SHELLS AND OTHER ANIMAL REMAINS FOUND ON THE MADRAS BEACH

I.—GROUPS OTHER THAN SNAILS, ETC. (MOLLUSCA GASTROPODA)

BY

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I.—GROUPS OTHER THAN SNAILS, ETC. (MOLLUSCA GASTROPODA).

Sandy beaches are often strewn with shells of many forms and colours. But the animals that made them live with few exceptions below low tide level and most of them are rarely if ever washed ashore. A few live in the sand between high and low tide marks, and others are sometimes brought up by fishermen in their nets ; but it is their shells alone that are commonly seen. People often begin to collect shells on account of their attractive colours and beautiful shapes and, as no very special care is needed for their preservation, they are probably the easiest of all natural objects to collect—a matter of importance to any collector, particularly in the tropics. But when it comes to trying to give them some sort of natural arrangement, and the question of their relationship to one another has to be faced, difficulties at once arise. And so, too often, the collecting commenced with interest leads nowhere and is soon given up.

Though the shells of molluscs are usually more numerous on a sandy shore than anything else belonging to the Animal Kingdom, many other objects are also washed up, some of them sometimes in large numbers. This paper has been written in the hope that by providing a convenient introduction it may lead to a wider interest in the shells and other animal remains found on the sandy beaches of Madras and other places on the Coromandel and Golkonda Coasts, and perhaps even beyond. The collections on which it is based have been made in and around Madras and cannot claim to be exhaustive even for this short stretch of shore. For it is one of the delights of the beach that, however long one may go on collecting, the sea will continue to throw up new objects now and again. But I hope I have succeeded in including all that are of everyday occurrence as well as most that are abundant at longer intervals.

I at first expected the paper to be based almost entirely on such collections and observations as I could myself make with the aid of my two small children. I soon learnt, however, that Mr. M. D. Crichton, Manager of the Madras branch of the National Bank of India, had for some time been keenly interested in shells and had already amassed an unrivalled collection of those found round about Madras, including many species not represented in the Museum. This wealth of material he has generously placed at my disposal, as well as enriching the Museum collection with many specimens ; and the whole of my work on the molluscs, which forms the greater part of this paper, has been done in close cooperation with him. All molluscan shells definitely known from Madras have therefore been

included, though many of them are only found in the harbour or brought up by fishermen in their nets and do not seem to get washed on to the sands. This has so greatly increased the size and I hope also the usefulness of the paper that, for the convenience of would-be purchasers of small means, it is having to be issued in two parts, one (the second) dealing with snails, etc., and this one dealing with everything else.

Except as regards molluscan shells, collecting in and around the harbour has been somewhat casual, and to have attempted a survey of all the various worms, crustacea, etc., that are known to live there would have been neither possible nor desirable in a semi-popular paper such as this. So I have only included those most likely to come to notice. Latterly I have carefully distinguished between finds from within the harbour and finds from Rayapuram bay into which it opens, where conditions are very different. But the need for this was not immediately apparent, and to start with specimens from both places were labelled " harbour " simply to distinguish them from those found washed up on the beach, and many of them have had to be so recorded below. Backwater species I at first thought should be excluded, but this proved both undesirable and impossible. Mr. Crichton has done intensive collecting in the Adyar backwater, but I have only been able to make somewhat casual observations in the one at Ennur. Had I not been leaving Madras so soon I should have made a point of looking into various matters that called for further investigation as the paper progressed, *e.g.*, the characteristic colours of living as opposed to spirit-preserved hermit crabs, and just what comes mostly on to the beach as waste from net fishing rather than by the processes of nature. The distinction between marine and backwater species also calls for closer attention. Many species that are marine at Krusadai Island near Pamban seem to be exclusively estuarine here, the determining factor in these cases being probably the confinement of mud to the backwaters here but not at Krusadai. But estuarine species must be able to stand the changes in salinity to which backwaters are subject if they are to survive there throughout the year, another point concerning which further observations are needed.

I am deeply indebted to Mr. R. Winckworth of London for his ever ready and prompt help in the naming of shells over which we were in doubt, and for much helpful advice. Without his assistance the paper could not have been written. And finally I must thank Mr. H. Chennappaiya for his constant help in preliminary sorting and identification, looking out literature, etc., Dr. B. Sundara Raj and Prof. R. Gopala Ayyar for assistance with material needed from the Fisheries and University Marine Zoological Departments respectively as well as for much personal help, Dr. Baini Prashad for assistance in connexion with the references given in the list at the end of the paper and Mr. S. Kanagasabai for the care and skill with which he has prepared the illustrations.

As my object is to try to interest and help the casual collector rather than the specialist I have tried to use popular names and to replace words that may not be generally understood such as " chitinous " and " calcareous " by simpler ones such as " horny " and

" stony." But this is not always possible without great awkwardness, even in such an apparently simple matter as the use of " front " and " back " in preference to " anterior " and " posterior," or " upper " and " lower " in preference to " dorsal " and " ventral." The floating sea-slug *Glaucus*, for instance, is an up-side-down creature which lives back downwards instead of stomach downwards. For the same reason author's names and all references to literature and synonymy have been relegated to a list at the end and are not mentioned in the descriptive part of the paper.

To give a full description and an illustration of every species recorded is clearly impossible in a paper of this size. All that I have tried to do, therefore, is to indicate the most distinctive characteristics of each, and to give a sufficiently representative series of illustrations to make the distinctions readily intelligible. The need for brevity has unfortunately necessitated extensive use of a somewhat formal style. Except in a few cases, individually indicated, all figures of molluscan shells are of natural size. This has necessitated the selection of small specimens where large species were concerned, and sometimes the only such specimens available have been smaller than the most suitable specimen available of a smaller species. The result is somewhat misleading unless due allowance is made, but I have found it unavoidable. The right valve has been figured in the case of all Lamellibranchs except *Isocardium*, of which a single valve alone was available, and that a left one.

Where the distinctions between a large number of species, genera or families have to be given this has mostly been done by means of a dichotomous key, *i.e.*, a key in which a series of different pairs of alternatives are given, each followed either by a number or by a name. Having decided which alternative of the first pair applies to the specimen to be identified, note the number to which it leads and go straight on to the pair bearing that number, and so on until the name is reached, with which the process ends.

For a list of species from the backwaters and some account of their habits and distribution therein, see " The Brackish-Water Fauna of Madras " by N. Kesava Panikkar and R. Gopala Aiyar (*Proc. Ind. Ac. Sci.* VI, 5, Bangalore 1937, pp. 284-337, pl. xviii–xix). Supplementary information will be found in Vol. V of the *Memoirs of the Indian Museum* which is devoted to a survey of the fauna of the Chilka Lake on the coast of Orissa. Several species from the Ennur backwater are described and figured as new in Vol. XII of the *Records of the Indian Museum*, pp. 27-40. M. D. Crichton's " Marine Shells of Madras " (*Journ. Conch.* XXI 1940, pp. 193–212, reprinted with some revision in *Journ. Bombay Nat. Hist. Soc. XLII*, 2.) gives notes on habits, etc.

SINGLE CELLED ANIMALS (PROTOZOA).

The most widely known members of this large group of small (mostly microscopic) animals, are the parasites which produce malaria, syphilis and certain other dreaded diseases. But the vast majority are not parasitic and some of these, especially *Noctiluca*, emit a

phosphorescent light in the waves at night, while others form shells which accumulate in such vast numbers of the floor of the ocean that, in spite of their individually minute size, they may in time form deposits hundreds of feet in thickness. If subsequently raised above sea level by pressure in the earth's crust, such deposits dry up and become large sheets of limestone rock.

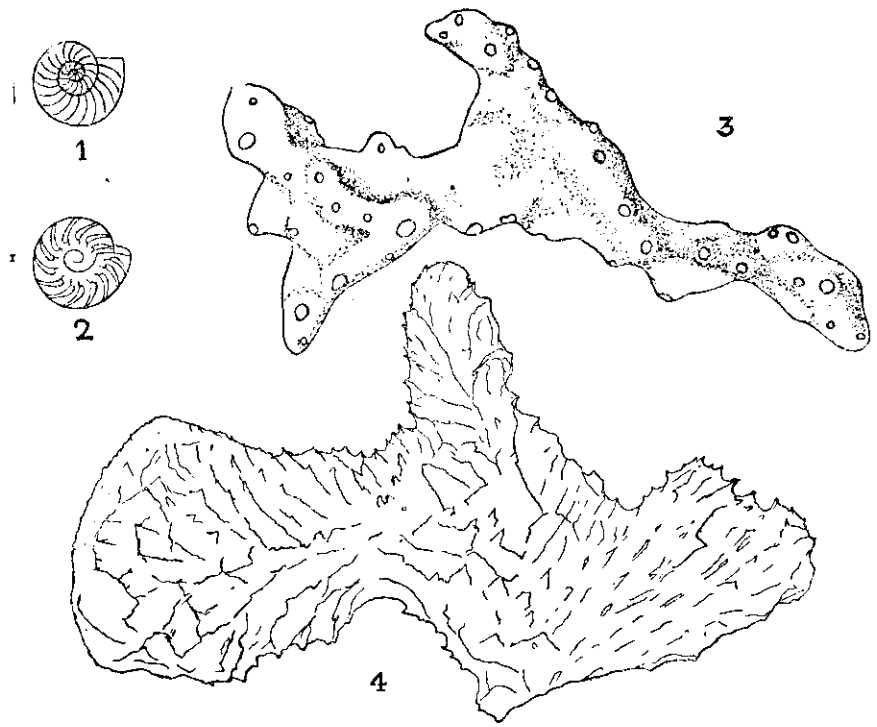

FIG. 1.

FORAMINIFERA AND SPONGES.

1. & 2. Foraminifera, magnified. The lengths of their actual diameters are indicated by the lines beside each.
3. *Adosia carnosa.*
4. *Calkyspongia fibrosa.*

The Protozoa which produce these shells belong to the subclass Foraminifera, of which several species have been found at Madras, one an attached form and the others free-living with chambered spiral shells (figs. 1, 1-2) of which fig. 1, 1 may perhaps belong to the genus *Cristatella.* The specimens figured were collected by Mr. Crichton, the larger on 19th February 1939, the smaller in the autumn of 1940. The attached form is a species of *Polytrema,* of a rich pink colour. A bleached shell of *Bursa margaritula* presented to the Museum by Mr. Crichton bears numerous examples all, unfortunately, too much worn to permit of satisfactory figuring or to show the external shape properly, but thereby exposing their vesicular internal structure. A few minute examples have been found among concrete blocks on the east side of the harbour entrance.

SPONGES (PORIFERA).

Sponges are attached animals which grow much as plants do. They obtain their food from currents of water drawn into their bodies by the rhythmic lashing of myriads of minute whips, and breathe the air dissolved in this water. In a few small and simple sponges the body consists of a single sac lined with cells, each bearing a whip surrounded at its base by a delicate collar, water being drawn in through numerous minute scattered pores and passed out through a comparatively large opening at the top. But in most sponges such chambers are more or less indefinitely multiplied in a more massive body and communicate with the exterior by means of a network of canals.

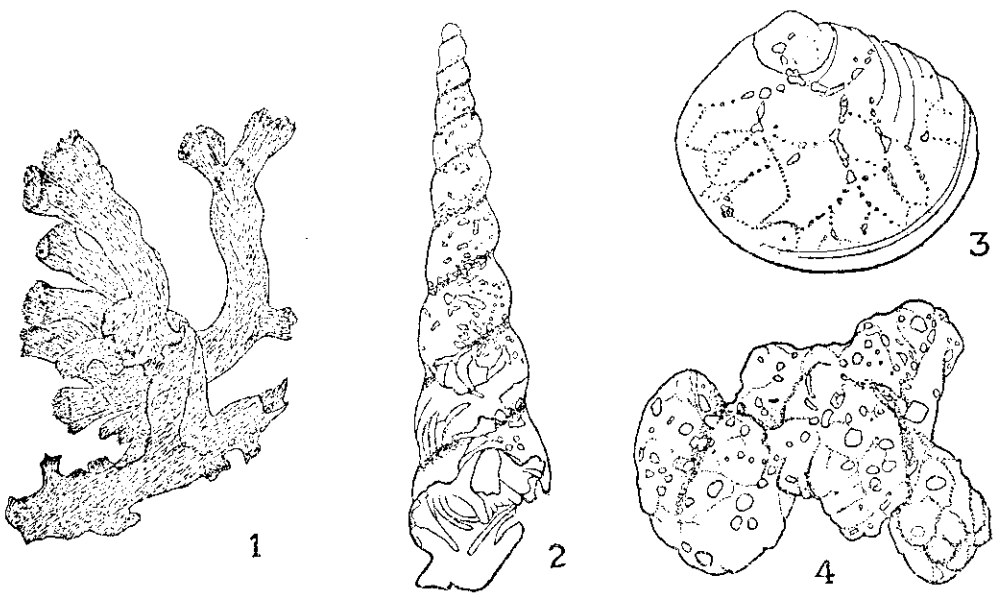

FIG. 2.

SPONGES.

1. Unidentified sponge.
2 & 3. Shells bored, probably by sponges.
4. *Spirastrella inconstans*.

As the tissues of sponges are extremely soft they have to be supported and protected by either a horny skeleton or spicules or both, and the sponge of commerce consists of a horny skeleton from which the living tissues have been cleaned away. Dry skeletons of several different kinds of sponge are sometimes found on the Madras beach but are not abundant there, probably because the sea bottom is too sandy to provide the firm base on which alone most sponges can grow. The kinds differ from one another in the form of the colony and in the nature of its skeleton.

The kind most usually found (fig. 1, 3) is a branching and often anastomosing species which has been found living in the harbour. Its circular exhalent openings (*oscula*) tend

to be arranged in lines. The branches are smooth and are usually more or less (often completely) flattened with the oscula mostly on their edges, the colony in that case being somewhat fan-shaped. The fibres contain numerous small simple spicules. This appears to be identical with specimens of *Adosia carnosa* from the Tuticorin pearl banks in the Museum collection.

A somewhat more massive species (fig. 1, 4), also more or less flattened, in which the surface is roughened by numerous pointed projections and the oscula are less numerous and not so definitely concentrated in rows or on the edges of the fronds, seems to agree in all respects with *Callyspongia fibrosa* from near Pamban, while a single small specimen of compact but somewhat irregular growth (fig. 2, 4) appears to be *Spirastrella inconstans* (? = *purpurea*[1]), a species extremely variable in its manner of growth that is abundant in the lagoon on the south side of Krusadai Island in the Gulf of Mannar, where it forms large masses varying from compact growths to clusters of finger-like tubes. Certain sponges, belonging to several widely separated families, bore into the substance of shells, limestone or coral ; and shells (mostly thick ones), riddled with such burrows are abundant (fig. 2, 2-3).

CORALS, JELLYFISH, ETC. (COELENTERATA).

The diverse looking creatures which make up this section of the Animal Kingdom all resemble one another in the fundamental form of their bodies, which is that of a sac with a mouth at one end but otherwise closed, the mouth being as a rule surrounded by tentacles armed with minute stinging organs known as thread-cells. With the exception of jelly-fish and a few other forms they live permanently fixed at their base to some solid object, and in many a plant-like colony is formed by one flower-like individual or " polyp " giving rise to another by a process of budding (fig. 3). In any close association of a number of individual animals, whether fixed and plant-like as are these colonies, or free and capable of moving about independently as are the different ants of a nest or the people of a town, it is generally advantageous to the association as a whole that different individuals should be specially adapted in some way for the performance of different necessary duties ; and in many Coelenterate colonies such adaptations result in great modifications of form. This is most marked in colonies which never produce eggs direct, but bud off free-swimming individuals to which this function is confined. In these latter polyps the area between the mouth and

[1] *Spirastrella inconstans* (Dendy) is recorded by Burton from Krusadai Island in his paper on its sponges (*Bull. Madras Government Mus.* N.S., Nat. Hist. I [2] 4, 1937), but the specimens of the genus returned were all labelled *S. purpurea* (Lamarck). When drawing up the appendix to his paper recording localities and colour in life I presumed the two species to be distinct, but after comparing Dendy's descriptions and figures I conclude that they are identical and that Lamarck's name, which has priority, was substituted for Dendy's on the specimens after the paper had been finished. The microscleres of the Madras specimen closely resemble the microsclere figured by Burton under Dendy's name (*loc. cit.*, pl. viii, fig. 51 *b*). Those of a more papillate specimen from Krusadai Island under Lamarck's name I find to be relatively stouter and shorter. I examined a second Krusadai specimen but could find only the megascleres, which were pin-headed and like those of the other two specimens.

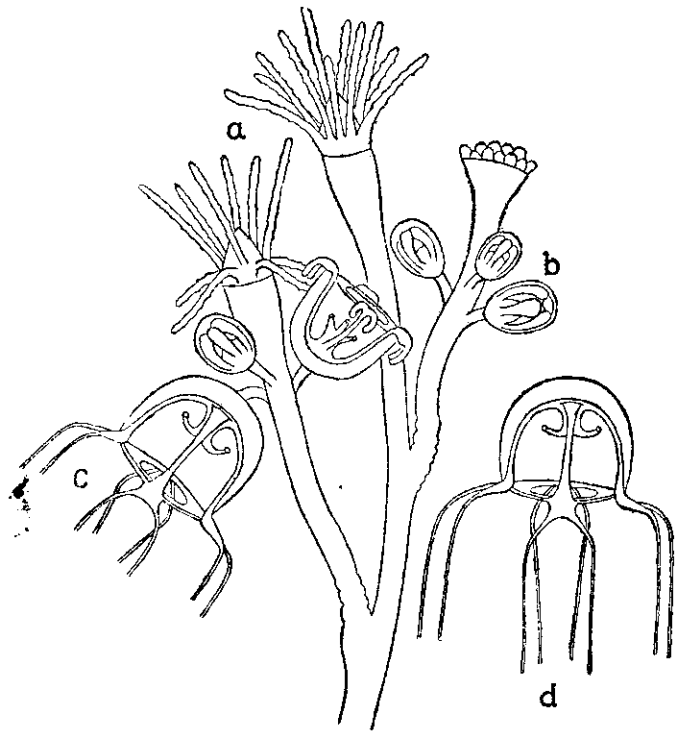

FIG. 3.

HYDROID COLONY SHOWING ALTERNATION OF GENERATIONS. (After Allman.)

a. Hydroid polyps.
b. Jellyfish buds.
c. Fully developed jellyfish.
d. Jellyfish after liberation.

the tentacles becomes so broad that the flower-like form is obscured and they become disc-like or bell-like and can swim about by means of rhythmic pulsations. As they commonly grow to a much larger size than the fixed polyps of the parent colony their delicate tissues require support, and this is given by a thick layer of stiff jelly-like substance of which they are as a rule mainly composed—hence the name jellyfish by which they are generally known. In many Coelenterates we thus find a regular alternation as shown in fig. 3, between an attached asexual generation represented by a colony, more or less plant-like in form, of small flower-like polyps, and a free-swimming sexual generation represented by larger single polyps in the form of jellyfish. But there seems always to be a tendency for one of these generations to predominate over the other, which is often more or less completely suppressed. A knowledge of these facts is essential for the proper understanding of the relationships of different Coelenterates to one another.

Coelenterates are of three different classes, Hydrozoa, Scyphozoa and Anthozoa, all of which are found on the Madras beach. Alternation of generations is found in the first two ; but in the Hydrozoa the fixed, plant-like sexual generation is usually dominant and in the

Scyphozoa the free-swimming sexual jellyfish generation. In the Anthozoa (sea-anemones, corals, etc.) there is no alternation of generations and the mouth opens into the general body-cavity not direct but through a throat. This is formed by a folding inwards and prolongation of the lip surrounding the mouth, and is supported by membranes which radiate from it to the body wall.

HYDROZOA.

Hydroids, as fixed plant-like colonies of Hydrozoa are commonly called, have the delicate tissues of their stems supported and protected by a horny tube, and this is the only part of them that can survive drying. An example of each of the two chief groups of hydroids are shown in fig. 4. In both, upright stems with smaller branches arranged alternately on either side arise from a network of creeping root-like tubes by which the colony is attached to its support; but in the first the polyps, which are fewer in number and larger in size than in the other, have no horny cup into which they can retract in case of danger. In the second each polyp arises from a separate horny cup. Polyps thus protected dry up less rapidly than those which are always exposed and are thus more likely than them to be found alive on the sands.

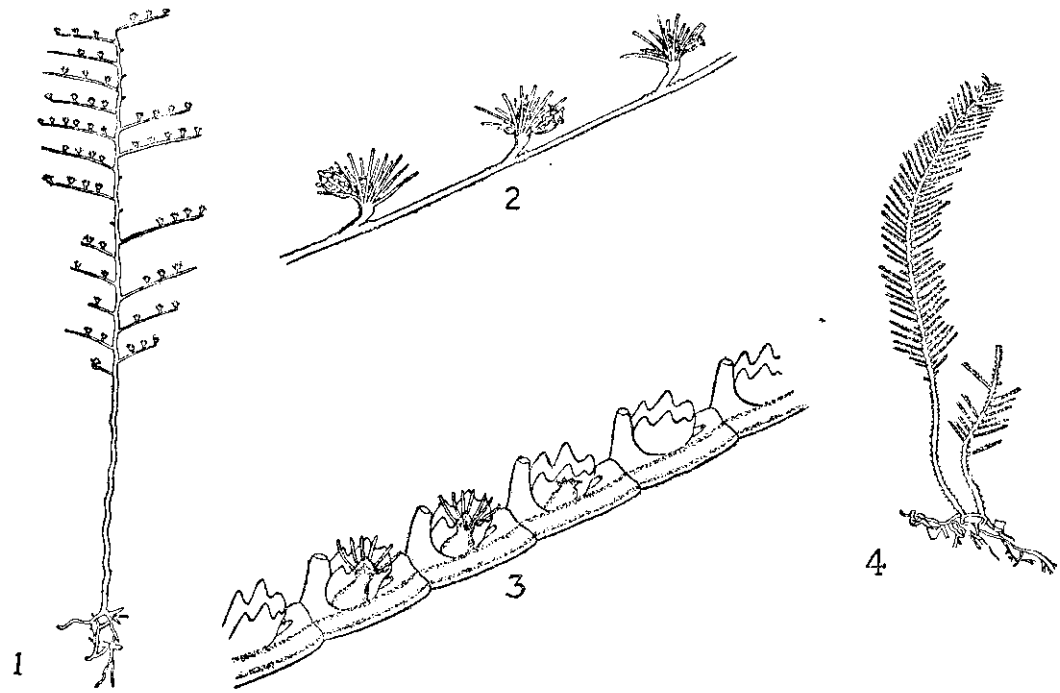

FIG. 4.

HYDROIDS.

1. *Pennaria disticha.*
2. Part of same magnified.
3. ?*Lytocarpus sp.*, part of branch magnified.
4. Colony of same.

Several species of both groups are occasionally found on the beach, but most are very small and inconspicuous. In the group without horny cups the only erect branching species of any size that is likely to be met with is *Pennaria*, the one figured. Its stout brown stems with alternate branches and characteristic rings can easily be recognized. *P. disticha* (fig. 4, 1-2) grows in the harbour and has been obtained on the beach from a fisherman's net. Shells inhabited by hermit-crabs often bear encrusting colonies of a smaller hydroid of this group. Its name is *Clavactinia gallensis* and in its dried condition it consists of a thin brown horny incrustation from which minute brown spines arise. When highly magnified this horny skeleton can be seen to be full of cavities which would be occupied by the tissues of the hydroid when alive, from which the polyps would arise side by side receiving a certain amount of protection from crushing from the erect spines. The polyps are of two kinds, one with a number of tentacles for catching food, the main function of which is the nutrition not of itself alone but of the whole colony, and one without tentacles for the production of eggs. In a typical hydroid with fully developed alternation of generations eggs, as has been explained above, are produced only by the free-swimming jellyfish generation. But this is often suppressed, and in *Clavactinia* they are produced by rudimentary jellyfish which never develop far enough to be freed from the special polyps on which they develop, the function of which is thus somewhat indirectly to produce eggs. Other species including representatives of the families Clavidae and Eudendriidae live in the harbour.

In the group with horny cups for the protection of the polyps a somewhat larger number of different kinds can be found, the group as a whole being more abundant and more varied, and having as a rule a stronger skeleton. The species shown in fig. 4, 3-4, belongs to the most highly specialized family of the group, the Plumulariidae or feather-hydroids, in which there are minute polyps loaded with stinging thread-cells in special cups arranged beside the unstalked cups of the other polyps. In many species of this family the reproductive polyps are grouped together on special branches so arranged as to form a sort of basket round them for their protection. The species shown probably belongs to the genus *Lytocarpus* but has not been fully identified. More recently I have found on the beach a fine specimen of *Lytocarpus philippinus* and little more than a main stem of *Idia pristis*, and Mr. Crichton has given us specimens of *Thuiaria interrupta*, the first two of these being species that live in the harbour and the third one that lives with fan-corals just outside. *Lytocarpus philippinus* is a tall feather-hydroid from the main stem of which a cluster of broad and delicate feather-like branches arises. When alive it can sting like a nettle. The other two both belong to the family Sertulariidae, in which the polyps are also in unstalked cups but in which these are arranged on the branches in two or more rows instead of in a single row as in the Plumulariidae. Special stinging polyps are absent, and the branches are usually broader and more widely separated than in the Plumulariidae, giving the colony a less plume-like appearance. *Thuiaria interrupta* is a somewhat variable species with tubular polyp cups arranged in

more or less approximately opposite pairs along the sides of each branch, the branches being interrupted by nodes at short intervals. Its special cups for reproductive polyps are roughly egg-shaped undecorated bodies scattered over the mature colony. *Idia pristis* is somewhat similar but its two rows of alternating polyp-cups tend to be situated close together towards one side of the branch from which they arise, and its special cups for reproductive polyps are decorated with longitudinal ridges. Other families, including the Campanulariidae and Haleciidae, are represented in the harbour.

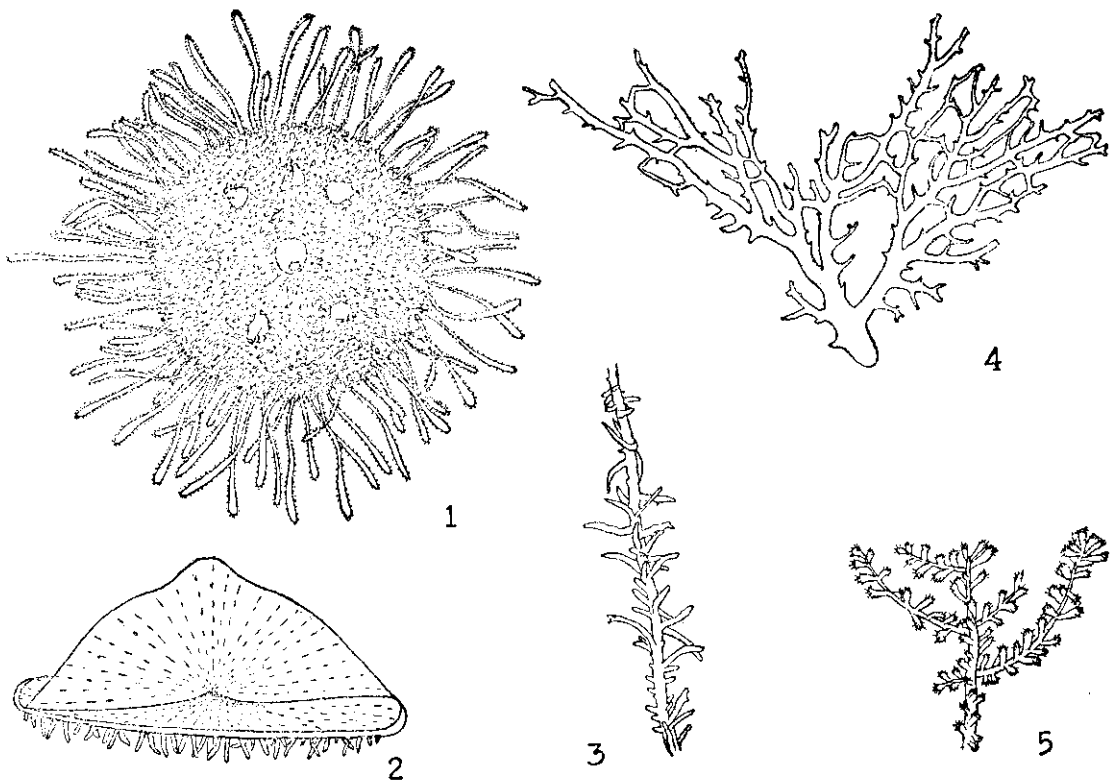

FIG. 5.

SIPHONOPHORA AND ALCYONARIA.

1. *Porpita pacifica.*
2. *Velella sp.*
3. Undetermined soft Alcyonarian.
4. Fan coral (skeleton).
5. Undetermined Alcyonarian with hard axis and expanded polyps (from harbour).

Though the typical manner of growth for a hydroid colony is from a root-like attachment to some solid support, in one group—the Siphonophora—the colonies float freely in the sea and tend to resemble jellyfish rather than plants. Three of these, all of a rich blue colour, are often washed up on the beach in large numbers. Other species having the form of an elongate little pyramid of clear white jelly, into which the filamentous colony of more

normally shaped polyps can contract, also occur but are smaller, less conspicuous and much less numerous. The blue species commonly occur together, and associated with them are blue floating species belonging to very different groups. The commonest of these is the blue sea-snail, *Janthina*. The blue sea-slug *Glaucus* is also not infrequently washed up with them, and more rarely a minute blue crustacean (see below, p. 70).

Of the three common kinds *Physalia*, the Portuguese man-of-war, is notorious in the Atlantic for the virulence of its sting ; but the Pacific species, *P. utriculus* (fig. 7, 1) which is the one found at Madras, seems to sting much less severely. When washed up on the shore the most conspicuous part of the colony is the bladder-like float which serves to buoy it up when in the sea, but cannot inflict a sting, so is the safest part by which to pick it up. From the base of this bladder spring clusters of various other types of polyps, some forming long tentacles full of stinging thread-cells for defending the colony and catching food, some for eating and digesting the food thus caught and some for reproduction.

The other two common kinds *Porpita pacifica* (fig. 5, 1) and *Velella sp.* (fig. 5, 2) belong to a different family and have a chambered disc with a horny skeleton as float, from the lower surface of which hang the nutritive, reproductive and defensive polyps densely massed together. The defensive polyps are concentrated round the margin, and the centre is occupied by a single large nutritive polyp, the reproductive polyps being between, with or without additional nutritive polyps among them. In *Porpita* the disc is round and in large specimens often somewhat suggestive of a biscuit. In *Velella* it is oval, with an erect, " sail " extending obliquely across it.

The jellyfish liberated by hydroids do not as a rule grow to any great size and are not, therefore, very likely to be found washed up on the beach. Many kinds do, however, occur off the Madras coast and an account of those so far known will be found in M. G. K. Menon's " The Hydromedusae of Madras " (for reference see below, p. 95).

SCYPHOZOA—JELLYFISH.

Many hydroids, as already explained, bud off jellyfish which often grow to be half an inch or more across, and the Hydrozoa include two groups in which the hydroid generation is suppressed and the jellyfish generation grows to a somewhat larger size. But the large and conspicuous jellyfish commonly washed up on the Madras beach belong to the class Scyphozoa, in which the asexual attached generation is either absent or but little developed. All except one family differ from the jellyfish of the Hydrozoa in that the lip of the bell, or umbrella as it is usually called, lacks the inwardly projecting membrane or *velum* characteristic of that class. The mouth is bordered by four lips, often subdivided and commonly drawn out into elongate mouth-arms.

Three large species of jellyfish are common in Madras. *Dactylometra quinquecirrha*, a brownish species in which the lips are produced to form delicate streaming arms often six feet or more in length, appears in the harbour in enormous numbers each hot weather, where the pulsations of its bell as it swims can readily be watched. This is the common stinging jellyfish of Madras. Single specimens can be most unpleasant, and accidental contact with the masses of them such as are sometimes brought up in fishing nets, has been known to result in a painful week in bed. When very thick in the harbour a number of specimens sometimes get their arms inextricably entangled so that the group comes to look like a huge brownish ball with the umbrellas all pulsating at the periphery in their efforts to get away.

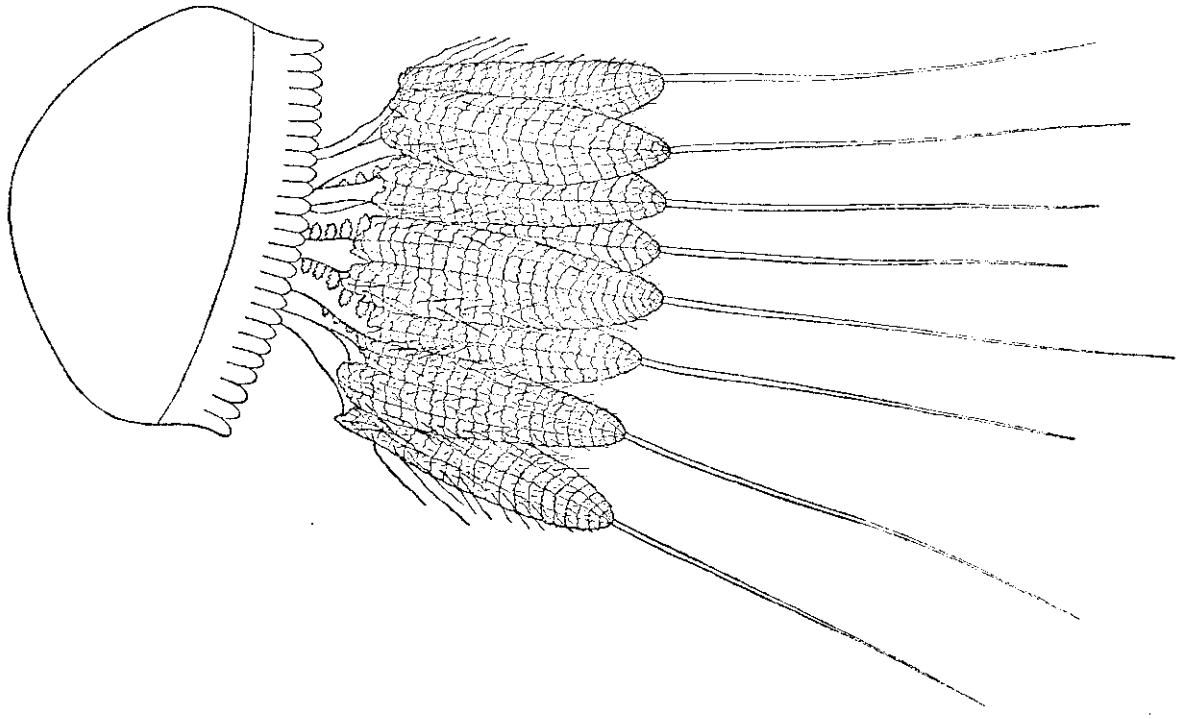

FIG. 6.

The jellyfish *Acromitus flagellatus*.

Acromitus flagellatus is whitish, with each of the four mouth-arms divided in two, making eight comparatively short thick arms each ending in a thread-like process (fig. 6). It occurs chiefly in more or less brackish backwaters and is well known to the fishermen of the Chilka Lake in Orissa who call it *Rabanchattu*, meaning Ravana's umbrella. *Aurelia solida* is less common than the other two and of a purplish blue colour. Its four arms are all simple.

Many other jellyfish occur and may be washed up occasionally, concerning which see M. G. K. Menon's paper on Madras Scyphomedusae noted on p. 95 below.

SEA ANEMONES, CORALS, ETC. (ANTHOZOA).

Two sections of this class have to be distinguished, one in which the tentacles are always eight in number and are fringed on either side somewhat like a feather, and one in which the tentacles are never eight in number—usually much more numerous, but sometimes only six—and are usually simple, never fringed as in the first section. The first section is spoken of as the Alcyonaria and the second as the Zoantharia.

