Pope, E. C., 1945. A simplified key to the sessile barnacles found on the rocks, boats, wharf piles and other installations in Port Jackson and adjacent waters. *Records of the Australian Museum* 21(6): 351–372, plates xxviii–xxx. [25 June 1945].

doi:10.3853/j.0067-1975.21.1945.550

ISSN 0067-1975

Published by the Australian Museum, Sydney

A SIMPLIFIED KEY TO THE SESSILE BARNACLES FOUND ON THE ROCKS, BOATS, WHARF PILES AND OTHER INSTALLATIONS IN PORT JACKSON AND ADJACENT WATERS.

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(Plates xxviii–xxx; Figures 1–5.)

Introduction.

It is generally considered by dock authorities that the fouling of ship bottoms by barnacles in the harbour of Sydney, Port Jackson, is heavy in comparison with other localities. Unlike most other organisms which attach themselves to the bottoms of ships, barnacle shells do not necessarily drop off or decay away once the organism in them dies, and docking and scraping are necessary to remove them effectively. This is an expensive process and consequently much attention is being given to the production of anti-fouling substances for use on harbour installations. Actually it is possible that a coating consisting of thousands of barnacles on a wharf pile or other wooden structure under water may itself, by the constant feeding of the individuals, cause considerable reduction in the numbers of swimming larvae of such undesirable wood-borers as the shipworm or Cobra (Teredinine borers).

Much work remains to be done in connection with both these problems, and it has become a primary necessity for the field worker to be able to distinguish quickly and easily the different species of barnacles found in the waters of Port Jackson. The various monographs and scientific papers dealing with this group of crustaceans are not as a rule easy of access to the workers on these problems and often contain unnecessarily detailed descriptions of the various species. This simple key has therefore been drawn up to help these workers. The author has assumed that some of the users of this key will be unfamiliar with the zoological terms usually applied to the various parts of the body and shells of these animals. Accordingly, as few of these technical terms as possible have been introduced, and differences in field occurrence and external structure will be used, as far as may be, to distinguish between one species and another, rather than the very necessary finer points of anatomical difference used by the specialists in this group. Workers desirous of more complete and detailed descriptions should refer to Darwin's monograph (1854) on this group or some other later standard work of that nature.

Relationships and Anatomy of the Barnacles.

In spite of their appearance, barnacles are not molluscs like mussels or oysters, but are close relatives of the prawns, crabs and other crustaceans. They have been aptly described by Huxley as shrimp-like animals which have become attached by their head ends to some submerged object and then have proceeded to construct round their bodies cases of armour-like plates. These plates butt one against the next and serve as a protection for the soft parts of the body. The technical name for the barnacles is Cirripedia, bestowed on them because of their feathery, cirrus-like feet which are protruded through a gap between parts of the hard shelly coat when the animal is feeding. These feathery feet are used to "comb" the barnacles' food-particles from the surrounding water.

Of the barnacles encountered on the rocky foreshores and installations of Port Jackson, two distinct kinds may easily be recognized: the stalked or "Goose" barnacles and the sessile or "Acorn" barnacles. In the stalked ones the body is protected by an outer covering of plates and the animal has a stalk or peduncle, sometimes several inches in length. In the sessile type there is no stalk, and the soft parts of the animal which are surrounded by a roughly cone-shaped wall of plates, grow directly attached to objects such as stones, piling, ships' bottoms or the shells of other animals. The stalked barnacles are mainly creatures of the ocean waters, while the acorn barnacles are commonest along the shores and shallow seas. It is with the latter group that this paper is concerned.

The barnacle reveals its real nature and its close affinity with other crustaceans in its life-history because the young leave the parent as the typical free-swimming crustacean larva called a nauplius. In this stage the young may be scattered far from their place of origin by currents. As the young larva grows, it undergoes several moults and changes its appearance radically, growing a two-piece shell and resembling another small crustacean type, the Ostracod *Cypris*, very closely in appearance. For this reason the young barnacle at this stage of its development is called the cypris stage.

The cypris stage swims about in the sea and seeks out a spot suitable for attaching itself. It does this by means of an adhesive cement poured out by a gland situated towards the head end of the body. After this stage, all the limbs of the adult are present. The bivalved shell remains until the barnacle is attached and then is cast off and the plates of the adult shell begin to grow, being laid down by an outer covering of the body.

In order to determine the genus of a barnacle it is necessary to be able to orientate and know the names of some parts of the shell and body.

The shell consists of a *basis* and a circular wall made up of 4, 6 or 8 main *plates*. These abut one against the next to make the solid outer coat of the animal. The basis is closely applied to the substratum on which the barnacle is growing and may be flat or cup-like and *calcareous* or *membranous*. Where the basis is calcareous it may be solid, or may have a series of radiating channels in it, called pores. The plates of the shell are separated from one another by *sutures* which can be quite distinct or may be obliterated as the barnacle matures and grows old.

At the upper or free end of the shell is the opening to the outside world, the *orifice*, the shape of which is often an aid in the determination of the species. The orifice is closed by a lid-like structure, the *operculum*, which is joined to the wall-like

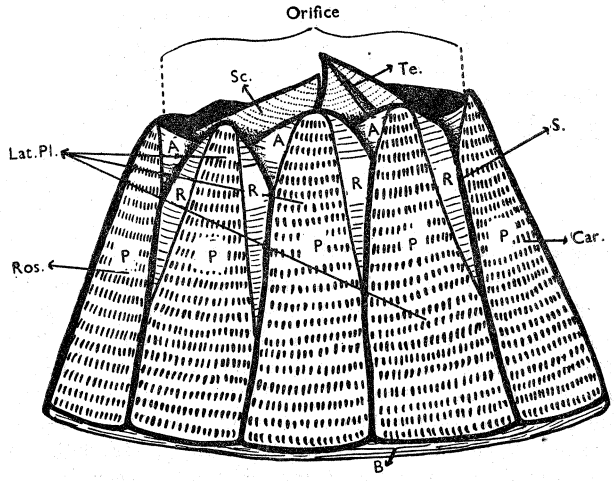

Figure 1.—Diagram of the whole shell of a barnacle. A., alae; B., basis; Car., carina; Lat. Pl., lateral plates; P., parietes; R., radius; Ros., rostrum; S., suture; Sc., scutum; Te., tergum.

part of the shell by a chitinous *opercular membrane*. The operculum is made up of two pairs of small shells or valves known as the *scuta* and *terga* and between them is a slit-like opening which leads into the sac inside the shell, where the soft body-parts lie. It is through this slit that the feathery cirri are poked when the animal feeds (Figs. 1, 2).

The structure of the opercular valves is of the utmost importance as an aid to the identification of barnacle species and should always be taken into account when checking field identifications. A low-powered microscope is generally necessary for viewing these valves, but in the larger species a hand lens may be sufficient (Figs. 3, 4).

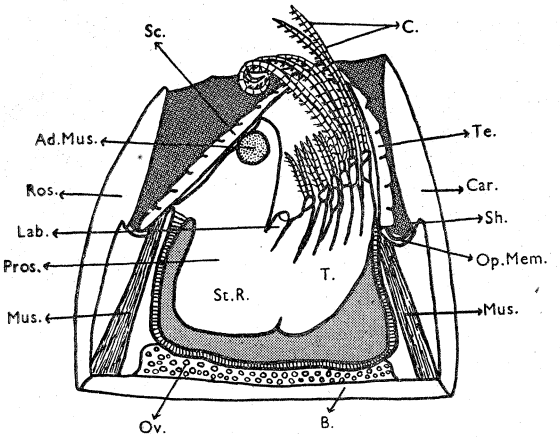

Figure 2.—Diagram of barnacle with part of shell removed to display soft parts. Ad. Mus., adductor muscle cut end; B., basis; C., cirri; Car., carina; Lab., labrum; Mus., muscle; Op. Mem., opercular membrane; Ov., ovary; Pros., prosoma; Ros., rostrum; Sc., scutum; Sh., tip of sheath; St. R., region of stomach; T., thorax; Te., tergum.

Each plate of the shell, apart from the opercular valves, consists of a central, triangular-shaped section, the *paries* (plural *parietes*) with, as a rule, two side parts called either radii or alae according to whether they overlap or underlie the side parts of the adjacent plate. Side pieces which overlap the next plate are called *radii*, and those which underlie them are called *alae*. A plate may have alae on either side of the central portion or radii, or one radius and one ala. (See Fig. 1.)

Examination of the basal end of a shell-plate of a barnacle such as *Tetraclita rosea* shows that the walls are not always simple, single-layered structures. Generally there is an outer and an inner *lamina* across which run strengthening *septa* dividing the walls into a series of tubes or *pores*. Further branchings of the septa may lead to the formation of more than one row of pores between the outer and the inner lamina of each shell-plate. Such a state of affairs is found in *Tetraclita purpurascens* (Plate xxix, fig. 3).

The various plates in the shell have names, and since the genus is generally decided by the arrangement of these shell parts it is necessary to know some of them. The most primitive type of acorn barnacle found today is the genus *Catophragmus*, and its shell is made up of eight main plates with numerous whorls of smaller ones outside. But in most other genera there has been a reduction in the number of main plates to six or four, and the outer whorls of small plates or scales are absent altogether. This reduction in the number has been brought about by fusion of some of the plates. Such a fusion during the development from juvenile to adult form of an individual has been observed and described by Miss Lucy B. Moore (1944) in the barnacle *Chamaesipho brunnea*, where the juvenile definitely has six plates and the adult four.

The plate situated at the end of the shell where the cirri are poked out (the end of the shell where the tergal opercular valves are) is called the *carina*. This plate always

has two alae and is, therefore, overlapped by adjacent plates. The plate in the shell directly opposite to the carina is the *rostrum*. In more primitive types of barnacles it also has two alae like the carina, and should the shell-pieces of such a barnacle become detached it is then difficult to distinguish the carina from the rostrum. Usually, however, the carina is more bent than the rostrum of the same species and in this way can be distinguished. Between the carina and the rostrum lie the lateral plates ranging from three pairs to one pair in number. It is not necessary for the purposes of this paper to know their names, but in determining the genus it is necessary to know their arrangement and to know whether they overlap or underlie the plates on either side. A rough cross-sectional diagram of the arrangement of the plates in the upper part of the shell should be made for comparison with those in Figure 5.

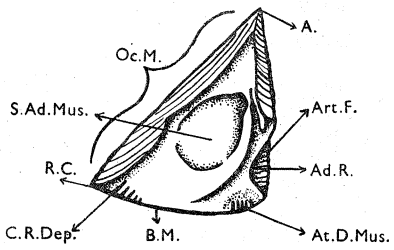

Figure 3.

