stimulants for pulsation, but are antagonized by Mg which alone is an inhibitor of pulsation, and thus a balanced solution is formed. Na and Mg exert their effect primarily through the marginal sense-organs, and Mg also acts upon the general system of muscles. Na, on the other hand, affects the nervous system. Potassium exerts its influence through the marginal sense-organs but has little or no direct influence upon the muscles and nervous network. Calcium in slight excess exerts all or nearly all of its effect through the marginal sense-organs.

Aluminium is an inhibitor of pulsation and is relatively more powerful in this respect than is magnesium. $MgSO_4$ is a less powerful inhibitor than $MgCl_2$ and the order of efficiency as stimulants of the sodium salts is beginning with the most powerful Na_2SO_4, NaCl, NaI, NaBr, $NaNO_3$, and of the potassium salts K_2SO_4, KCl, KNO_3. The rhythmical movement of the whole medusa is controlled by the marginal sense-organs.

The action of the cations of the sea-water upon *Rhizostoma* appear, from Bethe's work, to be similar to their effect upon *Cassiopea*, and I believe that the two medusæ are controlled in the same manner. (See *Cassiopea xamachana*.)

I think, therefore, that Bethe is mistaken in concluding that potassium and calcium stimulate pulsation. It is true in both *Rhizostoma* and *Cassiopea* that pulsation endures longer in NaCl+KCl or in NaCl+$CaCl_2$ than in pure NaCl, but its *rate* is slower. Indeed the *rate* of pulsation in NaCl is so abnormally rapid that the medusa soon comes to rest *exhausted*, and this exhaustion is partially prevented by the subduing effects of K or Ca and thus the pulsation *endures longer* but at a *slower* rate. The apparent stimulation upon adding calcium in excess is not due to the direct effect of the Ca, but to the fact that Ca counteracts the stupefying effects of Mg, thus permitting the *sodium* to act more effectively as a stimulant. Thus the sea-water is a balanced fluid, the stimulating effect of the Na cation being offset by the stupefying effects of Mg, K, and Ca.

Hargitt, 1904, has studied regeneration in *R. pulmo*, and he finds that it possesses a moderate capacity, in confinement, for replacing lost rhopalia. Often 2 rhopalia regenerate in the place of the one which has been cut away. The medusa has but little power to regenerate mouth-arms or gastric lobes.

Hesse, 1895, has made an elaborate study of the histology of the marginal sense-organs and of the nervous network of the subumbrella. Definite strands of nerve-fibers extend radially inward from the marginal sense-organs under the subumbrella epithelium. These radial-fibers bend circumferentially at the zone of the ring-canal, forming a wide ring-like band of nerve-fibers on the inner side of (centripetal to) the ring-canal. These nerve-fibers arise from bipolar ganglia which are found in considerable numbers in the ectoderm along the lines of the radial-canals which extend to the sense-organs. The bipolar ganglia are derived from ectodermal cells of the subumbrella.

The ectodermal cells of the marginal sense-organs bear cilia, and some of them are sensory while others are supporting cells. The sensory pit on the exumbrella side of the sense-club is also lined with a ciliated, ectodermal epithelium containing sensory and supporting cells, and also ganglion cells which send numerous nerve-fibers downward through the gelatinous substance into the entodermal core of the sense-club, where they form a felting of fibers extending into the region of the entodermal concretions.

The inner sensory pit on the subumbrella side of the sense-club is also lined with an epithelium similar to that of the exumbrella pit, and it also sends nerve-fibers into the sense-club. The sensory and ganglion cells of these 2 pits and of the sense-club constitute the central nervous system of the medusa.

Rhizostoma pulmo var. lutea Eschscholtz.

Orithyia lutea, Quoy et Gaimard, 1827, Annal. des Sci. Nat., Zool., tome 10, p. 175, planche 4B, fig. 1.
Rhizostoma lutea, Eschscholtz, 1829, Syst. der Acalephen, p. 51.
Pilema stylonectes, Haeckel, 1880, Syst. der Medusen, p. 595.
Rhizostoma luteum, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 43.—Grenacher und Noll, 1876, Abhandl. Senckenberg Naturforsch. Gesell., Bd. 10, p. 42, taf. 8.

See the tabular synopsis of species of *Rhizostoma*.

This medusa, from the Straits of Gibraltar, is intermediate in most of its characters between *R. pulmo* of the Mediterranean and *R. octopus* of the Atlantic coasts of Europe. Indeed the 3 forms are so closely related that we may consider them to be local varieties one of another. *R. lutea* is distinguished chiefly by its very long, terminal appendages on the mouth-arms.

Rhizostoma pulmo var. octopus Oken.

Urtica marina, etc., octopedalis, Borlase, 1758, Nat. Hist. of Cornwall, p. 258, plate 25, figs. 15–17.
Medusa octopus, Linné (Gmelin), 1788, Systema Naturæ, Ed. 13, Pars. 6, p. 3157.
Medusa bleu, Cuvier, 1799, Journal de Physique, Chimie, d'Hist. Nat. et des Arts, Paris, tome 49, p. 437, 1 planche.
Cassiopea borlasea+Rhizostoma cuvieri, Péron et Lesueur, 1809, Annal. du Mus. Hist. Nat. Paris, tome 14, pp. 357, 362.
Cassiopea lunulata, Eschscholtz, 1829, Syst. der Acalephen, p. 44.
Rhyzostoma octopus, Oken, 1835, Allgemeine Naturgesch., Bd. 5, p. 218.
Cassiopea anglica+C. rhizostomoidea+Rhizostoma sepioides, Tilesius, 1829, Nova Acta Acad. Cur., Leop. C., tome 15, pp. 273, 283, tab. 71.
Rhizostoma coeruleum, Cuvier, 1817, Règne Animal., tome 4, p. 57.
Holigocladodes lunulatus, Agassiz, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 155.
Pilema octopus, Haeckel, 1880, Syst. der Medusen, p. 593 (list of authors).
Rhizostoma octopus, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 43; 1906, Nordisches Plankton Acraspede Medus., Nr. 11, p. 63, fign. 33, 34; 1908, deutsche Südpolar Exped., 1901–03, Bd. 10, Zool. 2, pp. 28, 47.—Dahl, 1893, Kommiss. zur wissenschaft. Untersuch. deutsch, Meere Kiel, Ber. 6, p. 172.—Browne, 1905, Proc. Roy. Soc. Edinburgh, vol. 25, p. 776.

This form is closely allied to *R. pulmo* of the Mediterranean, but it ranges into the cold waters of the Atlantic coasts of Europe, being found off the shores of France, England, Scotland, Belgium, Holland, and Germany. Mature individuals occur in great swarms in September and October and are often cast ashore in vast numbers. The medusa differs from *R. pulmo* in having 96 to 112 marginal lappets instead of 80. The lappets are more pointed than in *R. pulmo*. The simple, upper part of the arm is shorter than the lower, 3-winged part, whereas in the typical *R. pulmo* the reverse is usually the case. The terminal clubs are widest near their outer ends, whereas in *R. pulmo* they are widest near their bases. In other respects it appears to be identical with *R. pulmo*.

Vanhöffen, 1906, describes the young ephyra, 3 mm. wide, in the stage wherein the 4 rays of the cruciform, central mouth are beginning to fork at their outer ends. There are 4 small clusters of gastric cirri. 16 radial-canals. The 8 rhopalar radial-canals extend to the marginal sense-clubs and the 8 adradial canals end in the ring-canal, which is at a considerable distance inward from the bell-margin. This ephyra is thus similar in all respects to that of *R. pulmo*.

It is somewhat remarkable that *R. octopus* is not found among the Azores, Canaries, or other island groups of the Atlantic. Borlase states that in 1758 it was sometimes eaten by man in Cornwall.

Rhizostoma pulmo var. corona Eschscholtz.

Medusa corona, Forskål, 1775, Descript. Anim. Itin. Orient., p. 107.
Rhizostoma corona, Eschscholtz, 1829, Syst. der Acal., p. 52.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 43.
Rhizostoma cuvieri, Ehrenberg, 1835, Abhandl. Berlin Acad., p. 184.
Pilema corona, Haeckel, 1880, Syst. der Medusen, p. 594.

See synoptic table of the species of *Rhizostoma*.

This imperfectly known Red Sea medusa appears to be closely related to *R. pulmo* of the Mediterranean, but is said to be distinguished by having 140 to 180 marginal lappets, instead of 80 as in *R. pulmo*.

Rhizostoma pulmo var. capensis Lesson.

Cephea capensis, Quoy et Gaimard, 1824, Voyage de l'*Uranie*, p. 568, planche 84, fig. 9.
Rhizostoma capensis, Lesson, 1843, Hist. Zooph. Acalèphes, p. 417.
Pilema capense, Haeckel, E., 1880, Syst. der Medusen, p. 645.
Rhizostoma capense, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 43.

Quoy and Gaimard give an artistic, but evidently inaccurate, figure of this medusa, and they fail to describe it. Their record is only interesting in that it indicates that a *Rhizostoma* is found in the South Atlantic.

This form is from Table Bay, coast of South Africa, in March. It may be identical with *R. octopus* or *R. pulmo*. Quoy and Gaimard's figure shows an evenly rounded, oval bell, higher than a hemisphere, with smooth or finely granular surface and with numerous rounded lappets, as in *R. pulmo*. The lower arms are apparently longer than the upper, as in *R. octopus*, and the terminal clubs are bluntly pointed, taper from base to tip, and are about as long as the upper arms.

The colors are as in *R. pulmo*, but the bell and terminal clubs appear to be of a deeper blue. Size (?) Number of lappets (?) The medusa has not been seen since the days of Quoy and Gaimard.

Genus RHOPILEMA Haeckel, 1880.

Rhopilema, HAECKEL, 1880, Syst. der Medusen, p. 596.—MAAS, O., 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 72.—CLAUS, 1883, Organisation und Entwick. Medusen, p. 60.—VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 291.—KISHINOUYE, 1890, 91, Zool. Magazine, Tokyo, vol. 2, p. 47; vol. 3, p. 53; 1899, Zoolog. Jahrbüch., Abth. Syst., Bd. 12, p. 205.
Rhizostoma (in part), VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 31, 43.
Nectopilema, FEWKES, 1887, American Journ. Sci., ser. 3, vol. 33, p. 120.

GENERIC CHARACTERS.

Rhizostomata scapulata with 8 separated, 3-winged, adradial mouth-arms which bear numerous filaments or club-shaped appendages.

The central stomach gives rise to 16 radial-canals placed in intercommunication by a network of anastomosing vessels. A ring-canal may or may not be present.

This genus is closely related to *Rhizostoma* (*Pilema* of Haeckel), but in *Rhizostoma* a single club-shaped appendage arises from the lower end of each of the 8 mouth-arms and there are no other clubs or filaments; while in *Rhopilema* there are many appendages upon each mouth-arm. The type species is *R. rhopalophora* of the Indian Ocean, and the same medusa appears to have been described by Kishinouye from Japan. "*Nectopilema*" of Fewkes is identical with *Rhopilema*.

The edible medusæ of China and Japan belong to the genus *Rhopilema*.

The terminal clubs upon the mouth-arms of *Rhizostoma* are merely the downward, mouth-free extension of the axial shaft of each arm. These terminal clubs are triangular in cross-section, as are the mouth-arms themselves, and they contain a continuation of the axial-canal of the arm. They are not homologous with the vesicular, club-shaped mouth-filaments of *Rhopilema*.

Rhopilema esculenta Kishinouye.

Rhopilema sp., KISHINOUYE, 1890, Zool. Magazine, Tokyo, vol. 2, p. 47, plate 2.
Rhopilema esculenta, KISHINOUYE, 1891, Zool. Magazine, Tokyo, vol. 3, p. 53; 1899, Zoolog. Jahrbucher, Bd. 12, Abth. Syst., p. 205, taf. 13, fign. 1–5.
(?) *Rhopilema rhopalophora*, HAECKEL, 1880, Syst. der Medusen, p. 596.

The umbrella is more than 450 mm. wide, about 330 mm. high when contracted, but nearly hemispherical when expanded. It is about 50 mm. thick at the center, but gradually becomes thin toward the margin. Exumbrella smooth, but the marginal lobes are furrowed with numerous, minute, longitudinal (radial) grooves. 8 marginal sense-organs, each with an exumbrella sensory pit which displays radiating furrows in its floor. In each octant of the margin there are 14 to 20 oval, velar lappets between 2 very small, lanceolate, ocular lappets. The ocular lappets are only about one-fourth as long and as wide as the velar lappets.

In the subumbrella the circular muscles are well developed and unitary, and the coronal furrow is not distinct. The arm-disk is very thick and prismatic, about one-third as wide as the bell-diameter and somewhat longer than wide. The 4 oral pillars are quadrate and the 4 subgenital ostia are somewhat heart-shaped and as wide as the pillars. There is a rough, prickly protuberance upon the floor of the subumbrella opposite the opening of each subgenital ostium. Altogether, therefore, there are 4 of these protuberances alternating with the 4

arm-disk pillars, and thus interradial in position. 4 separate genital cavities. 8 pairs (16) simitar-shaped scapulets arise from the adradial sides of the arm-disk. Their upper sides are convex and bear frilled mouths and numerous, hollow filaments which are about two-thirds as long as the scapulets themselves. The lower sides of the scapulets are concave and devoid of mouth-openings or filaments.