The alcyonarian most commonly found on the Madras beach is the fan coral (fig. 5, 4). This is the horny skeleton, generally more or less dark brown or black in colour, of the fan-shaped colony formed by most species of the family Gorgonidae. Living specimens are sometimes brought up in fishermen's nets and may occasionally be found attached to concrete blocks in Rayapuram Bay by the harbour entrance. In these the branches are much thicker and usually of a deep red or orange colour, the brown horny skeleton being covered with living tissue in which are embedded myriads of minute *spicules* or particles of more or less definite shape, composed of the same chemical substance as limestone, which the organism secretes. In the retracted condition in which they are ordinarily found the polyps can be seen as rounded projections ; but the beauty of their delicately fringed tentacles is only revealed when they expand and this they do not do very readily even when placed in good sea water.

Allied to the fan corals are species in which the colony is more irregular and often very straggly, some with (fig. 5, 5) and others without (fig. 5, 3) a hard axis. Some of them are allied to the precious coral used in jewelry, a species found mainly in the Mediterranean Sea and off the Japanese coast, in which the spicules, often of a very beautiful red or pink colour, are so densely massed together and so closely interlocked as to form a solid mass, hard enough to cut and polish.

Resembling some of these forms closely in general appearance and manner of growth, but in structure more closely allied to the sea-pens, is *Telesto trichostemma*, a whitish species which can be found in the harbour with its comparatively large flower-like polyps beautifully expanded or if taken home from there may be induced to expand in fresh and clean sea water. It seems to flourish best in dark and sheltered places.

The sea pens (Pennatulacea) are so called from the resemblance they mostly bear to the quill feathers from which pens were cut before the days of steel nibs, and from the quill-like horny skeletal rod by which the main axis of the colony is supported in such species. The only kind that is at all commonly found in Madras—a species of *Cavernularia* (fig. 7, 2-3) —is, however, not feather-like and has no such horny axis. It is only seen at somewhat long intervals, but is then often washed up on the beach in very great numbers, as a yellowish and more or less pear-shaped object, the narrow end rather hard and either smooth or longitudinally furrowed and the broad end softer, usually somewhat darker and dotted with small pits marking the positions of the contracted polyps. When living undisturbed at the bottom of the sea the narrow end is embedded in the ground and the broad end when fully expanded is many times as tall as when it is found contracted and thrown up by the waves, and

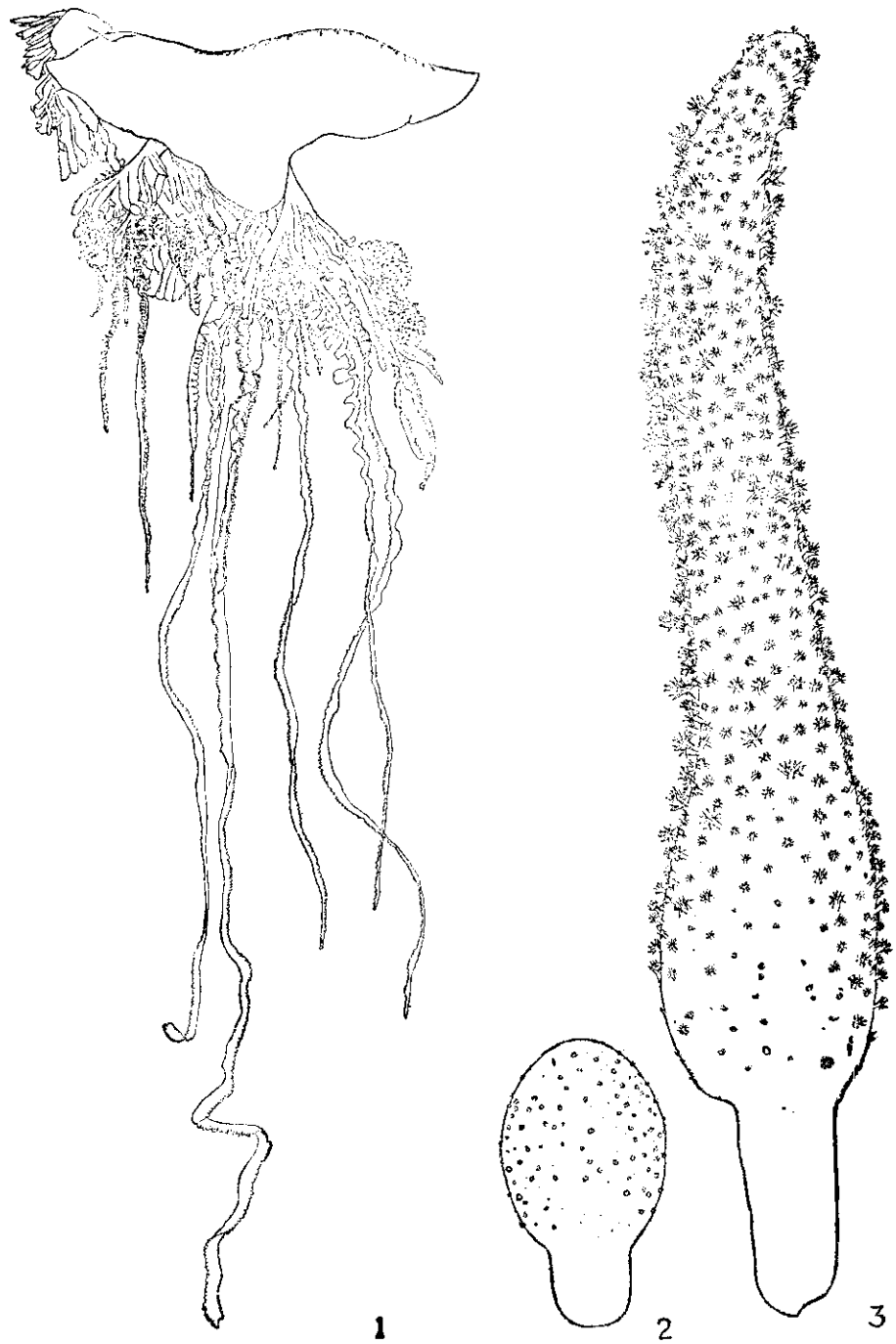

FIG. 7.
SIPHONOPHORA AND PENNATULACEA.

1. The Portuguese Man-of-War, *Physalia utriculus*.
2. *Cavernularia* contracted.
3. The same expanded.

is covered with beautiful semi-transparent polyps. If still healthy and in good condition, specimens picked up on the beach will often expand if placed in a large enough quantity of good sea water ; but they become so large and absorb so much water in doing it that an ample supply is necessary. Occasionally they may be seen fully expanded in large pools formed in the bar between the sea and a backwater. I have only seen this once, but it was a sight never to be forgotten. This was at Adyar.

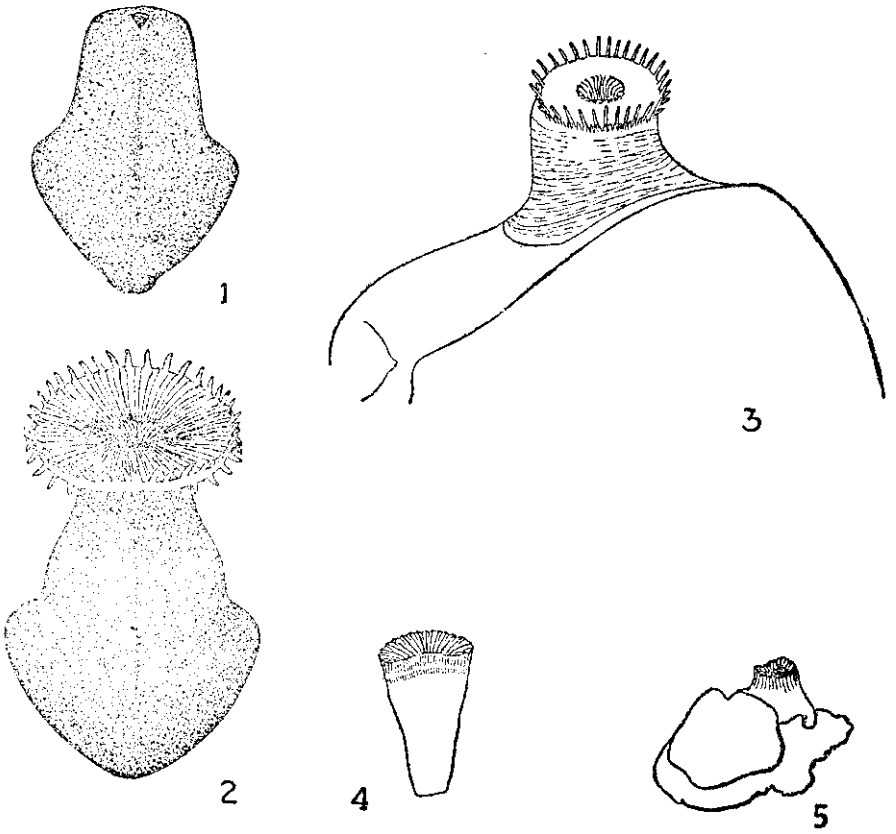

FIG. 8.

SEA ANEMONES AND CORALS.

1. *Sphenopus marsupialis* contracted.
2. The same expanded.
3. Sea anemone attached to shell.
4. *Flabellum pavoninum.*
5. *Trochocyathus* sp. attached to piece of shell.

The only occasion on which I have found true quill-like sea pens was in December 1939, when several were collected just inside the opening to the sea of the Ennur backwater. They were of a mottled greyish and whitish colour and belonged to the genus *Sarcophyllum.*

A Zoantharian that, like *Cavernularia,* is periodically thrown up in large numbers is the remarkable sea anemone *Sphenopus marsupialis.* In the contracted condition in which it is ordinarily found (fig. 8, 1), it is a somewhat flattened dark greyish object an inch or two

long, usually broad and more or less triangular at one end, and narrower but plumper and more or less cylindrical at the other. Its colour and hardish texture are due to a protective layer of fine sand grains, a considerable proportion of which are black, embedded in the skin. If healthy specimens are placed in a basin of clean sea water, the cylindrical end should after a time gradually expand till the grey disc appears with the mouth in its centre and short grey tentacles all round (fig. 8, 2). Under normal conditions of the creature's life, the broad flattened end serves to anchor it in sand or mud from which the disc alone would project. The genus *Sphenopus* is separated in a special family from the rest of the order Zoanthidea to which it belongs. The other family consists mainly of colonial forms and includes the soft, unencrusted genus *Zoanthus* and the finely sand-encrusted *Palythoa* (incl. *Gemmaria*), which form extensive sheets of moderate to somewhat large sized polyps on concrete blocks, etc., by the harbour arm in Rayapuram Bay, as well as the scarcer *Epizoanthus*.

The more typical sea anemones (fig. 8, 3) belong to the order Actiniidea and are solitary and mostly attached to some solid object by a flattened base, though in some otherwise typical species this is modified for anchorage in mud. They are occasionally found on the Madras beach in contracted condition as low mounds of soft greyish, yellowish or reddish substance attached to shells, particularly such as are carried as a protection by crabs[1] or are inhabited by hermit-crabs, while several that anchor themselves in mud inhabit the back-waters[2].

Some sea anemones secrete a basal limy skeleton and thus produce stony corals—the corals mainly concerned in the formation of reefs. Stony corals may be either solitary or colonial. The former usually have somewhat the form of a small cup, within which delicate plates radiate from the centre. Most live attached to some solid object, but in others the adult becomes detached and lies embedded in, or in some forms free upon, the sea bottom. In coral colonies the polyps multiply by budding or by longitudinal division and thus produce stony masses that may reach a very great size and weight, some kinds fragile, others extremely solid and hard.

The only coral that is at all common on the Madras beach is the solitary, tapered and flattened *Flabellum pavoninum* (fig. 8, 4). An attached solitary coral with more or less circular cup, dark brown within and whitish without, apparently identical with the *Trochocyathus* not uncommon on Krusadai Island, lives among concrete blocks beside the harbour arm in

[1] See "The Common Molluscs of South India" by J. Hornell, *Madras Fisheries Bulletin*, XIV, 1922, fig. 46 (p. 180).

[2] For a list of those found in the local backwaters see "The Brackish-Water Fauna of Madras" by N. Kesava Panikkar and R. Gopala Aiyar, *Proc. Ind. Ac. Sci.* VI, 5 (Bangalore, 1937), p. 292, and for notes on habitats subsequent pages.

Rayapuram Bay, and specimens attached to shells are sometimes washed up on the beach (fig. 8, 5). A single specimen of a somewhat larger and more solid species, in which the outer side of the cup is dark rimmed, has also been found washed up. Its cup is elongate and constricted as if in process of division and has the outer shell of a symbiotic barnacle attached to it at one end.

Two kinds of flat-based but unattached solitary corals of particular interest can be obtained by dredging. The young coral settles on a minute snail shell which forms the abode of a young Gephyraean worm of the genus *Aspidosiphon*. Eventually the coral completely engulfs the shell and as it grows the worm extends spirally, within the base of the coral, the cavity in which it lives. When dredged alive and placed in clean sea water the front end of the worm soon protrudes from a small hole in the coral, which it drags about after it as it searches for a place suited to its liking in which to settle. Though the two kinds of coral associated with this worm at first sight look much alike, they belong to two different and widely separated families in one of which the wall of the cup and the radiating plates within it are solid while in the other they are so perforated with cavities that under a lens the coral looks almost like a solidified sponge. The former, which belongs to the same family as *Flabellum* and *Trochocyathus*, is *Heterocyathus aequicostatus* and the latter *Heteropsammia cochlea*. Apart from the perforate or imperforate structure of the coral, the two can as a rule readily be distinguished by the outside of the cup of *Heterocyathus* being strongly ridged in continuation of the tops of the radial plates within it, while that of *Heteropsammia* is not.

Two colonial species with low cups, dark within and in other respects also very like those of the solitary *Trochocyathus*, have been found : one with relatively small cups washed up on the beach, and the other with larger cups covering a considerable area of one or two concrete blocks by the harbour arm in Rayapuram Bay, now well above water level.

The only branching coral that has been found is the beautiful *Pocillopora damicornis*, which grows beside the harbour arm in Rayapuram Bay but seems always to have its branches stunted there by wave action. Two specimens of a smallish-polyped species of the encrusting but commonly massive genus *Favia* have been found by Mr. Crichton on the beach, one a water-worn pebble, the other much larger and—though damaged in other ways—unworn and looking comparatively fresh. A single old-looking fragment of the massive encrusting coral *Symphyllia sinuosa*, in which the coral cups fail to separate when the polyps divide, and so combine to form long sinuous valleys each occupied by a row of polyp mouths, has also been found on the beach.

COMB-JELLYFISH (CTENOPHORA).

These are transparent, colourless, gelatinous animals bearing rows of *cilia* or vibratile hairs arranged longitudinally upon them, somewhat like the teeth of a comb. Like the true jellyfish belonging to the preceding group, they float in the sea and are sometimes washed up on to the sand, though as they are usually small and colourless they are less often seen.

The form most commonly met with belongs to the family Pleurobrachiidae (fig. 9), and when out of water appears as a small and more or less egg-shaped mass of rather firm jelly, on which the eight rows of cilia can usually be distinguished as eight slightly irridescent lines.

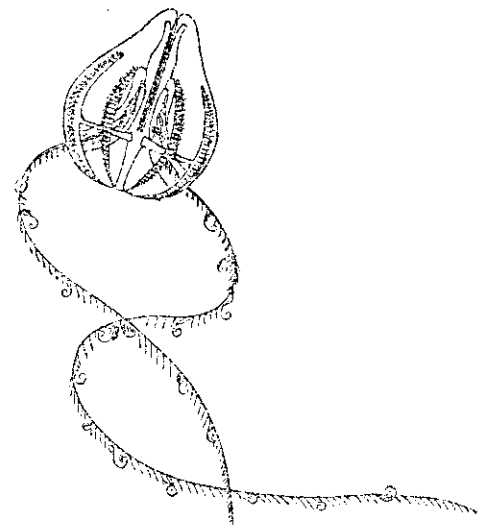

FIG. 9.
COMB-JELLYFISH (after Chun).

In water they are almost invisible except for the pair of pinnate tentacles which tend to be more opaque. These arise from a pair of pockets in the gelatinous substance and may either trail out behind, or may be contracted into these pockets for protection.

A thimble-shaped form, *Beroe*, which is without tentacles, also occurs in the sea near Madras, and sometimes attains a much larger size. But it is so fragile that it is not likely to be seen even if washed up.

FLATWORMS (PLATYHELMINTHES).

A turbellarian or free-living and non-parasitic flatworm about one and a half inches long and half as broad as long, of a brownish colour, is occasionally found among mussels, etc., in the harbour. But its thin soft body would almost certainly be destroyed before it could be washed up on the beach.

NEMERTINE WORMS.

The Nemertea are soft-bodied, elongate and extraordinarily contractile, and usually somewhat flattened worms with a protrusible proboscis that is hidden when at rest in a pouch opening at the extreme front end, in front of the mouth. A small somewhat flattened and extremely contractile flesh-coloured specimen was collected by Mr. Crichton in the Adyar backwater on 31st October 1940.

SEGMENTED WORMS (ANNELIDA).

Many different groups of worms—flatworms, roundworms, nemertine worms, bristle worms, leeches, etc.—live in the sea. But their bodies are so soft that the only ones of which remains are commonly found washed up on the beach are those which protect themselves by constructing tubes in which to live, as do certain species of marine bristle-worms (Polychaeta), in which the feet are often conspicuously developed and almost always contain numerous bristles, some of them of elaborate structure, the sexes being normally separate. They differ in these characters from the earthworms and fresh-water worms (Oligochaeta) the feet of which project scarcely if at all and contain few bristles always of simple structure, while a single individual normally contains both male and female organs.

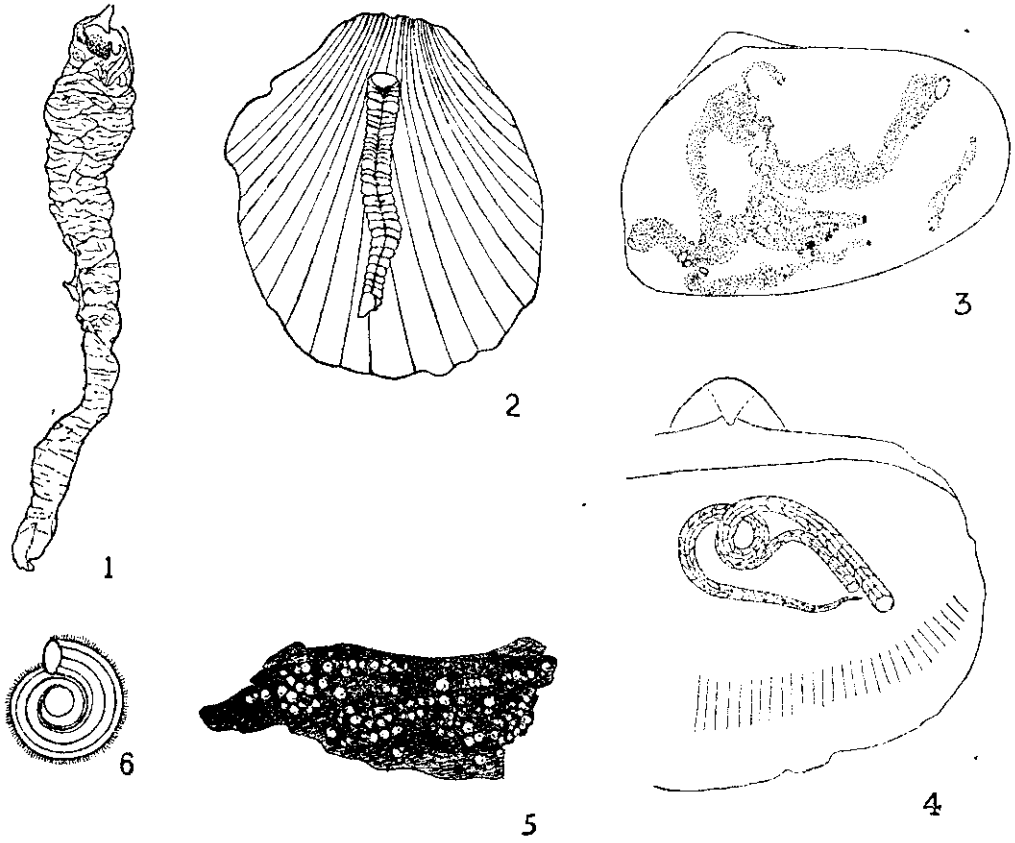

FIG. 10.
POLYCHAET WORMS.

1. Eunicid or Terebellid tube.
2. ? *Pomatoceros* tube.
3. Sand-encrusted worm tube on shell.
4. Tube of *Hydroides norvegica*.
5. Group of *Spirorbis sp.* on drift wood.
6. Single specimen of same shell magnified.

One family of marine worms, the Serpulidae, habitually secretes tubes, mostly of serpentine form, in which lime is deposited so that they become hard and shell-like, and these are naturally the ones most frequently found dry on the beach, usually adhering to the shells of molluscs or occasionally of crabs. The commonest is *Hydroides norvegica* (fig. 10, 4),

a species common in the harbour, in which the tube besides showing growth lines at longer or shorter intervals may be either evenly rounded or bear a varying number of low longitudinal ridges of which the uppermost (often the only) pair, sometimes with a smaller median ridge between, form together a flattened band along the top. Another species found in the harbour of which tubes are sometimes washed up is *Pomatoceros coeruleus* in which the top of the tube bears a strong median crest. A larger species, probably distinct from this, has an equally strong median crest and a varying number of longitudinal ridges below it.[1]

A third species of Serpulid tube sometimes found forms a close spiral and is very much smaller than any of the preceding. It is characteristic of the genus *Spirorbis* (fig. 10, 5–6). A serpentine tube attached to shells (fig. 10, 3) but formed of sand grains cemented together is no doubt that of a worm but must belong to some other family. The Sabellidae make sand-encrusted tubes, but these are usually more or less erect, not adherent.

A toughly membraneous tube thickly coated at one end with more or less stratified sand grains, small shells, fibre, etc. (fig. 10, 1), which is sometimes washed up, probably belongs either to the family Eunicidae, or to the family Terebellidae. But in the absence of tubes complete with worm the identification must remain somewhat tentative.[2]

Tapering tubes of the Terebelliform worm *Pectinaria*, originally embedded in sand, and exquisitely constructed by carefully fitting sand grains to each other and cementing them together, may also occasionally be washed up.

A Eunicid worm, *Onuphis eremita*, is common in the sand below high tide level, and fishermen who use it as bait have an ingenious method of catching it where the sand is loose. First the fisherman catches a crab, crushing its body in one hand and tearing off its legs. Then, after selecting a suitable place, he dips the hand containing the crushed crab in a receding wave and sprinkles the freshly exposed sand with crab-flavoured water. This attracts the worms to the surface and as soon as he detects one at a particular spot he holds upon it the muscles projecting from the base of one of the detached legs, till he can seize the front end of the worm and draw it slowly and steadily from its burrow.

A number of other kinds of worm occur in the harbour and among the concrete blocks outside it, including representatives of the families Aphroditidae, Nereidae, Eunicidae, Terebellidae, Cirratulidae and in some parts a definite zone of innumerable small horny tubes no doubt belonging to some Chaetopterid. A number of small red Cirratulidae were on one occasion found living together in burrows in the shell of a living *Thais bufo*, but shells burrowed in just this way have not been noticed on the beach. And in addition to these worms, all of which belong to the class Polychaeta, there are others much less numerous but including two different genera belonging to the curious class Gephyrea, in which segmentation is reduced or absent.

[1] The specimen from which fig. 10, 2, was drawn probably belongs to this species on account of its size. It is badly worn and as the species had not been recognized as distinct when it was drawn and reproduced the ridges are not shown for they are so faintly visible, and that on one side only, that they were unfortunately overlooked. In fresher specimens since obtained, with the serpentine posterior end complete, they are very clear and the median crest is similarly much more pronounced.

[2] I learn that one such tube has recently been collected by Mr. Crichton containing a Eunicid.

POLYZOA.

The Polyzoa, also known as Bryozoa or Moss Animals, form encrusting or erect and plant-like colonies, composed of a large number of individuals each retractile into its own little case or *zooecium*, produced by budding somewhat as in the Hydrozoa, a group with which they were classed as Zoophytes or Animal-Plants before the anatomy of the soft parts was sufficiently understood. Anatomically, however, they are far more advanced than the group to

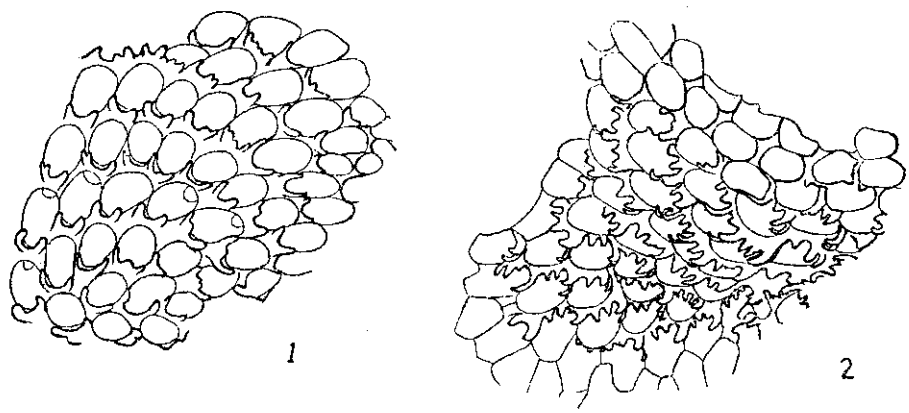

FIG. 11.

POLYZOA.

1 & 2. Zooecia of ? *Membranipora* (much enlarged).

which the Hydrozoa belong, having a well developed digestive tube with a mouth at one end for taking in food and an anus at the other for passing out excrement, this tube lying in a definite body cavity. The mouth is surrounded by tentacles as in the Hydrozoa, but instead of catching prey by means of stinging-cells they form together a funnel in which a current of water carrying air and food material is created and maintained by the myriads of minute vibrating hairs or *cilia* which they bear.

One species only (fig. 11, 1-2) seems at all commonly to be washed up on the Madras beach. It is an encrusting form with the side walls of the zooecia beautifully decorated in unworn specimens with small tooth-like projections. It is abundant both on shells and on floating seeds and pieces of wood, and probably belongs to the genus *Membranipora*. Other species occur in the harbour, including representatives of the families Cellulariidae and Vesiculariidae.

BRACHIOPODS.

Brachiopods are animals enclosed in a bivalve shell secreted by the surface of the body and by two leaf-like extensions of it known as the *mantles*, between which lie a pair of " arms ". These are often characteristically coiled or twisted, and each bears a row of tentacles the

cilia on which maintain in the mantle cavity a current of water for feeding and respiration. Though now a relatively small group, fossils show them to have been much more varied and abundant in earlier periods of the world's history.

Two species are found at Madras, both belonging to the order Ecardines in which the shell is horny, instead of stony as in the remaining order Testicardines. *Discinisca indica*

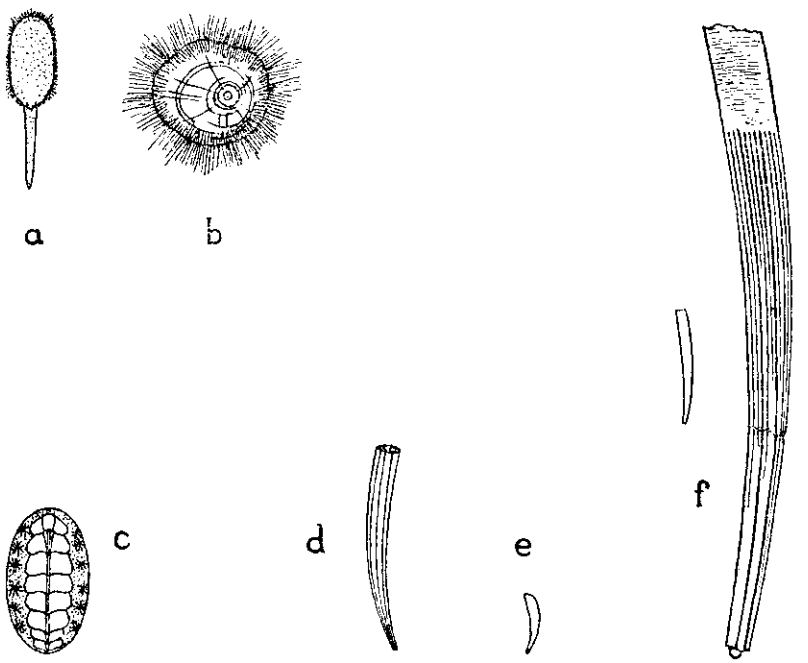

FIG. 12.

BRACHIOPODS, CHITONS AND TUSK SHELLS.

a. *Lingula sp.*
b. *Discinisca indica.*
c. *Acanthochitona mahensis.*
d. *Dentalium octangulatum.*
e. *Cadulus euloides.*
f. *Dentalium (Graptacme) pistis,* natural size and enlarged.

(fig. 12 b) lives attached by one valve to mussel shells and is common in the harbour. The attached valve is closely applied to the substratum and is therefore more or less flat, but the upper one is conical, often with dark radial lines, and very like a limpet. In living specimens it can readily be distinguished from a limpet by the circle of fine hairs that radiate from it. At first sight these are apt to appear as arising from the margin of one of the valves, but actually they arise from between them, disappearing as a rule when the specimen is detached and dried.

A single small specimen of the stalked Brachiopod, *Lingula*, in which the valves are more or less alike and attached to a stalk passing between their apices, has been found by Mr. Crichton in backwater mud at Adyar (fig. 12 a).

MOLLUSCA.

The great majority of the animal remains thrown up on the Madras beach are shells belonging to this large section of the Animal Kingdom, of which snails and slugs, mussels, and cuttlefish are the best known examples. Many of these shells are very beautiful in form or in colour, or in both ; and on account of their number and variety and of the fact that they are not so susceptible to decay as are most other dried animal remains, their collection is most attractive. It is therefore particularly unfortunate that a proper understanding of their relationship one to another, on which alone any satisfactory classification can be based, is rendered difficult by the fact that for this a knowledge of the animal which formed the shell is essential ; and as the animal is as perishable as its shell is imperishable it is the shell alone that is usually found. Yet to base a classification of molluscs on their shells alone would be about as sensible as it would be to base a classification of men on their houses—some facts about the inhabitants would in both cases be indicated, but not as a rule those of most fundamental importance.

The classification adopted is that of Thiele's " Handbuch der Systematischen Weichtierkunde " (1931), this being the most complete and convenient now available. But as Pelseneer's volume (1906) of Lankester's " Treatise on Zoology " is still the standard work on the subject in the English language his terms are given side by side with Thiele's. Technical terms have been kept to a minimum but could not be eliminated without making descriptions unduly cumbersome.

A mollusc may be recognised by its unsegmented body with ventral *foot* and dorsal mantle or *pallium*, which, as a rule, is protected by a shell which it secretes. On either side of the foot, about half way up, there is often a longitudinal ridge known as the *epipodium*, or the side margins may be expanded to form *parapodia*. The mantle forms the roof of a *pallial cavity*, which may either be freely open to the exterior or may open through one or more small apertures, one or two of which have, in many groups, the form of tubular *siphons*. In the pallial cavity the mantle normally bears, near the entrance, a pair of ridged or pitted sense-organs known as *osphradia*, whose function it is to test the quality of the respiratory currents in the cavity. And beyond the osphradia it bears a pair of feather-like gills or *ctenidia*. In some species, however, the ctenidia are reduced or absent, when they may be replaced by secondary gills distinguished as *pallial branchiae* ; and in air-breathing groups they are replaced by a *pulmonary sac* or lung formed from the pallial cavity. One of the most distinctive features of molluscs, excluding lamellibranchs and a few highly specialised forms in other classes, is the *radula* by means of which they feed. This consists of a series of horny teeth in transverse rows, each of which is symmetrically arranged about a single tooth (sometimes absent) in the middle-line.

Molluscs fall into five classes—

AMPHINEURA (*Chitons, etc.*).—Mouth and anus at opposite ends of the symmetrical and more or less elongated body; mantle provided with numerous spicules embedded in a cuticle.

GASTROPODA (*slugs, snails, etc.*).—Asymmetrical molluscs with well developed head; shell formed in one piece and spirally coiled, at least in the larval stage of early development. The resulting asymmetry, which comes about through the development of one side of the body at the expense of the other, carries the anus and the aperture of the mantle-cavity from a posterior to an anterior position and twists the internal organs including the nerve trunks.

SCAPHOPODA (*tusk shells*).—Body and shell elongated, symmetrical and nearly cylindrical. Mantle with ventral margins united to form a complete tube round body with anterior and posterior apertures. Head somewhat rudimentary, without eyes but with two dorsal appendages furnished with long filaments. Foot cylindrical, adapted for digging.

LAMELLIBRANCHIATA (*bivalve shells*).—Molluscs with mantle divided into right and left lobes which secrete, at least in the early part of their development and usually throughout, a shell consisting of two separate valves hinged together, this shell ordinarily covering the whole body.

CEPHALOPODA (*cuttlefish, etc.*).—Molluscs in which the edges of the foot are transformed into appendages completely surrounding the head, while the epipodium is modified to form behind the head a muscular exhalent siphon for the pallial cavity.

AMPHINEURA—CHITONS, ETC.

Chitons are more or less elongate and flattened molluscs protected above by a series of small shells jointed together. *Acanthochitona mahensis* (fig. 12 c) and *Plaxiphora indica* are common towards low tide level, the former mostly in the sheltered water of the harbour, the latter exposed to the waves outside. But as the sections of the shell when isolated are very small it is not surprising that they are rarely if ever found washed up on the sand. The former species can be distinguished from the latter by its conspicuous tufts of bristles arranged one pair to each segment in a line on each side, by its definite median thickening of each of the shell plates tapering to a somewhat rounded angle behind, and by its small scale-like tubercles on either side of these plates. In *Plaxiphora indica* the bristles are not arranged in tufts, the median dorsal thickening is inconspicuous or absent, and the scale-like tubercles are replaced by delicate zig-zag sculpture, superimposed on which are pale lines radiating from behind. In this latter species particularly, however, shells are apt to be so corroded or encrusted with seaweed that the markings frequently disappear.

A third form, of which Mr. Crichton has two specimens, one of them found attached to a *Ficus* shell washed up on the beach, resembles *Acanthochitona mahensis* in its well developed dorsal thickenings. But if it ever had any tufts of bristles they have disappeared, and its sculpture seems to indicate that it is a distinct species.

GASTROPODA—SNAILS AND SLUGS.

So many different kinds are found that it has been necessary to devote a separate part of this paper to them.

SCAPHOPODA—TUSK SHELLS.

Tusk shells are so called from their resemblance in shape to the tusk of an elephant, the concave side being dorsal and the convex ventral, though these terms have been transposed by some authors.

Two genera occur at Madras, *Dentalium* and *Cadulus*, the former evenly tapered from aperture to apex, usually ribbed, and attaining a much larger size than the latter which is somewhat narrowed in front as well as tapering behind and is smooth.

Dentalium is represented by at least four species, *D.* (*s. str.*) *octangulatum*, *D.* (*Laevidentalium*) *eburneum*, *D.* (*L.*) *philippinarum* and *D.* (*Graptacme*) *pistis*.

D. octangulatum (fig. 12 d) can at once be distinguished from the others by its strong longitudinal ribs, usually eight in number, more rarely nine or seven. Mr. Crichton has two specimens, each with six ribs, that may perhaps also belong to this species. Though not unlike the figures of *D. hexagonum* and its variety *sexcostatum* given in the Siboga Expedition report, they are not very like the only authentically named specimen of *D. hexagonum* that I have seen, and I hesitate to identify them with that species.

