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# A NATURAL HISTORY OF INHACA ISLAND, MOÇAMBIQUE

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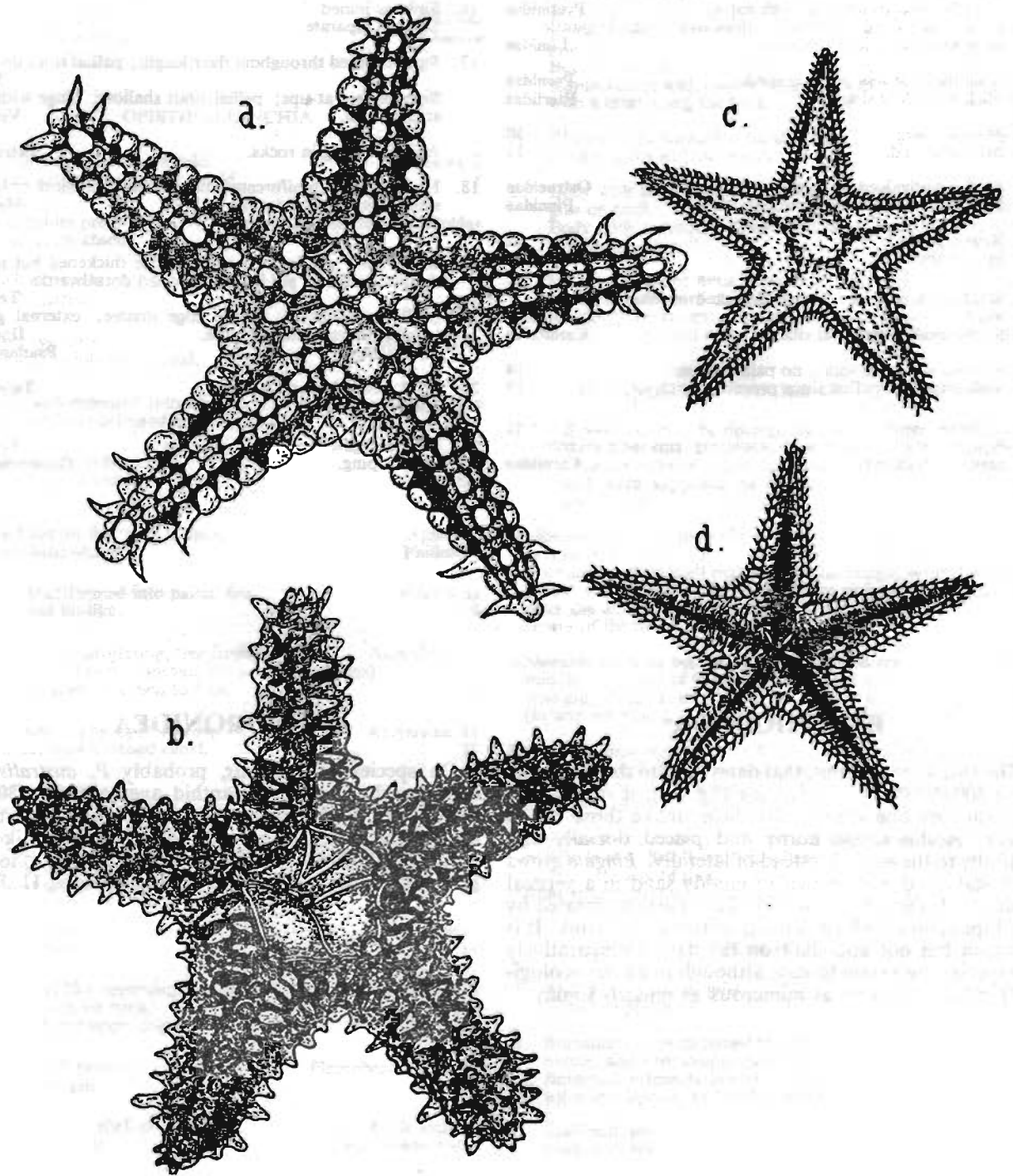


FIGURE 24

Some common echinoderms: (a) The starfish, *Protoreaster lincki*; (b) the starfish, *Pentaceraster mammillatus*; (c) aboral view and (d) oral view of the sand starfish *Asteropecten granulatus*.

## THE ECHINODERMS\*

Classes: Crinoidea, sea lilies,  
Asteroidea, starfishes,  
Ophiuroidea, brittle stars,  
Echinoidea, sea urchins,  
Holothuroidea, sea cucumbers.

Echinoderms are a prominent constituent of the littoral and infralittoral fauna on Inhaca Island. Echinoderms are characterized by their radial symmetry, more or less well developed calcareous external skeleton, and the presence of tube feet. The radial symmetry is most obvious in sea lilies, starfish and brittle stars, where it is manifested by the presence of a number of 'arms' arranged around the circumference of a central disc. In the sea urchins the radial symmetry is shown in the arrangement of the skeletal plates constituting the shell (test) and of the 5 double rows of tube feet. The sea cucumbers having a vermiform body, usually crawl on one side (the ventral), and the other (dorsal) side is permanently upwards. The radial symmetry manifests itself, however, in the arrangement of the circumoral tentacles and in details of internal anatomy.

The calcareous dermal skeleton makes most echinoderms hard to the touch, but it is reduced to spicules in sea cucumbers so that these are more or less soft bodied. The tube feet are best developed (that is, have adhesive discs at their tips) and serve for locomotion in starfish, sea urchins and some sea cucumbers. In other sea cucumbers, in the brittle stars and in sea lilies the tube feet are reduced and have no suckers.

The members of the five orders of echinoderms are easily distinguished. The sea lilies possess 5 arms each bifurcating right at the base so that the animal seems to have 10 arms. Each arm appears to be a feathery structure due to the presence of secondary branches—hence they are sometimes known as feather stars. Only one species of sea lily is common on Inhaca, *Tropiometra carinata*. Typical asteroids and ophiuroids are known as sea stars because they have in common the possession of distinct arms (usually 5 in number) which are not branched (except for representatives of the family Gorgonocephalidae, ophiuroids with branching arms—see further p. 99). In the order Asteroidea the arms are fairly thick and not very flexible, whilst in the order Ophiuroidea the arms

are long and thin, and are capable of moving rapidly by lateral flexions which give them a somewhat snake-like appearance. The sea urchins have no arms and the body has the form of a slightly flattened sphere, however, in the suborder Spatangoidea the body is ovoid, and it is quite flat in the suborder Clypeastroidea (the sand-dollars or pansy shells). The body of sea urchins is covered with spines attached at their bases to tubercles on the surface of the test. The spines are hard and prominent in Regularia, but thinner and softer in Spatangoidea, and in Clypeastroidea very short and fine so that these have a velvety appearance. Due to the worm-like or cucumber-like shape of the body, the Holothuroidea cannot be confused with other echinoderms. Some may perhaps be confused with worms from which they may be distinguished by their usually coarse skin and large size.

Apart from many ophiuroids, echinoderms are fairly large, some are brightly coloured, and easily attract attention from laymen as well as zoologists.

All echinoderms are marine, and cannot suffer being left out of the water except for a short time. They are found therefore at levels in the littoral which are never exposed to air even during the lowest tides, or only exposed for relatively short periods. The easiest way to collect them is to wade in shallow water during a very low tide when large numbers of sea urchins, starfish and sea cucumbers can be seen crawling on the sandy or muddy bottom or sheltering between and under rocks and blocks of dead coral.

The Cymodocea beds, especially in parts of the beach with scattered coral growth, contain numbers of the most beautiful and conspicuous representatives of the phylum. In such places the asteroids are represented by the very large *Protoreaster lincki* and the many coloured *Pentaceraster mammillatus* (fig. 24b); the sea urchins—by several common species: *Prionocidaris baculosa* (fig. 26b), *Tripneustes gratilla*, *Salmacis bicolor*, *Temnopleurus toreamaticus*, *Diadema setosa* and *Echinothrix calamaris*. The large brown sea urchin *Tripneustes gratilla* is sometimes difficult to notice as it has a habit of covering itself with dead leaves of Cymodocea which stick on its needles and thus conceal the animal. This habit is common among tropical and sub-tropical echinoids and

\*by Professor B. I. Balinsky

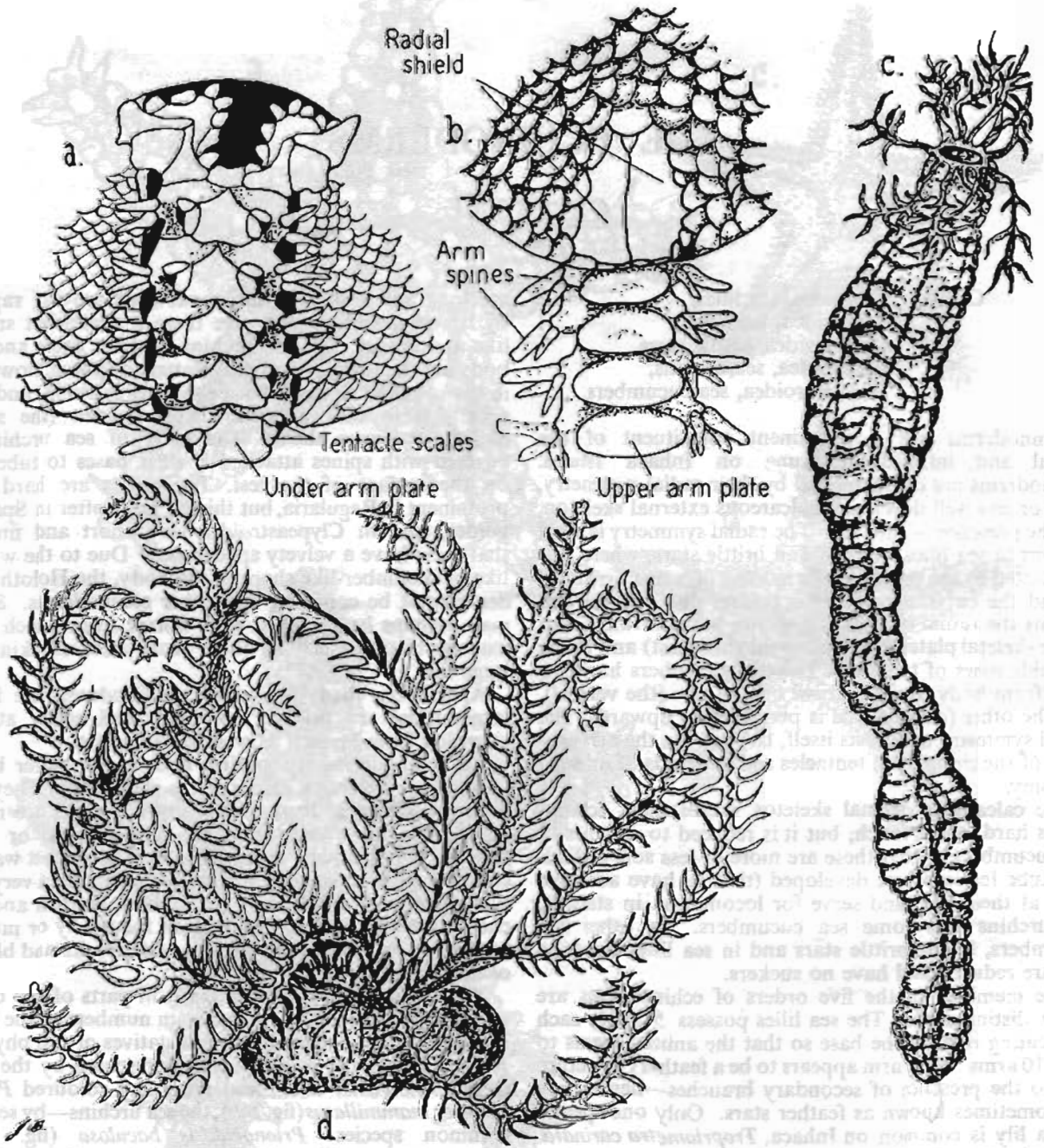


FIGURE 25  
 More common echinoderms: (a) a brittle star, *Amphipplus integer*, part of the disc from the oral side (after Mortensen); (b) aboral view of part of the disc and an arm; (c) a sea-cucumber, *Opheodesoma* sp. and (d) a leather star.

Prepared by J. J. ...  
 27

serves to give some shade from the sun. The holothuroids are represented by large numbers of two common and very large species: the black *Holothuria atra* and the mottled grey *Holothuria scabra*. Occasional strange species are found such as the large cushion-like, orange starfish with a pentagonal body and practically no arms, *Culcita schmideliana*; the pink-coloured sea urchin *Toxopneustes pileolus*; and very long (over 1 m.) snake-like holothurians of the genus *Synapta*. These are more common in warmer backwaters and bays.

A completely different fauna is to be encountered in the rock pools of the open coast of the Island, as at the Cabo Inhaca. The two main species of sea urchins here are *Stomopneustes variolaris* and *Echinometra mathaei*. Whilst the sea urchins on the Cymodocea beds crawl freely about, the urchins on the rock pools always hide in little hollows and depressions in the rock into which they fit quite closely, so that it would appear that the urchins excavate suitable hollows for themselves. It is often impossible to extract the urchins from their holes, for not only do they fit closely but also keep in their places very firmly, attaching themselves to the rock by their tube feet—an adaptation to life in localities exposed to heavy surf. With the urchins is associated here a pretty greenish brittle star *Ophiothrix echinotecta*, one or two specimens of which may be found concealing themselves beneath the sea urchin. Starfish have very rarely been found on exposed rocks or in the rocky pools; only members of the genus *Asterina*, rather small strongly flattened animals (under 4 cm. in diameter) with relatively short arms appear to occur here. These are most often found in masses of worm tubes. The holothuroids are represented by two large species, *Holothuria cinerascens* and *Actinopyga mauritiana*.

