

REPORT UPON THE SCYPHOMEDUSAE COLLECTED BY  
THE UNITED STATES BUREAU OF FISHERIES  
STEAMER "ALBATROSS" IN THE PHILIPPINE IS-  
LANDS AND MALAY ARCHIPELAGO.

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INTRODUCTION.

In 1909 Dr. Hugh M. Smith, the then Acting United States Commissioner of Fisheries (now Commissioner), gave to the author for study a part of the collection of medusae now under consideration in this article, and the authorities of the Smithsonian Institution kindly permitted the use of a table in the building in Washington while engaged upon this work. In 1910 the remainder of the collection was sent to Princeton University, where the author occupied a research room in Guyot Hall. Thus the collection was studied under the most advantageous conditions, and it is a pleasure to express my sense of indebtedness to the authorities of the United States Bureau of Fisheries, the Smithsonian Institution, and Princeton University for the opportunities I have enjoyed.

Previous reports upon this collection were published by the Carnegie Institution of Washington in Publications 109 and 212.

Thirty-one Scyphomedusae were obtained by the *Albatross* in the Philippines and adjacent regions, of which 10 were new to science, the list of species being as follows:

CARYBEIDAE.

- Carybdea rastonii* Haacke.  
*Carybdea alata*, var. *grandis* Agassiz  
and Mayer.  
*Chiropsalmus quadrigatus* Haeckel.

CORONATAE.

- Periphylla hyacinthina* Steenstrup.  
*Linuche unguiculata*, var. *aquila*  
Mayer.  
*Atolla bairdii* forma *wyvillei* Haeckel.  
*Atolla bairdii* forma *gigantea* Maas.  
*Atolla bairdii* forma *valdiviae* Van-  
höffen.

RHIZOSTOMATA.

- Cassiopea andromeda*, var. *baduensis*  
Mayer.  
*Cephea octostyla* (Forskål).  
*Cephea cephea*, var. *coerulea* Van-  
höffen.  
*Cotylorhiza pacifica* Mayer.  
*Catostylus purpurus* Mayer.  
*Catostylus townsendi* Mayer.  
*Catostylus mosaicus* (Quoy and Gai-  
nard).  
*Lychnorhiza bartschi* Mayer.  
*Lychnorhiza bornensis* Mayer.  
*Mastigias papua* (Lesson).  
*Mastigias ocellata* (Modeer).

## SEMAEOSTOMAE.

## RHINOSTOMATA—Continued.

<i>Pelagia panopyra</i> Péron and Lesueur.	<i>Phyllorhiza luzoni</i> Mayer.
<i>Chrysaora melanaster</i> Brandt.	<i>Versura maasi</i> Mayer.
<i>Dactylometra africana</i> Vanhöffen.	<i>Lobonema smithii</i> Mayer.
<i>Sanderia malayensis</i> Goette.	<i>Thysanostoma thysanura</i> Haeckel.
<i>Discomedusa philippina</i> Mayer.	<i>Lorifera lorifera</i> , var. <i>pacifica</i>
<i>Aurellia aurita</i> (Linnaeus).	(Schultze).
<i>Aurellia labiata</i> Chamisso and Eysenhardt.	

Also in 1914 S. F. Light<sup>1</sup> describes 7 species from the Philippines other than those obtained by the *Albatross*. Mr. Light's additional species are: *Dactylometra quinquecirrha*; *Cassiopea polypoides*; *Cassiopea medusa*, new species; *Acromitus maculosus*, new species; *Lobonema mayeri*, new species; *Lobonemoides gracilis*, new species; and *Rhopilema visayana*, new species.

Thus 38 Scyphomedusae are already known from the Philippines, which is thus one of the richest regions of the world for Scyphomedusae, and stands in marked contrast with the tropical Pacific coast of Queensland, Australia, of which only 10 species have been described.

This appears to be another illustration of the influence of a great ocean current, the rich region of the Philippines being in the sweep of the Japan Stream, whereas there is no well-defined current along the southern shore of Papua or off the Barrier Reef of Queensland. As is well known, H. B. Bigelow, in his report upon the Siphonophorae of the *Albatross*, shows how abundant these forms are in the Humboldt current off the coast of South America and how poor the region is in the mid-Pacific to the westward of this great current. My studies, made while assistant upon Dr. Alexander Agassiz's expeditions to the tropical Pacific, in 1899, as well as upon the Carnegie Institution of Washington expedition of 1913 to Torres Straits and Papua, show that the whole great belt of the South Tropical Pacific, from the western edge of the Humboldt current to the shores of Australia, is poor in pelagic life. A number of local medusae appear in some of the large island groups, as in Fiji, but the region as a whole is poor in forms peculiar to itself, and even those of wide distribution are, generally speaking, found only occasionally over this great desert of ocean.

STRUCTURE, PHYSIOLOGY, HABITS, AND DEVELOPMENT OF THE  
SCYPHOMEDUSAE.

The Scyphomedusae are the large jellyfishes, commonly called the sea blubbers, in which the body is umbrella shaped, the mouth parts

<sup>1</sup> Philippine Journal of Science, vol. 9, Section D, No. 3.

occupying the position of the handle of the umbrella. The animal swims by means of periodic expansions and contractions of the margin of the umbrella. If we look carefully, we will see that this margin is notched at regular intervals, forming a series of lappets, and that 8, or sometimes 16, of these notches are deeper than the others and contain each a minute finger-shaped or club-shaped sense organ which may be provided with an eye, but which always contains a mass of crystals or concretions concentrated at its outer end. These little sense organs are so small that they appear to the naked eye as mere pigmented specks set within the niches at regular intervals around the margin; but though small they are of vital importance to the jellyfish, constituting its principal nerve centers; and if we cut them off, the animal commonly becomes paralyzed and is no longer able to pulsate spontaneously. Mayer believes that the crystals or concretions within the sense clubs consist largely of calcium uric oxalate, and this makes it appear probable that sodium oxalate is constantly forming in the sense club and that the calcium chloride of the sea water, when it enters the sense clubs, is precipitated, forming calcium oxalate, and in this manner setting free sodium chloride (common salt), which is a powerful stimulant for the nerves, thus causing the pulsating reaction.

Thus in these animals it is found that a stimulus which is constantly present causes periodic contractions followed by periods of rest which are perhaps due to fatigue. In the case of the scyphomedusa *Cassiopea* this stimulus is internal, for the sea water itself neither stimulates nor inhibits the sense organs of the animal, the stimulating effect of the interaction of its sodium, potassium, and calcium being offset by the inhibiting effect of its magnesium upon the motor centers.

But the marginal sense organs do more than merely produce the pulsation stimulus, for Dr. L. R. Cary finds that if they be removed and the medusa be then wounded in any manner the first stages in regeneration are delayed, but if even a single sense organ be present regeneration proceeds at once and with normal rapidity.

In general, if the area of tissue enervated by a sense organ be large it pulsates more rapidly than if the area be small, and although the ratio is not strictly proportional to the area of tissue, for according to Dr. L. R. Cary (1917), the rate is reduced one-half when the area is reduced to one-sixteenth. But young, small jellyfishes pulsate more rapidly than large, old ones; yet if we graft two jellyfishes together the small active one will force the large one to pulsate at its own rate, which will be even more rapid than the normal rate of the small one, due to the large area of tissue the sense organs now control.

Eimer and Romanes found that if the marginal sense organs be removed the jellyfish is paralyzed and responds only by single contractions to external stimuli. Later, in 1906, Mayer found that if the sense organs be removed and we cut a ring-shaped or circuit-shaped strip of tissue from the concave part of the bell, we may then start a contraction wave proceeding in one direction through the circuit through which it travels continuously, being, indeed, entrapped by the circuit of tissue from which it can not escape. This movement is almost machinelike in its regularity, its rate being about 440 cm. a second, and in 1917 McClenden showed that this note remained practically unchanged even though the nerves were artificially stretched.

It is interesting to see that the pulsation stimulus in jellyfishes is conducted by the nerves, whereas in the vertebrate heart it is conducted by the muscles. There is, however, as Parker showed, a fundamental likeness between nervous and muscular activity, for in most essential features, such as the compensating pause following an extra pulsation and the refractory stage during systole, latent period, reaction to temperature, etc., the jellyfishes behave as does the vertebrate heart. In Europe Romanes, Bethe, and von Uexkull, and in America Loeb, Harvey, Cary, McClenden, and Mayer have been most active in these studies.

Recently Mayer finds that nerve conduction in *Cassiopea* is a chemical reaction in which the cations of sodium, calcium, and potassium take the active part, while magnesium is nonessential. Thus if we dilute the sea water with 0.4 molecular magnesium chloride the rate of pulsation declines only very slightly more than if we diluted it with distilled water, thus demonstrating the inert nature of magnesium in respect to the rate of nerve conduction. It is also interesting to see that this decline in rate is proportional to the decline in the concentration of the cations of sodium, calcium, and potassium which surround the nerves and not to the electrical conductivity of the sea water as a whole. Thus if we dilute with distilled water we decrease the electrical conductivity in nearly the same ratio as the dilution, while if we dilute with 0.4 molecular magnesium chloride the electrical conductivity remains nearly constant while we simply reduce the concentration of the sodium, calcium, and potassium cations. It is therefore these cations which are alone essential to the maintenance of the rate of nerve conduction.

The previous work of Mayer, 1906, Meltzer and Auer, 1908, and especially Osterhout, 1916, make it appear that sodium and calcium together combine with some proteid element forming a sodium-calcium-ion proteid, and this compound takes an essential part in nerve conduction. Mayer in 1916 showed that the rate of nerve conduction in the medusa *Cassiopea* has a temperature coefficient 2.5 times

as great as that of the electrical conductivity of the sea water, and this suggests that the sodium-calcium-ion proteid may have a high temperature coefficient of ionization; for if the rate of nerve conduction is proportional to the concentration of the reacting cations, this would account for the high temperature coefficient of the rate of nerve conduction.

Also the sodium-calcium-ion proteid is probably colloidal in character and being in an alkaline medium it is doubtless negative electrically. Thus, under the influence of the decided negative potential which accompanies the reaction of nerve conduction, the surface tension on the particles of this colloid must be augmented and this may reduce the size of the particles in the manner stated by Mayer, Schaeffer, and Terroine, 1907.

Granted this were the case, the solubility of the particles would be augmented; for the surface decreases only as the square, while the volume declines as the cube of the radius. Thus more ions of sodium and calcium would pass into solution in a given time from the many small than from the few large particles; the mass remaining constant.

Nerve conduction is therefore probably a very complex chemical reaction, in which also an enzyme action may possibly be involved as postulated by Harvey, 1911.

Goldfarb showed that *Cassiopea* regenerates more rapidly in 90 per cent of sea water (90 parts of sea water mixed with 10 parts of distilled water) than it does in normal sea water. Nerve condition is, however, most rapid in slightly concentrated sea water.

In all Scyphomedusae, excepting the Rhizostomae, tentacles are found at the bell-margin, and usually grow out from between the notches of the rim. These tentacles are hollow, the stomach cavity being continued into them as it is also into the sense-clubs; indeed, the sense organs are only highly modified tentacles.

Powerfully developed circular, or a combination of circular and radial, muscles are found in the under, concave part of the umbrella (the subumbrella), and here also there is a network of nerve fibers connecting the muscles with the sense clubs. Curiously, there are no muscles, and probably no nerves, over the outer convex part of the umbrella (the exumbrella).

Those who have handled jellyfishes know that they are capable of inflicting a sharp sting, the tentacles being especially active in this respect. Closely clustered over the surface of the tentacles and other parts of the jellyfish there are minute cells, each containing a hollow tube coiled rope-like within the cell. Upon excitation these little tubes are turned inside out and shot forward, and being more or less barbed they penetrates the skin, causing a sharp sting due in part, it appears, to formic acid. Thus it is that these large jellyfishes are

among the most persistent enemies of the fishes, for many an incautious victim is ensnared among their deadly tentacles only to be paralyzed and finally drawn upward into the mouth of the jellyfish. It is, however, a poor rule which does not work in both directions, and certain kinds of small fishes often accompany jellyfishes, swimming in and out among the dangerous tentacles, even biting off small pieces of the jellyfish itself and occasionally themselves falling a prey to the stings, but in general enjoying a peculiar protection from the attacks of larger fishes who dare not venture too near the jellyfish.

The mouth, or mouths, of the jellyfish may be surrounded by veil-like lips or, if the mouths are numerous, as in the so-called Rizostomae (root-mouthed) jellyfishes, by complex frills lined by minute tentacles which at intervals bend to and fro and sweep, as it were, for food, for the jellyfishes are all carnivorous. In the higher animals the intestine is a tube which lies suspended within the body cavity, but Huxley showed that the jellyfishes have no body cavity, and consist simply of a stomach and an outside with a mere structureless lamella, or a solid mass of jelly, between the stomach wall and the outer skin layer of the animal.

This gelatinous substance, which according to S. Hatai may be allied in composition to chitin or cartilage, may serve as a store of food for the animal in case of starvation, and *Cassiopea* can live at least 42 days without food, the weight of the jellyfish declining to less than one-hundredth of its original magnitude. The loss of weight after the first day of starvation, and thus after all undigested food has been discharged through the mouths of the jellyfish, follows a simple law which shows that the loss of weight each day is proportional to the weight of the animal at the beginning of that day and thus the lighter it becomes the less weight lost.

Thus, if  $W$  be the original weight of the jellyfish and  $y$  its weight after  $x$  days of starving, then  $y = W(1-a)^x$ ; where  $a$  is a constant, less than unity. This shows that the source of energy during starvation is chiefly the very large and simply organized gelatinous substance which, being very voluminous and heavy, is far more important than the mere thin layer of cellular elements possessed by the jellyfish. For, as is well known, vertebrates in starving first consume glycogen, then mainly fats and lypoids, and finally proteid elements. Due, however, to the large volume of its gelatinous substance, the jellyfish chiefly consumes this during starvation, although, as Doctor Hatai showed, the starvation is in other respects similar to that of vertebrates. However, jellyfishes have on hand a constantly ready source of sustenance, and can, so to speak, feed upon their own bodies if deprived of prey. Mayer, 1914, carried out some

work upon this subject, but the more recent study of S. Hatai is far more elaborate and convincing, and should be consulted by all students of the subject.

Indeed the rate of growth, and the ultimate size that an individual jellyfish attains before becoming mature, is a measure of its success in obtaining food, and it is interesting to see that the largest jellyfishes are those of the cold seas where the floating animal life is more abundant than in the Tropics. In common with the Corals, Sea-anemones, Alcyonaria, Siphonophores, and Hydromedusae the Scyphomedusae are, so far as is known, exclusively carnivorous and do not feed upon plant life. Thus it is possible that the more rapid growth rate of Pacific corals in comparison with those of the Atlantic may be due to the better food supply derived from the deep lagoons of the Pacific, whereas in the Atlantic the lagoons are shallow and the water is charged over these vast flats with a precipitate of calcium carbonate which collects upon all floating animals and tends to smother them; whereas in the Pacific this does not appear to be the case.

Jellyfishes are, then, all carnivorous, and, while few devour others of their own species, they often greedily feed upon other sorts of medusae. These animals are, indeed, an important factor in destroying the eggs of cod and other fishes whose spawn floats in the sea.

The prey is seized by the mouth, and after being held and partially digested in the stomach, the remnant is ejected through the mouth.

The central stomach is a space in the middle of the umbrella, but this always gives rise to an outwardly radiating system of pouches or tubes which may form a complex network of vessels under the muscular layer of the concave side of the umbrella. As this system of pouches is connected with the stomach, and nutrient fluids derived from the food circulate through it, it is often called the gastrovascular system, for it is both a sort of "chymiferous system" as well as a digestive and circulatory space.

In all the larger jellyfishes, or Scyphomedusae, we find within the stomach four clusters of tentacle-shaped organs of unknown function, placed at the broad sides of the cruciform mouth. The smaller jellyfishes, or Hydromedusae, lack these stomach-tentacles or gastric cirri, as they are often called; and in still another structural detail do they differ from the Scyphomedusae, for the Hydromedusae have a diaphragm-like membrane (velum) extending inward from the bell-margin and partially closing the opening of the umbrella, but the larger jellyfishes (Scyphomedusae) do not have a diaphragm of this sort, although it is true that the Carybeidae, or sea-wasps, appear to have such a diaphragm, but it is not strictly comparable with that of the Hydromedusae.

The sexual organs of the larger jellyfishes (Scyphomedusae) are entodermal and are found in the stomach, peripheral to, and closely associated with, the four clusters of gastric cirri. The sexes are usually separate, the animals being either male or female, although, in rare instances, as in *Chrysaora*, they are hermaphroditic, or male when young and female when old. When mature at the breeding season the males and females usually come to the surface in great numbers and may congregate in vast swarms many square miles in area. The larvae or eggs may then be cast out into the water by the breaking down of the stomach wall, or the larvae may undergo a part of their development within the stomach, or mouth parts, of the mother, finally to be cast out through the mouth, or set free from the disintegrating bodies of the dying parents.

In any event the larvae soon develop into minute pear-shaped creatures about as large as a pin's head, their bodies being covered with vibrating cilia, which enable them to spin and progress through the water. For a few days, or even weeks, they may remain thus swimming near the surface and may be drifted hundreds of miles by tide and ocean current. Soon, however, the little pear-shaped planula, as it is called, settles down head first upon the bottom and fastens itself to some fixed object. Then for the first time the mouth develops at that which was the posterior end of the planula, and tentacles grow out so that the mouth is soon surrounded by 16 or more of these organs which serve to capture the minute crustacea and other organisms upon which the little polyp feeds. Thus it remains sedentary for a long period, growing all the time and superficially resembling a small sea-anemone. Finally a series of constrictions develop at regular intervals around the sides, and the creature appears as if it were composed of a series of disks set one upon the other. The margin of each disk soon develops eight cleft lobes, and eight sense-clubs appear in the clefts. Then the uppermost disk, containing the mouth and the crown of tentacles, is cast off and perishes, while the others are set free in succession and swim away as minute jellyfishes, soon to develop tentacles and finally to become mature and repeat this peculiar process of development. After the last disk has been cast off, only the stump of the strobila, as it is called, remains, but this may regenerate a new ring of tentacles and continue to grow, and possibly to develop more jellyfishes at the succeeding season.

There are many interesting variations of this typical process of development. Often the strobila, instead of giving off a series of disks, develops only a single constriction, and every alternate tentacle changes into a sense-club, while the other tentacles may be wholly absorbed, so that they disappear. In this case only a single ephyra or larval jellyfish is set free. This form of development is especially characteristic of the Rhizostomae or multi-mouthed jellyfishes, such



as *Cassiopea*. In the free-floating *Pelagia*, however, the planula larva never becomes attached, but remains swimming through the water until it develops directly into a jellyfish. Thus it is that these jellyfishes are quite independent of the land and are widely distributed over the tropical and warm oceans; but this is exceptional, for most of the Scyphomedusae must spend their early days attached to some fixed object and usually in relatively shallow water near some coast.