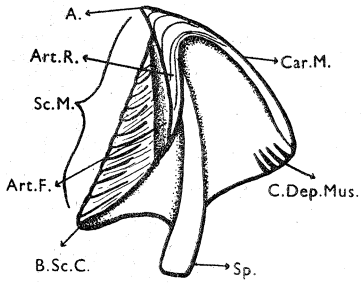

Figure 4.

Figure 3.—Scutum, inside view. A., apex; Ad. R., adductor ridge; At. D. Mus., Attachment of depressor muscle; Art. F., articular furrow; B.M., basal margin; C.R. Dep., crests for rostral depressor; Oc. M., occludent margin; S. Ad. Mus., scar of adductor muscle; R.C., rostral corner.

Figure 4.—Tergum, inside view. A., apex or beak; Art. F., articular furrow; Art. R., articular ridge; B.Sc.C., basi-scutal corner; Car. M., carinal margin; C. Dep. Mus., crests for depressor muscle; Sc. M., scutal margin; Sp., spur.

If part of the shell be removed, so that the soft body of the barnacle is displayed, the six posterior thoracic segments of the body may easily be recognized because they bear the feathery cirri. In front of them is a large swollen-looking portion called the *prosoma* which houses the stomach region of the barnacle. There is no abdomen comparable with that found in other crustaceans (Fig. 2).

The mouth is situated in front of the base of the first pair of cirri and is furnished with a prominent upper lip or *labrum* and four pairs of jaws. The finer structural differences of some of these are used as criteria for identifications by specialists.

The condition of the eggs in the ovaries may easily be observed, for the eggs lie at the base of the sac and are easy of access.

Determination of the Family.

As a first step towards identification, the barnacle should be orientated so that the carinal and rostral plates are known. A note should be made whether the rostrum has two radii or two alae, as this determines the family to which the barnacle belongs. Use of Figure 5 will help to determine the genus of the barnacle. Subsequent use of the keys for the species of each genus will then determine any of the more common Sydney species likely to be encountered on harbour rocks and installations.

Confirmation of the family to which the barnacle belongs can be made by making an examination of the labrum. In one family, the Balanidae, there is always a central notch in the labrum, whereas in the family Chthamalidae there is a concave edge to the labrum, but it is not sharply notched as in the previous family (Figure 5). While it is not generally necessary to resort to the use of this latter character for family

identifications, it can become exceedingly useful where the shelly parts have been eroded or the sutures have become obliterated with age or by encrusting growths.

If the rostrum of the barnacle has two alae and the labrum has a concave edge, not sharply notched in the centre, then it is a member of the family Chthamalidae and the ground plan of the arrangement of the plates should be found among those in the upper row in Figure 5. If, on the contrary, the barnacle has a rostrum with two radii and the labrum is notched in the centre, then the ground plan of the plates of the shell should be found among the members of the family Balanidae in the lower row in Figure 5.

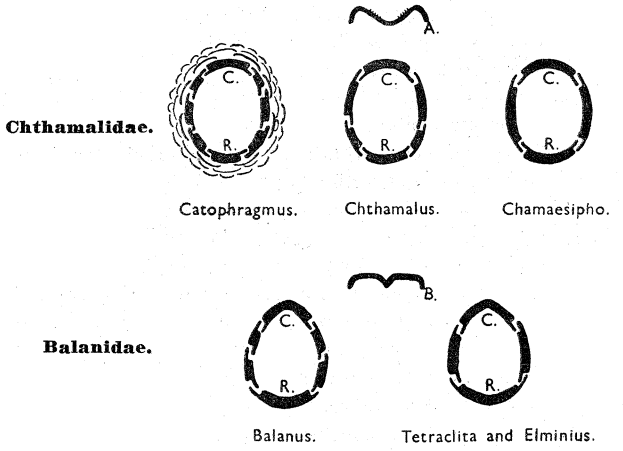

Figure 5.—Scheme showing arrangement of plates and structure of labrum in each family. Outline of anterior border of labrum in (A) Chthamalidae and (B) Balanidae.

Family Chthamalidae.

This family is represented by only three species in the Sydney district and all belong to different genera. Since each of these has a different number of plates in the shell, they are easy to distinguish one from the other.

All of them agree in having the rostral plate with alae, the walls of the plates never have pores, and the upper lip or labrum is not notched, being merely concave in the centre (Figure 5).

None of the members of this family appears to be concerned in the fouling of timber harbour-works since they are always found attached to littoral rocks, generally in spots exposed to a considerable amount of water movement.

In this family is found the primitive genus *Catophragmus*. In the shell are eight principal plates surrounded by several additional outer whorls of very much smaller plates or scales and these make the genus easy to distinguish. The genus *Chthamalus* has a shell composed of six plates, while the remaining genus, *Chamaesipho*, has only four plates often so fused together that no sutures can be distinguished. Sometimes boiling in a weak solution of caustic potash or soap will loosen the shell-plates by destroying the animal matter which holds them together.

Key to Genera and Species of the Chthamalid Barnacles.

A. Chthamalidae with eight plates round the orifice and additional outer whorls of small scales. Typical specimens three-quarters of an inch in basal diameter ..... *Catophragmus polymerus*

AA. Chthamalidae with less than eight plates round the orifice.

1. Shell with six plates. Typical specimens half an inch basal diameter ..... *Chthamalus antennatus*
2. Shell with four plates often so fused together that no sutures can be seen. Typical specimen one-quarter of an inch in basal diameter ..... *Chamaesipho columna*

Catophragmus (Catomerus) polymerus Darwin.

(Plate xxviii, fig. 1; and Plate xxx, figs. 1–2.)

Appearance.—This barnacle has a most characteristic structure and may be identified by the outer whorls of plates or scales which surround the eight principal ones making up the wall. Each of these small scales overlies the suture between two adjacent plates of the row immediately inside it. The scales increase in number but decrease in size in the outer whorls. On occasions, when a specimen is so eroded that the relationships of the radii and alae of the principal plates cannot be seen, these additional whorls make identification simple.

Size.—Large specimens may grow till the basal diameter is about one and a quarter inches, but slightly less than one inch is the typical size.

Basis.—The basis is thin and membranous.

Colour.—The general colour of the plates is grey-green, but the shell is sometimes coated with a hairy, brown-coloured alga.

Opercular Valves.—The scuta bear prominent articular ridges with deep furrows above and below, into which fit corresponding ridges on the tergum. The tergum has a most marked articular furrow and the crests for the attachment of the depressor muscles extend half-way across the basal margin of the valve. There is no true spur.

Habitat.—*Catophragmus* is popularly known as the Surf Barnacle, since its requirements seem to be a moderately high position, above low water mark, near the seaward edge of a rocky headland. Here, though it is out of water for some hours during the low tide, it is nevertheless bathed in spray and kept moist all the time.

Best developed colonies of *Catophragmus* are found on almost vertical rock faces, exposed to the surf, at the outer edges of rock platforms. In such positions they may grow so closely as to form an almost continuous, frieze-like band several feet high. Normally such a 'frieze' is found above the level of the reef where *Balanus nigrescens* grows and below the spots chosen by *Tetraclita rosea*, but on flatter rock platforms these three species may all be found growing together at the one level, and extending a considerable way up into the tidal area.

Localities.—Newport; Long Reef; North Head, Port Jackson; Middle Head, Port Jackson; Hunter's Beach, Port Jackson; Bondi; Maroubra.

Remarks.—Near Port Jackson *Catophragmus* is found chiefly on the open coast and not to any great extent in the harbour itself. It is, therefore, not an organism which fouls harbour installations.

The genus *Catophragmus* has been divided into three sub-genera and the local species belongs to the sub-genus *Catomerus*.

Chthamalus antennatus Darwin.

(Plate xxviii, fig. 4; and Plate xxx, figs. 3–4.)

Appearance.—*Chthamalus antennatus* is a small barnacle with a very strong shell, generally shaped like a flattened cone. The outer surfaces of the shell-plates are often rugged and corroded (more rarely quite smooth). The sutures between the plates are very clearly marked and the orifice is small, elongated, and sub-rhomboidal, with two shorter sides (the broader part of the orifice) towards the carinal end of the shell.

Size.—Large specimens are generally little more than half an inch in basal diameter and typical ones are slightly smaller.

Basis.—The basis is membranous and black and, since the barnacle adheres very closely to the substratum, the roughened edges of the plates often give a wavy outline to it.

Colour.—The colour of the shell is generally a light dirty-grey with pale green or brown overlying it according to the state of erosion. Internally the shell is lined by a black membrane which retains its colour even after preservation.

Opercular Valves.—The scutal valves are long and narrow and there is a small but deep depression for the attachment of the adductor muscle. There is also a prominent articular ridge which fits into a correspondingly deep notch on the tergum. The tergum

is small (about half the size of the scutum) and has no spur, but possesses a few pronounced crests for the attachment of the depressor muscles near the basi-carinal corner of the valve. Worn and eroded specimens often show this deep locking together of the opercular valves.

Habitat.—C. antennatus grows on rocks or the shells of molluscs living at a high level in the inter-tidal part of the shore. In fact, it manages to live on rocks which are only submerged during high spring tides and feeding can only take place at these times. The rest of the time the barnacle obtains its moisture requirements from the spray in the air and opens its opercular valves only in the cooler parts of the day or during the night. The necessity for continual moistening of spray, together with its intolerance of mud, limits the distribution of this species to parts of the Port near the outlet to the sea.

Ouside the Port, on the open coast *C. antennatus* is more plentiful on the higher parts of the rocky headlands than it is inside. In the latter place the barnacle is found at a slightly lower position on the rocks, probably owing to the lack of spray in the air.

Localities.—On rocks at Newport; Long Reef; Harbord; Maroubra; Hunter's Beach, Port Jackson; Bottle and Glass Rocks, Vaucluse, Port Jackson; Rose Bay, Port Jackson; Northbridge Headland, Middle Harbour; The Spit, Middle Harbour; Middle Head, Port Jackson.

Remarks.—Since *C. antennatus* prefers to attach itself to rock or other stone-like substrata and since it does not extend far into the waters of the harbour, it causes no trouble as a fouling organism in the Port.

Chamaesipho columna (Spengler).

(Plate xxviii, fig. 2–3; and Plate xxx, figs. 5–6.)

Appearance.—In single specimens of this barnacle the shell is low and conical, but, as a rule, a great many individuals grow so close together that they have to adopt a columnar shape. Often they become fused into sheets and look like honeycomb. So fused do the barnacles become that it is often impossible to tell where the plates of one end and the next begin.

There are four plates in the shell, which are so completely fused together in the adult that it is impossible to see the sutures between them from the outside and sometimes they are obliterated internally. Even maceration in boiling soap solution may fail to disclose the joints between plates. The orifice is comparatively large and sub-rhomboidal in shape, having the broader end towards the carinal part of the shell. In the crowded columnar sheets, the individuals appear much eroded and worn, and the scuta and terga may be firmly locked together by a deep ridge and notch.