The subgenus *Laevidentalium* is distinguished by its cylindrical shell being either quite smooth or with numerous low annular swellings. The commonest of the two Madras species, *D. philippinarum*, has the former character and the other, *D. eburneum*, has the latter, besides being somewhat broader, a trifle more curved, less translucent and without the rich golden brown colour often found in *D. philippinarum*.

In the subgenus *Graptacme* the shell is finely striated near the apex but quite smooth in front. Mr. Winckworth informs me that the Madras species *D. pistis* (fig. 12 f) is allied to his *D. elpis* but differs from it in having fewer ribs and a hexagonal apex.

Cadulus is represented by two species, *C. anguidens* and *C. euloides* (fig. 12 e). The former is broader than the latter and less obliquely truncate in front.

LAMELLIBRANCHIATA—MUSSELS, SHIPWORMS, ETC.

In Lamellibranchs the shell (see fig. 13) is *bivalve*, that is the right and left halves or *valves* are separate but are hinged together at their apex or *umbo*. The hinge commonly includes a system of interlocking teeth of which the central ones (immediately below the umbo) are known as *cardinal* and the outer ones as *lateral*. Usually there is also a chitinous *ligament* which may be either external or internal and may be simple or with one or more

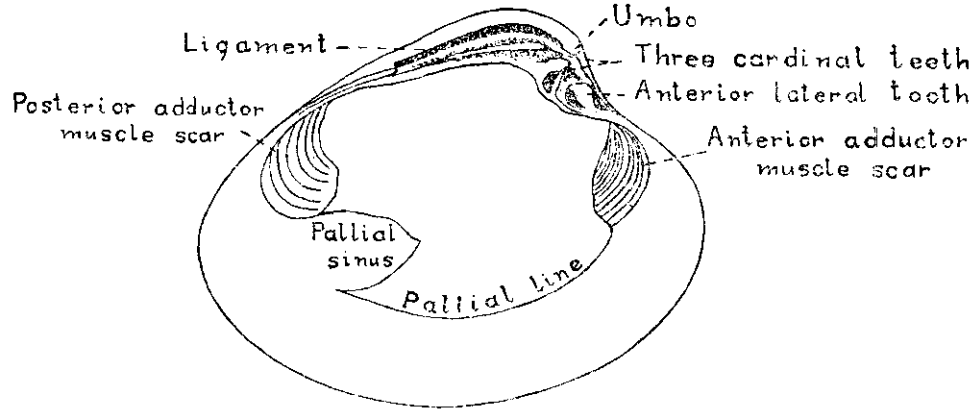

FIG. 13.

Inner side of left valve of *Pitar erycina* with names of the various parts.

nodular concentrations. This ligament makes the valves spring open after death or when the *adductor muscles* are relaxed. These muscles are normally two in number, but in some groups are reduced to one. Their impressions on the shell are joined by the *pallial line* which marks the boundary of union between the shell and the *mantle* or *pallium*. This line normally lies parallel to the ventral margin of the shell, extending from one muscle to the other, but when retractile siphons are present their musculature is apt to press it inwards so that it becomes more or less deeply sinuate below the impression of the posterior adductor. The anterior part of the shell is usually shorter than the posterior, but in some forms—such as the wedge shell, *Donax*—the reverse is the case. As the pallial sinus, when present, is always posterior it forms a useful guide to the correct orientation of the shell, another being the ligament which is always situated behind the umbo. A flattened *lunule* is sometimes present in front of the umbo and a similarly flattened *area* more rarely behind it. The internal layer of the shell is secreted by the general external surface of the mantle and is often pearly ;

but the external layer is secreted only by the mantle edges. When parasites or other foreign bodies get into the tissues pearly material is often secreted around them and thus true pearls are formed.

Many Lamellibranchs burrow in sand or mud, or otherwise move from place to place by means of the foot. But there are also many which are attached, some—such as the oyster—by one of the valves of the shell, others—such as the mussel *Mytilus* and the pearl-oyster—by a chitinous attachment known as the *byssus* which is secreted by a specially developed gland in the foot. A few—such as scallops and members of the families Galeommidae[1] and Limidae—have acquired the power of swimming.

For some reason that I cannot explain it seems quite usual for the valve of one side of a species to be washed up in large numbers, and that of the other side much more rarely.

The families represented at Madras, which are only a part of the total number known, may be distinguished from one another thus.—

1. Hinge with more or less numerous simple linear teeth, either parallel to one another or radiating from below upwards (TAXODONTA) 2
— Hinge either toothless or with a few teeth, usually much stronger, of which the central (cardinal) ones radiate from the umbo downwards 5

2. Shell very small and not very thick, usually smooth or concentrically ridged (fig. 14 a-b) 3
— Shell stony, generally large and usually radially striate or ribbed, covered with a brown or black hairy skin in life. 4

3. Shell pearly ... ... NUCULIDAE, p. 32.
— Shell not pearly ... ... NUCULANIDAE, p. 32.

4. Hinge straight (fig. 14 f) ... ... ARCIDAE, p. 33.
— Hinge strongly curved (fig. 14 g) ... ... GLYCYMERIDAE, p. 35.

[1] The Galeommidae are a family of shells too small and fragile to survive washing up on the beach, and are not known from Madras. Their swimming has been observed at Krusadai Island in the Gulf of Manaar. *Scintilla hanleyi* and *Galeomma paucistriata* both progress by extending the long slender foot and then contracting it so as to bring the shell on towards its tip. But this type of movement is somewhat ineffective if the tip cannot make a good grip, and is often supplemented by propulsion obtained by sharply closing the valves of the shell, their anterior part a little more quickly than their posterior, so as to expel water backwards through the spaces between the mantle edges. Such movements seem to be more pronounced in the former than in the latter species.

5. Anterior adductor muscle (and its scar) mostly reduced or absent, true hinge teeth scarcely developed, shell as a rule closing completely or with only a notch or irregularity of margin for byssus (ANISOMYARIA) 6

— Anterior adductor muscle well developed *or* true hinge teeth present ; shell in several families more or less gaping or reduced (EULAMELLIBRANCHIATA) 13

6. Ligament simple, without nodules 7

— Ligament with one or more internal nodules (fig. 15 c-d) ... 9

7. Anterior adductor almost always present, ligament almost always external ... ... MYTILIDAE, p. 35.

— Anterior adductor absent 8

8. Umbo at most subterminal, posterior angle often produced, ligament somewhat sunk ... ... PTERIIDAE, p. 38.

— Shell large and thin, pointed in front with umbo terminal. PINNIDAE, p. 38.

9. Shell more or less irregular, whitish or brownish in colour, not radially ribbed though sometimes thrown into large radial folds, very rarely radially striate ; a pair of large teeth never present (fig. 16 d-f) 10

— Shell either regular or of a pinkish colour (usually both), and as a rule strongly radially ribbed or striate ; *or* each valve with a pair of large teeth one on each side of the ligament nodule, right valve attached, shell less regular (fig. 16 a-c). 12

10. Shell rounded, only a little irregular, inclined to be translucent and more or less irridescent, umbo not projecting beyond hinge margin (fig. 16 d-e) ... ... ANOMIIDAE, p. 41.

— Shell not rounded ; *or* thick and stony and very irregular. 11

11. Attached by byssus or not at all, both valves being free, hinge margin (except in *Vulsella*) straight with umbo not projecting beyond it (fig. 15 c-d) ... ... ISOGNOMONIDAE, p. 37.

— Attached by left valve, umbo projecting beyond hinge margin, making it more or less rounded or angular (fig. 16 f) ... ... OSTREIDAE, p. 41.

12. Hinge margin straight and mostly rather long, produced on either side as a rule into a pair of "ears" below which the shell is usually more or less circular. Colour usually pinkish or mottled ... ... PECTINIDAE, p. 39.
— Hinge margin short, without definite "ears," more or less projecting in middle, shell higher than long, colourless. LIMIDAE, p. 41.

13. Shell irregular and very thick, often ornamented with elongate lamellae or spines, attached by one valve, usually the left (fig. 19 b) ... ... CHAMIDAE, p. 46.
— Not as above 14

14. Shell with valves equal or practically so and hinged together, more or less triangular, round or ovate, almost always with from one to three cardinal teeth immediately below the umbo, with or without lateral teeth (Heterodonta, figs. 13, 20, etc.) 15
— Shell more variable in form, often strongly inequivalve or greatly reduced, sometimes supplemented by a calcareous tube much larger than itself (Adapedonta and Anomalodesmata) 26

15. Ligament more or less internal but linear, not concentrated into a compact nodule. Shell round, at least moderately and often greatly inflated, usually very thin, hinge teeth often rudimentary or absent (fig. 19 a). Foot vermiform ... ... UNGULINIDAE and LUCINIDAE, p. 44.
— Not as above 16

16. Ligament without internal nodule 17
— Ligament with internal nodule lodged in a more or less triangular cavity just behind cardinal teeth 23

17. Umbo very large and forwardly inrolled (fig. 17 d) ... ISOCARDIIDAE, p. 44
— Umbo normal 18

18. Anterior cardinal teeth mostly reduced, posterior 2 on right valve and 1 on left very long and oblique; laterals rudimentary; shell mostly with strong radial ribs (fig. 17 b) ... ... CARDITIDAE, p 44.
— Not as above 19

19. Shell rounded and almost invariably radially ribbed, teeth alike on the two valves, both anterior and posterior laterals well developed and widely separated from cardinals (fig. 19 c-d) ... ... CARDIIDAE, p. 46.
— Not as above 20

20. Shell regular, somewhat convex, never gaping, usually thick, pallial sinus small or absent ... LIBITINIDAE and VENERIDAE, pp. 44 and 47.
— Pallial sinus deep, often more or less fully united with the lower part of the pallial line, shell somewhat flattened and usually somewhat thin, sometimes gaping 21

21. Shell more or less definitely triangular with umbo behind middle (fig. 21 f) ... ... DONACIDAE, p. 56
— Shell not (or less definitely) triangular 22

22. Shell much longer than high, moderately convex (fig. 22 a-c) ... ... PSAMMOBIIDAE, p. 57.
— Shell of varied shape, more or less flattened especially when much longer than high (fig. 22 g-j) ... ... TELLINIDAE, p. 59.

23. Pallial sinus absent 24
— Pallial sinus present 25

24. Hinge-plate normal, shell not gaping, usually thick (fig. 17 a) ... ... CRASSATELLIDAE, p. 43.
— Socket for ligament nodule projecting downwards into shell from hinge-plate, shell slightly gaping (fig. 21 e) ... ANATINELLIDAE, p. 53.

25. Pallial sinus broadly open behind ; shell mostly triangular, oval or more elongate (fig. 21 a-d) ... ... MACTRIDAE, p. 53.
— Pallial sinus narrowed behind ; shell mostly round or oval (fig. 22 d-f) ... ... SEMELIDAE, p. 58.

26. Valves normally developed and hinged together in normal fashion, not burrowing in hard material such as wood or coral and without calcareous tubes 27
— Valves protected or embedded in calcareous tubes or in burrows in hard material such as wood or coral, mostly held together by muscles only but sometimes by ligament also, often greatly reduced 31

27. Valves more or less elongate and flattened, equal, gaping at both ends (fig. 23 a-c) ... ... SOLENIDAE, p. 62.

— Not as above, valves often markedly unequal 28

28. Hinge formed by a process of one valve passing under dorsal margin of other with ligament between, inner surface of shell not pearly 29

— Hinge not formed as above, inner surface of shell more or less pearly 30

29. Shell closing completely, usually small but more or less thick, often with concentric sculpture (fig. 23 d) ... ALOIDIDAE, p. 64.

— Shell more or less gaping behind, usually larger and thinner (fig. 23 e-f) ... ... MYIDAE, p. 64.

30. Umbo undivided, shell strong and usually curved, with valves markedly unequal, usually left convex and right flat (fig. 24 d) ... ... PANDORIDAE, p. 66.

— Umbo divided into front and hind parts, shell often fragile and more or less equivalve (fig. 24 e) ... ... LATERNULIDAE, p. 66.

31. Shell free 32

— Shell more or less small with one or both valves embedded in calcareous tube (fig. 24 f) ... ... CLAVAGELLIDAE, p. 66.

32. Ligament present, shell more or less small, always protected either by a calcareous tube or within a burrow in coral or shell (fig. 23 g) ... ... GASTROCHAENIDAE, p. 64.

— Ligament absent 33

33. Valves well developed, accessory plates present (fig. 24 a-b). PHOLADIDAE, p. 65

— Valves small and somewhat rudimentary, enclosed in a large calcareous tube (fig. 24 c) ... ... TEREDINIDAE, p. 66.

TAXODONTA (= PROTOBRANCHIA + ARCACEA).

Nuculidae.

Shell small, pearly ; animal protobranch[1] with ventrally flattened foot and open mantle without siphons.

Two species of *Nucula* live in Rayapuram Bay. *N. mitralis* (fig. 14 a) is a somewhat triangular shell with a row of low tubercles on the dorsal margin of each valve and the ventral

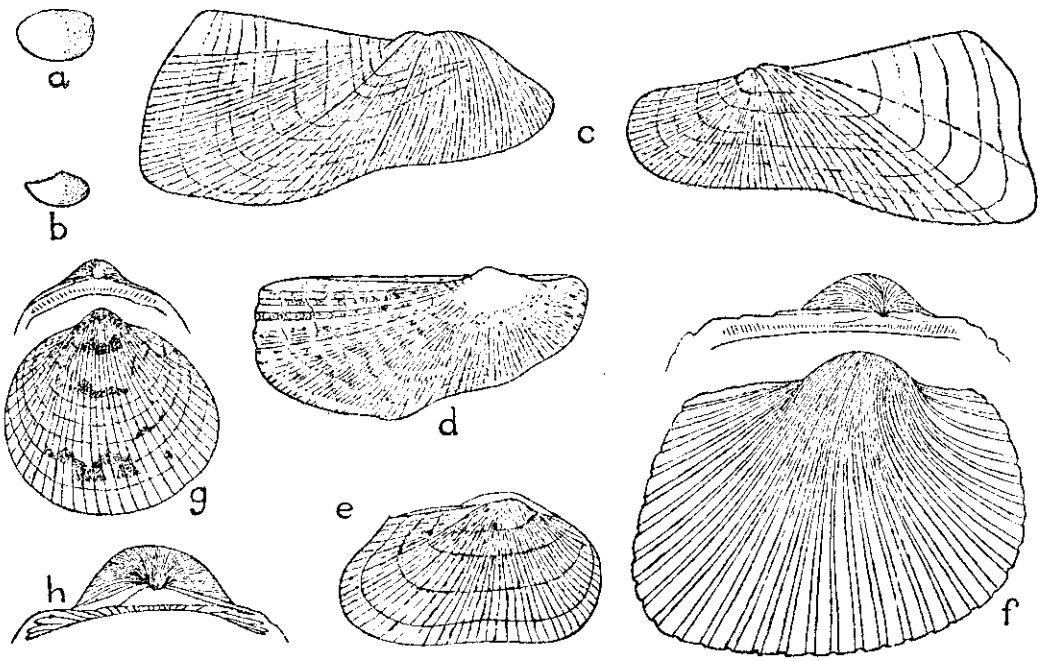

FIG. 14.

BIVALVE SHELLS (Ark Shells, etc.).

a. *Nucula mitralis.*
b. *Nuculana mauritiana.*
c. *Arca tortuosa,* right and left valves.
d. *Arca ventricosa.*
e. *Arca complanata.*
f. *Arca inaequivalvis.*
g. *Glycimeris taylori.*
h. *Arca concamera.*

margin finely radially striate inside, the striae appearing as fine teeth externally. The other species, which I have not been able to identify, is less common. It is a somewhat rounder shell with both dorsal and ventral margins smooth.

Nuculanidae (= Ledidae).

Shell small, not pearly ; animal protobranch,[1] with ventrally flattened foot and siphons.

Nuculana mauritiana (fig. 14 b) is a tiny shell which is rounded in front, produced and pointed behind and ornamented with fine concentric striation.

[1] *i.e.*, with simple feather-like gills, filaments of which are neither folded nor united together.

Ark Shells (Arcidae).

Shell not pearly, almost always radially ribbed or striate, covered in life with a horny skin that is usually dark brown or blackish and more or less hairy, hinge practically straight with numerous simple linear teeth. Animal filibranch[1] with normal foot and usually a simple byssus, its mantle open.

The Madras species of *Arca* may be distinguished from one another as follows.—

1. Outermost teeth of hinge more or less obliquely transverse 2
— Outermost teeth longitudinal, shell only slightly longer than high, radially striate but not strongly ribbed, attachment of posterior adductor muscle forming a conspicuous internal ledge ... ... *A. concamera* (fig. 14 h).

2. Shell strongly twisted, elongate, opposite valves markedly dissimilar ... ... *A. tortuosa* (fig. 14 c).
— Shell not twisted 3

3. Ribs more or less fine,[2] sometimes tending to disappear, ends of upper margin often rounded especially the front one, keel from umbo to hind part of lower margin never present 4
— Ribs broader, *or* keel from umbo to hind part of lower margin present ; ends of upper margin always angular. 6

4. Shell very narrow in front, very broad behind, sculpture often more or less obsolete ... ... *A. obtusoides.*
— Shell more broadly rounded in front, sculpture somewhat stronger 5

5. Shell with upper angles more or less rounded, especially the front one, distinctly narrower in front than behind; long double scar present inside from umbo to upper part of hind margin, very conspicuous in fresh specimens ... *A. lateralis.*
— Shell very variable in its proportions and more or less irregular in shape, both upper angles more or less angular, not as a rule much broader in front than behind, scars normal .. .. *A. complanata* (fig. 14 e).

[1] *i.e.*, with the gill filaments bent and united together only by interlocking tufts of cilia to form a folded sheet.

[2] This is unfortunately not very well brought out in the figure of *A. complanata.*

6.	A more or less distinct keel extending from umbo to hind part of lower margin, shell considerably longer than high.	7
—	No such keel present *or* shell about as high as long ...	9
7.	Shell very small, front margin rounded with slightly obtuse upper angle, hind margin oblique with strongly obtuse upper angle, umbones not very widely separated, ribs fine but strong and regular	*A. symmetrica.*
—	Shell growing much larger, umbones very widely separated by a broad hinge area, ribs coarser or less regular...	8
8.	Hinge moderately long, shape of shell somewhat variable, front margin rounded or oblique, with slightly obtuse upper angle, hind margin oblique usually with strongly obtuse upper angle, position of umbo variable and sometimes almost central, shell not striped	*A. avellana.*
—	Hinge very long, front margin oblique with acute upper angle, hind margin excavate with acute, or almost straight with rectangular upper angle, shell striped ...	*A. ventricosa* (fig. 14 d).
9.	Ribs on front part of shell double, hinge area broad ...	10
—	All ribs simple	11
10.	Shell very long and narrow, more or less irregular with concave lower margin, ribs at both ends more or less distinctly composite	*A. bistrigata.*
—	Shell deeper and very large, perfectly regular and without concavity in lower margin, ribs at hind end simple ...	*A. gubernaculum.*
11.	Shell fully twice as long as high, hinge area narrow ...	*A. indica.*[1]
—	Shell much less than twice as long as high	12
12.	Umbo much nearer front than hind end, ribs flattened and without transverse ridges	*A. inaequivalvis* (fig. 14 f).
—	Umbo more or less central, ribs more rounded or ornamented with transverse ridges	13
13.	Shell almost always longer than high, umbo broadening rapidly from apex, very broad as seen from above, ribs strong with strong transverse ridges, shell very thick and heavy	*A. granosa.*
—	Shell about as long as high, umbo narrower	14

[1] This species is very similar in shape to *A. gubernaculum*, but does not grow to nearly so large a size, has a narrower hinge area, and the hinge and lower margins more divergent behind, as well as having all its ribs simple.

14. Area between hinge and other margins somewhat longer than high, ribs coarse, a more or less distinct keel present from umbo to hind end of lower margin, shell thick and heavy ... ... *A. rhombea.*

— Area between hinge and other margins about as long as high, ribs finer, no keel from umbo, shell much thinner and lighter and somewhat smaller ... ... *A. pilula.*

Arca complanata and *A. lateralis* live in the harbour, *A. symmetrica* below the concrete blocks beside the harbour entrance and *A. avellana* (more rarely) in both places, but these three species seem rarely if ever to get washed on to the beach where alone the remaining species are found. Most of these are abundant but not all, and of *A. ventricosa* only a single much worn valve has been found.

Glycimeridae.

This family differs from the last in having the hinge strongly curved and in having no byssus.

Somewhat faintly ribbed, round, whitish shells more or less blotched with brown, of the species *Glycimeris taylori* (fig. 14 g) are often found on the beach. A species with flattened, strong and widely separated ribs and somewhat darker colour also occurs, though much more rarely, but I have been unable to identify it.

ANISOMYARIA (= FILIBRANCHIA + OSTREACEA—ARCACEA).

Mussels and Date Shells (Mytilidae).

Umbo at or near anterior end, which is often pointed; equivalve, often elongated; anterior adductor muscle rarely altogether absent, sometimes well developed.

This family, to which the term *mussel* is applied in its narrower sense though often also used for lamellibranchs generally, is represented by four genera: *Mytilus* in which the umbo is terminal, *Modiolus* in which the umbo is more or less definitely subterminal, *Septifer* which has an internal plate in the angle of each valve, and *Lithophaga* (=*Lithodomus*) the date-shell, a burrowing form with the shell elongate and rounded at both ends like a date fruit.

Only one species of *Mytilus* is found, a large green mussel of somewhat variable shape, *Mytilus viridis* (fig. 15 a).

There are at least four species of *Modiolus*. *M. auriculatus* is a comparatively large species which is likely at first sight to be confused with the preceding genus on account of its thick shell with umbo very close to the apex. It lives in the harbour in large numbers together with *Mytilus viridis* from which it can, however, readily be distinguished by its shorter and relatively broader shell of a dark brown or black colour covered with thick hair

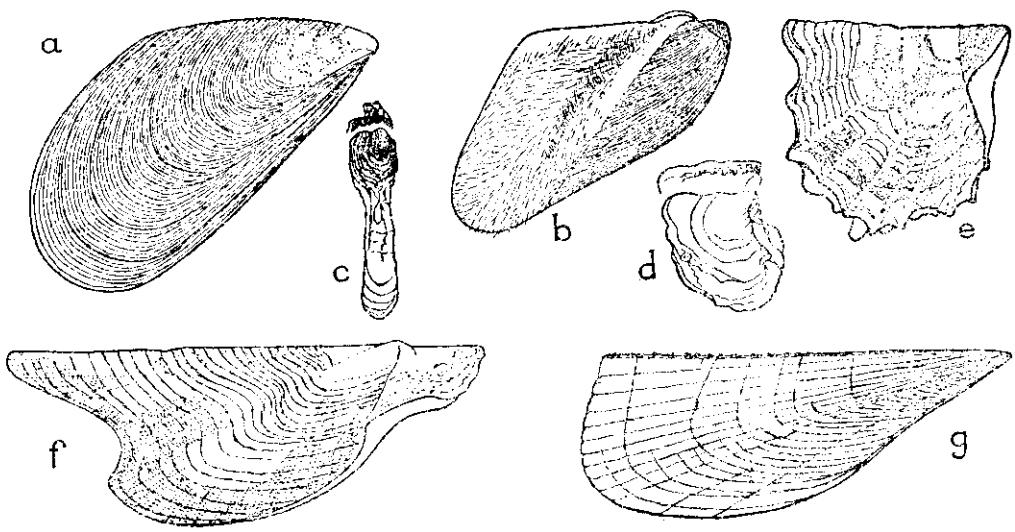

FIG. 15.

BIVALVE SHELLS (Mussels, Pearl Oysters, etc.).

a. *Mytilis viridis.*
b. *Modiolus metcalfei.*
c. *Malleus ? albus* young.
d. *Isognomon nucleus.*
e. *Pteria chemnitzii.*
f. *Pteria chinensis.*
g. *Pinna pectinata* (very young).

when fresh. It varies greatly in relative thickness, a common flattened form being perhaps a distinct variety, though this seems doubtful. *Modiolus metcalfei* (fig. 15 b) is also hairy in life but has the umbo well behind the apex. It is a thinner but often moderately large, unsculptured shell impressed only by its growth lines, but often with a whitish anterior and purplish posterior longitudinal band extending side by side obliquely from the umbo to the margin. *M. undulatus* and *M. striatulus* are both very much smaller and, though readily distinguishable from one another as a rule, are so variable and sometimes approach each other so closely that it seems best to quote here the distinctions recorded by Annandale and Kemp after a careful examination of extensive material from the Chilka Lake in Orissa. As compared with *M. undulatus* the shell of *M. striatulus* " is always more opaque and as a rule much more deeply pigmented, the pigment being of a duller shade. The upper margin is as a rule less strongly elevated and more evenly arched, the proportional depth of the shell being therefore less. The postero-dorsal margin is as a rule more declivous and the posterior extremity more narrowed and less strictly horizontal. In a large number of shells the ventral margin is boldly excavated or emarginate. Radial ridges, which are exceptional in *M. undulatus* are usually present ; but the anterior margin is sometimes quite smooth." They note that in the Chilka Lake *M. undulatus* was almost invariably found attached to slender plants or ropes that could sway freely in the water, whereas *M. striatulus* was

usually found attached to posts, stones or other solid objects. In Madras *M. striatulus* seems mostly to be found attached to solid objects in the harbour and *M. undulatus* to come from the backwaters. The former seems to me ordinarily to have the umbo closer to the apex than the latter. Two specimens collected by Mr. Crichton, with broad umbo from which a more or less definite convex ridge extends obliquely backwards, may possibly be distinct, but in view of the great range of variation found in *M. striatulus* it is impossible without further material to be sure that they may not be a form of that species. They closely resemble Reeve's figures of *M. arcuatulus.*

Septifer bilocularis is a moderately large and very solid shell occasionally found with the two preceding genera in the harbour. It is almost as large as *Modiolus auriculatus* but greener in colour, thus approaching *Mytilus viridis*, but can at once be distinguished from both by its strong fine and close radial sculpture.

Small specimens of a somewhat pale brown species of date shell, *Lithophaga cumingiana*, considerably tapered behind, can be dug out from their burrows in a coral (*Pocillopora*) found in the harbour. A single very small specimen was found to have burrowed in the shell of an immense rock oyster dredged from the bottom of the harbour.

Hammer Oysters, etc. (Isognomonidae).

Shell more or less flattened with straight toothless hinge, its ligament with one or several horny nodules.

Isognomon nucleus (fig. 15 d) belonging to a genus with a byssus and with a series of horny nodules in its hinge, is often found on other shells attached to piers in the harbour and on the under sides of stones among concrete blocks in Rayapuram Bay. Superficially it somewhat resembles a more or less minute flattened oyster. The outline of the shell, particularly its lower part, shows great variation and is often considerably elongated. The outer surface is more or less scaly, the inner pearly.

In *Vulsella* and *Malleus* the ligament has a single large nodule, but the former has no byssus and a short hinge margin more or less sunk in a groove, and the latter a longer hinge margin not thus sunk and a byssus. Mr. Crichton has a single specimen of the somewhat elongate and finely but somewhat irregularly radially striate *Vulsella vulsella* which he found in a mass of sponge growing in the harbour. It is about 2 inches high and about 1 inch in maximum length, somewhat narrower below.

The remarkable hammer oysters of the genus *Malleus* are represented in the Museum collection by two specimens of *M. albus* said to be from Ennur, and Mr. Crichton has collected a single valve from the beach. From the harbour Mr. Crichton has a single small specimen (fig. 15 c) without any special prolongation of the hinge margin and not unlike Reeve's figure of *M. legumen* but very much smaller, and the Museum has another, somewhat

bigger and with a distinct posterior prolongation of that margin but no anterior one—not unlike Reeve's figure of *M. anatinus* but again much smaller. These are probably early stages in the development of the shell of *M. albus*.

Pearl Oysters, Wing Mussels, etc. (Pteriidae).

Hinge straight and practically toothless, its ligament without definite nodules and somewhat sunk, concavity for byssus present below anterior angle, hind angle often produced, umbo not terminal, at most subterminal.

Pteria chemnitzii (fig. 15 e), belonging to the *Pinctada* or pearl oyster section of the genus, is common. It is an oyster-like shell but not very thick, outside with somewhat widely separated concentric scaly layers varying from different shades of grey to reddish brown and crossed by about half a dozen more or less distinct whitish radiating bands, inside with a beautiful pearly lustre, the hind angle always prominent and usually more or less produced, but much less so in proportion to the height of the shell than in *Pteria s. str.*

The common Indian pearl oyster, *Pteria vulgaris*, is not uncommon in the harbour. It is intermediate in character between *P. chemnitzii* and the much larger and solider blacklip pearl oyster (*P. margaritifera*) sometimes found in Indian seas but commoner in the Persian Gulf, and may perhaps bear somewhat the same sort of relationship to them that the true oysters of the harbour do to the backwater oyster and the rock oyster (below, pp. 41–42), but comes closest to *P. chemnitzii* which it resembles in size and in general shape and colour as well as in the relatively long hinge margin. The hind angle of the upper margin is not as a rule prominent, but may be as much so as in occasional specimens of *P. chemnitzii*, and the outer surface is much more closely scaled, characters in which it approaches *P. margaritifera*.[1]

The *Pteria* (*s. str.*) or wing mussel section of the genus contains less scaly shells with the hind angle definitely and often very greatly prolonged. They live attached by their byssus to sea-fans and are sometimes washed up on the beach. Madras specimens (fig. 15 f) seem all to belong to a single species, variable both in shape and in colour, usually reddish, sometimes yellowish brown, with long or short prolongation of the hind angle, and the front angle sometimes produced and either truncate or pointed. The species has been described under various names but *chinensis* seems to have priority over all others.

Feather Shells (Pinnidae).

Shell large and somewhat thin, pointed in front with umbo terminal. Hinge toothless, with ligament long and sunk in a groove in the edge of each valve, devoid of nodules.

The single genus of this family, *Pinna*, is divided into three sections, of which two are found in Madras, *Pinna s. str.* with, and *Atrina* without, a medial groove on the inside of

[1] For further discussion of these species see Prashad and Bhaduri, "The Pearl Oysters of Ind an Waters" (*Rec. Ind. Mus.* XXXV, 1933, pp. 167-174).

each valve from the pointed front end to the scar of the posterior adductor muscle, a groove usually indicated on the outer surface by a more or less distinct ridge in the same position. The two species commonly found on the Madras beach both belong to the latter group. *P. pectinata* (fig. 15 g) is a thin pale shell in which the hind margin is practically straight and approximately at right angles to the upper and lower margins, the hind parts of which are approximately paralled to one another. *P. vexillum* is a thicker and darker shell with the upper and lower margins, which may be either straight or concave, divergent throughout and the hind margin curved. Much rarer are *P. attenuata* and *P. incurva* of the *Pinna, s. str.* section, with upper and lower margins divergent throughout and hind margin curved, but longer and more slender shells than *P. vexillum.* Mr. Crichton has two specimens of the former from Madras. The latter I have not seen, but it has been recorded from Ennur by Mr. Winckworth.

Scallops, etc. (Pectinidae).

Hinge margin moderately long, without true hinge teeth, ligament with a medial nodule in a groove and often triangular. Shell usually brightly coloured, and as a rule radially ribbed.

Amussium pleuronectes, the sun and moon shell, is so called from its rounded form and smooth polished surface, the left valve being flesh-coloured and the right one pure white. Though smooth externally both valves are radially ribbed inside. Mr. Crichton records it from fishing nets off Tiruvamur, adults arriving in February and young being present from March to June.

By far the commonest scallop of the Madras coast is, however, *Pecten tranquebarius* (fig. 16 a) with both valves moderately convex, sometimes of a uniformly yellowish colour throughout but usually decorated with a somewhat irregular but sharply defined pattern of reddish brown on a pure white ground, the radial ribs well separated and strongly elevated, the hinge margin more prolonged in front of the umbo than behind. Allied to it but much rarer are *P. crassicostatus* and *P. splendidulus.* Both have a less sharply defined pattern, pinker in the former and redder (bleaching to pink or orange in somewhat worn specimens which alone have been found in Madras) in the latter, and both have the ribs rougher (the latter almost spiny) when fresh and less sharply separated, especially in the latter which is somewhat more elongated than either of the other two. They are so closely related that faded shells cannot always be separated with certainty. In *Pecten histrionicus* and *P. pyxidatus* the left valve is practically flat and the right convex, in the latter very strongly so. In the former the ribs are widely separated and alternate ones often more deeply marked with red than those between them. In the latter the flattened left valve has well separated narrow ribs and the convex right valve broad and closely set ones.

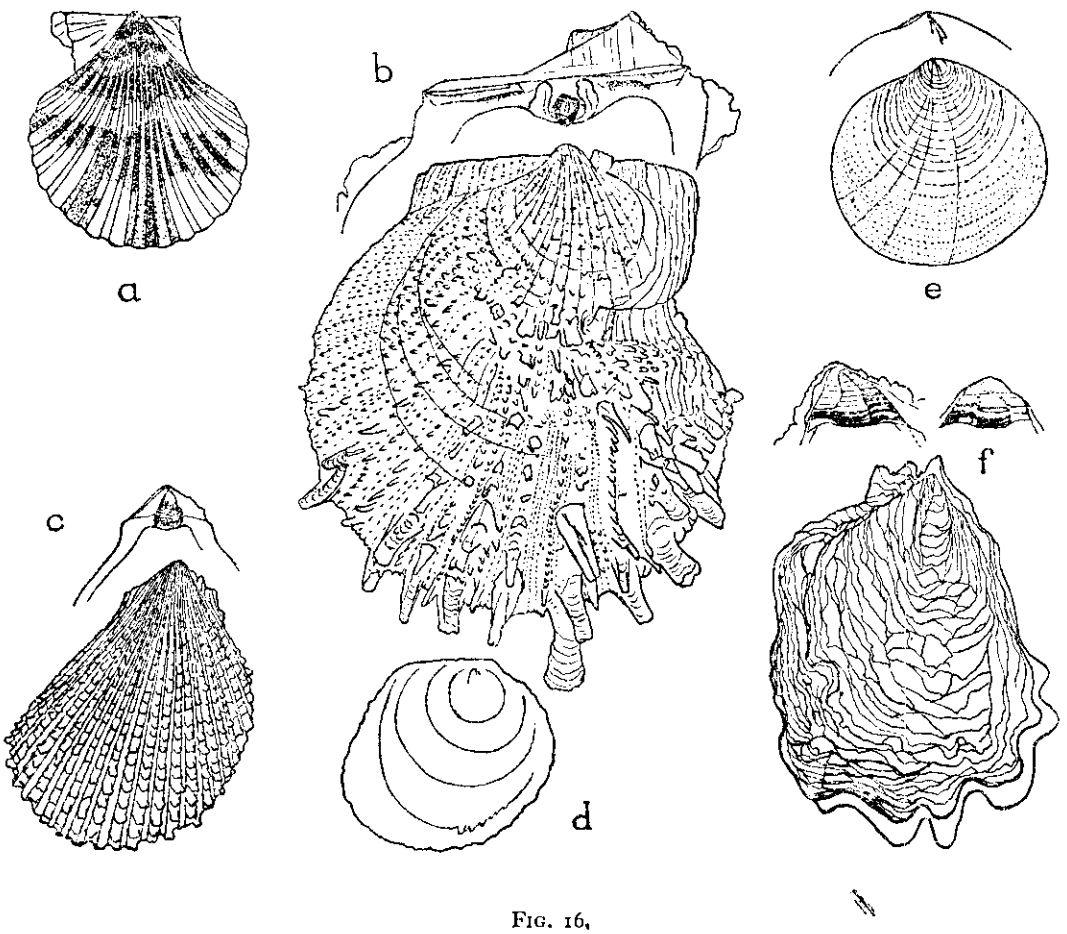

FIG. 16.

