

V. *Further Observations on the Metamorphosis of GASTEROPODA, and the Affinities of certain Genera, with an attempted Natural Distribution of the principal Families of the Order.* By JOHN DENIS MACDONALD, Assistant Surgeon of H. M. S. "Herald," Captain H. M. DENHAM, R.N., F.R.S. Communicated by Professor HUXLEY, F.R.S., F.L.S.

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IN offering to British Zoologists the following remarks on the metamorphosis of Gasteropoda, I am anxious to premise that, as my present opportunities of consulting the researches of others in this field are extremely scanty, it is quite possible that my independent observations may appear to be but newly garbled statements of already published facts. I am willing, however, to risk this, feeling that confirmation, which is the only prop of simple assertion however truthful, must widen the basis of even accepted views. If such confirmation be afforded by this paper, it will not be altogether unimportant; but if the facts are new, which they are likely to be, so much the better.

When I first recognized a conformity in the dentition of numerous pelagic Gasteropods with that of certain clearly defined families, the inference was natural enough, that those little creatures formed a group in themselves, admitting of a like classification, though still, as it were, of a representative value zoologically speaking. Another idea, however, gained weight in my mind, namely, that they were merely the larval forms of genera better known to us in their perfect or adult state. This view I have endeavoured to sustain, in a former paper, with the evidence available at the time; and however inconclusive the arguments then adduced may have been, I am quite satisfied that the facts and materials since obtained will place it beyond all reasonable doubt.

While H. M. S. "Herald" lay at anchor on the leeward side of the Wreck* and Cato† Reefs, the tideway caused by the water sweeping over and around those obstructions brought many interesting objects to the towing net, including several genera of pelagic Gasteropoda, with which we are more immediately concerned in the present paper.

To enter at once into particulars, I first observed a little shell bearing the toothed and sinuated lip of a *Cheletropis*, and appearing to be a new species of that genus; but, having been previously placed on my guard against this deceptive resemblance, which I detected in another instance, I watched the movements of the occupant the more closely. I soon found that the great activity of the little creature and the peculiar form of its foot, which had a broad anterior margin, sloping sides, and a bifid posterior extremity, gave evidence of its being the young of a species of *Nassa*; and when its lingual dentition was examined under the microscope, this proved to be the case. I may remark that the lingual strap of *Nassa* is distinguished from that of *Buccinum* and *Pisania* by the absence of smaller denticles between the two principal fangs of the pleuræ, so characteristic of the *Buccinidæ*.

* Lat. 22° 10' 30". Long. 155° 30' 00".

† Lat. 23° 15' 00". Long. 155° 35' 00".

I next observed a stout little shell, much resembling a *Macgillivrayia* in form, but having the spire more minute and sharply marked, and the whorls beset with epidermic spines, disposed in close spiral lines. The microscopic examination of the animal gave unmistakeable proof of its being a *Ranella*, the lingual dentition agreeing, at least generically, with my figures and specimens. The rachidian plates of *Ranella* are boomerang-shaped, with the convexity in front, bearing a recurved angular process divided into sharp denticles. There is often also a small tooth on the posterior border of each arm, near its outer extremity. The uncini of the first series are sickle-shaped and serrulated, with a tooth on the inner side of the base, and those of the second and third claw-shaped, simple.

On examining the operculum, which in *Ranella* is so very remarkable, exhibiting three successive stages of growth, I found that it was quite of the same character, only that it had but yet attained the second stage. Finally, on comparing the whole operculum, and the little shell, respectively, with the nucleus of the operculum, and the apex of the shell of an adult *Ranella* obtained on the reefs, I could detect no points of difference, even with magnifying powers; the conclusion, therefore, is irresistible, that the one is but the young state of the other.

The young of *Triton* was also determined by the same mode of analysis, and I have been able to confirm my former conviction, that *Cheletropis* belonged to the *Muricidæ*, and that certain other pelagic shells, which I also figured and described, were referrible to the *Naticidæ* and *Strombidæ* respectively.