Some of these coastal medusae are, however, widely distributed over the world, one of these being the large semi-transparent *Aurelia aurita* of our own bays and harbors, which appears so commonly during the summer, and may be recognized by its four horseshoe-shaped, milky or pink-colored genital organs. This form occurs from pole to pole.

Such adaptability to wide range of temperature is very rare among jellyfishes, and is known only in *Aurelia aurita* and according to Vanhöffen in *Nausithoë punctata* among the scyphomedusae, and *Solmundella* among hydromedusae; these forms occurring in seas of all temperatures.

Nevertheless, even tropical medusae are much more injuriously affected by a slight rise in temperature than are the jellyfishes of the temperate regions, and we may say that most tropical forms live within 12° C. of their heat-death-temperature, and even tropical forms can withstand cooling better than they can resist heat. To use an engineering expression we might say that the medusae of temperate regions have a larger "factor of safety" in respect to temperature. Harvey showed that, upon heating, the rate of conduction of the nervous stimulus which causes pulsation increases in an arithmetical ratio, so that its "curve" is a straight line. At from 34° to 39°, however, the curve makes a sudden bend downward and the rate declines sharply. This decline may, in part, be due to the formation of carbon dioxide (CO<sub>2</sub>) in the tissues, for Winterstein showed that the rate of oxygen consumption in jellyfishes is 3½ times more rapid at 30° to 35° than it is at about 12° C. Indeed, experiments made by the author in 1917 support the idea that high temperature causes acid to accumulate in the tissues and this causes death through acidosis.

The large, rich rosin-brown colored cyaneas of our New England coast are not found in the Tropics, but closely allied species reappear in the South Temperate Zone, so that somehow they have managed, perhaps in the glacial epoch, to cross the warm zone of the Tropics, or they may have succeeded in crossing the Equator in the cold, deep, underlying drift that moves toward the warm regions over the sea bottom from both the northern and southern polar seas.

The following table shows the range of the 174 species of Scyphomedusae, not counting varieties, described in Mayer's *Medusae of the World*.

Confined to the Tropics.....	77
Ranging from Tropics to Temperate regions.....	16
Ranging from Tropical to Polar regions.....	2
Confined to the North Temperate region.....	32
Confined to the South Temperate region.....	11
Ranging from Temperate to Polar seas.....	6
Confined to the Arctic Ocean.....	7
Confined to the Antarctic Ocean.....	7
Deep sea medusae all of wide range.....	16
Total .....	174

In this table the Mediterranean is designated "North Temperate" and the Red Sea "Tropical." In the "Tropics" the surface temperature in summer is above 70° F. (21° C.). The summer temperature of "Temperate Region" ranges from 70° F. to 50° (21° to 18° C.), and that of the "Polar Seas" below 50° F. (10° C.).

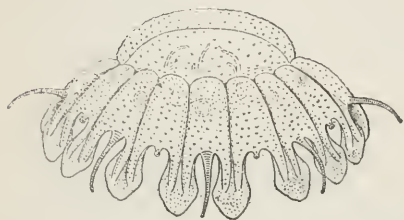


FIG. 1.—NAUSITHOË PUNCTATA FROM LIFE, BY THE AUTHOR. NAPLES ZOOLOGICAL STATION.

As is shown, 44 per cent of the known Scyphomedusae appear to be confined to tropical waters and only two species, *Aurellia aurita* and possibly *Nausithoë punctata* (fig. 1) range from Tropical to

Polar Seas. Indeed most of the scyphomedusae are confined within rather narrow temperature ranges, the only considerable number of widely ranging forms being the deep sea species whose habitat has about the same temperature whether under the Equator or in the Polar regions. Incidentally the table seems to indicate our deficiency of knowledge of the South Temperate regions for it is probable that the numbers of species in the North Temperate are more nearly equal to those found in the South Temperate Zone.

We may distinguish five main divisions or orders of the larger jelly fishes of scyphomedusae.

1. The Carybdeidae or Cubomedusae, with bell almost rectangular and with flexible tentacles mounted upon the ends of gelatinous wing-shaped expansions. They have four knob-shaped sense-clubs, which are very large and set within niches on the sides of the bell, with the eyes all directed inward, apparently to command a view of the mouth. These medusae have a marginal diaphragm which partially closes the opening to the umbrella cavity. The Carybdeidae are confined to tropical and warm seas and usually remain upon or near the bot-

tom until they become mature, when they often swim to the surface to cast out their eggs and sperm. They are dull milky-yellow, or livid in color, and their tentacles sting so sharply that they are commonly called "sea-wasps." None are known north of Cape Cod, but they are well represented in the Tropics throughout the world.

2. The Stauromedusae are attached forms which do not pulsate. The body is pear-shaped or pyramidal and the jellyfish fastens itself to seaweed or rocks by means of a stalk at the aboral end of the body. There are usually 8 clusters of knobbed tentacles which are developed at the pointed ends of eight marginal lobes, and 8 large "anchors" or suckerlike clubs upon the margin may alternate with the tentacles. These forms are confined to cold and temperate seas, and are known from the Arctic and Antarctic Oceans, although they have never been found in the Tropics.

3. The Coronatae are usually deep-sea forms distinguished by their peculiar dark purple or reddish-brown color, which is very characteristic of the invertebrate animals of the deep sea, due possibly to the fact that the red rays from the sun are rapidly absorbed as they penetrate into the ocean, so that at depths greater than 1,000 fathoms there is practically no red light, and here red-colored animals must appear black and be well concealed in the general darkness of their abysmal realm. The Coronatae are characterized by having a deep ringlike furrow cutting into the thick gelatinous wall of the sides of the umbrella; and peripheral to this are gelatinous thickenings in the radii of the tentacles and sense-organs. The gelatinous wall of the bell is much reduced in thickness at the ring-furrow, the thin part acting as a hinge to permit the creature to close its bell during contraction. These forms are common in the deep waters of the Philippines, as indeed they are upon the bottom of all seas 500 fathoms or more in depth. Most of the species, such as *Atolla* and *Periphylla*, do not normally come to the surface, but a closely allied form, the little *Nausithoë*, is one of the most universally present surface forms of all warm seas, while the mature *Linuche* occur in vast numbers, all rapidly pulsating and resembling little brown thimbles, the swarm often covering square miles of ocean in tropical regions.

4. The Semaestomata are the common large jellyfishes of our coasts, such as *Aurellia*, *Cyanea*, and *Dactylometra*. They have tentacles and a single cruciform mouth provided with veillike lips, and there is no ring-furrow cutting into the surface of the umbrella, such as is seen in the Coronatae. They are common in bays and brackish estuaries, and are the largest and most conspicuous of all jellyfishes in temperate regions.

5. The Rhizostomae are the large jellyfishes of the East Indian and tropical seas, where they are commonly as conspicuous as are the

Semaeostomeae in our cold northern waters. They have numerous mouths and no marginal tentacles, and their gelatinous substance is often as rigid as newly-formed cartilage. Often they occur in swarms in the harbors, swimming strongly against the tide, and after a storm great numbers are found stranded upon the shore. The rigid gelatinous substance of these jellyfishes is very characteristic and was seen in fossil forms found in the Jurassic lithographic slates of Steinheim in Bavaria, showing that in the age of the Reptiles these most highly differentiated jellyfishes existed. Indeed, so old are the jellyfishes that their relationship to the echinoderms, sponges, and ctenophores remains unknown; all intergrading forms, if such ever existed, having died out long ago, as is often the case in very ancient orders.

In an early stage of development the higher animals commonly pass through a condition in which they have only an outer cell layer and a cavity lined by cells destined to form the intestine. Theoretically speaking, they are simply little 2-layered sacks, the outer layer being the external skin with its nervous and sensory organs, and the inner layer being the stomach; and thus the name gastrula is applied to this stage. Jellyfishes are essentially in the gastrula stage, even when adult. Yet so extraordinary are the foldings, outgrowths, and adaptations that have arisen in their two body layers during the vast time they have existed upon the earth that, ultimately, simple as they are, no class of the animal kingdom exhibits a more surprising variety of forms than do the jellyfishes and their close allies the Siphonophorae.

It is interesting to observe that the large jellyfishes, Scyphomedusae, which have gastric cirri and no marginal diaphragm or velum, are probably only very remotely related to the small jellyfishes, the hydromedusae, which have a velum and lack gastric cirri. Indeed, we have good reason to believe that the jellyfish-shape and peculiar locomotion through pulsation have been derived independently in the two groups. The Scyphomedusae are probably allied to the actinians or sea-anemones, while the hydromedusae have probably been derived from hydroids. In fact a jellyfish shape and pulsating body have been acquired independently in widely different kinds of animals, such as *Pelagothuria*, a holothurian which bears a wonderfully close resemblance to a jellyfish and swims actively through the water in the tropical Pacific; and in *Craspedotella*, a minute unicellular marine animal, which would certainly have been mistaken for a jellyfish had it not been of microscopic size.

Indeed, there is reason to lead us to believe that the bell of the Narcomedusae is a mere outgrowth from the sides of the pyriform larva, and has thus been acquired in a manner quite different from

that of the other hydromedusae. Thus the umbrellalike bodies of jellyfishes have probably been acquired in at least three different ways within the group itself. Although nearly one-half of the known forms of Scyphomedusae are confined to the Tropics, yet many of these are rare, although, curiously, when found they usually appear in swarms. Thus one may explore the Florida Reef for 20 years and not find a single *Pelagia* or *Stomolophus*, yet if an individual be found there are almost certainly dozens or even thousands in the neighborhood. It is as if they had all remained floating side by side throughout their lives, or at least throughout the period when they come to the surface from some well-defined region of the bottom wherein they have spent their early days.

Apart from the harbors and semibrackish estuaries one rarely finds in the Tropics great swarms of medusae of a few species such as characterize the coastal waters of the temperate regions.

There are, however, exceptions to this rule, such as the enormous number of *Linuche*, which when mature rise suddenly and simultaneously to the surface to cast out their genital products and then to sink and die. For areas of square miles the tropical ocean is besprinkled with these little brown thimbles, darting in a rapid jerking movement.

Similarly the pale milky Cubomedusae with their long pink tentacles rise, when mature, from the depths to congregate along tropical shores for the few days or weeks of the breeding season.

Metschnikoff observed that many medusae cast out their eggs only at certain definite times of the day or night. One of his Mediterranean species, for example, laid its eggs always at about 3.30 o'clock in the afternoon, and Conklin observed that *Linuche* casts its eggs only at about 8 o'clock in the morning, but other Scyphomedusae are not so regular, and indeed may retain the developing young in their mouth folds for days or weeks before they escape into the ocean.

#### DESCRIPTION OF GENERA AND SPECIES.

##### Genus CARYBDEA Péron and Lesueur, 1809.

*Carybdea* PÉRON and LESUEUR, 1809, Ann. Mus. Hist. Nat., Paris, vol. 14, p. 332.—MAYER, 1910, Medusae of the World, vol. 3, p. 506.

*Generic Characters.*—Carybdeidae, with 4 simple, interradial tentacles and pedalia. Velarium supported by 4 bracket-like frenulae. Velar canals present. Stomach small and 4-sided.

##### CARYBDEA RASTONII Haacke.

*Carybdea rastonii* HAACKE, 1887, Jena, Zeitsch. für Naturwissen, vol. 20, p. 591, pl. 35, figs. 1-15.—MAYER, 1910, Medusae of the World, vol. 3, p. 508.

There are two specimens of this medusa in the *Albatross* collection from the Philippines. They are apparently mature and their dimensions in millimeters are as follows:

	Subig Bay, Luzon, surface, Jan. 6, 1908. Cat. No. 27937, U.S.N.M.	Taal Anchorage, Balayan Bay, Luzon, surface, Feb. 20, 1909. Cat. No. 28714, U.S.N.M.
Height of bell.....	34	33
Width of bell.....	20	23.5
Length of pedalia.....	11	9.5
Width of pedalia at base.....		4
Width of pedalia at widest part.....	6.5	5.5
Height of sensory niche above velar margin.....	6	6
Length of flexible shafts of tentacles.....	30	66

Two other specimens (Cat. No. 27935, U.S.N.M.) were taken by the *Albatross* at Nasugbu, Luzon, January 15, 1908, and still another (Cat. No. 27936, U.S.N.M.) at Mansalay, Mindoro.

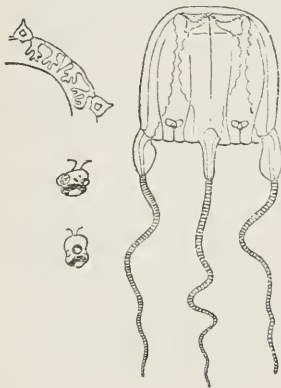


FIG. 2.—*CARYBDEA RASTONII* FROM THE HAWAIIAN ISLANDS. TWO VIEWS OF ITS SENSE-CLUBS AND A QUADRANT OF THE VELARIUM, SHOWING THE BRANCHED VELAR CANALS.

This is the commonest Cubomedusa of the tropical Pacific, being widely distributed from South Australia to the Hawaiian Islands. It can be recognized by its prismatic, 4-sided bell, the 4 pedalia being about one-fourth to one-third as long as the bell-height, flat and spatula-shaped and about three-fifths as wide as long. The sense-clubs have each 2 large median eyes and 4 small lateral ocelli. There are 4 short, branched, non-anastomosing velar canals in each quadrant of the velarium, 16 in all. Four very small branched tufts of gastric cirri. This medusa is very closely allied to *Carybdea marsupialis* of the Mediterranean, but is distinguished by

having only 16 instead of 24 to 30 velar canals, and by its somewhat more slender pedalia. In both forms the bell is dull milky yellow and the flexible parts of the tentacles are pink. In common with other Cubomedusae it comes to the surface when mature and is then abundant in harbors. The young usually remain in deep water at or near the bottom.

## CARYBDEA ALATA, var. GRANDIS Agassiz and Mayer.

*Charybdea grandis* AGASSIZ and MAYER, 1902, Mem. Museum Comp. Zoöl. at Harvard College, vol. 26, p. 153, pl. 6, figs. 26-31.

*Carybdea alata*, var. *grandis* MAYER, 1910, Medusae of the World, vol. 3, p. 511, fig. 329.

The bell of this medusa becomes 230 mm. high, but the largest specimen of this cruise was obtained by the *Albatross* in Borneo and is only 166 mm. high. This tropical Pacific form may be distinguished by its short, wide-flaring pedalia and by having only 1 or 2 median eyes upon each sense-club and no lateral eyes. When young, however, there are 2 large median and 2 small lateral eyes, but the latter appear to fuse later with the median eyes. There are 24 velar canals which are short, branched, and non-anastomosing. *C. moseri* Mayer is only a half-grown stage of this medusa. In *C. alata* there are 6 eyes in each sense-club, and the pedalia are longer and narrower than in the large variety *grandis*.

The dimensions and characters of the two largest of the three specimens found by the *Albatross* are as follows:

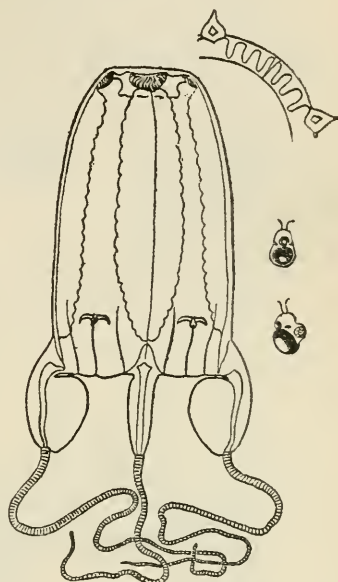


FIG. 3. — CARYBDEA ALATA, HALF-GROWN MEDUSA FROM THE HAWAIIAN ISLANDS. TWO VIEWS OF ITS SENSE-CLUBS AND A QUADRANT OF THE VELARIUM, SHOWING THE STRAIGHT SIMPLE VELAR CANALS.

	Station 5361, Feb. 9, 1909, Manila Bay, Luzon, 12 fathoms, 2 specimens. Cat. No. 28713 U.S.N.M.	D. 5594, Sept. 30, 1909, off Mount Putri, Borneo.
Height of bell.....	120.....	166.
Width of bell.....	88.....	144.
Length of pedalia.....	38 along inner side.....	77 along outer side. 36 along inner side. 29.
Width of pedalia at widest part.....	16.5.....	
Width of pedalia at base.....	14.....	
Height of sensory niche above velar margin.....	16.....	31.
Number of eyes in each sense-club.....	2 median, no lateral eyes....	2 median, no lateral eyes.
Gonads.....	Small, immature.....	Small.

Genus *CHIOPSALMUS* L. Agassiz, 1862.

*Chiropsalmus* L. AGASSIZ, 1862, Contr. Nat. Hist. U. S., vol. 4, p. 174.—MAYER, 1910, Medusae of the World, vol. 3, p. 515.

*Generic characters*.—Carybdeidae with four interradial, branching pedalia which give rise to a number of tentacles. Four wide per-radially situated stomach pockets in the subumbrella, each of which gives rise to finger-shaped, unbranched, hernialike pouches, which project into the bell cavity. Wide, marginal pouches and numerous canals in the velarium. Eight leaf-shaped gonads.

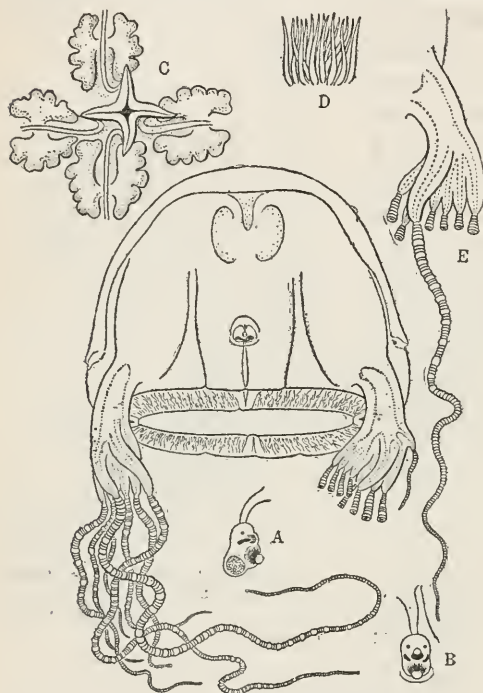


FIG. 4.—*CHIOPSALMUS QUADRIGATUS* FROM THE PHILIPPINE ISLANDS. A, B, VIEWS OF SENSE-CLUB. C, VIEW LOOKING DOWN ON THE CRUCIFORM MOUTH. D, GASTRIC CIRRI. E, BRANCHED PEDALIUM WITH SEVERED TENTACLES.