Masses of broken coral scattered on western shores of the Island shelter their own characteristic fauna. Underneath will be found numerous starfish with thin arms, *Linckia multifora* (fig. 29g). The sea urchins, *Echinometra mathaei* already mentioned as inhabiting rock pools, are also found here. But the most numerous echinoderms on dead coral are ophiuroids, represented in large numbers mainly by three species: the larger *Macrophiothrix hirsuta* (fig. 27b) and *M. aspidota*, and the small greenish *Ophiactis savignyi*. The holothuroids are represented by the pale brown smallish *Holothuria hilla* which is often found embedded in crevices of the dead coral, and the chocolate brown *Thyone sacellus* lying more openly. The latter shows a preference for large masses of rock, and is also found in abundance on rocky sections of the western coast of the Island, as at Ponta Rasa.

Coral reefs whilst supporting and sheltering various forms of life, do not have so rich an echinoderm fauna as might perhaps be expected. Sea urchins are hardly ever found amongst living corals, and starfish are scarce, although they may be abundant in the immediate vicinity of the reefs. Some rarer species have been found here, however, as the large grey-blue or orange *Linckia laevigata* and the enormous blood red *Leiaster leachi*, found at the foot of the main coral reef. The coral reefs are, however, the typical habitat of the sea lily, *Tropiometra carinata*, several specimens of which may be found wedged between the branches of a dead piece of coral (living corals appear to be avoided). On the coral reefs, again on dead rather than on living coral, is to be

found the relatively very large and pretty brittle star, *Ophiocoma erinaceus*, remarkable apart from its size by its very striking coloration—jet-black general colour with orange-red tentacles. At the foot of the main coral reef are to be found also one of the most remarkable of ophiuroids, *Astroboa nuda* var. *nigra* (fig. 28), representative of the family Gorgonocephalidae. These ophiuroids have branched arms and the disc alone may be up to 10 cm. in diameter. Most representatives of this family live in fairly deep water and do not belong to the littoral fauna. These ophiuroids (and the starfish *Leiaster leachi*) were discovered by skin divers. A collector wading at low tide along the beach has no chance of finding them.

Open stretches of sand would appear to be unfavourable places for collecting echinoderms. Several are, however, present. There are sand-dollars, of which there are two species at Inhaca, *Echinodiscus auritus* (fig. 26a) and *E. hisperforatus*. In the same localities are starfish of the genus *Astropecten*, the common species being *Astropecten granulatus* (fig. 24d).

These animals are normally concealed under a layer of sand but the sand tends to be raised slightly over the bodies of the animals, so that the outline (a distinct star in the case of *Astropecten*, a circle in the case of sand-dollars) can sometimes be readily seen. The sand-dollars of the genus *Echinodiscus* show an interesting case of commensalism: on the under side of most specimens may be found specimens of a small whitish brittle star, *Amphylicus androphorus*. The larger specimens of these are females, the males are smaller and spend their life sitting on the oral side of the disc of the larger female, whilst the female in her turn, attaches herself to the underside of an *Echinodiscus*! The heart-urchins (the Spatangoids) are also sand-dwellers. They are rather rare on Inhaca, but a few specimens of *Echinocardium cordatum* (fig. 26c, d, e) have been found crawling on the surface of the sand exposed at very low tides. Normally these sea urchins spend most of their time in self-excavated burrows in the sand, depending for their food on particles of organic matter swept into their burrows by a current of water created by movements of their spines. The large starfish *Luidia maculata* and its sister species *L. savignyi*, which differ from other starfish of Inhaca by having 7 arms instead of the usual 5, are also to be found lying on the sand at low tides. Amongst the sea cucumbers two species burrow in the sand, *Holothuria hilla* already mentioned, and *Holothuria pervicax*, easily recognizable by the presence of large dark brown spots on its light yellowish coloured body.

It has already been mentioned that the sea cucumber *Thyone sacellus* is often found on the rocks on the eastern side of the Island, where it wedges itself in crevices and small cavities, and apparently never moves from such a retreat, thus becoming a sedentary animal. At very low tides these holothuroids may be exposed to air for short periods, and they then retract their tentacles and even their bodies into the crevice each inhabits, but when covered with water they expand the tentacles again. The tentacles in this species are long and finely branched, so that when spreading in the water from under a stone they give the impression of a bunch of seaweed. Another echinoderm which inhabits crevices in rock ledges is the brittle star, *Ophiocoma scolopendrina*. At very low tides

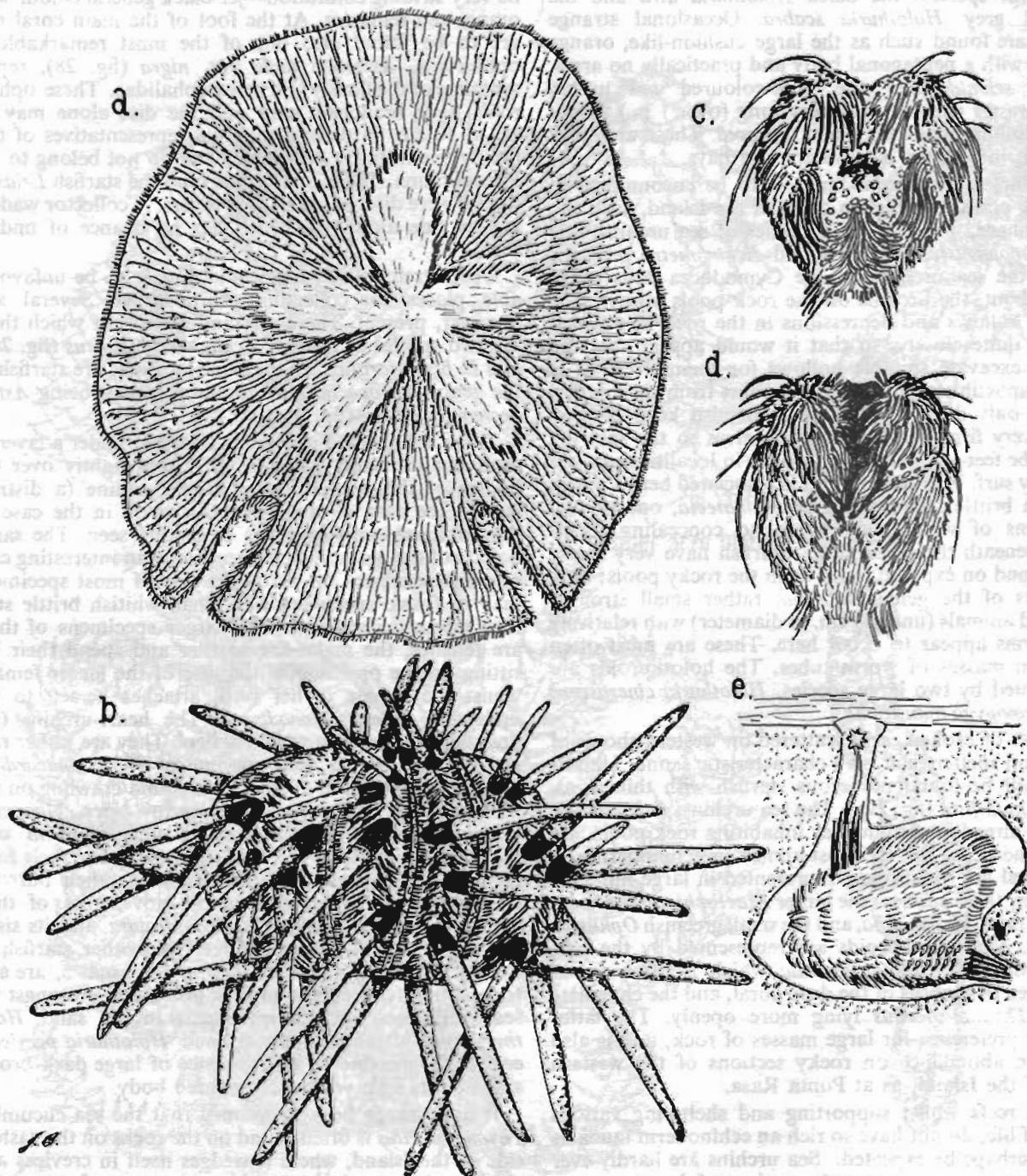


FIGURE 26

Some common echinoids: (a) The sand dollar, *Echinodiscus auritus*; (b) the slate-pencil urchin, *Prionocidaris baculosa*; (c) oral and (d) aboral views of the heart urchin, *Echinocardium cordatum*; (e) *E. cordatum* in its burrow (after v. Uexküll).

the animals withdraw into the depth of the crevice, but when the rock is covered with water they protrude three of their five arms and move them about in search of any food which they may capture, or perhaps also for respiration whilst the body and the remaining two arms remain concealed. The collector will find it very difficult to get these brittle stars out of their retreat; if the protruding arms are touched, they are immediately withdrawn. Even if the collector succeeds in getting hold of one or more of the protruding arms, and tries to pull the animal out, he will usually end by tearing the arms off whilst the body of the animal is held fast in the crevice by the remaining arms. This species is also to be found on flats of *Cymodocea*. Here it avails itself of any shelter—a piece of broken rock, an empty shell, a clump of algae. At low tide they are bunched up within their retreat. As the tide flows over them the three searching arms emerge and wave around in the water, the disc and the other two arms remaining hidden. A related species *Ophiocoma valenciae*, has a similar mode of life, but has not been found very often at Inhaca.

Echinoderms are absent from the mangrove swamps except for one sea cucumber, *Holothuria parva*, which was found amongst the roots of mangrove trees growing along the edges of the main canals of the mangroves. The bluish-grey mud of the Saco on the other hand provides a habitat for two species of ophiuroids, *Ophiopneustes africanus* and *Ophiopneustes sacensis*. Both these have a burrowing habit and live in vertical burrows in the mud. *Ophiopneustes sacensis* (fig. 27a) has a soft body, so that it can be stretched to fit into the narrow cavity in which it lives. Of the five arms three are extended in one direction, two in the other.

The numbers of echinoderms found in the littoral and infralittoral of Inhaca vary greatly from biotope to

biotope, but even in what would seem to be the same type of environment, the animals may be crowded in some places and sparse in others. Perhaps the most impressive aggregations of echinoderms are the masses of sea urchins (*Prionocidaris baculosa* and *Tripneustes gratilla*) found in some years on the *Cymodocea* beds along the channel separating the main Island from the Ilha dos Portugueses. Breaking up masses of dead coral often reveals great numbers of ophiuroids (especially *Macrophiothrix hirsuta* and *Macrophiothrix aspidota*). In randomly chosen areas of 25 cm. square on the flat in front of the station, composed of loam and old broken coral there were found 3-4 small specimens of *Ophiactis savignyi* per square, constituting about 0.2% by weight of all animals present.

The holothurians are mainly mud and detritus feeders. This can easily be confirmed by studying their gut contents. Forms such as *Holothuria atra* and *Holothuria scabra* pass large quantities of sand and mud through the alimentary canal, the organic substances being digested and the undigestible parts defaecated. Sea urchins feed mainly on vegetable matter which they collect on the sea bottom using their teeth to scrape such matter off the rocks. They do not feed on living microphytes, however. The starfish and brittle stars are carnivorous animals. The feeding of the starfish is very peculiar: the main food is bivalve molluscs, and the digestion of the food is carried out largely outside the body of the starfish. When consuming its prey, the starfish everts its stomach, passes it between the valves of the shell, envelops the soft parts of the mollusc and digests them *in situ*, after which the liquified food is sucked into the body of the starfish and the stomach withdrawn. It is sometimes possible to find starfishes in the process of feeding, with stomachs everted, consuming a bivalve mollusc. Ophiuroids feed on any small animals which

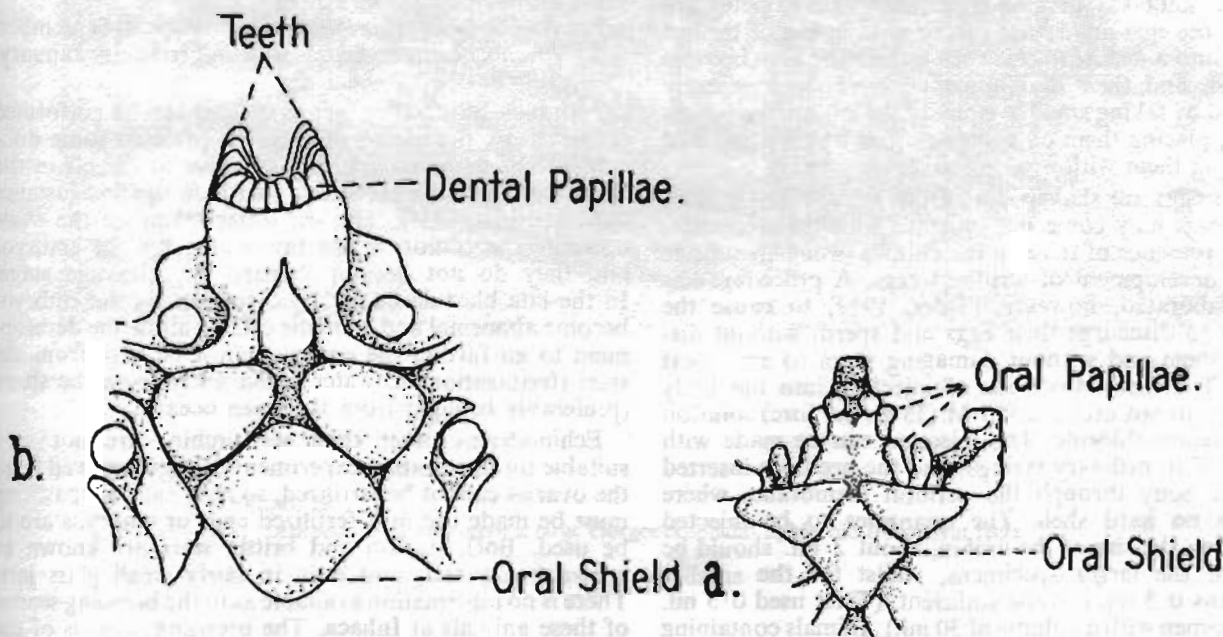


FIGURE 27

(a) Jaw of *Ophiopneustes sacensis* (after J. Balinsky), and (b) jaw of *Macrophiothrix hirsuta*.

they can capture and eat, using the teeth surrounding their mouths. The sea lilies are plankton feeders.