The 8 adradial mouth-arms are stout, triangular, and pyramidal, and exclusive of their appendages they are about two-thirds as long as the diameter of the umbrella. The upper parts of these arms are coalesced with each other along half their lengths. These upper parts

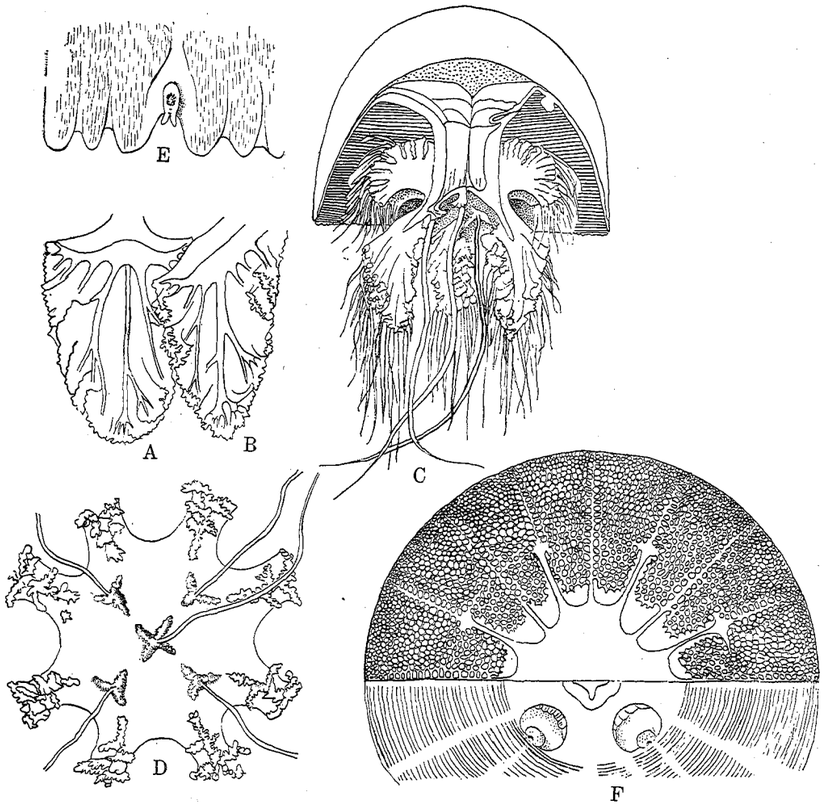


FIG. 423.—*Rhopilema esculenta*. After Kishinouye, in Zoolog. Jahrb., Abth. Syst., Bd. 12.
A and B, side and front views of mouth-arms. C, sagittal section of medusa. D, oral view of arm-disk. E, rhopalium. F, subumbrella showing canal-system (above) and muscular sectors (below).

of the arms are free of mouths and are about as long as the scapulets, while the lower parts are twice as long as the upper and bear numerous, frilled mouths and more than 100 appendages. There are 2 kinds of appendages—filamentous and fusiform. The fusiform appendages are longer than the filaments and may be three-fourths as long as the diameter of the umbrella, the 5 longest being found at the center and 1 at each perradial angle of the arm-disk. The filaments are much more numerous than the fusiform appendages. There are no definite terminal clubs at the lower ends of the mouth-arms.

The central stomach gives rise to 16 radial-canals, 4 perradial, 4 interradial, and 8 adradial. These canals extend to the bell-margin and are connected one with another by means of an indistinct ring-canal which is about midway between the margin and the periphery

of the stomach. On its inner side the ring-canal gives rise to an anastomosing network of vessels which fuse with the perradial and interradial canals, but not with the adradial. On its outer side the ring-canal gives off another network which fuses with all 16 radial-canals.

4 main canals arise from the lower part of the stomach in the 4 principal radii. These main canals fork and each fork extends down one of the 8 adradial mouth-arms, where they branch many times and go to the numerous frilled mouths.

The color of the medusa is usually blue, but occasionally dark-red. The mouth-frills are brown and the mouth-arm appendages are milky-white, or nearly transparent. The gonads are yellow, the male being lighter in color than the female.

This medusa is abundant in the Inland Sea of Japan, and is also found off the coast of China.

It is the custom in Japan to preserve it with a mixture of alum and salt or between the steamed leaves of a kind of oak. It is then soaked in water, flavored with condiments, and when so prepared constitutes an agreeable food.

Rhopilema rhopalophora Haeckel, from the Indian Ocean east of Madagascar, is closely allied to, if not identical with, this Japanese medusa, but it is said to have a large, terminal club at the end of each arm. This club is fusiform, triangular in cross-section, and as long as the whole lower-arm itself. There are 144 lappets, the velar ones being rectangular, and the bell is 100 mm. wide and hemispherical. In other respects it appears to be similar to Kishinouye's medusa, although Haeckel's description is too brief to be satisfactory.

Rhopilema hispidum Maas.

(?) *Pilema clavigera*, Haeckel, 1880, Syst. der Medusen, p. 595.
Rhizostoma hispidum, Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 32, 43, taf. 5, fign. 1, 2.
Rhopilema verrucosa, Kishinouye, 1899, Zoolog. Jahrbücher, Bd. 12, p. 208, 1 fig.
Rhopilema hispidum, Maas, 1903, Scyphomedusen der *Siboga* Expedition, Monog. 11, p. 73, taf. 9, fign. 78–81.

Bell hemispherical or higher than a hemisphere, and may become about 250 to 340 mm. in diameter. Walls very thin; the exumbrella is thickly besprinkled with small, sharp-pointed, conical projections. The 8 marginal sense-clubs have no ocelli, but above each is a large, sensory pit with radiating furrows. 80 marginal lappets. The 8 sense-organs are each flanked by a pair of very small, narrow, lanceolate lappets and there are typically 8 velar lappets in each octant of the bell-margin; these velar lappets are oblong, rounded, and 3 times as long and 5 times as wide as the ocular lappets.

The arm-disk is of the usual 8-sided form. The 4 interradial subgenital ostia are, according to Maas, not quite so wide as the perradial columns of the arm-disk between them; but according to Kishinouye the subgenital ostia in his "*Rhopilema verrucosa*," which appears to be identical with *R. hispidum*, are 3 times as wide as the perradial columns. The 4 genital cavities are only partially and irregularly fused and do not form a unitary genital space, as in *Mastigias* and *Crambessa*, nor are they completely separated into 4 cavities, as in *Cassiopea* (see Maas, 1903). The 8 mouth-arms are two-thirds as long as the diameter of the umbrella. They are fused one with another in the upper thirds of their lengths and are free in their lower two-thirds. There are 16 scapulets, 2 of which arise from the abaxial (outer) side of each of the 8 upper arms. Each scapulet is simitar-shaped and forked at its outer end, and is about half as long as the radius of the umbrella. There are frilled mouths and elongate filiform appendages upon the upper side of each scapulet.

The lower arms are 3-winged or Y-shaped in cross-section, one wing being inward and axial, the other wings being lateral and directed outwardly. Each of these lateral wings is of the shape of an equilateral triangle, and there are 4 elongate, sharp-pointed projections from the abaxial angle of each wing. The pointed lowermost end of the lower arm terminates in a large, club-shaped appendage, with a faceted, swollen end. This appendage is about as long as the upper arm and there are other much swollen, club-shaped appendages which arise between the frilled mouths of the 3 wings of each of the lower arms.

The canal-system of the umbrella consists of 16 radial-canals, 4 perradial, 4 interradial, and 8 adradial, the adradial ones being nearer to the perradial than to the interradial canals. All of the canals extend quite to the bell-margin, and all give off side branches which form an anastomosing network. A definite ring-canal is not present. The circular muscle-system

of the subumbrella consists of 16 triangular areas which alternate with and are widely separated by the 16 radial-canals.

This medusa was described by Vanhöffen from Hongkong, China, and later by Maas from the Malay Archipelago. It appears to be identical with *R. verrucosa* Kishinouye, from Japan. *R. hispidum* is possibly identical with *Pilema clavigera* Haeckel; but in Haeckel's medusa there are only 48 marginal lappets when the disk is 90 mm. wide, whereas in *R. hispidum* of the same width there are 80 marginal lappets. The granular projections upon the exumbrella in Haeckel's medusa are bluntly rounded, whereas in *R. hispidum* they are sharp and thorn-shaped. The terminal appendages of the mouth-arms appear to be somewhat longer in Haeckel's medusa than in *R. hispidum*. Haeckel describes "*Pilema clavigera*" from a single alcoholic specimen from Hongkong, China.

Rhopilema verrillii.

Plate 74, figs. 1, 1′.

Nectopilema verrillii, Fewkes, 1887, American Journ. Sci., ser. 3, vol. 33, p. 119, plate 4.

The disk is fully 350 mm. in diameter, hemispherical in contraction, but slightly flatter than a hemisphere when expanded. The gelatinous substance is thick and rigid. The center of the exumbrella is smooth, but over the lappets there are many shallow furrows and the surface near the margin resembles sand-paper, being covered with numerous minute elevations. There are 8 marginal sense-organs, each of which contains a terminal, entodermal concretion-mass of red pigment granules. There is a simple, exumbrella sensory pit without furrows; 64 marginal lappets. There are 6 large, oval lappets in each octant of the margin of the disk, together with 2 small, oval lappets adjacent to the sense organs.

The arm-disk is cruciform and about half as wide as the bell, and the 4 perradial columns are only three-fifths as wide as the heart-shaped, subgenital ostia. 8 short, tough, gelatinous, lower mouth-arms, which arise from the arm-disk, are each about 180 mm. long and Y-shaped in cross-section below. They branch sparingly and the very numerous mouths are found upon their lower and inner sides, in furrows bordered by numerous, small, waving cirri. There are about 25 to 60 blunt, translucent spindle-shaped appendages, which arise from the lower sides of the mouth-arms, and are besprinkled with wart-like clusters of nematocysts. The largest filaments arise from the principal crotches of the mouth-arms.

A pair of short flapper-like, lateral scapulets arise from the outer side of each of the 8 mouth-arms near its base, the mouth-openings of which are confined to their upper edges and connect by a main duct in each scapulet with the axial-canal of the arm to which they are attached. There are no appendages upon the scapulets. 4 short, gelatinous, perradial columns connect the arm-disk with the subumbrella. There are 4 deep, heart-shaped clefts or genital ostia between these 4 columns, but the bottom of each cleft is bridged over by a delicate membrane. The 4 separate gonads develop within this membrane and the stomach is bordered on the sides by the 4 stout, perradial columns and the 4 interradial membranes. The 4 genital sacs are separated one from another; indeed the gonads are somewhat protrusive in old medusæ.

There is a blunt wart-like papilla upon the subumbrella surface at a short distance beyond the opening of each genital ostium, and this partially constricts the opening, giving it a heart-shaped outline. The circular muscles of the subumbrella are very powerful, but are almost interrupted in the radii of the 16 radial-canals in old medusæ although they are entire near the margin in young animals. Thus in old medusæ there are 16 partially isolated arcades of circular muscles as in *Rhizostoma pulmo*. There are no radial muscles.

The stomach is wide and cruciform, and corresponds in outline with the cruciform arm disk under which it lies. Its exumbrella roof is plane, but the subumbrella floor dips downward into the center of the arm-disk, and 4 open, perradial, gutter-like furrows extend from this central depression down the center of each perradial column to the outer edge of the stomach. 4 perradial ducts arise from the depressed center of the stomach at the middle of the arm-disk, and these soon bifurcate giving 8 adradial ducts which extend down each of the 8 mouth-arms giving off side branches to the numerous mouths.

The axial ducts of the 16 small, flapper-like, lateral scapulets connect directly with the axial duct of the arm to which they are attached. The large, central stomach gives rise to 16 main radial-canals which extend outward to the 8 sense-organs and to intermediate points on the bell-margin. These 16 main radial-canals give rise to numerous side branches which anastomose in a network of vessels as in *Rhizostoma pulmo*. There is no definite ring-canal in the adult.

The gelatinous substance of the medusa is translucent, dull, milky-yellow. The mouths are rich yellow with chocolate-red blotches of pigment scattered at intervals at the bases of the cirri. The ring-muscles of the subumbrella are a decided yellow, and according to Fewkes the radial-canals are chocolate or rich chestnut in color. In the specimens studied by me, however, they were yellow. The gonads are dull milky-yellow. There are numerous, small, gastric cirri upon the gonads.

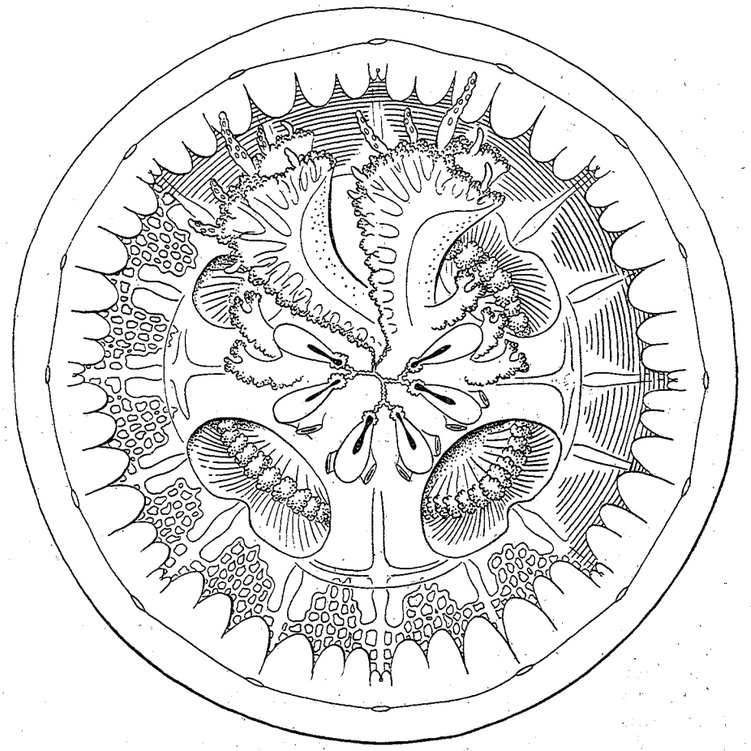


FIG. 424.—*Rhopilema verrillii*. Drawn by the author from a specimen obtained by Professor Verrill at Outer Island near Branford, Connecticut.
Drawing one-half natural size. 6 of the mouth-arms are cut off close to their bases, and the scapulets are cut off from 4 of them in order to show 2 of the subgenital ostia. The muscular arcades are shown in one-half of the subumbrella and the canal-system in the other half. Thus in old medusæ there are 16 partially isolated arcades of circular muscles as in *Rhizostoma pulmo*. There are no radial muscles.

