ON SOME TASMANIAN PATELLIDÆ.

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Our knowledge of Australian mollusca is almost confined to descriptions from the shells alone. Nearly all that we do know of the animals inhabiting the shells has been given to us by Messrs. Quoy and Gaimard in the voyage of the Astrolabe, where the plates as far as they go, leave but little to be desired. In the Nudibranchiate section Mr. G. F. Angas, F.L.S., etc., has done good service. But the greater part of the field remains untrodden. I propose in this paper to give a more detailed account than has yet appeared of the shells and animals of some Tasmanian Patellidæ. I choose this family because it is the one in which a knowledge of the animal is most required to arrive at correct principles of classification. Limpets cannot be determined from the shell alone. The genera are classed according to the respiratory organs of the animal. These can only be told by a study of the habits of the animal, and by dissection. To both of these methods I have given lately some attention, and a part of my conclusions are embodied in the present paper.

Before giving a glance at the character of the genera, let me state the principles which have guided me in the nomenclature. Conchology has recently increased its synonyms with a rapidity which is perfectly appalling. No naturalist can deprecate too strongly the practice of lightly changing a received name. It is embarrassing, nay, disheartening to students, and destructive of progress in science. This is not the place to enter into the causes of the evil, but it is in part due to a misunderstanding of the labours of Dr. Hermannsen, Chenu, and others, as embodied in the Manual of Conchyliologie. I shall adhere strictly to the British Association rules, and notably not to admit "priority" for *pre-Linnean* names, nor for those where no definition or figure has been given; and, even in the cases not thus exempted, not to change the name if it be generally received and known among naturalists.

For those reasons I shall adhere to Eschscholtz's genus of *Acmæa* instead of *Tectura*. First, because Messrs. Auduoin and Milne Edwards gave no definition of their genus, and secondly, because Acmæa is the name by which it is described in the works of Professors Forbes, Hanley, Woodward, Chenu, Carpenter, and the earlier writings of Mr. Angas.

Limpets, or bonnet shells (*Patellidæ* from *Patella*, Latin for a little dish) are classified according to the respiratory organs of the animals which inhabit them. This is true at least for the only genera known in Australia.

The true limpets—PATELLA—have the gills disposed in a circle round the mantle, in the space between it and the foot. On detaching a limpet from the rock and placing it upon its back in the water the mantle will be seen to spread out, disclosing the feathery filaments of the gills like a fringe round the upper part and below the silvery muscular attachments. Within this circle is the broad foot attached all round in its upper part by the silvery muscles aforesaid, except an open clear space for the free movement of the head, having a rather large chamber behind in which is the excretory orifice. The mantle is, however, continued round the shell in front of the head, and in one of the Tasmanian true limpets so are the gills.

But in some limpets there are no gills round the mantle. In this case, in one genus, they are placed at the back of the head, and can be seen as a long feathery plume, coming forth from the head chamber. This is the second genus *Acmæa*, I do not know of any difference by which the shells of the genus may be distinguished. True limpets are sometimes nacreous, *Acmæa*, are never so. We have only two species of true limpets in Tasmania certainly ascertained, while we have many of *Acmæa*. There are, of course, other limpets described, but the animals have not been examined, and until they are the shells must be considered as only provisionally classed.

Besides the above arrangement of the gills we have limpets which have no gills at all, but breath by a true lung. These are the Siphonariæ. Their anatomy is not well understood, but what little is known removes them in their whole organisation very far in the animal rank from true limpets. As I have had facilities for the examination of two of the species, I have preferred to place my observations in this paper; they are not Patellidæ, however. Their shells are only in some slight details to be distinguished from limpets, which shows us how little a shell of such simple character can be a guide to the knowledge of the animal it shelters.

In addition to the breathing apparatus we have in all mollusca a very valuable organ as a means of identification, if not of true classification. That is the lingual ribbon. It is a long horny membrane, studded with minute points or teeth of a very hard siliceous nature, sometimes vitreous and transparent, but in all the limpets of a rich golden or dark brown color. By some writers this organ is called a tongue, by others teeth, radula, &c. For convenience I shall adopt a name proposed by many naturalists, viz., *odontophore*. Its nature and office are not thoroughly understood. I here record my observations in the case of the Tasmanian limpets. All of these animals have strong cartilagenous jaws curved and swollen on