Some species of echinoderms show a remarkable variability of coloration. A good example of this is the common large starfish *Pentaceraster mammillatus*. In this animal the ground colour as well as the colour of the superimposed pattern (based on the spines and ridges on the surface of the body) may vary independently. The ground colour may be yellow, green, brown, or in different shades of red, and the pattern brownish or reddish against a differently coloured background, or conforming with the ground colour. These colour variations do not seem to bear any relationship either to the size (age) of the animals or to the locality which they frequent. Contrary to this diversity of colours, the nearly related species, *Pentaceraster lincki* shows very little colour variation; the ground colour is always greyish-brown and the pattern red. Another species showing a considerable colour variability is the brittle star *Placophiothrix foveolata*, found in numbers on the coral reefs and in Cymodocea beds. Different specimens of this brittle star show the same pattern of darker lines on a pale, whitish background, but the colour may vary from deep violet, through different shades of red (the usual colour) to orange and light brown. In one form the disc is uniformly bright scarlet, whilst the arms are dark red. (J. B. Balinsky, 1957).

Sea urchins are very favourable for the experimental study of fertilization and early embryology. The eggs and sperm become ripe in the gonads and are then discharged into the surrounding water, where fertilization takes place, and the eggs develop into pelagic larvae. The sea urchin larva is known as the pluteus (or echinopluteus). The larvae live as planktonic organisms for several weeks, then metamorphose and the newly formed tiny sea urchin falls to the bottom and starts a mode of life similar to that of the adult.

If the adult sea urchins containing ripe gametes are opened, the eggs and sperm can be shaken out of the cut gonads into a dish with clean sea water. The eggs become fertilized, and their development may be conveniently observed by taking small samples of the culture from time to time, placing them on a slide or in a watch glass, and examining them with a microscope.

When eggs are shaken out of the gonads into a dish, unripe eggs may come out together with the ripe ones, and the presence of these in the culture is not favourable for the development of fertilized eggs. A procedure has been elaborated, however, (Tyler, 1949) to cause the animals to discharge their eggs and sperm without dissecting them and without damaging them to any great extent. The method consists of injecting into the body cavity of the sea urchin a 0.5 M (35 gr. per litre) solution of potassium chloride. The injection can be made with the aid of an ordinary syringe, and the needle is inserted into the body through the perioral membrane, where there is no hard shell. The quantities to be injected depend on the size of the urchin, about 2 ml. should be used for the larger specimens, whilst for the smaller specimens 0.5 ml. is quite sufficient. (Tyler used 0.5 ml. per specimen with a volume of 30 ml.) Animals containing ripe sperm or eggs eject them through the gonopore in a matter of a few minutes, whilst unripe gametes are not shed at all. The eggs and sperm may be collected by

immersing the aboral surface of the animal in a dish of sea water, or they may be sucked up with a pipette. Animals treated in this way remain quite healthy, and may be used again for obtaining sperm and eggs after about two weeks, or even earlier. An interesting modification of the method may be used to ascertain whether a sea urchin contains ripe gametes or not. If a drop of concentrated solution of potassium chloride be applied to a gonopore on the aboral surface of the body, the animal, if containing ripe eggs or sperm, will extrude a small quantity of them on the surface. This incidentally can also be used to ascertain the sex of the mature animals as the male and female sea urchins do not differ externally. The animals which are to be used for fertilization experiments may then be injected as above to make them discharge large quantities of sperm or eggs. The species of sea urchins at Inhaca which have proved to be most convenient for fertilization experiments are: *Tripneustes gratilla*, *Salmacis bicolor* and *Temnopleurus toreumaticus*. In temperate countries the sea urchins have definite breeding seasons lasting only a relatively short part of the year (in spring or summer, depending on the species). In tropical waters one would expect animals to breed throughout the year, as the seasons are much less defined. Actually this is not quite correct. At least some of the tropical echinoderms breed only during certain parts of the year, whilst others may have ripe sperm and eggs most of the time. The following observations have been made in this connexion by the author of this chapter.

1. *Tripneustes gratilla*, *Salmacis bicolor*, *Temnopleurus toreumaticus* are probably to be found with ripe sperm and eggs at any season (certainly in January, July, and September).
2. *Echinometra mathaei* fully ripe only in January.
3. *Diadema setosa* found with ripe sperm in January; ripe eggs not observed.
4. *Echinodiscus auritus* found with ripe sperm in July; ripe eggs not observed.
5. *Stomopneustes variolaris* was not ripe in September.
6. *Prionocidaris baculosa* was not ripe in January, July nor September.

Although fertilization in sea urchins can be performed rather easily, the raising of embryos presents some difficulties. The embryos are very sensitive to defects in the quality of sea water (probably its pH in the first instance —Mortenson, 1931). The sea water taken off the coast opposite the station is not favourable for the embryos and they do not develop beyond the cleavage stage. In the late blastula or early gastrula stages the embryos become abnormal and soon die off. To allow the development to go further the embryos must be kept from the start (fertilization) in water taken away from the shore (preferably brought from the open ocean).

Echinoderms other than sea urchins are not very suitable for fertilization experiments. Eggs removed from the ovaries cannot be fertilized, so that natural spawning must be made use of if fertilized eggs or embryos are to be used. Both starfish and brittle stars are known to spawn in aquaria, and even in fairly small glass jars. There is no information available as to the breeding season of these animals at Inhaca. The breeding seasons of the local holothuroids or of the sea lily are not known.

Some echinoderms have a high ability for regeneration —renewal of lost parts. When collecting specimens of

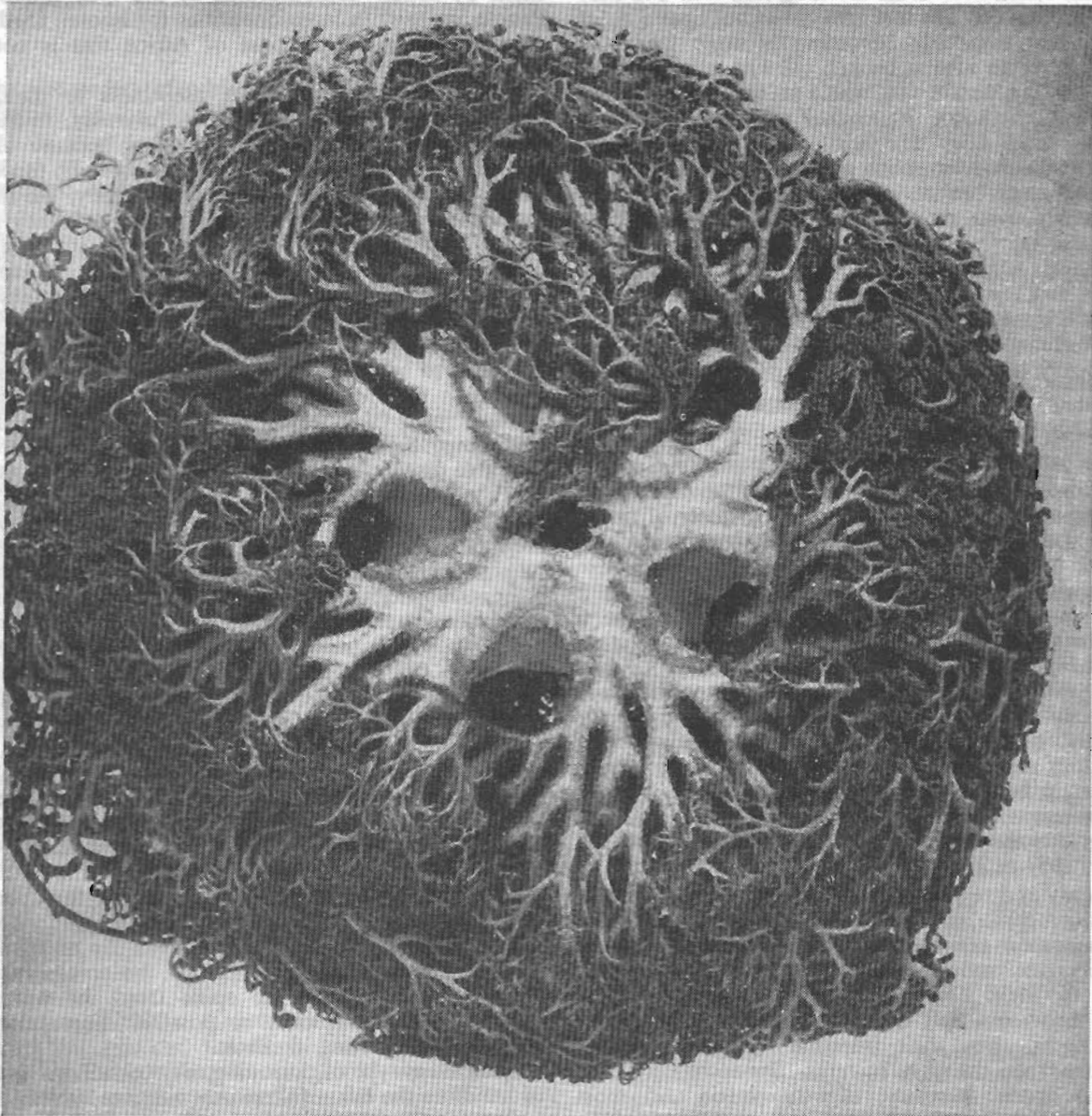


FIGURE 28

*Astroboa nuda* var. *nigra* a large Gorgonocephalid ophiuroid from coral reefs.

*Linckia multifora* on the beach one can often find specimens with unequally developed arms. Some of the arms may be shorter or be quite diminutive as compared with the other arms and the disc. The explanation of this is that in this species the arms are long and thin and may easily be broken off. The lost arm grows out again, but it is small at first, eventually becoming the same size as the other arms. If an arm is broken off with a part of the disc, it can regenerate the whole animal. During the period of regeneration the animal will have one large arm and 4 small ones. The brittle stars with their long and thin arms are even more exposed to the dangers of having the arms broken off, and correlated with this they regenerate even more quickly than starfish. These animals also possess the ability to throw off their arms spontaneously when they are molested. This phenomenon known as 'autotomy' is also shown by the starfish, *Luidia*, which for this reason is very difficult to bring home intact from an excursion.

In some ophiuroids the capacity for regeneration is made use of for the purpose of asexual reproduction. The animals break in two across the disc by autotomy, and then each half regenerates the missing half of the disc and three arms. This type of reproduction is practised only by small brittle stars with a disc diameter of under 6 mm. such as *Ophiactis savignyi*, and perhaps *Ophiocoma parva*. As it seems to be the rule that three arms are always regenerated the specimens reproducing by fission tend to have 6 arms instead of the usual 5; of the 6 arms 3 are younger than the other 3. It has been suggested that this type of reproduction is restricted to juvenile animals, and as these eventually grow larger they lose the capacity to break in half and become ordinary 5-armed brittle stars. This could not be confirmed by observations made on brittle stars at Inhaca: the largest specimens of the three species named above have 6 arms, and there seems to be no 5-armed form which could be interpreted as the adult form of the same species (J. B. Balinsky, 1957 p. 27).

Autotomy and regeneration appear in a different form in sea cucumbers; here the parts capable of being shed and regenerated are not external appendages but the alimentary canal and other internal organs. When handled roughly, or when kept in unsuitable conditions, these animals throw out first their Cuvierian organs, if they possess them, then their intestine together with the respiratory trees, through the anus. The secretion of the Cuvierian organs is sticky, slightly elastic and most unpleasant to the touch. This reaction on the part of the animal may be very disconcerting when attempts are made to preserve the larger species of holothuroids such as *Holothuria atra*. In this case the animals have to be injected with formalin and at the same time the anus must be kept closed by pressing it with the fingers or with a clamp of some sort, until the animals are dead. If the sea cucumbers are left alone after they have thrown

out the intestine, this will be restored after a while by internal regeneration.

Adult echinoderms do not appear to be used as food by other animals, except that the smaller ophiuroids are eaten by fishes. Holothuroids of the East Indies and Pacific are used in large quantities for human food, but on the Indian Ocean coast of Africa this is not the practice.