This rare medusa was first found by Prof. A. E. Verrill, in 1886, in New Haven Harbor, Connecticut, during September. In 1889, Professor Verrill again found it in considerable numbers among the Thimble Islands about 10 miles east of New Haven, in Long Island Sound, where they were common in August and September. They then disappeared, but were again found at the Thimble Islands during the summer and autumn of 1903, and again in Branford Harbor, Connecticut, in September and October, 1909. I secured the specimen figured on plate 74 at Middleton, Pamlico Sound, North Carolina, in November,

1904, where it was swimming near the surface on a calm morning. The fishermen informed me that it is seen quite frequently in Pamlico Sound in autumn. I believe, therefore, that it is a southern form which occasionally establishes itself in Long Island Sound.

The following are the dimensions in mm. of a specimen of *Rhopilema verrillii* found by Professor Verrill at Outer Island, near Branford, Connecticut, in Long Island Sound, on September 12, 1909.

Diameter of contracted bell, 218.
Diameter of fully-expanded bell, 268.
Perradial diameter of arm-disk, 135.
Interradial diameter of arm-disk, 76.
Width of each perradial column of arm-disk, 33.
Circumferential width of subgenital ostium, 49
Radial width of subgenital ostium, 27.
Width of zone of circular muscles, 54.
Width of ocular lappets, 3.
Length of ocular lappets, 5. 5.
Width of largest velar lappets, 11.
Length of largest velar lappets, 12.5.
Length of scapulets, 36.
Length of mouth-bearing part of scapulets, 35.
Length of lower arms, 65.
Width at widest distal part of lower arms, 54±.
Width of lower arms at points of origin from arm-disk, 26 to 32.
Length of longest mouth-arm appendages, 26.

Genus EUPILEMA Haeckel, 1880.

Eupilema, HAECKEL, 1880, Syst. der Medusen, p. 590.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 43.

The type species is *Euphilema scapulare* Haeckel, from the Malay Archipelago. *Cyanea rhizostoma* Brandt, 1838, may be of the same genus, but is too imperfectly described to be determined.

GENERIC CHARACTERS.

Rhizostomata scapulata with 8 free, 3-winged mouth-arms, without filaments, clubs, or other appendages. 16 radial-canals all connected by an anastomosing network of vessels in the outer parts of the subumbrella.

This genus is closely related to *Rhizostoma*, but has no mouth-arm appendages.

Eupilema scapulare Haeckel.

Eupilema scapulare, HAECKEL, 1880, Syst. der Medusen, pp. 582, 590.—VANHÖFFEN, 1888, Biblio. Zool., Bd. 1, Heft. 3, p. 43.

Bell 150 mm. wide, 50 mm. high, hat-shaped with rounded dome. 8 rhopalia, 144 lappets. In each octant 8 pairs of long, narrow, rectangular, projecting, velar lappets, between 2 small, oval, ocular lappets. Mouth-arms not quite as long as bell-radius. Scapulets simitar-shaped, as long as free, upper part of arm. 17 radial-canals all connected by an anastomosing network of vessels which extend inward to the zone of the bases of the arm-disk pillars. The form of the scapulets shows that they are only the secondarily separated, uppermost lappets of the dorsal wings of the mouth-arms. Color (?) Sunda Archipelago, Sumatra.

Very briefly described from a preserved specimen by Haeckel.

Genus STOMOLOPHUS L. Agassiz.

Stomolophus, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 138, 151.—AGASSIZ, A., 1865, North American Acal., p. 40.—CLAUS, 1883, Organisation und Entwick. Medusen, p. 60.—VON LENDENFELD, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 292.—VANHÖFFEN, 1898, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 30, 42.—MAAS, 1903, Scyphomedusen der *Siboga* Exped., Monog. 11, p. 80.
Brachiolophus+*Stomolophus*, HAECKEL, 1880, Syst. der Medusen, pp. 597, 598.

The type species is *S. meleagris* L. Agassiz, which ranges from South America to the mouth of Chesapeake Bay, United States, and is apparently found also on the Pacific side of the Isthmus of Panama.

GENERIC CHARACTERS.

Rhizostomata scapulata with a central mouth-opening. With a well-developed, tube-like manubrium formed by the fusion of the lateral edges of the 8 primitive mouth-arms. Only the extreme ends of the mouth-arms are free and they branch complexly. 8 pairs of scapulets. 4 separate invaginated gonads. The central stomach gives rise to 16 radial-canals, which are all connected by a marginal network of anastomosing vessels. 8 marginal sense-organs.

Brachiolophus Haeckel is only a young stage of *Stomolophus*.

Stomolophus meleagris L. Agassiz.

Plates 75 and 76, figs. 1–3.

Cephea rhizostoma, GIBBES, 1847, (non Lamarck) Fauna of South Carolina.
Stomolophus meleagris, AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, pp. 138, 151; *Ibid.*, 1860, vol. 3, plate 14, figs. 1–8.—AGASSIZ, A., 1865, North Amer. Acalephæ, p. 40.
Stomolophus meleagris+*S. agaricus* ?, HAECKEL, E., 1880, Syst. der Medusen, p. 599.
Stomolophus chunii, VANHÖFFEN, E., 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 31, 42, taf. 3, fign. 4, 5; taf. 4, fig. 1.—TRINCI, G., 1906, Annuar Mus. Zool. Napoli, ser. 2, vol. 2, No. 9, pp. 1–4.

Bell about 180 mm. in diameter, half-egg-shaped, higher than a hemisphere, the gelatinous substance thick and rigid; no marginal tentacles; 8 marginal sense-organs, 4 radial and 4 interradial. Each sense-club is deeply set within a niche between the ocular lappets and is protected above by a partial web between the lappets. Sense-club hollow and spindle-shaped, terminating in a knob-like end which contains an entodermal mass of deeply pigmented concretions. A deep, 3-sided, furrowed pit projects inward from the surface of the exumbrella just above the base of each sense-club (see [c] fig. 2‴, plate 75). About 128 marginal lappets, 16 in each octant, those flanking the sense-organs being about 3 times as long as the others. The velar lappets have rounded edges, but the ocular lappets are longer and sharp-pointed.

A rigid, thick-walled mouth-tube, or manubrium, projects downward from the center of the subumbrella and extends 40 to 50 mm. beyond level of bell-margin. This manubrium-like tube is formed by the lateral coalescence of the 8 adradial mouth-arms, which are fused along their adjacent sides, their extreme ends only being free. These free ends of the mouth-arms bifurcate and flare outward at lower end of manubrium. A deep groove, or gutter, extends along the ventral side of each of the 8 mouth-arms and branches dichotomously twice and extends outward over the lower sides of the 16 free ends of, the mouth-arms. The free edges of this branching groove are complexly branched and folded and are lined by a row of numerous small knobbed tentacles, which move constantly in such manner as to drive food particles into the mouth-grooves. In addition to the central mouth, there are numerous slit-like lateral mouths which are situated upon 16 knife-blade shaped scapulets attached to the upper part of, and occupying more than half of the length of, the manubrium. The free edges of these lateral mouths are complexly crenulated and lined with small, incessantly waving tentacles exactly as are the mouth-grooves at the free extremity of the manubrium (fig. 2, plate 76). The 8 main mouth-grooves of the manubrium lead into a 4-cornered, central œsophagus which extends upward into the wide, central stomach. 16 lateral branches, 4 from each side of this four-cornered œsophagus, extend outward to the slit-like mouths in the 16 scapulets. These radiating tubes arise from the œsophagus near the level of the upper parts of the scapulets. The central stomach is wide and lenticular, and occupies the midst of the umbrella. It gives rise peripherally to 16 radial-canals which in their outer halves give off many side branches which in turn form an anastomosing network placing all of the radial-canals in connection one with another, as in the genus *Rhizostoma*. No ring-canal.

There are 4 deep, cylindrical subgenital pits, and a blunt papilla is found on the subumbrella surface just beyond the opening of each genital ostium. The gonads are found in 4 folded regions in the wall of the subumbrella at the bottom of the subgenital pits. There are 16 semi-elliptical areas of circular muscles in the subumbrella, 2 between each successive pair of sense-organs. Alternating with the circular-muscle areas there are 16 narrow, triangular strands of weakly developed radial-muscle-fibers, the broad end of each triangle abutting against the side of the manubrium, and the narrow, pointed end being directed outward. 8 of these occupy the radii of the marginal sense-organs and 8 are intermediate in position. The bell-margin pulsates incessantly with remarkable strength and rapidity.

The gelatinous substance of the bell is of a milky bluish or yellowish color and the entodermal parts are dull yellow. The surface of the exumbrella is reticulated with brown pigment which is especially dense near the margin. There are numerous white or yellowish spots in this brown marginal zone. The mouth-frills are brownish-pink.

Young medusa.—I have captured an immature medusa of this species in which the bell was 3 mm. in diameter and the entire animal 5 mm. in length (fig. 3, plate 75). The bell was flatter than a hemisphere and the surface of the exumbrella was covered with wart-like clusters of nematocysts, among which there were numerous, brown-colored pigment cells.

There were 8 marginal sense-organs and 48 marginal lappets (fig. 1, plate 76). The lappets flanking the sense-organs were about twice as long as the others. The ocular lappets were, however, simple while the others were bifurcated and evidently in process of division. The central mouth was situated at the extremity of a long 4-cornered proboscis which possessed 4 bifurcated lips. The free edges of these lips were lined by a row of short, slender, knobbed tentacles which maintained a constant motion. In addition to the principal or terminal mouth there were 8 small, tube-like, lateral mouths arranged in 4 pairs, the beginnings of the scapulets. These mouths arose from the sides of the manubrium near its base and were interradial in position (*i. e.*, 90° from the radii of the 4 principal lips), and in addition to these lateral mouths there were 4 pairs of hernia-like projections upon the surface of the manubrium. These projections alternated in position with the already functional, lateral mouths, and would no doubt soon have broken through and formed another set of such mouths (fig. 1, plate 76). The functional mouths were each surrounded by 8 tentacles which were similar in structure to the tentacles lining the free edges of the principal mouth.

The medusa was quite transparent except for a trace of brown pigment in the ectoderm of the exumbrella and the dark-red pigment of the sense-organs.

I found it in Charleston Harbor, South Carolina, on September 9, 1898.

The resemblance between this young rhizostomous medusa and the adult condition in the Semæostomeæ is very striking. The terminal mouth was used, indeed, for the capture of food, an operation which was facilitated not only by the flexibility of the lips but also by the incessant motion of the tentacles.

This species is very common along the sandy coasts of North and South Carolina and Georgia. In April, 1910, mature medusæ were abundant at Tortugas, Florida. It does not extend north of the mouth of Chesapeake Bay. It is found along the northern coast of South America, and at many places in the Gulf of Mexico, and I believe it to be identical with *S. chunii* Vanhöffen, from the Bay of Panama on the Pacific side of the Isthmus. It often occurs in vast swarms, occupying an area which is sometimes over 100 miles in length. Mature individuals are abundant in winter and spring off the coast from Florida to South Carolina. It is not often seen in brackish harbors, but is practically confined to pure ocean water off the coast. At most it enters only the mouths of harbors.

I can see no difference between *S. chunii* Vanhöffen and *S. meleagris*. *S. chunii* is described as being only 90 mm. wide and with only 112 marginal lappets. In all respects it resembles a half-grown *S. meleagris*. Indeed, Trinci, 1906, records *S. chunii* from the Gulf of Paria between Trinidad and Venezuela, Atlantic coast of South America, and it appears, therefore, that "*S. chunii*" must occur on both Atlantic and Pacific sides of the Isthmus of Panama. It is probable that the medusa has remained unchanged since the closure of the Isthmus in Mesozoic times.

Haeckel's *Brachiolophus collaris* is only a younger stage of the same medusa with a bell 80 mm. wide and with 80 marginal lappets. It is described from the Galapagos Islands.

Stomolophus meleagris var. fritillaria.

Stomolophus fritillaria, Haeckel, 1880, Syst. der Medusen, p. 598, taf. 35, fign. 1–9.—von Lendenfeld, 1884, Proc. Linnean Soc. New South Wales, vol. 9, p. 292.—Vanhöffen, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, pp. 31, 42.

This form appears to be smaller than *S. meleagris*, the bell being only about 80 mm. in diameter and 60 mm. in height. The marginal lappets are more numerous, being 208 in number. The "manubrium" or fused tube of mouth-arms extends only about one-fourth the bell-height beyond the level of the margin, instead of about one-third the bell-height, as in *S. meleagris*. This medusa is found at Suranim on the Atlantic coast of South America. Color (?)

The only valid distinctions between this medusa and *S. meleagris* are in its large number of marginal lappets, and in the cleft in the middle of each octant of velar lappets. Also the 16 scapulets are hidden well up under the bell instead of extending down to about the level of the bell-margin. It may be regarded as a southern variety of *S. meleagris*. Haeckel describes it from 3 alcoholic specimens in the Copenhagen museum.