the upper side. Between these the odontophore is placed, and has, in this part alone, a wide transparent membranaceous expansion. From the under side and back of both jaws two muscles proceed and meet on the under side of the ribbon, and continue to its point, which is tongue-shaped, and with a gradually diminishing number of teeth. These muscles I call the retractors. There are also two extensor muscles proceeding from the point of the jaws and meeting under the odontophore, about half way down the membranaceous expansion, and continuing to its inner end. The membranaceous expansion itself appeared to have free movement and not to be attached in any way. Now,on turning a limpet on its back in the water and watching its mouth with a lens, the ribbon is seen to be in constant movement. First there is the outer lip of the mouth with cirrhi and notched below. Secondly, a mouth opening vertically. Within this the odontophore is seen to be constantly moving, being drawn back over the curved cartilaginous jaws like a strap, and when drawn back the mouth would close. It seemed also as if it was pushed in between and not over the jaws in returning to its place. The whole operation was much like the action of a strap drawn over a drum wheel.

The action of the odontophore, however, does not rest here. It is not only a rasp for tearing away from sea weeds, etc., the necessary portions, but it lines the whole of the œsophagous, and is continued along a considerable portion of the intestinal tube. Its length is consequently very much more than the length of the shell. In *Patella limbata* the length is enormous, being ten to eleven inches; while the longest diameter of the shell is seldom over two. Some naturalists have imagined that the length depends upon the age. I have not found it so. The proportionate length is generally the same in young as in old animals. The distal end of the ribbon is soft, and with rudimentary transparent teeth. This may have led to the idea that the odontophore was constantly being added to. It seems to me,however, that the rudimentary teeth were of a different character and structure from those of the rest of the ribbon, and serve some other purpose. All the teeth are hooked backwards,so that by the movement of the odontophore the fragments of sea-weed are torn off, and continually by the same action forced down the œsophagous, and literally shredded as they pass over the innumerable fine points. Properly speaking this process combines the office of mastication and digestion, teeth, gizzard, and stomach all in one, and as far as my examinations have gone there is really no stomach, that is to say, a cavity where food is specially reserved for assimilation. There is a dilatation of the intestinal tube

scarcely perceptible in some, as in *Patella limbata*, Phil., a kind of plexus where the odontophore is very much twisted and convoluted,so as scarcely to be drawn out without breaking, but this I imagine serves some purposes of digestion, very different from the action of what we usually call a stomach. These, however, are matters of my own opinion only, which I have not been able to bring to the test of any physiological experiment.

The odontophore is easily drawn out of all gasteropods examined by me, except the species just mentioned. In Patellæ and Littorinidæ (winkles) it is always long. In our Risellas and Littorinas it is of enormous length, but lies, in this case, in a simple coil immediately behind the mouth as a silky siliceous thread. In Chitons it is a closed tube with teeth all round it as in *Haliotis nævosa*.

Professor Forbes *(Brit. Moll.)* has remarked that the character of the teeth and their arrangement is very constant in the various genera. I have found that it varies also for the species in Tasmania, at least in the order I am now dealing with, and I hold it to be a very valuable test as to specific difference. Indeed it is a test where all others failed, because shells are often so corroded as to obliterate marks on which specific differences are chiefly erected. This is exclusively the field of the microscopist, but I am convinced, not only that it is a wide and valuable field for investigation, but that until it is carefully explored we shall have no solid system of conchology resting upon a secure scientific basis. The teeth in all the *Patellæ* and *Acmeæ* have raised double edges or points which curve, succeeded again by a smaller double edge or point. Thus each set is curved back from its attachment to the odontophore at its lower side. As far as my investigations have gone there is a general correspondence between the pattern of the odontophore and the organs of respiration. In Patellæ it is of one type, and Acmeæ of another, though the resemblance is very close. In Siphonaria, however, which is pulmoniferous, we shall see in the course of this paper that it has a dentition quite uniform with the land and freshwater mollusca. This can hardly be called an anomaly, though it points out a singular fact rather adverse in my mind to the theory of natural selection. Here we have a marine animal with a shell differing but slightly from the commonest of our marine types and apparently living under the same conditions, yet organised to breathe air and salt water, and with a dentition exactly similar to pulmoniferous mollusca living under totally different conditions. Of course a double inference may be drawn from this as from similar facts, but they point in my mind much in the stronger way to an

origin in an infinitely varied creative power, showing by its strange and complex variety that evidently no conditions organisations, nor combinations were an impossibility. Scientific observations as they are extended seem to show rather the absence of law than the existence of it, or rather, as I should phrase it, an infinitely creative power and inexhaustible mind.*