Whilst being of no direct usefulness to man, the echinoderms of Inhaca are not harmful either. In Europe certain starfish are regarded as pests because of the depredations that they make on the oysters, especially where the latter are cultivated commercially. On Inhaca the local oyster does not seem to suffer to any great extent from starfish, and in any case there being no commercial use for oysters, the question of damages caused by starfish does not arise. Some sea urchins may become disagreeable in a different way, however. Their spines are very sharp and penetrate human skin readily. This has to be borne in mind when trying to extricate specimens of *Stomopneustes variolaris* or *Echinometra mathaei* from their retreats in the rocks. Even if not poisonous, the spines penetrating the skin cause considerable discomfort, and are difficult to pull out, as they break off easily and the tip remains in the wound. The situation is still worse in the case of two species of sea urchins which are distinctly poisonous. These are *Diadema setosa* and *Echinothrix calamaris*. Both the poisonous species may be readily distinguished from other sea urchins by their very long spines (approaching or even exceeding the diameter of the body). *Diadema setosa* is bluish-black with beautiful white eye-spots on the aboral surface but the spines are striped in young specimens. *Echinothrix calamaris* is a shade of brown, and the spines are banded with brown or violet and white. Both these species will bristle their spines at the approach of any person and the spines may be directed towards the disturber. The spines of both species are very sharp and penetrate the human skin even on a slight touch. Once in the skin the spines cause acute pain and a numbness of the affected part of the body lasting for about an hour. The wound may remain very painful for a much longer period. The only treatment that can be applied in case of a person being pricked by the spines of these animals is to remove the spine from the wound as quickly and as completely as possible. Fortunately the poison has no lasting ill effect.

A different type of poisoning may be suffered as result of handling the beautiful creamy pink sea urchin *Toxopneustes pileolus*. This species possesses very large pedicellariae, which may, if given the opportunity, scratch and grip the skin of an unwary hand and in so doing inject sufficient poison to cause a feeling of discomfort and pain in the affected part.

It is advisable, therefore, when collecting on the beach, not to take the above-mentioned three species of sea urchins with the naked hand.

## KEY TO ECHINODERMATA

The five orders of echinoderms present very unequal difficulties for the classification of their representatives found on Inhaca. Only one species of sea lily is at all common on Inhaca. The sea urchins and starfish are represented each by a rather small number of species. Specimens are fairly large, and most of them may be identified without difficulty. Keys for classifying these animals based on easily discernible characters are appended. Ophiuroids present more formidable difficulties—the number of species is much greater, and the size of the animals smaller. It is therefore necessary to study the finer details of their structure under a low power microscope (dissecting microscope).

The following glossary will explain terms used in the keys for identifying Ophiuroids.

**Radial shields** (fig. 27): a pair of large plates situated on the aboral surface of the disc at the base of each arm.

**Oral shields** (fig. 27): unpaired large plates situated on the oral surface interradially, between the bases of the arms.

**Jaws**: parts of the body protruding into the cavity of the mouth interradially.

**Teeth**: calcareous granules or short spines situated on the surface of the jaws in the mouth cavity.

**Dental papillae**: a cluster of small elongated skeletal elements situated on the tip of the jaw in some ophiuroids (externally to the teeth).

**Oral papillae**: skeletal elements in the form of small plates or large granules situated in some ophiuroids along the sides of each jaw (these elements are therefore always distinctly paired).

**Upper arm plates**: the larger plates covering each segment of the arm on the aboral surface.

**Under arm plates**: corresponding plates on the oral surface of each arm segment.

**Arm spines**: a group of large spines arranged in a vertical row on each side of every segment of the arm.

**Tentacle scales**: small plates (one or two in number) situated at the base of each tentacle (reduced tube foot) on the oral surface of the arms.

The classification of holothuroids is largely based on internal features, and the recognition of many species can only be made with certainty by studying the shape of microscopic spicules situated in the skin. The key presented in this handbook makes use of external features only, so that it can be used in the field or laboratory with a minimum of dissection. It cannot therefore be considered as being completely reliable. For those who would like to use the more exact keys contained in the works of Clark (1923), Deichman (1948) or Cherbouner (1952) it would be necessary to make microscopic preparations of spicules. For this purpose a small piece of skin of the specimen which is being studied must be boiled in a solution of caustic soda until the skin is completely dissolved. The solution is then allowed to stand for a short while until the spicules settle at the bottom. A sample of the sediment can then be taken with a pipette, placed on a slide, covered with a cover slip and studied under a microscope.

## ASTEROIDEA

1. The margin between the oral and aboral surface of the arms more or less rounded. 2  
The margin between the oral and aboral surface of the arms drawn out in a very sharp keel. Asteriidae 10
2. Aboral surface of the body covered with paxillae (complex spines bearing several spinelets or granules on the tip of a common shaft). 3  
Aboral surface without paxillae. 5
3. Always 5 arms, a double row of conspicuous plates arranged along the margin of all arms (marginal plates); colour in life light buff. Astropectinidae  
*Astropecten granulatus*  
Usually 7 arms, the plates along the margins of the arms are obscured by spines and are not conspicuous, colour in life more or less greenish. Luidiidae 4
4. An enlarged central spinelet on many paxillae. *Luidia savignyi*  
No enlarged central spinelets on any paxillae. *Luidia maculata*
5. Arms long and narrow, several times the diameter of the disc. Ophiasteridae 6  
Arms not very long, not exceeding diameter of the disc or exceeding it only slightly. Oreasteridae 7
6. Arms 7-12 times the diameter of the disc, colour in life usually yellowish or greenish. *Linckia multifora*  
Arms 5-6 times the diameter of the disc, colour in life a bluish grey, orange, or bright red. *Linckia laevigata*
7. Central part of the disc raised, and the height of the body decreases towards the periphery, this decrease continuing along the length of the arms; aboral surface of the body bearing conspicuous thick conical spines. 8  
Body flattened, central part of the disc not raised; aboral surface without prominent conical spines. 9
8. One or two very large spines on each side of every arm towards its distal end, whilst along the rest of the margin of the arms the spines are very much shorter, or are reduced to small thickenings. *Protoreaster lincki*  
The spines along the margin of the arms more or less equal in development, though varying in length from one individual to another. *Pentaceraster mammillatus*
9. Arms short, but the contour of the body between the arms is distinctly concave; a pair of conspicuous plates, devoid of spines, near tip of each arm on aboral surface. *Asterodiscus elegans*  
The contour of the body between the tips of each two arms is a straight line, the body having the shape of a regular pentagon; no conspicuous plates near tip of each arm on aboral surface. *Calcita schmidelliana*
10. Plates on oral surface bear 2-4 spines each. *Asterina hurtord*  
Plates on oral surface bear 1-2 spines each. *Asterina dyscrita*  
Plates on oral surface bear 1 spine each (a few nearer the disc edge may have 2). *Asterina exigua*

## OPHIUROIDEA

(incomplete list, after J. B. Balinsky, 1957)

1. Arms branched. *Gorgonocephalidae*  
Arms not branched. *Astroboa nuda* var. *nigra* 2
2. Arm spines short, closely adpressed to the sides of the arm. 3  
Arm spines fairly long at right angles to the axis of the arm. 4
3. Disc covered by close granules, concealing plates. Arm spines 8-12. *Ophiodermatidae*  
*Ophiopezella decorata*  
Disc covered by smooth plates, arm spines 3. *Ophiolepididae*  
*Ophiolepis cincta*
4. The tip of the jaw i.e. the angle of the mouth projecting inwards bearing a cluster of small elongated skeletal elements the 'dental papillae'. 5  
The tip of the jaws not bearing 'dental papillae'. *Amphluridae* 13
5. In addition to the dental papillae each jaw bears 2 or more pairs of skeletal elements situated symmetrically along its free edge, these are the 'oral papillae'. *Ophiocomidae* 6  
No oral papillae on the free edges of the jaws. *Ophiotrichidae* 9
6. Disc granules taller than broad, at least near margin; tentacle scale single. 7  
Disc granules not taller than broad; tentacle scales generally 2 though there may be 1 distally. 8
7. Arms 5; size large. *Ophiocoma valenciae*  
Arms 6; size small. *Ophiocoma parva*
8. Colour greyish, variegated with lighter markings; arms 6 or more times disc diameter. *Ophiocoma scolopendrina*  
Colour usually jet black; arms 4-5 times disc diameter. *Ophiocoma erinaceus*
9. Disc covered, at least between the radial shields, with a coat of small thorny stumps or spinelets. 10  
Disc bare, though plates obscured by skin in older specimens. *Ophiotrichoides propinqua*
10. Arms 7-20 times disc diameter. 11  
Arms up to 6 times disc diameter. 12
11. Radial shields closely covered by a coat of thorny stumps which also cover the rest of the disc surface; a light (yellow in life) stripe along the upper side of arms, at least distally. *Macrophiothrix hirsuta*  
Radial shield completely or almost completely bare; no longitudinal light stripe on arms. *Macrophiothrix aspudota*
12. Disc completely covered by short spinelets which branch at the tips; colour green and white in life. *Ophiotrix echinotecta*  
Disc covered by rather long spinelets, but the radial shields are bare; colour in life reddish, brownish or yellowish. *Placophiothrix foveolata*
13. Tip of jaw occupied by a pair of oral papillae. 14  
Tip of jaw without oral papillae but occupied by the lowest tooth. 18
14. Two oral papillae on each side of the jaw, the second being at its distal angle. 15  
Three oral papillae on each side. 16  
Four oral papillae on each side. *Amphiplus integer*
15. 2 tentacle scales per arm pore; disc covered by scales, arms about 5 times disc diameter. *Amphiura kalki*  
No tentacle scales, disc entirely naked except for the radial shields and a few scales around them; arms ten or more times disc diameter. *Ophionephthys africana*
16. Margin of disc with distinct fence of erect plates. *Ophiophragmus sacensis*  
Margin of disc without fence. 17
17. Second oral papilla very small; outermost papilla very broad, with a serrated edge. *Amphylicus androphorus*  
First and second oral papillae subequal; outermost papilla with a smooth edge. *Amphipholis squamata*
18. Arms always 5, colour in life reddish-brown or whitish. *Ophiactis carnea*  
Arms usually 6 (rarely 5 or 7) colour in life greenish. *Ophiactis savignyi*

## ECHINOIDEA

1. Mouth in centre of oral surface of the body. 2  
Mouth at anterior edge of the body; body ovoid. *Spatangoidea*  
*Echinocardium cordatum*
2. Body very flattened, disc-shaped, breadth several times exceeds height. *Clypeastroidea* 3  
Body only slightly flattened, breadth exceeding height not more than by a factor of 2. 4
3. The disc with 2 deep narrow slits extending in from the posterior margin. *Echinodiscus auritus*  
The disc perforated with two narrow slits, which do not reach the margin. *Echinodiscus bisperforatus*
4. Spines very thick with blunt ends. 5  
Spines thin and pointed at the ends. 6
5. Primary spines with purple spots or longitudinal lines at base; size larger, up to 6 cm. in diameter. *Prionocidaris baculosa*  
Primary spines without purple spots or longitudinal lines at base; size smaller, usually not more than 2 cm. *Eucidaris metularia*
6. The tubercles, serving for the attachment of the larger spines, perforated, spines hollow. 7  
Tubercles serving for the attachment of spines not perforated, spines solid. 8
7. Colour bluish-black, spines of uniform colour when adult; in life on aboral side 5 conspicuous white or orange spots. *Diadema setosa*  
Colour a shade of brown, spines banded with dark and white. *Echinothrix calamaris*
8. Body elliptical. *Echinometra mathaei*  
Body circular. 9
9. Spines relatively short, conical, thick at base and evenly tapering distally. *Stomopneustes variolaris*  
Spines tapering very gradually, not very thick at base. 10
10. Test at least aborally or in midzone with deep pits or furrows between the tubercles. 11  
Test not pitted nor furrowed. 12
11. Spines more or less bright red. *Salmacis bicolor*  
Spines black or blackish. *Temnopleurus toreamaticus*
12. Body fairly high; diameter exceeding height by a factor of about 3/2; colour brown or yellowish. *Tripneustes gratilla*  
Body more flattened; diameter exceeding height by a factor of about 2; colour pink or red. *Toxopneustes pileolus*

HOLOTHUROIDEA

- |   |   |   |   |
|---|---|---|---|
| <p>1. Body not very elongated, length not more than 10 times breadth.<br/>Body very elongated, length at least 10 times breadth, usually more; no tube feet; tentacles pinnate.</p> | 2 | <p>5. Large pointed tubercles on back and sides of body; colour in life a deep green.<br/>No large pointed tubercles on back and sides; colour in life black, brownish or greyish, never green.</p>                                     | 6 |
| <p>2. Tentacles dendritic.<br/>Tentacles peltate (with a central short stalk giving off short horizontal branches).</p>   | 3 | <p>6. Colour more or less uniformly black.<br/>Colour grey mottled with white and black above, white below, skin very tough.<br/>Colour brown or brownish.</p>  | 7 |
| <p>3. Feet only in distinct ambulacral rows; colour in life pale pinkish or yellowish.<br/>Feet scattered in the interambulacral spaces; colour in life dark, brownish.</p>         | 4 | <p>7. Size large; fully grown specimens up to 20 cm. and larger.<br/>Size small; fully grown specimens not over 15 cm.</p>  | 8 |
| <p>4. A ring of 5 white calcareous teeth surrounding the anal opening.<br/>No calcareous teeth surrounding the anal opening.</p>  | 5 | <p>8. Colour in life brown on upper surface, rosy on under surface.<br/>Colour in life dark brown on upper surface, paler on lower surface; skin very tough resembling<br/>Colour in life light yellow with large dark brown spots.</p> | 9 |
|   |   | <p>9. Colour in life yellowish or light pinkish grey with small darker spots.<br/>Colour in life dark brown.</p>  |   |

Apoda  
*Synapta oceanica*

Dendrochirota  
*Aspidochirota*

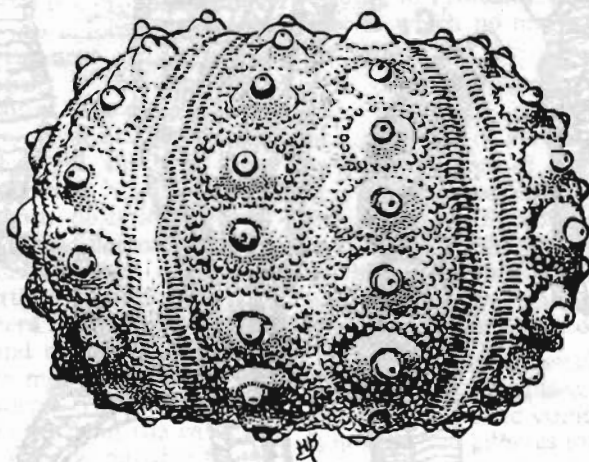
*Cucumaria crucifera*  
*Thyone sacellus*

*Actinopyga mauritiana*

*Stichopus chloronotus*  
*Holothuria atra*  
*Holothuria scabra*

*Holothuria cinerascens*  
*Holothuria leucospinata*  
*Holothuria pervicax*

*Holothuria hilla*  
*Holothuria parva*



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## INDEX TO GENERA

Figures in italics refer to the number prefixed to each genus of flowering plants in the checklist on pp. 139-155. Figures in heavy type indicate that the genus concerned is illustrated on or opposite the page listed.