Basis.—The basis is membranous and the bottom of the shell has a wavy, irregular outline.

Colour.—The colour is greyish-white, but the eroded tops of 'honeycomb' specimens may be a dirty brown or green, or flesh colour. The outer cover of the soft parts of the body is a dark navy blue verging towards brown and this colour persists in preserved and dried specimens.

Opercular Valves.—The shapes of the opercular valves are rather variable, but the scutum always has a wide articular furrow and a marked ridge for locking into the tergum. There is a very deep little pit for the attachment of the adductor muscle. The tergum is a small valve with no spur, and a deep articular furrow for the reception of the ridge of the scutum bites deeply into it. There are several small pits where the depressor muscles are attached.

Habitat.—Chamaesipho is found on the rocky shores of the coast outside and just inside the mouth of the Port. It favours the half-tide area of the rocks, occurring above *Tetraclita rosea*, but below *Chthamalus antennatus*. It does not grow on woody substrata, but is sometimes found attached to limpets or other fairly 'fixed' molluscs (see Pl. xxviii, fig. 3).

Localities.—Newport; Long Reef; Harbord; Cronulla; Middle Head, Port Jackson; Bottle and Glass Rocks, Vaucluse, Port Jackson; Rose Bay, Port Jackson; North Harbour, Port Jackson.

Remarks.—This species is easily the most abundant of the inter-tidal barnacles for it encrusts the rocks literally in millions in the half-tide area.

Although it is so prolific on rocks outside and near the mouth of the harbour, *C. columna*, because it grows mainly on rocks or stone-like substrata, is not a significant fouling organism on harbour installations.

Family **Balanidae.**

Representatives of three genera of this family are commonly found on harbour installations and rocks in the Port Jackson district, and of these, members of the genus *Balanus* cause most trouble. One species of the genus *Elminius* grows prolifically on all kinds of substrata near the upper limits of the tidal range and the genus *Tetraclita* is also represented among the organisms fouling harbour works.

One other genus of this family, *Acasta*, is occasionally found in sponges growing on piles and rocks, but, since it does not grow directly on the surface of these substrata and cannot, therefore, be reckoned as a true fouling organism, it is not dealt with here.

All the members of this family agree in having a rostrum with two radii, a labrum distinctly notched in the centre (Figure 5), and all of the lateral shell-plates have a radius on one side and an ala on the other.

The shell of the genus *Balanus* is made up of six plates, while the genera *Elminius* and *Tetraclita* each have four. However, these two latter are easily separated from one another because in *Elminius* the walls of the parietes of the plates are not porose, whereas in *Tetraclita* large prominent pores may be seen. *Elminius* has a southern distribution, whereas *Tetraclita* has a more tropical one.

Key to the Genera of Balanid Barnacles.

A. Balanidae in which the shell is composed of 6 plates ..... *Balanus*
AA. Balanidae in which the shell is composed of 4 plates.
1. Parietes of plates porose ..... *Tetraclita*
2. Parietes of plates not porose ..... *Elminius*

Genus **Balanus.**

The genus *Balanus* comprises members of the family Balanidae which have six plates in their shells. As a rule, the upper part of the inside of each of the plate walls is thickened, and these thickened upper portions together with the alae form a ring or *sheath* round the inside of the shell. It is to the bottom of this sheath that the membrane which joins the opercular valves to the rest of the shell is attached. The bases of the local species are all calcareous, though in the case of *B. imperator* it is a very thin layer and is not permeated by radiating pores, being formed rather by a mosaic of tiny calcareous beadlets.

In some of the species of the genus *Balanus* the lateral edges of the radii bear transverse ridges or *septa* which are toothed. These dovetail with corresponding grooves on the outside surfaces of the alae of the adjacent plates. In the species *B. nigrescens* the radii are pierced by pores which open between the septa and run perpendicular to those in the parietes. The course followed by the pores in this species may generally be seen, for they appear on the outside surface of the radii as black, transverse lines where the outer lamina of the radius is eroded away.

Five species belonging to this genus occur commonly in the Port of Sydney and environs. Of these, three types are found fouling boats and harbour installations. They are *B. amphitrite* var. *communis*, *B. amphitrite* var. *cirratus* and *B. trigonus*. *B. amaryllis* might be expected to be a fouling organism, but has not, as yet, been revealed as such here.

The two remaining local species of the genus are *B. nigrescens* and *B. imperator*, both of which attach themselves to rock or occasionally to mollusc shells, and they frequent the rocky shores near the mouth of the Port or the open coast. *B. nigrescens*

grows to the largest size among the local barnacles and seems to prefer positions where the salinity is high and where there is plenty of water movement—preferably surf. It attaches itself solidly to rocks near the low water mark, growing to a steeply conical shape and often becoming much corroded and overgrown by coralline algae, and limpets and other small animals attach themselves to the outside of the shells.

B. imperator, on the other hand, seems to prefer a slightly more sheltered situation than *B. nigrescens*, for on the open coast it is found chiefly in more sheltered crannies in the rocks or under boulders, while in the Port, in places where *B. nigrescens* grows very sparsely on the rocks, *B. imperator* becomes the dominant low-water-mark barnacle on the upper surfaces of the rocks and may occur in thousands. Such a condition may easily be seen on the rocks near Vaucluse Bay, near the mouth of Port Jackson.

Of the three chief fouling species, *B. amphitrite*, occurring in two varieties, is the one most frequently found on those parts of wharf piles which are exposed during low tides and on the bottoms of floating craft. It seems to attach itself indiscriminately to any substratum, and is found on almost every one of the test samples of timber which are submerged at various points in the Port by the Preservation and Research Laboratory of the Maritime Services Board of New South Wales. The majority of these samples are suspended so that they extend from two feet above zero tide mark down to three feet below this point.[1] On these samples *B. amphitrite* var. *cirratus* often grows in a very crowded manner and takes on an irregular tubular shape, whereas on the bottoms of small craft or in other places where it is not crowded it generally grows to a more conical shape. These differences in shape are shown in Plate xxviii, fig. 6. In forms with the tubular type of growth the orifice is comparatively larger and, in general, is more distinctly toothed than in the more cone-like forms. The change in shape is chiefly brought about by the change in the form of the basis. In cone-like forms the basis is flattish, whereas in tubular forms the basis is deep and cup-shaped.

The two varieties found are var. *cirratus* and less commonly var. *communis*. Often the two varieties occur side by side on one substratum, but whereas *B. amphitrite* var. *cirratus* often grows to a tubular shape, in the author's experience var. *communis* is generally much more the conventional depressed cone-shape. *B. amphitrite* seems to occur from the tidal range down to 50 feet below low water mark, and there has been no opportunity so far of checking its occurrence in depths below this point.

Balanus trigonus, the second of the species which foul boats and harbour structures, does not appear to extend its range up into the tidal area as frequently as does *B. amphitrite*. It is found chiefly on the shells of moluscs (mussels) which grow on buoys or the bottoms of boats, and it is also taken on timber such as the bottom sections of wharf piles or the specially long wooden test samples set 50 feet below low water mark by the Preservation and Research Laboratory of the Maritime Services Board. In the collections of the Australian Museum there are many dredged specimens of this species from slightly deeper waters both inside and outside the Port, and this would lead one to believe that it is a deeper water form. Although the bathymetrical range of this species overlaps that of *B. amphitrite* so that the two forms occur together, and although they belong to the one sub-genus of the genus (*Balanus*), they may be distinguished quite easily one from the other by an examination of the outer surfaces of the scutal valves. In *B. trigonus* there is a regular arrangement of deep little pits on the scutum. These occur in from one to six longitudinal rows and are formed because there are deep longitudinal furrows crossed (more or less at right angles) by very prominent lines of growth or transverse ridges. Sometimes the pits may be filled up by sediment, but a light brushing with a toothbrush will disclose their presence. In *B. amphitrite* the scutum is generally very smooth. There is usually also a basic difference between the shapes of the orifices in these two species. In *B. trigonus* it is sub-triangular in shape (nearly equilateral) and is not markedly toothed. In *B.*

[1] The height of the tide is measured in the Port of Sydney from an arbitrarily chosen zero mark on the official tide gauge at Fort Denison. This mark approximates to the average level of the low water mark for ordinary low spring tides.

amphitrite the orifice is in general markedly toothed and varies in shape from the more usual rhomboidal to a rounded triangular one.

B. amaryllis, the remaining member of the genus which may foul structures in the Port, is a deeper water form. All the local specimens of this species examined have solid walls in their parietes, with no pores in them and the colour of the outside of the plates of the shell is an even rosy-pink. The orifice is roughly rhomboidal in shape, deeply toothed, and comparatively large in size. The shell of the barnacle may be steeply conical in shape or tubulo-conical. One prominent distinguishing feature may be observed on the scutum which is striated longitudinally so that the prominent lines of growth are divided thereby into small squarish sections. This barnacle may grow to a relatively large size with a basal diameter of more than an inch and a half. Again, as in *B. amphitrite*, the growth of the tubulo-conical form is largely brought about by the cup-shaped growth of the basis.

Key to Species of Balanus.

A. Parietes of shell-plates permeated by pores, radii with edges crenated owing to the presence of transverse septa which are toothed.

1. Very large, steeply conical barnacles (adult specimens are typically 1½-2 inches high; basis 1¼-1½ inches diameter) with radii pierced by pores. In eroded, old specimens the pores may be seen as transverse straight lines on the outer sides of the radii, where the outer lamina has been worn away. In young specimens the pores in the radii are seen to best advantage ..... Sub-genus *Megabalanus*
   Living on rocks near low water mark, in places where considerable water movements take place ..... *B. nigrescens*

2. Smaller species (maximum basal diameter 1 inch; height rarely exceeds more than an inch, generally less) in which the radii are not pierced by pores. Lives generally below low water mark of neap tides and frequently fouls ships and harbour installations ..... Sub-genus *Balanus*

   a. Members of the sub-genus *Balanus* with the parietes with prominent external ribs. General colour pink with the raised ribs white. Orifice triangular (sub-equilateral) and not prominently toothed. Scutum with several longitudinal rows of deep, little pits on the outer surface. Tergum with very blunt, short spur approximately half the width of the valve. Shell always conical or near-conical; not tubular and deep ..... *B. trigonus*

   aa. Members of the sub-genus *Balanus* with the parietes smooth on the outer surface. Colour variable, but purple or purplish-brown predominates when colour is present. Shell may vary from depressed conical to deep tubular shape. Orifice generally deeply toothed and rhomboidal (sometimes rounded trigonal) in outline. Scutum generally rather thin and delicate with prominent lines of growth, often coloured with mauve tinges. There are no longitudinal bands of little pits as in *B. trigonus*. Internally the articular ridge of the scutum is very prominent and recurved. The tergum is very variable in shape and the spur may be either long, narrow and pointed or truncate and short, according to the variety .... *B. amphitrite*

      Variety 1. communis. Shell whitish-grey with longitudinal purple or violet stripes. Radii white, but flecked with red-brown patches. Opercular valves often somewhat eroded exteriorly and more heavily built than in the next variety. Spur of tergum comparatively short, broad and truncated. The bottom of the spur lies parallel to the basal margin of the scutum which is straight on either side of the spur. Shape of shell generally flattened cone type, never tubular in our experience. High water mark neap tide to, at least, 50 feet below low water mark. Grows on almost any type of substratum.