If I were to pursue the argument further I should reason thus: In the theory of natural selection we ought to perceive a certain congruity between organisations and the circumstances of their existence. This is no more than what was formerly used as an argument of design. Thus in the case of limpets with conical shells of simple structure, breathing by gills, and living sometimes in and sometimes out of salt water, digesting sea weed by means of a certain pattern of odontophore, we see conditions of life well ba anced, as we interpret them, to meet their requirements. In the land and freshwater mollusca we meet with more complex shells, breathing by lungs, and odontophore adapted to the food and the other conditions, and in this case also we may find very close relations between the conditions of life and the organisation. But all our inferences are set at naught, upon meeting a limpet with every habit and condition of life that is shared by its marine relations, but with lungs and an organisation exactly like land and fresh water mollusca. It will be urged that such instances are destructive equally of the argument of design. But this I readily admit, and I must say that one service which the theory of natural selection has rendered is in destroying this argument by showing that it can be read backwards. It is a contradiction of infinite power to suppose it to be tied to certain means to attain an end. The truth lies the other way, as such instances as the anomalous Siphonaria (the pulmoniferous marine mollusca referred to) show us. What makes the anomaly still more striking is that the genus is confined to the eastern hemisphere. Three species supposed to be of that genus are found in the Miocene of Europe,

* The following very apposite passage from Butler's Analogy is worth recalling:—"The thing objected against this scheme" (he is speaking of the Gospel) "is that it seems to suppose God was reduced to the necessity of a long series of intricate means in order to accomplish His ends. . . . . As men, for want of understanding, or power, not being able to come at their ends, directly, are forced to go roundabout ways, and make use of many perplexed contrivances to arrive at them. Now everything which we see shows the folly of this. . . . . For, according to our manner of conception, God makes use of a variety of means. . . for the accomplishment of His ends. Indeed, it is certain, there is somewhat in this matter quite beyond our comprehension, but *the mystery is as great in nature* as in Christianity."—Butler's Analogy, part 2, chap. 4. The italics are my own.

through an identification from the shell alone must at best be doubtful.

I will now proceed to a description of the species examined by me.

Patella limbata. *Philippi Abbild. und Besch Conch. pl.* 3 *fig.* 1 (as from North Australia).

Shell large, ovate or suborbicular, somewhat depressed, ribbed, dusky brown, with the intercostal spaces darker, apex anterior, rounded, nearly always much corroded, and slightly nacreous; ribs broad, rounded, thickly, often coarsely grooved with lines of growth; intercostal spaces concave, often containing smaller round ribs which do not reach the apex, the number apparently increasing with age; interior broadly margined with large pattern of alternate rich claret and brown, the claret marks intercostal, and may be traced some distance up the shell; within the margin interior of shell of a peculiar silky nacre, silvery, bluish yellow or golden; spatula well defined, bluish grey, slightly darker at the margin, with broad concretionary line outside for the muscular attachment, which is often coloured yellow. Held up against the light the shell shows beautiful double claret-coloured rays, which become smaller and interrupted by age, marking the intercostal spaces. As the dimensions vary I give the measurements of a few specimens, all taken from the rocks at Southport. Long. 62, * Lat 53, alt. 24, ribs 37, (old but not corroded); Long. 59, Lat. 47, alt. 27, ribs 37; Long. 71, Lat. 64, alt. 32, ribs 36; Lon. 54, Lat. 47, alt. 23, ribs 29, Long. 71, Lat. 61, alt. 28, ribs 37; Long. 67, Lat. 37, alt. 35, ribs 33. Thus the relative dimensions and number of ribs vary. The species is always found high above low water mark. It attains its largest dimensions in Tasmania, but is the commonest limpet of all the south coast of Australia.

Animal olive green, above base of foot bluish brown, mantle very pale yellowish green, fringed with numerous short olive or speckled tentacles, every fourth one of which is longer, head and muzzle olive green above, flesh-coloured elsewhere; tentacles of head somewhat long and tapering, and dark olive above; eyes scarcely perceptible at their outer base; gills pale, translucent, and narrow, fringing the mantle all round except at the excretory orifice above the head, no attachment to head or neck, and not apparently passing into the head chamber; muscles of attachment silvery and conspicuous within the gills. Odontophore very long from (8 to 10 inches), and curled in the upper cavity of the foot in large irregular folds, consisting of a series of pairs of long curved sharply pointed teeth, closely set, and of dark colour, with a small trian-

* All measurements in millimetres.

gular golden translucent cusp on the outer base. The whole odontophore enveloped in a fine golden yellow transparent membrane, which is either the intestinal tube or its lining. The odontophore never can be drawn from the animal without this membrane, owing to the long set pointed teeth which hold it in its place.