BIVALVE SHELLS (Scallops, Oysters, etc.).

a. *Pecten tranquebarius.*
b. *Spondylus layardi.*
c. *Lima lima.*
d. *Anomia achaeus.*
e. *Placenta placenta.*
f. *Ostrea madrasensis.*

Amussium and *Pecten* are free-swimming and have perfectly regular shells. The two remaining genera of the family live attached by the right valve and their shells are apt to be more or less irregular, especially those of *Spondylus* which alone are common. In both there is a pair of stout teeth in each valve. *Spondylus layardi* (fig. 16 b) is a large pinkish shell decorated with radiating lines of spines, often large and flattened, on the left valve and with concentric frills on the right. It is often found in a more or less worn condition on the beach and living specimens can be obtained from piers in the harbour though they are not very common. Two small whitish specimens of *Plicatula* (right valve only), in which the shell is thrown into radial folds, have been found on the beach by Mr. Crichton.

Limidae.

Shell colourless, higher than long, mostly ovate, radially ribbed, the ribs often transversely frilled or nodular.

Lima lima (fig. 16 c) is not uncommon on the beach and is occasionally found alive in the harbour. *L. fragilis*, a flatter and thinner shell with finer, closer and more numerous ribs, is occasionally found on the beach.

Window-Pane Oysters, etc. (Anomiidae).

Valves unequal, rounded, often more or less translucent, young shell attached by byssus passing through deep cleft in right valve which in adult either closes to form a circular perforation (*Anomia*) or disappears together with byssus leaving shell unattached (*Placenta*).

In *Anomia* the left valve is somewhat irregular and completely covers the right, which is much thinner and closely approximated to the substratum. In *Placenta* the two valves cease at an early stage to differ much from one another in general appearance. The former genus is represented by a single very variable species, *A. achaeus* (fig. 16 d), which can be found alive on other shells in the harbour and of which the somewhat irridescent brownish left valve is often washed ashore. The latter is represented by the common window-pane oyster *P. placenta* (fig. 16 e), which may grow to as much as 5 or 6 inches across and is sufficiently translucent to be extensively used in China for windows.

True Oysters (Ostreidae).

Valves dissimilar and more or less irregular, the left one firmly united to some support. Hinge toothless with a more or less distinct triangular groove for ligament nodule.

Two kinds of oyster are common at Madras, the backwater oyster, *Ostrea madrasensis* (fig. 16 f) and the rock oyster, *O. forskalii*. In the latter the margin of the shell is thrown into a series of folds, those of one valve interlocking with those of the other. In the former such folds are absent and if the margin develops processes somewhat resembling them they are opposite each other instead of alternating so as to interlock. On concrete blocks outside the harbour the rock oyster is found singly in its most typical form, and in certain places, apparently those where it is specially exposed to violent wave action, its marginal folds are sometimes elongated as in the cockscomb oyster, *O. crista-galli*, seeming to indicate that this may perhaps be only an adaptational variety, not a separate species, though completely typical specimens have not been seen.

The backwater oyster, like most inhabitants of brackish water, seems to be particularly hardy and well adapted to withstand adverse conditions, but under marine conditions it is unable to compete successfully with the rock oyster and, though the massive fringe of oysters that extends along the harbour arm between tide marks contains both, the former is much less numerous than the latter and confined to the upper part which is longest exposed when the

tide falls. On the wooden piers of the quay the two species occur in more nearly equal numbers, and the marginal folds characteristic of the rock oyster are apt to be so imperfectly developed that occasional specimens are found regarding which it is impossible to be sure of the species. This is more or less the case in the Ennur backwater also, but there the rock oyster is comparatively scarce. Presumably, therefore, the two are derived from a single ancestral species and are not yet completely separated. The following two characters sometimes help a decision in cases where identification is in doubt. The margin of the backwater oyster is often, but by no means always, much thinner than that of the rock oyster and, as thick margins seem more often to bear an internal line of tubercles than thin ones, these are more often present in the latter than in the former. But this is a very variable character and in one rock oyster from the harbour in the Museum collection they are very strongly developed all round the free valve though absent from the fixed one. In fresh specimens the colour of the inner surface tends to be suffused by a greenish tint in the rock oyster but in the backwater osyter to be pure white, often with purplish black showing through in places, particularly in the muscle scars.

The larvae sometimes attach themselves to small shells such as *Cerithidea* and *Nerita*, on which the oysters have then to develop, and both species have been found on *Cerithidea* at Adyar. When they grow thus from a very small base the fixed valve tends to become deeply cup-shaped, particularly in the rock oyster in which the cup is thrown into broad radial folds which give the shell a distinctive appearance though actually they are only extensions of the marginal folds characteristic of the species. Under suitable conditions oysters may grow to a very large size and Mr. Crichton has presented the Museum with a specimen of the rock oyster nearly 9 inches high by 8 inches long and very thick, which was dredged up by the Port Commission's dredger from the bottom of the harbour.

A small and very different looking oyster is represented by two specimens each attached to a *Meretrix* shell, one in the Museum collection and one in Mr. Crichton's, and by a single very young specimen attached to a *Cerithidea* shell from the Adyar backwater in the latter collection. It is brownish in colour and comparatively smooth, with a strongly curved umbo. They closely resemble Reeve's figures of *O. denticulata* and *O. lentiginosa*, Mr. Crichton's larger specimen agreeing with the former in having, and the others with the latter in not having, a line of marginal tubercles—a character which as already pointed out is of very doubtful value. None of them show the internal spots figured by Reeve as characteristic of *O. lentiginosa*, a species recorded by Preston from the Chilka Lake of the Orissa coast. But these spots may also be variable. In view of the shells to which they are attached it is clear that all three specimens are from backwaters, and a special search for more has kindly been made at Ennur by Mr. Giriappa of the Fisheries Department biological supply depot there, with the surprising result that a small number of what appear to be otherwise normal specimens of both the backwater androck oysters prove to have near

the umbo the characters common to *O. denticulata* and *lentiginosa*, and have therefore presumably developed from shells of this type and of about the same size as the two larger specimens described above, thus raising problems outside the scope of this paper. I have to thank Mr. Giriappa for his help in collecting for me an excellent selection of the different kinds of oysters found at Ennur, and Dr. Sundara Raj for permitting this.

Two other young backwater oysters from Ennur recently collected for the Museum are also of special interest. One is attached to the flattened upper surface of *Conus figulinus*, the spiral markings of which are clearly reproduced on the outer surface of the upper valve, exactly continuous with their exposed portions, though they are not visible on the inner surface of the attached valve. The other is attached to the body whorl of *Gyrineum natator*, the sculpture of which is clearly visible in both valves. In neither case can the sculpture reproduced on the upper valve be due to mechanical causes such as pressure in view of the soft flesh between the valves.

EULAMELLIBRANCHIA (EXCL. OSTRAEACEA BUT. INCL. SEPTIBRANCHIA OF PELSENEER).

Crassatellidae.

Umbo angular, ligament internal, shell often concentrically grooved. Left valve with two teeth enclosing between them the cardinal tooth of the right valve, a weak tooth in front of them and a more or less rudimentary one behind, often grooved; lateral teeth scarcely developed. Pallial line without sinus.

This family is rare at Madras, but Mr. Crichton has a single valve of *Crassatella radiata* (fig. 17 a) which he found here and a few of *C. rostrata*, the latter a much larger shell of somewhat similar shape but without concentric sculpture, faint radial sculpture being sometimes present instead.

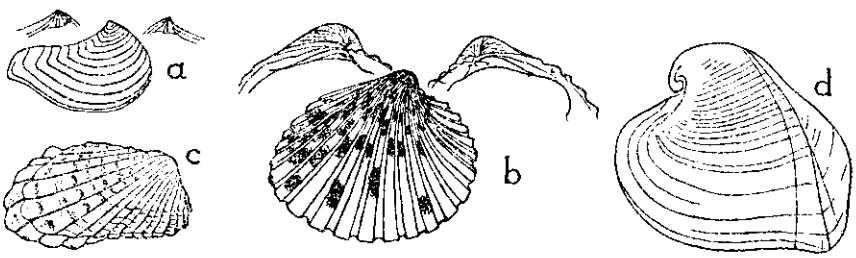

FIG. 17.

BIVALVE SHELLS (False Cockles and others).

a. *Crassatella radiata.*
b. *Cardita bicolor.*
c. *Beguina variegata.*
d. *Isocardia vulgaris* (left valve).

False Cockles (Carditidae).

Cardinal teeth almost always grooved so as to form one small anterior, and on the left valve one and on the right two very long oblique posteriors, the anterior inclined to be rudimentary, especially on the right valve, lateral teeth also usually rudimentary. Ligament as a rule external. Shell usually without pallial sinus, somewhat thick and with strong radial ridges.

The genus *Cardita*, in which the shell is more or less round with the umbo in the middle of the hinge margin, is represented by the common *C. bicolor* (fig. 17 b). The genus *Beguina*, in which the shell is much longer than high with the umbo in front, is represented by *B. variegata* (fig. 17 c).

Isocardiidae.

Umbo very large and forwardly inrolled, smooth or with concentric ridges. Ligament external. Each valve with two parallel and sometimes bifurcated cardinal teeth and a long lateral tooth behind and sometimes rudimentary lateral teeth in front. Pallial line not sinuate.

Mr. Crichton has collected a single valve of *Isocardia vulgaris* (fig. 17 d).

Libitinidae.

Shell more or less elongate with umbo towards front, each valve with two cardinal teeth and one more or less elongate posterior lateral tooth, a short anterior lateral tooth present on left valve.

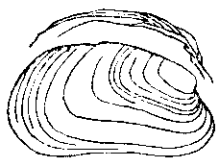

FIG. 18.
BIVALVE SHELL, *Libitina vellicata*.

Libitina vellicata (fig. 18) is a whitish shell, often more or less distinctly rayed with purplish markings, apparently common in cavities of the oyster belt on the harbour arm but not easily found. It is variable in shape and proportions, usually more or less constricted a little behind the lower front angle, and is apt to appear somewhat irregular in form.

Bladder Shells (Ungulinidae and Lucinidae).

Shell inclined to be convex, rounded and usually very thin, hinge teeth often reduced, umbo small, scar of anterior adductor continuous with pallial line and more or less long and narrow.

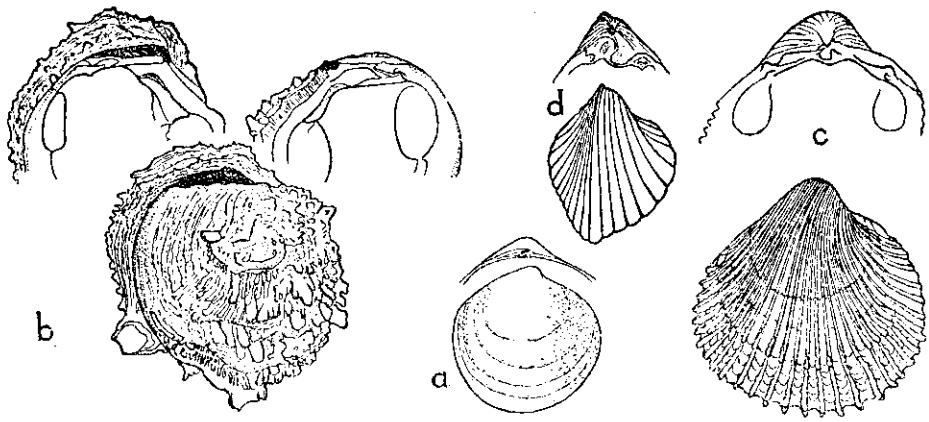

FIG. 19.
BIVALVE SHELLS (Cockles and others).

a. *Diplodonta globosa.*
b. *Chama reflexa.*
c. *Cardium coronatum.*
d. *Lunulicardia retusa.*

Of the six species of bladder shell found two, both of the genus *Diplodonta*, belong to the family Ungulinidae, and the other four to the Lucinidae. All except *Phacoides macassari*, which was dredged by Mr. Crichton in about 8 or 10 fathoms in the sea, were found together, washed up on the sandy northern shore of the Ennur backwater. These five are typical bladder shells, whereas the *Phacoides* is a thicker shell with strong sculpture.

The species may be distinguished thus.—

1. Hinge with well-developed teeth (fig. 19 a) 2
— Hinge toothless ... ... (*Lucina*) 5

2. Shell marked by growth lines only ... ... (*Diplodonta*) 3
— Shell more or less strongly sculptured 4

3. Front end of shell slightly narrowed and produced, hind end slightly flattened, size moderate ... ... *D. globosa* (fig. 19 a)
— Shell more symmetrically rounded, size smaller ... ... *D. nevilli.*

4. Strong concentric ridges present, with radial sculpture in the broad interspaces ... ... *Phacoides macassari.*
— Sculpture very much weaker, radial dominating concentric. *Codakia angela.*

5. Growth lines very pronounced, front upper angle somewhat more prominent owing to slightly greater prolongation of upper margin, hinge very narrow. White, moderately large ... ... *Lucina edentula.*
— Smoother, smaller, somewhat rounder and more yellowish, hinge thicker with cavity for attachment of elongate ligament strongly developed ... ... *Lucina ovum.*

Chamidae.

Valves more or less unequal, the left one usually attached, hinge margin thick, its teeth very large. Shell often pinkish in colour and decorated with large processes.

Chama reflexa (fig. 19 b) is common on the wooden piers in the harbour, but seems rarely to get washed ashore. It may easily be confused with *Spondylus* on account of its colour and processes of its shell, but can at once be distinguished by its characteristically toothed and less prominent hinge. It varies enormously—presumably according to the environment in which it settles, for individual clusters tend to be much more uniform —from rose pink shells with beautifully regular lines of processes, to white shells almost without processes, what processes there are being irregular. But there seems to be complete gradation between the two extremes.

Valves of *Pseudochama*, a subgenus in which the left valve is free instead of the right one, are occasionally found on the beach.

Cockles (Cardiidae).

Shell rounded, almost invariably (and usually strongly) radially ribbed, rarely longer than high. Ligament external. Hinge teeth alike on the two valves, cardinals two (of which one is apt to be rudimentary), both laterals present, anterior one often arising from cavity of umbo.

This family is divided into a number of genera often difficult to separate. For the purposes of this paper, it is sufficient to recognize two : *Cardium* with evenly curved shell and *Lunulicardia* with a keel, the latter being represented by a single species *L. retusa* (fig. 19 d).

The Madras species of *Cardium* may be identified thus.—

1. Ribs more or less obsolete at least towards middle of shell which is glossy, purplish when young, when older clouded or netted with pale brown, inclined to be purplish towards umbo ... ... *C. australe.*
— Ribs strongly developed throughout 2

2. Ribs very numerous and close together, shell higher than long ... ... *C. oxygonum.*
— Ribs less closely set ; *or* shell not higher than long 3

3. Shell much higher than long, pinkish when fresh, middle ribs very strongly keeled ... ... *C. assimile.*
— Shell not much higher than long 4

4. Shell rounded, ribs keeled and well separated 5
— Shell longer than high, ribs flattened and close together, each with a line of spines when fresh .. .. *C. setosum.*

5. Shell thick, not ribbed internally, hinge teeth stout, all ribs strongly crested in fresh specimens ... ... *C. coronatum* (fig. 19 c).
— Shell thin, strongly ribbed internally except when young, hinge teeth thin, only the hind ribs strongly crested in fresh specimens ... ... *C. asiaticum.*

Cardium coronatum and *C. asiaticum* are the two commonest species, followed by *C. oxygonum* and *C. setosum.*

Clams, etc. (Veneridae).

Shell regular, not gaping, often with well defined lunule. Hinge with three cardinal teeth, often with an additional tooth in front on the left valve and a hollow on the right, edges of this hollow bearing tooth-like processes. Pallial line mostly with a more or less definite sinus.

The Madras genera of this immense family may be separated thus.—

1. Right and left sides of hinge differing as above; *or* with cardinal teeth only 2
— Both valves with a sharply defined triangular cavity immediately in front of the cardinal teeth ... ... *Clementia, p.* 53.

2. Pallial line scarcely or not at all sinuate 3
— Pallial line with well-developed sinus[1] 5

3. Shell flattened, with concentric sculpture only ... ... *Circe, p.* 48.
— Shell inflated 4

4. Lunule flattened, distinct, shell concentrically and often also radially sculptured ... ... *Gafrarium, p.* 48.
— Lunule not flattened, obsolete, shell almost always smooth and glossy ... ... *Meretrix, p.* 50.

[1] The little round and delicately concentrically crested *Venus calophylla* forms an exception, being without any trace of a pallial sinus—though belonging to a genus that ordinarily has one. In its subgenus *Clausinella* the sinus is always very small.

5. Shell smooth except for growth ridges ; *or* with concentric grooves separating broad flat bands. Tooth on left and hollow on right valve in front of cardinal teeth well developed 6
— Tooth on left and hollow on right valve in front of cardinal teeth absent ; *or* shell finely or strongly concentrically ridged, the ridges not flat, often crested ; *or* shell radially ridged 7

6. Lunule flat, short and broad, sometimes more or less obsolete ; tooth or hollow in front of cardinal teeth normal. *Pitar, p.* 50.
— Lunule deeply depressed, long and narrow ; tooth or hollow in front of cardinal teeth elongate. ... ... *Sunetta, p.* 50.

7. Shell rounded with small but conspicuous umbo bent strongly forwards, sculpture fine ... ... *Dosinia, p.* 50.
— Not as above 8

8. Sculpture very strong, ridges often crested, shell rounded, tooth or hollow in front of cardinal teeth often reduced or absent ... ... *Venus, p.* 51.
— Tooth or hollow in front of cardinal teeth absent. Sculpture when present light, *or* shell more angular 9

9. Shell angular, usually with crested concentric ridges ... *Venerupis, p.* 52.
— Shell rounded, sculpture light or absent 10

10. Lunule (of both valves together) not more than about twice as long as broad, shell short and more or less inflated, smooth or concentrically ridged, hinge edge often rather thick ... ... *Catelysia, p.* 52.
— Lunule (of both valves together) much more than twice as long as broad, shell usually much more elongate, hinge margin usually thin 11

11. Hind end of shell narrow, rounded ... ... *Paphia, p.* 52.
— Hind end of shell very broad, more or less truncate ... ... *Tapes, p.* 53.

Circe, a genus of flattened shells not unlike *Dosinia* in general form but with more forwardly directed umbo, is represented by a single species, *C. scripta* (fig. 20 a).

Gafrarium is also represented by a single species, the somewhat finely radially and concentrically sculptured brown and white *G. divaricatum* (fig. 20 b).

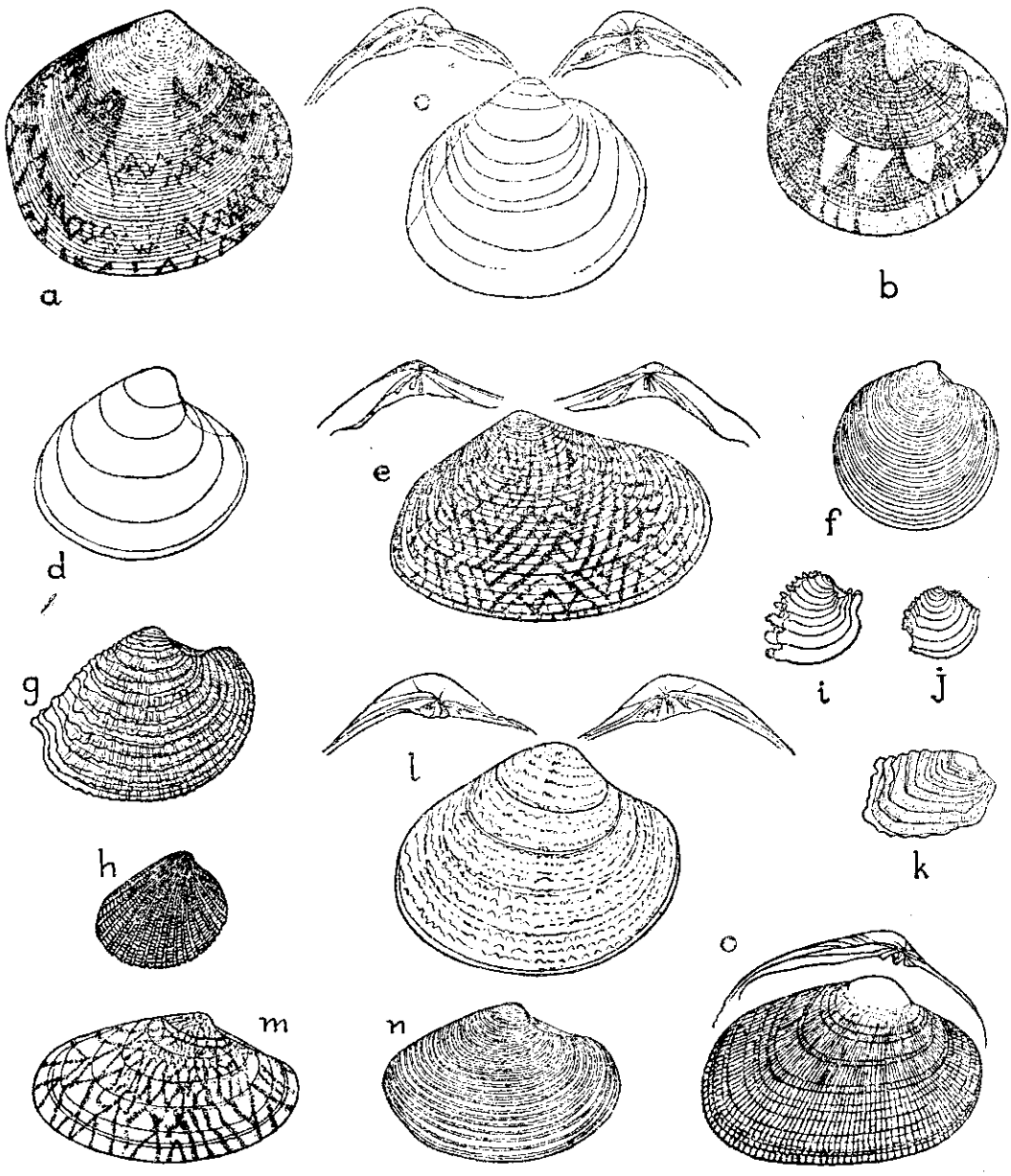

FIG. 20.

BIVALVE SHELLS (Clams).

a. *Circe scripta.*
b. *Gafrarium divaricatum.*
c. *Meretrix casta.*
d. *Pitar alabastrum.*
e. *Sunetta meroe.*
f. *Dosinia prostrata.*
g. *Venus lamellaris.*
h. *Venus imbricata.*
i. *Venus tiara.*
j. *Venus calophylla.*
k. *Venerupis macrophylla.*
l. *Catelysia opima.*
m. *Paphia textile.*
n. *Paphia malabarica.*
o. *Tapes bruguieri.*

Meretrix, the thick shelled backwater clam genus, is represented by the common *M. casta* (fig. 20 c), not more than about two inches long and rarely as much, with a very thick horny skin covering the shell in life, and by the rarer *M. meretrix* which may be as much as three inches long, of which a single valve has been found on the beach at Ennur. *M. meretrix* has in all stages a more polished surface and a thinner horny skin than *M. casta*, and its posterior lateral tooth is relatively longer. The front tooth of the left valve tends to be elongated in young specimens of *M. casta* and possibly in those of other species also. A more elongated form of *Meretrix* shell resembling the common clam of the west coast backwaters [1], which is usually separated from *M. casta* of the east coast under the name *M. ovum*, occurs here rarely and is recorded by Annandale and Kemp as occurring with, and in greater abundance than, *M. casta* in the Chilka Lake (outer channel).

Pitar may exceed even *Meretrix meretrix* in size. *P. alabastrum* (fig. 20 d) is white without definite sculpture. *P. erycina* is light brown with darker radiating bands and has strong concentric grooves somewhat widely spaced.

Sunetta is represented by four species. The common *S. scripta*, which is moderately elongate, and another species rarely found which is only very slightly longer than high differ from the other three in being entirely smooth. The unidentified smooth species is very like Reeve's figure of *S. excavata*.[2] *S. donacina* and *S. meroe* (fig. 20 e) are strongly concentrically grooved, though in well grown specimens of the former the grooves tend to disappear in front and towards the strongly convex lower margin. Small specimens of this species are always uniformly and particularly deeply grooved throughout and have consequently been distinguished under the name *S. effossa*, but the examination of a good series shows that they grow into typical *S. donacina* and cannot be separated from it.[3] *S. donacina* in all its stages differs from the other three species in having its hind end rounded instead of more or less distinctly truncate, while *S. meroe* differs from it and from both the others in being more elongate with the umbo well behind the middle.

Dosinia is represented by two well marked species, *D. excisa* with more or less obsolete and superficial lunule, and *D. prostrata* (fig. 20 f) with the lunule well defined, short and depressed. The latter is variable in detail and is often split into a number of species, which may more conveniently be regarded as varieties for the purposes of this paper. The following occur in Madras : *prostrata, s. str.*, differing from all the others in having the front shoulder short and rounded at least in large shells and the front tooth of the left valve small and

[1] *See* Hornell, "Common Molluscs of S. India" (Madras Fisheries Dept. 1922), p. 184.

[2] Mr. Winckworth tells me that Reeve's *S. excavata* appears to be an endemic Japanese species and that it is not the true *S. excavata* of Hanley which is only authentically recorded from Western Australia.

[3] Mr. Winckworth disagrees and considers *S. effossa* a distinct species ; and so, he tells me, does Fischer who reviewed the genus in detail in 1939 (*Journ. Conchyl.*, LXXXIII, pp. 181–213).

conical instead of small and elongate ; *modesta* with the angle between the lunule margin and posterior cardinal tooth somewhat obtuse ; and *cretacea* with this angle approximately a right angle.

Venus has a larger number of representatives, which may be identified thus.—

1. Radial ridges predominating throughout, shells small ...	2
— Concentric ridges predominating, at least in middle part of shell	3
2. Umbo thrown into prominence by a well defined lunule in front and a similarly depressed but longer, somewhat narrower and more or less ribless area behind	*V. squamosa.*
— Lunule and flat area behind umbo less marked	*V. imbricata* (fig. 20 h).
3. Shell small, with strong radial ribs in front and behind, concentric ridges between	*V. aracana.*
— Shell with concentric ridges predominant throughout ...	4
4. Shell large, inflated, with radial sculpture between the concentric ridges or crests	5
— Shell small, flattened, smooth between delicate concentric crests	6
5. Shell not much longer than deep, lightly shouldered in front of lunule, with low coarsely crested ridges when unworn ...	*V. crispata.*
— Shell more elongate, strongly shouldered in front of lunule, with elegant high crests when unworn	*V. lamellaris.*
6. Ligament margin elevated, decorated with thin plate-like processes, pallial line entirely without sinus	*V. calophylla* (fig. 20 j).
— Ligament margin depressed, concentric crests absent from it, pallial sinus present, more or less acute	7
7. Shell more or less round, its hind and lower margins meeting in a very obtuse angle	*V. sp. nr. tiara.*
— Shell more nearly triangular, its hind and lower margins meeting in about a right angle	*V. tiara* (fig. 20 i).

Venus imbricata is a small shell always washed up on the beach in abundance. *V. squamosa*, which is even smaller, is sometimes to be found living in profusion in the sand beneath shallow water in the backwaters, being collected thus at Ennur in July 1939. The other species are not very common.

Venerupis macrophylla (fig. 20 k), a small shell widely distributed in the Indo-Pacific region, lives in the harbour and is sometimes washed up on the beach. Its whitish colour and delicate concentric crests give it somewhat the appearance of the last few species recorded above in the genus *Venus*, but it is always somewhat (and often much) longer than high with the umbo pointing forwards, and is rectangular or triangular in shape instead of rounded. The crests always form an angle behind but are curved in front. The shape varies greatly, doubtless modified by the shape of the crevice in rock or among oysters, etc. in which the specimen has been living. The specimens collected fall into two groups, one in which the umbo is almost central with the front margin sloping back on either side to a greater or less extent, giving the shell a somewhat triangular shape, and one in which the umbo is situated very far forwards with the front margin consequently straighter, giving the shell a more rectangular shape. But the two are so closely alike in other respects and the shape so variable that I do not think they are likely to be distinct species. The largest specimen obtained is fully half an inch long.

Catelysia opima (fig. 20 l), the only Madras representative of its genus, is a species of backwater clam of about the same size as *Meretrix casta* and about equally abundant, but with a thinner and more richly coloured shell which lacks the anterior tooth of the left valve and the corresponding cavity of the right one. Still thinner but also of about the same size and about equally abundant in the backwaters is the false clam *Mactra mera* belonging to the next family (see below, pp. 54 and 55).

Paphia is represented by five species. *P. marmorata* and *P. malabarica* are short forms, the latter being scarcely twice as long as high and the former often still shorter, whereas the remaining three are all about three times as long as high. *P. marmorata* is a backwater form, more or less distinctly radiately marbled much as in *Catelysia opima* with which it is found, but concentrically grooved. Specimens collected at Ennur in the spring of 1939 are all small and about twice as long as high, almost as in Reeve's figure of "*Tapes*" *lirata* but more broadly rounded behind, some being very strongly grooved. Specimens collected there and at Adyar in the spring of 1940 are much larger, more elongate and less strongly grooved. *P. malabarica* (fig. 20 n) is a marine species, deeply excavate in front of the umbo and altogether more elegantly shaped and more strongly and evenly grooved. Of the three species nearly three times as long as high, all of which have a glossy surface of exquisite texture, *P. ala-papilionis* is distinctly but somewhat lightly concentrically grooved except near the hind margin where it is smooth. *P. undulata* is characterised by a series of faint and somewhat wavy but perfectly distinct grooves that instead of being concentric cross the growth lines obliquely from the front end to the hind part of the lower margin, the upper hind part being without them. *P. textile* resembles the last species so closely as to appear indistinguishable from it at first sight but lacks its characteristic faint wavy grooves, having only faint concentric growth lines.

Tapes bruguieri (fig. 20 o) is somewhat lightly radially ribbed, more strongly behind than in front. A fragmentary specimen of an additional species has been found by Mr. Crichton but has not been identified. It has concentric sculpture.

Clementia papyracea is an extremely thin and fragile shell with concentrically somewhat wavy surface.

False Clams, etc. (Mactridae and Anatinellidae).

Ligament with large internal nodule behind cardinal teeth. Left valve with one cardinal tooth, often bent at an acute angle above or grooved throughout, front and hind side teeth usually present. Right valve, when side teeth are present on left valve, with grooves for their reception which commonly have raised tooth-like edges, always with two cardinal teeth. Shell more or less triangular or oval.

Five genera are represented, all belonging to the family *Mactridae* except *Anatinella*. They may be separated thus.—

1. Pallial sinus present 2
— Pallial sinus absent ... ... *Anatinella*, p. 56.

2. Ligament separated from its nodule by a calcareous ridge : shell more or less triangular (rarely rounded), never greatly elongated ... ... *Mactra*, p. 54.
— No such ridge present ; *or* shell elongated and more or less rectangular 3

3. Shell triangular with strong and sharply defined concentric grooves, socket of internal nodule of ligament not projecting ... ... *Spisula*, p. 55.
— Shell oval, radial grooves when present not sharply defined ; socket of internal nodule of ligament projecting obliquely inwards from hinge margin 4

4. Hind part of upper margin of shell definitely oblique, left valve with side teeth well developed though front one is small and close to cardinal tooth, right valve with grooves for their reception ... ... *Standella*, p. 55.
— Hind part of upper margin of shell more or less parallel to lower margin, side teeth and grooves for their reception more or less obsolete, especially behind ... ... *Lutraria*, p. 56.

The Madras species of *Mactra* may be identified thus.—

1. Shell approximately equilateral or slightly longer behind than in front 2
— Shell distinctly longer in front than behind 9

2. Shell strongly inflated, without keel from umbo to hind end of shell 3
— Shell at most moderately inflated 4

3. Umbo broad and only moderately elevated, front end of shell somewhat more broadly rounded than hind end, shell not attaining a large size ... ... *M. mera* (fig. 21 a).
— Umbo narrower and more strongly elevated, hind end of shell somewhat more broadly rounded than front end, shell attaining a much larger size, sometimes over 3 inches long ... ... *M. turgida.*

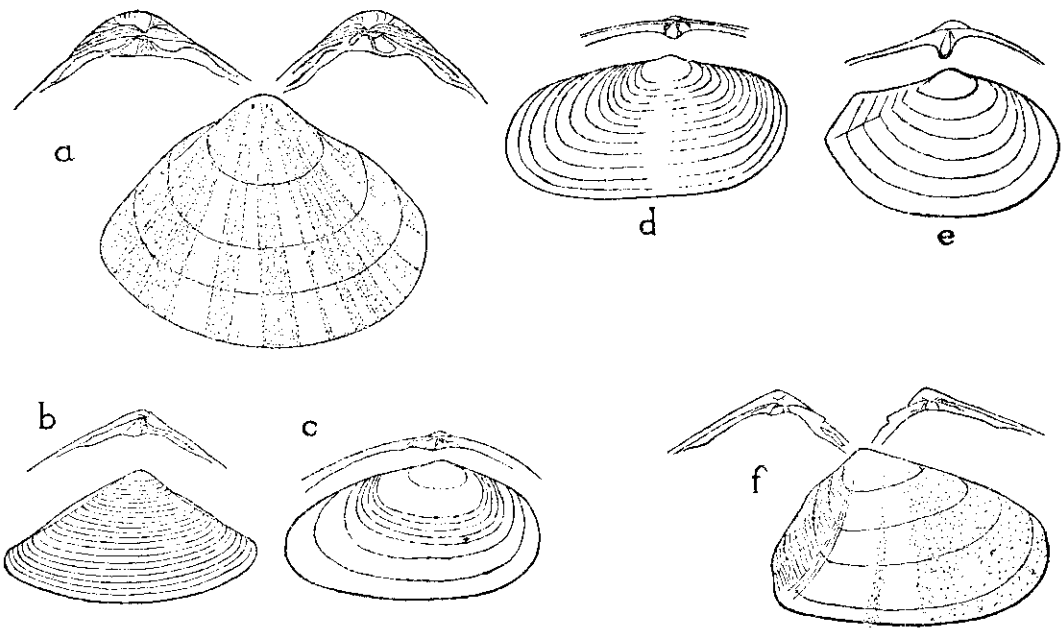

FIG. 21.

BIVALVE SHELLS (False Clams and Wedge Shells).

a. *Mactra mera.*
b. *Spisula triangularis.*
c. *Standella pellucida.*
d. *Lutraria philippinarum.*
e. *Anatinella nicobarica.*
f. *Donax cuneatus.*

4. Shell without distinct posterior keel from umbo	5[1]
— Shell with distinct and as a rule more or less crested posterior keel from umbo	6
5. Shell violet throughout, triangular, moderately inflated.	*M. violacea.*
— Shell pink or mottled with brown, transversely ovate, less inflated	*M. achatina.*
6. Keel from umbo not crested, shell moderately inflated and somewhat elongate	*M. sp.* nr. *dysoni.*
— Keel more or less distinctly crested, shell flatter	7
7 Shell distinctly elongate, not very large, moderately flattened	*M. ? dysoni.*
— Shell less markedly longer than high, greatly flattened ...	8
8. Shell moderately high, whitish with delicate silky brown periostracum when fresh, attaining a very large size ...	*M. complanata.*
— Shell relatively shorter, little longer than high, violet, small	*M. cygnus.*
9. Shell attaining large size, more or less inclined to develop concentric waves especially near umbo and in front, front end moderately elongate	*M. plicataria.*
— Shell much smaller, without wave-like folds, front end distinctly elongate	*M. dolabrata.*

M. violacea has been obtained by Mr. Crichton from the Coromandel Coast, but whether it occurs at Madras seems to be somewhat doubtful. All the others are common except *M. achatina*, of which only a single valve has been found, and *M. ?dysoni*, *M. sp.* nr. *dysoni* and *M. dolabrata* of each of which only two or three specimens have been found. The first agrees fairly well with Reeve's figure and description both of *M. dysoni* (fig. 64) and *M. angulifera* (fig. 83) but seems probably nearer the former and perhaps identical with it. *M. sp.* nr. *dysoni* is a much stouter and more convex shell. The form of *M. plicataria* common at Madras is the one figured by Reeve as *M. laevis*. *M. mera* is the common false clam of the backwaters where it occurs in large numbers and may at first sight be confused with the two true clams *Meretrix casta* and *Catelysia opima*, which it resembles in size and general shape. It is, however, a much thinner shell than even the thinner of them as well as having the Mactrid hinge.