      Variety 2. cirratus. Shell with longitudinal mauve and white stripes intersected by horizontal, purply-brown circular bands which run round the shell. Radii white, occasionally some brown epidermis remains to colour the radii near the parietes. Shape of shell may be either flattened conical or tubular if crowding is taking place. Orifice generally deeply toothed. Scutum thin and delicate with rather

prominent lines of growth. The outer surface of this valve is concave. Tergum with long, narrow, rather sharply pointed spur and the basal margin of the valve slightly hollowed out on either side of the spur.

AA. Parietes solid, not permeated by pores. Radii more or less distinctly developed.

1. Walls of shell-plates a deep, imperial purple colour and comparatively thick. Generally much eroded and encrusted externally by marine growths so that the colour is masked. The colour may be clearly seen on the internal surfaces of the shell, below the sheath. Radii are poorly developed .... Sub-genus *Austrobalanus*. *B. imperator*

2. Walls of shell-plates thin and a rosy-pink in colour, but not ribbed longitudinally as in *B. trigonus* with which it is often associated in the field. Basis calcareous and permeated by pores. Lower section of parietes ribbed internally below the sheath. Radii with smooth edges, slightly recurved at free edges. Orifice comparatively large and distinctly toothed. Grows in deeper waters—not in tidal range ..... Sub-genus *Chirona*. *B. amaryllis*

Balanus (Megabalanus) nigrescens Lamarck.

(Plate xxviii, fig. 9; and Plate xxx, figs. 7–8.)

Appearance.—A tall and conical barnacle often much corroded and encrusted with marine growths. Orifice smallish and much worn.

Size.—Height one and a half to two inches. Basal diameter one and one-quarter to one and one-half inches.

Basis.—The basis is strong and calcareous and pierced by pores.

Colour.—Greenish-white in young and uneroded specimens. In older ones a dark navy blue or black colour shows through where the outer lamina of the plates is worn away. In living specimens, when the opercular valves are open, a cerulean blue colour may be seen inside the sac at one end.

Opercular Valves.—The opercular valves are often obscured by a growth of algae. The tergum has a beaked or hooked apex, except where it has been eroded away, and this can be used as a weapon of offence. The shapes of the two valves may be seen in Plate xxx, figs, 7, 8.

Habitat.—*B. nigrescens* grows on rocks or shells at low water mark of the spring tides, where there is a good movement of water—preferably surf.

Localities.—Long Reef; Harbord; Newport; Bondi; Cronulla; Watson's Bay, Port Jackson; Balmoral, Port Jackson; Bottle and Glass Rocks, Vaucluse, Port Jackson; Middle Head, Port Jackson; Bradley's Head, Port Jackson.

Remarks.—Since this species grows only on rocks and stone-like substrata, and since it also requires much water movement, it is not a fouling organism in the Port. It is the largest of our local barnacles and is a prominent member of the fauna of the rocks on the open coast.

Balanus (Balanus) trigonus Darwin

(Plate xxix, fig. 6; and Plate xxx, figs. 9–10.)

Appearance.—A moderate-sized barnacle of conical shape with the orifice distinctly triangular in shape and not deeply toothed as in *B. amaryllis* or *B. amphitrite*. The walls of the plates are permeated by pores and on their outsides have distinct raised ribs.

Size.—The height of a typical specimen is from half to three-quarters of an inch. The basal diameter is generally slightly more than three-quarters of an inch, up to one inch.

Basis.—The basis is calcareous, porose and generaly rather flat; hardly ever is a cup-shaped or deep basis seen.

Colour.—The walls of the plates are dark pinkish, with the raised ribs white. The radii are pale pink or white.

Opercular Valves.—Generally only the scutum can be seen through the orifice of a living specimen and, when scrubbed, it shows characteristic longitudinal rows (1–6 in number) of small pits. The tergum is often much worn and has an extremely wide, blunt spur, often half the width of the valve.

Habitat.—This species grows attached to molluscs such as mussels or wood with equal facility. Occasionally it turns up in the tidal area, but, in general, prefers to live below low water mark, and most of the specimens in the collections of the Australian Museum have been dredged, some coming from the deepest parts of the harbour, off Ball's Head in 60 fathoms. It has also been collected off the bottom sections of the wood test samples set by the Preservation and Research Laboratory of the Maritime Services Board at a depth of fifty feet. It is often associated with *Balanus amphitrite* and *B. amaryllis*.

Localities.—Growing on shells and ascidians (*Boltenia* sp.) and kelp at Steele's Point, Vaucluse, Port Jackson; on the foot of piles in Hermit Bay, Port Jackson; dredged off Ball's Head, Port Jackson, on mussels; Bantry Bay, Middle Harbour, on bottom of 50-foot timber test sample; Fort Macquarie picnic jetties, Port Jackson, on piles in tidal area; also dredged at numerous points outside the Port, on the open coast.

Remarks.—This species must be numbered among the fouling organisms in the Port, for it will grow on almost any flat, hard surface that presents itself in deeper waters. It is not, however, as common on small craft as *B. amphitrite*. *B. trigonus* is generally most strongly attached to the substratum and is difficult to remove properly.

Young specimens make their first appearance on the timber test samples in August, according to Mr. D. Moore, of the Preservation and Research Laboratory of the Maritime Services Board, and within a few months have grown to adult size. Mr. Moore also states that the presence of bark on a test sample inhibits the settling of the cypris young which seem to prefer to attach themselves to cut or sawn surfaces, probably because they are flatter and less rough. In 1915 C. Hedley, in his presidential address to the Royal Society of New South Wales, stated that the pneumatophores of the mangroves are "sometimes loaded with oysters or bristle with barnacles, *Balanus trigonus*". Either conditions of existence have changed very much in the harbour since 1915, when Hedley made this statement, or else the common barnacles of the mangroves were misidentified, for this species is not found in this situation today, *Balanus amphitrite* and *Elminius modestus* being the species found there.

Balanus (Balanus) amphitrite Darwin.

Variety 1. *communis* Darwin.

Variety 2. *cirratus* Darwin.

(Plate xxviii, figs. 5–6; Plate xxix, fig. 6; and Plate xxx, figs. 13–16.)

Appearance.—Moderate-sized barnacles with the shell either conical or tubular, the latter being found in the variety *cirratus* where crowding is taking place. The tubular shape is brought about by a change in the method of the growth of the basis, which is flat or nearly so in conical forms, but is cup-shaped and deep in tubular ones. The orifice is sub-rhomboidal in shape, but is somewhat variable and may even be trigonal. In var. *cirratus* it is generally deeply toothed, whereas in var. *communis* the toothing of the orifice is not nearly so marked. Nevertheless it is much more pronounced in both varieties of *B. amphitrite* than it is in *B. trigonus*. Comparatively the orifice is larger in tubular forms than in conical ones.

The walls of the shell-plates are smooth externally and not ribbed.

Size.—In conical forms the basis of a typical barnacle may be up to three-quarters of an inch in diameter and the height about half an inch. In tubular forms of the var. *cirratus* the height may be an inch and the basal diameter of a typical specimen is about half an inch.

Basis.—The basis is calcareous and pierced by radiating pores. The colour of the basis is white.

Colour.—The colour of the shell differs in the two varieties. Purple, brownish-purple and white are the chief colours present. In the first variety, *communis*, the shell is a whitish-grey with longitudinal purple or violet stripes. Its radii are generally white, flecked with mahogany. In var. *cirratus* the shell has alternate white and mauve stripes which are intersected at right angles by purply-brown circular bands which run round the shell. Under a microscope, these brown bands may be seen to have a wavy

appearance. The radii are generally pale pink or white and the opercular valves are tinged with patches of mauve or purple.

Opercular Valves.—Very often the opercular valves are eroded in var. *communis*, but the uneroded portion of the valve should nevertheless show the prominent lines of growth which are a feature in var. *cirratus*. There are no longitudinal rows of little pits as on the corresponding valve of *B. trigonus*. The terga of the two varieties are somewhat different in shape. In var. *communis* the spur is broad and truncate (Plate xxx, fig. 15), while in var. *cirratus* it is longer, thinner, and pointed (Plate xxx, fig. 14). The basal margins of the two terga also differ, as may be seen by comparing the two figures.

Habitat.—This species appears to have catholic tastes with regard to the substratum chosen, and it may be found growing on wood, including the bark and roots of living mangroves (*Avicennia*), on steel plates and chains, on buoys of all kinds, and the shells of molluscs such as mussels. Its bathymetrical range seems to extend from the level of the low water mark of neap tides down to considerable depths (at least 50 feet on the deep timber test samples set by the Preservation and Research Laboratory of the Maritime Services Board in Bantry Bay, Middle Harbour). According to records at present available, both varieties of this barnacle appear to grow with equal facility at all depths and often they appear side by side in the one place.

Localities.—On the bottom of a yacht and on a buoy in Pittwater; on pilings, boat bottoms, living mangroves, and timber test samples in Middle Harbour; on steel test plates at Fort Macquarie picnic jetties, Port Jackson; on piling of baths in Rose Bay, Port Jackson; on the bottom of a boat at Carramar, George's River; also on pilings and timber test samples from numerous stations in the Parramatta and Lane Cove Rivers, which form the upper reaches of the Port.

Remarks.—*B. amphitrite*, and especially var. *cirratus*, is by far the most common of the barnacles fouling harbour installations and small craft in this Port. From information supplied by Mr. D. Moore the young of this barnacle are believed to make their first appearance on timber test samples in the months of November, December and January and to grow to adult size in a few months.

Mud seems to have little or no effect on this species, for they flourish in situations where they are so choked by it that their shells are completely obscured. Also certain chemical wastes which are poured into the Parramatta River at various points seem to have little effect on the barnacle populations. Some of them, no doubt, are of an oily nature and therefore float on top of the water and so come in contact only with those barnacles which live between tide marks.