*CHIOPSALMUS QUADRIGATUS*  
Haeckel.

*Chiropsalmus quadrigatus* HAECKEL, 1880, Syst. der Medusen, p. 447.—MAYER, 1910, Medusae of the World, vol. 3, p. 516, fig. 331.—LIGHT, 1914, Philippine Journ. Science, vol. 9, p. 197.

The 44 specimens of this medusa were collected by the *Albatross* from the Philippines, but not one seems to be mature.

Light (1914) found this medusa at Culion Bay, Culion, and at Palawan, and

thus it ranges widely in the Philippines. Light's specimens were larger than those found by the *Albatross*, being at least 200 mm. in diameter and usually with seven tentacles to each pedalium. The tentacles are 1.5 meters or more in length and have lavender-colored bands of nematocysts. Light reports that the sting of this medusa is very severe and may even be fatal to man. The *Dactylometra* of the Philippines is also a dangerous form, but *Lobonema*, which some of the members of the *Albatross* expedition believed to be virulent, is not capable of inflicting a very severe sting.<sup>1</sup>

<sup>1</sup> Light, 1914, Philippine Journal of Science, vol. 9, pp. 291-295.



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

Locality.	Date.	Height of bell in mm.	Width of bell in mm.	Number of tentacles upon each pedaliium.	Remarks.
	1908				
Subig Bay, Luzon, caught in a seine. Cat. No. 27911, U.S.N.M.	Jan. 7	18	20	4, 4, 4, 4	No gastric sacculles and no gonads.
Subig Bay, Luzon, caught in a seine. Cat. No. 27915, U.S.N.M.	...do....	70	80	9, 5, 8, 8	With well-developed but immature gonads; large cockscomb-shaped gastric sacculles.
Cataingan Bay, Masbate, near shore. Cat. No. 27913, U.S.N.M.	Apr. 13	49	55	6, 6, 7, 7	Immature. The 8 gastric sacculles only beginning to appear.
Do. ....	...do....	51	51	8, 6, 7, 5	Do.
Do. ....	...do....	40	20	6, 5, 6, 6	Do.
Mansalay, Mindoro. Cat. No. 27917, U.S.N.M.	June 4	97	100	8, 8, 8, 8	Apparently mature.
Point Jamelo, Southern Luzon, one specimen. Cat. No. 28700, U.S.N.M.	July 13	.....	.....	.....	Immature. Caught in a seine at a depth of 150 feet.
Tilig Bay, Southern Luzon, one specimen. Cat. No. 28698, U.S.N.M.	July 14	.....	.....	.....	Immature. Caught in a seine at a depth of 130 feet.
Malcochim Harbor, Linapacan Island, 7 specimens, Cat. No. 28696 U.S.N.M.	Dec. 18	86	95	6, 7, 8, 8	Cockscomb-shaped sacculles. Gonads small.
Malcochim Harbor, Linapacan Island, 7 specimens. Cat. No. 28692, U.S.N.M.	Dec. 19	25.5	25	5, 6, 6, 6	No sacculles. No gonads.
Beach near mouth of Malampaya River, Palawan Island, 2 specimens. Cat. No. 28699, U.S.N.M.	Dec. 26	75	83	8, 8, 8, 8	Cockscomb-shaped sacculles. Gonads small.
Ulugan Bay, Palawan Island, near mouth of Baheli River, 6 specimens. Cat. No. 28691, U.S.N.M.	Dec. 28	.....	.....	.....	All small. Caught in seines.
	1909				
San Miguel Bay, east coast of Luzon, 8 specimens. Cat. No. 28695, U.S.N.M.	June 14	76	74	7, 7, 7, 7	Immature. Cockscomb-shaped sacculles.
		81	89	7, 7, 5, 5	Do.
		73	80	5, 7, 4 <sup>1</sup>	Do.
Bolinao Bay, west coast of Luzon, seine 130 feet, 13 specimens. Cat. No. 28694, U.S.N.M.	May 10	69	76	6, 7, 7, 7 <sup>2</sup>	Cockscomb-shaped sacculles well developed. Immature gonads, very small. Height of sensory niche above margin, 11.5 mm.
		22	26	6, 6, 6, 5	No gastric sacculles and no gonads. Bell more transparent than in adult. Sensory niche 3 mm. above margin.

<sup>1</sup> Lost.<sup>2</sup> Largest specimen.

Three other unmeasured specimens were obtained as follows: Two (Cat. No. 27914 U.S.N.M.) at Mati, Pujada Bay, Mindanao, May 15, 1908; and one (Cat. No. 27916 U.S.N.M.) at Panabutan Bay, Mindanao, February 6, 1908.

#### Genus PERIPHYLLA Steenstrup, 1837.

*Periphylla* STEENSTRUP, 1837, Acta et Cat. Mus. Hafniensis.—MAYER, 1910, Medusae of the World, vol. 3, p. 543.—BROWNE, 1910, National Antarctic Expedition, vol. 5, Medusae, p. 42.

*Generic characters.*—Coronatae with 4 interradial rhopalia and 12 tentacles, 4 peridial 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 four deep, interradiial subgenital pits in the floor of the subumbrella, lined above their edges by rows of internal gastric cirri. The large central stomach extends peripherally out-

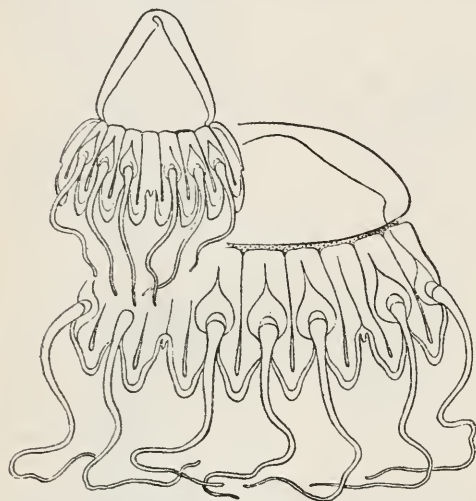


FIG. 5.—PERIPHYLLA HYACINTHINA FROM THE HAWAIIAN ISLANDS, SHOWING RANGE IN SLOPE OF THE BELL.

ward into the subumbrella in the four perradii. These four 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.

I believe that *Periphylla hyacinthina* can not be separated specifically from *P. dodecabostrycha*. The shape of the bell is quite

variable, and when large the medusa usually becomes relatively flat and domelike, whereas it is relatively high and conical when young. *P. hyacinthina* is said to be densely pigmented with purple-brown so that the gonads can not be seen through the bell walls, whereas *P. dodecabostrycha* is said to be less densely colored and semitranslucent. This distinction does not always apply, and certainly the degree of pigmentation appears to be quite independent of the shape of the bell, whether flat and domelike or high and pointed. Browne (1910), in his study of the Scyphomedusae of the National Antarctic Expedition, concludes that *P. dodecabostrycha* is probably only a large-growth phase of *P. hyacinthina*, and with this opinion I am heartily in accord.

## PERIPHYLLA HYACINTHINA Steenstrup.

*Periphylla hyacinthina* STEENSTRUP, 1837, Act. Mus. Hafniensis.—MAYER, 1910, Medusae of the World, vol. 3, p. 543, figs. 342 and 343.

*Periphylla hyacinthina* forma *dodecabostrycha* MAYER, 1910, Medusae of the World, vol. 3, p. 546.

The *Albatross* obtained 21 specimens of this common deep-sea medusa among the Philippine Islands between depths of 338 and 1,291 fathoms, as follows:

Station.	Date.	Depth.	Character of bottom.	Size and number of specimens.	Variety.
D 5201 and D 5203, Cat. No. 28704, U.S.N.M., off Limasaua Island.	1908. Apr. 10	<i>Fathoms.</i> 554-775	Gray sand and mud and green mud.	2 large, 190 mm. wide, 105 high.	<i>Dodecabostrycha.</i>
D 5373, near Marinduque Island, about 15 miles off shore. Cat. No. 28705, U.S.N.M.	1909. Mar. 2	338	Soft sand.....	2 large.....	Do.
D 5379, about 37 miles off Mompog Island, near Marinduque Island. Cat. No. 28706, U.S.N.M.	Mar. 4	920	.....	4 medium.....	Do.
D 5471, from about 15 miles off Point, Light, east coast of Luzon. Cat. No. 28738, U.S.N.M.	June 19	568	.....	.....	<i>Hyacinthina.</i>
D 5486, from 6 miles off Batobobo Point, Panaon Island.	July 31	585	.....	7 large and medium.	<i>Dodecabostrycha.</i>
D 5497, about 10 miles off Bantigui Island.	Aug. 3	960	Green mud and fine sand.	1 large.....	Do.
D 5507, off northern Mindanao. Cat. No. 28703, U.S.N.M.	Aug. 5	425	.....do.....	2 medium.....	Do.
D 5628, Pariente Strait, about 7 miles from St. Lamo Island. Cat. No. 28707, U.S.N.M.	Nov. 30	1,291	Gray mud....	1 medium.....	<i>Hyacinthina.</i>
D 5647, Buton Strait.....	Dec. 16	519	Green mud....	.....do.....	Do.
D 5652, Gulf of Boni.....	Dec. 17	525	.....	.....do.....	Do.

## Genus LINUCHE Eschscholtz, 1829.

*Linuche* ESCHSCHULTZ, 1829, Syst. der Acalephen, p. 91.—MAYER, 1910, Medusae of the World, vol. 3, p. 557.

*Generic characters.*—Coronatae with 8 rhopalia, 4 perridial, and 4 interradiial. Eight tentacles, 16 marginal lappets; with hernia-like sacs of the gastrovascular cavity protruding from the floor of the subumbrella. Eight gonads grouped in four pairs close to the four perradii. The central stomach opens by four perradial ostia into a ring-sinus, which in turn breaks up into 16 branching, radiating pouches in the lappets. A marginal ring canal is present in the Pacific *L. aquila*, and according to Vanhöffen also in *L. unguiculata* of the Atlantic, but I believe it is not always present in the Atlantic form, for I am unable to demonstrate it by inflation of the pouches with air in the living or recently preserved specimens.

## LINUCHE UNGUICULATA, var. AQUILA Mayer.

*Linerges aquila* HAECKEL, 1880, Syst. der Medusen, p. 496.

*Linuche aquila* MAYER, 1910, Medusae of the World, vol. 3, p. 560, figs. 356 B and C.

*Linuche unguiculata* VANHÖFFEN, 1913, Zoologischen Jahrbüchern, Suppl. 11, Heft 3, p. 429.

*Linuche unguiculata* forma *aquila* MAYER, 1915, Publication No. 212, Carnegie Institution of Washington, p. 174, fig. 1, B and C.

This variety 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 wartlike protuberances upon the subumbrella arranged in two rows instead of in three, as is commonly the case

in the Atlantic medusa. Eight of the subumbrella sacs in the variety *aquila* alternate with the gonads and eight 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 midregions of the gonads, while the 32 small saccules lie at the zone of the outer ends of the gonads. In the Atlantic form the areas of brown cells are commonly developed only centrifugal to the zone of gonad, while in the Pacific variety they occur between the gonads as well as beyond them. A marginal ring canal is present. The Pacific variety is, however, found also in the Atlantic.

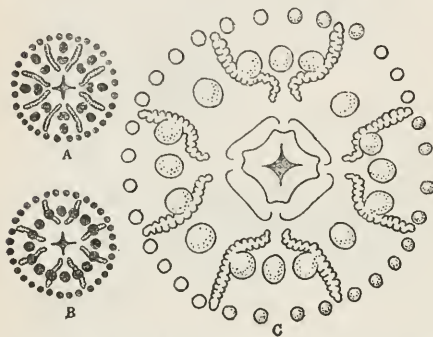


FIG. 6.—LINUCHE UNGUICULATA. A, THE USUAL ARRANGEMENT OF THE SUBUMBRELLA WARTS IN THE TROPICAL ATLANTIC FORM. B, THE USUAL ARRANGEMENT OF THE SUBUMBRELLA WARTS IN THE PACIFIC FORM. C, ENLARGED VIEW OF LIPS, GONADS, AND SUBUMBRELLA SACCULES IN THE PACIFIC FORM FROM THE PHILIPPINES.

developed only centrifugal to the zone of gonad, while in the Pacific variety they occur between the gonads as well as beyond them. A marginal ring canal is present. The Pacific variety is, however, found also in the Atlantic.

Vast swarms of these Medusae are found among the Samoan, Fiji, and Paumotos Islands, and they extend to the coasts of Africa and to Queensland, Australia. They abound in Queensland in the spring months, in Fiji in December, and at Singapore in April. I have studied a large collection of these medusae taken in the Philippine Islands at Mactan, near Cebu, on April 6, 1908, Cat. No. 27944, U.S.N.M., by the United States Bureau of Fisheries steamer *Albatross*. All were mature.

Vanhöffen (1913) reported that he succeeded in demonstrating that a marginal ring canal is present in the Atlantic *L. unguiculata*, although after many tests I have been unable to detect its presence in

living or freshly preserved animals, and am inclined to believe that the delicate membrane separating adjacent pouches was broken in Vanhöffen's specimens, which had been preserved for a long time in formalin. Moreover, Vanhöffen found that in some of the Atlantic medusae from the Bahama-Florida region the subumbrella warts are arranged as in *L. aquila* of the Pacific. It thus appears that the Pacific form is at best only a variety of the Atlantic species, and both should be called *Linuche unguiculata*.

Prof. E. G. Conklin in 1908<sup>1</sup> described the swarming habits, structure of the egg, and the segmentation in this medusa. The eggs are laid at 8 o'clock in the morning, after which the medusa sinks and soon dies. The segmentation is nearly equal and synchronous. The peripheral layer of oöplasm of the egg becomes the peripheral layer of the gastrula and gives rise to the cilia of the ectoderm. The intermediate layer gives rise to the principal part of all the cells of the gastrula, while the central part of the egg is the precursor of the cleavage cavity and serves as a kind of a fluid yolk for the nourishment of the surrounding cells.

#### Genus ATOLLA Haeckel, 1880, sensu Fewkes.

*Atolla* HAECKEL, 1880, Syst. der Medusen, p. 488.—FEWKES, 1886, Report Commissioner of Fish and Fisheries of U. S. for 1884, p. 934.—MAYER, 1910, Medusae of the World, vol. 3, p. 561.—BROWNE, 1910, National Antarctic Expedition, Nat. Hist., vol. 5, Coelenterata, V. Medusae, p. 47.

*Generic characters*.—Coronatae with numerous (nine or more) tentacles and equally numerous marginal sense organs. Twice as many marginal lappets as sense organs. Eight adradial gonads and four interradial subgenital ostia. Four lips. The tentacles and marginal sense organs alternate regularly, but the insertions of the tentacles and their pedalia are higher up on the sides of the exumbrella than are the insertions of the pedalia of the sense organs.

The *Albatross* collection serves to show that *A. wyvillei* and *A. bairdii* are closely related if not mere extremes of an intergrading series of one and the same species. For example, two specimens from station D. 5652 in the Gulf of Boni, depth of 525 fathoms, have the margin of the central lens distinctly notched with radial furrows as in the typical *A. wyvillei*; but there is an annular ridge on the outer side of the ring-furrow with a plain peripheral margin as in *A. bairdii*. Also several other specimens show such very slight notches in the margin of the central lens that if one were not looking carefully for this feature it would surely pass unobserved and the medusa would be called *A. alexandri*. A large specimen of *A. gigantea*, from a depth of 519 fathoms in Buton Strait, shows affini-

<sup>1</sup>Papers from the Tortugas Laboratory of the Carnegie Institution of Washington, vol. 2, p. 155.

ties with *A. wyvillei*, *A. bairdii*, and *A. verrillii*. Thus the margin of its central lens is irregularly notched as in *A. wyvillei*, but without radial furrows. There is an annular ridge upon the outer side of the ring-furrow, and the outer edge of this ridge is simple and entire, as in *A. bairdii*, in about two-thirds of its circumference, and notched as in the typical *A. gigantea* in the remaining one-third. The central lens is more than half as wide as the medusa, as in *A. bairdii*, *A. verrillii*, and *A. valdiviae*.

It is evident that intergrading conditions prevail to a hopeless degree among many of the so-called "species" of *Atolla*. In fact, I think there are but two well-distinguished species: *A. bairdii* with smooth exumbrella and *A. chuni* with well-developed and quite regularly arranged papillae upon the exumbrella sides of the lappets. As a matter of convenience, however, we may distinguish *A. bairdii* var. *wyvillei* by the notched margin of its central lens, and the absence of a well-marked annular ridge on the outer side of its coronal

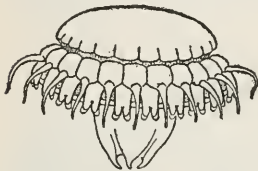


FIG. 7.—*ATOLLA BAIRDII*,  
VAR. *WYVILLEI* FROM THE  
PHILIPPINES, GULF OF  
BONI; DEPTH, 492 FATH-  
OMS.

furrow; for while there is often an annular ridge on the outer side of the ring-furrow, the margin of the central lens usually projects over it, overarched and concealing it from view. *A. bairdii* is a case where this ridge is so well developed that it projects beyond the margin of the central lens.

Some 35 specimens of *Atolla* were found by the *Albatross* among the Philippine Islands; and of these 18 are more or less typical *A. wyvillei*, 4 are intermediate in condition between *A. wyvillei* and *A. alexandri*, 3 are intermediate between *A. wyvillei* and *A. bairdii*, 1 combines the characters of *A. bairdii* with the forma *valdiviae*.

The specimen of *Atolla gigantea*, Cat. No. 28690, U.S.N.M., which shows affinities with *A. bairdii* and *A. verrillii*, was dredged at Station D. 5647, from Buton Strait, about 11.6 miles off North Island, depth 519 fathoms, bottom green mud. This medusa is a large one, being 130 mm. wide and with 29 tentacles. The diameter of the central lens is 94 mm. and the thickness of its gelatinous substance 21 mm. The margin of the central lens is irregularly notched, but is without distinct radial furrows. Its margin overarches the ring-furrow, which is 15 mm. deep. The outer edge of the ring-furrow exhibits an annular ridge, which is, however, overarched and hidden under the projecting margin of the central lens. Two-thirds of the circumference of the peripheral edge of this annular ridge is entire and plain, as in *A. bairdii*, but about one-third of it is notched, the notches tending to lie in the radii of the tentacular pedalia, as in the typical *A. gigantea*.