The only species of *Spisula* found is *S. triangularis* (fig. 21 b) and the only *Standella* is *S. pellucida* (fig. 21 c). *Spisula* is found washed up on the beach, *Standella* is found in backwaters.

[1] Traces of the keel are occasionally present in *M. achatina*.

There are three Madras species of *Lutraria* which can be recognized as follows.—

1. Shell thin, with well marked but somewhat irregular corrugations, upper margin approximately straight ... ... *L. philippinarum* (fig. 21 d).
— Shell thicker, marked only by lines of growth 2
2. Shell scarcely as deep as in preceding, upper margin approximately straight ... ... *L. dissimilis.*
— Shell deeper than in *L. philippinarum*, front and hind parts of upper margin inclined to one another at a slight angle. *L. maxima.*

The genus *Anatinella* is represented only by a single species, *A. nicobarica* (fig. 21 e).

Wedge Shells (Donacidae).

Shell more or less triangular, flattened and elongate, with umbo usually much behind middle of upper margin. Ligament in a groove, its nodule external, mounted on a short ledge. Cardinal teeth two, often more or less completely fused into one on right valve; lateral teeth present or obsolete. Pallial sinus usually deep.

The six species found at Madras all belong to the genus *Donax* and can be separated as follows.—

1. Umbo not much behind middle, a sharply defined keel extending obliquely from it to sharply pointed hind angle. Shell concentrically strongly and radially more finely ridged throughout, concentric striations strongly crested in front and behind in unworn specimens ... ... *D. scortum.*
— Umbo further back, hind end more rounded 2
2. A sharply defined and strongly concentrically ridged keel extending from umbo to hind angle ... ... *D. spinosus.*
— Keel from umbo to hind angle obtuse or absent 3
3. Area between obtuse keel and hind margin ridged radially beside former, concentrically beside latter, the two types of ridging crossing to form granules between, rest of shell smooth or very finely radially ridged ... ... *D. cuneatus* (fig. 21 f)
— Shell radially striate throughout, mostly very finely, sometimes quite indistinctly 4
4. Umbo very near hind end of shell, lower part of hind margin almost vertical ... ... *D. spiculum.*
— Umbo not so near hind end of shell, hind margin strongly oblique 5

5. Hind end of shell strongly radially ridged, rest very finely striate ... ... *D. aperittus.*
— Shell finely striate only ... ... *D. aeneus.*

Donax cuneatus and *D. scortum* are common and moderately large, the others are quite small and more rarely found. *D. cuneatus* can often be seen near low tide level, burrowing its way back into the sand from which it has been washed out by a retreating wave.

Psammobiidae.

Shell oval or elongate, ligament external and mounted on a thick ledge. Hinge margin usually with two cardinal teeth on each valve, without lateral teeth. Pallial sinus deep, its lower side often fused with the part of the pallial line immediately below it. Gill-plates folded.

Sanguinolaria (*Soletellina*) *diphos* (fig. 22 a) is a large and elongate deep bluish shell, with a greenish brown skin when alive, that is frequently met with.[1] The pallial sinus is very large and its lower margin fused throughout to the lower part of the pallial line.

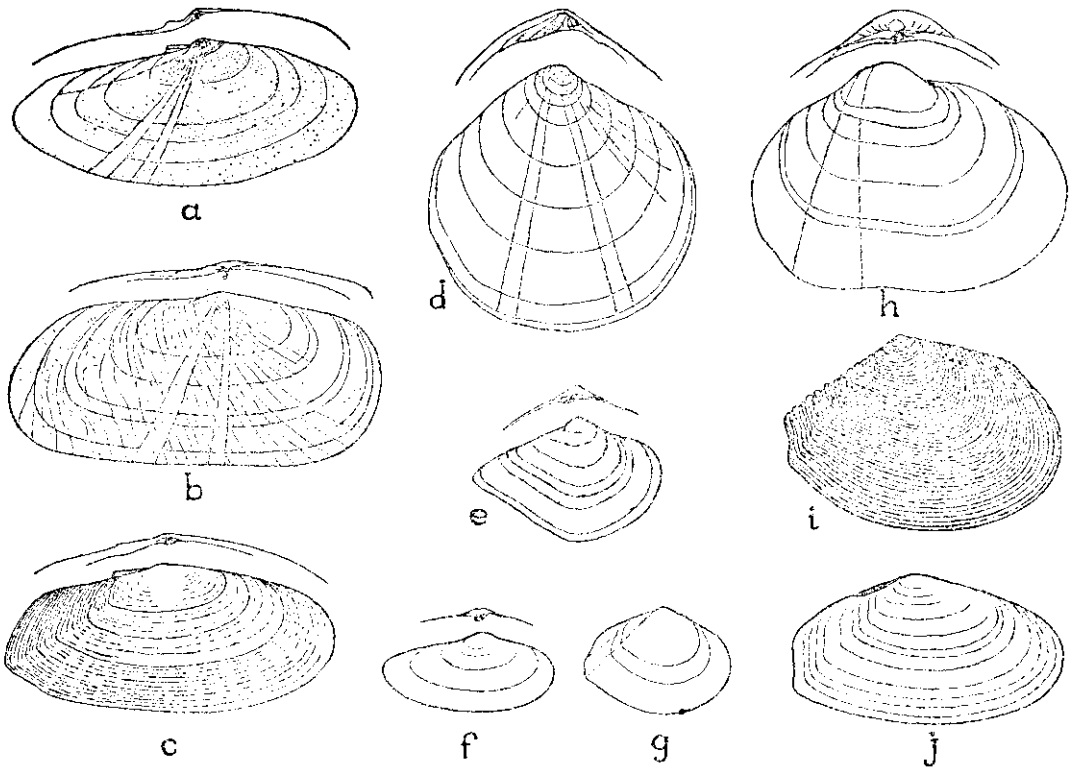

FIG. 22.

BIVALVE SHELLS (Paper shells and others).

a. *Soletellina diphos.* c. *Psammobia amethystus.* e. *Leptomya cochlearis.* g. *Tellina cuspis.*
b. *Solecurtus philippinarum.* d. *Semele sinensis.* f. *Theora opalina.* h. *Tellina coarctata.*
i. *Tellina pristis.* j. *Tellina emarginata.*

[1] Mr. Crichton has a single specimen of an intensely dark purplish colour, less elongate and somewhat thicker, which probably belongs to a different species.

In *Psammobia* the pallial sinus is not quite so large and is sufficiently free at its front end for this to be rounded. Three species are found, none of them common, and all of them elongate pale bluish shells rounded in front and more or less distinctly obliquely truncate behind with a somewhat indistinct keel between the umbo and the lower hind angle. *P. bipartita* is the one most frequently found. It is grooved concentrically behind and obliquely in front of a sharply defined line extending obliquely backwards from the umbo to the lower margin, which it meets about as far from the lower hind angle as this is from the upper hind angle, this angle being more strongly marked than in either of the other two species. In *P. amethystus* the grooves are somewhat widely separated by flattened interspaces in front but become about twice as numerous, and consequently much more crowded, across the middle of the shell, while behind they are at least equally numerous and the lower margins of the interspaces tend to overlap the upper margins. In *P. radiata* the grooves are obsolete in front, appearing only as strongly emphasized growth lines behind.

Solecurtus philippinarum (fig. 22 b), which is not uncommon on the beach, is an elongate, parallel-sided shell with rounded widely gaping ends, pale brownish in colour with two white rays and a series of finely sculptured oblique striae. *S. exaratus*, of which only a single valve has been found at Ennur, is larger and thicker with its striations much more widely separated, especially behind [1].

Semelidae.

Ligament not mounted on projecting ledge but with nodule situated internally in cavity behind cardinal teeth. Shell mostly round or oval, usually with one or two cardinal teeth and also lateral teeth, pallial sinus narrowed behind.

The position of the ligament nodule gives the hinge a strong resemblance to that of the false clams (Mactridae), but the shell is usually less inclined towards angularity.

The four genera found at Madras may be separated thus.—

1. Shell thick, more or less circular, the nodule socket not projecting inwards ... ... *Semele.*
— Shell thinner, nodule socket more or less projecting ... 2
2. Shell elongate and somewhat rounded behind, nodule socket strongly projecting ... ... *Theora.*
— Shell less elongate and more or less angular behind ... 3
3. Shell somewhat triangular with lower margin evenly rounded, finely and regularly striate concentrically in front but lines bending obliquely downwards at a somewhat obtuse angle near middle and subsequently forwards at an acute angle to become concentric again behind, nodule socket conspicuously projecting ... ... *Iacra.*
— Shell somewhat acute-angled behind, hind part of lower margin straight or lightly concave, nodule socket only slightly projecting ... ... *Leptomya.*

[1] *Zozia emarginata*, allied to this genus, has recently been collected by Mr. Crichton.

Semele is superficially very like *Dosinia*, but has the umbo straighter. *S. sinensis* (fig. 22 d) is a common shell with somewhat indistinct radial striation. Another species, very rarely met with and not yet identified, has low concentric crests each united by radial striation with a raised line a little behind it.

The other genera are represented by a single species each, *Theora* by *T. opalina* (fig. 22 f), *Iacra* by a species not yet identified with certainty [1], and *Leptomya* by *L. cochlearis* (fig. 22 *e*).

Paper Shells (Tellinidae).

Shell usually more or less oval, sometimes elongate or pointed behind, sometimes more or less irregular, the two valves not always alike. Ligament external, right valve usually with lateral teeth as well as cardinals. Pallial sinus large, its lower margin often fused with lower part of pallial line. Gill-plates smooth.

The family has been extensively subdivided, but the characters used are so slight and so difficult to distinguish that some authors reunite most genera into the original genus *Tellina*, in which all the Madras genera can most conveniently be united here. The Madras representatives of the genus as so constituted may be separated thus.—

1. Umbo broad, rounded or lightly hollowed, shell not flattened and not very thin, growth lines coarse 2
— Umbo, small, angular, growth lines generally finer, often obsolete 3

2. Umbo medial or a little towards front, shell somewhat thick, truncate behind, very variable ... ... *T. multangula.*
— Umbo posterior, hind margin rounded, shell thinner ... *T. coarctata* (fig. 22 *h*).

3. Umbo posterior 4
— Umbo medial or anterior 14

4. Hind margin of shell broadly rounded, or truncate with angles more or less rounded and lower one not more prominent than upper ; shell not much elongated, usually attaining a fairly large size 5
— Shell usually more pointed behind, when truncate lower angle more prominent than upper ; *or* shell elongate. Smallish species 7

[1] Mr. Winckworth has not been able to examine a Madras specimen, but thinks the species must be *I. seychellarum* which he considers identical with the species figured by Preston as *Strigella densistriata*. I have not had an opportunity of looking into the matter myself, but Mr. Crichton reports that his Madras specimens seem to differ from Preston's figure both in their shape and in their striations, and that the figure closely resembles a specimen from Aden in his collection. This Aden shell is less produced behind than his Madras ones which have the upper hind margin definitely concave, the oblique striations more nearly vertical and the striations behind them less upwardly directed.

5. Hind border more or less wrinkled and separated from rest by a keel, especially that of right valve, wrinkles less distinct and keel sometimes obsolete on left	*T. angulata.*
— Hind border not markedly different from rest of shell ...	6
6. Shell thin, white, matt, more or less distinctly truncate behind with upper angle more prominent than lower ...	*T. papyracea.*[1]
— Shell somewhat thicker and more glossy, tinged with pinkish yellow towards umbo	*T. ? pellucida.*
7. Shell vertically and somewhat excavately broadly truncate behind, elongate, not very small, white tinged with pink.	*T. emarginata* (fig. 22 j).
— Hind margin not as above	8
8. Shell neither much elongated, nor conspicuously pointed behind	9
— Shell more pointed behind and sometimes considerably elongated	10
9. Ligament and hind upper margin elongate, front upper margin parallel to lower margin or even slightly diverging from it, shell somewhat small, deep pink, not very thin.	*T. nobilis.*
— Ligament and hind upper margin short, front upper margin and lower margin strongly convergent, shell pale pink, very small and thin	*T. immaculata.*
10. Shell fully twice as long as high	11
— Shell not twice as long as high	12
11. Shell pink, somewhat indistinctly keeled from umbo to hind angle which is rounded	*T. rhodon.*
— Shell white, more distinctly keeled from umbo to hind angle which is pointed	*T. sp.* nr. *texturata.*[2]
12. Upper hind margin straight, area behind umbo concave, concentric sculpture microscopic but strong especially behind, colour white	*T. methoria.*
— Upper hind margin arched and projecting, concentric sculpture weak, colour orange pink	13

[1] A single well grown specimen from the sea in Mr. Crichton's collection seems to be identical with a number of small ones he had previously collected from the Adyar backwater which I had tentatively identified as *T. simplex* from Reeve's figure of that species, which they closely resemble.

[2] Differing from this species chiefly in that it lacks the "numerous concentric riblets" behind that are described and figured by Reeve.

13.	Shell nearly twice as long as high	*T. rutila.*
—	Shell only about one and a half times as long as high ...	*T. ? philippinarum.*
14.	Umbo medial	15
—	Umbo anterior, shell elongate and much flattened ...	20
15.	Shell more or less round, sculpture weak or absent ...	16
—	Shell more or less elongate, mostly somewhat pointed behind, concentric sculpture distinct though often microscopic	17
16.	Shell thick and comparatively large, hind upper margin arched	*T. bruguieri.*[1]
—	Shell small and thin, hind upper margin practically straight.	*T. pinguis.*
17.	Shell moderately large, about two and a half times as long as high, white but often tinged with pink	*T. lanceolata.*
—	Shell about one and a half times as long as high	18
18	Shell deep pink, somewhat small, not radially furrowed behind	*T. cuspis* (fig. 22 g)
—	Shell white, larger, radially furrowed behind	19
19.	Shell concentrically microscopically grooved, hind upper margin smooth	*T. ala.*
—	Shell concentrically crested, hind upper margin toothed ...	*T. pristis* (fig. 22 i).
20.	Upper hind margin strongly toothed, shell more than twice as long as high, large and of a golden yellow colour.	*T. foliacea.*
—	Upper hind margin not toothed, shell white, not so large...	21
21.	Lower margin practically straight	*T. timorensis.*[2]
—	Lower margin more arched with well marked hollow behind, shell somewhat higher in proportion to its length.	*T. sinuata.*

Only one specimen of *T. foliacea* and one well grown specimen of *T. papyracea* have been found. The remaining larger species are more or less common on the beach, where some of the small ones may also be collected, but many of the latter are found in greater abundance in sand or mud at the bottom of the backwaters (*T. ala, cuspis, nobilis, rutila, rhodon* and *sp.* nr. *texturata*) or of the sea (*T. methoria* and *immaculata*). The shells regarded as the young of *T. papyracea* were all found in a backwater, but the single well grown specimen came from the sea.

[1] A single specimen believed to be from Ennur but needing confirmation.

[2] *T. chinensis* which occurs with *T. timorensis* at Tuticorin, but has not been found at Madras, so closely resembles it that the two may easily be confused. The former seems to be a somewhat smaller shell than the latter, from which it is distinguished by its medial umbo and less broadly rounded hinder end.

Razor Shells, Sunset Shells, etc. (Solenidae).

Shell more or less elongated, often very greatly, foot large and strong, without byssus, siphons mostly short. In the principal subfamily, which alone has been found at Madras, the umbo is always situated in the front part of the shell.

The Madras genera may be recognized as follows.—

1. More than one tooth in each valve, shell rounded in front and usually at both ends, moderately elongated as a rule. 2
— Only one tooth in each valve, shell truncate in front and usually at both ends, greatly elongated as a rule ... *Solen.*
2. Inner surface of shell with a strong ridge extending from hinge teeth towards lower margin ... ... *Siliqua.*
— No such ridge present 3
3. Anterior muscle scar elongate, shell somewhat thickened in front of it, sometimes truncate behind ... ... *Phaxas.*
— Anterior muscle scar round with its upper margin thickened. *Cultellus.*

Siliqua radiata (fig. 23 c), a large thin deep bluish shell with four expanding white bands radiating from the umbo, is the common sunset shell of the Madras beach. Several

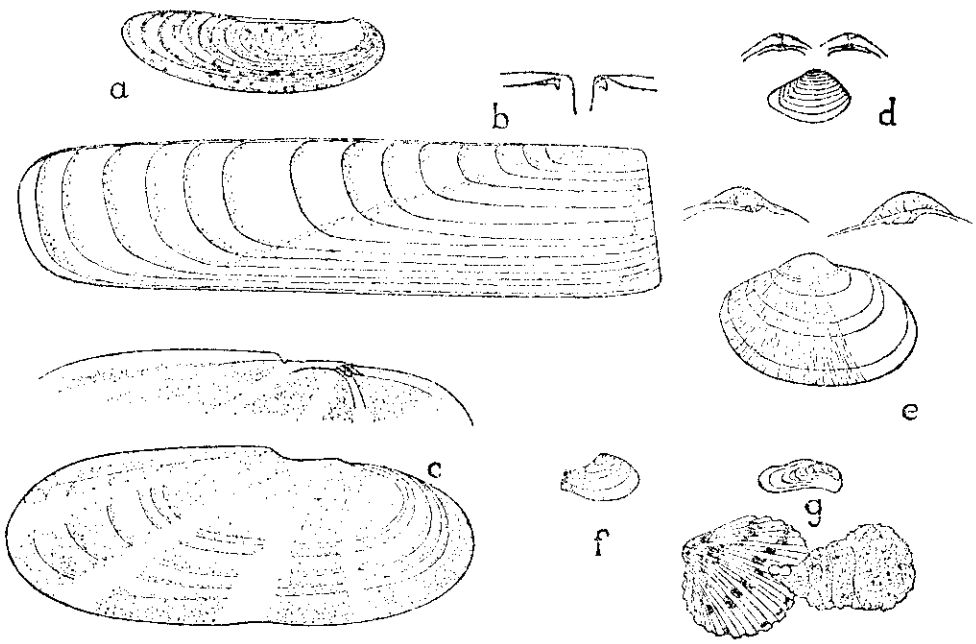

FIG. 23.
BIVALVE SHELLS (Razor Shells and others).

a. *Phaxas cultellus.* c. *Siliqua radiata.* e. *Cryptomya philippinarum.* g. *Cucurbitula cymbium*
b. *Solen lamarckii.* d. *Aloidis sulcata.* f. *Sphenia sowerbyi.*

much smaller species also occur : one parallel sided with broadly rounded ends and very pale which may possibly be *S. albida*, one colourless and tapering behind, one remarkably short for this genus and tapering at both ends the upper and lower margins being both of them markedly convex, and apparently others also, but none of them commonly met with.

Phaxas cultellus (fig. 23 a) is a somewhat delicate shell with lightly arched lower margin. It is curiously marbled with purplish brown.

Cultellus maximus is large, rather thick, white in colour with a yellowish brown horny skin. A much smaller and more delicate species of similar colour and appearance but with slightly convex upper and concave lower margin is also occasionally found.

Solen is represented by several species which may be distinguished as follows.—

1. Shell very small, horn coloured, not more than four times as long as high ; a backwater species ... ... *S. aquae-dulcioris.*
— Shell larger and more slender 2

2. Teeth situated well behind front margin, shell small and thin with purplish markings 3
— Teeth situated close behind front margin, tooth of right valve arising at margin 4

3. Shell about 6 times as long as high ... ... *S. kempi.*
— Shell 10 or 12 times as long as high ... ... *S. linearis.*

4. Shell with parallel and straight upper and lower margins, somewhat abruptly truncate behind, hind margin vertical or sloping slightly backwards from top to bottom, coloured bands strongly developed ... ... *S. truncatus.*
— Hind parts of upper and lower margins very slightly convergent, hind margin sloping more or less definitely forwards from top to bottom 5

5. Shell from about four to nearly five times as long as high, indistinct colour bands present, marine ... ... *S. lamarckii* (fig. 23 b).
— Shell distinctly more than five, usually about six, times as long as high, from backwaters ... ... *S. annandalei.*

The specimens identified as *S. lamarckii* differ from Reeve's figure of this species (fig. 16) in having only very faint colour bands, but their shape is so characteristic as to leave little doubt as to their identity, though they may perhaps represent a more or less distinct local race.

S. aquae-dulcioris and *S. annandalei* are backwater species. The rest are probably all marine. Though *S. kempi* was originally described from the Chilka Lake, the only living specimen collected " was dug from pure sea sand near the mouth of the lake " and the only additional shells (all described as being fresh) were from Satpara not far from the mouth of the lake and Nalbano (*Mem. Ind. Mus.* V, p. 355). As Nalbano Island is situated not far from the sand banks separating the lake from the sea, but at the place where the water had the lowest specific gravities obtained, it seems likely that shells may have been washed there from nearer the sea. The few specimens I have collected from the neighbourhood of Madras have been from the beach between the Ennur backwater and the sea where marine species are washed up but not as a rule backwater ones.

Aloididae (= Corbulidae).

Shell rather small, more or less asymmetrical, closed, usually pointed or beaked behind, often with strong concentric sculpture, ligament with internal nodule mounted on a projection of one valve fitting into a socket in the other, right valve with a tooth in front of it (usually strong) fitting into a cavity of the left valve which bears a more or less distinct tooth behind the nodule attachment.

This family is not a common one at Madras, where the two principal species are *Aloidis modesta* and *A. sulcata* (fig. 23 d) in both of which the right valve at least is strongly concentrically ribbed. The former is a small shell with the left valve not very noticibly smaller or more finely ribbed than the right and the hind upper margin practically straight or lightly convex. The latter is a larger shell with the hind upper margin concave and the right valve very boldly concentrically ribbed but the much smaller left valve more or less smooth. Single specimens of two other species have also been found, one of them *A. monilis*, the other not yet identified.

Myidae.

Valves somewhat unequal, more or less gaping behind, internal ligament nodule attached to a projection of margin of left valve which fits beneath margin of right valve, without definite teeth.

Cryptomya philippinarum (fig. 23 c) is a fragile whitish shell, more or less definitely concentrically striate in front but with radial striations definitely predominant over concentric behind. *Sphenia sowerbyi* (fig. 23 f), which has been found by Mr. Winckworth at Adyar, is a smaller and browner shell, rounded in front, strongly tapered and truncate behind, without radial striations.

Gastrochaenidae.

Shell more or less elongate, thin, gaping widely in the front part of the lower side, ligament external, the ledge for its attachment not very prominent, teeth absent.

The members of this family either live in sand where they form a club-shaped tube enclosing shell and siphons, or burrow in limestone or in mollusc shells. The former are classed in the genus *Cucurbitula,* of which one species occurs at Madras, the only other species found belonging to the genus *Gastrochaena.*

Cucurbitula cymbium (fig. 23 g) forms around itself a more or less club-shaped calcareous tube attached to some shell and usually coated with adherent sand grains. The shell within is fully three times as long as high. *Gastrochaena gigantea* is found in coral (*Pocillopora*) in Rayapuram Bay. It is less twisted than *Cucurbitula cymbium.*

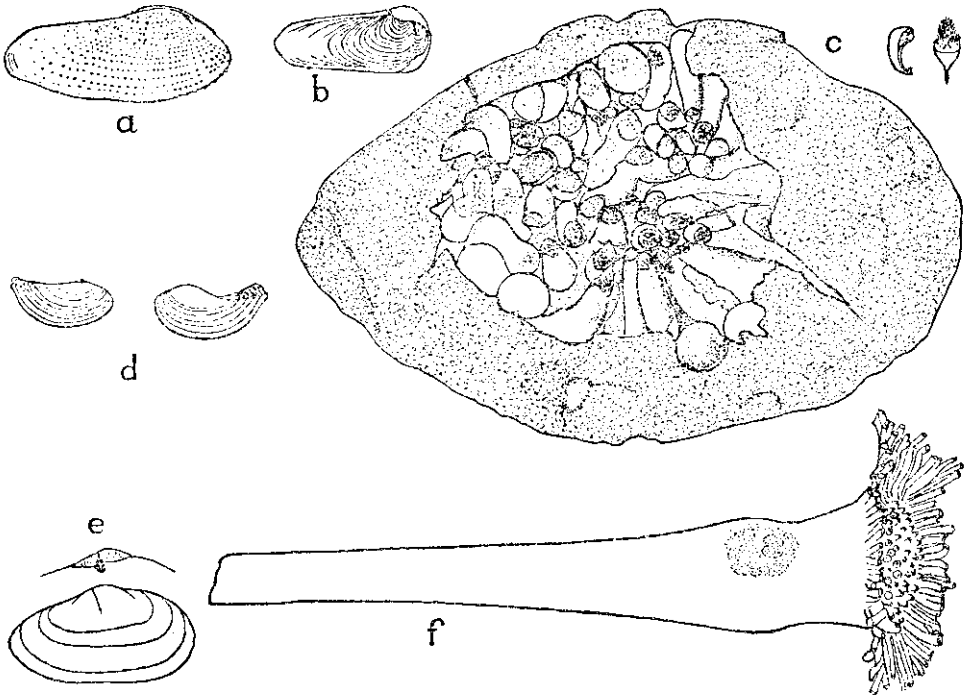

FIG. 24.

BIVALVE SHELLS (Piddocks, Shipworms and others).

a. *Barnea birmanica.*
b. *Martesia striata.*
c. *Teredo clava* (group of shells in nut; also isolated value and pallet).
d. *Pandora flexuosa.*
e. *Laternula marilina.*
f. *Brechites ? dichotomus.*

Piddocks (Pholadidae).

Shell colourless, equivalve, externally mostly ribbed and in front often toothed, gaping at both ends, without ligament or hinge-margin, the two valves being held together by the muscles; front part of upper margin produced and folded upwards over outer surface of adjoining part, accessory plates sometimes present behind, the front aperture sometimes closed by accessory plates fused to the shell. Borers in stone or wood.

Barnea birmanica (fig. 24 a) and *Pholas* (*Monothyra*) *orientalis* are comparatively large elongate fragile shells sometimes washed up on the beach. In the former the front part is fully sculptured, but the rays thin out behind, the extreme posterior part being smooth. In the latter the sculpture is evenly spread so far as it goes, but stops abruptly leaving an extensive smooth area behind. *Martesia striata* (fig. 24 b) is a much smaller shell in which the front aperture is closed by fused accessory plates. Pieces of timber washed up on the beach sometimes contain numerous specimens in their burrows.

Shipworms, etc. (Teredinidae).

Shell very small in proportion to size of animal, which is protected by the secretion of a calcareous tube. Siphons long, extensively united, furnished with two posterior calcareous "pallets" on the character of which, as well as on those of the shell, the definitions of genera and species are based.

Teredo clava (fig. 24 c) forms its tubes in the floating corky seeds of the mangrove *Carapa moluccensis* which grows abundantly in the deltas of the Kistna and Coleroon rivers.

Pandoridae.

Shell pearly within, elongate, flattened, snouted behind, often with upper margin concave behind anteriorly situated umbo, left valve usually convex and right valve flat, ligament with small internal nodule in a groove directed obliquely backwards from the umbo, from which extend also strengthening ridges on the inner surface.

Pandora flexuosa (fig. 24 d) is the only species recorded, and is not common.

Laternulidae (= Anatinidae).

Shell ovate, without teeth, ligament nodule mounted on a process arising from an internal strengthening ridge, umbo cleft.

Laternula marilina (fig. 24 e) is a very thin and fragile colourless shell, gaping widely behind and moderately in front, highest towards the front and mostly of fairly regular form though distinctly variable. It is sometimes abundant in patches in the mud of backwaters. *L. anatina* is much rarer and more definitely marine. It is highest about opposite the umbo, which is situated somewhat behind the middle of the upper margin, and is less regular in shape owing to the gaping posterior portion being constricted and directed somewhat obliquely upwards.

Pepper-Pot Shells, etc. (Clavagellidae).

Shell small, embedded in a calcareous tube which may either be simple or have the front surface studded with small perforations and surrounded by a number of finer tubes.

A species of *Brechites*, the pepper-pot shell (probably *B. dichotomus*) is occasionally found (fig. 24 f).

CEPHALOPODA—CUTTLEFISH, NAUTILUS, ETC.

Cephalopods are of two main types, one in which the only living representative, the Pearly Nautilus, has two pairs of gills, a lobed foot bearing tentacles and an external shell attached to the body, and another in which there is only a single pair of gills, the foot is developed into either eight or ten arms bearing suckers and the shell when present is either more or less completely internal or not attached to the body, being in the latter case secreted by the dorsal pair of arms instead of by the mantle and therefore not homologous with other shells. All the main types of recent Cephalopod shells have been found at

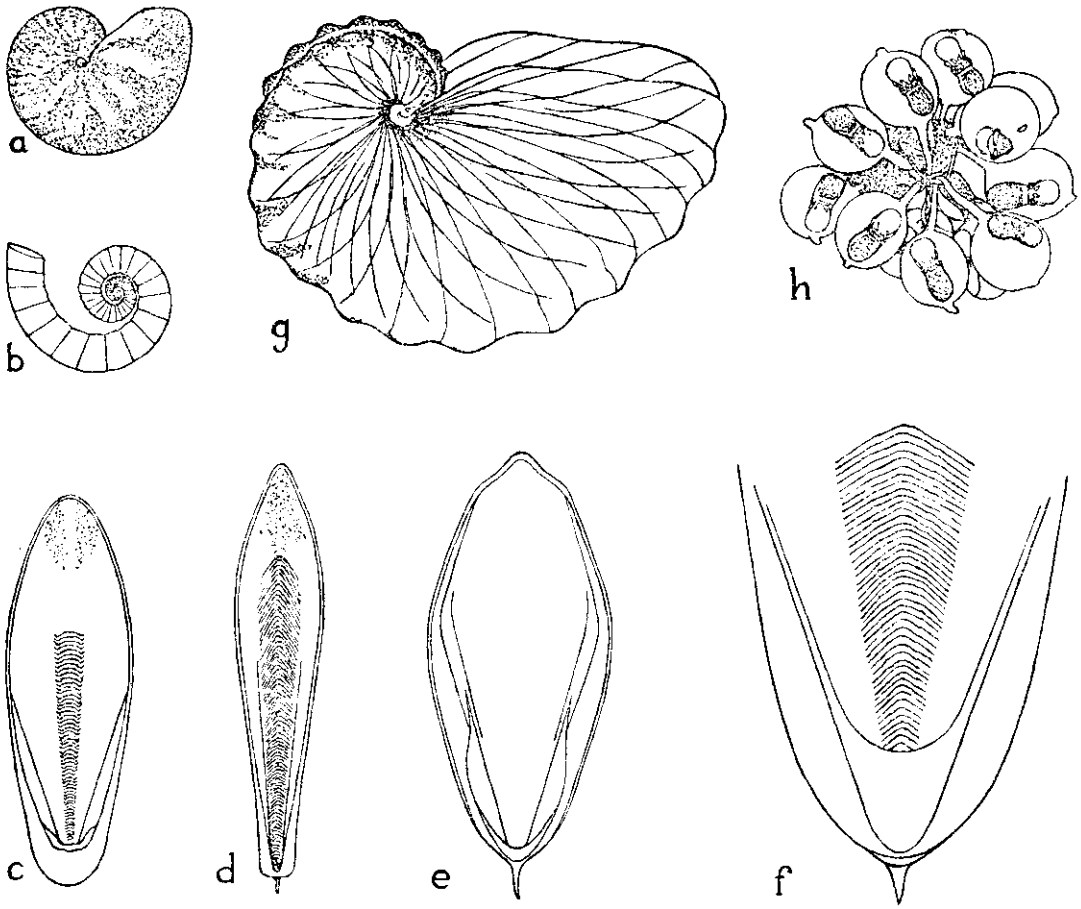

FIG. 25.

CUTTLEFISH, etc.

a. *Nautilus sp.* (very young).
b. *Spirula prototypos.*
c. *Sepiella inermis.*
d. *Sepia andreanoides.*
e. *Sepia winckworthi.*
f. *Sepia rouxii* (hind part).
g. *Argonauta sp.*
h. *Cuttlefish eggs.*

Madras, cuttle-bones always and *Spirula* shells sometimes being abundant. And large clusters of white cuttlefish eggs (fig. 25 h) like gigantic bunches of small grapes, are sometimes brought up by fishermen in their nets. Much scarcer is another type in which the eggs though of much the same shape and size, are brown in colour and arranged in more slender and very much smaller clusters.

The pearly nautilus, *Nautilus sp.* (fig. 25 a), is the only living representative of an order which was very large and varied in earlier geological ages, including as it does, the Ammonite group of fossils from which the sacred salagrammas of the Hindus are derived. It has a large spiral shell with a fine pearly lustre inside, divided by partitions into a series of chambers of gradually increasing size, the animal occupying only the part of the shell in front of the last partition, moving onwards and secreting another partition behind it as often as it outgrows this accommodation. Each partition is pierced by a small canal through which a strand of living tissue, the *siphuncle* extends from the mantle through each chamber back to the initial one. As the siphuncle completely fills the canals the chambers do not communicate with one another or with the exterior. They are filled with a nitrogenous gas and form a hydrostatic apparatus.

Cephalopods with only a single pair of gills are grouped as cuttlefish and squids on the one hand, or octopods on the other, according to whether or not a pair of more or less retractile " tentacular " arms, with their suckers mostly concentrated at the end, are present in addition to the eight normal arms with suckers all along them. Many of the former have an internal shell, whereas only one of the latter secretes a shell at all and that an external one.

The ram's horn nautilus, *Spirula* (fig. 25 b), belonging to the former group, is the only one with a chambered shell, a shell which is not completely internal. It is circular in section and forms a neat but loosely coiled spiral, white externally but somewhat pearly within. As in the pearly nautilus, the partitions separating its chambers are pierced by a strand of living tissue. The species common at Madras has been identified as *S. prototypos.*

In certain fossil cephalopods the shell is internal with a calcareous secretion of the reflected part of the mantle around it, forming a pointed guard or rostrum behind and a cephalic plate in front. In all living forms except *Spirula* the true shell and rostrum are rudimentary, the former being represented only by a hollow or pocket, while a short spine represents the rostrum. Both are situated at the hind end of an elongate and more or less flattened shell or " bone " representing the cephalic plate and thus not homologous with the shells of other molluscs, which serves for the attachment of retractor arm muscles. In cuttlefish such bones are often of considerable size and are mainly composed of parallel calcareous layers, but in squids, which also occur at Madras, they consist only of a blade of horn too delicate to survive washing up on the beach. The cuttle-bones of male animals

often differ slightly but consistently from those of females and several species have received two names, one for the male and the other for the female, before this was recognized.

The cuttle-bones found on the Madras beach may be identified as follows.—

1. Rostrum absent, horny margin forming a thin broad plate behind calcareous portion, pocket rudimentary with obsolescent but widely arched horns, colour white ... *Sepiella inermis* (fig. 25 c).

— Rostrum present 2

2. Small and slender, somewhat attenuate behind; horny margin forming a small thin plate between rostrum and pocket; pocket rudimentary, but with thickened ventral wall the horns of which are continued forwards on either side as a strong horny crest to the longitudinal convexities bordering the median furrow [1]; upper surface tinged with pink near rostrum ... ...*Sepia andreanoides* (fig. 25 d).

— Larger and less attenuate behind, horny margin forming at most a thin low crest between rostrum and pocket; pocket more developed, its horns continued forwards on either side in hollow between calcareous mass and horny margin 3

3. Upper surface pink, with a pair of broad longitudinal grooves on either side of a low median ridge; pocket small and widely open, its horns outwardly arched; crest present between pocket and rostrum ... ... *Sepia prashadi.*

— White, dorsal surface not definitely grooved 4

4. Front end lightly excavate on either side of extremity, crest between pocket and rostrum absent, pocket and its horns much as in *S. prashadi* ... ... *Sepia winckworthi* (fig. 25 e).