B. amphitrite var. *cirratus* seems to have a tolerance of a wide range of salinities, for it is found anywhere from the main harbour waters, where the salinity is that of normal seawater, to places such as Carramar on the George's River, where the salinity is never more than eight parts per thousand.

On the wharf piles in the upper reaches of the Port, the zones inhabited by *Elminius modestus* and *B. amphitrite* overlap and unless a sharp watch is kept it is quite possible to confuse small specimens of *B. amphitrite* with large ones of *Elminius* since the shapes of the orifices are similar and even the valves have a superficial resemblance. A count of the number of plates will settle the matter at once.

B. amphitrite, and especially var. *communis*, is often found on the pneumatophores and trunks of mangrove trees, together with *Elminius modestus*, and there is a possibility that Hedley mistook this species for *B. trigonus*.[1] An examination of barnacle clusters on mangroves in the Middle Harbour area has failed to disclose a single specimen of *B. trigonus*, whereas the colouring of the specimens of *B. amphitrite* var. *communis* which were there, might have been confused with that of *B. trigonus* if only a cursory glance was given to them, for the purply-violet stripes on the plates are wide enough in some specimens to give the illusion of being the ground colour, and the white between looks like the ribs. However, the opercular valves settle the matter at once.

[1] See note under *B. trigonus* on this matter.

Balanus (Austrobalanus) imperator Darwin.

(Plate xxviii, figs. 8 and 10; Plate xxx, figs. 11–12.)

Appearance.—The shell is moderately large, conical, and thick-walled, and generally very much encrusted by coralline growths and worm tubes. Also where the shell is much eroded the appearance is whitish. The walls of the shell-plates are solid and have no pores in them. The radii are poorly developed and are whitish in colour and marked by some low, irregular, wavy, transverse septa. The lower portions of the edges of the plates bear white dendritic septa which interlock with corresponding depressions in the next plate. The sutures are almost obliterated externally, being very firmly joined together and masked by the corrugations on the outside of the shell. The basal edges of the shell plates have a characteristic nodular appearance (Plate xxviii, fig. 10). The orifice is generally irregular and eroded.

Size.—A typical specimen has basal diameter one and one-quarter inches with the height slightly less than one inch. In maximum sized specimens the basal diameter reaches one and three-quarter inches.

Basis.—The basis is extremely thin and calcareous (it might almost be mistaken for a membranous one unless a chemical test is made) and is composed of a mosaic of tiny granules. There are no pores among these granules.

Colour.—Externally the barnacle often appears white or pink owing to erosion or overgrowths, but internally the walls are seen to be a deep imperial purple in colour.

Opercular Valves.—Internally the opercular valves are yellowish-white in colour with dark purple patches developed near the apices. The scutum is triangular in shape with a very acute apex. The articular furrow is narrow and there are well-marked ridges for the attachment of muscles at both the rostral and basi-tergal corners of the valve. The tergum has a bluntly-pointed beak and a short, wide spur with a rounded end. There are many well-marked crests for the attachment of the tergal depressor muscles at the basi-tergal corner of the valve.

Habitat.—*B. imperator* lives attached to rocks and appears to require a certain degree of shelter, but, on the other hand, cannot tolerate still water, probably owing to the depositions of mud which would result from these conditions. It does not frequent the very exposed spots favoured by *B. nigrescens*, but inhabits the same tidal zone, choosing, however, more sheltered nooks and crannies among the rocks and boulders of the open coast. In harbour waters, where *B. nigrescens* finds the water movements insufficient for its needs, *B. imperator* seems to reach its best development, and at points near the outlet of the Port, where there is a reasonable swell, e.g. Bottle and Glass Rocks, Vaucluse, it becomes the dominant barnacle at the level of low water mark of spring tides.

Localities.—In sheltered crannies and rock pools at Newport; Long Reef and Harbord. On the tops of rocks at Bottle and Glass Rocks, Vaucluse, Port Jackson; Hunter's Beach, Balmoral, Port Jackson; and Steele's Point, Port Jackson.

Remarks.—Since *B. imperator* attaches itself only to stones and requires a certain amount of movement in the surrounding water, it is not a fouling organism in the Port. Darwin (1854) points out that the reduction in size of one of the pairs of lateral plates (the carino-lateral) till it is almost lost, makes this species more close than any other of the genus *Balanus* to the condition found in *Tetraclita* or *Elminius*, where there are four plates in the shell. The bases also bears a resemblance in these groups.

Balanus (Chirona) amaryllis Darwin.

(Plate xxviii, fig. 7; and Plate xxx, figs. 17–20.)

Appearance.—The shell is generally tubulo-conical in shape, moderately large, and has a comparatively large orifice. The latter is sub-rhomboidal in shape and generally deeply toothed. The carinal angle of the orifice is very acute and gives a spout-like appearance to this part of the shell. The outer sides of the parietes are smooth or slightly marked by horizontal ridges near the basis (like lines of growth). The radii are moderately developed, being narrow and having oblique summits. The alae have their

free edges almost parallel to the basis. The walls of the parietes are not permeated by pores, but are ribbed internally near the basis. The radii have no transverse septa on their edges, but the latter are slightly recurved.

Size.—Typical specimens are about one inch in height and have a basal diameter of from half to three-quarters of an inch. Large specimens of height three inches and basal diameter two inches have been recorded, but not from the Port Jackson area.

Basis.—The basis may be flat or cup-shaped, and is calcareous and permeated by radiating pores.

Colouring.—The colour is a pale rose-pink, with the alae white and very prominent, while the radii are little differentiated in colour from the parietes.

Opercular Valves.—Externally the scutum has prominent lines of growth which are divided by longitudinal grooves into small squarish sections which are plainly visible with the aid of a powerful hand lens. The tergum has a beaked apex which curves forwards over the scutum. There is also a long, narrow spur. Externally a deep longitudinal groove runs down the valve and the centre of the spur. The edges of this groove are folded inwards, and as the barnacle grows may in time come to obliterate the furrow completely .

Habitat.—*B. amaryllis* appears to be a deeper water form, since it is dredged in the harbour along with *B. trigonus* in depths of twelve fathoms or more. This species has not as yet been taken by the author in the tidal range even after much intensive searching, nor has it appeared on the timber test samples set by the Preservation and Research Laboratory of the Maritime Services Board at various points in the Port. It appears to settle on almost any type of substratum of a solid nature, such as shells, alcyonarians or pieces of rock.

Localities.—Off Ball's Head, Port Jackson, in twelve fathoms and below.

Remarks.—This species may reasonably be suspected of being a fouling organism on deep harbour structures or on boats with a very deep draught. It has not, as yet, manifested itself in this role in the Port, but the species has been recorded in other localities as appearing frequently on ships' bottoms.

Genus **Tetraclita.**

The genus *Tetraclita* comprises Balanid barnacles with four plates in the shell, the parietes of which are porose. Sometimes the sutures between the plates are obliterated externally, but they can be seen by examining the inside of the shell or by boiling it in a solution of caustic potash for some minutes. The basis is always flat, never cup-shaped. Two species of this genus are found in the Port Jackson district, *T. rosea* and *T. purpurascens*. Both are common species, but since they occur attached to littoral rocks and shells and rarely, if ever, attach themselves to anything other than rock, they are not of much importance as fouling organisms. Occasionally they may cause a nuisance in swimming pools made by hollowing out rocks (like some found on the open coast near Sydney) by scratching the bathers who cling to the side, but for the most part they can be neglected. The only place where the author has encountered this genus fouling harbour structures was where stone or concrete works or piles were near the open sea, at the harbour entrance.

The two local species of this genus are easy to separate by reason of the difference in structure of the pores of the parietes. In all but the very youngest specimens of *T. purpurascens* there is more than one row of parietal pores; usually there are ten to fifteen which, when viewed from below, have a honeycombed appearance.

In *T. rosea* there is only a single row of pores, formed by the large primary septa which extend from the outside lamina of the parietes across to the inside wall. In addition to these primary septa other strengthening septa grow inwards from the outside lamina, but do not extend across to the inner wall. Some of these secondary septa are branched as may be seen in Plate xxix, fig. 3. Their presence gives the characteristic appearance to the base of the shell of *T. rosea*.

Other species of this genus, not found in the vicinity of Port Jackson, have a honeycombed appearance on the base of the parietes also. *T. squamosa*, for instance, which occurs in more northerly waters and does not grow here, is very similar in the appearance of its base to *T. purpurascens*, but for local barnacles the following key is sufficient:

Key to the Species of Tetraclita.

A. Walls of the parietes enclosing a single row of rather peculiar pores; basis thin and calcareous ..... Sub-genus *Tesseropora*. *T. rosea*

AA. Walls of parietes with many rows of small pores, so that there is a honeycombed appearance. Basis membranous ..... *T. purpurascens*

Tetraclita (Tesseropora) rosea (Krauss).

(Plate xxix, figs. 2–3; and Plate xxx, figs. 21–22.)

Appearance.—The shell is steeply conical, and in young and uneroded specimens the sutures between the four plates are quite distinct. In older, eroded shells the sutures often become indistinct. The radii are narrow and have their free edges crenated, but they are only seen clearly in uneroded specimens. If uneroded, the outside lamina of the parietes is smooth; if, however, disintegration has set in, the upper parts of the shell have a columnar appearance owing to the fact that the large, square tubes of the parietes become partly filled with shell matter and the wearing away of the outside lamina exposes them. When the parietes are viewed from below there is seen to be a single row of rather rectangular tubes or pores. It is the possession of this single row of pores which assigns the species to the sub-genus *Tesseropora*. Adults of other species of the genus always have more than one row of pores.

The orifice is pentagonal in uneroded specimens, but as it wears, its shape changes through rhomboidal to triangular in the largest worn specimens.

Size.—Typical specimens are about three-quarters of an inch in basal diameter and half an inch in height. The largest specimen collected was slightly more than one and one-tenth of an inch in basal diameter and its height was slightly more than half an inch.

Basis.—The basis is mostly calcareous, consisting of a very thin, central, calcareous plate which, towards the edge of the shell, becomes merely membranous. The basis is almost invariably left on the rock when the barnacle is removed, and in order to test its calcareous nature an application of hydrochloric acid may be necessary. The bubbles of carbon dioxide given off by the basis will prove its calcareous nature.

Colour.—Young specimens are a dirty grey in colour with traces of pink towards the tips of the compartments. In eroded specimens the colour is pink.

Opercular Valves.—The opercular valves are generally much eroded externally. The scutum is a thick, solidly built valve with a deep articular furrow. There is a prominent adductor ridge and a deep scar for attachment of the adductor muscle. There are three to five small crests for attachment of the lateral depressor muscle. The tergum is also heavily built and rather small and has a short, broad, bluntly-pointed spur close to the basi-scutal angle of the shell. There is a wide articular furrow and crests for the attachment of the depressor muscle.