Other dimensions of this medusa (given in millimeters) are as follows: Tentacular pedalia, 11.5 long, 10.5 wide; rhopalar pedalia, 11.5 long, 8.5 wide; diameter across subumbrella to outer edge of ring-muscle, about 126; width of ring-muscle, 77.5; diameter across zone of gonads, about 96 (each gonad is circular, disk shaped, and about 15 in diameter, the medusa being a female and apparently nearly mature); diameter across central stomach, about 66; length of manubrium, 46.

It thus appears that in this specimen the central lens is more than half as wide as the medusa, as in *A. bairdii* and *A. verrillii*, its outer margin being slightly notched as in *A. bairdii* and *A. valdiviae*. The annular ridge is probably concealed under the over-arching edge of the central lens, as in *A. wyvillei* and *A. verrillii*. Part of the outer edge of the annular ridge is entire and even, as in *A. bairdii* and *A. valdiviae*, and part of it is notched and furrowed, as in the typical *A. gigantea*.

It is probable that most of the so-called specific distinctions between the various *Atollas* are mere individual peculiarities of no greater specific value than the difference between blue eyes and brown in man.

*List of stations among the Philippines from which specimens of Atollas allied to A. wyvillei were obtained.*

- D 5201, April 10, 1908, from Sogod Bay, Southern Leyte Island, depth 554 fathoms, bottom gray sand and mud. One typical *A. wyvillei* with 23 tentacles. Dimensions given in table. Cat. No. 28231, U.S.N.M.
- D 5285, July 20, 1908, about 17.5 miles off Malavatuan Island in the China Sea, depth 272 fathoms, bottom soft mud. Eleven specimens of medium size, not well preserved, but all are probably *A. wyvillei*. Cat. No. 28685, U.S.N.M.
- D 5348, December 27, 1908, in Palawan Passage, about 33.5 miles from Point Tabonan, depth 375 fathoms, bottom coarse sand. One specimen too imperfect for accurate specific determination. Cat. No. 28681, U.S.N.M.
- D 5471, June 19, 1909, about 15 miles off Sialat Point Light on the east coast of Luzon, depth 568 fathoms. Two specimens closely allied to *A. alexandri*, one with 29 and the other with 26 tentacles. The dimensions of both are given in the table. Cat. No. 28686, U.S.N.M.
- D 5486, July 31, 1909, about 6 miles off Batobolo Point, between Leyte and Mindanao, depth 585 fathoms. Four badly preserved specimens, too imperfect for specific determination. Cat. No. 28708, U.S.N.M.
- D 5493, August 2, 1909, about 5.5 miles off Diuata Point, between Leyte and Mindanao, depth 478 fathoms, bottom green mud. Four specimens of *A. wyvillei*. The largest was 60 mm. wide, central lens 44 mm. wide with indented margin, 22 tentacles each 21 mm. long. Another medusa was 50 mm. in diameter, central lens 29.5, with indented margin and 23 tentacles. Another medusa was 42 mm. in diameter, central lens 33 mm. wide with distinct radial furrows and notched margin, 24 tentacles. The smallest medusa was 31 mm. wide, central lens 21 mm. wide with radial furrows and notched margin, 23 tentacles. Cat. No. 28689, U.S.N.M.

- D 5533, August 19, 1909, between Cebu and Siquijor, about 9.5 miles off Balicasag Island, depth 432 fathoms, bottom green mud and sand. One specimen of *A. wyvillei*. Cat. No. 28684, U.S.N.M.
- D 5631, December 2, 1909, south of Patiente Strait, about 4.5 miles off Doworra Island, depth 809 fathoms, bottom green mud. One specimen approaching condition of *A. alexandri* in having no distinct indentations or furrows at the margin of the central lens. The dimensions of this specimen are given in the table. Cat. No. 28682, U.S.N.M.
- D 5650, December 17, 1909, in the Gulf of Boni, about 12.5 miles off Lamulu Point, depth 540 fathoms, bottom green mud. One specimen distorted by pressing upon the bottom of the bottle in which it was preserved, so that its specific affinities can not be determined with accuracy. The medusa was 60 mm. wide, central lens 42 mm. wide, with a few faint indentations in its margin. Twenty-four tentacles. Cat. No. 28683, U.S.N.M.
- D 5652, December 17, 1909, in the Gulf of Boni about 7.5 miles off Lamulu, depth 525 fathoms, bottom green mud. Four specimens, one of which is 89 mm. wide with 31 tentacles and is an *A. wyvillei* approaching the condition of *A. alexandri*. Its dimensions are stated in the table. Another specimen has five furrows in the margin of its central lens, but there is a plain-edged, projecting annular ridge on outer side of ring furrow, as in *A. bairdii*. It thus combines characters of *A. wyvillei* with those of *A. bairdii*. This medusa is 51 mm. wide and has 29 tentacles. Two other specimens, one 33 and the 37 mm. in diameter, have each 20 tentacles, with the margins of their central lenses notched as in *A. wyvillei*, while they have well-developed annular ridges which project beyond the margin of the ring furrow, resembling *A. bairdii* in this respect. Cat. No. 28687, U.S.N.M.
- D 5657, December 19, 1909, in the Gulf of Boni, about 15.5 miles off Oland Point, depth 492 fathoms, bottom gray mud. One specimen of *A. wyvillei* 54 mm. wide, central lens 41 mm. wide, 25 tentacles. Cat. No. 28688, U.S.N.M.

*Dimensions (in mm.) of some specimens of nontypical and typical A. wyvillei, collected by the "Albatross" in the Philippine Islands.*

	Forma <i>A. wyvillei</i> approach- ing the condition of <i>A.</i> <i>alexandri</i> . <sup>1</sup>	Typical <i>A.</i> <i>wyvillei</i> . <sup>2</sup>	<i>A. wyvillei</i> approach- ing <i>A.</i> <i>alexandri</i> . <sup>3</sup>	<i>A. wyvillei</i> approaching <i>A. alexandri</i> . <sup>4</sup>	
Diameter of entire medusa.....	89	55	68	91	44
Thickness of bell.....	15	26	.....	19	8
Number of tentacles.....	31	23	23	29	25
Diameter of central lens of exumbrella.....	51	40	45.5	54	25
Condition of margin of central lens of exumbrella.....	( <sup>5</sup> )	( <sup>6</sup> )	( <sup>7</sup> )	(8)	
Depth of coronal furrow.....	13	3	.....	9.5	4
Length of tentacular pedalia.....	7	6.5	5.75	8.25	6
Width of tentacular pedalia.....	6.5	6	6.75	7.5	4.5
Length of rhopalar pedalia.....	6.5	6.5	6.75	6.25	3.5
Width of rhopalar pedalia.....	5	5	5.25	5.75	3
Length of marginal lappets.....	8	.....	.....	.....	.....
Length of tentacles.....	19	13	14	.....	.....
Diameter to outer edge of ring-muscle of subumbrella.....	73	48	56.5	75	39
Width of subumbrella ring-muscle.....	5.5	3	4	4.5	2.75
Diameter across zone of gonads.....	47	28.5	38	50.5	25.5
Dimensions of each gonad (circumferential×radial).....	.....	7×5	( <sup>9</sup> )	.....	.....
Diameter of central stomach.....	37	21	24	37	18
Length of manubrium.....	22	22	.....	42	.....

<sup>1</sup> D 5652, Dec. 17, 1909, Gulf of Boni, depth 525 fathoms, near Lamulu.

<sup>2</sup> D. 4201, Apr. 10, 1908, south end of Leyte Island, depth 554 fathoms.

<sup>3</sup> D. 5631, Dec. 2, 1909, south of Patiente Strait, depth 809 fathoms.

<sup>4</sup> D 5471, June 19, 1903, off Siale Point Light, east coast of Luzon, 568 fathoms.

<sup>5</sup> Notched with about 5 more or less distinct radial furrows.

<sup>6</sup> Notched with 22 radial furrows.

<sup>7</sup> Only slightly wavy in places, no distinct notches.

<sup>8</sup> Faintly wavy in outline, no furrows.

<sup>9</sup> Spherical.



## ATOLLA BAIRDII forma VALDIVIAE Vanhöffen.

*Atolla valdiviae* VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, vol. 3, Lief. 1, p. 13, pl. 1, fig. 3; pl. 6, figs. 41-46.—MAAS, 1903, Schphomedusen der *Siboga* Expedition, Monog. 11, p. 17, pl. 1, figs. 3, 4; pl. 3, fig. 23; pl. 12, fig. 108.—MAYER, 1910, Medusae of the World, vol. 3, p. 565, 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 four septal nodes are wider than in *A. bairdii*.

The *Albatross* obtained three specimens (Cat. No. 27927, U.S.N.M.) of this medusa in the Philippine Island on April 10, 1908, at dredging station No. 5202, in Gogod Bay, depth 502 fathoms, bottom green mud. The characters and dimensions of these specimens are given by Mayer.<sup>1</sup>

## Genus PELAGIA Péron and Lesueur, 1809.

*Pelagia* PÉRON and LESUEUR, 1809, Annal. du Mus. Hist. Nat. Paris, vol. 14, p. 349.—MAYER, 1910, Medusae of the World, vol. 3, p. 570.

*Generic Characters.*—Semaestomata of the family Pelagidae, in which the central stomach gives rise to 16 completely separated radiating pouches, 8 in the radii of the tentacles and 8 in the radii of the sense-organs. There are 8 adradial tentacles, 8 rhopalia, and 16 partially cleft marginal lappets. Each of the 16 stomach pouches is cleft at its distal end, where it enters the marginal lappets. There is no ring-canal.

## PELAGIA PANOPYRA Péron and Lesueur.

*Medusa panopyra* PÉRON and LESUEUR 1807, Voyage aux terres Australes, pl. 31, fig. 2.

*Pelagia panopyra* MAYER, 1910, Medusae of the World, vol. 3, p. 575.

This widely distributed tropical Pacific species is distinguished by its small, low, rounded exumbrella warts, which are elliptical in outline and have a longitudinal furrow with cross-foldings. The bell becomes about 50 mm. wide, and the esophagus is about as long as the bell-diameter, the mouth-arms being somewhat longer. In common with other species of *Pelagia*, the color is highly variable, but the bell is usually rose-colored or violet, and the netting-warts are violet. The gonads are usually purple and the mouth-arms violet.

There are 21 specimens of this medusa in the collection of the *Albatross* from the Philippines; 10 (Cat. No. 28719, U.S.N.M. are from Station 5422, March 30, 1909, from a tow made at a depth of 15 feet below the surface, about 10 miles off Lusaran Point Light, between Panay and Guimaras; the largest specimen is 33 mm. wide and with large gonads, while another 28 mm. wide has only small gonads. Eleven young specimens (Cat. No. 28716, U.S.N.M.) were

<sup>1</sup> Medusae of the World, vol. 3, p. 565.

obtained at Station D5220, April 24, 1908, on the surface between Luzon and Marinduque at 12.57 p. m. These are all small and about 10 mm. in diameter, evidently being taken from a swarm of immature individuals.

**Genus CHRYSAORA Péron and Lesueur, 1809.**

*Chrysaora* PÉRON and LESUEUR, 1809, Annal. du Mus. Hist. Nat., Paris, vol. 14, p. 364.—MAYER, 1910, Medusae of the World, vol. 3, p. 577.

*Generic Characters.*—Pelagidae with 8 marginal sense-organs, 24 ( $3 \times 8$ ) tentacles, and typically 32 ( $4 \times 8$ ) marginal lappets; although in *C. melanaster* the lobes may still further divide, giving 48 ( $6 \times 8$ ) marginal lappets.

**CHRYSAORA MELANASTER Brandt.**

*Chrysaora melanaster* BRANDT, 1838, Mém. Acad. Sci. St. Petersburg, Sci. Nat., sér. 6, vol. 4, p. 385, pls. 16, 17.—MAYER, 1910, Medusae of the World, vol. 3, p. 582.

There is a well-preserved specimen of this medusa from station D5461, June 14, 1909, San Miguel Bay, east coast of Luzon, depth 11 fathoms (Cat. No. 28712, U.S.N.M.).

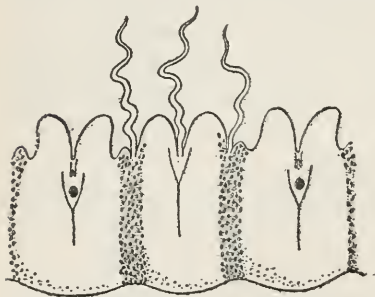


FIG. 8.—CHRYSAORA MELANASTER. AN OCTANT OF THE BELL MARGIN. SAN MIGUEL BAY, EAST COAST OF LUZON.

The bell is about 130 mm. in diameter and slightly flatter than a hemisphere. There are 16 radiating spoke-like streaks of faint umber color extending from near the apex of the exumbrella to the bell-margin in the radii of the 16 cleft velar lobes. These 16 streaks occupy depressed radial areas sunken below the general level of the contour of the exumbrella, and they are besprinkled coarsely with wart-like

nematocyst clusters of cinnamon-brown color.

There are 8 rhopalia,  $3 \times 8$  tentacles, and  $6 \times 8$  marginal lobes. The velar lobes are cleft as in Brandt's figures and are nearly similar in shape and size to the ocular lappets. They are, however, not narrower at the base than outwardly, as in Brandt's figures, but are oval and taper quite regularly from base to tip.

The tentacles are short and slender, the longest being not over 60 mm.

The mouth-arms are long and slender, folded complexly, and about 170 mm. long. The gonads are well developed, apparently mature, and protrude through the subgenital ostia, the subgenital ostia being fully twice as wide as the perradial columns between them. Thus

each ostium is 28 mm. long (circumferentially) and 15 mm. wide (radially), while the perradial columns of the mouth-arms are only 13 mm. wide.

In formalin the general color of the medusa is milky custard-yellow, the gonads being lighter. The apex of the exumbrella is besprinkled with cinnamon-colored nematocyst warts, and the 16 radial streaks of light umber color are also besprinkled with brown-colored clusters of nematocysts. This medusa is widely distributed over the north Pacific from Kamtschatka to California, but this Philippine Island specimen is the first which has been obtained in the tropics.

Genus *DACTYLOMETRA* L. Agassiz, 1862.

*Dactylometra* L. AGASSIZ, 1862, Contributions to Nat. Hist. U. S., vol. 4, p. 166.—MAYER, 1910, Medusae of the World, vol. 3, p. 583.

*Generic Characters*.—Pelagidae with 8 rhopalia.  $5 \times 8$  tentacles and  $6 \times 8$  marginal lappets.

*DACTYLOMETRA AFRICANA* Vanhöffen.

*Dactylometra africana* VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition, Dampfer *Valdivia*, vol. 3, Lief. 1, p. 40, pl. 4, fig. 20.—MAYER, 1910, Medusae of the World, p. 588.

Disk 100 to 130 mm. wide with exumbrella thickly covered with wart-like clusters of netting cells. Six well-developed marginal lappets and five long tentacles in each octant. Lappets and tentacles red. Red radial streaks over exumbrella. Esophagus, palps, and gonads not highly colored. Colors of large specimens duller and more brownish than those of small medusae and not unlike the coloration of *D. quinquecirrha*. Distinguished by its lappets being deeply pigmented near the margin on the exumbrella side.

Vanhöffen's specimens came from the Great Fish Bay, coast of German southwest Africa, in October, 1898. Five specimens (Cat. No. 28679, U.S.N.M.), all imperfect, the largest about 105 mm. in diameter and with only  $3 \times 8$  tentacles and  $4 \times 8$  marginal lappets, were found by the *Albatross* at station D5461, June 14, 1909, at a depth of 12 fathoms, about 7.2 miles off Corregidor Light, Manila Bay, Luzon. The bells are pinkish in hue, and thickly and uniformly besprinkled over the exumbrella with red-brown nematocyst warts. The lappets are edged on the exumbrella side with reddish brown. The tentacles have been lost and the mouth parts are imperfect.

Another specimen (Cat. No. 28680, U.S.N.M.), 166 mm. in diameter and with mouth-arms 280 mm. long, was found at Kowloon, China, on August 14, 1908. It was  $3 \times 8$  tentacles, and  $6 \times 8$  marginal lappets, the lappets being edged on their exumbrella margins with russet brown.

Light records a *Dactylometra* from the Philippines which he believes is identical with *D. quinquecirrha*. The bell is white, translucent, and covered on the exumbrella with minute white spots.

Light's specimens were all in the *Chrysaora* stage with 24 tentacles and 32 marginal lappets. The sting which this medusa inflicts is apparently far more severe than that given by the *Dactylometra* of our American coast.

Genus SANDERIA Goette, 1886.

*Sanderia* GOETTLE, 1886. Sitzungsber. Akad. Wissen. Berlin. Jahrg. 1886, p. 535.—VANBÜFFEN, 1902. Wissen. Ergeb. deutsch. Tiefsee Expedition. Dampfer *Valdivia*, vol. 3, Lief. 1, p. 37.—MAYER, 1910. Medusae of the World, vol. 3, p. 590.

*Generic Characters*.—Pelagidae with 16 marginal sense-organs, 16 tentacles, and 32 cleft marginal lappets. Four lips, 4 interradial



FIG. 9.—*SANDERIA MALAYENSIS*, AFTER VANBÜFFEN IN "VALDIVIA" EXPEDITION.

gonads, and 32 peripheral stomach-pouches in the radii of the tentacles and sense-organs. No marginal ring-canal.

*SANDERIA MALAYENSIS* Goette.

*Sanderia malayensis* GOETTLE, 1886. Sitzungsber. Akad. Wissen. Berlin. Jahrg. 1886, p. 535.—VANBÜFFEN, 1902. Wissen. Ergeb. deutsch. Tiefsee Expedition. Dampfer *Valdivia*, vol. 3, Lief. 1, p. 38, pl. 3, fig. 12; pl. 5, figs. 68-74.—MAYER, 1910. Medusae of the World, vol. 3, p. 590.

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 United States Fisheries Bureau steamer *Albatross* in the Philippine Islands between March and June, 1908.

A perfect specimen (Cat. No. 27947, U.S.N.M.), found by the *Albatross* on March 8, 1908, at station D5175, 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 upon each gonad.

One large imperfect specimen about 97 mm. in diameter is from station D5291, July 23, 1908, depth of 173 fathoms, about 2.2 miles off Escarceo Light, southern Luzon. Only 3 gonads are left. These have between 14 to 26 papillæ.

Eight other specimens of medium size are from station D5386, March 9, 1909 (Cat. No. 28727, U.S.N.M.). Depth 287 fathoms, about 25.3 miles off Arena Point, Ragay Gulf, Luzon.

One imperfect specimen (Cat. No. 28731, U.S.N.M.) is from station D5532, August 13, 1909, from between Masbate and Leyte. Bell about 73 mm. wide and with 26 to 29 finger-shaped processes on the gonads.