Of *Macgillivrayia* I obtained a new species, closely resembling that named *M. echinata* by Mr. A. Adams, only that the spines, which are disposed in a single row on the dorsum of the whorls, were perfectly straight and not "recurved;" and the later additions made to the outer lip extended as a thin lamina over the whorls towards the apex of the shell,—a condition which I have also discovered in the young of *Triton*, and which affords one amongst many reasons for placing *Dolium* and *Malea* (to which the several species of *Macgillivrayia* appear to belong) with *Triton* and *Ranella* in one natural family, culling them from amongst the very numerous and heterogeneous genera of the two families, *Strombidæ* and *Buccinidæ*, in which they are at present to be found. All these animals have a protractile proboscis with a septiserial lingual ribbon, partaking of the characters of that of *Ranella*, as above described. A pair of lateral oral plates, in general composed of indurated rhomboidal cells, is also invariably present; and if these particulars cannot be affirmed of a genus selected for this family from some fancied resemblance of its shell-characters, nothing is more certain than that some other natural family will be minus a member.

I obtained once more the little Gasteropod which I was unfortunate enough to name *Jasonilla*, it having previously, according to Mr. Adams, received no less than three titles, viz. *Brownia* (D'Orb.), *Echinospira* (Krohn), and *Calcarella* (Souleyet), though the anatomy of the animal remained unknown. I am now fully satisfied that the true shell is developed within the outer cartilaginous case which rejoices in the above synonyms, and that it is merely the young state of *Lamellaria* (a Gasteropod with a concealed spiral shell), of which we obtained a living specimen at the Cato Reef.

Having thus fallen in with the genus which I believe to be the adult state of *Brownia*, I transcribe its characters from rough notes taken at the examination of the solitary example alluded to:—

“*Shell* thin, membranous, depressed, paucispiral, with an open columella, communicating with a shallow and expanded aperture; completely inclosed in a thick outer mantle covering the back. This mantle may be described as a convex, mushroom-like shield investing the shell and viscera, and arching over the whole foot and head, with an emargination in front, admitting of the protrusion of the latter, and corresponding with the true mantle opening.

“A combed gill is distinctly visible in the mantle cavity, and the genital and excretory orifices are also included, on the right side. The foot is elongate, truncated and dilaminated in front, but flat and pointed behind, lying altogether in a depression within the thick margin of the epipodial shield. Tentacula conical, flattened, arising from the angles of a thin frontal lobe overlapping the muzzle; the ocelli placed behind the tentacula and close to the outer side of their base.

“The muzzle appears to be probosciform, and the mouth is armed with two strong lateral labial plates, jagged in front and united in a hinge-like manner in the middle line.

“Lingual ribbon of moderate length, triserial, with arched rachidian plates, armed with small teeth recurved from the anterior convex border. The uncini are sickle-shaped, serrulated internally and externally, and interlock over the rachis as in *Brownia*. Spherical otoliths are contained in the acoustic sacs; and the sexes appear to be distinct; but of this I cannot be certain, having had but a single individual to examine, which had been for some time preserved in spirits.”

The animal is very different from *Natica* and its allies, and I know of no family into which it may be with propriety received, except perhaps the *Velutinidæ**. Its true position appears to me to be between the *Muricidæ* and *Ranellidæ*, and side by side with *Velutina*.

I have already figured and described a little larval Gasteropod, having a subglobular cartilaginous case including the true spiral shell of the animal; and to this I have to add another and very beautiful species, of which we obtained several specimens off the Wreck Reef. In this instance the transparent outer case is subcylindrical and spirally fluted, one flute commencing at the apex, and then crossing the others obliquely, so as to form the principal part of the columellar lip, which is completed by a prominent and slightly involute process near the base of the slit-like aperture. The little contained animal, with its spiral shell and operculum, is distinctly visible within; but, as in the other examples noticed, the shell is so thin as to require additional protection in the morning of life. It must be stated, as furnishing one link in the series of changes here supposed to take place, that considerable numbers of the empty cases, rejected by their former occupants, are occasionally to be met with—a fact which I particularly observed at the Conway Reef. As to the mode of development of these curious structures I have but little to say. From the comparison of numerous specimens, it appears to proceed *pari passu* with that of the

* Dr. Gray established this family for *Velutina* with a (?), which latter I anticipate we shall soon find reason to remove.