- Abrus *3856*  
 Abudedefduf 34, 37, 41, 119, 134  
 Abutilon *4983*  
 Acacia *3446*, 9, 10  
 Acalypha *4407*  
 Acanthastraea 56, 123  
 Acanthistius 132  
 Acanthopagrus 116, 134  
 Acanthopora 18, 21, 19, 27, 121  
 Acanthoplesiops 132  
 Acanthurus 133, 136  
 Accipiter 137  
 Acentronura 132  
 Acetabularia 20, 21, 25, 121  
 Achaeus 37, 65, 79, 125  
 Achatina 71  
 Acrochietum 25  
 Acrophytum 48  
 Acropora 21, 51, 52, 55, 118, 120, 122  
 Acrosorium 27  
 Acrostichum 13, 139  
 Actaea 71, 82, 125  
 Actinaria 117  
 Actinia 47, 120, 122  
 Actinioidea 122  
 Actitis 137  
 Actinopyga 34, 99, 107, 120, 130  
 Adenia *5370*  
 Aeoliscus 114, 117, 132  
 Aeschynomene *3793*  
 Agaricia 55, 122  
 Agathisanthemum *8736A*  
 Aglaurides 124  
 Agrioposphyraena 134  
 Albizia *3443*  
 Albula 131  
 Aletris 114, 132  
 Aletria *7597*  
 Alicia 47, 122  
 Alloniscus 36, 75, 83, 126  
 Allophylus *4734*, 9  
 Almamiella 62, 123  
 Aloe *7026*  
 Alpheus 36, 37, 40, 43, 75, 80, 117, 119, 126  
 Alsidium 27  
 Alticops 135  
 Alveopora 53  
 Alysicarpus *3810*  
 Amanses 135  
 Amansia 27  
 Amaranthus *2299*  
 Ambassis 41, 119, 133  
 Amblyapistus 115, 118, 135, 137  
 Amblyorhynchotes 136, 137  
 Amblyospiza 138  
 Ammodytes 132  
 Amphiplus 42, 98, 105, 117, 129  
 Amphipholis 105, 129  
 Amphiprion 43, 47, 54, 117, 134  
 Amphiroa 26, 51  
 Amphiuira 105, 129  
 Amphyliscus 44, 99, 105, 118, 129  
 Amplustrum 45, 88, 128  
 Anacardium *4546*, 11  
 Anadara 90, 117, 129  
 Anadyomene 24  
 Ananas *857*  
 Anathelges 83, 127  
 Anchistus 43, 75, 80, 117, 126  
 Anchoviella 131  
 Ancilla 86, 128  
 Ancylocaris 75, 126  
 Andropadus 138  
 Andropogon *734*, 12  
 Aneilena *899*  
 Angraecum *2255*, 9  
 Aniculus 45, 82, 83, 126  
 Annona 2729, 12, 145  
 Anochetus 16  
 Anomastraea 34, 51, 52, 120, 123  
 Anoplolepis 16  
 Ansellia *1568*, 9  
 Antennarius 115, 119, 136, 137  
 Antennablennius 135, 137  
 Anthias 132  
 Anthreptes 138  
 Antidesma *4327*  
 Antithamnion 27  
 Aonides 44, 124  
 Apalis 138  
 Apaloderma 138  
 Aplidium 37, 110, 112, 119, 130  
 Aplysia 86, 128  
 Apodocreeidia 132  
 Apodytes *4686*, 9, 10  
 Apogon 37, 114, 115, 117, 119, 132  
 Apogonichthyoidea 132  
 Apogonichthys 132  
 Apolectus 114, 132  
 Apus 138  
 Arabella 124  
 Archamia 114, 132  
 Architectonica 127  
 Ardea 137  
 Arelia 131  
 Arenaria 137  
 Arete 36, 75, 80, 126  
 Argus 128  
 Argyrops 115, 134  
 Ariosoma 135  
 Aristida *208*  
 Armandia 43, 124  
 Arothron 115, 136, 137  
 Artabotrys *2724*  
 Arthrocardia 26  
 Arthrocnemum *2255*, 13, 119  
 Ascidia 37, 110, 112, 119, 130  
 Asilus 16  
 Asparagus *7113*, 10, 13  
 Aspidontus 135  
 Asplenium 139  
 Asterina 99, 104, 120, 129  
 Asterodiscus 104, 129  
 Asteropteryx 135  
 Astreopora 50, 51, 52, 55, 122  
 Astroboa 36, 99, 105, 103, 130  
 Astropecten 43, 96, 99, 104, 118, 129  
 Astropyga 45, 130  
 Asystasia *8007*  
 Atergatis 37, 82, 125  
 Athanas 41, 80, 126  
 Atherina 41, 117, 134  
 Atrina 43, 45, 65, 75, 80, 90, 92, 117, 129  
 Audouinia 124  
 Austrolethops 135  
 Autolytus 62, 123  
 Avicennia *7205*, 13, 14, 21, 40, 67, 119  
 Avrainvillea 24  
 Azinia *6444*  
 Balanoglossus 43, 45, 108, 109, 117, 119, 130  
 Balanus 34, 36, 37, 40, 77, 78, 118, 119, 127  
 Balistapus 136  
 Balistes 119  
 Balistoides 135, 137  
 Bangia 25  
 Barbatia 37, 119, 129  
 Barberia *7973*  
 Basecodium 57, 117  
 Bathycoelia 16  
 Bathygobius 134  
 Batis 138  
 Belonichthys 119, 136  
 Bembix 16  
 Bhawania 123  
 Bidens *9237*  
 Blennius 120, 136  
 Blumea *8939*  
 Boerhaavia *2340*, 13  
 Bonatea *7422B*, 9  
 Boodlea 23, 24, 45, 121  
 Boodleopsis 20, 21, 24  
 Bopyrus 83  
 Bostrychia 18, 20, 21, 23, 27, 40, 76, 121  
 Bothus 131  
 Botryllus 110, 112, 130  
 Bradornis 138  
 Brachiaria *766C*  
 Brachydontes 118, 129  
 Brachylaena *8936*, 10  
 Branchiomma 63, 118, 124  
 Branchiostoma 110, 118, 130  
 Branchophyllum 88, 128  
 Bregmaceros 131  
 Breviceps 17  
 Brexia *3225*, 10  
 Bridelia *4345*, 11, 12  
 Brotula 135  
 Bruguiera *2556*, 13, 14, 40, 119  
 Bryopsis 24, 88  
 Bubo 137  
 Bubulcus 137  
 Bulbostylis *471A*  
 Bulla 128  
 Bullia 38, 86, 120, 128  
 Bunodactylus 47, 122  
 Bunodeopsis 47, 122  
 Bursa 86, 118, 128  
 Butis 135  
 Butorides 137  
 Caesalpinia *3559*  
 Caesio 115, 133  
 Cajanus *3892*  
 Calanus 77  
 Calappa 42, 44, 70, 71, 82, 117, 118, 125  
 Calcinus 45, 73, 82, 126  
 Calidris 137  
 Calleleotris 135  
 Calliaetis 47, 71, 73, 117, 122  
 Callionymus 132  
 Calliostoma 127  
 Callithamnion 27  
 Callyodon 114, 134, 136  
 Caloglossa 21, 23, 27  
 Camaroptera 138  
 Campephaga 138  
 Canavallia *3897*, 13, 15  
 Cancellaria 128

- Canthigaster 115, 136  
 Canthium 8532  
 Capparis 3101, 9  
 Caprella 37, 76, 83, 117, 126  
 Caracanthus 135  
 Caranx 114, 116, 132  
 Carapus 135, 137  
 Carcharias 115, 131  
 Carcharinus 131  
 Carcharodon 115  
 Cardiogyne 1924, 9  
 Cardisoma 40, 69, 80, 119, 125  
 Cardita 37, 129  
 Cardium 90, 117, 129  
 Carica 5377  
 Carissa 6559  
 Carpilius 37, 82, 125  
 Carpobrotus 2405, 13, 15  
 Cassia 3536  
 Cassidula 41, 119, 128  
 Cassine 4647, 9, 10, 13  
 Casuarina 1855, 13, 15  
 Cassytha 2825, 12  
 Catenella 18, 20, 21, 23, 26  
 Caulerpa 18, 19, 20, 21, 24, 121  
 Cavernularia 118  
 Cecropis 138  
 Cellana 32, 120, 127  
 Cellepora 51  
 Cenchrus 174  
 Centella 5894, 12  
 Centroceras 27  
 Centropus 137  
 Centropyge 133  
 Cephalopholis 132  
 Ceramium 27  
 Ceratonereis 42, 43, 58, 59, 62, 124  
 Ceratosoma 45, 88, 119, 128  
 Cerianthus 42, 44, 117, 122  
 Ceriops 5522, 13, 14, 16, 40, 67, 119  
 Cerithidea 41, 71, 86, 119, 127  
 Cerithium 34, 36, 73, 86, 118, 127  
 Ceropogia 6874  
 Ceryle 138  
 Chaetacme 1906  
 Chaetodon 37, 41, 114, 119, 120, 133  
 Chaetomorpha 24  
 Chaetopterus 58, 63, 124  
 Chalcomitra 138  
 Chamaedoris 20, 22, 24, 121  
 Chamaeleo 17  
 Champia 21, 26  
 Chanos 131  
 Charadrius 137  
 Charybdis 37, 81, 117, 125  
 Cheilinus 114, 134  
 Cheilio 115, 134  
 Cheilodipterus 114, 132  
 Cheilosporum 26  
 Cheimerius 134  
 Chelidonura 128  
 Chelonodon 115, 136  
 Chenolea 2238, 13, 38, 119  
 Chenopodium 2223  
 Chicoreus 84, 128  
 Chione 117, 129  
 Chirocentrus 114, 131  
 Chiridota 130  
 Chlamys 90, 129  
 Chloris 288  
 Chlorocichla 138  
 Chlorodiella 71, 82, 125  
 Chlorophoneus 138  
 Chlorodopsis 82, 125  
 Choreonema 26  
 Chorinemus 116, 133  
 Chromis 134  
 Chrysocoma 8930  
 Chrysanthemoides 9427B, 10  
 Chrysococyx 137  
 Chrysopetalum 123  
 Chthamalus 32, 34, 77, 78, 118, 120, 127  
 Chylociadia 26  
 Cineraria 9406  
 Cinnypis 138  
 Cinnycinclus 138  
 Circaetus 137  
 Circe 129  
 Cirratulus 124  
 Cirrhimuraena 135  
 Cirripectes 115, 135  
 Cirrhitichthys 132  
 Cirrhitioidea 132  
 Cirrhitus 132  
 Cissampelos 2574  
 Cissus 4918, 9, 10  
 Cisticola 138  
 Citharoides 131  
 Cladium 489, 12  
 Cladophora 24  
 Clanculus 84, 118, 127  
 Clausena 4091, 9, 11  
 Clavelina 37, 110, 111, 112, 119, 130  
 Clavernularia 44  
 Cleistanthus 4343  
 Cleome 3082  
 Clerodendron 7191, 9, 11  
 Clibanarius 34, 36, 42, 44, 46, 71, 73, 82, 83, 117, 118, 120, 126  
 Clivia 1770  
 Clymene 124  
 Clytia 46, 122  
 Coccinea 8628  
 Cocos 663  
 Codakia 90, 129  
 Codium 23, 24, 25, 88, 121  
 Coeloria 51  
 Coenobita 38, 71, 73, 79, 117, 126  
 Colius 138  
 Colochirus 130  
 Colpomenia 20, 25, 121  
 Columbella 118, 128  
 Colus 128  
 Commelina 896, 13  
 Commiphora 4157, 9, 11  
 Conger 135  
 Conopharyngia 660, 9  
 Conus 34, 45, 84, 120, 128  
 Convoluta 38, 57, 117  
 Conyza 8926, 12  
 Corallina 21, 26, 121  
 Corallopsis 26  
 Cordia 7038, 9  
 Coris 134  
 Corvus 138  
 Coryne 47  
 Coscinarea 55, 123  
 Cossypha 138  
 Crassocephalum 9405A  
 Crassostraca 18, 32, 34, 40, 92, 118, 119, 120, 129  
 Crassula 3768  
 Creatophora 138  
 Crematogaster 16  
 Crenidens 136  
 Crenimugil 134  
 Crinum 7189  
 Crithagra 138  
 Crocethia 137  
 Crotoparia 3669  
 Croton 4348, 9, 13  
 Cryptocentrus 43, 134  
 Cryptochirus 71  
 Cryptodon 129  
 Cryptodromia 44, 79, 125  
 Cryptolepis 9, 11  
 Cryptotomus 114, 134  
 Ctenochaetus 133  
 Ctenomeria 4416A  
 Cucumaria 107, 119, 130  
 Culcita 99, 129  
 Culicia 37, 52, 104, 123  
 Cultellus 129  
 Cussonia 5872, 9  
 Cyanomitra 138  
 Cyathula 2372  
 Cyclichthys 136  
 Cyclograpsus 81  
 Cyerce 128  
 Cylas 16  
 Cylichna 44, 88, 90, 128  
 Cymadusa 76, 83, 117, 126  
 Cymatoceps 113  
 Cymatium 37, 84, 86, 117, 118, 127  
 Cymbopogon 134G  
 Cymo 125  
 Cymodocea 60, 3, 18, 20, 21, 23, 28, 29, 30, 34, 43, 44, 45, 46, 48, 65, 83, 88, 90, 110, 117, 121  
 Cymolutes 134  
 Cynanchium 6834, 11  
 Cynodon 282  
 Cynoglossoides 131, 136  
 Cynoglossus 136  
 Cyperus 459, 12, 13  
 Cyphastraea 49, 51, 55, 123  
 Cyphocarcinus 44, 65, 66, 80, 125  
 Cypraea 34, 36, 43, 45, 117, 118, 120, 127  
 Cypraecassis 84, 86, 127  
 Cypsiurus 138  
 Cystoseira 20, 25  
 Dactyloctenium 305, 12, 13, 15, 135  
 Dactyloptena 135  
 Dalbergia 8327, 9  
 Dalechampia 4422  
 Dasycyllus 43, 47, 54, 117, 134  
 Dasson 114, 135  
 Dasya 27  
 Dasyatis 131  
 Dasybranchus 60, 63, 124  
 Dasychone 63, 118, 124  
 Dasycladus 20, 25, 121  
 Decapterus 133  
 Dehaanias 34, 65, 80, 120, 125  
 Deinbollia 4740, 9  
 Dendrochirus 115, 135  
 Dendrodoris 88, 119, 128  
 Dendronephthya 48  
 Dendroneis 41, 44, 59, 60, 62, 117, 124  
 Dendrophyllia 51, 52, 56, 120, 123  
 Dendroscorpaena 135  
 Dermatolithon 26  
 Desmodium 3807  
 Diadema 36, 97, 102, 103, 105, 119, 130  
 Diatropura 138  
 Dicerocaryum 7780, 12  
 Dichrostachys 3452  
 Dicurus 138  
 Dictyopteris 18, 20, 25, 121  
 Dictyosphaeria 20, 21, 22, 24, 121  
 Dictyota 21, 25  
 Dietes 7265A, 9  
 Digenia 20, 27  
 Digitaria 766F, 13  
 Dinoperca 132  
 Diodon 136, 137  
 Diodora 118, 120, 127  
 Diogenes 42, 44, 73, 82, 83, 117, 126  
 Diopatra 42, 58, 63, 117, 118, 124  
 Dioscorea 7252  
 Diospyros 6406, 9, 10  
 Dipcadi 7084, 12, 13  
 Diphyes 47  
 Diplanthera 67, 3, 28, 29, 30, 42, 43, 69, 109, 121  
 Diplodus 113, 136  
 Diplosoma 112, 130  
 Diplothyxus 83, 124  
 Dissoura 137  
 Dodonia 4837  
 Dolabella 37, 45, 88, 90, 118, 128