One perfect specimen (Cat. No. 28726, U.S.N.M.) is from station D5456, June 7, 1909, east coast of Luzon, about 6.7 miles off Legaspe Light.

#### Genus DISCOMEDUSA Claus, 1877.

*Discomedusa* CLAUS, 1877, Denkschrift, Wien Acad., vol. 38, p. 42.

*Ulmaris*+*Umbrosa* HAECKEL, 1889, Syst. der Medusen, p. 545.

*Umbrosa* MAAS, 1908, Expédition Antarctique Française, Meduses, p. 9.

*Discomedusa* MAYER, 1910, Medusae of the World, vol. 3, p. 606.

*Generic Characters*.—Ulmaridae with 24 ( $3 \times 8$ ) tentacles, 32 ( $4 \times 8$ ) lappets, and 8 sense-organs. The tentacles arise from the clefts between the marginal lappets. There are 8 simple, unbranched, adradial canal, 8 branched, 4 perradial, and 4 interradial canals, and a marginal ring-canal.

#### DISCOMEDUSA PHILIPPINA Mayer.

*Discomedusa philippina* MAYER, 1910, Medusae of the World, vol. 3, p. 607, fig. 388.

This medusa bears a close resemblance to *Parumbrosa polylobata* Kishinouye (1910, Journal College of Science, Tokyo, Japan, vol. 27.

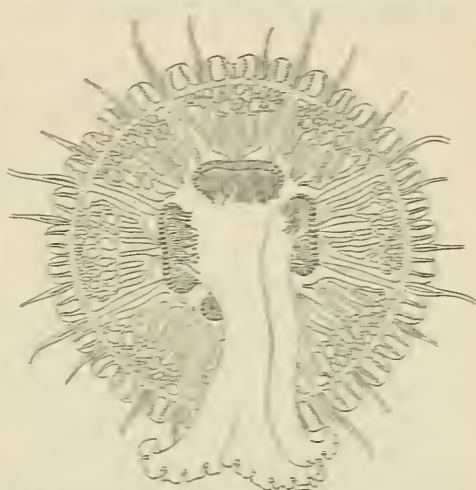


FIG. 16.—DISCOMEDUSA PHILIPPINA FROM COTINGAN BAY, PHILIPPINE ISLANDS, APRIL 20, 1908.

art. 9, p. 19, pl. 4, figs. 20–23); but in Kishinouye's medusa the marginal lobes are still further divided, being 64 instead of 32 as in *D. philippina*. Moreover, the canal system appears to be less complex in its branching in *P. polylobata*, so that it seems probable that the two are distinct species, not mere growth-stages one of the other. Should this view prove erroneous, however, the medusa should be called *Parumbrosa polylobata* Kishinouye.

Six specimens were collected by Fisheries steamer *Albatross*, station 5213, Masbate Island, Philippine Islands, April 20, 1908. (Cat. No. 27948, U.S.N.M. Type.)

#### Genus AURELLIA Péron and Lesueur, 1809.

*Aurellia* PÉRON and LESUEUR, 1809, Annal. du Mus. Hist. Nat., Paris. vol. 14, p. 357.

*Aurelia* LAMARCK, 1817, Syst. Anim. sans Vertébrés, vol. 2, p. 512.

*Aurellia* MAYER, 1910, Medusae of the World, vol. 3, p. 619.

*Generic Characters*.—Semaestomata with a simple central mouth-opening, which is surrounded by four well-developed, perradially situated, unbranched mouth-arms or palps. Eight 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 four interradial gonads and four well-developed subgenital pits.

#### AURELLIA AURITA (Linnaeus).

*Medusa aurita* LINNAEUS, 1758, Systema Naturae, ed. 10, vol. 1, p. 660.

*Aurellia flavidula* PÉRON and LESUEUR, 1809, Annal. du Mus. Hist. Nat., Paris, vol. 14, p. 369.

*Aurellia aurita* LAMARCK, 1817, Hist. Anim. sans Vert., vol. 2, p. 513.—MAYER, 1910, Medusae of the World, vol. 3, p. 623.

Some 13 specimens of this universally distributed medusa were found by the *Albatross* among the Philippine Islands. Of these, 11 half-grown specimens (Cat. No. 28718, U.S.N.M.) are from station D 5663, December 28, 1909, in Macassar Strait, depth 11 fathoms, about 1.7 miles off Kapoposang Island, 7h. 20m. p. m., while 2 larger but still immature are from Station D 5662, December 21, 1909, Flores Sea, near Tana Keke Island, 5h. 40m. to 6h. 12m. a. m. There are only 8 notches in the bell margin corresponding to the 8 rhopalia, instead of 16 notches, 8 rhopalar and 8 inter-rhopalar as in *Aurellia labiata*.

*Aurellia aurita* is found in all seas from the Polar regions to the Tropics. In the Tropics it lives very close to its heat death-temper-

ature, and thus it is barely able to survive in the surface waters of the warmer seas in summer. Romanes found that specimens of this medusa from the British seas can withstand being frozen solidly into ice, and I find this to be true also of this medusa from Halifax, Nova Scotia. At Halifax, on the other hand, the medusa ceases to pulsate at 29.4° C., at which temperature it is most active at Tortugas, Florida. On the other hand, the Florida medusa is killed by being frozen into the ice. Thus the medusa becomes somewhat acclimated to the temperature of the waters in which it lives, and if accustomed to warm water it loses its resistance to cold and the opposite.

**AURELLIA LABIATA** Chamisso and Eysenhardt.

*Aurelia labiata* CHAMISSO and EYSENHARDT, 1820, Nova Acta Phys. med. Leop. Car., vol. 10, p. 358, pl. 28, figs. 1 A. B.

*Aurelia labiata* MAYER, 1910, Medusae of the World, vol. 3, p. 628, fig. 398.—

LIGHT, 1914, Philippine Journal of Science, vol. 9, p. 200.

Light (1914) records a specimen from the Philippines, the bell of which was 225 mm. in diameter.

*Aurelia labiata* differs from *A. aurita* by having 16 notches in its bell-margin, by its peculiar velum-like, interrhopalar, 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*, and the terminal branches of the radial-canals anastomose to a greater degree than in *A. aurita*.

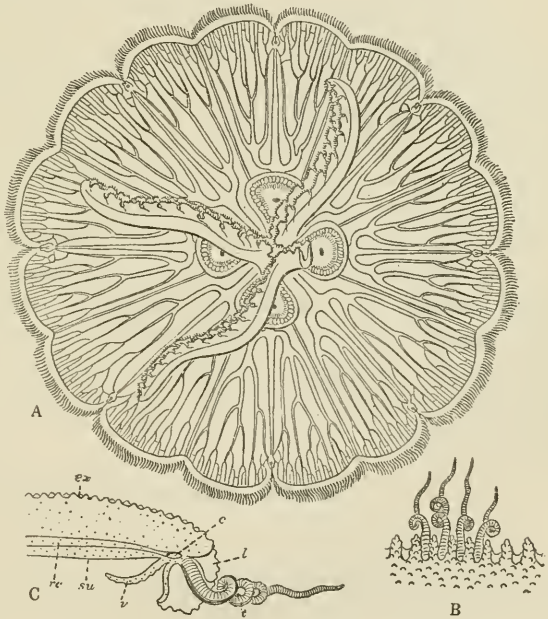


FIG. 11.—AURELLIA LABIATA FROM THE PHILIPPINES. A, ORAL VIEW SHOWING THE 16 NOTCHES IN THE BELL MARGIN. B, ABORAL VIEW OF TENTACLES AND LAPPETS. C, DIAGRAMMATIC CROSS SECTION OF BELL MARGIN. *c*, RING CANAL; *ex*, EXUMBRELLA; *l*, LAPPETS; *rc*, RADIAL CANAL; *su*, SUBUMBRELLA; *t*, TENTACLE; *v*, VELARIUM.

The dimensions of three specimens, Cat. No. 27923, U.S.N.M., obtained by the United States 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

Four other specimens (Cat. No. 27979, U.S.N.M.) were caught at night upon the surface under the electric light at Jolo Anchorage, on February 8, 1908; while seven more (Cat. No. 27924, U.S.N.M.) were taken at *Albatross* station D 5230, between Bohol and Leyte, May 7, 1908.

An abnormal but perfect specimen of *Aurellia aurita* was found at Tortugas, Florida, on July 27, 1914. This aberration closely resembled the normal *A. labiata* of the Pacific. There were 16 deep notches in the bell-margin, 8 perradial and 8 interradian, and the velumlike marginal membrane was like that of *A. labiata*. The small subgenital ostia and simple mouth-arms also recalled *A. labiata*; but the terminal branches of the adradial-canal system did not anastomose and in this resembled *A. aurita* rather than *A. labiata*. The case is interesting, as it leads one to suspect that *A. labiata* of the Pacific has been derived as a mutation from the universally distributed *A. aurita*. The bell of this Tortugas medusa was 270 mm. in diameter; diameter of genital cross, 78 mm. Palps simple and each about one-eighth longer than the bell-radius. Eight sense organs, 8 interradian notches in the bell-margin. Eight straight, simple, non-pigmented perradial-canals, 8 straight pink-colored interradian-canals. The sparingly branched adradial-canals reach the bell-margin without anastomosing, and in this respect resemble those of *A. aurita*. The male gonads were pink, the tentacles rich purple, the velarium creamy white, the palps purple-pink, and the gelatinous substance pink.

## Order RHIZOSTOMAE.

Scyphomedusae without marginal tentacles and with numerous mouths borne upon four dichotonously branched (eight) mouth-arms. Most of these forms are tropical and none are found in Arctic seas. They are the conspicuous large jellyfishes of harbors and coastal waters in the East Indies, although usually rare and represented by but few species in the West Indies.

### Genus CASSIOPEA Péron and Lesueur, 1809.

*Cassiopea* PÉRON and LESUEUR, 1809, Annal. du Mus. Hist. Nat. Paris, vol. 14, genre 24, p. 356.—MAYER, 1910, Medusae of the World, vol. 3, p. 636.

*Generic Characters.*—Rhizostomata pinnata with eight (four pairs of) adradial, complexly branched mouth-arms, the lower or ventral



surfaces of which bear numerous mouth-openings and vesicles. There are four gonads and four separate subgenital cavities. There are more than eight 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 well-defined ring-canal may or may not be present, but is commonly absent.

CASSIOPEA ANDROMEDA, var. BADUENSIS Mayer.

*Medusa andromeda* FORSKÅL, 1775, *Descript. que in Itinere Orientali Observavit, Hauniae*, p. 107, pl. 31.

*Cassiopea andromeda* ESCHSCHOLTZ, 1829, *Syst. der Acalephen*, p. 43.

*Cassiopea andromeda*, var. *baduensis* MAYER, 1915, *Publication No. 212*, Carnegie Institution of Washington, p. 183.

A specimen of this medusa (Cat. No. 28730, U.S.N.M.) is from Endeavour Strait, between Australia and New Guinea, and was found by the *Albatross* on December 23, 1908. The bell is 101 mm. in diameter, flat without an aboral depression, and with 18 rhopalia. There are four to eight, usually six, lappets between successive rhopalia. The arm-disk is octagonal, 36 mm. wide, and the eight mouth-arms are each 34 mm. long and definitely bifurcated, the forks being 16 mm. long, thus nearly half as long as the total length of the mouth-arms. There are no appendages among the mouth-arms, but these may have been lost. The color has wholly faded in formalin.

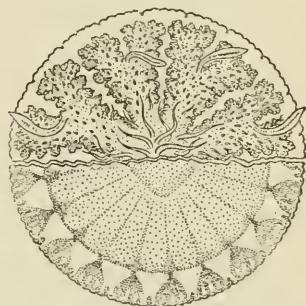


FIG. 12.—CASSIOPEA ANDROMEDA, VAR. BADUENSIS, FROM TORRES STRAIT, BADU ISLAND. ORAL VIEW ON THE RIGHT; ABORAL VIEW OF BELL ON THE LEFT.

Another specimen of this medusa was found at Badu Island, Torres Straits, Australia, within a few miles of Endeavour Strait, by the expedition of the Carnegie Institution of Washington, on November 5, 1913, and was studied alive, and is herewith figured.

The bell is 61 mm. in diameter. There are 22 marginal sense-organs and (5×22) 110 bluntly rounded, barely perceptible, evenly spaced marginal lappets all similar each to each. The arm-disk is about one-third as wide as the bell-diameter and the mouth-arms are compressed dorso-ventrally and when fully expanded extend slightly beyond the bell-margin, but in their ordinary state of contraction they do not quite reach the bell-margin. The side branches of these mouth-arms are short, but each arm is bifurcated at its outer end, the forked part being about one-third as long as the entire arm. There are about 20 slender, flat, tapering, central arm-disk appendages of various lengths, the longest of which is at the center of the oral side

and is about as long as the bell-radius. There is also a spatula-shaped appendage at the crotch of bifurcation of each mouth-arm. These are somewhat stouter than the central appendages, about half as long as the bell-radius, and their entoderm is bluish. There are numerous, minute, spatulate appendages among the mouth-arms.

The general color of the bell of the medusa is olive-brown. There are 22 large, triangular white spots with forked outer ends near the bell-margin in the radii of the sense-organs, and also (3×22) 66 short white streaks near the margin in the radii of the velar lappets. There are 22 interradial, dull bluish streaks in the subumbrella alternating with the rhopalia in position.

This variety is distinguished by its bifurcated mouth-arms. Its nearest ally appears to be *Cassiopea andromeda*, var. *acycloblia* Schultze, from Amboina, but it differs in its color pattern, in the absence of a central dome, and in its simple bifurcated mouth-arms, those of the Amboina medusa branching dichotomously.

*Cassiopea andromeda* is the common species of the Indian Ocean, Red Sea, and Malay Archipelago, and Kellar records its having wandered into the Suez Canal. It gives rise to numerous local varieties.

There are evidently a number of other varieties of *Cassiopea* in the Philippines, for Light<sup>1</sup> describes *Cassiopea polypoides*, var. *culionensis*, *C. polypoides?*, and *C. medusa*, new species. The last named is distinguished by its very large mouth-arm appendages, which in a medusa whose bell is 260 mm. in diameter are 110 mm. long and 7.5 mm. in diameter, being cylindrical near the base and flattened at their outer ends. *C. medusa* is described from Culion Bay, Culion, Philippine Islands.

#### Genus CEPHEA Péron and Lesueur, 1809.

*Cephea* PÉRON and LESUEUR, 1809, Annal. du Mus. Hist. Nat., Paris, vol. 14, p. 360.—MAYER, 1910, Medusae of the World, vol. 3, p. 651.

*Generic Characters.*—Rhizostomata dichotoma in which the eight 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 eight rhopalar and numerous inter-rhopalar radial-canals, all of which connect with a network of anastomosing vessels in a wide zone near the margin. Rhopala without ocelli and without sensory pits on the exumbrella. There is no definite ring-canal. Development unknown.

<sup>1</sup> 1914, Philippine Journal of Science, vol. 9, p. 201.

## CEPHEA OCTOSTYLA (Forskål).

*Medusa octostyla* FORSKÅL, 1775, Descript. Anim. Itin. Orient., p. 106, No. 18, Icon., pl. 29.

*Cephea octostyla* MAYER, 1910, Medusae of the world, vol. 3, p. 652, fig. 405.

A number of well-preserved specimens of *Cephea octostyla* were obtained by the following localities:

Jolo, Philippine Islands, February 8, 1908, 1 specimen. Cat. No. 27906, U.S.N.M.

Jolo Anchorage, Philippine Islands, February 13, 1908, 3 specimens. Cat. No. 27908, U.S.N.M.

Jolo Anchorage, Philippine Islands, March 5, 1908, 1 specimen. Cat. No. 27907, U.S.N.M.

Station 5173, Jolo, Philippine Islands, March 5, 1908, 9 specimens. Cat. No. 27910, U.S.N.M.

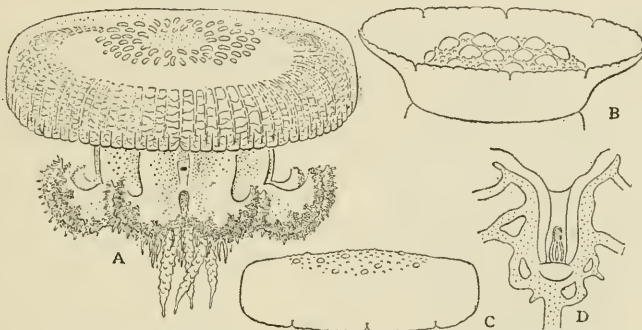


FIG. 13.—*CEPHEA OCTOSTYLA* FROM JOLO ANCHORAGE, PHILIPPINE ISLANDS. A, B, AND C, VARIATIONS IN THE DEVELOPMENT OF THE CENTRAL WARTS OF THE EXUMBRELLA. D, RHOPALIUM FROM THE SUBUMBRELLA SIDE.

Bell 90 mm. wide, exumbrella flat, rim vertical, 20 mm. high. Near the center of the exumbrella there is a zone of numerous low wart-like protuberances, leaving the exact center smooth. Eight rhopalia without ocelli and without sensory pits. Seven velar and two ocular lappets in each octant, all similar each to each and indistinct rectangular in outline and separated by very slight indentations spanned by a web. Fairly deep grooves extend up the vertical rim of the exumbrella surface of the bell between the lappets.

Arm disk as wide as the bell radius. At its center 4 to 12 or more tapering, somewhat flattened, wart-covered filaments about one-fourth as long as the bell diameter. Each filament terminates in a simple, slender, pointed end. There are also numerous simple short filaments ranging from 15 to 5 mm. in length near the center of the arm disk, and in addition many still shorter arms between the numerous frilled mouths of the mouth arms.

Four small subgenital ostia and a unitary genital cavity. Ring muscles of subumbrella entire, but weakly developed. Eight rhopa-

lar and (8×7) somewhat narrower radial canals all connected by anastomosing side branches. The eight rhopalar canals lead straight out to the rhopalia, but the 56 inter-rhopalar canals tend to lose themselves in the network of vessels. No distinct ring canal. Numerous small yellowish spots over the exumbrella and reddish brown dots over the outer surface of the arm disk and reddish-brown streaks around the warts of the exumbrella.

CEPHEA CEPHEA, var. COERULEA, atypical.

*Cephea coerulea* VANHÖFFEN, 1902, Wissen. Ergeb. deutsch. Tiefsee Expedition *Valdivia*, vol. 3, Lief. 1, p. 45, fig. 13, 14.—MAYER, 1910, *Medusae of the World*, vol. 3, p. 657.

One well-preserved specimen of this medusa was found by the *Albatross* at Station D 5457, June 8, 1909, 5 miles off Legaspi Light, east coast of Luzon. Cat. No. 28715, U.S.N.M.