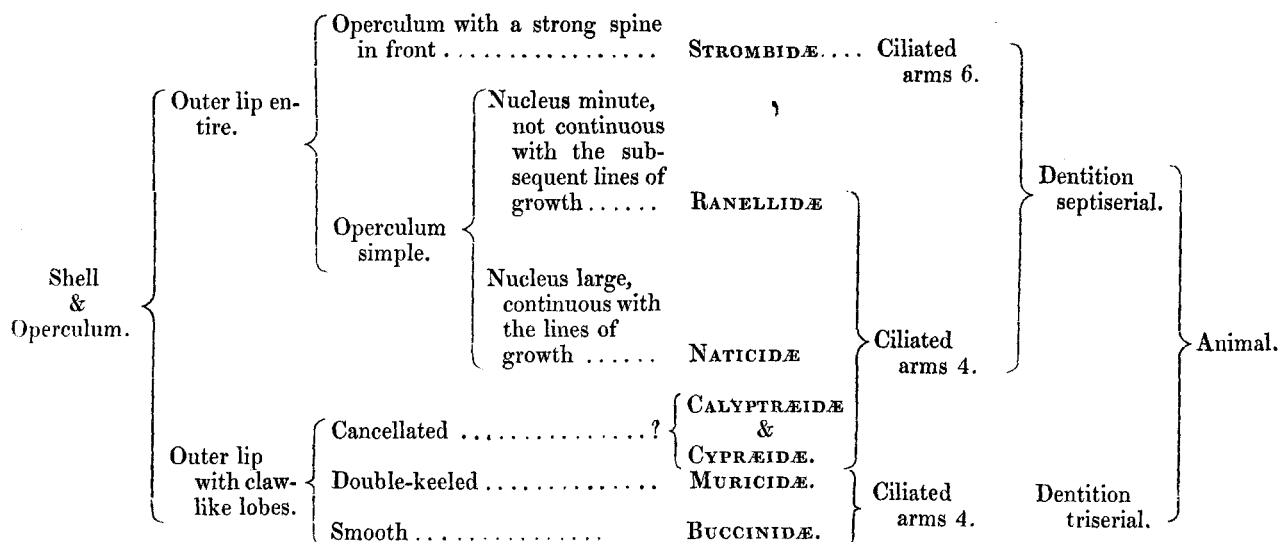
shell. Ample provision is made for this contingency by a dense epithelial pavement, which lines the cartilaginous shell, and which may possibly be homologous with that by which the test is evolved in the Tunicata. As the chief agent in the development of the outer shell, it may be termed the outer mantle; and there is much reason to believe that it is persistent in the adult *Brownia* and in many other cases. It is probably within an outer mantle, homologous with this, that the first rudiments of the shell are formed in the *Helicidæ*, and the outer thickened rim of the mantle in the adult animals may be the remnant of such a structure. Its coexistence with the true epipodia in *Aplysia* and other instances precludes the notion that it may be altogether composed of these processes which have coalesced over the back. These facts and considerations afford a simple explanation of the development of internal shells in general, not even excluding those of the Cephalopoda, into which the homologues of the retractor muscles of the Gasteropoda are fixed, although the shells themselves in the two Orders are not generally admitted to be homologous, even against the light which the scutellum of the slug is calculated to throw on the subject.

I must not omit to notice the capture of a minute *Pleurobranchus* in company with the pelagic forms, off the Cato Reef. It was entirely naked, with broad ciliated head-lobes, or festooned folds, apparently continuous with the epipodia. The large and beautiful labial plates exceeding the dimensions of the double lingual pavement of uncinat teeth, and the auditory sacs (in this stage containing single but minute otoliths) lying wide apart from the eye specks, at once distinguished it from *Doris* and other allied genera.