— Front end normal, crest between pocket and rostrum present, pocket better developed and with straighter horns, larger species 5

[1] In this they seem to differ from Adam's figure of the cuttle-bone of *Sepia andreanoides* (see below, p. 103). Mr. Winckworth tells me, however, that the species is variable and seems to include both forms. Mr. Crichton has specimens which he collected at Aden and all of them agree with the Madras form.

5. Lower surface of thickened calcareous portion convex without distinct median furrow, broadest a little in front of middle as in preceeding species ; pocket shallow, widely open, with ventral wall more or less thick and inflated. Size moderately large ... ... *Sepia aculeata.*

— Thickened calcareous portion broadest about the middle, usual median furrow well developed ; pocket large, very deep but greatly flattened. Size very large ... ... *Sepia rouxii* (fig. 25 f).

In the paper nautilus, *Argonauta*, which belongs to the 8-armed group, the young are born naked and the male remains so throughout its life, and much smaller than the female. After about ten or twelve days the enlarged extremities of the dorsal pair of arms of the female secrete a shell which has no muscular attachments to the body. Mr. Crichton's collection includes a single specimen from Madras, a beautiful shell of thin translucent brown horny material (fig. 25 g).

CRABS, BARNACLES, ETC. (CRUSTACEA).

The Crustacea form one of the five classes which make up the great section of the Animal Kingdom known as the Arthropoda, or animals with jointed feet. Its species are mostly aquatic, whereas those of the remaining classes—which include the centipedes and millipedes (Myriapoda), the insects (Hexapoda) and the scorpions, spiders, etc. (Arachnida)—are mostly terrestrial.

Those seen on the Madras beach all belong either to one of the subclasses Copepoda and Cirripedia (barnacles), to the orders Isopoda (woodlice, etc.), or Stomatopoda (mantis shrimps) or to one of the many sections of the order Decapoda (shrimps, crabs, etc.) of the sub-class Malacostraca.

COPEPODS (COPEPODA).

Copepods are minute and usually colourless crustacea, some parasitic and often comparatively large, but most free-swimming in either fresh or salt water and very like the true water-fleas (*Cladocera*) in their more or less minute size and somewhat jerky swimming movements, the antennae being their main organs of locomotion. Some species commonly live in enormous swarms and form the principal food of certain fishes of special economic importance.

A few specimens of a comparatively large blue copepod were collected by Mr. Crichton, washed up on the beach with the blue Portuguese man-of-war (*Physalia*) on Oct. 22, 1939.

BARNACLES (CIRRIPEDIA).

When first liberated into the water, barnacles are free-swimming like most other crustaceans, and have three pairs of appendages only, like the early larvae of the other subclasses to which they are most closely allied such as the Copepods and Ostracods. While still

free-swimming they develop additional appendages and a bivalve shell, in which condition they closely resemble their nearest permanently free-swimming relatives the Ostracods. But they soon attach themselves to some solid object by means of their first pair of antennae and develop into the sedentary adult barnacles that grow so abundantly in the sea wherever they can find a suitable support. A barnacle may therefore be described roughly as a kind of shrimp standing on its head which is attached to some support, with its legs projecting upwards and serving to produce currents in the surrounding water by means of which food is carried to the mouth and respiration takes place.

Barnacles are divided into two groups, in one of which the shell is mounted on a stout stalk while in the other it is attached direct to the substratum. Stalked barnacles of the genus *Lepas* (fig. 26, 1) are sometimes washed up attached to pieces of wood, etc., that have been floating in the sea. This genus includes two species of cosmopolitan distribution,

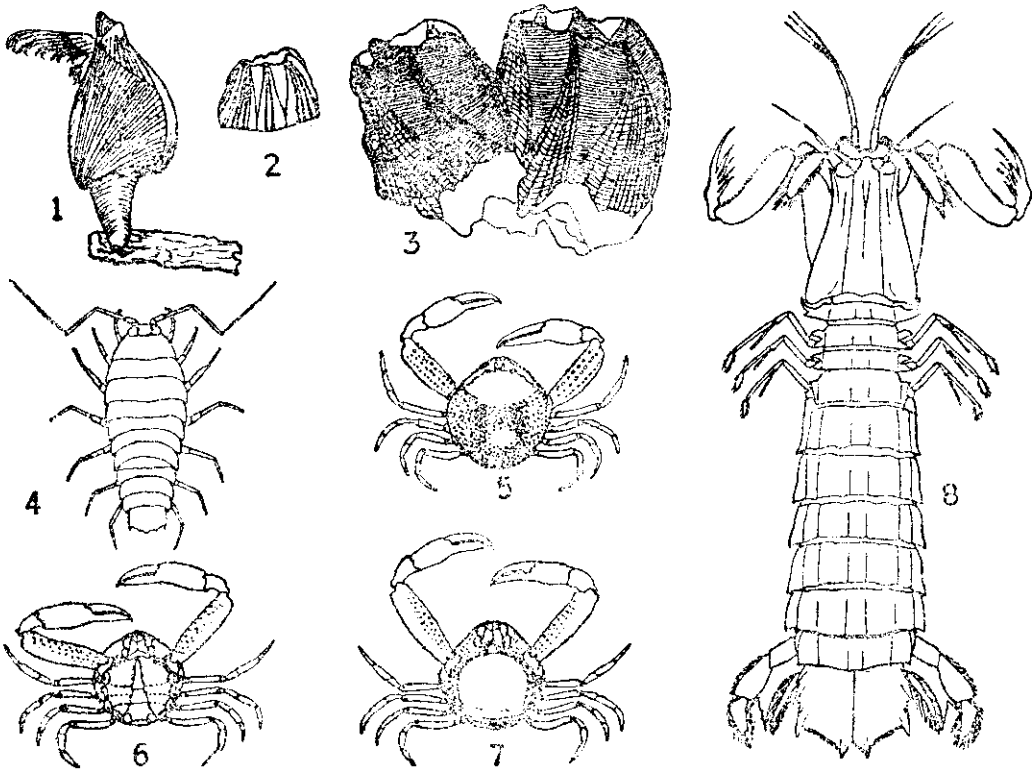

FIG. 26.

BARNACLES, CRABS, ETC.

1. *Lepas sp.*
2. *Balanus amphitrite.*
3. *Balanus tintinnabulum.*
4. *Ligia exotica.*
5. *Philyra scabriuscula.*
6. Same, male from below.
7. Same, female from below.
8. *Squilla nepa.*

L. anserifera and *L. anatifera.* The former differs from the latter in the pale colour of the upper part of its stalk and in the character of its filamentous appendages[1]. Both probably occur, but they are not readily distinguishable from one another by their shells alone. Sometimes these barnacles are associated with an orange-red deposit on the substratum to which they are attached, a deposit consisting of enormous numbers of their freshly attached bivalve larvae, as can be seen with the aid of a strong lens.

By far the commonest barnacles are, however, unstalked forms of the genus *Balanus*, the vast majority of those washed up at Madras belonging to one or other of the two common and widely distributed species *B. tintinnabulum* (fig. 26, 3) and the still more abundant *B. amphitrite* (fig. 26, 2). *B. tintinnabulum* when full grown is very much larger than *B. amphitrite*, specimens over an inch across being fairly common ; and attached to the piers of the railway bridge across Pamban Channel, where the strong tidal currents carry them a particularly abundant supply of food, they reach the prodigious size (for a barnacle) of two and a half inches across the base. But small specimens of *B. tintinnabulum* are not easy to distinguish from full grown ones of *B. amphitrite.* The most definite difference between the two, a difference characteristic of the two different sections of the genus to which they respectively belong, is a difference in the structure of the plates of the shell known as *radii* which can only be seen when these have been suitably broken across or (better) have been suitably ground down, as explained below.

The shells of these barnacles are composed of two alternating series of plates. From the outer side, each plate appears to be roughly triangular in shape, those of one series having their apices pointing upwards and those of the other downwards, the former being much larger than the latter, and having " wings " extending from one or both sides beneath them. It is the small plates with downwardly directed apices that are known as *radii*, and in *B. amphitrite* these are solid, whereas in *B. tintinnabulum* they are traversed by a series of horizontal canals running parallel to one another in the thickness of the plate. The surface of the plate usually shows a series of transverse markings apparently corresponding to the canals, but as such markings are present in both species they are of no use in distinguishing them from one another. These canals evidently weaken the plates, some of which are commonly found to be broken in such a way as to show them broken across in specimens of *B. tintinnabulum* that are washed up dead upon the beach. In *B. amphitrite*, in which they are absent, the radii are stronger and rarely broken. When they are broken, however, the fracture often appears to suggest their presence, but the distinction can always be made clear by grinding the vertical edge, or one of the upper corners as is often easier.

There seem, however, to be two other characters by which Madras specimens at least of the two species can be distinguished one from another, though with less certainty.

[1] See Annandale, p. 139 of Herdman's " Report on the Pearl Oyster Fisheries of the Gulf of Mannar ", Vol. V.

In *B. tintinnabulum* the plates, especially the *parietes* or plates with upwardly directed apices, are usually rougher and more irregular than in *B. amphitrite*, and the transverse striations on the outer surface of the radii are uniformly coloured, whereas in *B. amphitrite* they are alternately light and dark, the dark portions of the whole series of striae together forming one or more somewhat irregular lines extending from top to bottom of the plate.

Several less common species live in close association with other animals, and in Madras stalked barnacles may sometimes be found growing on the tails of sea-snakes or the hind limbs of the little masked crab *Dorippe facchino* or of the spider crab *Doclea hybrida*, and unstalked barnacles of the genus *Chelonobia* on the shells of turtles. Other barnacles live embedded in the tissues of sponges or corals.

Isolated plates or *compartments* of barnacle shells, or isolated bases of them detached alike from the substratum and from the plates they supported, are not infrequently found and may at first prove very puzzling, especially the latter which often include some length of vertical wall on two adjacent sides or all round, with delicate veining inside, that may at first sight suggest affinity with a coral.

WOOD-LICE, ETC. (ISOPODA).

The large Isopod, *Ligia exotica* (fig. 26, 4), of cosmopolitan coastal distribution, is abundant in boats. Aquatic smaller species occur in the harbour.

SAND-HOPPERS, ETC. (AMPHIPODA).

These seem to be abundant on the Indian coast, wherever drift seaweed is washed up in any quantity. But drift seaweed is not very common at Madras, so the sand-hoppers that shelter in it are not much in evidence and none have been collected, though they may be expected to occur[1].

MANTIS-SHRIMPS (STOMATOPODA).

Mantis-shrimps are so called from the raptorial form of the second pair of thoracic legs which somewhat resemble the first legs of a praying mantis. Though not as a rule found among objects washed up on the beach they are often brought in by fishermen in their nets and, being inedible, are left there as useless. Two genera are found at Madras, *Squilla* with, and *Lysiosquilla* without, longitudinal ridges on the dorsal plates of the anterior segments of the abdomen. The latter is much rarer than the former and there is reason to think that this may be due to its making deeper burrows and keeping more closely to them (see p. 110 of Kemp's paper referred to on page 103 below).

The commonest species of *Squilla* are *S. nepa* (fig. 26, 8) and *S. wood-masoni*. These and *S. holoschista*, so closely allied to *S. nepa* as to have sometimes been confused with it and recorded by Kemp (*loc. cit.*, p. 65) as also found at Madras, all have their raptorial

[1] They are abundant in weed stranded at the edge of the backwaters I have recently found.

appendages normal and have eight longitudinal ridges on the dorsal plates of the first five abdominal segments, which must be carefully distinguished from the four smaller ones immediately preceding them, these belonging to the thorax as will be seen if the character of the legs these segments bear is examined. *S. wood-masoni* and other species allied to it differ from the other two in having their eyes set very obliquely to the eye-stalks, *S. nepa* and *S. holoschista* having them set at right angles to the axis of the stalk. The eyes of *S. nepa* are somewhat broader in proportion to their stalks than are those of *S. holoschista* and the median ridge of the carapace (or large plate covering the fore part of the thorax) forks about in the middle of the carapace and is single behind the fork, whereas that of *S. holoschista* forks much further forward but is double in the greater part of its length behind the fork.

In December 1939, a number of *Squilla wood-masoni* were found beside the fishing villages south of Adyar, and with them one specimen of *S. nepa* and one of a rare species, *S. lirata*, described from two specimens from Singapore. But the Madras specimen probably belongs to a distinct local race. *S. lirata* differs from all the above species, as well as from *S. raphidea*, in having much more numerous longitudinal ridges on the upper surface everywhere.

S. raphidea, which also occurs, is a larger species and differs from all the others in having the comb-like fringe of the upper margin of the penultimate joint of the raptorial claw replaced by strong and well separated spines, large ones alternating with small.

Two species of *Lysiosquilla* occur, both recognisable at sight from the above mentioned species of *Squilla* by their conspicuous broad black and white transverse bands. *L. maculata* is a very large species without spines on the upper surface of the telson (the terminal median swimming plate), of which a row of five is present in the much smaller *L. acanthocarpus*.

PRAWNS, CRABS, ETC. (DECAPODA).

This section of the Crustacea comprises the forms characterised by having five pairs of legs for walking or grasping, the whole of the *thorax* or fore part of the body bearing these ten legs and the appendages in front of them, being covered by a single shell or *carapace*.

SHRIMPS, PRAWNS, ETC. (MACRURA NATANTIA).

Long-tailed swimming decapod crustacea are represented by the shrimps and prawns fished for eating, but they are not often washed up on the beach and none have been collected. Kesava Panikkar and Gopala Ayyar record about a dozen species from the backwaters.[1]

[1] *Loc. cit.*, p. 3 above.

LOBSTERS (MACRURA REPTANTIA).

Three kinds of spiny lobster (Palinura)—*Panulirus fasciatus*, *P. ornatus* and *P. dasypus*—are fished along the Madras coast, and I have once found an unidentifiable fragment and once an almost complete specimen of spiny lobster shell on the beach. But the latter, which is not quite sufficiently complete for identification, looks as if it may belong to a fourth species.

The second at least of the species mentioned sometimes attains a very large size, a specimen from Kilakarai (Gulf of Manaar) in the Madras Museum collection being $4\frac{1}{2}$ inches across the carapace and $1\frac{1}{2}$ feet long, or more than double that length if the antennae are included.

P. dasypus has on the plate between the bases of the antennae four minute spines arranged more or less in a square within a definite square of four much larger spines, and differs from both the other species in having a transverse groove towards the back of each abdominal upper plate. *P. ornatus* has the square of four large spines but no inner square, while *P. fasciatus* has only two spines on the front margin of the plate.

MOLE CRABS (ANOMURA HIPPIDEA).

Two species of mole crab, *Emerita asiatica* (fig. 27, 2) and *Albunea symnista* (fig. 27, 1) occur. The latter lives below low tide level, but is sometimes brought to the shore entangled in fishing nets. The former, on the other hand, which is pinkish in colour, lives between tide marks, where it is sometimes disturbed from its hiding place under the sand by a retreating wave and so exposed to view for the brief period that elapses before it can bury itself again, which it does with great rapidity. It is so abundant that its remains, comparatively soft though they are, may often be found among the debris deposited at high tide mark. After the breeding season, when its free-swimming larvae have settled to the bottom and grown into small specimens of the adult form, they are apt to be stirred up in millions from the surface layers by each retreating wave, so that the sand seems positively alive with them as they hastily shuffle back into it again.

Albunea symnista is stouter than *Emerita asiatica* and has a more or less fine shallowly M-shaped groove extending right across the carapace, of which the central part is intensified and the outer parts absent in *Emerita asiatica.*

HERMIT CRABS (ANOMURA PAGURIDEA).

A hermit crab (fig. 27, 3 and 4) is a Decapod Crustacean the soft abdomen of which necessitates its securing some sort of covering for its protection, usually a snail shell, which it carries about as a sort of portable shelter into which the fore part of the body can be more or less completely retracted. In order to fit such a shell the abdomen is in most species spirally twisted in the same direction as are the vast majority of snail shells, and the last

pair of abdominal appendages—which in most of the higher Crustacea (other than crabs) form the side-pieces of a powerful tail fin for use in swimming—are reduced and modified as organs for holding the shell, especially on the left side the last appendage of which is hooked so as to grip the columella firmly. So strong is this grip that any attempt to drag a healthy hermit crab out of its shell generally results in the extraction of the front part only, this being torn from the abdomen which remains behind. The last two pairs of thoracic appendages are also reduced and modified to help in carrying the shell.

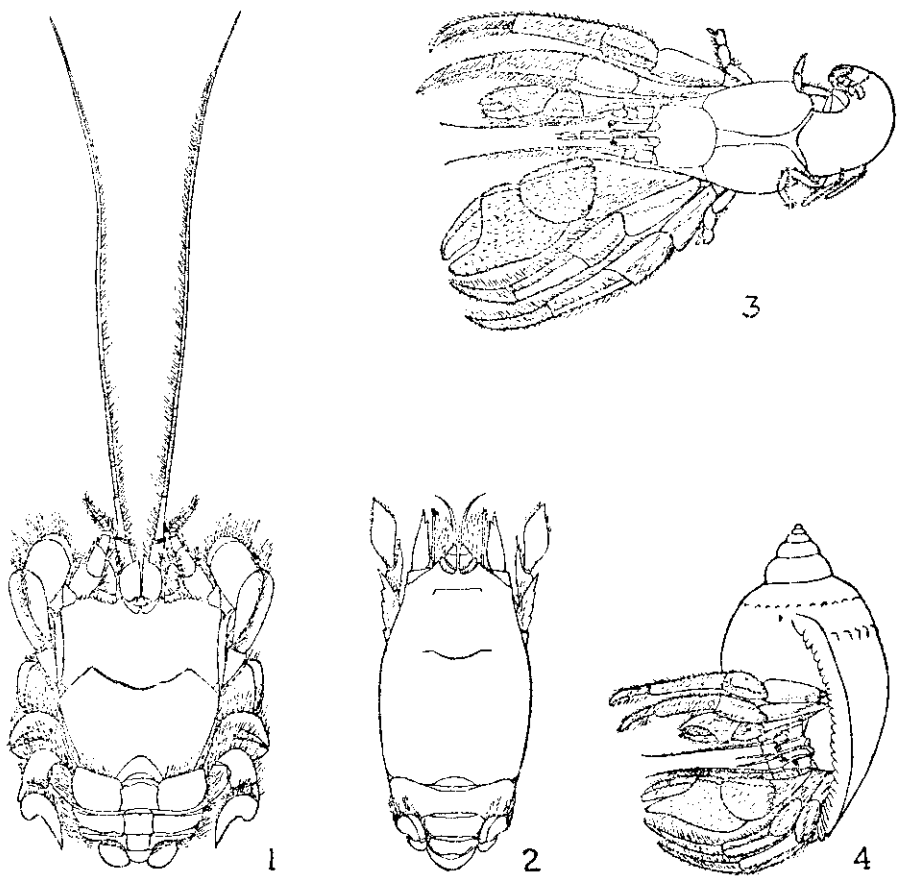

FIG. 27.

HERMIT CRABS AND MOLE CRABS.

1. *Albunea symnista.*
2. *Emerita asiatica.*
3. *Diogenes custos.*
4. Same in shell.

Three genera of hermit crabs are common in Madras, all with spiral abdomen. *Clibanarius*, the common genus of the backwaters, differs from the other two in that its hands do not differ markedly in size (instead of the left being much larger than the right) and have

their fingers opening horizontally instead of obliquely or nearly vertically. *Coenobita*, which lives mostly on shore, differs from both the others in the form of its antennules or first pair of appendages—situated between and in front of the very much longer second appendages or antennae. Its antennules end bluntly instead of tapering to a fine point, and their peduncles are about as long as the carapace. *Diogenes*, which is sometimes found in the backwaters but mostly lives in the sea, has antennules resembling those of *Clibanarius* but hands more like those of *Coenobita.*

Four species of *Clibanarius* are found in the Madras backwaters. They may be distinguished thus.—

1. Arms, hands and legs olive green, not striped. Eye-stalks with longitudinal stripe on either side and sometimes also above.[1] ... ... *C. olivaceus.*
— Legs with conspicuous longitudinal stripes even in specimens long preserved in spirit 2

2. Eye-stalks without stripes, at least in spirit specimens. A single red-bordered blue longitudinal stripe extending along middle of outer side of penultimate segment of each walking leg and similar stripes more or less distinct on inner side and on adjoining segments ... ... *C. longitarsis.*
— Eye-stalks longitudinally striped above and usually also on sides 3

3. Stripes on legs resembling those of *C. longitarsis* in type, but middle red-bordered stripe pale yellowish (in spirit) not blue; a strong tooth found in no other Madras species present on inner lower border of arm ... ... *C. infraspinatus.*
— Legs with alternating longitudinal stripes of red and bluish grey in fresh specimens or whitish in spirit ones ... *C. padavensis.*

The genus *Diogenes* is represented by three species, *D. custos* (fig. 27, 3-4) in which the carapace is considerably longer than broad, and *D. avarus* and *D. miles* in which it is scarcely as long as broad. *D. miles* differs from both the others in being extraordinarily flattened, apparently to fit it for life in shells with a long narrow aperture such as is found in olive and cone shells, to which it seems partial. Its enlarged left hand, even when fully extended, is directed strongly inwards, thus fitting this form of aperture. *D. avarus* can

[1] I have recently collected two small specimens in *Cerithidea* shells at Ennur. Three other specimens in the Museum collection, also from Ennur and in shells of the same species, which have been long in spirit, have lost all trace of colour including the stripes on the eye-stalks, but must I think belong to this species as the legs show no trace of the bands characteristic of the others even in spirit specimens.

be found in the backwaters even in the late autumn when they have long been cut off from the sea, but the other two species seem to be definitely marine. *D. diogenes*, which differs from *D. custos* chiefly in having the surface of the left hand covered with clawed spines instead of being closely and finely granular, is recorded by Sundara Raj as common in Madras but I have not come across it.

Of *Coenobita* only a single species has been found, *C. cavipes*, without any oblique file of upright laminar teeth to form a sound-producing organ on the outer surface of the left hand.

SQUAT-LOBSTERS, PORCELAIN CRABS, ETC. (ANOMURA GALATHEIDEA).

Though none have been found on the beach, this group is common under stones among the concrete blocks east of the harbour entrance and among mussels, oysters, etc., on wooden piers in the harbour, where the following have been collected: *Petrolithistes boscii*, *Polyonyx hendersoni*, and undetermined species of *Pachycheles*, *Porcellana* and perhaps other genera. With the exception of the first named, of which only a single specimen has been found, they are all minute.

TRUE CRABS (BRACHYURA).

In crabs the abdomen is reduced and tucked underneath the enlarged front part of the body, which is protected by a shell that is commonly hard enough to be washed up and remain on the sand for some time in recognisable condition. But these shells are not the only part of a crab that may be found; for jaws (usually attached to the shell), crab "claws" or *chelipeds*, and the whitish jointed ventral plates of the fore part of the body are also to be seen, the ventral plates either having the abdominal plates in place or showing the groove along the middle where they fitted during life. As the abdomen forms a protection for the eggs as these develop into embryos, it is usually much broader in the female than in the male (see figs. 26, 6 & 7, and 28, 5).

A crab's eggs hatch into a characteristically shaped swimming larva, the *zoea*, in which the shell over the front part of the body is produced in the middle in front into a large spine and usually bears another such spine directed backwards further back, the abdomen being developed much as in a prawn. The zoea eventually develops into a second type of larva the *megalopa*, in which the front part of the body no longer bears the spines characteristic of the zoea and is altogether more crab-like and relatively larger, the abdomen though relatively much smaller still functioning in swimming. Finally the megalopa sinks to the bottom and turns into the crab. Megalopa larvae are occasionally thrown up on the beach alive in considerable numbers.[1]

[1] Concerning the life-histories of Madras crabs, etc., see Krishna Menon, *Bull. Madras Govt. Mus.* III (3, 5 & 6).

Crabs are classified into three tribes : Dromiacea, Oxystomata and Brachygnatha[1]. In the first the mouth is square and the last pair of legs is modified. In the second the mouth is triangular and produced forwards, the last pair of legs being either normal or modified. In the third the mouth is square and the last pair of legs normal or practically so. Examples of all three tribes occur off the Madras coast, but those which have been found on the beach all belong to the families Calappidae, Leucosiidae or Dorippidae of the Oxystomata or to the families Portunidae, Xanthidae, Grapsidae, Ocypodidae or Maiidae of the Brachygnatha. The first four of these families of Brachygnatha belong to the subtribe Brachyrhyncha in which the body is of normal form, and the Maiidae to the subtribe Oxyrhyncha (spider crabs) in which it is somewhat triangular, being narrowed to a pointed rostrum in front.

Only crabs of which parts at least have actually been found on the beach or which have been found living in the backwaters adjoining the beach, are noted. The number of kinds living locally in the sea is of course far greater, so it is quite likely that others may also be found. Only those with sufficiently durable shells or chelipeds can, however, long survive desiccation and all genera at least that are likely to be found are probably included.

Calappidae.

The box crab *Calappa lophos* (fig. 28, 2) is rare, and the eight-oared swimming crab *Matuta victor* (fig. 28, 3) very abundant, in the backwaters and remains of both have been found on the beach.

The box crab is a strange creature, so constructed that when at rest its broad, somewhat flattened and strongly crested hands are closely apposed to the front of the carapace, the narrow space between being fitted with barriers of hair, and thus serving as a filter for the water sucked in to supply the gills. A prolongation of the inner fork of the first maxillipedes forms the lower wall of a passage through which the water passes out again.

Matuta, the eight-oared swimming crab, also spends much of its time buried in sand but is less specialised for this mode of life than *Calappa* and more active, being of lighter build with the feet of all four pairs of walking legs more or less broad and flat like the blade of an oar to facilitate swimming. Its body is somewhat rounded in outline, with a large triangular spine projecting from each side.

Leucosiidae.

The shells of *Philyra globosa* and *P. globulosa* have been found, the former with chelipeds attached ; and at low tide *P. scabriuscula* (fig. 26, 5-7) is sometimes to be seen a little above low water level hurriedly burying itself in the sand after disturbance by a retreating wave. All are small whitish crabs with very hard shells more or less globular in shape and with relatively long slender chelipeds. They can most easily be distinguished from one another by the character of the line of granules that encircles the shell at its widest part

1 See Borradaile, "On the Classification of Decapod Cructaceans." *Ann. Mag. Nat. Hist.* (7) XIX, 1907, pp. 457-486. For keys to families (according to older classification which Borradaile revises), genera and species see Alcock "Materials for a Carcinological Fauna of India," which appeared in parts from 1896-1900 in *Journ. Asiatic Soc. Bengal* (II Nat. Hist.), LXIV, LXV and LXVII—LXIX.

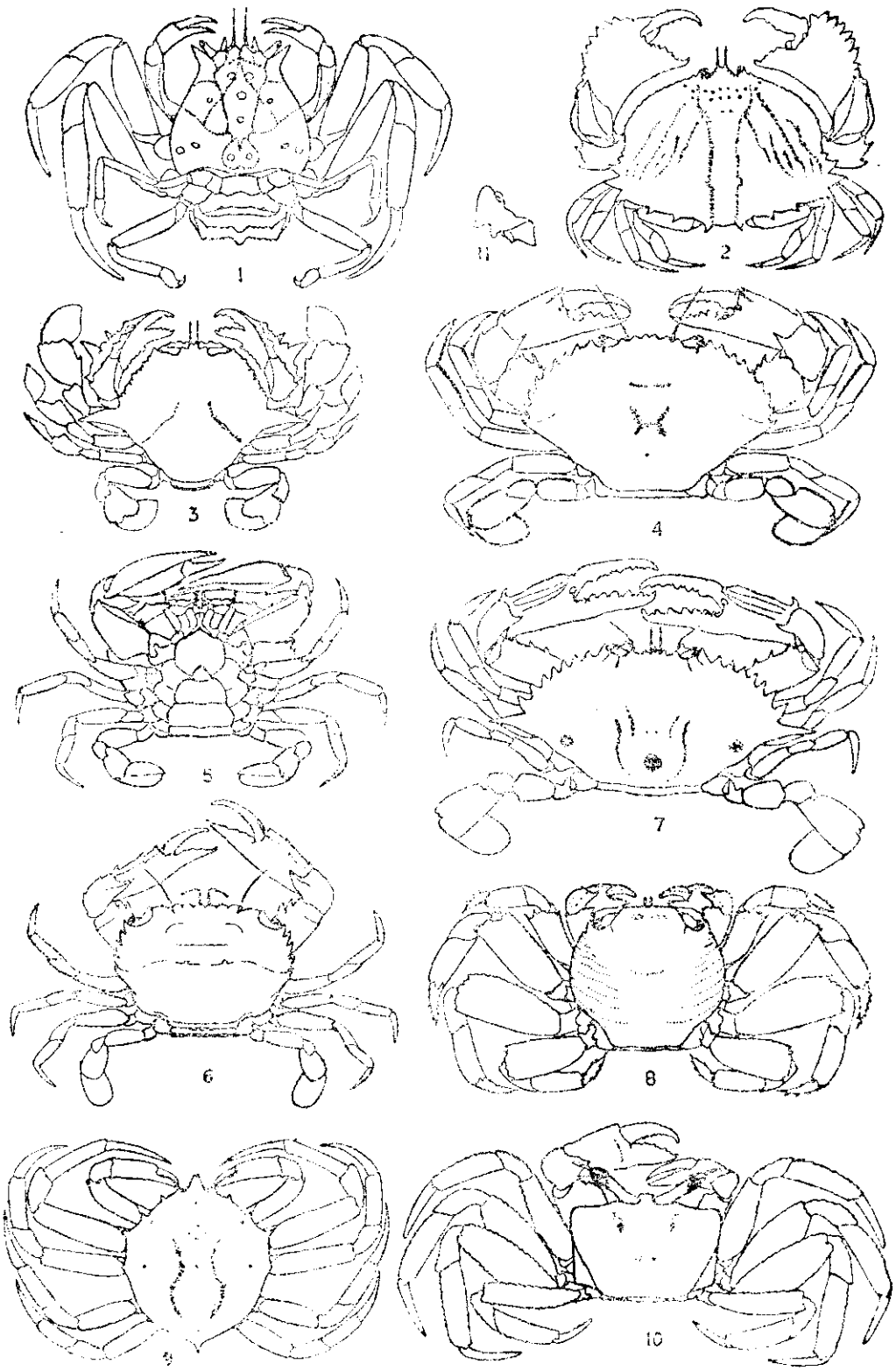

FIG. 28.
CRABS.

1. *Dorippe dorsipes.*
2. *Calappa lophos.*
3. *Matuta victor.*
4. *Scylla serrata.*
5. *Thalamita crenata*, female from below.
6. Same from above.
7. *Neptunus sanguinolentus.*
8. *Grapsus strigosus.*
9. *Doclea hybrida.*
10. *Ocypoda platytarsis.*
11. Jaw of *Neptunus sanguinolentus.*

In *P. scabriuscula* the granules form a uniform series, but the line becomes somewhat confused a little behind the eyes where it divides into two, the lower line being the sharper and extending forwards below the eyes. In the other two species this line does not divide and is sharply defined right up to the eyes, but in *P. globulosa* some of the granules are much larger than the rest, standing out as a series (not very regular) of fine denticles, while in *P. globosa* all form a uniform series as in *P. scabriuscula.*

Dorippidae.

The Dorippidae are sometimes called masked crabs from their habit of holding as a mask to their backs some sort of a defensive or protective object, the last two pairs of legs being modified for this purpose, much smaller than the two preceding pairs, dorsally situated, and with strong hook-like claws.

Much the commonest Madras species seems to be *D. facchino,* a smallish flattened mud-coloured crab sometimes brought up in large numbers by fishing nets, holding over their backs a lamellibranch shell, usually a Tellinid, to which a sea-anemone is attached. A specimen collected by Mr. Crichton holding a shell of the clam *Catelysia opima*, without a sea-anemone, had a fleshy pinkish stalked barnacle attached at the base of the right leg of the penultimate pair and near the end of the left leg of the last pair. The carapace is scarcely as long as broad and has a simple stout forwardly directed spine at the inner end of the lower margin of the eye socket. Its surface varies from almost smooth and hairless to more or less extensively granular or hairy, and the extent of the strong fringes of hair on the two pairs of long walking legs of the male is likewise very variable, not infrequently differing markedly even on opposite legs of a pair in a single individual. I feel sure therefore that, as Alcock himself suspected, the form he tentatively referred to *D. granulata* is not really distinct. These fringes are mostly, but not always, entirely absent in the female.

In the other two species the carapace is distinctly longer than broad. *D. dorsipes* (fig. 28, 1) attains a much larger size than the preceding species and has a more solid shell, which is no doubt why this is the only shell of the family found dry on the beach. Its carapace is more extensively and strongly sculptured, and the base of the spine at the inner end of the lower margin of the eye socket bears a series of stout teeth. *D. astuta* is the smallest of the three species found and has longer and more slender legs than either of the other two. The spine below its eye socket is obsolete.

Portunidae.

The Portunidae, or two-oared swimming crabs, may be recognized by the broadened and flattened form of the feet of the last pair of legs only, the previous three pairs being walking legs of normal form.

The following genera have been found.—

1.	Antero-lateral borders of carapace, or shell covering upper (more strictly anterior) part of body, with 9 teeth ...	2
—	Antero-lateral borders of carapace with not more than 6 teeth	3
2.	Hand inflated and almost smooth, surface of carapace smooth and unbroken	*Scylla.*
—	Hand ridged, surface of carapace almost always in some way broken	*Neptunus.*
3.	Antero-lateral borders of carapace with 6 teeth	*Charybdis.*
—	Antero-lateral borders of carapace with 5 teeth of which the fourth is often small or obsolete	*Thalamita.*

In *Thalamita* the front of the shell is more or less rectangular, with the eyes widely separated and approximately at its angles, while in the other three genera it is more rounded with the eyes nearer to the middle. The shell of the species of *Neptunus* with which we are here concerned differs from that of the other genera in having a pair of very strong spines that project outwards one on each side, somewhat as in *Matuta*, though the shell is much broader and more strongly toothed in front than in that genus. In *Scylla* the chelipeds are more massive than those of the other genera, with the hand free from strong ridges. The only species of *Scylla* found is *Scylla serrata* (fig. 28, 4), the large edible swimming crab of the backwaters and the only known Indian species of the genus.

The two common backwater species of *Neptunus*—*N. pelagicus* and *N. sanguinolentus*—have both been found at Ennur and *N. gladiator*, which is probably marine, has been picked up near the fishing villages south of Adyar, where they have probably been brought up in fishing nets. The last differs from the other two in having the pair of large spines somewhat short and broad instead of long and slender, and in having both the spines on the hind margin of the end of the arm of the chelipeds well developed. In *N. pelagicus* the shell is decorated all over with a network of markings and the hind margin of the arm of the chelipeds bears a terminal well developed spine only, though a rudimentary one may be present a little further back. In *N. sanguinolentus* (fig. 28, 7 and 11) which seems to be the species most commonly met with, the shell is without reticulate markings but bears three large red spots near the hind margin, the hind margin of the arm of the chelipeds being without teeth. In the case of shells from which the colour has been bleached by exposure the last two species can be distinguished from one another by the pair of teeth in the middle of the front margin, which are somewhat stronger in *N. sanguinolentus* than in *N. pelagicus*, but the difference is apt to be very slight.

Two species of *Charybdis* were found near the fishing villages south of Adyar in December 1939. The commoner of the two, *C. callianassa*, has the first of the teeth on

the antero-lateral margins of the carapace pointed, and the last one enlarged almost as in *Neptunus gladiator*, and has no paired ridges on the carapace behind the level of the last of these teeth. The other, *C. natator*, has the front antero-lateral tooth on each side truncate and the last one not enlarged, and has two short ridges on either side behind the level of the last of these teeth. A single specimen was collected in June 1925, and one of what appears to be a variety of it was obtained with *C. callianassa*. The variety differs from the typical form in its much broader teeth between the eyes, the two innermost pairs being somewhat truncate.