RHIZOSTOMATA SIMPLICIA Vanhoffen, 1888.

Archirhizidæ, HAECKEL, 1880, Syst. der Medusen, p. 565.—CLAUS, 1883, Organisation und Entwick. Medusen, Leipzig.—VON LENDENFELD, 1888, Zeit. für wissen. Zool., Bd. 47, p. 210.
Rhizostomata simplicia, VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 39.

These are probably only immature or torn and regenerating forms which are rendered still more unnatural through shrinkage in alcohol. I present this account of them merely in the hope that some may be rediscovered. At present they are wholly apocryphal. A description of the genera follows:

Archirhiza HAECKEL, 1880. 8 free mouth-arms, 4 separate, subgenital cavities.
Haplorhiza HAECKEL, 1880. 8 free mouth-arms. A unitary, subgenital cavity.
Cannorhiza HAECKEL, 1880. Mouth-arms fused along their sides, forming a mouth-cylinder.

Haeckel is the only naturalist who has seen any of these forms. They are all small and I incline to the belief that they are merely immature stages or injured and regenerating specimens of various other rhizostomæ in the condition preceding the development of the ultimate ramuli of the mouth-arms. Vanhöffen (1902, Wissen. Ergeb. *Valdivia* Exped., Bd. 3, Lfg. 1, p. 52) believes them to be merely mutilated medusæ with the branches and appendages of the mouth-arms lost or reduced. I have recorded them merely because they may still have a place in literature if not in the ocean.

Genus "ARCHIRHIZA" Haeckel, 1880.

Archirhiza, HAECKEL, 1880, Syst. der Medusen, p. 565.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Bd. 1, Heft. 3, p. 39.

GENERIC CHARACTERS.

Rhizostomata simplicia with 8 simple separate, unbranched mouth-arms. With 4 separate, subgenital cavities. With 16 radial-canals, some or all of which may give rise to anastomosing side branches. The ring-canal gives off an anastomosing network of vessels which ramify through the marginal lappets. The mouths have no appendages and are found only on the ventral sides of the mouth-arms. 8 rhopalia.

Haeckel founded this genus for *Archirhiza primordialis* from Bass Strait, Australia. Later he describes another medusa, *A. aurosa*, from New Zealand, which is apparently only a later stage in the growth of his *A. primordialis*. Indeed, I suspect that both of these medusæ are immature, or "reconstructed" from fragmentary specimens.

Archirhiza aurosa Haeckel.

Archirhiza primordialis (young ?), HAECKEL, 1880, Syst. der Medusen, p. 565, taf. 36, fign. 1, 2.—HAMANN, 1881, Jena Zeit. für Naturw., Bd. 15, p. 245 (anatomy of mouth-arms).—VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, p. 39.
Archirhiza aurosa (mature ?), HAECKEL, *loc. cit.*, p. 645.

Young medusa (?).—Bell flatly and evenly rounded, hemispherical in contraction, 2 to 3 times as wide as high when expanded. 40 mm. wide. Exumbrella finely granulated as in *Aurellia*. 8 rhopalia, perradial and interradial. 48 marginal lappets. In each octant 2 large median, flanked by 2 smaller velar lappets, and with 2 still smaller, rhopalar lappets flanking the sense-organs. All of the lappets are pointed. Diameter of arm-disk two-thirds as wide as bell-radius. 8 simple, separate, fleshy, unbranched, recurved mouth-arms arise in 4 pairs on either side of each perradial corner of arm-disk. These mouth-arms lack appendages, but there is a zigzag row of fringed mouths along the ventral side of each arm. These 8 lines of mouths of the mouth-arms fuse into 4 perradial lines over the mouth-arm-disk. The mouth-arms are shorter than the bell-radius and are simitar-shaped, but fleshy and blunt at their ends. 4 separate interradial genital sacs are invaginated into the stomach cavity, so the arm-disk displays 4 interradial subgenital ostia. The central stomach gives rise to 16 radial-canals, of which the 8 perradial and interradial canals give off branching side branches near the bell-margin. The 8 adradial canals are simple. All 16 canals and their side branches fuse with a well-developed ring-canal at the zone of the rhopalia, and on its outer side this ring-canal gives off a close-meshed network of small vessels which anastomose through the marginal lappets. Color (?) Found in Bass Strait between Australia and Tasmania.

It is highly probable that the medusa described above is only the young of the form called *Archirhiza aurosa*, by Haeckel, from New Zealand. This is larger, being 50 mm. in diameter. There are 80 instead of 48 marginal lappets. In each octant 8 oval, pointed velar, between 2 small, triangular, rhopalar lappets. Mouth-arm conical, more pointed than in *A. primordialis*, and 1.5 times as long as bell-radius. All 16 of the radial-canals give off anastomosing side branches.

Altogether, the differences between *A. "primordialis"* and *A. aurosa* are precisely such as one would expect to occur during the growth of the medusæ. They are probably only young stages of some species of *Catostylus*.

"Genus HAPLORHIZA" Haeckel, 1880.

Haplorhiza, HAECKEL, 1880, Syst. der Medusen, p. 604.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, p. 39.

GENERIC CHARACTERS.

Similar to *Archirhiza* but with a unitary subgenital cavity instead of 4 cavities as in *Archirhiza*.

This single, subgenital cavity or "porticus" is cruciform in shape and formed by the fusion of the 4 primitive interradial genital sacs and the breaking down of the walls in the fused regions, thus forming a cross-shaped cavity beneath the stomach. It is in communication with the outer world through the 4 genital ostia, and is separated completely from the central stomach. Its side walls constitute partitions between it and the central stomach and they contain the genital products.

Haplorhiza simplex Haeckel.

Haplorhiza simplex, HAECKEL, 1880, Syst. der Medusen, p. 604.

Bell flat, shield-shaped, 40 mm. wide, 20 mm. high. 8 rhopalia. 48 marginal lappets. In each octant 4 large, quadratic velar, between 2 tongue-shaped, projecting, ocular lappets. 8 simple, cylindrical mouth-arms, as long as bell-radius. 4 interradial, subgenital ostia, not quite as wide as the arm-disk-pillars between them. 16 radial-canals and a ring-canal. Bass Strait, southern Australia.

This medusa is very briefly described by Haeckel, but in all respects it appears to be an immature stage of some other rhizostomous medusa such as *Catostylus*. Its 8 simple mouth-arms lack appendages and resemble those of the immature *Archirhiza primordialis* Haeckel. The mouths are confined to the ventral sides of the mouth-arms.

Haplorhiza punctata Haeckel.

Haplorhiza punctata, HAECKEL, 1880, Syst. der Medusen, p. 604.

Bell flatly rounded, 40 mm. wide, 20 mm. high. 8 rhopalia. 176 marginal lappets, in each octant 10 pairs of small, rounded velar lappets between 2 small, rhopalar lappets. 8 simple, cylindrical mouth-arms, hardly half as long as bell-radius, arise in pairs from the 4 perradial angles of the wide 4-cornered arm-disk. The frilled mouths are confined to the ventral sides of the mouth-arms and there are no appendages. The 4 subgenital ostia are 3 times as wide as the columns between them.

Exumbrella dark violet-brown, besprinkled uniformly with round white points.

Arnheims Land, coast of northern Australia. This medusa is apparently immature.

"Genus CANNORHIZA" Haeckel, 1880.

Cannorhiza, HAECKEL, 1880, Syst. der Medusen, p. 605.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, p. 39.

The type species is *Cannorhiza connexa*, Haeckel, from the neighborhood of New Zealand, South Pacific.

GENERIC CHARACTERS.

Rhizostomata simplicia with 8 simple, unbranched mouth-arms, the sides of which are fused one to another forming a hollow mouth-arm-cylinder, and leaving only the lower ends of the arms free. There were neither clubs nor filaments upon the mouth-arms. There is a unitary subgenital porticus. 8 rhopalia. The central stomach gives rise to 24 branching radial-canals which fuse with a ring-canal. Peripherally the ring-canal gives off a network of vessels which ramify through the lappets.

Cannorhiza connexa Haeckel.

Cannorhiza connexa, HAECKEL, 1880, Syst. der Medusen, p. 605, taf. 40, fign. 1–8.—VANHÖFFEN, 1888, Bibliotheca Zoologica, Heft. 3, p. 39.

Bell flatly rounded, exumbrella surface finely granulated, 80 mm. wide, 30 mm. high. Gelatinous substance tough and horny in consistency. 8 rhopalia. 80 marginal lappets. In each octant are 8 small, rectangular, velar lappets between 2 small, oval, pointed, rhopalar lappets. The 8 mouth-arms are fused along their sides forming a mouth-arm-cylinder. Each mouth-arm is cylindrical, somewhat longer than the bell-radius. The short, free, lower end of each mouth-arm is simple, unbranched, curved outward and somewhat upward. The lateral fusions of the 8 adradial mouth-arms are marked by 8 longitudinal furrows, the 4 perradial being shallower than the 4 interradial. The frilled mouths are developed only on the lower sides of the mouth-arms and there are neither filaments, clubs, nor other appendages. The 4 interradial, subgenital ostia are not quite as wide as the perradial spaces between them, and the arm-disk is not quite as wide as the bell-radius. There is a cruciform unitary subgenital porticus and the 4 gonads are in the side walls of this space, the cruciform roof being thick and gelatinous. The 4 genital membranes are much folded. The cruciform central stomach lies above the subgenital porticus from which it is completely separated by the lateral genital membranes and gelatinous, cruciform roof of the porticus.

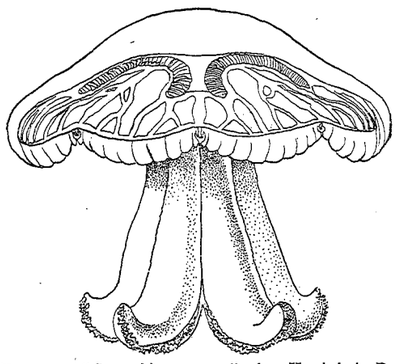


FIG. 425.—"*Cannorhiza connexa*," after Haeckel, in Das Syst. der Medusen.

A wide canal extends downward from each of the 4 perradial corners of the stomach, through the columns, into the arm-disk, where they fuse at the center, forming a small cavity from which arise the 4 pairs of canals leading down the lower sides of the 8 adradial mouth-arms. Each mouth-arm canal gives off numerous short side branches which lead to the frilled mouths. 24 radial-canals arise from the margin of the cruciform stomach and extend outward into the subumbrella. The 8 perradial and interradial canals are about twice as wide as the others. The 4 perradial canals are very short and the 4 interradial very long. All 24 canals give off anastomosing side branches and then fuse with the ring-canal. The ring-canal, in turn, gives rise on its outer side to a fine-meshed network of narrow, anastomosing vessels which ramify through the lappets. Found near New Zealand, South Pacific. Described in detail by Haeckel.

"Stomatonema reticulatum" Fewkes.

Stomatonema reticulatum, FEWKES, 1884, American Naturalist, vol. 18, p. 300.

Bell 36 mm. wide, with thick walls, thinner at margin. There are no marginal tentacles. There are 8 marginal sense-organs which bear some resemblance to those of *Aurellia*. Shape and number of marginal lappets (?) The 8 mouth-arms arise from the arm-disk by 4 attachments and are bordered on their lower sides by a double row of mouths which also extend half-way up the upper side of each mouth-arm. 4 large, globular, ovarian sacs lie in the interradii of the arm-disk alternating with the 4 primary branches of the mouth-arms. A number of radial-canals arise from the central stomach and fuse with a narrow zone of anastomosing vessels at the bell-margin. Fewkes does not state how many radial-canals there are in this medusa, nor does he give any account of the marginal lappets, musculature, relative sizes of the parts of the medusa, color, gonads, or mouth-arm-appendages. He mentions a single specimen found in Montevideo Harbor, Atlantic coast of South America.

The description given by Fewkes is unfortunately too fragmentary even for generic determination, but apparently the medusa is related to Haeckel's *Aurosa*, but is distinguished by having mouths on the dorsal as well as on the ventral sides of the 8 mouth-arms.

FOSSIL MEDUSAE.

Fossil medusæ, or in many cases fossils supposed to be those of medusæ, have been described from the lower Cambrian and Devonian, and especially from the Jurassic lithographic slates of Bavaria wherein their preservation is so perfect that in some cases, as in *Paraphyllites distinctus*, they can be classified accurately with relation to living forms.

Owing to the uncertainty with which we must regard many of these fossils I have deemed it best to group them together and not to attempt the fruitless task of classifying them, excepting in cases wherein their state of preservation warrants such a procedure.

A thorough review accompanied by excellent illustrations of all fossil medusæ known previous to 1898 is given by Walcott in Monographs U. S. Geological Survey, vol. 30, 1898, and this work should be consulted by all students of the subject, for the account here given does not attempt to present detailed descriptions.

Medusina radiata Walcott.

Astylospongia radiata, LINNARSSON, 1871, Köngl. svensk. Vet.-akad. Handl., vol. 9, No. 7, p. 13, plate 2, figs. 15, 16.
Medusites radiatus, NATHORST, 1881, Köngl. svensk. Vet.-akad. Handl., vol. 19, No. 1, p. 25, plate 6, figs. 1, 2.—(?) POMPECKJ, 1896, Jahrbuch, K.-k. geol. Reichsanstalt, Bd. 45, p. 501, taf. 14, fig. 3.
Medusina radiata, WALCOTT, 1898, Monographs U. S. Geol. Surv., vol. 30, p. 56, plate 28, fig. 2.