Besides the numerous groups yet to be determined as fulfilling the conditions set forth in this paper, I believe that I have already identified members of no less than six or seven natural families, which may be distinguished by the simple characters given in the following Table.

PELAGIC GASTEROPODA (so called).

With strap-like dentition and otoliths in the ear-sacs.



To these may be added *Brownia*, and those species which are included in a cartilaginous case.

General Classification of the GASTEROPODA.

I am thus insensibly led into the subject of classification, which I must say I approach with considerable diffidence, being fully conscious of the danger of falling into a dictatorial style, where the results of my own researches are at variance with the views of many worthy cultivators of the science of Malacology. It is quite foreign to my present purpose to enter upon the analysis of any single system. Well-informed zoologists naturally make what they believe to be truthful selections from all available systems, and thus, as it were, compound their own creed; hence I have to deal rather with such matters as are generally accepted than with the tenets of particular men. In justice to Mr. S. P. Woodward, I do not hesitate to state that the soundest general work on the Mollusca that has hitherto appeared in England is his little Manual published by Weale. There is more nature, truth, and judicious conciseness in all the descriptive parts than one is accustomed to meet with in works of this kind; and, although I am sometimes at issue with him, I trust that my opposition is never factious or merely for victory's sake.

Mr. Woodward has availed himself of the characters afforded by the lingual dentition more extensively, I believe, than any previous writer, if we except Professor Lovèn; but much remains to be done before these can be successfully applied in the defining of the natural families, and still more before all the genera of Gasteropods can be referred to their proper places in the system. In the following Table, showing the general nature of the lingual dentition and of the auditory concretions in the principal families, I have merely endeavoured to make a step in the right direction; though I have little doubt that when the numerous errors which are always incident to attempts embracing so wide a scope shall have been cleared away, and the right exposition given of the value and bearing of assumed points of affinity, a system will result inferior to none in the whole department of Zoology in the truthfulness of its natural arrangement.

From more extended study of the subject, since my former paper on the materials of classification was written, I have arrived at the conclusion that the nature of the contents of the auditory sacs is of minor importance to the primary characters of the lingual dentition, as to whether it is elongated and strap-like, or broad and pavimental. Two circumstances in particular suggest this view, viz.:—1st. The close anatomical relationship existing between *Cerithium* and *Planaxis*, and even the almost actual similarity of their lingual teeth, although the auditory sacs in the former contain otoconia and in the latter spherical otoliths. 2ndly. Several of the *Eolidæ* (if I am not mistaken, I think I may venture to add the genus *Flabellina*) have otoconial particles, while the others in general have otoliths. It cannot be supposed, however, on this account that the few belong to a different family; for their whole anatomy refutes such a supposition.

I may remark that amongst the *Doridæ* also I have observed the occasional occurrence of minute otoliths instead of *otoconia*. It is worthy of note that the *otoliths*, wherever they occur in such families as usually present *otoconia*, are exceedingly small, like the single primordial otoconial particle of the young *Pteropod* or *Nudibranch*; and in the converse examples, as in the *Cerithiidae*, where the presence of otoconia might *a priori* be quite unexpected, they are, as a rule, both few and large.

We now know enough of the distribution of otoliths and otoconia in the Molluscan Orders to perceive that there is a definite purpose in the bestowment of the one or the other, in particular cases ; and as this purpose is never the subject of caprice, but permanent, the resulting characters must be always significant, and therefore available in classification.

The division of the lingual dentition into straps and pavements, as previously defined, is not altogether free from imperfection, although it is most satisfactorily available in by far the greater number of genera. Indeed, it is only amongst the *Opisthobranchiata* that any difficulty in this respect presents itself. Can anything, for example, be more diversified than the characters of the lingual dentition in the *Bullidæ* of authors ? No less than four distinct types are distinguishable in this family, thus :—

Central series absent.		* Central series present.	
Laterals 1 or 2, uncinate, as in	Laterals more numerous, as in	Laterals more numerous, as in	Laterals 1 or 2, the third rudimentary, as in
SCAPHANDER and BULLÆA. (Philinidæ of Gray.)	BULLINA (Risso)* and APLUSTRUM. (Bullinidæ and Amplustridæ of Gray.)	BULLA (numerous species) and CYLINDRELLA. (Bullidæ of Gray.)	BULLA <i>ampulla</i> and AMPHISPHYRA. (Occurring respectively in the Bullidæ and Philinidæ of Gray.)