- Dolichos 3970  
 Donax 38, 86, 90, 92, 117, 120, 129  
 Dorippe 44, 70, 79, 126  
 Doryrhamphus 132  
 Dosinia 117, 129  
 Dotilla 42, 45, 65, 66, 69, 81, 117, 125  
 Dovyalis 5328, 9  
 Drepane 120, 133  
 Drimiopsis 7090, 9, 10  
 Dromas 137  
 Dromia 44, 71, 79, 117, 125  
 Dromidia 71, 79, 125  
 Drupa 73  
 Dryopteris 12, 139  
 Dryoscopus 138  
 Drypetes 4309  
 Dules 34, 120, 132, 136  
 Duymeria 114, 134  
 Dynamena 46, 122  
 Dynoides 76, 83, 126
- Eastonia 129  
 Ebalia 71, 126  
 Echeneis 135  
 Echidna 37, 119, 135  
 Echinocardium 44, 99, 105, 100, 118, 130  
 Echinodiscus 43, 44, 71, 86, 99, 100, 102, 105, 118, 130  
 Echinometra 34, 36, 75, 99, 102, 103, 105, 119, 120, 130  
 Echinophyllia 52  
 Echinopora 55, 123  
 Echinothrix 37, 45, 97, 103, 105, 130  
 Eclipta 9766  
 Ectocarpus 21, 25, 121  
 Egretta 137  
 Elamena 37, 65, 66, 125  
 Eleotriodes 135  
 Eleotris 135  
 Elephantorrhiza 3467  
 Elfochelon 134  
 Elops 131  
 Elysia 86, 88, 119, 128  
 Emerita 38, 70, 71, 79, 120, 126  
 Encephalartos 5, 9  
 Engina 37, 118, 128  
 Engyprosopon 131  
 Enneapterygius 135  
 Entalophora 51  
 Enteromorpha 21, 24, 118, 121  
 Enterospermum 8279, 10  
 Entomacrodus 135  
 Epibulus 134  
 Epidiopatra 124  
 Epinephelus 37, 119, 132, 136  
 Epinetrum 2643  
 Epixanthus 34, 69, 82, 118, 125  
 Eragrostis 347  
 Erichthonius 76, 83, 117, 126  
 Erigeron 8901  
 Eriosoma 3898  
 Eriphia 34, 68, 69, 82, 118, 120, 125  
 Erodium 3927  
 Erythropgia 138  
 Erythroxyton 3956, 9  
 Estrilda 138  
 Etione 123  
 Ethulia 8734  
 Etisus 81, 118, 125  
 Etrumeus 131  
 Eucalyptus 5598  
 Eucidaris 36, 105, 119, 130  
 Euclea 6404, 9, 10, 12, 13  
 Eucomis 7088  
 Eucrate 71, 125  
 Eudendrium 47, 122  
 Eudistoma 32, 34, 36, 37, 110, 111, 112, 119, 120, 130  
 Eugenia 5578  
 Eugyrina 128
- Eulophia 1648, 9  
 Eulophidium 1735, 9  
 Eumedomus 125  
 Eunice 60, 63, 120, 124  
 Euphorbia 4498, 9  
 Euphosyne 123  
 Eurüpellia 125  
 Eurycarcinus 41, 71, 82, 119, 125  
 Eurythoe 37, 60, 62, 118
- Fagara 3991  
 Falkenbergiella 27  
 Fasciolaria 37, 86, 90, 117, 128  
 Favia 49, 51, 55, 71, 118, 123  
 Favites 51 55, 123  
 Fibbristylis 477  
 Ficus 7967, 9, 11  
 Fingeruthia 326  
 Fiona 128  
 Fistularia 114, 132  
 Fossularca 37, 129  
 Fuirena 467, 12  
 Fungia 55, 123  
 Fusinus 84, 128
- Gaffarium 129  
 Galathea 73, 79, 126  
 Galaxaura 22, 26  
 Galaxea 118, 123  
 Galeocerdo 115  
 Galpinia 5480, 9  
 Garcinia 5199, 11, 12  
 Gastrana 129  
 Gastrochaena 37, 92, 119, 129  
 Gastrolepida 60, 62, 123  
 Gastrophysus 115, 136  
 Gaterin 120, 133, 136  
 Gazania 9434, 13  
 Gazza 133  
 Gelidium 20, 26, 32, 86, 121  
 Gellidiopsis 26, 121  
 Gelonina 4464, 9  
 Gerres 133, 136  
 Gigartina 26, 121  
 Gilchristella 131  
 Gisekia 2382  
 Gladiolus 1877  
 Glaucidium 137  
 Glaucus 128  
 Glinus 2388  
 Gloriosa 963, 12  
 Glossobalanus 108, 109, 130  
 Glossodoris 128  
 Glycera 42, 43, 58, 59, 62, 117, 118, 124  
 Glycimeris 129  
 Gnaphalium 8992  
 Gnathophyllum 79, 126  
 Gobiichthys 134  
 Gobiodon 134  
 Gobius 41, 43, 115, 117, 119, 120, 135  
 Gomeza 44, 71, 80, 125  
 Gomphosus 134, 136  
 Gonadactylus 37, 75, 83, 119, 126  
 Gonatopus 693, 9, 10  
 Goniada 124  
 Goniastrea 50, 55, 120, 123  
 Goniopora 51, 52, 55, 118, 123  
 Goniotrichum 25  
 Gracilaria, 20, 26  
 Grammistes 132  
 Grapsus 32, 36, 68, 69, 81, 118, 120, 125  
 Gravicrella 124  
 Grewia 4966, 9  
 Griffithsia 27  
 Gymnoceramus 115, 133  
 Gymnodoris 88, 128  
 Gymnothorax 135  
 Gynnura 131  
 Gypsina 51
- Habenaria 7422  
 Haemanthus 7167, 10, 11  
 Haemarthria 727A  
 Hagedashia, 137  
 Halcyon 138  
 Halichoeres 115, 134  
 Halimeda 18, 19, 20, 25, 51, 88, 121  
 Haliotis 86, 127  
 Halmabernius 135, 137  
 Halophila 85, 28, 29, 30, 121  
 Halopteris 122  
 Haminea 44, 88, 90, 117, 128  
 Hanomancus 135  
 Hapalocarcinus 37, 71, 80, 125  
 Harengula 131  
 Harmothoe 60, 62, 123  
 Harpa 84, 128  
 Harpiliopsis 126  
 Harpius 80  
 Heeria 4589, 12  
 Helichrysum 9006, 12, 13  
 Hemibalistes 135  
 Hemidactylus 17  
 Hemigymnus 134  
 Hemipteronotus 134  
 Hemirhamphus 114, 131  
 Heniochus 133  
 Hepsetia 134  
 Hermannia 5056  
 Herpetolitha 55, 123  
 Herposiphonia 27  
 Hesione 62, 123
- Heteranthera 94  
 Heteroleotris 135  
 Heteropsammia 50, 52, 56, 123  
 Heterosiphonia 27  
 Hewittia 6995  
 Hexabranchus 45, 129  
 Hexanchus 131  
 Hibiscus 5073, 12  
 Hippocampus 118, 132  
 Hippolysmata 37, 80, 126  
 Hippolyte 43, 75, 80, 126  
 Holocentrus 120, 131  
 Hololepidella 60, 62, 123  
 Holothuria 34, 36, 41, 42, 43, 60, 62, 88, 99, 101, 103, 107, 117, 119, 120, 127, 130  
 Holotrachys 131  
 Homotrema 51  
 Hormophysa 18, 20, 25, 121  
 Huania 125  
 Hyale 32, 34, 36, 75, 76, 83, 126  
 Hyastenus 80, 125  
 Hyboscolex, 124  
 Hydatina 45, 128  
 Hydnothora 55, 123  
 Hydractinia 46, 73, 117, 122  
 Hydroclathrus 20, 25  
 Hydrocotyle 5893  
 Hydroides 63, 124  
 Hydrophyllax 8467, 13  
 Hydroprogne 137  
 Hymenocardia 4325, 9, 11, 12  
 Hymenocera 126  
 Hymenosoma 43, 65, 79, 117, 125  
 Hypargos 138  
 Hyparrhenia 7844, 11  
 Hyperolius 17  
 Hyphaene 10  
 Hyphanturgus 138  
 Hypnaea 20, 26  
 Hyporhamphus 131  
 Hypoxis 1230  
 Hyppolysmata 73
- Ibis 137  
 Idanthyrus 20, 32, 36, 59, 60, 63, 65, 73, 120, 124  
 Ilyograpsus 39, 41, 69, 125

- Imperata 709, 12, 13  
 Indicator 138  
 Indigofera 3702, 13  
 Indospiraena 134  
 Iniistius 134  
 Iphione 37, 60, 61, 62, 118, 123  
 Ipomoea 7003, 13, 15, 16  
 Irona 76, 83, 127  
 Isaurus 32, 48, 120, 122  
 Ischaemum 179, 12  
 Isipidina 138  
 Isophyllia 56, 123  
  
 Jacquemontia 6997  
 Jania 20, 26, 121  
 Janthina 127  
 Jocaste 126  
 Johnius 113  
 Juncus 936, 13  
 Jussieua 5797, 12  
  
 Kalanchoë 3166  
 Kaupifalco 137  
 Krausseola 2453  
 Kraussia 8308A, 9, 10  
 Kützingia 18, 20, 27  
 Kyphosus 133  
  
 Labroclinus 135  
 Labroides 134  
 Lachnosiphonium 8283  
 Lactoria 115, 118, 136  
 Lagocephalus 136  
 Lagonosticta 138  
 Lagynias 8357  
 Lambis 88, 127  
 Lamprocolius 138  
 Landolphia 6562, 9  
 Lanarius 138  
 Lanice 63, 124  
 Lanius 138  
 Lanocira 83, 126  
 Lantana 7144  
 Lapeyrousia 1374, 11  
 Larus 137  
 Latreutes 43, 75, 80, 117, 126  
 Launea 9293, 13  
 Laurencia 20, 27, 34, 121  
 Leiaster 99  
 Leiochone 44, 124  
 Leiognathus 133  
 Leiroleotris 135  
 Leiuranus 135  
 Lemna 795  
 Leocrates 60, 62, 117, 123  
 Leonnates 124  
 Lepadichthys 135  
 Lepidaplois 134  
 Lepidasthenia 60, 62, 123  
 Lepidium 2883  
 Lepidonotus 34, 60, 62, 120, 123  
 Leptastrea 55, 123  
 Leptoria 55, 123  
 Leptoscarus 114, 134  
 Lethrinus 115, 120, 134  
 Leveillea 27  
 Liagora 21, 25, 26, 121  
 Ligia 76  
 Lima 37, 129  
 Limnophyton 72  
 Linckia 36, 37, 60, 88, 99, 103, 104, 111,  
 119, 127, 129  
 Lingula 42, 95, 111, 130  
 Liomera 82, 125  
 Lissocarcinus 69, 81, 125  
 Lissochilus 1647, 11  
 Lissotis 37  
 Listrostachys 7835, 9, 10  
 Lithodomus 37, 90, 92, 119, 129  
 Lithognathus 136  
  