Patella ustulata. *Reeve Icon. pl.* 31, *fig.* 88. If I am right in my identification of this shell it must be the same as my *P. tasmanica*, described in last year's proceedings of this Society. Reeve gives no habitat for his shell, which from appearance was worn and corroded. The unworn specimens found living on the rocks are as different as possible, the ribs and riblets being then conspicuous, and the whole shell a dull yellowish white with no trace of the scorched colouring. When dead, however, and thrown on the beach this feature is conspicuous. It has many fine riblets between the coarse somewhat nodular ribs, and the margin is very finely pectinated. A peculiarity of the animal is that it seldom comes above low water mark, and prefers situations where it is much exposed to the waves. It is very stationary, often being sunk into a regular pit in the rock, and appears to live upon the fine green ulva on the rocks. It is nearly always covered, not only with confervoid growths, but also nulliporæ so as to quite alter its shape and appearance. This often alters the height of the shell, which is usually depressed, and changes the position of the apex, which is usually submarginal. The interior is white and the spatula not defined.

The animal is of uniform pale yellow at the base; white above the foot, gills semi-pellucid and continued as a delicate fringe *all round* the mantle. I, however, noticed one exception where, like the former species, the gills were discontinued in front of the head, mantle without tentacles; head livid, with semi-pellucid tentacles; eyes very small and at exterior base; buccal mass red and fleshy; cartilaginous jaws long and less tumid than most limpets; odontophore *scarcely as long as shell;* not coiled, but bending with intestine in two folds. Teeth closely set and not high, composed of five central small curved cusps, and two tri-lobed laterals, all narrowly tongue-shaped, laterals more acute. The five centrals have the middle tooth often small. Teeth brown, lighter on the summit.

There are many other Patella known to us from the shells alone, the animals of which I have not examined, viz., *P. decora*, *P. aculeata*, *P. chapmani*, *P. radians*. Some of these will doubtless prove to be Acmæa.

GENUS 2.—ACMÆA.

Animal with a limpet shell, but breathing by a plume-like gill inserted at the back of the head.

Acmæa costata. *Sowerby Zool. Voy. Beag.*, as Patella, Probably also *P. alticostata, Angas. Proc. Zool. Soc.* 1865, p. 56, pl. 2 fig. 11. This shell has always been set down as a Patella, but the animal shows it to belong to the above genus. The shell is oval or elliptic, depressed and somewhat tumid, apex submedian with from 12 to 30 coarse-rounded rough uneven ribs, irregularly marked with lines of growth which makes them almost nodular. Interstices concave, transversely barred at intervals with black or brown lines, which are the remains of successive marginal marks; they are seldom regular, appearing at intervals and frequently corroded away; interior porcellanous, white or faintly bluish white, irregularly stained pale brown, shining; margin undulating, with a well-defined narrow brown edge, which is spotted deeper brown or black at the intervals between the ribs; spatula generally well defined, reddish brown, paler in the centre. Size varying, but generally 30 to 40 mill., and the proportions of length, breadth, and height being as 10, 8, and 4.

Animal a dull yellow below, blending into brown at the base of the foot, tentacles fine and short, with eyes at the external base; gill plume long, flat and lanceolate, flexuously extended over the head; muzzle yellow, and notched below; inner lip cartilaginous and transparent, with a shelly appendage coming down from above horizontally across the tongue and apparently holding the food against the rasp; jaws cartilaginous, crescentic, but pointed and attached; very massive red muscles; odontophore one and a half the length of shell, with broad membranaceous expansion at mouth; teeth in pairs, alternating large and small, the small ones close together and somewhat narrow; the larger with a broadly semi-circular edge and a small lateral cusp on the outer side.

This Acmæa is equally common in South Australia and Tasmania. It exists between the tidal marks, and is of such a large size that it was never suspected to be other than a Patella. Yet in Australia the Acmæa genus has species quite as large as Patella, though this I think is a new fact in zoology. They feed on ulva, and are considered better eating than true limpets, though these shellfish are seldom eaten in Australia.

Acmæa septiformis. *Quoy and Gaimard, Voy. de l' Astrolabe*, pl. 71, f. 43, 44. *A. scabvilirata*, Angas, Zool. Proc. 1865, p. 154, *Tectura septiformis*, Cox Exchange list: Sydney, 1867. *Patella cantharus*, Reeve (probably) pl. 4, f. 131.