The only species of *Thalamita* found are *T. crenata* (fig. 28, 5-6) with the front cut into six approximately equal lobes exclusive of the broad supra-orbital angles and with all five spines on antero-lateral borders well developed, and *T. admeta* with the front cut into two lobes and the fourth spine on the antero-lateral borders rudimentary. Both are back-water species but neither are commonly seen.

Xanthidae.

No specimens have been found on the beach, but *Sphaerozius nudus* is common among mussels, oysters, etc., on wooden piers in the harbour, where a single specimen each of *Xantho euglyptus*, and of two species probably belonging to the genus *Actaea*, have also been collected.

Grapsidae.

A single bleached cheliped which seems to be that of *Varuna litterata* is the only specimen from the beach that can be referred to this family, though other genera such as *Sesarma* might also be expected.[1] The concrete blocks by the harbour arm, however, are always swarming with *Grapsus strigosus* (fig. 28, 8), a medium sized somewhat round and flattened crab, which can scarcely fail to be noticed by anyone walking there.

Ocypodidae.

The most familiar genera are *Ocypoda*, stout crabs burrowing in sand near or above high tide mark ; *Dotilla*, tiny crabs burrowing in sand or mud between tide marks ; and *Gelasimus*, the dhobi crabs or calling crabs, which burrow in mud between tide marks ; but *Macrophthalmus*, grey crabs with conspicuously long slender eye-stalks, and carapace usually transversely quadrangular, are also to be found in backwater mud.

The best known crabs on the sands are *Ocypoda cordimana* and *O. platytarsis*, sand-coloured species of which numbers can be seen everywhere on the beach running about on the surface or bringing up pellets of sand from the depths of their burrows and piling them in irregular heaps, the latter near high tide level, the former further from the sea.

[1] Panikkar and Gopala Ayyar record two species of *Sesarma* and two additional Grapsid genera from the back waters, in addition to *Varuna litterata*.

Colonies of *O. macrocera*, a somewhat larger species of which adults are usually of a deep red colour also occur, particularly near the backwaters.[1] The first species lacks and the last two have a horn projecting beyond the eyes, and a sound-producing organ consisting of a series of tubercles or ridges on the lower side of the larger hand which can be rasped against a ridge on the lower side of the last of the three small basal segments of the arm. In *O. platytarsis* (fig. 28, 10) the sound producing organ on the hand consists entirely of small tubercles. In *O. macrocera* the sound producing organ on the hand consists entirely of fine ridges.

Dotilla is a very small crab that burrows in both sand and mud, but only below high tide level and apparently not on such steep beaches as that of Madras, where it appears to be confined to the backwaters. Though the crab is always very small, its burrows on suitable beaches are often so numerous as to form one of their most noticeable features on account of the careful way in which the pellets of excavated material are arranged beside their mouths.[2] Two species have been collected from the Ennur backwater, *D. myctiroides* which differs from all other Indian species in having the carapace about as long as broad and the chelipeds at least three times the length of the carapace, and *D. intermedia* with the carapace distinctly broader than long and the chelipeds relatively much shorter.

The dhobi crab or calling crab, *Gelasimus*, is so named from the habit the male has of sitting at the mouth of its burrow waving an immense and conspicuous hand, like a dhobi beating clothes on a stone, or as if beckoning someone towards it. This hand is often as big as or even bigger than the body, though the pair to it is quite small as are both those of the female. The genus prefers mud to sand, frequenting mangrove swamps and backwaters. Two species are found, *G. annulipes* and *G. triangularis*. In the former the almost microscopically beaded ridges marking the true lateral borders of the carapace are less convergent behind than in the latter, and an enlarged tooth near the tip of the immovable finger of the large hand of the male gives the end of this finger a notched-truncate appearance. In *G. triangularis* the end of this finger scarcely differs from that of the movable finger.

Several specimens of a single species of *Macrophthalmus* have been obtained from the Ennur backwater, but I have been unable to identify them.

Maiidae.

Shells of the common spider crab, *Doclea hybrida* (fig. 28, 9) have been collected from the beach, some of them with the appendages attached.

[1] For details as to the colouring of living specimens of this species, and notes by Annandale on the habits of its megalopa larvae at Ennur, where he found them on the sandy beach of the backwater in January 1915, see "Fauna of the Chilka Lake" *Mem. Ind. Mus.* V; 1915-1924 ("Crustacea Decapoda" by S. W. Kemp, pp. 199-325, 38 text figs., pl. xii-xiii), pp. 219-220, text-figs. 6.

[2] See Symons, "Notes on Certain Shore Crabs" (*Gelasimus*, *Dotilla* and *Scopimera*), *Spolia Zeylanica* XI, 1920, pp. 306-313, 3 text figs.

NOBODY CRABS (PYCNOGONIDA).

These curious little creatures have bodies so small that the greater part of their digestive and reproductive organs have to be accommodated in their legs, though these too are usually very slender. They are sometimes called sea spiders, but that name leads to ambiguity and should be reserved for true marine spiders such as *Desis*, which lives in silky lairs spun in cavities of dead coral between tide-marks on the reefs. Nobody crabs live among hydroids, seaweeds, etc., and are not things one would expect to find on a sandy beach. But in February 1935, several specimens of *Anoplodactylus investigatoris* (fig. 29,1), both male and female, yellowish in colour,[1] were found among filamentous seaweed that had

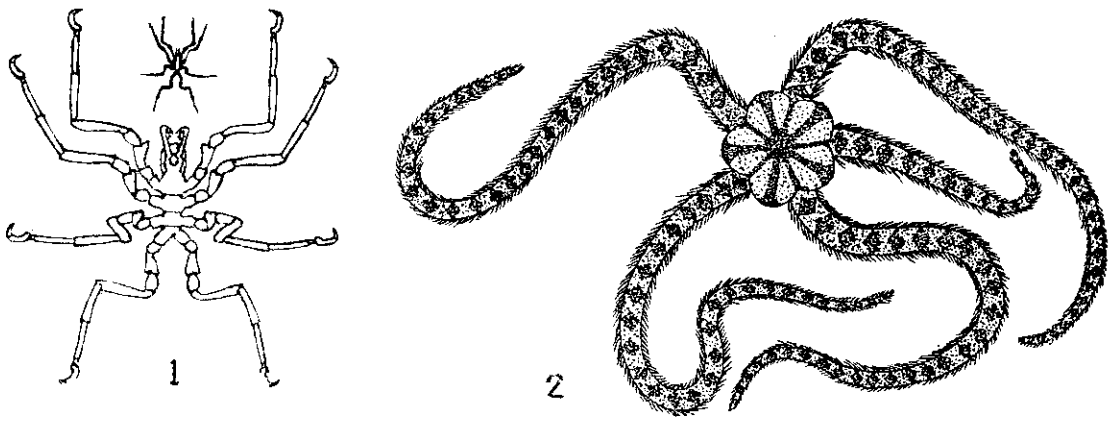

FIG. 29.

NOBODY CRAB AND BRITTLE-STAR.

1. *Anoplodactylus investigatoris*, female (natural size and enlarged).
2. *Ophiocnemis marmorata*.

been washed up. One of the specimens from which the species was originally described came from the Madras harbour. The species is easily identified by the four papillæ arranged in a square on the lower surface of the base of the proboscis in both sexes, the front pair smaller than the hind pair. The eggs are carried by the male, which is somewhat slighter in build than the female, and in this genus the female lacks the special pair of legs used for this purpose though in many genera they are present in both sexes and evidently have other functions also, probably sensory.

For classification see the " Crustacea and Arachnids " volume of the Cambridge Natural History.

[1] This is the colour of specimens preserved in spirit. A specimen later collected with crabshermit from a fishing net and only noticed after decomposition had set in was whitish, faintly banded with dull red.

STARFISH, SEA URCHINS, ETC. (ECHINODERMATA).

To this group belong the sea lilies, starfish, sea urchins and sea cucumbers. They are radially symmetrical animals, though some show a secondary bilateral symmetry. They almost always have five radii or some multiple of five. Numerous *tube-feet* are arranged along the radii, each terminating as a rule in a sucker for adhesion and locomotion, but sometimes purely respiratory.

SEA LILIES (CRINOIDEA).

Typical sea lilies growing on stalks attached to some fixed object, though abundant in past geological epochs, are now extremely rare and are found mostly in the deeper parts of the ocean. But species which become detached from their stalks early in life and can subsequently move about are more abundant and two of them, *Tropiometra encrinus* and *Lamprometra palmata*, are to be found in the harbour. The former is a graceful purplish brown creature with ten plume-like arms. The latter has thirty or forty arms.

STARFISH (ASTEROIDEA).

The only starfish that is at all common is *Astropecten mauritianus* (fig. 30, 1). Like other members of its genus it has its five arms bordered by a row of well developed stony plates. But as its plates are not firmly cemented together it soon falls to pieces after death, and is not likely to be found except when freshly washed up.

A single specimen, somewhat incomplete, of *Anthenea*, probably *A. regalis*, has also been found. Its disc is large and its arms relatively broad, short and bluntly pointed, being more or less merged in the disc. The arms are bordered by comparatively large plates as in *Astropecten*, but there is an extensive area between these plates and the five grooves for the tube-feet running from the mouth to the tips of the arms on the under side, which is filled with more or less oval plates each with a broad slit-like cavity in the middle.

BRITTLE-STARS (OPHIUROIDEA).

Brittle-stars have a comparatively small, flattened disk and very long, slender arms which they are apt to throw off either whole or in fragments when irritated—hence the name brittle-star.

One moderately large species, *Ophiocnemis marmorata* (fig. 29, 2), with the usual five arms and with a characteristic 10-armed cross of small spines on the upper surface of the disc, is common on the sandy sea bottom and is sometimes caught in fishing nets and so

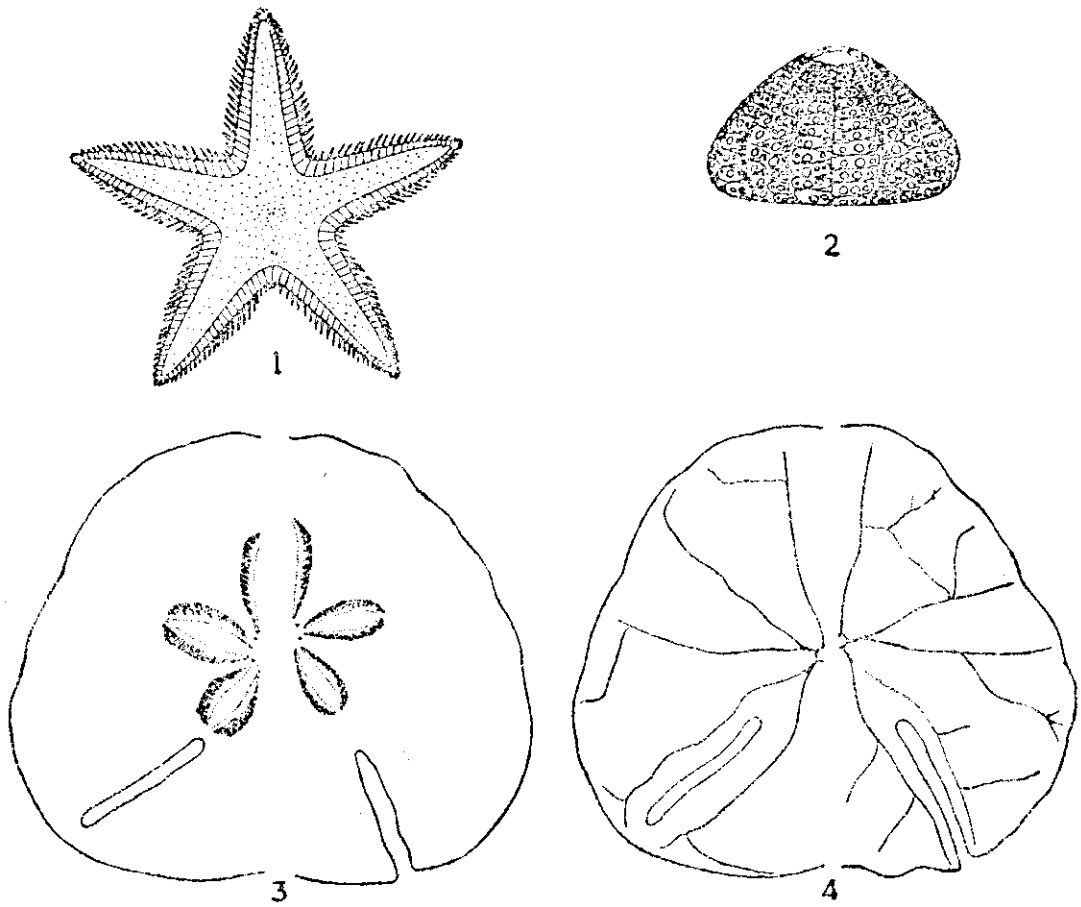

FIG. 30.

STARFISH AND SEA URCHINS.

1. *Astropecten mauritianus.*
2. *Temnopleura toreumaticus.*
3. & 4. *Echinodiscus bisperforatus* (left half) and *E. auritus* (right half) from above and from below.

brought to the beach. Another species of about the same size, with slightly clubbed spines, lives in the harbour where a smaller species with six arms, *Ophiothele danae*, is common among oysters, etc., attached to piers.

SEA URCHINS (ECHINOIDEA).

Examples of each of the three principal types of sea urchin, the regular or true sea urchins, the cake urchins and the heart urchins, may at times be found on the Madras beach, but as their shells are more or less fragile they are not very common and are usually found in a somewhat broken condition. The true sea urchins (*Endocyclica* or *Regularia—Echinidea*)

are more or less perfectly radially symmetrical, with mouth and anus at opposite poles. The cake and heart urchins (*Irregularia*) are definitely bilaterally symmetrical, this type of symmetry being superimposed upon the fundamental radial symmetry characteristic of the group, with the anus behind the mouth and almost always on the under surface. Cake urchins (*Clypeastridea*) are greatly flattened and heart urchins (*Spatangidea*) are commonly more or less heart shaped.

TRUE SEA URCHINS (ECHINIDEA).

Two families are represented at Madras, but all the shells that have been found on the beach belong to the Temnopleuridae, in which the horizontal sutures between the separate plates composing the shell are more or less distinctly sunk in grooves, and the pores from which the tube-feet arise are arranged in series of groups of three pairs each on compound plates, each composed of three elements. Of the two Madras genera *Temnopleura* has its horizontal sutures sunk in deep hollows at one or both ends, while *Salmacis* has them lightly sunk throughout in shallower grooves. Each suture terminates at one or both ends in a pore-like cavity in both genera.

The only common species strong enough to be washed up whole as a rule, when washed up at all, is *Temnopleura toreumaticus* (fig. 30, 2), a small grey-brown shell and the only Madras representative of its genus. It is abundant in the harbour, covered with somewhat long and slender red-banded white spines, the bands being somewhat narrow and fading out towards the base.

Two species of *Salmacis*—*S. bicolor* and *S. sphaeroides*—are recorded by Gopala Ayyar[1] from Madras harbour, but no specimens of the latter are now available, and a single shell of a third species, *S. dussumieri*, has been picked up on the beach. More recently he has found *S. virgulata* common further out to sea. Though much thinner and more fragile than *Temnopleurus toreumaticus*, which it resembles in colour, the single shell of *S. dussumieri* is practically complete. It differs from all other Madras species of sea urchin in being much less elevated, in having its under surface strongly concave around the aperture occupied in life by the membrane surrounding the mouth, and in having one large tubercle on every alternate plate of the series the outer ends of which bear the pores for the tube-feet, instead of on every plate. The pores in which the horizontal sutures terminate are somewhat small, and their grooves on the upper part of the shell very feebly developed.

The base of a larger shell of similar pale brownish colour picked up on the beach presumably belongs to *S. bicolor*, which is the common species in the harbour, but in the absence of the upper parts of the shell it is impossible to be certain. When fresh the shell of this species is covered with spines characteristically banded with purple and pale green. Much

[1] *Indian Zoological Memoirs*, VIII Salmacis (Lucknow, 1938, 68 pp., 1 pl., 47 text figs., p. 7).

commoner on the beach are fragments of a pale greenish shell with extremely shallow horizontal sutural grooves on the upper parts of the shell, undoubtedly *S. virgulata*, the spines of which are deep blue and not banded. Shells that have lost their spines can easily be distinguished from those of *S. bicolor* when sufficiently complete, not only by their colour if fresh enough to show it, but also by the sutural grooves of the upper part of the shell, those of *S. bicolor* being much more pronounced than those of *S. virgulata*. The species which serves as host to the parasitic snail *Stylifer sibogae* seems to be distinct from any of these but has not been satisfactorily identified. It lives far from the shore and its shell has not been found on the beach.

A big urchin, *Stomopneustes variolaris*, with very long and thick spines of a deep violet colour mounted on large tubercles, can sometimes be found at extreme low tide clinging to the outermost concrete blocks east of the harbour entrance.

CAKE URCHINS (CLYPEASTRIDEA).

Two species of *Echinodiscus* are not infrequently found on the beach, and occasional examples have been obtained by Mr. Crichton, and presented to the Museum, of three other genera, *Fibularia*, *Clypeaster* and *Peronella*.

The family Fibulariidae differs from all others in having the pores from which the tube feet arise relatively large and few, and arranged in more or less straight radial lines, not in lines that curve so that five pairs of double lines form together a figure resembling a flower with five petals as in the remaining families. The single Madras species, *Fibularia volva*, is somewhat minute, egg-shaped, not greatly depressed, slightly pointed in front, anus not far behind mouth, tube-foot pores in front half of shell tending to be very large and more or less triangular.

The other three Madras genera belong to three different families, all with well developed petals. *Peronella*, differing from the only other genus *Laganum* of its family Laganidae in having four instead of five genital pores in its apical area, is represented by two smallish discoidal species with slightly raised centre and the anus a little in front of the hind margin. One is white and very thin, with the outlines of the plates well marked on both surfaces. The other is somewhat thicker, pinkish at the edge above, with no trace visible of the outlines of the plates of the upper surface. I have not been able to identify either of them.

The genus *Clypeaster* is represented by three specimens about three quarters of an inch, one and a half inches, and four and a half inches in diameter respectively. Though at first sight differing considerably from one another they resemble each other so closely in detail that I think the differences in appearance can only be due to size and that all must be different stages in the growth of a single species. The smallest specimen, except for its somewhat darker colour, slightly more pentagonal shape and very slightly more elevated centre, is very like the first of the two species of *Peronella* just described, but its ambulacral plates

meet round the peristome from which they cut off the interambulacral plates, instead of the interambulacra being continuous from apical system to peristome as in the Laganidae.[1] The intermediate specimen is greenish in colour with brown showing through in places and is more definitely pentagonal. The largest specimen is brown and pentagonal but somewhat less regular in outline. All are slightly longer than broad. The petals are beautifully regular with a row of small tubercles in the larger specimens between the grooves separating consecutive pairs of tube-foot pores. In the largest specimen the petals are very broad and are not closed as in the younger ones, in which they are somewhat more slender also The species seems to be near *C. rarispinus*, which it resembles in the relatively slight elevation of its centre, but is probably I think distinct from it.

The genus *Echinodiscus* can at once be recognized by its pair of oblique slits, either continuous with or near to the hind margin of the shell. On the Madras beach the large *E. auritus* (figs. 30, 3 and 4, right half of each) in which the slits are continuous with the margin is less commonly washed up than the smaller *E. bisperforatus* (figs. 30, 3 and 4, left half of each). Complete shells of the former can easily be distinguished from those of the latter by the shape of the shell and of the five petals of the flower-like areas of double pores on the upper surface, and also by the pattern of the more or less branched grooves that radiate from the mouth in the middle of the lower surface. In *E. bisperforatus* the shell is somewhat broader than it is long, with the anus very near the hind margin. It has a pair of extensive linear slits situated at an obtuse angle to one another near the hind margin with which, however, they are not confluent. In *E. auritus* the shell is somewhat longer than it is broad with the anus nearly half way from the margin to the mouth, while the slits extend at an acute angle to one another and are usually (but apparently not always) confluent with the hind margin. In *E. bisperforatus* the posterior pair of petals is much shorter than the other three, and its petals each little longer than broad, while in *E. auritus* this is not so, though in both the anterior petal is somewhat the longest and the posterior are the shortest. Finally, in *E. bisperforatus* the radiating grooves on the lower surface divide close to the mouth but do not branch again till very near the margin where a single branch arises at about a right angle from both forks of the anterior one, from the posterior fork of the following pair and sometimes from the anterior fork of the posterior pair, while the posterior fork of this pair gives off a similarly placed branch making with it an inner acute angle and an outer obtuse one ; whereas in *E. auritus* all ten forks give off one or more branches, making with them an inner obtuse angle and an outer acute angle or more rarely two right angles, the first of these branches arising about half way to the margin and the last much further from the margin than in *E. bisperforatus*. When pieces of shell have to be identified this last character usually supplies the best clue to their identity.

[1] See Bather in Lankester's "Treatise on Zoology" (Oxford Natural History) III Echinoderma, p. 317.

In *A. bisperforatus* var. *truncatus* the slits are broader and much shorter than in the typical form and are inclined to one another at a less obtuse angle. This variety is occasionally found at Madras.

HEART URCHINS (SPATANGIDEA).

Occasional shells of three species belonging to three different genera are to be found on the beach, where I once picked up a living specimen also of one of them, *Pseudomaretia alta.*

The least scarce, an undetermined species of *Echinolampas* (fig. 31), belongs to a family in which all the petals have the same essential structure and the tubercles are all small and

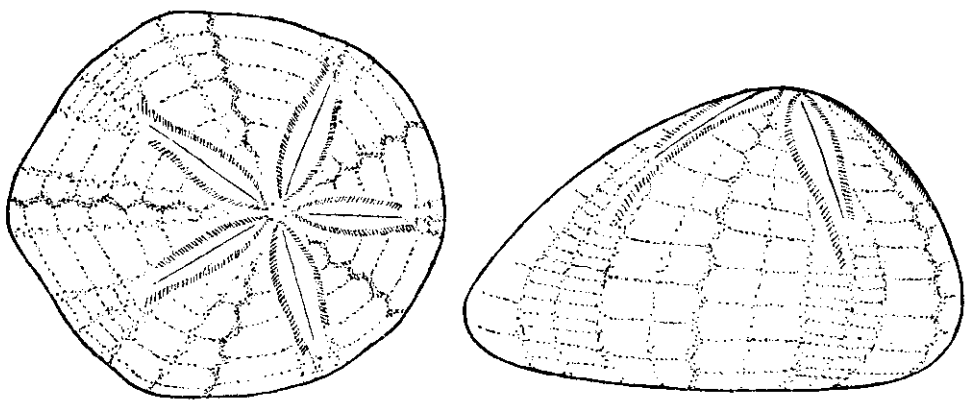

FIG. 31.
HEART URCHIN, *Echinolampas sp.*

simple. It is not heart-shaped as are the other two, in both of which the anterior petal differs markedly in structure from the rest and groups of greatly enlarged special tubercles are present, especially on the under side. In life these bear specially long spines. Of the two such species found, *Pseudomaretia alta* bears only a small group of three or four large tubercles on either side of the upper surface, while in *Lovenia elongata* they are much more numerous. The petals are also less specialized in the former than in the latter.

SEA CUCUMBERS (HOLOTHUROIDEA).

These are soft but usually tough skinned and somewhat sausage-shaped creatures with the mouth surrounded by retractile feathered tentacles at one end and the anus at the other, the five radii extending lengthwise between them as would result if the girth of a regular sea urchin were to be reduced and the height greatly elongated. None have been found on the beach ; but *Thyone sacellus,* a smallish species reddish in colour, with the ventral pair of tentacles (in one of our specimens the ventral two pairs) much smaller than the rest, is not

uncommon among mussels, oysters, etc., on wooden piers in the harbour. The spicules in its skin agree closely with those described from Krusadai Island, differing from those described by Pearson from the Ceylon pearl banks in exactly the same way as they do.[1]

Single specimens of two other species have been obtained from the same place, one of them an active bluish creature probably belonging to the genus *Synapta.*

VERTEBRATE ANIMALS, ETC. (CHORDATA).

In the lower orders of this group there is no true vertebral column surrounding the spinal nerve cord, but only a *notochord* situated just beneath it. These orders include the Ascidians in most of which a free-living larva, that swims about by means of a tail containing dorsal nerve cord and notochord, becomes permanently attached, loses its tail and develops into an entirely sedentary adult, often forming colonies by budding. Several species live in the harbour and though none have been found washed up on the beach a colonial form in which the individuals are embedded in a mass of sand-encrusted jelly has been collected from the low rocks of Kassimode bay.

True vertebrates are numerous on the beach if the various kinds of fish caught by net or line and the various birds that frequent it are included—far too numerous to be dealt with here, where attention must therefore be concentrated upon those which can be picked up on the sand.

Two or three species of small fish sometimes get washed up. But the species most likely to attract attention are the puffer fish thrown out of their nets by fishermen as useless for food, and the curious sea horse collected, dried and offered for sale by small boys. The former, when left to itself, is a somewhat stoutly built fish with four large teeth, one pair upper and one lower, its skin being covered with small backwardly directed spines. When it feels itself to be in danger, however, it blows itself out till it becomes more or less spherical, a process which causes all its sharp little spines to stand erect. If this happens out of water it can only inflate itself with air, and if washed back into the sea by a wave it floats helplessly on its surface.

The sea horse belongs to the pipe-fish family, in which the body is protected by a series of hard rings and the snout is much produced, in the sea horse being set at an angle to the rest of the body which gives it a remarkable resemblance to the head of a horse. It can always be seen alive in the Madras Aquarium, where its elegant and peculiar mode of swimming may be watched.

[1] For reference see below, p. 106.

Sting rays should also be mentioned as they occasionally inflict large poisoned wounds on bathers. The sting somewhat resembles a big flattened double-edged saw with pointed end, and is situated on the back of the whip-like tail some little way beyond the base. When the tail is lashed from side to side it can inflict a very nasty wound and though the sting has no special poison glands, poison enough is provided by the mucous glands with which the skins of fishes are always copiously supplied.

In sharks and rays the skeleton consists entirely of cartilage (as in the early stages of development of the higher vertebrates including man), the gill-slits are exposed, and the scales take the form of denticles. A piece of hardened and waterworm cartilage, evidently from the skull of a large fish of this group, is the only specimen picked up by which they are represented. Of the bony fishes, in which the gill-slits are covered by an *operculum* and the scales are commonly flattened and overlapping, a complete brain case with adjoining bones has been found, as well as other bones including supporting rays from the fins of some very large species of fish, and scales. The bones of the upper surface of the brain case are strongly granular, the granules on some of them being arranged in radiating lines, a feature characteristic of the skulls of many fishes. Fin rays are usually lightly curved backwards and longitudinally grooved on one or both sides for the attachment of the fin membrane. The large examples found are strongly grooved on both sides and bear six or seven strong keels in the distal part while near the base they are closely covered with pits the edges of which are raised and strongly toothed.

In the spring large pits surrounded by quantities of crumpled white leathery objects appear in the sand a little above high tide mark in quiet places such as the beach on the northern side of the opening to the sea of the Ennur backwater. These mark the places where large marine turtles have come ashore and laid their eggs, the white objects being the leathery egg-shells from which the baby turtles have emerged.

Snakes of two different types are sometimes found, the blackish backwater snake *Cerberus rhyncops* with round tail, and the true sea snakes with flattened tails. Neither prove dangerous in practice though the latter are deadly poisonous if they bite. But this they very rarely do, being extremely quiet and having very small mouths. On one occasion I myself trod on a full-grown one in the Ennur backwater and, mistaking it for a large sea cucumber such as I had never found near Madras, I raised it to the surface first between my feet and then with my hands. On seeing it of course I at once let go, when it swam quietly away without showing the slightest inclination to attack.

Gulls, terns and various other birds including the ubiquitous crow are constantly seen but cannot be dealt with here.

LIST OF IDENTIFIED GENERA AND SPECIES AND OF REFERENCES TO LITERATURE.

References to authorities could not be fitted into the above account of the animal remains of the Madras beach without awkwardness. They are therefore given below. A complete bibliography would be out of place and is in any case beyond me, but I have tried to indicate for each species either a helpful figure or a recent reference from which earlier references, often with figures, can readily be traced.

It should be pointed out here that, as the paper deals primarily with remains washed up on the beach, the inclusion of a species in this list does not necessarily imply that it lives anywhere in the immediate neighbourhood. In some cases indeed—*e.g.*, the coral *Symphyllia sinuosa*—this seems most improbable. Species marked with an asterisk have been referred to but are either not recorded from Madras or are recorded only with some uncertainty. Three molluscs thus marked—*Meretrix meretrix, Tellina bruguieri* and *Solecurtus exaratus*—have definitely been collected, but only on a single occasion each and that on the sea beach at Ennur. All are likely to occur naturally, but confirmation is needed as it is possible that they may have been brought from elsewhere to the Biological Supply Depot there, thrown out later and eventually washed up again. This is presumed to have been so in the case of the strictly Californian species of cockle, *Cardium elatum* Sowerby (consequently not recorded) of which I recently picked up single valves from two small specimens on two different days.

PROTOZOA.

FORAMINIFERA.

Three undetermined species, one belonging to the genus *Polytrema*. Further information regarding this subclass will be found in Pt. I of "Lankester's Treatise on Zoology."

MASTIGOPHORA (FLAGELLATA).

None have been recorded above, as none were collected. But one of the causes of phosphorescent sparkles in the waves at night is the large flagellate *Noctiluca*.

PORIFERA.

TETRAXONIDA.

Clavulidae.

Spirastrella inconstans (Dendy, ?=*purpurea* Lamarck, see above, p. 6 footnote). Burton, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (2) 4, 1937, pp. 14-15, pl. viii, fig. 51.

Haploscleridae.

Adocia carnosa (Dendy). Burton, *loc. cit.*, p. 19, pl. i, fig. 11.

Callyspongia fibrosa (Ridley and Dendy). Burton, *loc. cit.*, p. 21.

COELENTERATA.

HYDROZOA.

Pennariidae.

Pennaria disticha Goldfuss. Gravely, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (1), 1927, p. 10, pl. ii, fig. 1.

Hydractiniidae.

Clavactinia gallensis Thornely, Ceylon Pearl Oyster Report, II, p. 111, pl. i, fig. 3.

Sertulariidae.

Thuiaria interrupta Allman. Gravely, *loc. cit.*, pp. 13-14, pl. ii, figs. 7 and 12.

Idia pristis Lamouroux. Gravely, *loc. cit.*, p. 15, pl. iii, fig. 21.

Plumulariidae.

Lytocarpus philippinus (Kirchenpauer). Gravely, *loc. cit.*, p. 18, pl. iii, fig. 18.

Rhizophysaliidae.

Physalia utriculus (La Martinière). Sundara Raj, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (1), 1927, p. 21, pl. iv, figs. 2-2 B.

Chondrophoridae.

Porpita pacifica Lesson. Sundara Raj, *loc. cit.*, pp. 21-22, pl. iv, figs. 1-1 A.

Velella sp.

Hydromedusae.

For a descriptive list of Madras species, see M. G. K. Menon's " The Hydromedusae of Madras ", *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. III (2), 1932, 32 pp., 3 pl.

SCYPHOZOA.

For a descriptive list of Madras species, including *Dactylometra quinqicirrha* L. Agassiz, *Aurelia solida* Browne and *Acromitus flagellatus* (Haeckel), see M. G. K. Menon's " The Scyphomedusae of Madras and the Neighbouring Coast", *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. III (1), 1930, 28 pp., 3 pl.

ANTHOZOA.

Gorgonidae.

None identified.

Telestidae.

Telesto trichostemma (Dana). Gravely, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (1), 1927, pp. 28–29.

Pteroeidae.

Sarcophyllum sp.

Veretillidae.

Cavernularia sp.

Zoanthidae.

Zoanthus, *Palythoa* (incl. *Gemmaria*) and *Epizoanthus.*

Sphenopidae.

Sphenopus marsupialis (Gmelin). Gray on the Zoanthinae, *Proc. Zool. Soc., London*, 1867, p. 236, figs. 2–5.

Turbinoliidae.

Flabellum pavoninum (Lesson). Gardiner, *Marine Investigations in S. Africa* II (Dept. of Agriculture, Cape-town, 1902), p. 123, pl. iv, figs. 18-21.

Trochocyathus sp.

Heterocyathus aequicostatus Milne Edwards and Haime. Gardiner, Turbinolid Corals of S. Africa, Vol. III of same series, pp. 105-112, pl. iii, figs. 1-43.

Pocilloporidae.

Pocillopora damicornis (Linnaeus). Gravely, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (1), 1927, p. 43.

Astraeidae.

Favia sp.

Symphyllia sinuosa Quoy and Gaimard. Matthai, Madreporarian Corals of Indian Museum, *Mem. Ind. Mus.*, VIII (1), 1924, p. 31.

Eupsammidae.

Heteropsammia cochlea (Spengler). Van der Horst, Madreporaria of Siboga Expedition III, *Siboga Reports*, XVI *c*, 1922, pp. 66–67.

CTENOPHORA, PLATYHELMINTHES AND NEMERTEA.

For further information on the Ctenophora, Vol. I, and on the other two groups the "Worms, Rotifers and Polyzoa" volume of the Cambridge Natural History may be consulted.

ANNELIDA.

POLYCHAETA.

Eunicidae.

Onuphis eremita Audouin and Milne Edwards. Fauvel, *Mem. Ind. Mus.*, XII, 1932, p. 146.

Amphictenidae.

Pectinaria sp.

Serpulidae.

Hydroides norvegica Gunnerus. Fauvel, *Mem. Ind. Mus.*, XII, 1932, p. 242.

Pomatoceros coeruleus (Schmarda). Fauvel, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (2) 1, 1930, p. 67.

Spirorbis sp.

POLYZOA.

Concerning South Indian Polyzoa see Gravely, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (1), 1927, pp. 89–94, pl. xi.

BRACHIOPODA.

Lingulidae.

Lingula sp.

Discinidae.

Discinisca indica Dall, *Proc. U.S. Nat. Mus.*, LVII, 1921, p. 279.

MOLLUSCA.

See also Preston's "Report on a Collection of Mollusca from the Cochin and Ennur Backwaters" (*Rec. Ind. Mus.*, XII, 1916, pp. 27-39, figs. 1-17) regarding Ennur backwater shells, and regarding other estuarine shells from the Indian side of the Bay of Bengal his papers on shells from the Chilka Lake in Vols. X and XI of the same publication and from the outskirts of Calcutta in Vol. XI.

AMPHINEURA.

Mopaliidae.

Plaxiphora indica. Thiele, "Revision...Chitonen", *Zoologica*, heft 56, 1909, p. 23, pl. iii, figs. 15–19.

Cryptoplacidae.

Acanthochitona mahensis Winckworth, *Proc. Malacol. Soc.*, XVII, 1927, pp. 207-208, pl. xxix, figs. 9-10.

SCAPHOPODA.

All references to Boissevain refer to her report on the Scaphopoda of the Siboga Expedition, published in 1906.

Dentaliidae.

Dentalium (s. str.) octangulatum Donovan. Boissevain, pp. 17–18, pl. i, fig. 8, pl. iv, figs. 8–9.

* *Dentalium hexagonum* Gould and its var. *sexcostatum* Sowerby. Boissevain, pp. 12–13, pl. i., fig. 14, pl. vi, figs. 1-2.

* *Dentalium* (*Graptacme*) *elpis* Winckworth, *Proc. Malacol. Soc.*, XVII, 1927, pp. 167–169.

Dentalium (*Graptacme*) *pistis* Winckworth, *Proc. Malacol. Soc.*, XXIV, 1940, p. 43, fig. 6.