Habitat.—This species is very common on rocks and shells on the exposed parts of the coast and near the mouth of the Port, where it is found round about the level of the low neap tide mark. It lives above the level frequented by *B. nigrescens* and is often associated with *Catophragmus polymerus* on flat rock platforms.

Localities.—Newport; Long Reef; Harbord; Manly; Bondi; Maroubra; Cronulla; Bottle and Glass Rocks, Vaucluse, Port Jackson; Steele's Point, Port Jackson; Hunter's Beach, Balmoral, Port Jackson; Middle Head, Port Jackson; Bradley's Head, Port Jackson.

Remarks.—Since this barnacle is found on the rocks of the open coastline or near to the mouth of the Port, where the surge of the waves is considerable, it is not numbered among the fouling organisms of the Port, especially as it attaches itself only to rocks and shells above low water mark. It does not attach itself to wooden substrata.

The orifice appears to enlarge itself as the barnacle grows, by the wearing away of the tops of the shell-plates rather than by the growth of the radii and alae, so that the corrosion of the shell is an important factor in its growth.

Tetraclita purpurascens (Wood).

(Plate xxix, figs. 1 and 3; Plate xxx, figs. 23–24.)

Appearance.—The shell of this barnacle is generally in the form of a very much depressed cone, with a more or less diamond-shaped orifice unless the specimen is worn, when the orifice is sub-rhomboidal. Two distinct forms are found, so different in external appearance that they might be mistaken for two species if intermediate types did not show the transition from one to the other. In uneroded specimens the four plates of the shell are easily seen, the radii are wide and well developed, having their tops parallel to their bases. On the parietes of the shell-plates are developed from five to six clear, longitudinal ribs (Plate xxix, fig. 1).

In the eroded form, where the outer lamina is completely gone, the shell has a rough, granular appearance and there is little or no trace of the sutures between the plates. The radii are little developed and the orifice is enlarged only by the wearing away of the summits of the plates, so that the shape of the orifice is more rhomboidal and not diamond-shaped. There may be no trace of ribs on the parietes. Plate xxix, fig. 1, shows an eroded specimen of *T. purpurascens.*

In both types of this species the bottom of the shell-plates shows the same structure, namely numerous rows of pores running up into the parietes so that there is a honey-combed appearance to the bottom of the shell (Plate xxix, fig. 3.).

Size.—The basis of a typical specimen is from three-quarters to one inch across, but the shell is only about a third of an inch high. Comparatively this is much lower than *T. rosea*, with which it is occasionally found on rocky shores. Very large specimens may be slightly more than one inch across in basal diameter.

Basis.—The basis of the shell is entirely membranous, thus differing from other described Tetraclitas.

Colour.—The colour ranges from ivory-white in specimens which have grown in shaded spots with a good degree of shelter, to dirty-grey in eroded forms, or sometimes a pale mauve tinge colours the shell.

Opercular Valves.—The scutum is much more elongated in *T. purpurascens* than in *T. rosea*, and has a wide, shallow articular furrow. The adductor ridge is not as prominent in this species as in *T. rosea*, being merely a shallow ridge, lying nearly parallel to the basal margin. Sometimes none is present. There are no crests for the attachment of the depressor muscles, this purpose being served by some small pits. The tergum is a small valve about half the size of the scutum and has little or no spur, for what there is merges with the basi-scutal corner, thus differing again from *T. rosea.* There is a wide, shallow articular furrow, and there are five or six crests for attachment of the depressor muscles.

Habitat.—*T. purpurascens* appears to attach itself either to stones or to wooden wharf piles and to grow equally well on the open coast as near the mouths of estuaries. It inhabits a high level on the rocks, extending from a little above low water mark to a point a little above high water mark of neap tides. It is, therefore, associated with *T. rosea* at the bottom of its range and with *Chthamalus antennatus* at the top. It differs in its habits from the two latter species, however, in that it prefers a shaded situation such as the sides or the lower surfaces of boulders. In fact, it seems to flourish best on the under sides of large, sloping boulders below which water can swirl at high tide. It is in such situations that the ivory-white forms are found. *T. rosea* seems to prefer the upper sides of boulders.

Localities.—Pittwater on boatshed piles; Newport; Long Reef; Harbord; Hunter's Beach, Balmoral, Port Jackson; The Spit, Middle Harbour; Bottle and Glass Rocks, Vaucluse, Port Jackson; Rose Bay, Port Jackson; Middle Head, Port Jackson, and at Bradley's Head, Port Jackson.

Remarks.—Although *T. purpurascens* may attach itself to stones, wood or molluscs, it is not a fouling organism of any note in the Port. This is due to the fact that it requires to live in the tidal range and in spots where there is a good deal of water movement. It does not penetrate, therefore, to the upper reaches of the Port.

Tetraclita radiata (Blainville).

In a previous paper[1] the author recorded *T. radiata* as occurring at Long Reef, near Collaroy, but this was due to a mistaken identification. The species taken there was, in fact, *Elminius simplex*, and *T. radiata* has not as yet been found in the neighbourhood of Port Jackson.

Genus Elminius.

The genus *Elminius* comprises Balanidae with only four plates in the shell, and these have solid walls not permeated by pores. The basis is always membranous.

Two species of the genus occur in the Port Jackson area, *Elminius simplex* and *E. modestus*. The latter is a prominent fouling organism in the upper reaches of the Port, since it grows on wood, stone or any other substratum with equal facility. *E. simplex* is moderately rare and is not of importance as a fouling organism.

There should be little difficulty in separating these two species because of the difference in size between them and also the difference in their field occurrence. *E. modestus* rarely, if ever, exceeds one-quarter of an inch in basal diameter and is found growing on any sort of substratum at the level of the high neap tides and above. It occurs in harbours and estuaries where there is a slight admixture of mud in the water and on the bottom. *E. modestus* occupies the level on the rocks which is colonized in more seaward parts of the harbour and on the open coast by *Chthamalus antennatus*. In fact it is possible to find these two barnacles occurring side by side in certain parts of the harbour.

E. modestus is as a general rule rather dull muddy-grey in colour and has a comparatively large orifice. It may grow crowded together, when it has a more tubular shape, or it may be solitary, when it is flattened conical. This latter is usually only at the extreme upper limit of its range.

E. simplex, on the other hand, is found on the under side of boulders and ledges of rock, near the low water mark of spring tides. It has not, in the author's experience, so far been collected in muddy situations and has a rather solitary habit of growth. Two or three may be found under the one boulder, but they are never crowded together. The colour is white and the outside of the parietes of the shell is longitudinally ribbed and has a regular corrugated appearance. When one of the shell-plates is broken across, parallel to the basis, and the fractured edge is examined under the microscope, a row of minute dark yellow dots can be detected between the outer and inner laminae of the parietes. *E. simplex* is larger than *E. modestus*, the usual adult size being about half an inch basal diameter. The shape is also more steeply conical in *E. simplex* than in *E. modestus*.

Key to Species of Genus Elminius.

A. Up to a quarter of an inch basal diameter; colour of shell greyish-brown or grey; grows in muddy estuaries near high water mark of neap tide; has comparatively large orifice ..... *E. modestus*

AA. Generally about half an inch basal diameter; colour of shell white; shell steeply conical with comparatively small orifice; parietes longitudinally ribbed or corrugated; frequents open coast and attaches to under side of rocks near low water mark. A characteristic row of microscopic yellow dots lies between the inner and outer laminae of the parietes ..... *E. simplex*

Elminius modestus Darwin.

(Plate xxix, fig. 4; and Plate xxx, figs. 27–28.)

Appearance.—This very common, small barnacle has, as a rule, a flattened conical shape, though where specimens grow in very crowded conditions there is some tendency

[1] "Animal and Plant Communities of the Coastal Rock Platform at Long Reef, New South Wales", *Proc. Linn. Soc. N.S.W.*, Vol. lxviii, Parts 5 and 6, 1943.

for the shell to become tubular. The outside walls of the four shell-plates are smooth and faintly ribbed longitudinally, this ribbed structure being most marked in the large, rather solitary specimens which grow on the mangroves (*Avicennia*) in the upper reaches of the Port and Middle Harbour. The shell is comparatively fragile in that the plates come apart easily when the barnacle is removed from its substratum. The orifice is large and diamond or rhomboidal in shape and is not toothed. The scuta generally have a light coloured, longitudinal band running outwards from the apex to the margin of the valve. The walls of the parietes are not permeated by pores.

Size.—Typical specimens are slightly less than a quarter of an inch in basal diameter, while large ones reach half an inch. Such large specimens, however, are very low and flattened and the continuations of the ribs stick out round the margin of the shell in a series of points.

Basis.—The basis is membranous and flat.

Colour.—The colour is rather variable, being pale grey in specimens on rocks exposed to full sunlight, while ones from more shaded habitats such as wharf piles and walings or mangroves are very dark grey-brown with light ribs of white or pale grey. The light band running across the scutum often seems to be confluent with one of the light coloured ribs on the lateral plates of the shell. The rest of the opercular valves are generally darker than the remainder of the shell.

Opercular Valves.—The scutum has no remarkable characters, for the adductor ridge is no more than an undulation. The articular ridge is moderately well developed and has a slight peak in the centre. The articular furrow is shallow and comparatively wide towards its basal end. There is a small depression for the attachment of the lateral depressor muscle. The tergum is a small valve, rather variable in shape. In local specimens the most usual condition is for the valve to be hatchet-shaped because the basal margin is very deeply notched, thus dividing the valve into two portions. There is no spur, for it is incorporated into the basi-scutal corner of the valve (the handle of the "hatchet") and this section of the valve is long and narrow, and grooved down the centre. The articular ridge is prominent and forms one of the sides of the groove. The other section of the valve, the basi-carinal corner, has several crests on it for the attachment of the depressor muscles. Occasionally the notching of the basal margin is not so marked and the basi-carinal portion of the valve is, in consequence, broader and larger.

Habitat.—*E. modestus* is an estuarine barnacle and is easily the most common barnacle growing in the inter-tidal area of the harbour, for it grows on any kind of substratum. It frequents the highest parts of the inter-tidal area (from about high neap tide mark up to high spring tide mark) and seems to have a wide tolerance of mud in the surrounding waters or it could not frequent the mangrove swamps. On the other hand, *E. modestus* is not found very near the entrance to the Port where there is much wave action.

Localities.—In Port Jackson it occurs at the following localities: Hermit Bay, Fort Macquarie picnic jetties, Long Nose Point, Cabarita, Mortlake, and Homebush Bay, Woodford Bay on the Lane Cove, and at Seaforth, Sugarloaf Bay and Roseville Bridge in Middle Harbour.