This shell varies so much in colouring and the fine markings that I am afraid it has received a longer list of synonyms than I can enumerate. The shape of the shell is, however, constant. It is small, broadly ovate, depressed, apex acute, submarginal; in young well preserved specimens,

ornamented with fine distinct liræ faintly decussated with lines of growth ; edge entire, sometimes transparent ; colour olive with greenish gray spots ; deep olive approaching black ; greenish gray with network of brown ; yellowish, marked with zigzag lines of brown, pale transparent tortoise-shell, or, rarely, beautifully and regularly rayed with broad lines of brown on a pale green ground. Interior with a transparent or dark olive margin, rather evenly circumscribed by a bluish white porcellanous enamel, which is opaque, opalescent or translucent, showing external pattern, spatula imperfectly defined in various shades of brown and often absent. Average dimensions, Long. 14, Lat. $11\frac{1}{2}$, alt. $4\frac{1}{2}$.

Animal very pale yellow, base of foot sometimes a little darker ; mantle translucent, muscular attachment silvery ; gill plume long, coarse, and conspicuous ; head somewhat large and livid ; tentacles pale purple brown, rather long and fine pointed ; eyes conspicuous at external base, and somewhat on upper side ; buccal mass red and fleshy ; jaws stout, translucent cartilaginous ; odontophore about a fourth longer than the shell, composed of pairs of broadly lanceolate recurved teeth, concave on the inner side and convex on the recurved side. The pairs of teeth are alternately large and small, the larger pairs having a broad short cusp on the outer side.

This species often so closely resembles *A. testudinalis, Müll.* that I was inclined to believe it is the same, but the teeth are slightly different. That shell is found in *N.-East* America, in all the circumpolar seas, and in Japan, from 4 to 48 fathoms. Professor Forbes *(Brit. Moll.)* says that the eyes are always at the *internal* base of the tentacles ; this peculiarity I have met in some specimens but rarely. Common everywhere in pools, under stones.

Acmæa Flammea. *Quoy and Gaim. Voy. de l' Astrol. Vol.* 3, *p.* 354, *pl.* 71, *fig.* 15-24, as Patelloida. Shell oblong, *elliptic, convex and turgidly conical*, apex anterior acute and moderately inclined, *shell somewhat solid*, with obsolete radiating striæ, which, however, are seldom visible ; lines of growth numerous and conspicuous ; of varied colour, but generally marbled olive, fuscous brown and dingy yellow, reticulated or in straight or forked lines ; interior margin acute and rayed or reticulated a deeper brown than exteriorly ; spatula brownish, badly defined and interrupted, circumscribed by a ring of faint translucent enamel marking the muscular attachment.

Animal creamy white, base of foot dingy yellow ; head small, tentacles short and swollen, eyes at base *above*, branchial plume *very inconspicuous*, odontophore *scarcely length of shell*. Unfortunately I have mislaid the specimens I reserved

of this animal before submitting them to microscopical examination.

MM. Quoy and Gaimard say the animal is also found at Guam Island.

I have much doubt on my own mind if this species is not identical with *A. subundulata*, Angas. Zool. Proc. 1865, p. 155. I have marked in italics the difference between this species and the preceding. Its habits are different, as it is found generally out of water on rocks. Not common at Southport, where alone I found it. Mr. Angas found it at Port Lincoln, South Australia; and Mr. Archer found it in Hobson's Bay, Victoria. Mr. Angas says (*Zool. Proc.* 1867) that the worn specimens of this shell are prettily marked with a cross. I have not found it so, but I have found it the case with the worn specimens of the young of a new and large species of Acmæa, which I shall now describe for the first time.

Acmæa crucis. *n.s. A.t. ovata, postice latiuscula, alta, conica apice acuto, ante mediano, sordida, sæpe corrosa, absque liris radiantibus; striis tamen incrementi irregularibus (sub lente confertissimis); margine acuto, integro, intus linea fusca constricta exacté fimbriato; aliquando rufo fusca tesselato; intus alba nitida, encausta, irregulariter rugosa; spatula eleganter lineis undulosis rufo-fuscis margine, concentrice definita et lineis radiantibus decussata, intus cæruleo-albo nebuloso.* Long. 31, Lat. 31, alt. 19 mil.

Shell ovate, broader behind, very high, conical; apex acute antemedian, sordid white, often corroded *without any radiating ribs*, but irregularly and finely concentrically sulcate with lines of growth; margin acute, entire, ovate, fringed with a well defined brown line which is often tesselated with red brown, above this line, the interior is white and highly enamelled; spatula well defined by undulating concentric rich red brown lines, and crossed with radiating lines; in the centre the spatula is clouded with pale or opalescent blue.