The bell is flat, 109 mm. wide, with a low dome-like apex 34 mm. wide, which is completely covered with long, conical, wart-shaped protuberances. There are two small ocular and eight completely fused velar lappets in each octant, forming mere thickenings on the exumbrella side of the bell wall and bridged over on the subumbrella side by a web of tissue. The arm disk is 50 mm. wide and the mouth arms are laterally flattened, 29 mm. wide in the radial direction, and 44 mm. long. There are three to six slender filaments among the mouths of each mouth arm. These taper to pointed ends and the longest are only 13 mm. long. There are no filaments upon the central parts of the arm disk, but there are some at the bases of the mouth arms. The filaments are thus much smaller and less numerous than in Vanhöffen's *C. coerulea* from the east coast of Africa.

There are eight rhopalar radial canals which extend straight to the sense organs, and in addition there are from five to seven inter-rhopalar canals in each actant, which anastomose and lose their identity in a wide network of vessels which send branches to the rhopalar canals. The subgenital porticus is unitary. A color note states that the mouth arms were pale hyaline blue and raw umber.

CEPHEA, species.

Five specimens of *Cephea*, too poorly preserved to be determined specifically, were collected at the following stations:

April 25, 1909, from Manila Bay, surface.

April 29, 1909, from Manila Bay, behind the breakwater.

D 5452, June 7, 1909, off Legaspi Island, east coast of Luzon.

D 5453 June 7, 1909, off Legaspi Island, east coast of Luzon.

D 5461, June 14, 1909, Carino Island, east coast of Luzon.

Light (1914) records *Cephea cephea* from Manila Bay in January, 1912.

## Genus COTYLORHIZA L. Agassiz, 1862.

*Cotylorhiza* AGASSIZ, L., 1862, Contr. Nat. Hist. U. S., vol. 4, p. 152.—MAYER, 1910, Medusae of the World, vol. 3, p. 658.

*Generic Characters.*—Rhizostomata dichotoma with eight simple, bifurcated mouth-arms, the ends of which branch pinnately. The four 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 eight 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.

## COTYLORHIZA PACIFICA Mayer.

*Cotylorhiza pacifica* MAYER, 1915, Publication No. 212. Carnegie Institution of Washington, p. 185.

A single specimen of this interesting medusa was obtained at the launch landing in Manila Bay, Luzon, Philippine Islands, on January 24, 1908 (Cat. No. 28729, U.S.N.M. type). Un-

fortunately it was cut into several pieces before being preserved, and this renders an attempt to study it unsatisfactory in many respects. The bell appears to have been about 200 mm. wide, exumbrella finely granular, with a central dome as in the Mediterranean *Cotylorhiza tuberculata*.

There are 8 rhopalia without ocelli (in formalin), and without exumbrella pits, being similar in essential respects to those of *Cotylorhiza tuberculata*. The rhopalar lappets are short and pointed. There are about eight irregularly spaced, bluntly pointed, large velar lappets in each octant, and deep furrows between them extend radially inward over the exumbrella, as in *C. tuberculata*. The velar lappets vary in length, but the largest are about twice as long and twice as wide as the ocular lappets.

The circular muscles occupy the entire zone of the subumbrella beyond the arm-disk. They are broken in the eight principal radii, and unlike *C. tuberculata* there are no radial muscles.

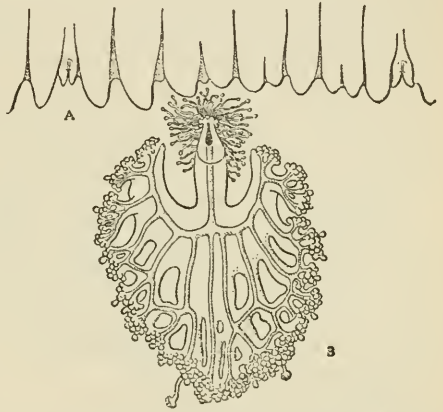


FIG. 14.—COTYLORHIZA PACIFICA FROM MANILA BAY, LUZON. A, AN OCTANT OF THE BELL MARGIN. B, APAXIAL VIEW OF ONE OF THE MOUTH-ARMS.

The arm-disk is about 100 mm. wide, the perradial columns being each 36 mm. wide. The subgenital ostia are much larger than in *C. tuberculata*, but they were so mutilated that one can not state their exact size, which appears, however, to be nearly that of the perradial columns themselves. The specimen having been cut into pieces, we can make no statement concerning the condition of the subgenital porticus.

The eight mouth-arms resemble those of *C. tuberculata*, but there are windowlike openings in the lateral membranes, as in *Lobonema smithii*. The total length of each arm is 81 mm., the upper arm being one-fourth as long as the lower arm. At their widest part the arms are about three-fourths as wide as they are long. The center of the arm disk is thickly covered with slender filamentous appendages which terminate in nematocyst-bearing, swollen, knoblike ends, as do the appendages of the mouth-arms of *C. tuberculata*. In this Philippine Island medusa the appendages of the outer parts of the mouth-arms much less numerous and smaller than in *C. tuberculata*, but are similar in general form to those of the Mediterranean medusa. The longest are about 15 to 20 mm. long.

The cruciform central stomach gives rise to about 140 radial-canals, the eight rhopalar canals being about twice as wide as the others, instead of being of the same caliber, as in *C. tuberculata*. All these canals anastomose in a network under the zone of the circular muscles. There is no distinct ring-canal. In formalin the specimen is dull uniform yellowish brown.

It differs from *Cotylorhiza tuberculata* in having no radial-muscles, and in the circular muscles being interrupted in the eight principal radii. The subgenital ostia and arm-disk are larger and the appendages of the mouth-arms smaller and fewer than in *C. tuberculata*. Moreover, the peculiar perforations in its mouth-arm membranes at once distinguish this species.

These distinctions are indeed of such nature that if one felt so inclined a new genus could be established to receive this medusa. I believe, however, that its relationships will be more clearly indicated by placing it in the genus *Cotylorhiza*, within which it forms a well-marked species.

#### Genus CATOSTYLUS L. Agassiz, 1862.

*Catostylus* (part) AGASSIZ, L., 1862, Contr. Nat. Hist. U. S., vol. 4, pp. 152, 153.

*Generic Characters.*—Rhizostomata triptera, in which the mouth-arms bear neither clubs, filaments, nor other appendages. Sixteen 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 anas-

tomosing 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 eight principal radii. There is an exumbrella pit with radiating furrows above each sense-organ.

**CATOSTYLUS PURPURUS** Mayer.

*Catostylus purpurus* MAYER, 1910, Medusae of the World, vol. 3, p. 671, fig. 412.—LIGHT, 1914, Philippine Journ. of Science, vol. 9, p. 207.

This form is closely related to *Catostylus stiphropeterus*, from Ternate, but differs in the number and arrangement of its marginal lappets and in its deep uniform purple-brown color. Light (1914) describes this medusa from life, whereas Mayer had only preserved material. In life the bell is higher than a hemisphere, whereas in its contracted state in preservative fluids, as in our figure, it is flatter

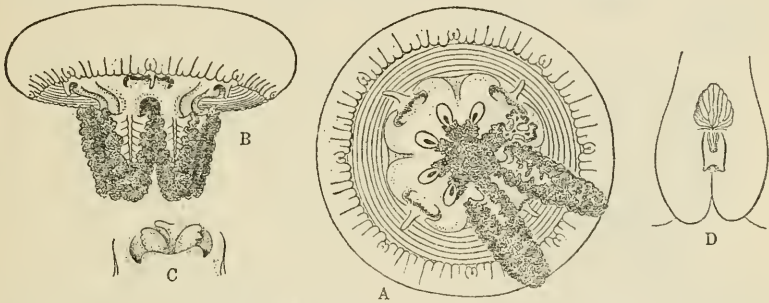


FIG. 15.—CATOSTYLUS PURPURUS, MANILA BAY, LUZON. A, ORAL VIEW, SIX MOUTH-ARMS CUT OFF. B, SIDE VIEW, BELL CONTRACTED. IN LIFE IT IS NEARLY HEMISPHERICAL. C, GENITAL OSTIUM. D, EXUMBRELLA VIEW OF RHOPALIUM.

than a hemisphere. When mature it is deep purplish brown, and the sense-organs have brilliant silver ocellus-like spots which are larger in small than in full-grown medusae. When young the medusa may be plum-colored, or even translucent white. Small cyclops-like crustacea were found by Light to be commensal with this medusa, the crustaceans lying upon the rhopalar canals close to the sense-organs.

Light finds that this medusa is not a bottom form, but swims in shallow water near the surface.

Seven specimens (Cat. No. 27934, U.S.N.M.) found in Manila Bay on December 9, 1907, are in the collection made by the United States Fisheries Bureau steamer *Albatross*, and a larger one (Cat. No. 27980, U.S.N.M.) found on March 11, 1908. This largest specimen serves as the type of the species in the United States National Museum at Washington. Its dimensions in millimeters 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.

Another specimen (Cat. No. 28723, U.S.N.M.) of medium size, nearly mature, was found at Cavite Anchorage, Manila Bay, Luzon, on July 2, 1909.

Light (1914) states that this is the commonest medusa in Manila Bay in November and December.

**CATOSTYLUS TOWNSENDI** Mayer.

*Catostylus townsendi* MAYER, 1915, Publication No. 212, Carnegie Institution of Washington, p. 183.

This species is named in honor of the author's friend, Dr. Charles H. Townsend, the distinguished director of the New York Aquarium.



FIG. 16.—*CATOSTYLUS TOWNSENDI* FROM OFF POINT PUTRI, BORNEO.

Six specimens were found at Station D5594, September 30, 1909, about 6 miles off Mount Putri, Borneo, in 11 fathoms. Type, Cat. No. 28722, U.S.N.M.; paratypes 28721, U.S.N.M. This medusa is closely allied to *Catostylus purpurus* of Manila Bay, Philippine Islands, but in formalin its exumbrella is milky in color and bespeckled irregularly with numerous conspicuous purple-brown spots. The mouth-arms are more pointed than in *C. purpurus*. In some octants of the bell-margin the velar lappets are arranged as in *C. purpurus*,

but they are usually more numerous and more irregularly arranged than in *C. purpurus*.

The dimensions of the largest specimen of *C. townsendi*, stated in millimeters, are as follows: Bell 97 wide, flatter than a hemisphere, exumbrella finely granular, gelatinous substance of horny rigidity. Shape and consistency of the bell as in *C. purpurus*. Eight rhopalia without ocelli, in formalin, and with a deep dark-colored, furrowed, exumbrella pit.

The rhopalar lappets are small and oval, but the velar lappets are about twice as wide as long. Deep clefts between the lappets extend a short distance up the sides of the exumbrella. The velar lappets are very irregular in arrangement, although they tend to conform to that seen in *C. purpurus* of Manila Bay, Luzon, yet in most of the octants the subdivisions of the principal lappets are more pronounced and irregular than in *C. purpurus*, so that there are usually 7 or 8 main velar lappets with 10 to 14 marginal lobes in each octant.

The arm-disk is similar in shape to that of *C. purpurus*. It is 61 mm. in perradial and 45 mm. in interradial diameter. The perradial



columns are 17 mm. and the subgenital ostia 20 mm. wide. The projections and papillae of the subgenital ostia are similar to those of *C. purpurus*. The subgenital cavity is unitary.

The eight mouth-arms are each about 64 mm. long, the upper, naked outer part of each arm being 14 mm. and the 3-winged lower part 50 mm. long. The arms are widest at the proximal parts of the 3-winged expansions which, when spread out, have a span of about 31 mm. They taper to pointed distal ends and have no appendages among the mouth-frills.

There is a powerful unbroken zone of circular muscles in the subumbrella, 27 mm. wide, from the outer edge of the arm-disk to the bell margin. There are also radial muscle fibers on the abaxial sides of the four perradial columns of the arm disk, as in *C. purpurus*.

Sixteen radial canals arise from the cruciform central stomach. The eight rhopalar canals extend straight to the rhopalia, but the eight adradial canals end in the ring canal, which is beneath an annular furrow or bend in the subumbrella 13 mm. inward from the bell margin. On its inner side the ring canal gives rise to from 4 to 7, usually 5, centripetal canals between each successive pair of radial canals. These centripetal vessels anastomose with one another and with the 16 radial canals, and end blindly before reaching the stomach margin. On its outer side the ring canal gives off a network of vessels which ramify through the lappets. In formalin the medusa is opaque milky white with irregularly clustered brown spots over the exumbrella.

This medusa is closely related to *Acromitus maculosus* Light,<sup>1</sup> but it has no filaments upon its mouth arms. It is possible, however, that these were lost, but this seems improbable among six well-preserved specimens.

Moreover, in *Catostylus townsendi* the centripetal vessels anastomose with the 16 radial canals, whereas in *Acromitus*, according to Light, they join only with the eight rhopalar canals. It seems probable, therefore, that *Catostylus townsendi* is a distinct species, separate from *Acromitus maculosus* Light, and that *Acromitus* is a genus derived by mutation from *Catostylus*.

#### CATOSTYLUS MOSAICUS (Quoy and Gaimard).

*Cephea mosaica* QUOY and GAIMARD, 1824, Voyage de l'*Uranie*, Zoologie, p. 569, pl. 85, fig. 3.

*Catostylus mosaicus* AGASSIZ, 1862, Contr. Nat. Hist. U. S., vol. 4, p. 152.—MAYER, 1910, Medusae of the World, vol. 3, p. 666.

A single immature medusa (Cat. No. 28720, U.S.N.M.) which may possibly be the young of *C. mosaicus*, was taken by the *Albatross* in a seine off the beach near the mouth of Malampaya River, Palawan Island, Philippine Islands, on December 26, 1908. It differs

<sup>1</sup> 1914, Philippine Journal of Science, vol. 9, No. 3, sec. D, p. 212, figs. 4-6.

from *C. mosaicus* in having only 10 marginal lappets in each octant instead of about 16, as in *C. mosaicus*. Moreover, in *C. mosaicus* the lappets are all long, pointed, and similar in size and shape each to each, whereas in the Philippine medusa there are eight long, pointed velar and two much shorter, oval, ocular lappets in each octant. The Philippine medusa is, however, quite small, being only 86 mm. in diameter, whereas *C. mosaicus* becomes fully 350 mm. wide. These differences may therefore be due to immaturity. In the Philippine medusa the bell is 86 mm. wide, mouth arms 63 mm. long, the upper arms being 11 mm. and the lower 52 mm. The interradial subgenital ostia are 18 mm. wide, with a large oval or nearly spherical papilla on the subumbrella. The perradial columns of the arm disk are only 12 mm. wide, thus the ostia are 1.5 times as wide as the columns. The perradial diameter of the arm disk is 52 mm. and its interradial diameter 44 mm. The powerful ring muscles of the subumbrella are only partially interrupted in the eight chief radii. The exumbrella is coarsely granular and besprinkled thickly with numerous minute cinnamon-brown flecks. Other parts of the medusa are pale milky pink. The gelatinous substance is tough and rigid.

If this be not *C. mosaicus* it is certainly very closely related to this well-known Australian medusa. *C. mosaicus* is abundant in bays and estuaries along the Australian coast from Melbourne to the mouth of the Brisbane River in Queensland.

In Sydney Harbor all specimens of this medusa are dull creamy brown or yellowish in color, but in Moreton Bay, Queensland, most of them are cobalt blue. It is interesting to see that H. B. Bigelow<sup>1</sup> finds that *Stomolophus meleagris* in San Diego Bay, California, is prussian blue instead of being dull yellow, as in the Atlantic.

*Catostylus mosaicus* appears to breed throughout the year in Moreton Bay, Queensland, but in the temperate regions of Australia it is said to become mature only in summer and autumn.

#### Genus LYCHNORHIZA Haeckel, 1880.

*Lychnorkiza*+*Cramborhiza* HAECKEL, 1880, Syst. der Medusen, pp. 587, 633.—MAYER, 1910, Medusae of the World, vol. 3, p. 672.

*Generic Characters*.—Rhizostomata triptera with filaments, but without clubs, upon the 3-winged mouth-arms. No axial terminal club at 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.

<sup>1</sup> 1914, University of California Publications in Zoology, vol. 13, p. 239.

## LYCHNORHIZA BARTSCHI Mayer.

*Lychnorhiza bartschi* MAYER, 1910, *Medusae of the World*, vol. 3, p. 674, figs. 413, 414.

Named in honor of Dr. Paul Bartsch, of the United States National Museum, to whom we owe the excellent preservation of all specimens of medusae which passed through his hands.

Bell 84 mm. wide, flatter than a hemisphere and with smooth exumbrella surface. Gelatinous substance thick but not very rigid. Eight rhopalia, each with an ocellus, and an exumbrella sensory pit with dendritic furrows

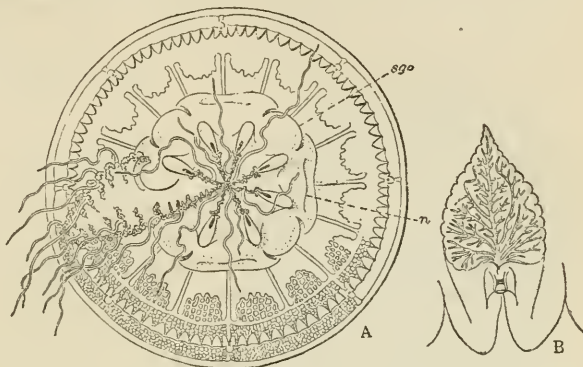


FIG. 17.—LYCHNORHIZA BARTSCHI FROM JOLO ANCHORAGE, PHILIPPINE ISLANDS. A, ORAL VIEW; n, NOTCH IN THE PERRADIAL COLUMN OF THE ARM DISK; sgo, SUBGENITAL OSTIUM. B, RHOPALIUM FROM THE EXUMBRELLA SIDE.

over its floor. About 96 ( $8 \times 12$ ) lappets, 10 bluntly pointed velar lappets between 2 somewhat smaller ocular lappets in each octant. Arm-disk 51 mm. wide where it arises from the subumbrella, but only 47 mm. wide at the level of origin of the 8 mouth-arms. The 4 subgenital ostia 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 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 mm. long and 23 mm. 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

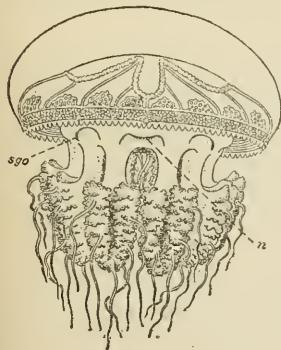


FIG. 18.—LYCHNORHIZA BARTSCHI. SIDE VIEW. LETTERING AS IN FIGURE 17.

about 30 mm. long, but those from the outer parts of the mouth-arms are shorter.