Remarks.—Although its powers of growing with equal facility on all types of substratum would appear to make this species a menace as a fouling organism, its habit of growing only towards the upper limit of the tidal range prevents it from becoming much of a nuisance on ships and small craft. However, the parts of wharf piles and walings which come within its range of settlement are practically always completely encrusted by *E. modestus*. The rocks of the harbour foreshores in the upper reaches are frequently also encrusted to the same extent, so that *E. modestus* fulfils inside the estuary the role that *Chamaesipho columna* takes outside, except that *E. modestus* inhabits a higher level than its counterpart.

E. modestus is mostly associated with *Balanus amphitrite* var. *communis* on wooden substrata, since the two species are found side by side on wharf piles and walings and

on the stems and roots of mangroves. Hedley (1915) makes no mention of *E. modestus* in his very able paper on the "Ecology of the Sydney Beaches", and this fact is hard to reconcile with the vast numbers which are found in the Port. Darwin (1854) is of the opinion that both species of the genus *Elminius* do not extend their range much to the north of Port Jackson and they are, therefore, southern forms.

Elminius simplex Darwin.

(Plate xxix, fig. 5; and Plate xxx, figs. 25–26.)

Appearance.—The shell is comparatively tall and steeply conical, corrugated externally by foldings of the parietes. The rostral plate is often backwardly curved. The orifice is generally small and pentagonal and has a somewhat jagged edge. The sutures between the shell-plates are always well marked and the radii are very narrow. The shell is generally little eroded and the sculpture, in consequence, well shown. The walls of the parietes are solid and when broken across, and viewed under a microscope, show a row of tiny orange dots between the outer and inner laminae.

Size.—Typical specimens are about half an inch in basal diameter and about the same height. The largest specimen collected by the author is only a little larger than these dimensions, being five-sixths of an inch in basal diameter and three-quarters of an inch high.

Basis.—The basis is flat and membranous.

Colour.—The colour is white or off-white and the insides of the opercular valves show faint purple tinges. The orange dots show only when the parietes are broken across.

Opercular Valves.—The scutum is a comparatively thick, solidly built valve. There is a prominent adductor ridge and a long, rather pronounced articular ridge. At the basi-tergal corner of the valve are six or seven small crests for the attachment of muscles. The occludent margin is distinctly infolded towards the basal part of the valve. The tergum is very much elongated along the basal and scutal margins by the incorporation of the rounded spur into their length—the edges of the spur being confluent with both these margins. There is a prominent, wide articular furrow, a beaked apex and approximately six radiating crests for the attachment of muscles towards the basi-carinal corner of the valve. The articular ridge is prominent and merges with the raised central area of the spur. The valve in local specimens does not appear to be so similar in shape to that of *E. simplex* (a New Zealand species) as Darwin states in his description, although the scuta are similar.

Habitat.—This species has been collected by the author only from the under sides of boulders or in holes under overhanging ledges of rock platforms on the open coast. It is probably the rarest sessile barnacle in the Port Jackson area and has not, so far, been found inside the Port itself. This would indicate that the species requires a considerable amount of movement in the surrounding water as well as showing a preference for subdued lighting or no light. It lives at low water mark of spring tides.

Localities.—Under boulders at Long Reef; Newport and Harbord.

Remarks.—This species seems to settle only on stony substrata and to frequent the open coast, so that it does not figure among the fouling organisms of the Port.

Acknowledgements.

Much help and encouragement has been supplied in this work by all the officers of the Preservation and Research Laboratory of the Maritime Services Board, particularly by Mr. R. A. Johnson, A.M.I.E. (Aust.), Chartered Engineer, and Mr. D. Moore, B.Sc., A.S.T.C., his Senior Assistant. Both these officers collected numerous specimens and made available very helpful field notes, besides allowing the author to accompany them on launch trips to visit their timber test samples at stations scattered throughout the main Port and Middle Harbour.

Assistance in checking and criticizing the manuscript has also been received from the following: Professor W. J. Dakin, D.Sc., Mr. D. Moore, my father, and Mr. F. A.

McNeill of this Museum, who throughout the preparation of the manuscript has freely given help and advice. Miss I. Bennett of the Zoology School, Sydney University, very kindly made special collections of barnacles in places inacessible to the author. To all these people thanks are rendered.

Thanks are also due to Mr. G. C. Clutton, who photographed the barnacles for the plates.

Summary.

The barnacles found in Port Jackson and the surrounding districts are described and a simplified key for their identification is supplied, together with a few notes of their field occurrence.

The species dealt with are as follows:

Catophragmus (*Catomerus*) *polymerus* Darwin.
Chthamalus antennatus Darwin.
Chamaesipho columna (Spengler).
Balanus (*Megabalanus*) *nigrescens* Lamarck.
„ (*Balanus*) *trigonus* Darwin.
„ (*Balanus*) *amphitrite* Darwin var. *communis* Darw.
„ „ „ „ „ *cirratus* Darw.
„ (*Austrobalanus*) *imperator* Darwin.
„ (*Chirona*) *amaryllis* Darwin.
Tetraclita (*Tesseropora*) *rosea* (Krauss).
„ *purpurascens* (Wood).
Elminius modestus Darwin.
„ *simplex* Darwin.

A correction of an error made in a previous paper with regard to the occurrence here of *Tetraclita radiata* is made.

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EXPLANATION OF PLATES.

PLATE XXVIII.

Fig. 1.—*Catophragmus* (*Catomerus*) *polymerus* Darwin. Three whole shells. × 1.

Fig. 2.—*Chamaesipho columna* (Spengler). Bottom left: A piece of rock with conical, less crowded barnacles. Bottom right: Crowded specimens in a honeycomb-like mass. Top: The lower edges of the shell showing characteristic crinkly appearance. × 1½.

Fig. 3.—Inter-tidal rock showing mass and numbers of *Chamaesipho columna* (Spengler). Photograph by Miss G. Burns. × ½.

Fig. 4.—*Chthamalus antennatus* Darwin. Four little eroded specimens. × 2.

Fig. 5.—*Balanus* (*Balanus*) *amphitrite* var. *communis* Darwin. Whole shells. × 1½.

Fig. 6.—*Balanus* (*Balanus*) *amphitrite* var. *cirratus* Darwin. Top shell shows conical form. Lower shell shows tubular form. × ½.

Fig. 7.—*Balanus* (*Chirona*) *amaryllis* Darwin. Whole shells. × ½.

Fig. 8.—*Balanus* (*Austrobalanus*) *imperator* Darwin. Top left: A small uneroded shell. Top right: A much eroded specimen. Lower group: A clump of shells overgrown with brown alga and worm tubes. × 1.

Fig. 9.—*Balanus* (*Megabalanus*) *nigrescens* Lamarck. Top: Two old and encrusted shells. Bottom: Two younger specimens from the same locality. × ½.

Fig. 10.—*Balanus* (*Austrobalanus*) *imperator* Darwin. Lower edges of the plates of the shell. × 1.

PLATE XXIX.

Fig. 1.—*Tetraclita purpurascens* (Wood). Whole shells. Two specimens on the left uneroded. Two specimens on the right eroded and showing granular appearance. × 1½.

Fig. 2.—*Tetraclita* (*Tesseropora*) *rosea* (Krauss). Whole shells. Those on the left are much eroded. Those on the right comparatively uneroded. × 1½.

Fig. 3.—Structure of shell walls in genus *Tetraclita*. Left: *T. rosea* (Krauss) with single row of pores. Right: *T. purpurascens* (Wood) with numerous rows of pores. × 1.

Fig. 4.—*Elminius modestus* Darwin. Some whole shells growing on bark and two specimens from a rocky substratum. × 2.

Fig. 5.—*Elminius simplex* Darwin. Two whole shells. × 1½.

Fig. 6.—*Balanus* (*Balanus*) *trigonus* Darwin. Two whole shells of *B. trigonus* on a mussel shell together with seven specimens of *B. amphitrite* var. *cirratus* Darwin. Note the prominent white ribs on *B. trigonus* Darwin and the rows of little pits on the scutum of the specimen in the lower right hand corner of the photograph. × 1.

PLATE XXX.

Figs. 1-2.—*Catophragmus* (*Catomerus*) *polymerus* Darwin. Inside view of scutal and tergal valves.

Figs. 3-4.—*Chthamalus antennatus* Darwin. Inside view of scutal and tergal valves.

Figs. 5-6.—*Chamaesipho columna* (Spengler). Inside view of tergal and scutal valves.

Figs. 7-8.—*Balanus* (*Megabalanus*) *nigrescens* Lamarck. Inside view of scutal and tergal valves.

Figs. 9-10.—*Balanus* (*Balanus*) *trigonus* Darwin. Outside of scutal valve and inside of tergal valve.

Figs. 11-12.—*Balanus* (*Austrobalanus*) *imperator* Darwin. Inside view of tergal and scutal valves.

Figs. 13-14.—*Balanus* (*Balanus*) *amphitrite* var. *cirratus* Darwin. Inside view of scutal and tergal valves.

Figs. 15-16.—*Balanus* (*Balanus*) *amphitrite* var. *communis* Darwin. Inside view of tergal and scutal valves.

Figs. 17-20.—*Balanus* (*Chirona*) *amaryllis* Darwin. (17) Edge of radius which is smooth and slightly recurved. (18) Inside of tergal valve. (19) Outside of scutal valve. (20) Inside of scutal valve.

Figs. 21-22.—*Tetraclita* (*Tesseropora*) *rosea* (Krauss). Inside view of scutal and tergal valves.