The aggregate character of the dentition here tabularized is pavimental ; but in *Bulla ampulla* it is more strap-like, on account of the great breadth of the rachidian plates, and the remarkable difference between these and the laterals.

It would be difficult also to form a judgment of the dentition of *Bullæa* taken by itself, the rachis being altogether absent, and the laterals much reduced in number.

In the Nudibranchiata, moreover, the pavimental character prevails, although in the *Elysiidæ* and *Eolidæ* the teeth are reduced to a single strap-like series ; and, considering the collateral relationships of both families, I think that this view is more natural than to assume that their dentition is essentially constructed on the type of the strap. With this explanation, the consistency of the present system of determining affinities is quite unaffected by the retaining of *Eolis* and its allies in that position, which their general anatomy indicates to be the natural one. On comparing the median row of teeth in the broad pavement of *Phyllirrhoë* with the single series of *Glaucus* or *Eolis*, a close observer cannot fail to be struck with their great similarity. According to my own experience, the formula of the dentition of *Phyllirrhoë* (3.0.3), as given by Mr. Woodward, is incorrect.

I have, I trust, already sufficiently proved the impropriety of founding a classification on the physiology of respiration alone, to say nothing of the peculiar anatomical conditions respecting it, which we may presume are always present, though not sufficiently known to be available. We know, from the analogy of the Crustacea in particular, that whether an animal breathe in water (fresh or salt) or in air, the general scheme of its structure exhibits no necessary restriction to this habit. The principle here indicated

* *Cylichna* (Lovén) and *Cylindrella* (Sw.) are regarded as synonyms of *Bullina* (Risso), though the two former genera present a central series in the lingual pavement, while Dr. Gray gives the dental formula of *Bullina* as 6.6.

is altogether ignored when all the air-breathing Gasteropods are associated in one so-called natural Order, *Pulmonifera*. Indeed the difference is so great in the two principal divisions of this Order, that the most superficial of all distinctions, namely, the presence or absence of an operculum, is sufficient to distinguish them. In this way, bisexual animals with a pavimental dentition are associated with unisexual animals having a lingual ribbon, and several more striking external differences. Indeed the characters common to both are such as apply to Gasteropods generally, affording no proof of their morphological agreement. This, therefore, must be my apology for separating the *Pulmonifera operculata* in the subjoined Table from their supposed alliance with *Limax* and *Helix*, and placing them in another division, with animals having an organization in more complete harmony with their own. The *Pulmonifera inoperculata* together with the *Opisthobranchiata* (M. Edwards) are retained in the position which Mr. Woodward gives them, as two natural series demanding no special change. I have, however, been obliged to place between them the transitional genera *Siphonaria* and *Amphibola*, removing the former from the *Patellidæ*, which it resembles only in the shell, and the latter from the Apple-snails (*Paludinidæ*), with which, even taking into account the obscure resemblance of its shell, it cannot have the remotest affinity. I refrain from the use of a family term to include those genera, because I have much reason to believe that *Siphonaria* is a member of the *Onchidiidæ*, while *Amphibola*, though *prosobranchiate*, exhibits an alliance with the Tectibranchs. However this may be, taking them in the order given, they render the passage from the *Pulmonifera inoperculata* to the Opisthobranchiate families easy and natural.

The members of the second division in the Table are unisexual, and in this primary character differ from those of the first. They admit of arrangement into three sections, in one of which the dentition is pavimental; in another altogether absent, while in the third it is strap-like. From actual observation and comparison of genera belonging to all the families cited, with one or two trifling exceptions, I am convinced that, first, the character, and, next, the number of the dental plates and processes, afford a truly natural test of the affinities of unisexual genera with strap-like dentition.