 Lithothamnion 51  
 Littorina 32, 34, 36, 40, 86, 90, 118, 119,  
 120, 128  
 Liza 134  
 Lobelia 8694, 12  
 Lobophyllia 55, 123  
 Lobophytum 48  
 Lochnera 6597  
 Loimia 58, 63, 117, 118, 124  
 Loligo 92  
 Lonchura 138  
 Lophodioidon 115, 119, 136  
 Loranthus 2074  
 Loripes 20, 21, 41, 90, 117, 129  
 Lotorium 127  
 Luidia 43, 99, 103, 104, 118, 129  
 Lumbrineris 62, 124  
 Lummitzera 5550, 13  
 Lupa 43, 69, 70, 81, 117, 125  
 Lutianus 37, 115, 120, 133  
 Lybia 47, 69, 82, 125  
 Lybius 138  
 Lycium 7379, 13, 15  
 Lycodontis 135  
 Lycopodium 139  
 Lygodactylus 17  
 Lyngbya 24  
 Lysidice 32, 63, 124  
 Lysilla 124  
 Lysiosquilla 75, 83, 119, 126  
 Lytocarpus 37, 46, 76, 83, 117, 118, 122  
  
 Macropharyngodon 134  
 Macrophyothrix 36, 99, 101, 105, 119, 127,  
 129  
 Macropodia 44, 125  
 Macrophthalmus 36, 39, 42, 45, 65, 66, 69,  
 81, 117, 119, 125  
 Mactra 129  
 Macrura 131  
 Maera 76, 83, 126  
 Maerua 3112  
 Magelona 42, 63, 124  
 Makaira 134  
 Malacanthus 132  
 Manihot 4444  
 Mangifera 4545  
 Manicinia 51  
 Mariscus 459B, 12  
 Marphysa 32, 41, 42, 43, 60, 61, 63, 117,  
 119, 124  
 Matuta 42, 44, 70, 71, 82, 117, 118, 125  
 Maytenus 4626, 10, 13  
 Meandrina 118, 123  
 Medaeus 125  
 Megalaspis 133  
 Megalops 131  
 Megastachya 347A  
 Melampus 41, 119  
 Melanthera 9204, 12  
 Meleagrina 37, 129  
 Melibe 45, 88, 128  
 Melichthys 135  
 Mellittophagus 138  
 Melobesia 51  
 Melongena 42, 44, 117, 128  
 Melothria 8562  
 Menaethiops 34, 80, 120  
 Menaethius 44, 65, 66, 80, 117  
 Meoremia 6997  
 Meretrix 129  
 Mesochaetopterus 42, 58, 63, 117, 124  
 Mesophox 137  
 Metagobius 135  
 Metapenaeus 41, 80, 119, 126  
 Metopograpsus 36, 69, 81, 118, 125  
 Micippa 44, 65, 117, 125  
 Microcoelia 7837  
 Microdictyon 20, 24  
 Micrognathus 132  
  
 Microspicularia 37, 48  
 Milvus 137  
 Mimusops 6386, 11  
 Mitra 84, 117, 128  
 Mobula 131  
 Modiolus 43, 65, 90, 117, 129  
 Monadenium 4503  
 Monilia 36, 118, 127  
 Monodactylus 133  
 Monostroma 24  
 Monotaxis 133  
 Montastrea 55, 123  
 Montipora 50, 51, 52, 55, 118, 122  
 Moringua 135  
 Mormordica 8597  
 Morus 137  
 Motacilla 138  
 Mucronalia 88, 127  
 Muggiaea 47  
 Mugil 114, 134  
 Mulloidichthys 114, 130  
 Muraenesox 135  
 Muriea 6386A, 9, 11  
 Murrayella 21, 23, 27  
 Murex 84, 117, 128  
 Musa 7378  
 Muscicapa 138  
 Mussa 55, 123  
 Mustelus 131  
 Mycedium 52, 55, 123  
 Mychodea 26  
 Mytrophum 131  
 Myra 44, 71, 79, 126  
 Myrichthys 135  
 Myripristis 131  
 Mytilus 120, 129  
  
 Nainereis 124  
 Nannocampus 132  
 Nassa 42, 43, 44, 46, 86, 117, 128  
 Naso 133  
 Natica 42, 44, 86, 117, 127  
 Neoscorpis 133  
 Nereis 32, 62, 120, 124  
 Nerine 42, 58, 63, 124  
 Nerita 32, 34, 36, 71, 86, 118, 120, 127  
 Neomeris 20, 25  
 Nephthys 42, 43, 58, 59, 62, 118, 124  
 Neurytemia 27  
 Nicomache 44, 124  
 Nidorella 8929, 12  
 Nikoies 80, 126  
 Nomeus 134  
 Notomastus 124  
 Novaculichthys 114, 134  
 Novostoa 32, 36, 120, 127  
 Numenius 137  
 Nymphaea 2573, 12  
  
 Obelia 46  
 Obeliscus 44, 45, 88, 118, 127  
 Ochaetostoma 37, 111, 118, 122  
 Ochna 5772, 9, 12  
 Ocimum 7366  
 Octolasmis 77  
 Octomeris 78  
 Ocyrode 38, 65, 66, 67, 81, 117, 120, 125  
 Odonus 135  
 Odontodactylus 75, 83, 126  
 Odontosyllis 62, 123  
 Odostomia 88, 127  
 Oecophyllum 16, 40, 119  
 Ogyrides 126  
 Olax 2737, 10  
 Olea 6434, 9  
 Oliva 128  
 Omobranchus 135  
 Oncoba 5284, 12  
 Oncidium 34, 44, 128  
 Onithochiton 84, 120, 127

- Opheodesoma* 43, 98, 130  
*Ophiactis* 36, 45, 99, 101, 103, 105, 119, 120, 129  
*Ophichthus* 135  
*Ophidocladus* 27  
*Ophiocara* 135  
*Ophiocentrus* 44, 129  
*Ophiocoma* 36, 44, 45, 99, 101, 103, 105, 119, 120, 130  
*Ophioglossum* 139  
*Ophiolepis* 105, 119, 130  
*Ophiomastix* 130  
*Ophionephthys* 101, 105, 129  
*Ophionereis* 130  
*Ophiopezella* 105, 130  
*Ophiophragmus* 101, 105, 129  
*Ophiothrix* 34, 99, 105, 120, 129  
*Ophiothela* 44, 117, 129  
*Ophiotrichoides* 105, 129  
*Ophisurus* 135  
*Opisthognathus* 132  
*Opisthosyllis* 32, 62, 123  
*Opuntia* 5417  
*Orbinia* 58, 63, 124  
*Ornithogalum* 7089, 12  
*Orthoprotella* 46, 76, 83, 126  
*Orthopyxis* 46, 122  
*Osbeckia* 135  
*Oscaniella* 119, 128  
*Ostracion* 115, 136, 137  
*Osyris* 2708  
*Otolithes* 133  
*Ottelia* 95  
*Oulophyllia* 52, 55, 123  
*Owenia* 42, 58, 61, 63, 117, 124  
*Oxalis* 3936  
*Oxygonum* 2204  
*Oxypora* 52, 55, 123  
*Oxysteles* 86, 127  
*Oxyurichthys* 134
- Pachycheles* 34, 73, 120, 126  
*Pachygrapsus* 125  
*Padina* 19, 20, 21, 25, 37, 121  
*Pagellus* 136  
*Pagurus* 45, 47, 71, 73, 77, 82, 117, 120, 126  
*Palaemon* 41, 75, 80, 119, 126  
*Palythoa* 32, 47, 48, 71, 120, 122  
*Panicum* 766, 12  
*Panulirus* 37, 73, 79, 126  
*Papillapogon* 114, 132  
*Paphia* 129  
*Paracanthurus* 133  
*Paraciliacea* 76, 117, 126  
*Paracleistosoma* 125  
*Paragobiodon* 134  
*Paralepidonotus* 123  
*Paramonocanthus* 115, 135  
*Paranthura* 76, 83, 117, 126  
*Parapallene* 75, 78  
*Parapegasus* 132  
*Paraperis* 132, 136  
*Parapilumnus* 125  
*Paraplagusia* 131  
*Parascolopsis* 133  
*Parascorpaena* 114, 135  
*Pardalaspis* 16  
*Pareulepis* 43, 60, 62, 117, 123  
*Parexocoetus* 131  
*Parheteromastus* 124  
*Patella* 20, 32, 36, 86, 120, 127  
*Pavetta* 8383  
*Pavoclinus* 135  
*Pavona* 50, 51, 55, 118, 122  
*Pavonia* 5007  
*Pecten* 129  
*Pectinaria* 63, 125  
*Pegasus* 132  
*Pelargonium* 3928  
*Pelates* 115, 120, 132  
*Pelecanus* 137
- Pellaea* 9, 139  
*Pellona* 131  
*Pellonulops* 131  
*Peltogaster* 73, 77, 79, 127  
*Pempheris* 133  
*Penaeopsis* 43, 80, 117, 119, 126  
*Penaeus* 41, 73, 75, 80, 117, 119, 126  
*Pennatula* 44, 48  
*Pennisetum* 775  
*Pentacaster* 43, 96, 97, 102, 104, 117, 129  
*Pentodon* 8145, 12  
*Perenon* 69, 81, 125  
*Periclymenaeus* 126  
*Periclimenes* 43, 47, 54, 75, 80, 117, 126  
*Periglossum* 6783A  
*Perinereis* 60, 62, 124  
*Periopthalmus* 41, 119, 136  
*Peristernia* 37, 118, 128  
*Perna* 34, 119, 120, 129  
*Pervagor* 135  
*Petaloproctus* 124  
*Petricola* 92, 119, 129  
*Petrolisthes* 34, 73, 83, 118, 126  
*Petroscirtes* 135  
*Phalacrocorax* 137  
*Phacelocarpus* 26  
*Phalerebus* 134  
*Phalium* 84, 127  
*Phaulopsis* 7932  
*Pheidole* 16  
*Pherecardia* 123  
*Philine* 44, 88, 118, 128  
*Philoscia* 32, 36, 75, 83, 126  
*Philyra* 42, 44, 70, 71, 117, 126  
*Phylactis* 47  
*Phoenicopteris* 137  
*Phoenix* 528, 10  
*Phoronis* 43, 47, 95, 111, 130  
*Phragmites* 333, 12  
*Phyla* 7145, 12  
*Phyllanthus* 4299  
*Phyllastrephus* 138  
*Phyllidia* 45, 128  
*Phyllochaetopterus* 42, 58, 59, 117, 124, 163  
*Phyllodoce* 62, 123  
*Phyllophichthys* 135  
*Phymodius* 37, 82, 119, 125  
*Physalia* 47  
*Physcosoma* 32, 37, 118, 120, 125  
*Pilargis* 60, 123  
*Pilumnus* 36, 68, 69, 119, 125  
*Pinctada* 37, 43, 118, 129  
*Pinna* 129  
*Pinnotheres* 43, 65, 66, 117, 125  
*Pisidium* 5559  
*Pisodonopsis* 135  
*Pista* 37, 61, 63, 117  
*Pittosporum* 3252  
*Placophiothrix* 36, 102, 105, 119, 130  
*Placophora* 27  
*Plagusia* 69, 81, 125  
*Planaxis* 34, 36, 86, 118, 127  
*Planes* 125  
*Platux* 133  
*Platycephalus* 135, 137  
*Platylambrus* 44, 125  
*Platynereis* 43, 62, 124  
*Platysiphonia* 27  
*Platysteira* 138  
*Plectanthus* 7350  
*Plectrogyphiædon* 134  
*Plectropomus* 132  
*Pleonosporium* 27  
*Plesiops* 132  
*Plocanium* 20, 26  
*Ploceus* 138  
*Plotosus* 114, 115, 131  
*Pluchis* 133  
*Plumbago* 6364  
*Plumularia* 46, 120, 122
- Pocillopora* 34, 49, 50, 51, 52, 55, 118, 120, 122  
*Pocockiella* 25, 121  
*Podobacia* 51, 123  
*Pocilasma* 77, 79, 127  
*Pogoniulus* 138  
*Pollichia* 2467  
*Polyandrocarpa* 44, 71, 110, 112, 130  
*Polyboroides* 137  
*Polycarpoea* 2455  
*Polydactylus* 134  
*Polydora* 34, 36, 44, 60, 61, 63, 118, 124  
*Polygala* 4273  
*Polygonum* 2201, 12  
*Polymnia* 124  
*Polynices* 42, 44, 86, 117, 118, 127  
*Polyonyx* 58, 73, 83, 126  
*Polyopthalmus* 124  
*Polypodium* 9, 139  
*Polyrachis* 16  
*Polysiphonia* 27  
*Pomacanthus* 133  
*Pomacentrus* 114, 115, 134, 136  
*Pomadasyx* 116, 133, 136  
*Pomatoleios* 34, 36, 60, 61, 63, 120, 124  
*Pomatopus* 115, 133  
*Pontogeloides* 32, 36, 76, 83, 126  
*Pontogenia* 62, 123  
*Pontophilus* 43, 75, 117, 126  
*Popowia* 2697, 9  
*Porcellana* 73, 83, 126  
*Porcellanella* 83, 126  
*Porites* 50, 51, 52, 55, 118, 123  
*Porpita* 47  
*Portulaca* 3427  
*Potamilla* 124  
*Potamon* 80  
*Priacanthus* 132  
*Prinia* 138  
*Prionocidaris* 36, 43, 97, 100, 101, 102, 117, 130  
*Pristis* 131  
*Priva* 7153  
*Processa* 80, 118, 126  
*Promicrops* 116, 132  
*Protoreaster* 36, 43, 96, 97, 104, 119, 129  
*Psalidoprocne* 138  
*Psammobia* 129  
*Psammocora* 51, 123  
*Psenes* 134  
*Psettodes* 131  
*Pseudactinia* 47  
*Pseudafuterius* 135  
*Pseudahirundo* 138  
*Pseudobalistes* 135, 136  
*Pseudorhombus* 131  
*Pseudocheilinus* 134  
*Pseudochromis* 132  
*Pseudococcus* 16  
*Pseudocodium* 20, 25, 121  
*Pseudogramma* 132  
*Pseudograpsus* 125  
*Pseudonereis* 32, 62, 124  
*Pseudopristipoma* 133  
*Pseudorhombus* 131  
*Pseudosquilla* 75, 83, 126  
*Pseudupeneus* 114, 133  
*Psilotrichum* 2324  
*Plarvus* 135  
*Pteragogus* 115, 134  
*Pteria* 43, 129  
*Pteridium* 139  
*Pterois* 37, 41, 115, 119, 135  
*Pterosiphonia* 27  
*Pleliopsis* 5589, 9, 11, 12  
*Ptychodera* 45, 86, 88, 108, 109, 130  
*Puliella* 124  
*Puparia* 2734  
*Pycnodonta* 129  
*Pycnogonum* 78