When this shell is cast upon the beech it is quite of a different appearance. The apex has radiating brown lines generally in the form of a Maltese cross. The rest of the shell is white and the margin worn away. There is a limpet with a cross upon the apex figured in *Wood's Index Testa.*, p. 189, sp. 78, and named *Patella cruciata*, with the following references, which I have not been able to verify. *Acmæa Lin. Sys. M. U.* Schr. Em. ii. 432, pl. 5, f. 6.—A. c. Han. Ips. Lin. 429. Locality unknown. This limpet, however, has a *white* cross on a brown ground. In the Proceedings of the Linnean Society, 1859, Mr. S. Hanley, on the Linnean MS. in the Museum Ulricæ, has this extract "*P. cruciata, P. ovalis convexa, integerrima, cruce picta.*" The name *cruciatus* (tormented) is evidently a grammatical mistake.

Animal, blueish black round the base of the foot and head; muzzle and mantle, pale creamy white; muscles of jaw, red; jaws, cartilaginous, semi-lunar, pellucid, swollen; head, purple above, livid below; tentacles, short, swollen; eyes, small, and at outer base; mouth, with cirrhi, and opening lengthwise; gill plume, fine pointed and long, white; odontophore transparent, divided into small squares, each sustaining two pairs of broadly round edged minute curved teeth, opaque, pale, and with a fine dark edge; one pair close together in the centre of the odontophore, the other pair wide apart and with a fine lateral cusp on the outer side.

Acmæa marmorata *(mihi. Vide Proceed. R.S. Tasm.*, 1875., *Diagnosis auct.)* Shell small, ribbed irregularly elliptic, depressed, generally much corroded, dirty yellowish brown, often stained, and mis-shapen; apex when not corroded somewhat elevated and anterior, but more often quite obliterated; ribs, from eight to ten, rugged and often much distorted with lines of growth, projecting conspicuously beyond the periphery; interior edge undulating, deep fuscous brown, lines of ribs concave and white, giving the interior a rayed appearance; spatula black, irregularly margined, with opaque white, more or less black spotted. Dimensions of five rather large specimens, Long. 19, Lat. 17, alt. 5; Long. 20, Lat. 16, alt. 7; Lon. 19, Lat. 12, alt. 5; Long. 18, Lat. 16, alt. 9; Long. 17, Lat. 17, alt. 8. The variation in the relative dimensions will show the extreme variation in shape to which the species is subject.

The mantle of the animal is of pale transparent neutral tint, showing veins very clearly and sufficiently translucent to show the pattern of the shell underneath. The edge of the foot is yellow with the upper part and base darker neutral tint; upper part of head lemon yellow, with fine, somewhat long, and translucent tentacles, with eyes on external base on a swollen tubercle; outer lips with coarse cirrhi; inner lips opening perpendicularly and displaying a lanceolate unarmed tongue, with a rachis (odontophore) at its base; gill plume small, translucent, and seldom exserted beyond the head. The animal is found above low water mark in crevices, etc., at Southport, and generally throughout Tasmania; odontophore about one and a half length of shell; teeth in pairs, and recurved, broad, and rounded into a semicircular edge, first pair largest and somewhat oblique, and with a small cusp at each side on the outer edge; central pair, small, narrow and close together; roots curved. The larger pairs have a curve in both directions, and not unlike the upper part of a lady's tortoiseshell comb.

The species that I am about to notice are included under quite another family from Patellidæ. At present Molluscan

science has not arrived at sufficient accuracy to make any system of families of much value, especially as naturalists are so divided on the subject, and none are generally received. I include the genus Siphonaria in my observations, only because they have limpet shells, and their habits of life being entirely similar they are generally mistaken for true Patellidæ. They are widely distinct in their anatomy, organs of respiration, digestion, dentition, vision, touch, etc. But they are found on our rocks just as limpets are, and in the midst of them and externally cannot be distinguished from them. They are very common. Two species have been examined by me, and a third is said to occur, but I have not been able to find it. Four or five are known in Australia, but the number is not very clearly ascertained, nor will it be until the animals have received more attention than they have met with from Australian naturalists.

Siphonaria denticulata. *Q. and G., Voy. Astrol., Vol.* 2, *p.* 340, *pl.* 25, *f.* 19 *and* 20, *var. Tasmanica, mihi.*

Shell, irregularly oval, with protuberance on the siphonal side, tumidly conical, high, apex median, subacute; with 40 to 50 fine, flattened and diminishing ribs; ribs interrupted by a sinus at the siphonal side; color, bluish white, apical area brown or olive, lines of growth olive, giving the shell a zoned appearance, but varying in every individual shell; often stained an uniform bluish black or much corroded; interior rich purple brown, highly enamelled; edge crenulate, spatula brownish white, extending partly down siphonal sinus.