The central stomach is cruciform and about 46 mm. wide. Sixteen 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 outward to the sense-organs. On its inner side the 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 is a marginal ring-canal of fine caliber. There is a unitary uninterrupted system of ring-muscles in the marginal zone of the sub-umbrella, but no radial-muscles.

The gelatinous substance is translucent and milky in formalin, and the gonads, mouth-frills, and canal-system are milky yellow. Doctor Bartsch states that these colors in the living animal were nearly as they appear in the specimen preserved in formalin.

The type-specimen, Cat. No. 27942, U.S.N.M., was found by the United States Fisheries Bureau steamer *Albatross* at Jolo Anchorage, Philippine Islands, on February 13, 1908, and three others (Cat. no. 28737, U.S.N.M.) were taken in Limbé Strait, Celebes, in December, 1909. The dimensions given above are those of the largest specimen from the Celebes, this being somewhat larger than the type-species previously described.<sup>1</sup>

#### LYCHNORHIZA BORNENSIS Mayer.

*Lychnorhiza bornensis* MAYER, 1915, Publication No. 212, Carnegie Institution of Washington, p. 191, fig. 6.

A single specimen of this medusa was found at Tawao, Borneo, on September 30, 1909, at 9h. 30m. a. m. Cat. No. 28736, U.S.N.M. Type.

Bell 89 mm. wide, exumbrella smooth, somewhat flatter than a hemisphere. Eight rhopalia, each with an ocellus and a furrowed exumbrella pit. The rhopalar lappets are very short and lanceolate. In each octant there are usually seven, occasionally eight, velar lappets. The lappets adjacent to the rhopalar lappets are about twice as wide as the remaining velar lappets. All are oval and bluntly rounded.

The arm disk is half as wide as the bell, and the subgenital porticus is unitary. The external faces of the perradial columns have each a slight concavity, not a deep niche, as in *Lychnorhiza bartschi*. The subgenital ostia are twice as wide as the perradial columns and each is arched over by a flap-like projection. There are also four inter-radial papillae upon the subumbrella, one opposite the opening of each subgenital ostium.

The eight mouth-arms are not quite two-thirds as long as the bell-diameter, the upper arms being not quite half as long as the lower arms. Each mouth-arm terminates in a single, slender, tapering,

<sup>1</sup> Medusae of the World, p. 674.

thread-like filament about 50 mm. long. There are also a few shorter, more slender filaments which arise from the sides of the mouth-arms between the mouths. There are no filaments upon the arm-disk.

There is a wide zone of circular muscles in the subumbrella, and these are only partially interrupted in the eight rhopalar radii.

The central stomach gives rise to 16 radial canals, 8 of which extend to the rhopalia and the 8 others end in the ring canal. On its inner side the ring canal gives rise to 16×4 radial vessels, which do not reach the margin of the stomach but anastomose one with another and with the 16 chief radial canals. On its outer side the ring canal gives rise to about 100 radiating vessels, all of which anastomose by side branches, forming a reticulum in the outer zone of the subumbrella.

In formalin the gelatinous substance is translucent and milky, and the gonads and mouth frills are milky yellow.

The following table will serve to indicate the distinctions between *Lychnorhiza bornensis* and *Lychnorhiza bartschi* of the Philippines:

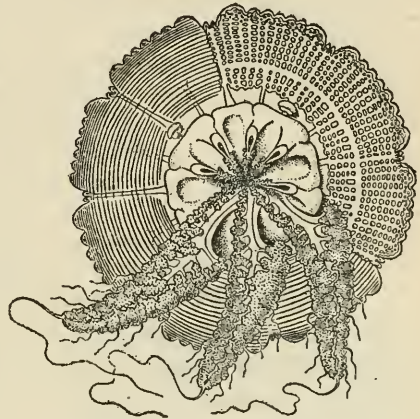


FIG. 19.—LYCHNORHIZA BORNENSIS FROM TAWAO, BORNEO.

	<i>L. bartschi.</i>	<i>L. bornensis.</i>
Velar lappets.....	(8×12) all oval and similar each to each.	(8×7) those adjacent to rhopalar lappets being twice as wide as the others.
Interradial papillae on the subumbrella.	None.....	4.
Perradial niches in the arm-disk...	Four deep clefts.....	Four wide, shallow grooves.
Mouth-arms.....	Less than half as long as bell-diameter.	About two-thirds as long as bell-diameter.
Filaments.....	Numerous. Lateral filaments as long as those at outer tips of mouth-arms. Longest filaments are upon arm-disk.	A single slender filament at outer end of each arm. Other arm-filaments are very short and slender. No filaments upon arm-disk.
Circular muscles.....	Entire.....	Almost interrupted in 8 principal radii.
Canal system.....	Network on inner side of ring-canal does not fuse with 16 radial-canals.	Network on inner side of ring-canal fuses with 16 radial-canals.
Central stomach.....	Narrow and cruciform.....	Wide and cruciform.

**Genus MASTIGIAS L. Agassiz, 1862.**

*Mastigias* L. AGASSIZ, 1862, Contr. Nat. Hist. U. S., vol. 4, p. 152.—MAYER, 1910, Medusae of the World, vol. 3, p. 677.

*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 three 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 eight 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 eight rhopalar radii. There is a unitary subgenital porticus.

**MASTIGIAS PAPUA (Lesson).**

*Cephea papua* LESSON, 1829, Voyage de la *Coquille*, Zooph., p. 122, pl. 11, figs. 2, 3.

*Mastigias papua* AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 162.—MAYER, 1910, Medusae of the World, vol. 3, p. 678, fig. 415.—LIGHT, 1914, Philippine Journ. of Science, vol. 9, p. 209.

This common medusa is widely distributed over the Malay Archipelago, Indian Ocean, and China Sea to Japan, and outward over the Pacific to the Fiji Islands. It gives rise to a number of varieties. Eight specimens, the largest 59 mm. in diameter, were found by the *Albatross* in the Philippines. Two specimens are from Santiago River, Pagapas Bay, Luzon, February 20, 1909; two, Cat. No. 28735, U.S.N.M., are from Pandanon Island, between Cebu and Bohol, March 24, 1909, and four, Cat. No. 28732, U.S.N.M., were taken on the surface off Cebu on September 5, 1909. It was abundant in shallow water among the mangroves in Port Moresby, Papua, in November, 1913.

**MASTIGIAS OCELLATA (Modeer).**

*Medusa ocellata* MODEER, 1791, Nova. Acta. Phys. Med., N. C., vol. 8, Appendix, p. 27.

*Cephea ocellata* PÉRON and LESUEUR, 1809, Annal. du Mus. Hist. Nat., Paris, vol. 14, p. 361.

*Mastigias ocellata* HAECKEL, 1880, Syst. der Medusen, p. 623.—MAYER, 1910, Medusae of the World, vol. 3, p. 680.

The *Albatross* found small medusæ of this variety in March and April, and a mature one, Cat. No. 27919, U.S.N.M., in January in the Philippines, in 1908. It is distributed over the eastern parts of the Indian Ocean and in the China Sea.

**Genus PHYLLORHIZA L. Agassiz, 1862.**

*Phyllorhiza* AGASSIZ, L., 1862, Cont. Nat. Hist. U. S., vol. 4, p. 158.—MAYER, 1910, Medusae of the World, vol. 3, p. 684.

*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*. The canal-system resembles that of *Mastigias*, but the mouth-arms have no terminal clubs.

**PHYLLORHIZA LUZONI** Mayer.

*Phyllorhiza luzoni* MAYER, 1915, Publication No. 212, Carnegie Institution of Washington, p. 194, fig. 7.

Two specimens of this medusa were captured at a depth of 150 feet in Varadero Bay, Southern Luzon, Philippine Islands, on July 23, 1908. Cat. No. 28728, U.S.N.M. Unfortunately both became somewhat macerated in the preservative fluid.

The bell of the larger and more perfect specimen is 60 mm. wide, flat, and with finely granular exumbrella. Eight rhopalia without ocelli in formalin and without exumbrella pits. Sixteen scimeter-shaped rhopalar lappets, and (9×8) 72 rounded velar lappets which are somewhat wider but not longer than the rhopalar lappets, so that the general contour of the bell-margin is circular, without deep niches in the rhopalar radii.

The arm-disk is cruciform, 32 mm. in perradial and 20 mm. in interradial diameter. The subgenital ostia are 14 mm. and the perradial columns 8 mm. wide, and the subgenital porticus is wide and unitary.

The eight mouth-arms are slender and strongly compressed laterally, their lower parts being 3-winged with deeply incised lateral membranes. The naked outer part of each upper arm is 13 mm. and the 3-winged lower part only 11 mm. long. Any appendages which may have existed among the mouth-frills have disappeared in the preservative fluid, owing to the maceration of the specimens.

The muscular system of the subumbrella consists of a broad, uninterrupted zone of weakly developed circular muscles. In other hitherto known species of *Phyllorhiza* the muscles are interrupted in the eight principal radii.

The central stomach is cruciform, 32 mm. in perradial and 16 mm. in interradial diameter. Eight radial-canals arise from the stomach and extend straight to the eight rhopalia; these main canals are connected one with another by a ring-canal which is 6 mm. inward from the margin of the bell. In each octant six to nine radiating vessels arise from the cruciform stomach anastomosing in an irregular network with one another and with the eight main canals. On



FIG. 20.—PHYLLORHIZA LUZONI FROM VARADERO BAY, LUZON.

its outer side the ring-canal gives rise to a fine-meshed network of vessels which ramify through the lappets.

A color note states that the medusa was light green with grayish white spots.

**Genus VERSURA Haeckel, 1880.**

*Crossostoma* preoccupied for mollusks by NORRIS and LYCETT, 1850.

*Crossostoma* AGASSIZ, L., 1862, Contr. Nat. Hist. U. S., vol. 4, p. 155.

*Versura*+*Crossostoma* HAECKEL, 1880, Syst. der Medusen, pp. 606, 607.

*Versura* MAYER, 1910, Medusae of the World, vol. 3, p. 685.

*Generic Characters.*—Rhizostomata triptera with clubs and filaments upon the mouth-arms. The 4 perradial canals arise directly from the stomach, but the 4 interradianal canals result from the fusion of a number of anastomosing vessels which arise from the interradianal sides of the stomach. There is no definite ring-canal, but merely a marginal network of vessels. There are no radial-muscles in the sub-umbrella, but the ring-muscles are well developed. Among the 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.

**VERSURA MAASI Mayer.**

*Versura maasi* MAYER, 1910, Medusae of the World, vol. 3, p. 687, fig. 416.

Named in honor of Prof. Dr. Otto Maas, in recognition of his notable researches upon Medusae. A single perfect specimen (Cat. No. 27943, U.S.N.M. Type) was obtained by the United States Fisheries Bureau steamer *Albatross* on April 8, 1908, along the shore at Mantacao Island, west coast of Bohol, Philippine Islands.

Bell 90 mm. wide, flatter than a hemisphere and evenly rounded. Exumbrella finely granular without furrows. Gelatinous substance fairly thick but not very rigid. Eight rhopalia each with a pigment spot and an exumbrella pit with smooth floor. Usually 12 marginal lappets in each octant, with outer edges bluntly rounded. The 16 rhopalar lappets are slightly narrower than the velar lappets. Arm disks five-ninths as wide as bell-diameter at the level of the origin of the eight mouth-arms. The four interradianal subgenital ostia are two times as wide as the perradial columns of the arm-disk. Eight mouth-arms each one-third as wide as the bell-diameter. The three-winged lower part of each arm is somewhat more than two times as long as the unbranched upper part of the arm. The two lateral outer wings of each arm are deeply cleft. (See fig. 21, *C.*) There are a large number of laterally flattened clubs at the center of the arm-disk. These are besprinkled with small nettle-warts which are most prominent at the broad outer end of the club. In addition there are a few



very small appendages among the mouths of the mouth-arms. The mouth-arms are strongly compressed laterally. A single duct extends down each mouth-arm and gives rise to four terminal branches, two to the lateral wings and two to the triangular extremity of the arm.

There are eight wide rhopalar radial canals, of which the four perradial ones rise directly from the stomach; but each of the 4 inter-radial arise from the confluence of a Y-shaped fork. Seven to nine narrow radial vessels arise in each inter rhopalar octant and extend outward anastomosing profusely with each other and with the eight rhopalar canals. There is no definite ring-canal.

A wide, entire, annulus of circular muscles is found in the sub-umbrella, but there are no radial muscle strands. This muscular zone

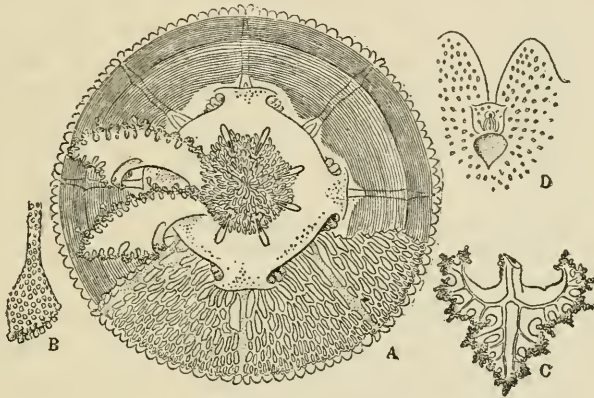


FIG. 21.—VEERSURA MAASI FROM MANTACAO ISLAND, WEST COAST OF BOHOL. A, ORAL VIEW. B, A CLUB FROM THE MOUTH-ARMS, MUCH MAGNIFIED. C, A MOUTH-ARM SEEN FROM THE OUTER (ABAXIAL) SIDE. D, EXUMBRELLA VIEW OF ONE OF THE MARGINAL SENSE ORGANS.

is wider in the interradii than in the perradii, and is somewhat thinned but still unbroken in the eight rhopalar radii.

In formalin the rhopalar canals, and all vessels near the stomach, are bluish purple. The mouth-frills are brownish to brownish purple. The bell is milky and the gonads dull brownish yellow.

#### Genus LOBONEMA Mayer, 1910; sensu Light, 1914.

*Lobonema* MAYER, 1910, *Medusae of the World*, vol. 3, p. 688.—LIGHT, 1914, *Philippine Journ. of Science*, vol. 9, p. 216.

*Generic Characters*.—Rhizostomata triptera in which the marginal lappets are greatly extended, tapering to pointed ends. These lappets are noncontractile and lack muscles. Mouth-arms with numerous filaments. Mouth-arm membranes perforated by windowlike openings. Eight to sixteen rhopalia and twice as many 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 stom-

ach. All of the radial-canals extend beyond the ring-canal. The subumbrella exhibits a well-developed system of ring-muscles. There are numerous, prominent, tapering papillae upon the exumbrella. There is a sensory pit on the exumbrella side above each rhopalium, and the floor of the pit exhibits radiating, dendritic furrows.

*Lobonema smithii*, the first-known species and type of the genus, was obtained by the *Albatross* in Manila Bay, Philippine Islands, late in April, 1908. It is named in honor of Dr. Hugh M. Smith, Commissioner of Fisheries of the United States. Another species from Palawan was described by Light<sup>1</sup> under the name *Lobonema mayeri*.

*Lobonema smithii* has only eight marginal sense-organs, and the subumbrella ring muscles are entire; while in *L. mayeri* there are 12 to 16 marginal sense organs, and the circular muscles are completely interrupted in the ocular radii. Light, who studied the medusae in life, states that the colors of *Lobonema mayeri* are an exquisite scheme of purple, violet, and rose pink. The gonads are, as a rule, pink, the general color is violet, and the fringe of tapering marginal lappets purple. Doctor Light tells me that in *Lobonema smithii* these colors are not so brilliant, and the bell of the medusa may be white. Light finds that the sting of this medusa is not very severe, and that the cases of poisoning reported by Old were probably due to *Dactylometra* and not to *Lobonema*.

Light describes *Lobonemoides gracilis*, an immature medusa which may possibly be a young stage of *Lobonema mayeri*. The marginal lappets are pointed but are not very long, and there are no window-like openings in the mouth-arm membranes.

#### LOBONEMA SMITHII Mayer.

*Lobonema smithii* MAYER. A. G., 1910, *Medusae of the World*, vol. 3, p. 689, figs. 417, 418.

The *Albatross* found this medusa in Manila Bay, Luzon, at the ship's anchorage on April 25, 1908, and again (Cat. No. 28725, U.S.N.M. Type) on the surface at station D. 5222, between Marinduque and Luzon. 9 miles off San Andreas Island.

This species is named in honor of Dr. Hugh M. Smith, now United States Fish Commissioner, who found it in Manila Bay, Philippine 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 papillae

<sup>1</sup> 1914. *Philippine Journal of Science*, vol. 9, p. 217, figs. 7-9.

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 papillae 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. Eight 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 semaeostomous Scyphomedusæ. They trail downward from bell margin, waving flexibly to and fro, as do veritable tentacles. I can find no muscles in these lappets, however, and Light confirms the statement that they can neither contract nor elongate. They are deep clefts in the exumbrella surface between the lappets, but these clefts are bridged over by a thin sub-

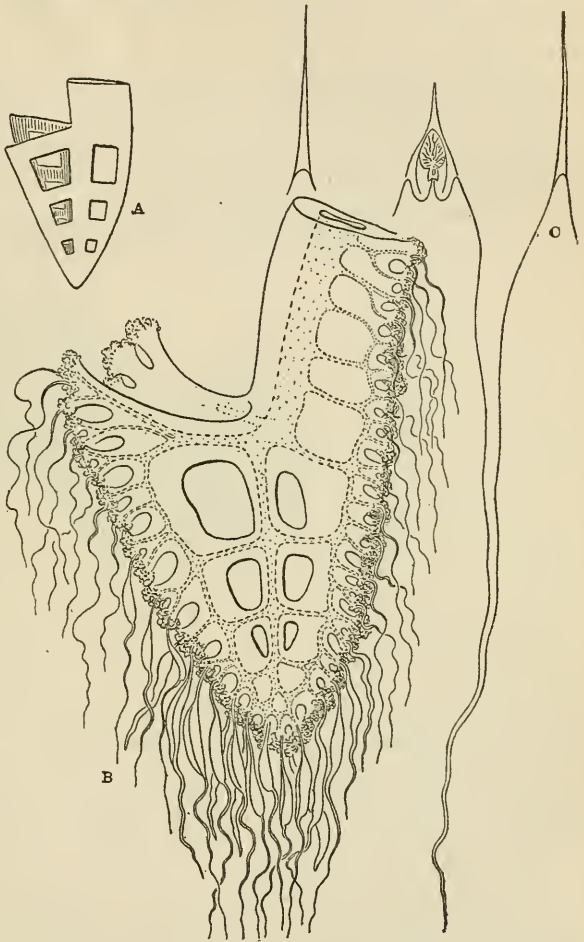


FIG. 22.—LOBONEMA SMITHII. A, DIAGRAM SHOWING THE PLAN OF STRUCTURE OF THE MOUTH-ARMS. B, SIDE VIEW OF ONE OF THE MOUTH-ARMS. C, RHOPALIUM AND ONE OF THE LONG, TAPERING MARGINAL LOBES.

rella membrane spanning between the lappets. The eight inter-rhopalar grooves are 35 mm., the 8 rhopalar 16 mm., and the 16 intermediate clefts 31 mm. long. The eight rhopalar clefts are U-shaped and the exumbrella sensory pit is at the middle of the crotch of the Y with the divided groove on either side of it (see fig. 22, C). The grooves between the velar lappets are simple, undivided, linear clefts.