This fossil medusa from the lower Cambrian sandstone of Sweden is probably one of the Æquoridæ and bears a general resemblance to the genus *Zygodactyla*. Bell 40 to 60 mm. wide. Central stomach 25 to 30 mm. wide. 130 to 150 radial-canals which occasionally branch. Subumbrella with radiating string-of-pearl-like papillæ as in *Zygodactyla*. Nathorst describes these papillæ as being upon the radial-canals, but to me it seems more probable that they are interradial as in *Zygodactyla*.

Pompeckj's somewhat similar medusa from the middle Cambrian beds of Bohemia is probably an *Æquorea*, and not a *Zygodactyla*.

Medusina princeps Torell.

Protolyellia princeps, TORELL, 1870, Lunds Universitets Årks-Skrift, 1869, No. 8, p. 10.
Astylosponiga radiata, LINNARSSON (in part), 1871, Köngl. svensk. Vet.-akad., Handl., Bd. 9, Nr. 7, p. 13, taf. 2, fig. 15.
Medusites favosus, NATHORST, 1881, Köngl. svensk. Vet.-akad. Handl., Bd. 19, Nr. 1, p. 25, taf. 25, taf. 5, fign. 5, 6 (?).
Medusites princeps, MATTHEW, 1890, Trans. Royal Soc. Canada, vol. 8, p. 140.
Medusina princeps, WALCOTT, 1898, Monographs U. S. Geol. Surv., vol. 30, p. 54, plate 28, fig. 1.

This fossil from the lower Cambrian of Sweden is of doubtful affinities. Nathorst's conclusion that it is one of the Cyaneidæ because the exumbrella floor of the stomach exhibits polygonal facets appears to me to be too venturesome, for the radiating furrows of the subumbrella resemble the radial-canals of Æquorea.

Medusina deperdita Walcott.

Acalepha deperdita, BEYRICH, 1849, Zeitschrift deutsch. Geol. Gesell., Bd. 1, p. 437, taf. 39, fig. 1.
Medusites deperditus, HAECKEL, 1865, Zeitschrift für wissen. Zool., Bd. 15, p. 506, taf. 39, fig. 1.
Medusina deperita, WALCOTT, 1898, Monograph U. S. Geol. Surv., vol. 30, p. 91, plate 44, fig. 1.

It is possible that this fossil medusa from the Jurassic limestone of Eichstädt may belong to the genus *Cunoctantha*, but there are no tentacles and we have only the 8 stomach-pouches upon which to hazard this inference The bell is 70 mm. and the diameter through the stomach-pouches 45 mm. wide.

Paraphyllites distinctus Maas.

Paraphyllites distinctus, MAAS, 1906, Neu. Jahrb. Min. Geol., Paläontol., Bd. 2, p. 90, 4 fign.

The preservation of this fossil from the Jurassic lithographic slates is so perfect that its affinities with living medusæ can be determined. It is therefore described on page 549 in connection with *Paraphyllina* to which it is closely related.

Cannostomites multicirrata Maas.

Cannostomites multicirrata, MAAS, 1902, Paläontographica, vol. 48, p. 303, taf. 23, fig. 1, text-fig.

This is a fossil from the Jurassic lithographic slates of Bavaria. A single specimen was studied by Maas. It may possibly be allied to *Atolla*. Only the subumbrella is known. Bell about 100 mm. wide. An open, central mouth with 4 perradial, gelatinous columns. Subumbrella simple with 4 interradial sickle-shaped, notched, and swollen gonads. Marginal ring-muscle entire and powerfully developed as in *Atolla*. Numerous marginal lappets of varying sizes arranged in multiples of 4. Short, simple tapering tentacles arise from notches between the lappets.

Atollites minor and Atollites zitteli Maas.

Atollites minor and *A. zitteli*, MAAS, 1902, Paläontographica, Bd. 48, p. 319, taf. 23, fign. 5 und 6.

These fossils are from the lower chalk of Carpathia from the Warnsdorf strata. There are more than 10 marginal lappets in high relief, quite variable in size and number. A small, plain center of the exumbrella and an intermediate zone with raised streaks radiating outwardly. The medusæ may be allied to *Atolla*. They are well figured by Maas.

Acraspedites antiquus Haeckel.

Medusites antiquus, HAECKEL, 1865, Zeit. für wissen. Zool., Bd. 15, p. 509, taf. 39, fig. 2.
Acraspedites antiquus, HAECKEL, 1869, Zeit. für wissen. Zool., Bd. 19, p. 559; 1880, Syst. der Medusen, p. 647.—VON AMMON, 1886, Abhandl. Math.-phys. Classe Königl. bayer. Akad. Wissen., Bd. 15, p. 157.—WALCOTT, 1898, Monographs U. S. Geol. Surv., vol. 30, p. 75, plate 44, fig. 2.

This is the vague impression of a medusa in the Jurassic white coral limestone, lithographic slate of Eichstädt, Bavaria. It is about 140 mm. in diameter and appears to have 8 marginal lobes. The sculpturing of the bell may place it among the Coronatæ, but Haeckel is inclined to classify it with the Pelagidæ.

Semaeostomites zitteli Haeckel.

Semaeostomites zitteli, HAECKEL, 1874, Jena. Zeitsch. für Naturw., Bd. 8, p. 323, taf. 11; 1880, Syst. der Medusen, p. 647.—VON AMMON, 1886, Abhandlung Math.-phys. Classe Königl. bayerischen Akad. Wissen., Bd. 15, p. 157.—WALCOTT, 1898, Monographs U. S. Geol. Surv., vol. 30, p. 70, pl. 39, text-fig. 17.

This semæostomous medusa is found fossil in the Jurassic lithographic slate of Solenhofen, Bavaria. According to Haeckel the disk is 80 mm. wide, mouth with 4 lips each about 80 mm. long and 10 mm. wide. Central stomach cruciform. 4 interradial, elliptical, genital pouches each 8 to 10 mm. wide. 16 unbranched (?) radial-canals, 4 perradial, 4 interradial, and 8 adradial. A ring-canal at some distance inward from the margin. 120 to 128 marginal lappets, and an equal number of tentacles each about 30 mm. long. This medusa is apparently one of the Ulmaridæ allied to Discomedusa.

Eulithota fasciculata Haeckel.

Eulithota fasciculata, HAECKEL, 1869, Zeit. für wissen. Zool., Bd. 19, p. 549, taf. 42, fign. 1, 2; 1880, Syst. der Medusen, p. 647.—VON AMMON, 1886, Abhandl. Math.-phys. Classe Königl. bayer. Akad. Wissen., Bd. 15, p. 157.—WALCOTT, 1898, Monographs U. S. Geol. Surv., vol. 30, p. 73, plate 45, figs. 3, 4.

This is a fossil medusa from the Jurassic lithographic slate of Solenhofen, Bavaria.

16 marginal lappets. 8 clusters, each composed of at least 4 tentacles, which arise from 8 perradial and interradial (?) thickened pads between the lappets. These pads may represent the 8 rhopalia. 16 crescentic gonads around the stomach-margin. 16 interlobular radial-canals. 4 (?) simple, short lips. The affinities of this medusa are uncertain but its nearest living ally appears to be *Sthenonia* or *Poralia*.

Myogramma speciosum Maas.

Myogramma speciosum, MAAS, 1902, Paläontographica, Bd. 48, p. 298, tafn. 22, 23.—VON AMMON, 1908, Geonostischen Jahresheften, Jahrg. 19, p. 174, fign. 2, 3.

This fossil is from the lithographic slate of Solenhofen. Discomedusæ with flatly rounded bell. 4-rayed in the organization of the central stomach. 8-rayed at the bell-margin. In the subumbrella a wide marginal ring-muscle, an intermediate zone of 16 feathered arcades as in *Cassiopea*, and an inner zone of ring-muscles around the central stomach.

At the bell-margin there appear to be numerous thickly set, short, branched, tree-like tentacles. The mouth-parts are lost. Maas studied 3 imperfect specimens of this remarkable medusa which appears to be distinguished from all other Scyphomedusæ by its branched marginal tentacles. His best preserved specimen was 300 mm. wide.

Genus MEDUSINA Walcott, 1898.

Medusina, WALCOTT, 1898, Monograph U. S. Geol. Surv., vol. 30, p. 49.

Walcott proposes the name *Medusina* to designate all fossil medusa whose generic characters can not be determined.

Among the most obscure are *M. quadrata*, *M. bicincta*, *M. staurophora*, *M. circularis*, and *M. porpitina* from the Jurassic lithographic limestone of Bavaria, and *M. atava* from the Permian. All of these are well described by Walcott, *loc. cit.*, pp. 93 to 96. Beyond the fact that these fossils are apparently medusæ not much can be said of them, and in most cases we can not be certain as to whether they are Scyphomedusæ or Hydromedusæ.

Medusina costata Walcott.

Spatangopsis costata, TORRELL, 1870, Lunds Universitets Års-Skrift, 1869, No. 8, p. 11.
Agelacrinus lindstromi, LINNARSSON, 1871, Köngl. svensk. Vet.-akad. Handl., Bd. 9, Nr. 7, p. 11, taf. 1, fign. 6–7, taf. 2, fign. 10–14.
Medusites lindströmi, SCHMIDT, 1888, Mém. Acad. Imp. Sci. St. Pétersbourg, sér. 7, tome 36, p. 27, planche 2, figs. 34, 35.—WALCOTT, 1891, Tenth Ann. Report, U. S. Geol. Surv., Part 1, plate 56, figs. 1–1c.
Medusites costatus, MATTHEW, 1890, Trans. Royal Soc. Canada, vol. 8, p. 142.
Medusina costata, WALCOTT, 1898, Monographs, U. S. Geol. Surv., vol. 30, p. 49, plates 29, 30.

This fossil from the lower Cambrian sandstone of Sweden, at Lugnas and Timmerdala in Mount Billingen, is probably an *Aurellia*. The best description is presented by Walcott.

Medusina geryonides Huene.

Medusina geryonides, HUENE, 1901, Neues Jahrbuch für Mineralogie Geol. und Palaeontol., Bd. 1, p. 1, taf. 1, fign. 1, 2.—FUCHS, 1901, Centralblatt für Mineral. Geol. und Palaeontol., Jahrg. 1901, p. 166.

This fossil medusa is from the Murchison sandstone of Wiesensteig in Würtemburg. It is about 28 to 30 mm. in diameter. In the center there is a crater-like elevation with an irregular, flat, 6-sided knob at its middle. Surrounding this crater-shaped center there is a zone of 12 radiating concavities, the deepest being 2.5 mm. deep. Huene suggests that this medusa may have been related to the Geryonidæ, but this is wholly problematical, and it appears to me that it might equally well be a cast of *Brooksella*. Fuchs casts doubt upon its being a fossil medusa.

Laotira cambria Walcott.

Laotira cambria, WALCOTT, 1896, Proc. U. S. Nat. Mus., vol. 18, p. 613, plate 32, figs. 1–8; 1898, Monographs U. S. Geol. Surv., vol. 30, p. 32, plates 5–19, 21–23.

This is a fossil from the middle Cambrian shale of Coosa Valley, Alabama, and is supposed to be that of a medusa. It is a remarkably variable form and quite distinct from any living medusa. It probably reproduced by fission as does *Gastroblasta*.

Walcott defines it as Discomedusæ with a lobate umbrella with 4 to 12 lobes in simple forms and with a large number in the compound forms. No tentacles and no central mouth-openings in the adult. A simple radial-canal in each lobe of the umbrella and in the interradii. Oral arms represented by interradial lobes attached to the central axis and to the central lobes. Described in full detail by Walcott, 1898. It shows a tendency to intergrade in its simplest forms with *Brooksella confusa* from the same formation.

Dactyloidites asteroides Walcott.

Buthotrephis (?) *asteroides*, FITCH, 1850, Trans. New York State Agricult. Soc., vol. 9, p. 863.
Dactyloidites bulbosus, HALL, 1886, 39th Ann. Report State Museum Nat. Hist. New York, p. 160, plate 11, figs. 1, 2.
Dactyloidites asteroides, WALCOTT, 1891, 10th Ann. Report U. S. Geol. Surv., Part 1, p. 605, plates 57, 58, fig. 61; 1898, Monographs U. S. Geol. Surv., vol. 30, p. 41, plates 24–28.

This fossil is from the lower Cambrian terrane of Eastern New York at Penrhyn Quarry, Middle Branville, Washington County, and from St. Albans, Vermont. It is an irregular,

star-like fossil, and sometimes two stars are joined by a single lobe. It appears to have been gregarious, for Walcott records 42 specimens on a slab of slate 37 by 62 inches. There is of course no proof that these fossils are those of medusæ.

Rhizostomites admirandus Haeckel.