Animal, dull brown, with numerous small light spots of varying size; foot yellowish, shading to orange near the head; mantle, brown, fringed at the edge with whitish and black spots. When the mantle is irritated the black spots seem to be the points where it is drawn in. Head, a large and many lobed mass, forming a cup-like expansion round the very small mouth; no eyes visible, and though they are represented in Messrs. Quoy and Gaimard's figures of *S. diemenensis*, I have never been able to detect anything, but a single black dot of varying position on one of the lobes of the head. Above the foot on the left side of the animal is a lobe which forms a kind of semicircular tube, closely pressed to the shell, and here the mantle is not visible. This tube is the siphon, and is lobed so as to be capable of a kind of bipartition which probably divides the orifice into an excretory as well as respiratory duct. This lobe of the foot acts as a kind of operculum, closing the orifice when necessary. My belief is that the animal breathes both air and water. If placed in the open air the siphon tube opens at once, and the tube is always open when the animal is taken from the rocks which it inhabits, and which are not long covered by the tide. On

placing weak carbonate of ammonia about an inch from the orifice the animal emitted bubbles of air and showed signs of distress by movement and by pouring forth water from the mantle. On immersing in water animals long exposed to the air many bubbles of air rapidly escape, and then the siphon became tranquil and full of water. In this state the animal continued many days. Magenta dropped into the water gradually spread out and was drawn imperceptibly into long threads of currents towards the siphon. Magenta dropped into the siphon was not emitted for a long time, and then thoroughly diluted and in fine streaks. All these facts tend to show that respiration is accomplished by no muscular movements, but by the ciliated surface, of the simple sac of which the lung is composed.

In the circumstance of breathing air and water the animal has this peculiarity in common with all our fresh water mollusca. I am not aware that this has been ascertained of our Siphonariæ, and certainly it was not known that its anatomy corresponds in every respect with the fresh water pulmonifera. The lingual ribbon of this and the following species I find to be in keeping with its pulmoriferous character. Mr. Woodward in his Manual (p. 286, 2 edit.) says, "The inoperculated air-breathers, without known exception, have rows of similar teeth with broad bases resembling tesselated pavement, whose crowns are recurved, and either aculeate or dentated." I may quote also on this subject the observations of W. Thomson (Annals Nat. Hist., 1851, p. 86). He says, "The tongue of the Pulmonobranchiata generally is a thin expansible membrane, two-thirds or three-fourths of which is rolled into a tube; the posterior end of this tube is closed, while at its anterior extremity the remaining portion of the membrane is expanded into a flattened or spoon shaped form which plays against the edge of the horny upper jaw, thus acting more as an under jaw than a tongue. It is enclosed in the muscular head and connected with the œsophagus at the anterior end of the tube, the extended upper portion of the œsophagus forming the roof of the mouth, while the expanded surface of the tongue covers the lower part of the mouth. From the junction of the œsophagus and tongue the former passes backward and leaves the head at the upper part, while the latter takes at once a downward and backward direction, and protrudes its closed end at the lower part of the head. The tongue when laid open is of the same width throughout. It is covered with a vast number of plates with tubercles which are curved backwards." The plates are in rows which are straight in the antero-postero diameter, but variously curved or angular transversely. The number of teeth is not constant in indi-

viduals, but is so within certain limits for the same species. The central tooth or plate is symmetrical and the lateral diverge from it in form as they are distant from it." They do this according to a certain rule, which is, "By the *suppression* of the prominences on the *inner side* of each lateral tubercle, and by the *increase* of the corresponding parts on the outer side." Again, "a gradual curve in the transverse line causes a gradual change in the form of the teeth; great angularity causes a sudden change: and the degree of duration from a straight line is the measure of the difference between the central and lateral teeth."

These valuable observations give the key to the form of the teeth in Siphonaria, though subject to considerable modifications. In a figure after Wilton in Woodward (*loc. cit. p.* 305) the teeth of a Cape Siphonaria is given (*S. venosa ?*) where the teeth are not in plates but linear, hooked, the *plate* or tubercle being both oblique, but the plate sloping from the centre, and the hooked tubercle towards it, with about 40 on each side, the transverse line curved upwards.