Sixteen radial canals, eight rhopalar and eight 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

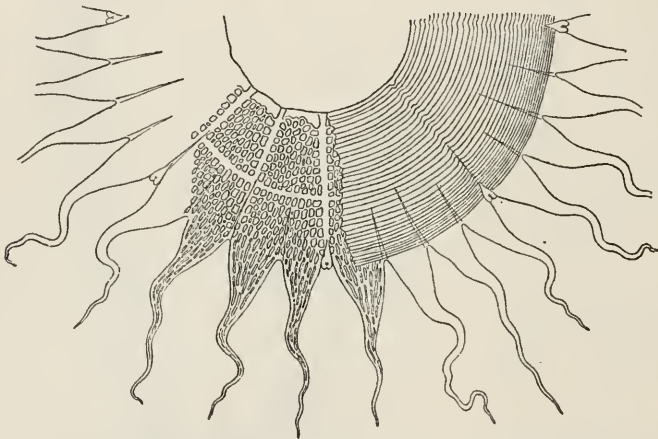


FIG. 23.—LOBONEMA SMITHII FROM MANILA BAY. PART OF THE OUTER ZONE OF THE SUBUMBRELLA, SHOWING CANAL SYSTEM AND MUSCLE STRANDS.

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 (fig. 23).

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 eight 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 three lateral membranes is perforated by three windows or openings (see diagram A, fig. 22). 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 mouth (see fig. 22, *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 threadlike 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.

**Genus THYSANOSTOMA L. Agassiz, 1862.**

*Thysanostoma* AGASSIZ, 1862, Contr. Nat. Hist. U. S., vol. 4, p. 153.—MAYER, 1910, Medusae of the World, vol. 3, p. 691.

*Generic Characters.*—Rhizostomata lorifera having mouth-arms bearing three rows of frilled mouths from base to lower end, without a terminal club. Among characters of minor importance, the four interradial, subgenital ostia are wider than the perradial columns between them. There are eight 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 eight principal radii. There is a small, shallow, exumbrella pit above each sense organ, and there are no 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., vol. 2, p. 153; 1830, Centurie Zoologique, p. 227, pl. 80.

*Thysanostoma* AGASSIZ, 1862, Contr. Nat. Hist. U. S., vol. 4, p. 153, figs. 1-9.—MAYER, 1910, Medusae of the World, vol. 3, p. 692, fig. 420.

The dimensions, in millimeters, of a specimen (Cat. No. 27929, U.S.N.M.) obtained at Mindanao, Philippine Islands, by the United States 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 (Cat. No. 27930, U.S.N.M.) from Mansalay, 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 mm. long. In a half-grown medusa (Cat. No. 27928, U.S.N.M.) obtained on the surface at the same time and place the bell is 59 mm. wide with finely granular exumbrella; mouth-arms, 67 mm. 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.

Two specimens (Cat. No. 28710, U.S.N.M.) are from Atulayan Bay, east coast of Luzon, June 17, 1909. Of these the larger one was cut into two pieces when viewed by me, but the bell appears to have

been about 106 mm. in diameter, the mouth-arms being 167 mm. long, the upper arm 20 mm., and the lower arm 147 mm. long.

A color note leads one to infer that in life the bell was translucent with a slightly brownish margin, and with the frilled mouths dark burnt-umber. The smaller specimen when alive had a translucent bell with some whitish spots and with eight indigo streaks along the eight principal radii. The frilled mouths and bell-

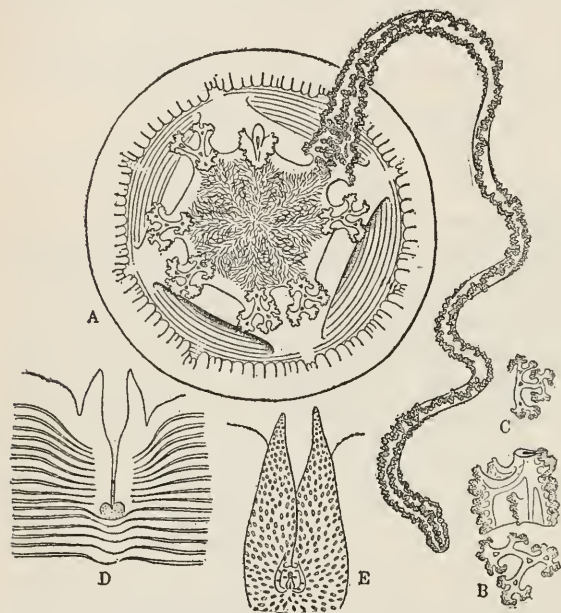


FIG. 24.—*THYSANOSTOMA THYSANURA* FROM PANABUTAN BAY. A, ORAL VIEW OF THE 8 MOUTH-ARMS BEING REMOVED. B, CROSS SECTION OF MOUTH-ARM NEAR THE BASE. C, CROSS SECTION OF MOUTH-ARM NEAR THE OUTER END OF THE ARM. D, ORAL VIEW OF RHOPALAR LAPPETS. E, RHOPALAR LAPPETS FROM THE EXUMBRELLA SIDE.

margin were pale brown. One specimen (Cat. No. 28711, U.S.N.M.) 91 mm. in diameter with mouth-arms 155 mm. long, is from Station D2268, September 21, 1909, depth 13 fathoms off Singaan Island north of Tawi Tawi. In this the arm-disk is 59 mm. in perradial diameter, and the upper arms are 13 and the lower 142 mm. long.

#### Genus *LORIFERA* Haeckel, 1880.

*Himanostoma* preoccupied for Diptera by LOEW, 1853.

*Himanostoma* AGASSIZ, L., 1862, Contr. Nat. Hist. U. S., vol. 4, p. 152.

*Lorifera* HAECKEL, 1880, Syst. der Medusen, p. 628.—MAYER, 1910, Medusae of the World, vol. 3, p. 693.

*Generic Characters.*—Rhizostomata lorifera in which the eight mouth-arms bear rows of frilled mouths throughout their lengths 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. This genus is distinguished from the closely allied *Thysanostoma* only by the naked, club-shaped extremities of its mouth-arms.

**LORIFERA LORIFERA, var. PACIFICA (Schultze).**

*Himanostoma loriferum*, var. *pacifica* SCHULTZE, L. S., 1897, Abhandlung, Senckenberg, Naturf. Gesell., vol. 24, Heft 2, p. 153, pl. 15, figs. 1, 1a, 6; 1898, Denkschr. Med. Nat. Gesell. Jena, vol. 8, p. 446, pl. 34, fig. 9 (young medusa).

*Lorifera lorifera*, var. *pacifica* MAYER, 1910, Medusae of the World, vol. 3, p. 695.

A single half-grown specimen of this medusa, Cat. No. 28709, U.S.N.M., was found at Port Palapag, Luzon, by the United States Fisheries Bureau steamer *Albatross* on June 2, 1909, being captured through the use of dynamite. Its bell is 98 mm. wide, exumbrella finely granular, flatter than a hemisphere. The bell margin is badly damaged but there appear to be six to eight cleft or subdivided velar lappets in each octant. Their general contours are rounded, and interlobular clefts extend radially a short distance up the exumbrella surface.

The eight rhopalia have each an ocellus, but no exumbrella pit. Perradial diameter of arm disk, 55 mm.; width of subgenital ostia, 34 mm.; width of perradial columns of arm disk, 12 mm.; subgenital porticus wide and unitary; naked upper arm, 20 mm. long; length of the abaxial side of the mouth-bearing part of each arm, 35 mm.; length of the terminal naked axial filament of each arm at least 40 mm., but all are broken at their ends.

There is a thick felting of short filaments upon the arm disk.

The circular muscles are unitary, being only partially interrupted in the eight principal radii.

The eight radial canals are each about 3.5 mm. wide, and in addition there are about 8×10 slender radial canals, all of which anastomose with one another and with the eight chief radial canals, forming a wide network in the subumbrella.

In formalin the eight chief radial canals are violet.

Schultze describes this medusa from Ternate and from Amboina, Malay Archipelago.

## TABULAR DESCRIPTIONS.

Table showing the chief characteristics of Philippine Scyphomedusae. This table is designed to enable one to recognize each species from its most conspicuous features, but it must be used with caution, and is worthless for the medusae of regions other than the Philippines.

## Family CARYBDEIDAE.

Bell high, pale milky colored, more or less rectangular. Four small niches on the sides of the bell alternating with the tentacles. A minute club, bearing several eyes, is set within each niche. The tapering flexible, *pale pink* sharply stinging tentacles arise from the ends of stiff, spatula-shaped projections from the rim of the bell.

1. Bell about  $1\frac{1}{2}$  inches high, only slightly higher than it is wide. Four tentacles-----*Carybdea rastonii*.
2. Bell about 9 inches high, about twice as high as wide. Four tentacles.  
*Carybdea alata*, var. *grandis*.
3. About 28 tentacles arising from the ends of four stiff finger-shaped clusters of projections from the rim of the bell-----*Chiropsalmus quadrigatus*.

## Family CORONATE.

These medusae have a deep constriction, or ring-furrow, cutting into the sides of the bell.

1. A deep-sea medusa, purple-brown or claret colored. Usually about 2 to 6 inches high. Sixteen marginal lobes, 12 tentacles. Bell conical or dome-like with a deep ring-furrow extending around about one-third the way up the side of the bell-----*Periphylla hyacinthina*.
2. Bell *thimble-shaped*,  $\frac{1}{2}$  an inch high, brown with darker colored warts on the concave side. Swims very actively, with an incessant pulsation, near the surface in great swarms-----*Linuche unguiculata*.
3. A deep-sea medusa with flat, thick lenticular bell usually about  $1\frac{1}{2}$  to 4 inches wide; the central part separated by a deep constriction from the numerous lappets. Numerous short tentacles alternate with the equally numerous cleft lappets. Deep brownish red lappets and mouth parts.

*Atolla bairdii*, etc.

## Family SEMAEOSTOMAE.

Usually large medusae, with *marginal tentacles*. Without a ring-furrow in the bell. With a single cross-shaped mouth at the middle of the concave side of the umbrella. Often seen in harbors.

1. Animal blue-violet with purple streaks on the outer side of the bell, eight long, tapering tentacles, and four long, flexible curtain-like lips. Bell about 2 inches wide, and lips 3 inches long-----*Pelagia panopyra*.
2. Sixteen areas of reddish-rosin colored dots radiate outward in a spokelike manner from the center to the bell margin. *Twenty-four tentacles* and 48 marginal lobes (16 *small* and 32 *large*). Bell about 5 inches wide.

*Chrysaora melanaster*.



(3 and 4.) Resemble *Chrysaora melanaster*, but there are 40 tentacles.

3. Marginal lobes not highly colored.....*Dactylometra quinquecirrha*.<sup>1</sup>  
 4. Marginal lobes red.....*Dactylometra africana*.  
 5. Resembles *Dactylometra* (3) in general appearance, but the color is more yellowish, and there are only 16 tentacles. Bell about 4 inches wide. Thirty-two cleft marginal lobes.....*Sanderia malayensis*.  
 6. Bell only about  $\frac{1}{2}$  inch wide, translucent, 24 tentacles, 32 marginal lobes, 8 simple radial canals, alternating with 8 complexly branching canals on the concave side of the bell.....*Discomedusa philippina*.  
 7 and 8. Bell gelatinous, about 10 inches wide or larger, hyaline or slightly milky, with 4 whitish or pinkish *horseshoe-shaped* genital organs near the center of the bell. 4 long, fleshy lips. More than 100 short tentacles. 8 simple and many branched and anastomosing canals all of which are conspicuous, due to their milky color.  
 7. 8 clefts in the bell-margin.....*Aurellia aurita*.  
 8. 16 clefts in the bell-margin.....*Aurellia labiata*.

### Family RHIZOSTOMAE.

Usually large medusae *without* marginal tentacles. With *numerous* minute mouths, the frilled tentacle-bearing lips which superficially resemble sea weed. Mouths born on 8 more or less branched projections (mouth-arms) arising from the center of the concave side of the bell. Common in harbors in the East Indies. The *gelatinous* substance of the bell is often remarkably rigid. The branched, frilled, and tentacle-bearing mouth-arms are often greenish or reddish in color, thus giving the appearance of some sort of vegetable growth arising from the center of the concavity of the bell.

Living *on the bottom*, slowly pulsating, "lying on its back," with the concave side of the bell, and its 8 mouth-arms, and mouths uppermost; remaining for hours, or days, fixed at one place and rarely swimming through the water.....*Cassiopea*.

1. Bell flat, about 4 inches wide, without a concavity where it lies upon the ground. Olive-brown in color with about 18-22 triangular *large whitish spots* in the radii of the marginal sense organs. 3 small white streaks near the bell margin between the large triangular spots. 8 bifurcated mouth-arms.....*Cassiopea andromeda*, var. *baduensis*.  
 2. Bell olive green about 6 inches wide with a suckerlike concavity where it touches the ground. Dull inconspicuous, white bands radiate outward in the radii of the 16 or more marginal sense organs. The leaflike appendages of the mouth-arms are opaque white.  
*Cassiopea polypoides*, var. *culionenus*.<sup>2</sup>  
 3. Bell about 11 inches wide. Numerous *large ribbonlike appendages* on the mouth-arms,  $4\frac{1}{2}$  inches long.....*Cassiopea medusa*.<sup>3</sup>

Large free swimming medusae a foot or more wide with a more or less conspicuous dome covered with *wart-like* projections at the center

<sup>1</sup> See S. F. Light, 1914, Philippine Journal of Science, vol. 9, section D, p. 198.

<sup>2</sup> Idem, p. 201.

<sup>3</sup> Idem, p. 204.

of the convexity of the bell. The dome may be sky blue, rose-colored, or amber colored and the bell blue with reddish spots and markings. Mouth-arms fused forming an eight-sided prism, flaring outward below. Gelatinous substance tough.....*Cephea*.

1. Dome low, warts small.....*Cephea octostyla*.
2. Dome high, warts conspicuous.....*Cephea cephea*.

Bell amber colored, about 9 inches wide, with a *smooth* central dome without wartlike projections. Clusters of grapelike appendages on the eight leaflike mouth arms. Windowlike openings in the membranes of the mouth arms. Marginal lappets of the bell short and oval.....*Cotylorhiza pacifica*.

Bell smooth, hemispherical, about 8 inches wide when full grown. Deep uniform, *purple-brown*. The commonest medusa in brackish water canals in shallow water along shore in Manila Bay in November and December.....*Catostylus purpurus*.

Similar to the above but with *irregular purple brown spots* over the convex side of the bell. No filaments on the mouth arms.

*Catostylus townsendi*.

Similar to *Catostylus townsendi* but with *numerous long filaments* on the mouth arms. The longest ones being near the outer ends of the mouth arms.....*Acromitus maculosus*.<sup>1</sup>

Bell high, domelike,  $4\frac{1}{2}$  to possibly 12 or more inches wide, slightly granular on the convex surface. Yellowish-white or cobalt blue. Eight tapering mouth arms without filaments or other appendages. Common in the mouth of Brisbane River, Queensland, Australia, but widely distributed over this general region.....*Catostylus mosaicus*.

Bell about  $3\frac{1}{2}$  inches wide, smooth, evenly rounded, flatter than a hemisphere, milky-yellow, with smooth convex surface. Slender tapering filaments in the eight mouth arms. No prominent spots in the convex surface of the bell.....*Lychnorhiza*.

1. A single long filament at the pointed end of each mouth arm. All other filaments very short.....*Lychnorhiza bornensis*.
2. With numerous long filaments on the mouth arms.....*Lychnorhiza bartschi*.

Bell smooth, about  $2\frac{1}{2}$  to  $3\frac{1}{2}$  inches wide. With eight mouth arms, each tapering to end in a long naked more or less club-shaped filament. This small medusa pulsates and swims rapidly, is usually greenish or reddish brown, and is common in harbors in the East Indies.

1. Bell blue, greenish, olive, or brown with *solid* white, brown or yellowish spots. The eight terminal clubs on the mouth arms each as long as the diameter of the bell.....*Mastigias papua*.
2. Bell reddish brown, with ringlike spots of white and brown. Eight terminal clubs only about half as long as the diameter of the bell....*Mastigias ocellata*.

<sup>1</sup> See S. F. Light, 1914, Philippine Journal of Science, vol. 9, section D, p. 212, fig. 4.

Bell *flat*, about  $2\frac{1}{2}$  inches wide, light green with grayish white spots. Eight laterally flattened mouth arms, each ending in three expansions, eight simple radial canals in the radii of the eight marginal sense organs and a network of vessels between these canals and on both sides of the ring canal. No appendages on the mouth arms.-----*Phyllorhiza luzoni*.

Similar to *Phyllorhiza luzoni* in general shape, but there is no ring canal and there are numerous small clubs upon the eight mouth arms, especially at the center of the disk.-----*Versura maasi*.

Bell 15-20 inches wide, flat topped and thickly covered above with *flexible tapering projections*, the largest near the center. The marginal lobes are greatly extended, forming *tapering filaments*. The mouth arms are perforated with windowlike openings and bear numerous long filaments. Common in Harbors, Manila, and west coast of Palawan in April and May.

1. Twelve to 16 marginal sense organs and 70-80 *long tapering marginal lobes*. Purple, violet, and rose pink are the prevailing colors of the animal.

-----*Lobonema mayeri*.<sup>1</sup>

2. Only eight marginal sense organs and 32 marginal lobes. Colors not so bright as in *L. mayeri*, and the bell may even be white.-----*Lobonema smithii*.

Bell 4 or 5 inches wide. Eight very long, "snakelike," mouth arms with frilled "seaweedlike" mouths all down their sides *even to the tips of the arms*.-----*Thysanostoma thysanura*.

Similar to *Thysanostoma thysanura*, but the eight arms end each in a *naked club*.-----*Lorifera lorifera*.

<sup>1</sup> See S. F. Light, 1914, Philippine Journal of Science, section D, vol. 9, p. 217, figs. 7-9.