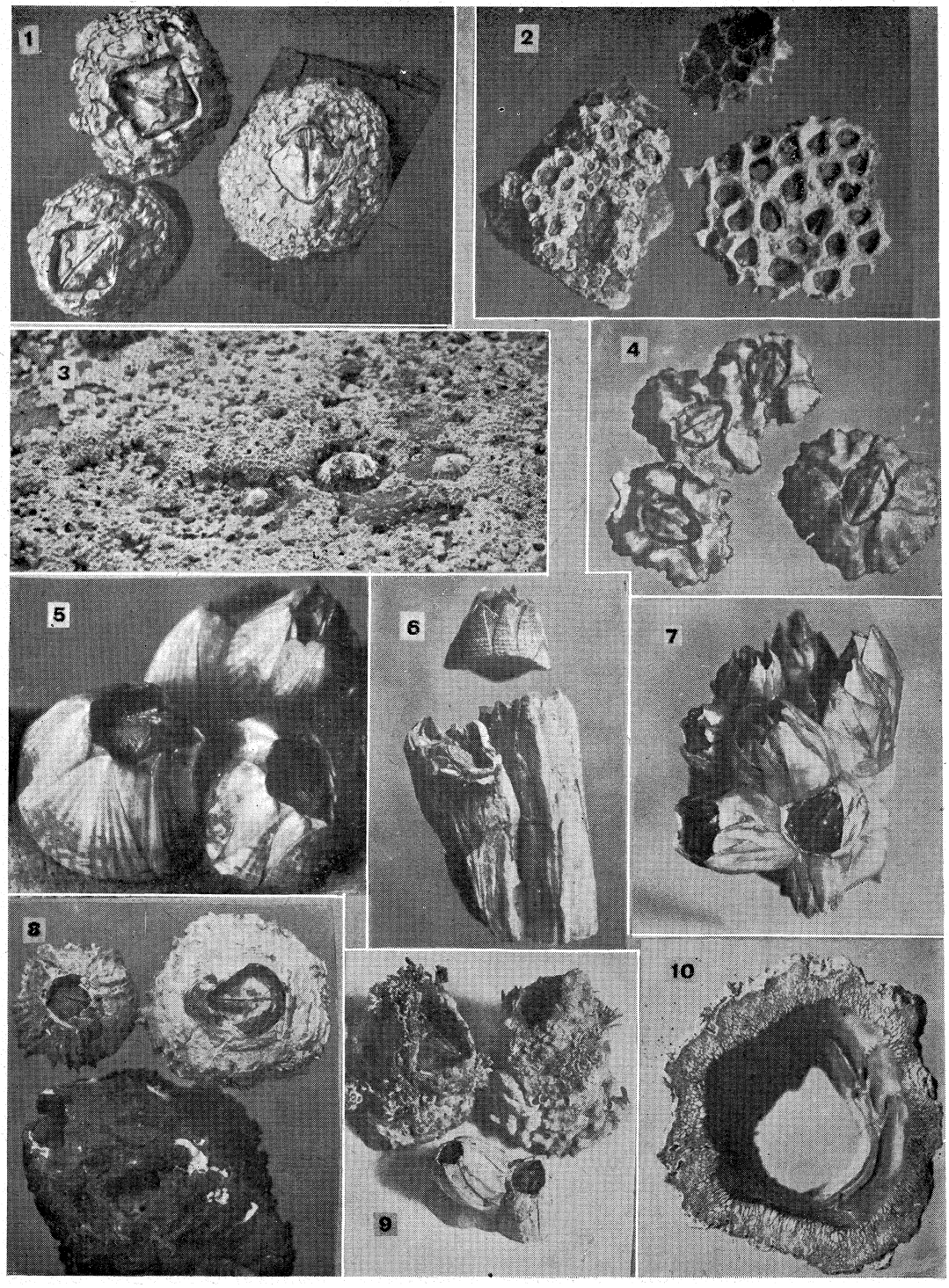
Figs. 23-24.—*Tetraclita purpurascens* (Wood). Inside view of scutal and tergal valves.

Figs. 25-26.—*Elminius simplex* Darwin. Inside view of scutal and tergal valves.

Figs. 27-28.—*Elminius modestus* Darwin. Inside view of tergal and scutal valves.

All figures on this plate slightly larger than natural size.

G. C. Clutton, photo.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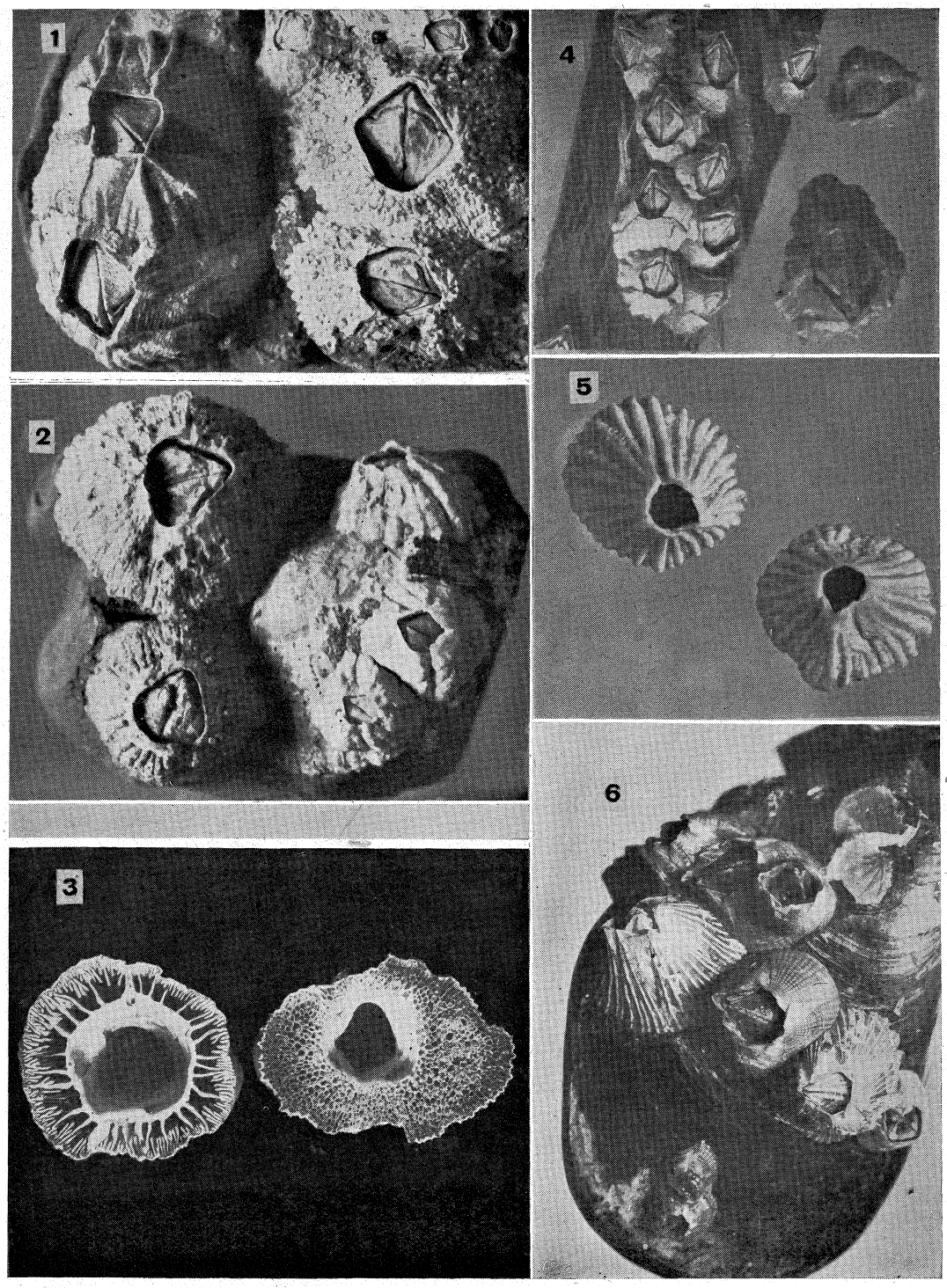
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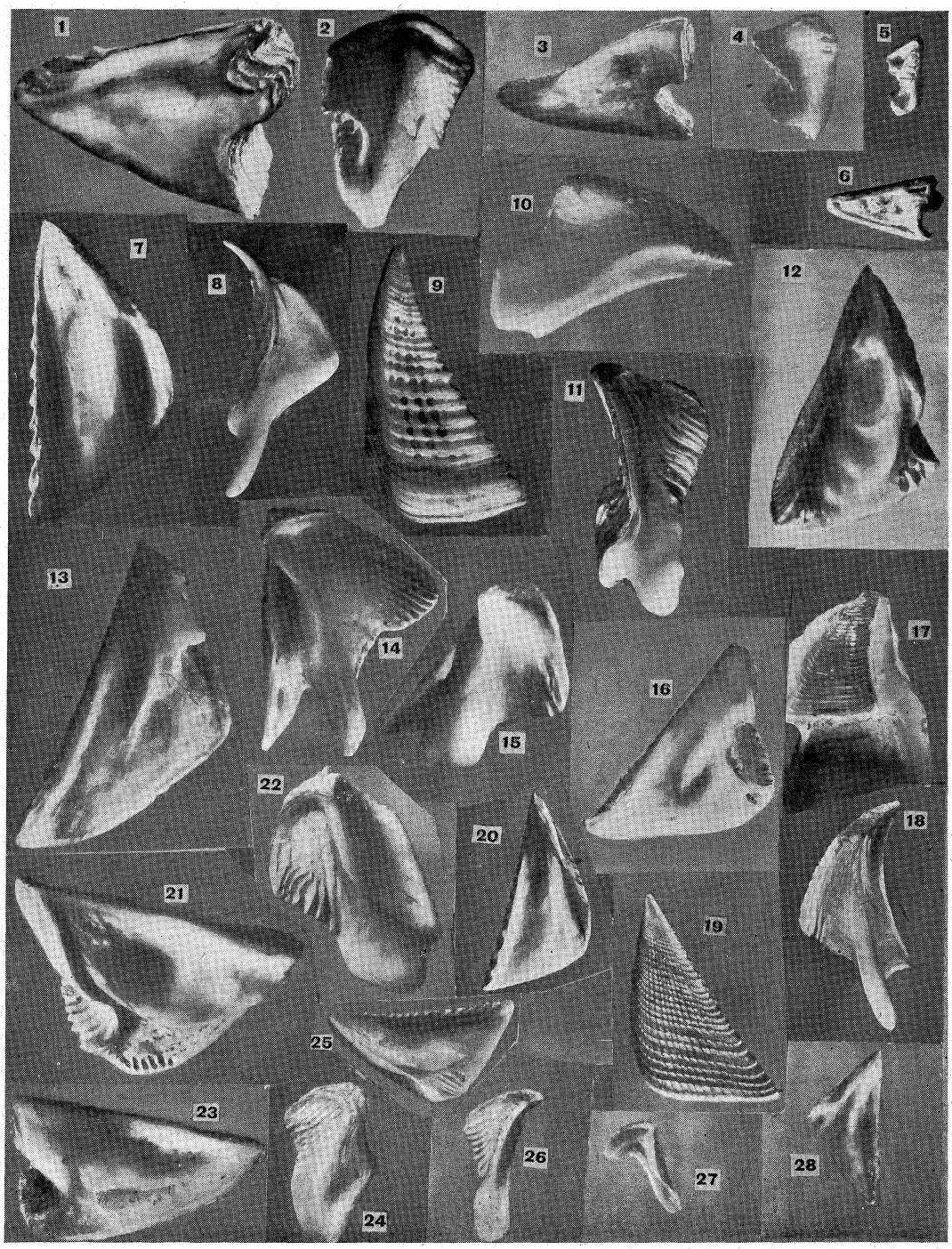
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