In *S. denticulata*, the buccal mass is red and fleshy, in which two long, thin, rather broad cartilaginous jaws are imbedded. Amid these the broad ribbon is spread, working almost perpendicularly, with a very slight movement backwards, as far as I could ascertain in the few opportunities which the shy and sluggish animal gave me of observing. The œsophagus is a bright orange yellow, and terminates at the distance of about 20 mil. in a sac of the same colour. The odontophore soon becomes a tube enclosed in membrane. It does not follow the œsophagus, but curls round and projects as a closed hyaline tube outside the buccal mass. When the animal is wounded it admits a viscid milky blood (?) of quite a different character from other gasteropods.

The odontophore with careful manipulation may be easily extracted and spread out. It is very difficult to clean it from the attached membranes, but when spread is about 8 mil. long by 3 broad. It is a series of curved lines of teeth diminishing in size from the centre to the margin. The teeth have a broad crescentic edge, which increases in width downwards and is fixed upon the membrane. The teeth gradually diminish outwardly to a mere faint line of curved tubercles. The appearance of the whole is more like a series of combs with long curved teeth. There appears to be, properly speaking, no plate from which each tooth projects, and the central tooth from which each row diverges in a curved line, is rudimentary.

Siphonaria diemenensis. *Quoy and Gaim. Loc. cit.*, vol. 2, p. 327, pl. 25., fig. 1 to 12. Shell oval, convex somewhat high, apex acute, median, with numerous small, con-

spicuous ash grey, rounded, radiating, slightly rugose ribs, about 40 in number, interstices dark brown, concave, with smaller ribs occasionally, which reach half up the shell. Margin acute and finely undulating Interior regularly marked with dark brown and white lines, the latter concave and corresponding with the ribs, the brown marks becoming broader towards the edge and often bifurcating, spatula badly defined and clouded reddish brown, siphon not always defined

The animal is a citron yellow beneath; above dusky, speckled with yellow. The head is separated from the foot by a deep transverse fissure. The base of the head is pale neutral tint. When the mouth is closed it appears as a reddish brown spot. The lower lip is yellowish, and when closed is like a longitudinal fissure. As it opens it becomes crescentic. The upper lip is then seen. It is arched; fine reddish brown above, with yellow cirrhi below. The odontophore is protruded from this, and moves up and down with an ordinary licking movement. The appearance it presents is that of the finger of a glove with the end pushed in upon itself, and the crowded edges of the tube thus formed brought together by the drawing in of the top until they unite in a rounded point, which is then drawn up. The pushing out and drawing in of the top of the "finger" from within is the manner in which it feeds. Thus the free end of the tube is apparently brought backwards and forwards, and the food triturated and carried into the œsophagus.

No eyes are visible, though Messrs. Quoy and Gaim. say they detected them *above*. They would be of no use above, as they would touch the shell. The aperture of the siphon is the same as in the last species. The process of the mantle which forms a kind of operculum, is often protruded a considerable distance from the shell. Messrs. Q. and G. say, "A little in front of the siphon is the female organ, and on the right side of the head the male, where the tentacle would be if there were one. These holes are very difficult to see. When the animal is taken from the shell it is found attached by a horse shoe muscle running round the posterior half of the shell above the mantle and foot. The siphon is seen as a tube running in a sinuous form through the pulmonary sac. By its side runs the intestine, which continues round the posterior part of the foot, and then disappears under the liver, and the ovary, which is often the largest organ, and of a bright salmon colour. The intestine makes many convolutions in the liver. The buccal mass is like the preceding species with the same kind of œsophagus, and, according to the Messrs. Q. and G., two large salivary glands below. The same authors say that the oviduct is carried under the uterus, which has the shape

of a '*cornemuse*' (the wind-bag of a bagpipe?) with a neck opening in front of the siphonal fold of the mantle. Upon this organ, and a little folded upon itself, is applied the canal of the vesicle, which is common to all the pulmoniferous mollusca, and whose use is unknown." The authors believe it has an opening in common with the uterus. Full details of the nervous and reproductive organs are given by the same authors, which, however, I have been unable fully to verify, but without further examination, I could not pronounce any opinion as to the correctness of their careful observations.

The odontophore of this species differs from the preceding in being much broader and not so long or so much curved, but the place and arrangement is the same. The central tooth is rudimentary, and the series diminishes in length and width in a curved line outwardly until it becomes a series of tubercles.

Mr. Reeve *(Icon. Siph.)* mentions another species peculiar to Australia and Tasmania, *S. funiculata*, but I believe it to be no more than a variety of the preceding.

Dr. Otto, A.L., Mörch, has in the Annals of Nat. History (1865, *Vol.* 16, *p.* 73 *et seq.*) given some very interesting and important details on the Buccal organs of Mollusca. He uses the name Radula for lingual ribbon, which probably is on the whole more expressive and convenient than Odontophore.