Dentalium (*Laevidentalium*) *eburneum* Linnaeus. Boissevain, pp. 52–54, pl. ii, fig. 31, pl. iv, figs. 10–11.

Dentalium (*Laevidentalium*) *philippinarum* Sowerby. Boissevain, p. 53 (regarded there as synonym of *eburneum*, under which references are given).

Siphonodentaliidae.

Cadulus euloides Melvill and Standen. Boissevain, pp. 70–71, pl. iii, fig. 52.

Cadulus anguidens Melvill and Standen. Boissevain, p. 74, pl. iii, fig. 50.

LAMELLIBRANCHIATA.

Reeve's "Conchologia Iconica" (published 1843–1878), of which the first fifteen volumes were prepared by himself and the remaining five after his death by Sowerby, and Baini Prashad's report on the Lamellibranchia of the Siboga Expedition (published 1932) are so frequently mentioned below that to avoid unnecessary repetition of titles they are referred to briefly as "Reeve" and "Prashad" respectively Each of Reeve's volumes contains a series of monographs on individual genera the plates and figures of which are numbered independently. The volume number is therefore quoted in capital Roman figures, followed after a comma by the plate number in small Roman figures and by the figure number in ordinary numerals. Thus under *Nucula mitralis* the entry Reeve, XVIII, ii, 8, means "Conchologia Iconica", Vol. XVIII, Monograph of the genus *Nucula*, pl. ii, fig. 8. Lynge's "Marine Lamellibranchiata of the Danish Expedition to Siam, 1899–1900" was published in *K. Danske Vidensk. Selsk. Skrs.* Nat. Math. 7, v, 3 (Copenhagen, 1909). The full reference is too long to quote each time.

Nuculidae.

Nucula mitralis Hinds. Reeve, XVIII, ii, 8.

Nuculanidae (= Ledidae)[1].

Nuculana (=*Leda*) *mauritiana* Sowerby. *Laeda mauritiana*, Reeve, XVIII, vi, 33.

Arcidae.

Arca tortuosa Linnaeus. Reeve II, xiii, 86.

Arca obtusoides Nyst (= *obtusa* Reeve). Prashad, p. 47.

Arca lateralis Reeve, II, xvii, 115 (figure poor and misleading).

Arca complanata Bruguière. *A. velata* Reeve II, xii, 79.

Arca symmetrica Reeve. Prashad, p. 54.

Arca avellana Lamarck. Prashad, p. 32.

Arca ventricosa Lamarck. Prashad, p. 33.

Arca bistrigata Dunker, "Novitates Conchologicae", 1886, p. 87, pl. xxx, fig. 46.

Arca gubernaculum Reeve, II, iii, 14.

Arca indica Gmelin. Lynge, Marine Lamellibranchiata of the Danish Expedition to Siam 1899–1900, pp. 30–31 or pp. 126–127, pl. ii, figs. 5–12.

Arca inaequivalvis Bruguière. Reeve II, viii, 54.

Arca granosa Linnaeus. Prashad, p. 36.

Arca rhombea Born. Reeve II, ii, 12.

Arca pilula Reeve. Prashad, p. 40.

Arca concamera Brugui re. *Arca concamerata* Reeve XVII, i, 1.

Glycimeridae.

Glycimeris taylori (Angas) *Proc. Zool. Soc., London*, 1879, p. 417.

Mytilidae.

Mytilus viridis Linnaeus. *M. smaragdinus* Reeve X, vii, 28.

Modiolus auriculatus (Krauss). *Modiola auriculata* Krauss "Die Sudafricanischen Mollusken" (Stuttgart 1848), p. 20. pl. ii, fig. 4. See also Lamy, *Journ. Conchy.* LXXX, 1936, pp. 288–292.

Modiolus metcalfei (Hanley). *Modiola metcalfei* Reeve X, iv, 16.

Modiolus undulatus (Dunker). *Modiola undulata* Annandale and Kemp, *Mem. Ind. Mus.*, V (4) 1916, pp. 358–360, pl. xv, figs. 1–6, pl. xvi, fig. 1.

Modiolus striatulus (Hanley). *Modiola striatula* Annandale and Kemp, *loc. cit.*, pp. 360–362, pl. xv, figs. 7–18, pl. xvi, fig. 2.

Septifer bilocularis (Lamarck). *Mytilus nicobaricus* Reeve X, ix, 42.

Lithophaga cumingiana (Reeve). *Lithodomus cumingianus* Reeve X, ii, 8.

[1] See Prashad, p. 18.

Isognomonidae (= Vulsellidae).

Isognomon nucleus (Lamarck). *Perna nucleus* Reeve XII, i, 4.

Vulsella vulsella (Linnaeus). Prashad, pp. 88–89.

Malleus albus Lamarck. Prashad, pp. 104-105.

Pteriidae.

Pteria chemnitzii (Philippi). Prashad and Bhaduri, *Rec. Ind. Mus.*, XXXV, 1933, pp. 171–172.

Pteria vulgaris (Schumacher). Prashad and Bhaduri, *loc. cit.*, pp. 169–171.

Pteria chinensis (Leach ; incl. *Avicula radiata* Hornell "Common Molluscs of S. India," Madras Fisheries Dept., 1922, p. 166, fig. 40). Prashad, pp. 92–93.

Pinnidae.

Pinna (*Atrina*) *pectinata* Linnaeus. Prashad, pp. 137–138.

Pinna (*Atrina*) *vexillum* Born. Prashad, pp. 135–136.

Pinna attenuata Reeve. Winckworth, *Proc. Malacol. Soc., London*, XVIII (6), 1929, p. 287.

Pinna incurva Gmelin. Winckworth, *loc. cit.* p. 287.

Pectinidae.

Amussium pleuronectes (Linnaeus) *Pecten pleuronectes* Reeve VIII, xiii, 48.

Pecten tranquebarius (Gmelin). Reeve VIII, iii, 14.

Pecten crassicostatus Sowerby.[1] Reeve VIII, xviii, 64.

Pecten splendidulus Sowerby.[1] Reeve VIII, xix, 67.

Pecten histrionicus (Gmelin). Reeve VIII, xxix, 130.

Pecten pyxidatus (Born). Reeve VIII, xxiv, 96.

Spondylus layardi Reeve IX, xviii, 66.

Plicatula sp.

Limidae.

Lima lima (Linnaeus, = *squamosa* Lamarck). Prashad, pp. 119–122, pl. iii, figs. 23-24.

Lima fragilis (Gmelin). Prashad, pp. 124–125.

Anomiidae.

Anomia achaeus Gray. Prashad, pp. 29–30.

Placenta placenta (Linnaeus). *Placuna placenta* Reeve XVIII, iii and iv, 3 *a-d.*

Ostreidae.[2]

Ostrea madrasensis Preston (= *virginiana* Hornell, Common Molluscs of S. India, *non virginica* Gmelin, *non virginiana* Röding ; ?=*margaritacea* Lamarck) *Rec. Ind. Mus.* XII, 1916, pp. 33–35, figs. 11–11 *a.*

Ostrea forskalii Gmelin (?=*cucullata* Born). *O. cucullata* var. *forskali* Lynge, Marine Lamellibranchiata of the Danish Expedition to Siam 1899–1900, pp. 64–65 or pp. 160-161.

* *Ostrea crista-galli* Linnaeus. Prashad, pp. 131-133.

* *Ostrea denticulata* Born. Reeve XVIII, ix, 14.

* *Ostrea lentiginosa* Sowerby. Reeve XVIII, xxiv, 58.

Crassatellidae.

Crassatella radiata Sowerby. Prashad, p. 141.

Crassatella rostrata Lamarck. Reeve I, ii, 10.

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[1] Dautzenberg and Bavay (Lamellibranchiata of the Siboga Expedition—Pectinidae—Leiden 1912, pp. 4–5) regard *P. crassicostatus* Sowerby as a synonym of *P. senatorius* Gmelin. Their description of colour variation leads me to wonder if *P. splendidulus* should not also be so regarded.

[2] For a synopsis of Indian species of oyster, incomplete and without synonymy, but recognizing several species not recorded here, see Awati, Ostraea cucullata, *Indian Zoological Memoirs* III, Lucknow 1931 (107 pp. 51 text figs.), pp. 5–8.

Carditidae.

Cardita bicolor Lamarck. *C. antiquata* Reeve (*non* Linnaeus) I, vi, 29.
Beguina variegata (Bruguière). *Cardita* (*Arcinella*) *variegata* Prashad, pp. 143–144.

Isocardiidae.

Isocardia vulgaris Reeve. Prashad, pp. 150–151.

Libitinidae.

Libitina vellicata (Reeve) *Cypricardia vellicata*. Reeve I, ii, 7.

Ungulinidae.

Diplodonta globosa Gmelin. Prashad, pp. 165-166.
Diplodonta nevilli Sowerby, *Ann. Mag. Nat. Hist.* (7) XVI, 1905, p. 191

Lucinidae.

Phacoides macassari (Prashad). *Dentilucina* (*Bellucina*) *macassari* Prashad, p. 163 pl. v figs. 13-16.
Codakia angela (Melvill). *Lucina* (*Codakia*) *angela* Melvill, *Ann. Mag. Nat. Hist.* (7) IV, 1899, p. 98, pl. ii, fig. 8.
Lucina edentula (Linnaeus). *L. philippiana* Reeve VI, v, 23.
Lucina ovum Reeve, VI, v, 21.

Chamidae.

Chama reflexa Reeve, IV, iv, 16.
Pseudochama sp.

Cardiidae.

Cardium australe Sowerby. Prashad, pp. 280–281.
Cardium oxygonum Sowerby. Reeve II, xvi, 77.
Cardium assimile Reeve, II, ix, 45.
Cardium coronatum Spengler. Lynge, Marine Lamellibranchiata of the Danish Expedition to Siam 1899–1900, p. 159 or 255.
Cardium asiaticum Bruguière. Lynge, *loc. cit.*, p. 159 or 255.
Cardium setosum Redfern. *Cardium latum* (*non* Born) Reeve II, iv, 21.
Lunulicardia retusa (Linnaeus). Prashad, pp. 287–289.

Veneridae.

Circe scripta (Linnaeus). Prashad, pp. 223–225.
Gafrarium divaricatum (Chemnitz). Reeve XIV, vi, 23.
Meretrix casta Deshayes. Annandale and Kemp, *Mem. Ind. Mus.* V (4) 1916, pp. 351-352.
* *Meretrix meretrix* (Linnaeus). *Cytherea impudica* Reeve XIV, iii, 10.
Meretrix ovum Deshayes. Annandale and Kemp, *loc. cit.*, p. 352.
Pitar alabastrum (Reeve). *Dione alabastrum* Reeve XIV, x, 42.
Pitar erycina (Linnaeus). *Dione erycina* Reeve XIV, i, 3.
Sunetta scripta (Linnaeus). *Meroe scripta* Reeve XIV, ii, 6.
* *Sunetta excavata* (*non* Hanley[1]). Reeve XIV, iii, 11.
Sunetta donacina (Gmelin, = *birmanica* Philippi + *seminuda* Anton + ? *effossa* Hanley[2]). *Meroe seminuda* + *effossa* Reeve XIV, i & ii, 1 & 4.
Sunetta meroe (Linnaeus). *Meroe picta* Reeve XIV, ii, 5.
Dosinia excisa (Gmelin). *Artemis excisa* Reeve VI, vii, 43.

[1] See above, p. 50, footnote 2.

[2] See above, p. 50, footnote 3.

Veneridae—*cont.*

Dosinia prostrata (Linnaeus). *Artemis prostrata* Reeve VI, iv, 23.
var. *modesta* Reeve. *Artemis modesta* Reeve VI, ix, 54.
var. *cretacea* Reeve. *Artemis cretacea* Reeve VI, vi, 35.
Venus squamosa (Linnaeus). *Anomalocardia squamosa*, Prashad, pp. 260-261.
Venus imbricata Sowerby. Reeve XIV, xxiv, 118.
Venus arakana (G. and H. Nevill). *Cryptogramma arakana* G. and H. Nevill, *Journ. Asiatic Soc. Bengal* XL (2) 1871, p. 10, pl. i, figs. 16.
Venus crispata Deshayes. Reeve XIV, ix, 31.
Venus lamellaris (Schumacher). *Antigona lamellaris* Prashad, pp. 247–248.
Venus calophylla Philippi. *Chione calophylla* Prashad, pp. 258–259.
Venus sp. nr. *tiara.*
Venus tiara (Dilwyn). *Chione tiara* Prashad, pp. 259–260.
Venerupis macrophylla Deshayes. Prashad, pp. 263–264.
Catelysia opima (Gmelin). *Tapes pinguis* Reeve XIV, vii, 33.
Paphia marmorata (Reeve). *Tapes marmorata* Reeve XIV, vi, 26.
Paphia malabarica (Dilwyn). *Tapes malabarica* Reeve XIV, vi, 27.
* *Paphia lirata* (Philippi). *Tapes lirata* Reeve XIV, v. 20.
Paphia ala-papilionis Röding. Prashad, pp. 233–234.
Paphia undulata (Born). Prashad, pp. 240–241.
Paphia textile (Gmelin). Prashad, pp. 239–240.
Tapes bruguieri (Hanley). *Paphia bruguieri* Prashad, pp. 242–243.
Clementia papyracea (Gray). Prashad, pp. 262–263.

Mactridae.

Mactra mera Reeve. Prashad, p. 209.
Mactra turgida Gmelin. *Mactra tumida* Reeve VIII, vi, 21.
* *Mactra violacea* Lamarck. Reeve VIII, xii, 57.
Mactra achatina Dillwyn. Lynge, Marine Lamellibranchiata of the Danish Expedition to Siam 1899–1900, p. 124 or 220.
* *Mactra dysoni* Reeve VIII, xiii, 64.
Mactra complanata Reeve VIII, xii, 54.
Mactra cygnus Gmelin. *Mactra delicatula* Preston, *Journ. Malacol.* XII, 1904, p. 78.
Mactra plicataria (Linnaeus). *M. plicataria* + *laevis* Reeve VIII, vii, 26 and 27.
Mactra dolabrata Reeve. Prashad, pp. 210–211, pl. vi, figs. 3-4.
Spisula triangularis (Lamarck). *Mactra triangularis* Reeve VIII, i, 1.
Standella pellucida (Gmelin). Reeve VIII, xx, 118.
Lutraria philippinarum Deshayes. Prashad, pp. 211-222.
Lutraria dissimilis Deshayes. Reeve VIII, ii, 8.
Lutraria maxima Jonas. Reeve VIII, iii, 11 (*non.* v, 18).

Anatinellidae.

Anatinella nicobarica (Gmelin). *Anatinella siebaldii* Reeve XIX, i, 1.

Donacidae.

Donax scortum Linnaeus. Reeve VIII, i, 1.
Donax spinosus Gmelin. *Donax paxillus* Reeve VIII, viii, 55.
Donax cuneatus Linnaeus. *Donax cuneata* Prashad, pp. 202-203.
Donax spiculum Reeve VIII, ix, 67 (incl. *D. dussumieri* Bertin).
Donax aperittus Melvill, *Mem. Proc. Manchester Lit. and Phil. Soc.* XLI (7), 1897, p. 24, pl. vii, fig. 33.
Donax aeneus Mörch. *Donax aenea* Reeve VIII, viii, 52.

Psammobiidae.

Sanguinolaria (*Soletellina*) *diphos* (Gmelin). *Soletellina diphos* Reeve X, ii, 8.

Psammobia bipartita Phillppi (?=*caerulescens* Lamarck, part). *Psammobia caerulescens* Reeve X, viii, 60.

Psammobia amethystus (Wood)[1]. *Gari amethystus* Prashad, pp. 303-304.

Psammobia radiata Philippi. *Gari radiata* Prashad, p. 300.

Solecurtus philippinarum Deshayes. Reeve XIX, viii, 38.

* *Solecurtus exaratus* Philippi. Reeve XIX, i, 1.

Zozia emarginata (Spengler). *Novaculina andamanensis* Preston. *Rec. Ind. Mus.* II 1908, p. 209, pl. xvi fig. 40.

Solecurtus (*Azor*) *emarginatus* Lynge, p. 279.

Semelidae.

Semele sinensis A. Adams. *Amphidesma sinensis* Reeve VIII, v, 28.

Theora opalina (Hinds). *Neaera opalina* Hinds, *Proc. Zool. Soc. London* 1843, p. 78.

* *Iacra seychellarum* (A. Adams). *Scrobicularia seychellarum* A. Adams, *Proc. Zool. Soc. London* 1856, p. 53, *Strigilla densistriata Preston, Rec. Ind. Mus.* II (1908), *p.* 210 pl. xiv, fig. 20.

Leptomya cochlearis (Hinds). *Neaera cochlearis* Hinds, *Proc. Zool. Soc. London* XII, 1844, p. 98.

Tellinidae.

Tellina multangula Gmelin. *Tellina polygona* Reeve XVII, xlvi, 273.

Tellina coarctata Philippi. Lynge, Marine Lamellibranchiata of the Danish Expedition to Siam 1899-1900, pp. 109-110 or 205-206.

Tellina angulata Gmelin (=*edentula* Spengler). *Tellina edentula* Reeve XVII, xxviii, 153.

Tellina papyracea Spengler (?incl. *T. simplex* Sowerby, Reeve XVII, xli, 240). Lynge, Marine Lamellibranchiata of the Danish Expedition to Siam 1899-1900, pp. 206-207, pl. iii, figs. 50-52.

* *Tellina pellucida* Philippi. Reeve XVII, xxix, 162.

Tellina emarginata Sowerby. Prashad, p. 182.

Tellina nobilis Hanley. Reeve XVII, xv, 74 (=*Sanguinolaria hendersoni* Melvill and Standen, *Journ. Conch.* IX (2) 1898, p. 33).

Tellina immaculata Philippi. Reeve XVII, liii, 312.

Tellina rhodon Hanley. Prashad, p. 194, pl. v, figs. 37-38.

* *Tellina texturata* Sowerby. Reeve XVII, xli, 233.

Tellina methoria Melvill, *Mem. Proc. Manchester Lit. and Phil. Soc.* XLI (7), 1897, p. 23, pl. vii, fig. 31.

Tellina rutila Dunker, *Moll. Japon.* 1861, p. 27, pl. iii, fig. 6 (= T. *subtrigona* + *cuneolus*, Reeve. XVII, xliv, 259, and xlv, 263).

* *Tellnia philippinarum* Hanley. Reeve XVII, xxiv, 131.

* *Tellina bruguieri* Hanley. Reeve XVII, xxviii, 153.

Tellina pinguis Hanley. Reeve XVII, xxxi, 172.

* *Tellina chinensis* Hanley. Reeve XVII, xv, 75.

Tellina lanceolata Chemnitz. Reeve XVII, iv, 13.

Tellina cuspis Hanley. Reeve XVII, xvi, 80.

Tellina ala Hanley. Reeve XVII, xxvii, 144.

Tellina pristis Lamarck. Reeve XVII, xxxiii, 185.

Tellina foliacea Linnaeus. Prashad, pp. 190-192.

Tellina timorensis Lamarck. Reeve XVII, iv, 14.

Tellina sinuata Spengler. Reeve XVII, v, 16.

[1] Mr. Crichton's single shell agrees perfectly with Reeve's description (x, iii, 20) of *P. tripartita* Detshayse which Prashad quotes as a synonym, including the "obsolete obtuse angle running from the umbo." In Reeve's figure this is greatly over emphasised and appears anything but obsolete, making the figure very misleading.

Solenidae.

Siliqua radiata (Linnaeus). *Cultellus radiatus* Reeve XIX, iv, 13.

* *Siliqua albida* (Dunker). *Cultellus albidus* Reeve XIX, v, 16.

Phaxas cultellus (Linnaeus). *Cultellus cultellus* Prashad. pp. 312-313,

Cultellus maximus (Gmelin = *lacteus* Spengler). Prashad, p. 313.

Solen aquae-dulcioris (Ghosh). *Neosolen aquae-dulcioris*, Ghosh, *Rec. Ind. Mus.* XIX, 1920, pp. 57-58, pl. ii, fig. 12.

Solen kempi Preston. Annandale and Kemp, *Mem. Ind. Mus.* V (4) 1916, p. 355, pl. xvi, fig. 8 (*non* fig. 9).

Solen linearis Spengler. Reeve XIX, v, 22.

Solen truncatus Wood. Reeve XIX, i, 1.

Solen lamarckii Deshayes. Reeve XIX, iv, 16.

Solen annandalei Preston. Annandale and Kemp, *loc. cit.*, p. 355, pl. xvi, fig. 9 (*non* fig. 8).

Aloididae (= Corbulidae).

Aloidis modesta (Hinds). Prashad, pp. 308-309.

Aloidis sulcata (Lamarck, =*fortisulcata* Smith). *Corbula sulcata* Reeve II, i, 2.

Aloidis monilis (Hinds). Prashad, p. 307.

Myidae.

Cryptomya philippinarum (A. Adams). *Mya philippinarum* Reeve XX, ii, 5.

Sphenia sowerbyi Smith, *Ann. Mag. Nat. Hist.* (6) XII 1893, p. 280, pl. xv A fig. 7.

Gastrochaenidae.

Gastrochaena gigantea Deshayes. Lynge, Marine Lamellibranchiata of the Danish Expedition to Siam 1899–1900, pp. 280-281.

Cucurbitula cymbium Spengler. Lynge, *loc. cit.* pp. 281–282.

Pholadidae.

Barnea birmanica (Philippi). *Pholas birmanica* Philippi, Abbildungen Beschreib. Conch. 1849. (?=*Pholas bakeri* Wood, Reeve XVIII, xii, 47).

Pholas (*Monothyra*) *orientalis* Gmelin. Reeve XVIII, ii, 5.

Martesia striata (Linnaeus). *Pholas striata* Reeve XVIII, viii, 32.

Teredinidae.

Teredo clava Gmelin (=*nuciwora* Spengler). *Teredo nucivora* Reeve XX, iv, 17.

Pandoridae.

Pandora flexuosa Sowerby. Reeve XIX, iii, 16.

Laternulidae (= Anatinidae).

Laternula marilina (Reeve). *Anatina marilina* Reeve XIV, ii, 10.

Laternula anatina (Linnaeus). Prashad, pp. 319–320.

Clavagellidae.

* *Brechites dichotomus* (Reeve).[1] *Aspergillum dichotomum* Reeve XII, iii, 9.

CEPHALOPODA.

Nautilidae.

Nautilus sp.

[1] The genus is recorded but there is some doubt as to the species.

Spirulidae.

Spirula prototypos (Peron and Lesueur 1807 = *australis* + *peronii* Lamarck 1816 and 1822 respectively). *Spirula peronii* Huxley and Pelseneer, Challenger Reports part lxxxiii, 1895, pp. 4–32, pl. i, pl. ii, figs. 4–7. pl. iii–vi.

Sepiidae.

Sepiella inermis Férussac and d'Orbigny. Adam, Cephalopoda of Siboga Expedition II, Leiden 1939, pp. 94–98 and 104–105, text figs. 1–5, pl. iv, figs. 5–6, pl. vi–vii.

Sepia andreanoides Hoyle. Adam, *loc. cit.* pp. 38–39, pl. i, fig. 6.

Sepia prashadi Winckworth. Adam, *loc. cit.*, pp. 86–87.

Sepia winckworthi Adam (= *rostrata* d'Orbigny). Adam, *loc. cit.*, pp. 79–80, pl. iii, figs. 7–9.

Sepia aculeata d'Orbigny (incl. *indica* d'Orbigny). Adam, *loc. cit.*, pp. 67–71, pl. ii, figs. 1–5.

Sepia rouxii d'Orbigny (incl. *cingalensis* Goodrich). Adam, *loc. cit.*, pp. 56–61, pl. i, fig. 4 and pl. ii, figs. 6–7.

Argonautidae.

Argonauta sp.

CRUSTACEA.

CIRRIPEDIA.

Lepadidae.

Lepas sp.

Balanidae.

Balanus tintinnabulum (Linnaeus). Sundara Raj, *Bull. Madras Govt. Mus.* N.S., Nat. Hist. I (1) 1927, p. 112, pl. xiv, figs. A1–5.

Balanus amphitrite Darwin. Annandale, *Mem. Ind. Mus.* V (1) 1915, p. 138.

Chelonobia sp.

ISOPODA.

Ligiidae.

Ligia exotica Roux. Chilton, *Mem. Ind. Mus.* V (5) 1916, pp. 462–474, figs. 1–22.

STOMATOPODA.

Squillidae.

Squilla nepa Latreille. Kemp, *Mem. Ind. Mus.* IV 1913, pp. 22 and 60–64, pl. iv, fig. 49.

Squilla holoschista Kemp, *loc. cit.*, pp. 22 and 64–65, pl. iv, figs. 50–53.

Squilla wood-masoni Kemp, *loc. cit.*, pp. 23 and 74–76, pl. v, figs. 63–65.

Squilla lirata Kemp, *Rec. Ind. Mus.* XXII, 1921, pp. 303–307, figs. 3–4.

Squilla raphidea Fabricius. Kemp, *Mem. Ind. Mus.* IV, 1913, pp. 24 and 88–92, pl. vii, fig. 77.

Lysiosquilla maculata (Fabricius). Kemp, *loc. cit.*, pp. 110 and 111–116, pl. viii, figs. 86–91.

Lysiosquilla acanthocarpus Miers. Kemp, *loc. cit.*, pp. 111, 120–122 and 196–197.

DECAPODA.

Penaeidae, Palaemonidae, etc.

For records see Kesava Panikkar and Gopala Ayyar, *loc. cit.* (p. 3 *ante*).

Palinuridae.

Panulirus fasciatus (Fabricius). *Palinurus fasciatus* Milne Edwards "Histoire Naturelle des Crustacés", Paris 1837, pp. 295–296.

Panulirus ornatus (Fabricius). *Palinurus ornatus* Milne Edwards, *loc. cit.*, pp. 296–297.

Panulirus dasypus (Latreille). *Palinurus dasypus* Milne Edwards, *loc. cit.*, p. 300.

Hippidae.

Emerita asiatica (Milne Edwards). *Hippa asiatica* Miers, *J. Linn. Soc., London*, Zool. XIV (76) 1878, pp. 325–326, pl. v, fig. 11.

Albuneidae.

Albunea symnista (Linnaeus). *Albunea symnista* Miers, *loc. cit.*, pp. 326–327.

Paguridae.

Clibanarius olivaceus Henderson, *Rec. Ind. Mus.* XI 1915, pp. 26–28, figs. 1–3.

Clibanarius longitarsis de Haan. Sundara Raj, *Bull. Madras Govt. Mus.* N.S., Nat. Hist. I (1), 1927, p. 130.

Clibanarius padavensis de Man. Alcock, Catalogue of Indian Decapod Crustacea in the collection of the Indian Museum, II Anomura, (1) Pagurides, Calcutta, 1905, pp. 42 and 44–46, pl. iv, fig. 2.

Clibanarius infraspinatus Hilgendorf. Alcock, *loc. cit.*, pp. 42 and 44.

* *Diogenes diogenes* (Herbst). Alcock, *loc. cit.*, pp. 60 and 62–63, pl. xv, fig. 3.

Diogenes custos (Fabricius). Alcock, *loc. cit.*, pp. 60 and 64–67, pl. vi, figs. 1–4.

Diogenes miles (Herbst). Alcock, *loc. cit.*, pp. 61 and 67–68, pl. vi, fig. 5.

Diogenes avarus Heller. Alcock, *loc. cit.*, pp. 61 and 68–69, pl. vi, fig. 6.

Coenobita cavipes Stimpson. Alcock, *loc. cit.*, pp. 141 and 146–148, pl. xiv, fig. 1.

Porcellanidae.

Petrolithistes boscii (Audouin). Gravely, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (1), 1927, p. 140 pl. xx, fig. 7.

Polyonyx hendersoni Southwell. Gravely, *loc. cit.*, p. 141, pl. xx, fig. 11.

Pachycheles sp.

Porcellana sp.

Calappidae.

Calappa lophos (Herbst). Alcock, *Journ. Asiatic Soc., Bengal* (II Nat. Hist.) LXV 1896, pp. 141 and 144–145.

Matuta victor Fabricius. Gravely, *loc. cit.*, p. 142, pl. xxii, fig. 28.

Leucosiidae.

Philyra scabriuscula (Fabricius). Gravely, *loc. cit.*, p. 142, pl. xx, fig. 16.

Philyra globosa Fabricius. Alcock, *loc. cit.* LXV, pp. 238 and 243–245.

Philyra globulosa Milne Edwards. Alcock, *loc. cit.* LXV, pp. 238 and 245–247.

Dorippidae.

Dorippe facchino (Herbst, incl. Alcock's *D. ?granulata* De Haan). Alcock, *loc. cit.* LXV, pp. 276 and 278–279.

Dorippe dorsipes (Linnaeus). Gravely, *loc. cit.*, p. 142, pl. xxv, fig. 41.

Dorippe astuta Fabricius. Alcock, *loc. cit.* LXV, pp. 276 and 280–281.

Portunidae.

Scylla serrata (Forskal). Gravely, *loc. cit.*, pp. 141–142, text fig. 2 B.

Neptunus sanguinolentus (Herbst). Alcock, *loc. cit.* LXVIII, pp. 31 and 32–33.

Neptunus pelagicus (Linnaeus). Gravely, *loc. cit.*, pp. 141–142, text fig. 2 A.

Neptunus gladiator (Fabricius). Alcock, *loc. cit.* LXVIII, pp. 31 and 35–36.

Charybdis callianassa (Herbst). Alcock, *loc. cit.* LXVIII, pp. 50 and 57–59.

Charybdis natator (Herbst). Alcock, *loc. cit.* LXVIII, pp. 50 and 61–62.

Thalamita crenata (Latreille). Gravely, *loc. cit.*, p. 144, text fig. 1 C.

Thalamita admeta (Herbst). Gravely, *loc. cit.*, p. 143, text fig. 1 B.

Xanthidae.

Sphaerozius nudus (A. Milne Edwards). *Actumnus nudus* Alcock, *loc. cit.* LXVII, pp. 201–207.
Xantho euglyptus Alcock. Gravely, *loc. cit.*, p. 146, pl. xxiii, fig. 35.
Actaea sp.

Grapsidae.

Grapsus strigosus (Herbst). Alcock, *loc. cit.* LXIX 1900, pp. 393–394.
Varuna litterata (Fabricius). Alcock, *loc. cit.* LXIX, pp. 401–402.

Ocypodidae.

Ocypoda cordimana Desmarest. Alcock, *loc. cit.* LXIX, pp. 345 and 349–350.
Ocypoda platytarsis Milne Edwards. Alcock, *loc. cit.* LXIX, pp. 345 and 348.
Ocypoda macrocera Milne Edwards. Alcock, *loc. cit.* LXIX, pp. 345 and 347.
Dotilla myctiroides (Milne Edwards). Kemp, *Rec. Ind. Mus.* XVI 1919, pp. 326–327.
Dotilla intermedia de Man. Kemp, *loc. cit.*, pp. 326 and 331–333, figs. 10.
Gelasimus annulipes Milne Edwards. Alcock, *loc. cit.* LXIX, pp. 352 and 353–355.
Gelasimus triangularis A. Milne Edwards. Alcock, *loc. cit.* LXIX, pp. 352 and 356–357.
Macrophthalmus sp.

Maiidae.

Doclea hybrida (Fabricius). Alcock, *loc. cit.* LXIV, 1896, pp. 226 and 231.

PYCNOGONIDA.

Phoxichilidiidae.

Anoplodactylus investigatoris Calman, *Rec. Ind. Mus.* XXV, 1923, pp. 288–289, fig. 14 (p. 290).

ECHINODERMATA.

CRINOIDEA.

Tropiometridae.

Tropiometra encrinus A. H. Clark, "Crinoids of the Indian Ocean", (Ind. Mus., Calcutta, 1912), pp. 177–178, fig. 29.

Mariametridae.

Lamprometra palmata (J. Müller). A. H. Clark, *J. Linn. Soc. London*, Zool xxxvi, 1929, p. 641. (*Dichrometra protectus* A. H. Clark, "Crinoids of the Indian Ocean" pp. 143–147, figs. 17–18).

ASTEROIDEA.

Astropectinidae.

Astropecten mauritianus Gray. Kochler, "Shallow Water Asteroidea", (Ind. Mus., Calcutta, 1910), pp. 32-37, pl. v, figs. 7–9.

Antheneidae.

Anthenea regalis Koehler, *loc. cit.*, pp. 82–86, pl. ix, figs. 1–2.

OPHIUROIDEA.

Ophiothricidae.

Ophiocnemis marmorata (Lamarck). Koehler, Ophiures de l'Expedition du Siboga, 2, Ophiures Littorale (Leiden, 1905), p. 112.
Ophiothela danae Verrill. Koehler, *loc. cit.*, pp. 117–118.

ECHINOIDEA.

Temnopleuridae.

Temnopleura toreumaticus (Klein). Gravely, *Bull. Madras Govt. Mus.* N.S., Nat. Hist. I (1) 1927, p. 170. Also Kochler "Echinoidea III" (Ind. Mus., Calcutta, 1927), pp. 76-78, pl. xiii, figs. 14–17, pl. xiv, figs. 1–2.

Salmacis dussumieri Agassiz. Koehler, *loc. cit*, II, pp. 82–83, pl. xii, fig. 11, pl. xiii, fig. 5.

Salmacis bicolor Agassiz. Koehler, *loc. cit.* III, pp. 78-80, pl. xiii, figs. 1–4 and 6–11.

* *Salmacis sphaeroides* Linnaeus. Meijere, Echinoidea der Siboga-Expedition (Leiden, 1904), pp. 82–83 and 229, pl. xvii, fig. 272.

Salmacis virgulata Agassiz. Koehler, *loc. cit.* III, pp. 81–82.

Salmacis sp.

Stomopneustidae.

Stomopneustes variolaris.

Fibulariidae.

Fibularia volva L. Agassiz and Desor. Koehler, "Echinoidea II" (Ind. Mus., Calcutta, 1922), pp. 139–140, pl. xii, fig. 15.

Laganidae.

Peronella sp.

Clypeastridae.

* *Clypeaster rarispinus* Meijere (*loc. cit*). Koehler, *loc. cit.* II, pp. 55-60, pl. v, figs. 1, 2 and 7, pl. vi, figs. 7–11, pl. xiv, fig. 9.

Scutellidae.

Echinodiscus auritus (Leske). Kochler, *loc. cit.* II, pp. 123-128, pl. iv, fig. 9, pl x, fig. 14, pl. xi, figs. 5–6, pl. xv, fig. 12.

Echinodiscus bisperforatus (Leske). Kochler, *loc. cit.* II, pp. 128–129, pl. xv, fig. 9.

E. bisperforatus var. *truncatus* (Agassiz). H. L. Clark, "Catalogue of Recent Sea-Urchins", Brit. Mus., London, 1929, pp. 170–171.

Cassidulidae.

Echinolampas sp.

Spatangidae.

Pseudomarettia alta (Agassiz). Kochler, "Echinoidea I" (Ind. Mus., Calcutta, 1914), p. 111, pl. xi, figs. 14–17 and 20, pl. xx, figs. 1–7.

Lovenia elongata (Gray). Koehler, *loc. cit.* I, pp. 111–114, pl. xi, figs. 5–6, pl. xii, fig. 10, pl. xiii, fig. 8, pl. xix, figs. 25–32.

HOLOTHUROIDEA.

Cucumariidae.

Thyone sacellus (Salenka). Gravely, *Bull. Madras Govt. Mus.*, N.S., Nat. Hist. I (1) 1927, p. 166.

Synaptidae.

? *Synapta sp.*

CHORDATA.

Dealt with very briefly, species not generally named.

INDEX.

Names of genera and species (whether accepted or mentioned as synonyms) are printed in Roman type, as are also names of families, orders, etc. All other terms, including technical terms defined in the text, and popular names, are printed in italics.

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