- Pycnonotus 138  
 Pycreus 459A, 12  
 Pyramidella 44, 86, 88, 118, 127  
 Pyrgoma 78  
 Pyura 34, 65, 110, 112, 116, 120, 130  
  
 Quadrella 69, 82, 125  
 Quelea 138  
  
 Racilius 126  
 Ralfsia 20, 25  
 Randia 8283, 9  
 Ranella 128  
 Ranina 44, 70, 71, 79, 126  
 Rapana 86, 128  
 Rastrelliger 134  
 Remora 135  
 Rhabdosargus 134, 136  
 Ricinus 4424  
 Rhina 131  
 Rhinecanthus 136  
 Rhinobatus 131  
 Rhinoptera 131  
 Rhizoclonium 24  
 Rhizophora 5523, 13, 16, 21, 40, 41, 119  
 Rhizopsammia 52, 56, 123  
 Rhodomelopsis 27  
 Rhodymenia 20, 26  
 Rhoicissus 4977, 9, 10  
 Rhynchelytrum 768A, 12  
 Rhyneops 137  
 Rumex 2195  
 Rhus 4594, 11, 13  
  
 Sabellaria 60, 63, 124  
 Sabellastarte 37, 60, 63, 118, 124  
 Saccharum 111  
 Sacciolepis 166E  
 Saccoglossus 108, 109, 117, 130  
 Sacculina 69, 76, 77, 79, 127  
 Salacia 4662  
 Salarius 137  
 Salicornia 2257, 13, 38, 119  
 Salmacis 43, 97, 102, 105, 117, 130  
 Sanseveiria 1110, 9, 10  
 Sapium 4483, 9  
 Sarcophytum 48  
 Sarcostemma 6849, 9  
 Sarda 134  
 Sardinella 131  
 Sargassum 18, 20, 22, 25, 34, 121  
 Saron 43, 54, 73, 75, 80, 126  
 Satyrium 1430  
 Saurida 131, 136  
 Saxicola 138  
 Scaevola 8776, 13, 16  
 Scatophagus 133  
 Schizophrys 66, 80, 125  
 Schizostylis 1299, 11  
 Schmidtia 372  
 Sciaena 133  
 Scilla 1086  
 Sclerocarya 4558, 11, 12  
 Sclerochiton 7978  
 Scolecolepis 124  
 Scoliophon 136  
 Scolopia 5304, 9  
 Scoloplos 42, 43, 63, 124  
 Scolopsis 115  
 Scolops 136  
 Scolopsis 133  
 Scomberesox 131  
 Scomberomorus 114, 116, 134, 136  
 Scorpaena 118, 119, 137  
 Scorpaenodes 135  
 Scorpaenopsis 135  
 Scutus 127  
 Scylla 41, 69, 77, 81, 117, 119, 124  
 Sebaea 6487  
 Sebastapistes, 135  
 Secamone 6860, 9, 11  
  
 Securinega 4297  
 Secutor 133  
 Selar 132  
 Semonvillea 2376A  
 Senecio 9417  
 Sepia 92  
 Sepioteuthis 92  
 Septifer 34, 36, 37, 118, 119, 129  
 Seriatopora 52  
 Serinus 138  
 Serpula 63, 118, 124  
 Sertularia 46, 122  
 Serturella 46, 122  
 Sesamum 7777  
 Sesarma 39, 41, 68, 69, 81, 119, 125  
 Sesbania 3747  
 Sesuvium 2394, 13, 119  
 Sida 4998  
 Siderastrea 55, 123  
 Siderea 135  
 Sideroxylon 6368, 9, 11  
 Siganus 114, 134  
 Sigaretus 44, 88, 118, 127  
 Sigelus 138  
 Siliqua 129  
 Sillago 117, 132  
 Siphonaria 32, 34, 118, 120, 128  
 Siphonocladus 24  
 Siphonocoetus 126  
 Siphonophora 47  
 Siphonosoma 42, 117, 125  
 Sistrum 34, 77, 86, 120, 128  
 Smilax 1757, 11  
 Solanum 7407  
 Solen 92, 129  
 Solenastrea 55, 123  
 Solenomya 129  
 Solenostomus 132  
 Soliera 26  
 Sonchus 9595  
 Sophora 3602, 13  
 Spermothamion 27  
 Sphacelaria 25  
 Sphaeroma 76, 83, 126  
 Sphaerozium 71, 82, 125  
 Sphenotrochus 50, 52, 123  
 Sphyaena 134, 136  
 Sphyaenella 134  
 Spilotichthys 133  
 Spirochaetopterus 124  
 Spirobranchus 60, 63, 124  
 Spirobis 63, 124  
 Spondylus 129  
 Sporobolus 230, 12, 13  
 Spyridia 27  
 Squatarola 137  
 Squilla 83, 126  
 Stegosoma 131  
 Stenopus 73, 79, 126  
 Stenotaphrum 180  
 Stephanolepis 115  
 Sterna 137  
 Stethojulis 62, 114, 134  
 Stenelais 123  
 Stenopus 107, 119, 130  
 Stiliger 128  
 Stizus 16  
 Stoasodon 131  
 Stoichactis 37, 43, 54, 73, 75, 80, 117, 118, 122  
 Stolephorus 131  
 Stomatella 37, 118, 127  
 Stomopneustes 34, 99, 102, 103, 105, 120, 130  
 Streblacladia 27  
 Streptosoma 42, 63, 117, 124  
 Stephanolepis 135  
 Streptopelia 137  
 Strializa 136  
 Striga 7625  
 Stombus 84, 86, 127  
  
 Struvea 20, 24, 121  
 Strychnos 6460, 11, 12  
 Styela 110, 112, 119, 130  
 Stylifer 36, 86, 88, 111, 127  
 Stylocheilus 128  
 Stylochiton 764  
 Stylocoeniella 52, 122  
 Stylophora 49, 50, 51, 52, 55, 71, 80, 118, 122  
 Stylosanthes 3802  
 Stypopodium 18, 19, 20, 25, 121  
 Suaeda 2267, 38  
 Sufflamen 135  
 Syllis 60, 62, 118, 120, 124  
 Symphyllia 51, 52, 56, 120, 123  
 Symplectes 138  
 Symplegma 32, 110, 112, 120, 130  
 Synadenium 4500, 9  
 Synalpheus 75, 80, 120, 126  
 Synanceja 115, 135  
 Synapta 43, 69, 75, 99, 107, 117, 130  
 Synaptolepis 5442  
 Syngnathoides 41, 119, 132  
 Syngnathus 132  
 Synidotea 83, 126  
 Synodus 131, 136  
 Syringodium 60A, 28, 44  
 Syzigium 5583, 11, 12  
  
 Tachysurus 131  
 Taeniolabrus 132  
 Taenionotus 135  
 Taenioma 27  
 Taeniura 131  
 Talium 2406  
 Talorchestia 76, 83, 118, 126  
 Tchagra 138  
 Tecomaria 7713, 9  
 Tectarius 32, 34, 36, 86, 90, 118, 120, 127  
 Tellina 44, 118, 129  
 Temnopleurus 43, 97, 102, 105, 117, 130  
 Tephrosia 3718, 13  
 Terathropus 137  
 Terebella 63, 124  
 Terebellides 37, 63, 124  
 Terebra 44, 84, 117, 128  
 Terebralia 41, 71, 86, 119, 127  
 Terminata 5544  
 Terpsiphone 138  
 Tetraclita 20, 32, 34, 37, 75, 77, 78, 120, 127  
 Tetralia 69, 82, 125  
 Tetrosomus 136  
 Thais 34, 36, 77, 84, 118, 120, 128  
 Thalamita 37, 41, 43, 69, 81, 117, 119, 125  
 Thalassia 92, 28, 29, 30, 88  
 Thalassoma 134  
 Thaliurus 114, 134  
 Thecacera 88, 119, 128  
 Thelepus 37, 63, 118, 124  
 Themedra 136  
 Thenus 37, 73, 79, 126  
 Therapon 41, 117, 119, 132  
 Thesium 2178  
 Thespesia 5078, 9  
 Threskornis 137  
 Thrissocles 131  
 Thunbergia 7974  
 Thyca 36, 88, 111, 127  
 Thyone 36, 99, 107, 119, 130  
 Thyrsoida 135  
 Tiraphis 377  
 Tivela 129  
 Tonna 71, 84, 128  
 Torpedo 131  
 Toxopneustes 37, 45, 99, 103, 105, 130  
 Trachinocephalus 131  
 Trachinotus 114, 116, 133  
 Trachurus 132  
 Tragia 4416  
 Trapezia 37, 68, 69, 82, 119, 125

*Trema* 1902, 11  
*Treron* 137  
*Trienodon* 131  
*Tribulus* 3978  
*Tricalysia* 8308, 9, 10  
*Trichilia* 4195, 11, 12  
*Trichiurus* 134  
*Tricholaena* 168  
*Tridacna* 20, 37, 90, 119, 129  
*Triglochin* 66  
*Tringa* 137  
*Tripneustes* 43, 97, 101, 102, 105, 117, 130  
*Tripterodon* 133  
*Tritonia* 1307, 12  
*Trochus* 45, 117, 127  
*Troglopagurus* 126  
*Tropiometra* 97, 99, 119, 130  
*Triumfetta* 4975  
*Trypanosyllis* 60, 62, 124  
*Turbinaria* (alga) 20, 25, 121  
*Turbinaria* (coral) 51, 56, 118, 123  
*Turbo* 36, 118, 127  
*Turtur* 137  
*Tylosurus* 76, 131  
*Typha* 49, 12  
*Typhlocarcinodes* 125  
  
*Uca* 39, 41, 65, 66, 67, 69, 81, 119, 125  
*Udotea* 18, 19, 20, 21, 23, 24, 121  
*Ulva* 20, 24

*Umbraculum* 45, 88, 128  
*Upeneus* 133  
*Upogebia* 39, 41, 69, 73, 79, 119, 126  
*Upupa* 138  
*Urelytrum* 125, 11  
*Urochloa* 166B, 12  
*Urocoleus* 138  
*Urodemas* 130  
*Uropterygius* 135  
*Urosalpinx* 34, 77, 118, 128  
*Utricularia* 7907, 12  
  
*Valamugil* 134  
*Valonia* 20, 21, 24, 45, 121  
*Valoniopsis* 24  
*Vangueria* 8357  
*Vanikoro* 37, 127  
*Vanilla* 1480, 9, 11  
*Variola* 132  
*Varuna* 69, 125  
*Velella* 47  
*Venus* 129  
*Vepris* 4076  
*Vermetus* 34, 118  
*Vernonia* 8737  
*Veronica* 7379  
*Vexillum* 86, 128  
*Vidua* 138  
*Vigna* 3905  
*Vinciguerria* 131  
*Virgularia* 44, 48, 116

*Viscum* 2903  
*Vitex* 7816  
*Voandzeia* 3903  
  
*Wahlenbergia* 8668  
*Waltheria* 5059  
*Wedelia* 9192, 10  
*Willeya* 108, 109, 130

*Xanthon* 114, 134  
*Xantho* 36, 68, 69, 77, 82, 118, 125  
*Xenophora* 84, 86, 127  
*Xenophthalmodes* 125  
*Xenus* 137  
*Ximenes* 2136  
*Xiphias* 134  
*Xyris* 826

*Yozia* 132

*Zamioculcas* 692, 9  
*Zanclus* 133, 136  
*Zantedeschia* 748  
*Zebrosoma* 133  
*Zoanthus* 32, 37, 48, 71, 118, 120, 122  
*Zonardinula* 26  
*Zonaria* 25  
*Zornia* 3804  
*Zosterops* 138  
*Zozymodes* 71, 82, 125