Rhizostomites admirandus, HAECKEL, 1866, Neues Jahrbuch für Min. Geol. und Paleontol., p. 261, taf. 5; 1869, Zeit. für wissen. Zool., Bd. 19, p. 557; 1880, Syst. der Medusen, p. 647.—BRANDT, 1871, Mém. Acad. Imp. Sci., St. Pétersbourg, sér. 7, tome 16, p. 1, planche 1, figs. 1–4.—VON AMMON, 1886, Abhandl. Math.-phys. Classe, Akad. Wissen München, Bd. 15, p. 123, 158, 163, taf. 2, fig. 2.—WALCOTT, 1898, Monographs U. S. Geol. Surv., vol. 30, p. 76, plates 40, 42.—MAAS, 1902, Palaeontographica, Bd. 48, p. 306, taf. 23, fig. 2.—VON AMMON, 1908, Geonostischen Jahresheften, Jahrg. 19, p. 174, fig. 1.

von Ammon, who has made the most thorough study of this fossil from the Jurassic lithographic limestone of Solenhofen and of Eichstädt, Bavaria, has decided that it is identical with Haeckel's *Rhizostomites lithographicus*, and that *Leptobrachites trigonobrachius* is probably the same medusa turned over on its side. He also concludes that Haeckel's *Hexarhizites insignis* is only a 6-rayed aberration of the same medusa. A thorough review of the literature of this subject and excellent figures are presented by Walcott, 1898, *loc. cit.*

According to von Ammon and Walcott the disk in *Rhizostomites* is round and as large as 400 mm. in diameter, with 4 to 8 principal lobes and about 128 small marginal lappets of various sizes, and indentations of the bell-rim marking the places of the 8 marginal sense-organs. No marginal tentacles. A wide zone of circular muscles in the subumbrella, unbroken in the rhopalar radii. 16 radial-canals, 8 rhopalar and 8 inter-rhopalar; and a circular canal in the external third of the umbrella. A strongly marked, circular depression between the muscle-zone and the arm-disk may indicate an inner ring-canal. 4 not very wide subgenital ostia, with 4 opercula forming lappets. Probably 8 long, thin mouth-arms with crinkled appendages, and apparently with a tassel-shaped tuft at the lower end.

This is undoubtedly a Rhizostomous medusa which appears to belong to an extinct genus related to the modern *Rhizostomata triptera* or *lorifera*. Maas, 1902, gives a remarkably clear photograph of the margin showing one of the sense-organs, and he discusses the probable form of the gonads.

Brooksella alternata Walcott.

Brooksella alternata, WALCOTT, 1986, Proc. U. S. Nat. Mus., vol. 18, p. 612, plate 31, figs. 1–5; 1898, Monographs U. S. Geol. Surv., p. 23, plates 1–4.

This fossil from the middle Cambrian shale from Coosa Valley, Alabama, is supposed to be that of a medusa. They are 40 to 50 mm. in diameter. From 5 to 20, usually 5 to 8, more or less distinct marginal lobes. No tentacles. A simple radial-canal in each lobe of the umbrella. Oral plate quadripartite with 4 oral arms arising from it. Central stomach well developed, but apparently there was no central mouth-opening.

This form was possibly allied to the Rhizostomæ and may have had habits similar to those of *Cassiopea*.

Brooksella confusa Walcott.

Brooksella confusa, WALCOTT, 1896, Proc. U. S. Nat. Mus., vol. 18, p. 612, plate 31, figs. 7a-b; 1898, Monographs U. S. Geol. Surv., vol. 30, p. 30, plate 3.

In *Brooksella confusa* the marginal lobes do not unite at the center of the bell but join irregularly, whereas in *B. alternata* they radiate from the center of the disk. This fossil is found in the middle Cambrian shale of Coosa Valley, Alabama.

Brooksella rhenana Kinkelin.

KINKELIN, 1903, Bericht Senckenberg Naturf. Gesell., Theil 2, p. 89, taf. 1, fign. 1, 2.

An 8-lobed medusa from the middle Devonian of Ruplach. Only one specimen, showing its exumbrella, was found, and this appears to me to be identical with, or at any rate very closely related to, Walcott's *Brooksella alternata*.

APPENDIX.

PREOCCUPIED GENERIC NAMES.

The establishment of the International Commission upon Zoological Nomenclature and the general recognition which the code that controls its decisions has won for itself among naturalists makes it more than ever desirable that the validity of the generic names we now use should be firmly established. Accordingly, the tenability of each and every generic name adopted in this work has been made the subject of a thorough search, and I am somewhat surprised to find that certain names which have been used for generations without question of their priority are actually preoccupied for other groups of animals and can not be applied to medusæ. Unfortunately I did not carry out this investigation until after volumes I and II were printed. A list of the generic names which can not be applied to medusæ follows:

Corynitis (page 71, Vol. I) = Linvillea nom. nov.

Both *Corynitis* and *Corynetes* are preoccupied, the former having been applied to Arachnids in 1854, and the latter to Coleoptera by Herbst, 1792. Wagner's *Plotocnide* is vaguely described and figured, but it appears to me to be a *Protiara*, and Browne's *Tiaricodon*, while it may be a "*Corynitis*," is too imperfectly known to be determined. We must therefore give to this genus a new name, and I propose *Linvillea* in honor of Dr. Henry R. Linville, who found the hydroid. The type species is therefore *Linvillea agassizii*.

Slabberia (page 73, Vol. I) = Dipurena.

Slabberia is preoccupied by Oken, 1815 (Lehrbuch der Naturgesch., Theil 3, Zool., p. 828), for Slabber's *Medusa marina*, which is an *Obelia* and therefore wholly different from the medusa to which the name *Slabberia* was applied by Forbes, 1846. We must therefore drop *Slabberia* in the sense in which I have used it and substitute for it the generic name *Dipurena* McCrady, 1857.

Turris and Tiara = Clavula.

Both *Turris* and *Tiara* are preoccupied and can not be used for medusæ. The name *Clavula* may be applied to these medusæ, as has been explained on page 491, Volume II.

Laodicea (see page 201, Vol. I).

According to L. Agassiz, 1842–46, Nomenclator Zoologicus, the generic name *Laodicea* was used by Lamouroux, 1816, Hist. Polypiers Coralligenes, and this statement of Agassiz's is copied in Scudder's Universal Index to Genera in Zoology, 1882, p. 167. Upon referring to Lamoroux's work, however, I can not discover that he used the name *Laodicea*, and believe that Agassiz is mistaken, and that *Laodicea* of Lesson, 1843, may be retained for medusæ. *Laodice* is preoccupied, having been used by Gemminger, 1871, for Coleoptera, before Haeckel, 1879, applied it to medusæ, but this does not interfere with the use of *Laodicea*. Indeed, several medusa genera escape by so narrow a margin; for example, *Amalthea* takes precedence over *Amalthaea*, yet the latter, differing as it does by a single letter, may be used. Similarly *Chrysaor* takes precedence over *Chrysaora*, yet both may be used.

HYDROMEDUSÆ.

Maas, 1909 (Abhandl. Math. phys. Klasse der K. Bayer. Akad. der Wissenschaft, München, Suppl. Bd. 1, Abhandl. 8), gives a description of 23 hydromedusæ from Japan obtained upon Doflein's voyage.

The old species are *Cytæis vulgaris*, *Tiara papua*, *Proboscidactyla flavicirrata* var. *stolonifera*, *Spirocodon saltatrix*, *Eucheilota paradoxica*, *Phialidium pacificum*, *Phialidium discoida*, *Mesonema pensile*, *Gonionemus vertens* var. *depressum*, *Olindioides formosa*, *Liriope rosacea*, *Rhopalonema velatum*, *Aglaura hemistoma*, *Ægina rosea*, *Solmundella bitentaculata*, *Cunina peregrina*, and *Solmaris rhodoloma*.

The new forms are called *Sarsia japonica*, *Nemopsis dofleini*, *Turritopsis nutricula* var. *pacifica*, and *Willsia pacifica*. A *Zanclea* and an *Obelia* are possibly new.

It is interesting that *Eucheilota paradoxica*, known hitherto only from the Florida-Bahama region, should be reported from Japan.

One of the most valuable features of Maas's paper is his redescription, accompanied by an excellent account of the post-embryonic development of *Spirocodon saltatrix*. Reviews of his account of this, and of the new forms, are presented in this Appendix.

An important paper upon Arctic Hydromedusæ and Scyphomedusæ is that of Hartlaub, 1909, Croisière Océanographique *Belgica* dans la Mer du Grönland, Meduses, 18 pp., planches 76-77. Unfortunately this has reached me too late to be reviewed for this work.

Pennaria tiarella (see page 25, Vol. I).

Pennaria tiarella, HARGITT, G. T., 1909, Bull. Mus. Comp. Zool. at Harvard College, vol. 53, p. 164, 5 plates, 44 figs.

Hargitt studies the development of *Pennaria tiarella* and finds that the oöcyte nucleus dissolves within the germinative vesicle before the nuclear membrane is ruptured. The linine network of the germinative vesicle extends to the nucleolus, so that an interchange of substances may possibly occur between the chromatin and the nucleolus.

The two polar bodies appear to be formed at about the time of the liberation of the medusa, by a process of mitosis of which Hargitt gives a detailed account.

Fertilization usually occurs after the polar bodies have been formed. The cytoplasm is very active at this time, forming protuberances upon the surface of the egg. The male and female pronuclei unite by apposition.

The first cleavage spindle seems to form from the cytoplasm. The cytoplasmic division is delayed, the second nuclear division being completed before the first cleavage furrow has cut half through the egg.

Hargitt disagrees with Beckwith, 1909, and finds that the polar bodies are seen only at or near the time of the liberation of the medusæ, about 7 p. m. He also finds, contrary to Beckwith, that the nucleolus disappears within the germinative vesicle before the dissolution of the nuclear membrane, whereas Beckwith states that it is cast out into the cytoplasm.

Corymorpha nutans (see page 31, Vol. I).

Corymorpha nutans, MALARD, 1907, Bull. Museum Paris, p. 563.—TORREY, 1907, Science, vol. 25, p. 734.

Malard finds *Corymorpha nutans* when dredging in deep water northeast of the Ile Tatihou, coast of France, and Torrey observes spontaneous fission in the stems of the hydroid.

Sarsia rosaria (see page 59, Vol. I).

Sarsia rosaria, KISHINOUYE, 1910, Journ. College of Sci., Tokyo, vol. 27, art. 9, p. 24.

Kishinouye finds this medusa off the Kurile Islands, north of Japan. A. Agassiz records it from the Pacific coast of North America.

Sarsia japonica Maas.

Sarsia japonica, MAAS, 1909, Abhandl. Akad. Wissen., München, Suppl. Bd. 1, Abhandl. 8, p. 6, taf. 1, fig. 1.

Bell 12 to 15 mm. high, 4 to 6 mm. wide, with flatly rounded apex. Bell walls 2 mm. thick. Manubrium nearly cylindrical, four-fifths to five-sixths as long as the depth of the bell-cavity. Gonads scattered irregularly over the manubrium from the base to near the mouth.

Tentacle-bulbs large pyramidal, without ocelli and without nettling warts. Tentacles tapering, shorter than bell-height when contracted, their proximal parts with scattered nematocysts, and distal two-thirds with ring-like nettle-batteries. 4 straight, slender radial-canals without an axial-canal above the stomach. Gonads and tentacle bulbs yellowish-brown, other parts colorless. From Todohokke and Hokkaido, Japan. Hydroid unknown. It is probably an Arctic form.

It is distinguished from *S. resplendens* and *S. brachygaster* by having no ocelli, and from *S. apicula* by having no axial-canal and by its bluntly rounded apex. Its nearest relative is *S. flammea*, with which, indeed, it may prove to be identical.

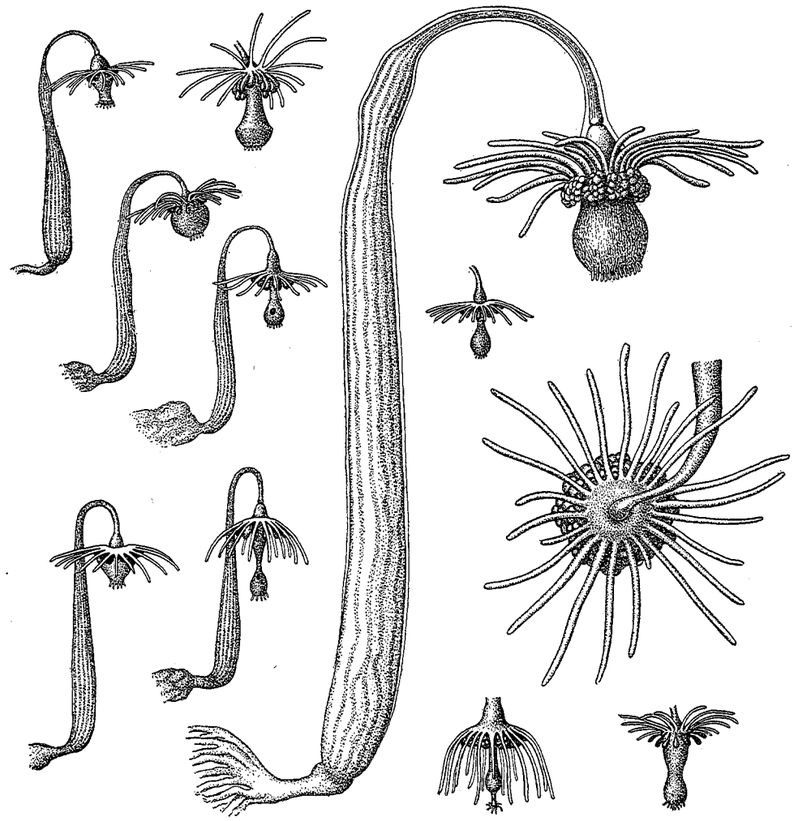


FIG. 426.—*Corymorpha pendula*. After L. Agassiz in Contributions to the Natural History of the United States, vol. 4.

Eleutheria (see page 93, Vol. I).

Eleutheria, BADE, 1907, Das Seewasser-Aquarium, Magdeburg, 2 fign.—KRUMBACH, 1907, Beitrage zur Kenntniss der Medusa *Eleutheria*, Breslau, 47 pp.

Krumbach gives a detailed account of *Eleutheria*. Unfortunately I have not seen his paper and am unable to review it.

Cladonema radiatum (see page 99, Vol. I).

Cladonema radiatum, BINDER, 1908, Bull. Muséum, Paris, p. 385.—RICHTERS, 1908, Zool. Anzeiger, Bd. 33, p. 687.

Binder gives a good description of the hydroid from the Atlantic coast of France, and Richters records it from Helgoland, German Ocean.

Urashimea globosa Kishinouye.

Urashimea globosa, KISHINOUYE, 1910, Journal College of Sci., Tokyo, vol. 27, art. 9, p. 27, plate 5, figs. 27–29.
Young medusa, *Urashimea macrotentaculata*, *Ibid.*, p. 28, fig. 30.

Bell 17 mm. high, 15 mm. wide, globular with very thick walls. Numerous meridional bands of nematocysts arranged more or less definitely in 4 perradial groups. There are 4 interradial, hollow spaces between the exumbrella and the subumbrella, and these have many pointed processes on the aboral side. Unfortunately Kishinouye's description is lacking in detail and his figures only add to my confusion respecting the nature of these spaces. Are they entirely cut off from the gastrovascular system? "The radial-canals have many minute processes on the aboral side."

There are 4 tapering tentacles longer than bell-height and with numerous, short, capped filaments on all sides. Each tentacle with an abaxial ocellus at its base. Mouth with 4 triangular lips. The gonads are 4 pouches hanging down from the horizontal parts of the radial-canals near the stomach. Each gland is broadest at its "axial extremity" and exhibits two longitudinal folds. Found at Saghalin and at Monbetsu in Kitami, Hokkaido.

This remarkable medusa is so briefly described and figured that I can not venture to define its generic characters. Kishinouye states that it is one of the Cladonemidæ. From Japan and Saghalin Island.

Urashimea macrotentaculata is apparently a young specimen of the same medusa from Kuno in Suruga Bay, Japan.

Turritopsis pacifica Maas.

Turritopsis nutricola var. *pacifica*, MAAS, 1909, Abhandl. Akad. Wissen, München, Suppl. Bd. 1, Abhandl. 8, p. 14, taf. 1, fign. 6–8; taf. 2, fig. 9.

Bell of adult medusa 8 to 9 mm. high, 5 to 6 mm. wide. This form is distinguished by the number and arrangement of its tentacles, 120 to 150 of which arise, not in a single row, as in the Atlantic *Turritopsis*, but in 3 or even 4 rows, one above the other; the number of rows increases with age. The tentacles are tapering, their entoderm chordate, and each has a small, projecting ocellus on the abaxial side of its swollen bulb, whereas the ocelli of the Atlantic *Turritopsis nutricula* are on the axial (inner) sides of the tentacles. There are 4 diffuse interradial gonads. The manubrium and radial-canals are as in *T. nutricula*. Gonads and stomach orange, ocelli red, entoderm of tentacles greenish. Ten specimens, from Sagami Bay near Misaki, Japan, in October.

This form differs so markedly from the American medusa that we may safely call it a distinct species.

Rathkea octopunctata (see pages 175, 177, Vol. I).

Cytæis octopunctata, MARKOW, 1908, Zool. Anzeiger, Bd. 33, p. 664.

Markow finds that this medusa is very abundant near Sebastopol between February and April, from the surface to a depth of not more than 7 feet. Budding medusæ were abundant from January 27 to February 12 in water of 6.1° to 6.9° C. The rediscovery of this medusa in such abundance in the Black Sea makes it practically certain that it was described by Brandt, 1838, under the name *Rathkea blumenbachii*, and that this name is merely a synonym of *Rathkea octopunctata*, which is the type of the genus. Brandt's figure shows pinnately-branched oral tentacles, but this is evidently a mistake.

Rathkea octopunctata var. grata (see page 179, Vol. I).

Lizzia shimiko, KISHINOUYE, 1910, Journal College of Sci., Tokyo, vol. 27, art. 9, p. 25, plate 5, fig. 24.

I believe this to be identical with the Arctic variety of *R. octopunctata*, commonly called *R. grata*. Kishinouye found it to be quite common in winter at Misaki, Hamana Inlet, and in Omura Bay, Japan. He says that the bell is 2 mm. wide and that the 8 basal bulbs are red and each gives rise to 3 or 4 tentacles. The manubrium and medusa-buds are pinkish. Kishinouye's description and figure might equally well have been derived from a study of *R. octopunctata* var. *grata*, from our Massachusetts coast, the Japanese and American medusæ apparently being identical in all respects.

The medusa is so abundant in Japan that it has received the vulgar name "shimikò."

Nemopsis dofleini Maas.

Nemopsis dofleini, MAAS, 1909, Abhandl. Akad. Wissen., München, Suppl. Bd. 1, Abhandl. 8, p. 11, taf. 1, fign. 4 und 5.
Favonia nipponica, KISHINOUYE, 1910, Journal College of Sci., Tokyo, vol. 27, art. 9, p. 26, plate 5, fig. 25.
(?) *Favonia sulcata*, KISHINOUYE, *Ibid.*, p. 26, plate 5, fig. 26 (contracted specimen from Korsakoff).

It is probable that *Nemopsis dofleini* Maas is identical with *Favonia nipponica* Kishinouye and that the pair of small median tentacles of each perradial cluster was lost in the 9 preserved specimens studied by Maas. These are very brittle and are often lost in large specimens of the American *Nemopsis*, especially after preservation in formalin. Kishinouye finds that the marginal tentacles arise in two rows from the "epaulets," whereas Maas finds them in a single, closely crowded row. The appearance of two rows is often due to contraction or to crowding. Bearing these differences in mind, I present the descriptions of both authors in order that they may be compared in detail.

	Nemopsis dofleini.	Nemopsis "nipponica."
Size in mm.	20 to 22 high, 12 to 15 wide.	17 high, 15 wide.
Shape of bell.	4-sided, prismatic with flatly rounded apex and thick walls.	As in N. dofleini.
Shape of tentacular epaulet from which each group of marginal tentacles arises.	Cleft in the middle. The two halves wing-shaped.	As in N. dofleini.
Number of tentacles in each perradial marginal cluster.	40 to 60, simple, tapering, set in one row. Tentacles shorter than bell-height. No median clavate pair of tentacles observed. Ocelli at the tentacle bases.	About 50 in two rows. A median pair of small clavate tentacles. Ocelli at tentacle bases.
Number of dichotomous branchings of the oral tentacles.	5 to 7.	About 10 times.
Size and shape of gonads.	In the form of a double fold along the radial-canals almost reaching the ring-canal. A perradial separation between each half of each gonad.	As in N. dofleini but shorter, being, however, more than half as long as radial-canals.
Color.	Stomach, gonads, and tentacle-bulbs yellowish, ocelli dark brown.	Tentacle-bulbs and lips orange, ocelli brown. Male gonads bluish, female pale yellowish.
Where found.	Bay of Tokyo, Japan.	Bays of Tokyo and Mikawa, very abundant in spring.

Willsia pacifica Maas.

Willia pacifica, MAAS, 1909, Abhandl. Akad. Wissen., München, Suppl. Bd. 1, Abhandl. 8, p. 17, taf. 3, fig. 16.

Bell flat, 2 to 3 mm. high, 5 to 7 mm. wide; 6 regularly spaced radial-canals arise from the stomach and branch so that about 6×18 terminal canals reach the bell-margin. Manubrium flat, 6-sided, with 6 complexly-folded lips. 96 to 108 tentacles as numerous as the terminal branches of the radial-canals. 96 to 108 short, narrow nettling streaks upon the exumbrella, alternating with the tentacles. No ocelli. Ring-canal rudimentary. Color (?) Coast of Japan in September. One specimen.

Polyorchis karafutoensis Kishinouye.

Polyorchis karafutoensis, KISHINOUYE, 1910, Journal College of Sci., University Tokyo, vol. 27, art. 9, p. 30, plate 5, fig. 31.

This medusa differs from *Polyorchis penicillata* in its greater size, being 60 mm. high and 50 mm. wide. Also its gonads are dichotomously branched, many of the marginal tentacles are forked, and the ring-canal gives off centripetal branches.

There are about 40 gonads, 10 on each radial-canal, and these are longer than the manubrium, which latter is of the size and shape seen in *P. penicillata*. There are about 120 marginal

tentacles, said to arise in several rows from the bell-margin. Each of the 4 radial-canals gives off from 14 to 16 long, lateral branches which branch at their outer ends but do not anastomose. Many short, usually unbranched, centripetal canals arise from the ring-canal and end blindly.

A single specimen was obtained at Korsakoff, Saghalin Island, on September 19, 1906.

In the character of its canal-system this medusa is intermediate between *Polyorchis* and *Spirocodon*, but the bell-margin is simple, not cleft into lappets, and the tentacles are spaced at equal distances apart around the margin.

Spirocodon saltatrix Tilesius (see page 220, Vol. I).

Spirocodon saltatrix, Maas, 1909, Abhandl. Akad. Wissen., München, Suppl. Bd. 1, Abhandl. 8, p. 18, taf. 2, fign. 10–13.

Maas gives by far the best published description of this medusa and corrects several errors of former students, especially in respect to the character of the gonads.

When the bell is only 12 mm. high and 5 mm. wide, with high, slightly bulging sides and dome-like apex, the gelatinous substance is thick, being thicker in the perradii than in the 8 adradii. The circular muscles of the subumbrella are entire. There are 8 clusters, each with about 20 tapering tentacles. The stomach is a long, simple tube with 4 distinct lips

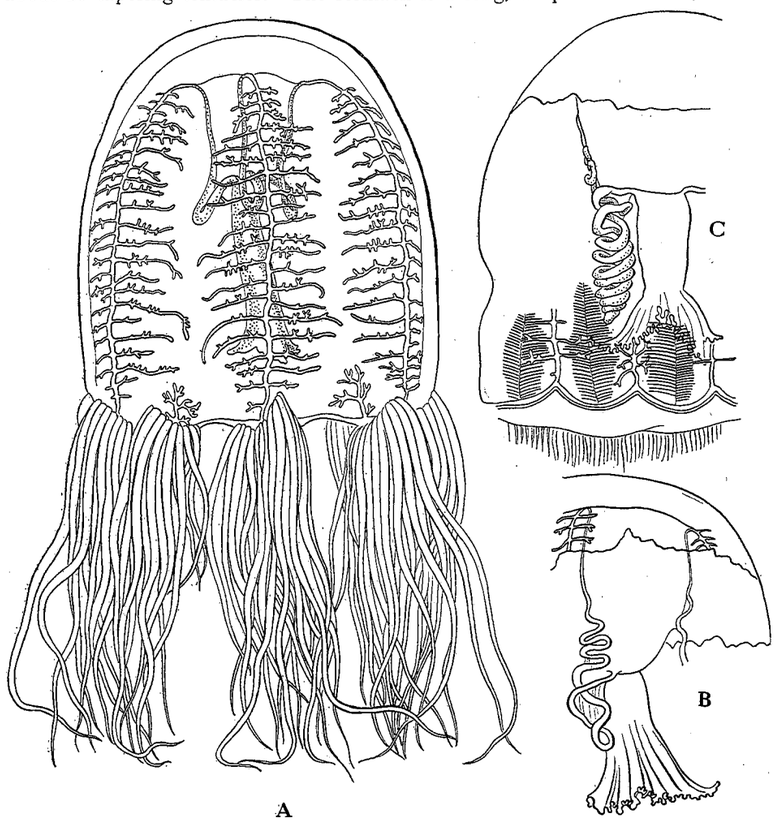


Fig. 427.—*Spirocodon saltatrix*. After Maas in Abhandl. Akad Wissen., München. A, young medusa with small gonads and tentacles, still in 8 clusters. B, half-grown medusa, showing one of the gonads. C, full-grown medusa, tentacles and canals omitted to show the form of one of the gonads.

which are at a level about one-eighth of the height of the bell-cavity above the margin of the bell. There is a well-developed peduncle above the stomach. The 4 radial-canals each give off about 20 branched but non-anastomosing side branches in the subumbrella. Over the peduncle the canals do not branch. There is a ring-canal with 4 short interradial, branched, blindly ending centripetal canals. In this young stage the gonads are not apparent.

The gonads begin to develop along the 4 radial-canals on the peduncle close to the base of the stomach when the medusa is about 18 mm. high and 15 mm. wide (see text-figure 426A). The radial-canals at this point begin to elongate more rapidly than the portion of the peduncle upon which they lie, and thus they begin to loop outward into the subumbrella cavity. Finally these freely-projecting canals twist spirally and hang downward into the bell-cavity, the canal extending around the free edge of a mesentery (figs. 426B and C). In later stages the bell-margin develops 8 indentations, 4 perradial and 4 interradial, with 8 adradial convexities between. The 8 clusters of tentacles of the young medusa spread laterally as new tentacles develop, until finally the tentacles become congruous entirely around the bell-margin.

The specimens studied by Maas were from the shore at Yokohama and from the Bays of Tokyo and Sagami, Japan. The largest were 40 mm. high and 30 mm. wide.

According to Maas the 4 interradial vessels are the only blindly ending canals which arise from the ring-canal, this being contrary to the observations of other authors.

Obelia congdoni Hargitt (see page 248, Vol. II).

Obelia hyalina, Congdon, 1907, Proc. American Acad. Arts and Sci., Boston, vol. 42, p. 468, figs. 7–9.
Obelia congdoni, Hargitt, C. W., 1909, Biol. Bulletin, Woods Hole, vol. 17, p. 375.

Hargitt believes this to be specifically distinct from *O. hyalina* Clarke. The branches of the stem do not arise in the axils of the hydrothecæ as in *O. hyalina*. The gonangia are larger, being about 4 times the length of the hydrothecæ, and the opening is not simple, but there is a neck with everted rim. Moreover, the colony is 20 to 30 mm. high and profusely branched instead of being about 12 mm. high and but little branched. The newly liberated medusa has 24 tentacles, but within 10 or 12 hours it has 30 to 36. The hydroid is found upon drifting *Sargassum* and is a tropical form.

Staurophora mertensii (see page 291, Vol. II).

Staurophora discoidea, Kishinouye, 1910, Journal College of Sci., Univ. of Tokyo, vol. 27, art. 9, p. 29.

Kishinouye describes this medusa from Japan and Saghalin Island. I believe it to be identical with *S. mertensii*. He states that it closely resembles *S. mertensii*, but that there are about 30 folds on each side of a limb of the gastric cross, instead of 17 as in *S. mertensii*. These folds of the genital glands vary greatly in number and increase with age in the Atlantic *Staurophora;* they afford therefore an insufficiently definite criterion upon which to base specific distinctions.

Cubaia gemmifera.

Scolionema gemmifera, Kishinouye, 1910, Journal College of Sci., Tokyo, vol. 27, art. 9, p. 31, plate 5, figs. 32, 33.

This appears to be an immature *Cubaia*. The largest of Kishinouye's specimens was 4 mm. wide and medusiform buds were beginning to develop upon its gonads. The distal ends of the tentacles beyond the adhesive disks are longer than in any species of this genus hitherto described. The manubrium is light red with brown mouth. Of the 16 tentacles, 8 were with "suckers" and 8 smaller ones were without them. 8 lithocysts. Entoderm at base of tentacles greenish and in the distal parts reddish. Found at Misaki, Japan, in winter.

Craspedacusta sowerbii Lankester (see page 363, Vol. II).

Craspedacusta sowerbii, Decisions of International Commission on Zool. Nomenclature, 1910, Science, vol. 31, p. 150.

The International Commission on Zoological Nomenclature publishes its unanimous decision that the name of this medusa is *Craspedacusta sowerbii* Lankester, not *Limnocodium victoria* Allman.

Microhydra ryderi (see page 366, Vol. II).

Microhydra ryderi, GOETTE, 1908, Mitt. philomath. Gesell., Strassburg, Bd. 4, Jahrg. 16, p. 35, 1 taf.

Goette records the finding of this hydroid in the neighborhood of Strassburg. Hitherto it has been known only from Tacony Creek near Philadelphia. Unfortunately I have not been able to see his paper.

Genus Limnocnida (see page 370, Vol. II).

Limnocnida, GRAVIER, 1908, La Méduse du Tanganyika et du Victoria Nyanza. Sa dispersion en Afrique, Résult. Scientifiques voyages en Afrique Edouard Foà, Paris, pp. 601–611.

Gravier gives an account of the dispersion of this genus in Central Africa.

Ægina citrea (see page 451, Vol. II).

Ægina pentamera, KISHINOUYE, 1910, Journ. College of Sci., Tokyo, vol. 27, art. 9, p. 32, plate 5, fig. 34.

This is a 5-rayed *Ægina citrea* from Misaki and Suruga, Japan, in winter. Vanhöffen, 1908, called attention to the frequent occurrence of 5-rayed aberrations of *Ægina*. Kishinouye's medusa is about 20 mm. wide and 10 mm. high, with thick gelatinous bell having a flat top and sloping sides. The mouth is a simple round opening and the 10 genital sacs are nearly quadrate. The 5 tentacles are each about twice as long as the bell-radius. Color (?)

SCYPHOMEDUSÆ.

Carybdea rastonii (see page 508, Vol. III).

Charybdea mora, KISHINOUYE, 1910, Journ. College of Sci., Univ. of Tokyo, vol. 27, art. 9, p. 6, plate 1, figs. 4–9.

This form from Japan appears to be identical with *C. rastonii* of the Pacific. It may possibly be distinguished, however, as a local variety by the large nettling warts over its exumbrella and its relatively long pedalia, these being about two-fifths as long as the height of the umbrella. I have, however, seen specimens of *C. rastonii* with pedalia one-third as long as the bell-height.

Carybdea alata (see page 508, Vol. III).

Tamoya virulenta, KISHINOUYE, 1910, Journal College of Sci., University Tokyo, vol. 27, art. 9, p. 6, plate 1, figs. 4–9.

This form, from the Inland Sea of Japan, is apparently identical with *C. alata*. Kishinouye describes large specimens 100 mm. high and 60 mm. wide. He finds from 6 to 8 dendritic velar canals in each quadrant, whereas I have not seen more than 6 in specimens of *C. alata*. A variation of this sort may be expected, however, in specimens of such great size as those found by Kishinouye.

Haliclystus octoradiatus (see page 534, Vol. III).

Haliclystus octoradiatus, WIETRZYKOWSKI, 1909, Comptes Rendus Acad. des Sci., Paris, tome 149, p. 746 (development).

Wietrzykowski gives the best account yet published of the early stages of *Haliclystus*. The planula is about 116μ long, 18μ wide. The ectoderm forms a continuous sac of flat, hexagonal cells, apparently without cilia. There are generally about 16 entodermal cells arranged in a single row. After 1 to 4 days of free life, the planulæ settle down upon their anterior ends and become hemispherical. They are apt to settle down in clusters and feed upon *Nauplius* larvæ, which they capture by means of their nematocysts. The mouth breaks through by the perforation of the ectodermal sac at the summit of the larva. The larva then gradually becomes vaguely 4-lobed and about 150μ in diameter, and a tentacula-form bud develops at the summit of each of the 4 lobes. These buds become detached and resemble the original planula, which developed from the egg, and go through developmental stages similar to those of the mother-larva, fixing themselves by their anterior ends and in turn giving rise to buds, as did their mother.

At the time of formation of the primary buds, one sees a well-developed invagination of a glandular character at the center of the adherent surface of the larva. This is the beginning of the pedal zone. The body then elongates, becoming filiform, and then 2 tentacles, 180° apart and exactly similar in structure to the knobbed tentacles of the adult, develop on opposite

sides of the mouth. The hypostome then elongates. This stage, with two well-developed tentacles and the hypostome, persists for several days.

A third tentacle similar to the first two then develops and the three tentacles set themselves 120° apart, giving the polyp a triradial symmetry. Finally, a fourth tentacle develops and the larva has 4 knobbed tentacles 90° apart. No later stages were observed at Roscoff. France, where these studies were undertaken by Wietrzykowski.

Genus Thaumatoscyphus Kishinouye, 1910.

Thaumatoscyphus, KISHINOUYE, 1910, Journ. College of Sci., Tokyo, vol. 27, art. 9, p. 2.

The type species is *Thaumatoscyphus distinctus* Kishinouye, from the most northeastern island of Chishima, Kurile Islands, Japan.

GENERIC CHARACTERS.

Stauromedusæ closely allied to *Haliclystus* and *Stenoscyphus*, but with a unitary coronal muscle in the exumbrella; with rudimentary adradial lobes and small, non-adhesive perradial and interradial tentacles. 4 interradial pits in the subumbrella. Peduncle 4-chambered. 8 adradial gonads. Gastric cavity as in Eleutherocarpidæ.

This genus is distinguished from all other Stauromedusæ by its exumbrella coronal muscle. This structure is so remarkable, being unknown in any other Scyphomedusæ, that its existence requires confirmation, for contraction in preservation may have produced the furrows which Kishinouye observes and believes to be the outlines of strands of muscle fibers. He cut no sections.

Thaumatoscyphus distinctus Kishinouye.

Thaumatoscyphus distinctus, KISHINOUYE, 1910, Journ. College of Sci., Tokyo, vol. 27, art. 9, p. 2, plate 1, figs. 1 and 2.

Body goblet-shaped, 30 mm. high. Calyx 15 mm. wide and half as high as height of entire animal. 8 short, adradial lobes, each with about 40 short, captate tentacles growing in a lanceolate tract on the aboral side of each lobe. The tentacles in the proximal part of the tentacular tract have very large, swollen stalks and degenerate distal knobs. These swollen stalks serve as adhesive organs.

The 8 perradial and interradial tentacles are small, cylindrical, and without well-developed distal knobs, although their ends are captate with a median depression at the tip. These tentacles bear black pigment at their bases and along the median line. They are not adhesive organs. The peduncle is more or less quadrate, about as long as the calyx and 4 times as long as wide. It is 4-chambered.

Four deep, interradial infundibula in the subumbrella. The subumbrella is beset with large, spherical, wart-like clusters of nematocysts, those near the margin and middle parts of the mesogonia being the largest, and about 1 mm. in diameter.

The coronal muscle is a broad, undivided band, the greater part of which is said to lie in the exumbrella beyond the clusters of tentacles. 4 broad but weakly developed perradial areas of radial muscles extend from the pyloric region through the stomach wall. The interradial muscles are better developed and extend from the aboral end of the peduncle to the bell-margin. Each interradial muscle band is divided at its distal end into two short limbs which extend to the bases of the adradial clusters of tentacles.

The œsophagus is short, somewhat quadrangular, and with deep longitudinal folds. The 4 lips are folded. The central stomach-cavity is long and prismatic and there are 8 adradial rows of simple, long, gastric cirri. There are 8 adradial lanceolate gonads, each consisting of 7 or 8 oblong follicles. The abaxial surface of each gonad is black and can be seen through the translucent wall of the body.

Two specimens found in August, 1903, from Shimushiri, Kurile Islands, Japan.

Unfortunately Kishinouye appears to have cut no sections and he bases his statement of the existence of an exumbrella coronal muscle upon the presence of annular folds in the external surface of the body-wall. This appearance may well be due to unnatural contraction in the killing fluid. He studied two preserved specimens. Even if this coronal muscle does not exist, the medusa may still be called *Thaumatoscyphus*, for it is distinguished from *Stenoscyphus* by its adradial lobes, and from *Haliclystus* by having 4 subgenital pits in its subumbrella.

Genus Parumbrosa Kishinouye, 1910.

Parumbrosa, KISHINOUYE, 1910, Journ. College of Sci., Univ. Tokyo, vol. 27, art. 9, p. 19.

The type species is *Parumbrosa polylobata* Kishinouye from Toyama Bay, Japan.

GENERIC CHARACTERS.

Ulmaridæ similar to the genus *Discomedusa*, but with 64 marginal lappets instead of 32. This genus is evidently derived from *Discomedusa* by the bifurcation of its marginal lappets.

Parumbrosa polylobata Kishinouye.

Parumbrosa polylobata, KISHINOUYE, 1910, Journ. College of Sci., Univ. Tokyo, vol. 27, art. 9, p. 19, plate 4, figs. 20–23.

Bell 160 mm. in diameter, flat, about 4 times as wide as high. Gelatinous substance of delicate consistency. Exumbrella finely and uniformly graduated. 64 narrow, lanceolate, pointed marginal lappets. 6 velar lobes between every 2 divergent ocular lobes. The velar lobes are 3 times as long as wide, but the ocular lobes are only about half as long as the velar and about twice as long as wide. Each pair of ocular lobes is, however, mounted upon a common basal projection which causes them to project beyond the contour of the velar lobes.

FIG. 428.—*Parumbrosa polylobata*. After Kishinouye, in Journal College of Science University of Tokyo.

There are 24 tentacles and 8 sense-organs arranged so that 2 marginal lappets are placed between a tentacle and a sense-organ or between two successive tentacles. The adradial tentacles are the longest. There are powerful muscle fibers on the axial side and transverse bands of nematocysts on the abaxial side of each tentacle.

The subumbrella is nearly smooth with weakly developed muscles. The canal-system is as in *Discomedusa philippina* (see page 607) except that the perradial and interradial canals are less complex in their branching and there is but a single, blindly ending side branch from the ring-canal in each lappet, instead of two as in *D. philippina*. *D. philippina* may, indeed, be only the young of *P. polylobata*, and later the 32 lappets may divide to form 64. The large size of the gonads and complex branching of the interradial and perradial canals in *D. philippina*, however, cause me to hesitate before drawing this conclusion. The bluntly rounded lappets of *D. philippina* are also very different in shape from the long pointed ones of *P. polylobata*. In any event *P. polylobata* was evidently derived philogenetically if not ontogenetically from some such medusa as *D. philippina*.

The œsophagus of *P. polylobata* is about as long as the bell-radius, is 4-sided and prismatic, and the richly folded, lanceolate lips are as long as the mouth-tube. They are thick and keeled along the midrib, and their margins bear numerous minute filaments. The 4 long, narrow gonads are about 5 times as wide as the perradial spaces between them. The medusa is colorless and nearly transparent. It was found in large numbers in a haul of a shrimp-trawl in Toyama Bay, Japan, in June, 1907, from a depth of about 65 fathoms.

Kishinouye gives excellent figures of the medusa.

FOSSIL MEDUSÆ.

Ephyropsites jurassicus von Ammon.

Ephyropsites jurassicus, VON AMMON, 1908, Geonostischen Jahresheft, 1906, Jahrg. 19, p. 169, taf. 3, 2 fign.

This is one of the *Coronatæ* closely allied to *Nausithoë*. It is from the Upper Jurassic limestone of Pfalzpaint. Bell 150 mm. wide with a distinct annular furrow and a pedal zone 40 mm. wide. 8 tentacles and 8 rhopalia. 16 pedalia in the radii of the tentacles and sense-organs. The tentacular pedalia are twice as wide at the zone of the tentacles as the rhopalar pedalia. A median ridge upon each pedalium, and near the margin on the rhopalar pedalia a pair of short, radiating ridges, each of which gives off a divergent cross-furrow arising from the inner end of each radiating ridge. There are ring muscles in the subumbrella. A single impression of this medusa was studied by von Ammon.

INDEX TO VOLUME III.