In studies of this kind I always bear in mind a grand principle, for which I am indebted to Mr. W. S. Macleay, namely, that *no character is natural until it has been proved to be so*. No scheme, for example, however plausible from its delusive applicability to a certain number of cases, can be accepted as natural, when conditions of greater value are violated by its adoption. The employment of the mere number of longitudinal rows of teeth in the lingual ribbon as a means of classification may be compared to the method of Linnæus, who based his Botanical System on the number and arrangement of the stamens, and would threaten at first sight to be equally artificial; but I find that the legitimate sway of characters of greater as well as of minor value is not interrupted or violated by its adoption. Hence it proves to be natural, sustained also by the axiom, "*natura non facit saltum*."

Errors with respect to sex may still lurk in the present Table, as I know to have been the case in a former one. I must state, however, that the sexual character of those instances which I have not been able to determine personally is supported by good

authority; and even though errors should here and there occur, it is much better, if possible, that nothing should be taken for granted merely because it might appear to harmonize with a pet theory.

Malacologists have always been at a loss to ascertain the natural position of *Janthina*; and the whole truth seems to be this—that it is not correctly referrible to any of the families already formed. Even though it should be placed by itself, as has been done by several authorities, its true relationship to other families in the series is still a matter of doubt. Dr. Gray interposes *Janthinidæ* between the Apple-snails and the Heteropods, though the general disposition of authors is to place the solitary genus near *Nerita* or in some neighbouring family. Mr. Woodward has selected the *Haliotidæ* for it, probably conceiving that the notch at the outer angle of the shell represented that of *Scissurella*, *Pleurotomaria*, &c. Taking the anatomy of the animal into consideration, however, it is easy to show that this position is most unnatural. It has often suggested itself to me, that *Janthina* was in some particulars related to the Opisthobranchiate families; and, although the affinity is certainly not immediate, I apprehend that it will be difficult to find a better place for it than between these and the very natural family composed of the genera *Solarium*, *Torinia*, *Scalaria*, and perhaps some others. If the latter family, which may be named *Solariidæ*, and the *Janthinidæ* are really unisexual, they will form a remarkable and beautiful link or passage between the Opisthobranchiata and the unisexual Gasteropoda with a lingual ribbon.

The following extracts from my notes will show that the family of the *Solariidæ* is founded on no hypothesis, but on facts:—

“ In upwards of ten fathoms at the Feejee Islands we obtained a small species of *Solarium*, apparently quite new. The shell is orbicular, much depressed, with a wide umbilicus, increasing with the growth of the whorls, and bounded by an angular and minutely beaded border, corresponding with the union of the lower and inner walls of the shell. This results from the revolution of a small lunated notch at the base of the columella, which is perfectly straight, directly joining the body-whorl. The outer lip is thin, and slightly angular at its central or more convex part. The mouth of the shell is trapezoidal, the angles being situate respectively at the base and summit of the pillar, at the middle of the outer lip, and at the union of this latter with the body-whorl. The most interesting part of this little shell is discovered on looking down to the bottom of the deep umbilicus, in which the sinistral nucleus, smooth, polished and completely inverted, may be distinctly seen. Operculum thin, horny, multispiral, slightly concave externally and minutely tuberculated.” (The operculum of the typical *Solaria* is paucispiral.)

“ The animal, in general appearance, much resembles one of Cuvier’s Tubulibranchiata. The creeping-disc of the foot is small, but the operculigerous lobe is large and subcylindrical. The tentacula are moderate, conical, with the eyes on the outer side of the base.

“ The proboscis is armed with two lateral oral plates, and the tongue with several series of tenaculiform teeth, of which the innermost are simple, the external trifid, and the intermediate bifid. Finally, the acoustic capsules contain minute *otoconia*.

“ *Solarium perspectivum*. This species occurs plentifully on the sea-side of Kamba

point, *Na Viti Levu*, Feejee group; and several specimens were selected for examination. The tentacula are stout, conical, and closely approximated above the mouth, with a longitudinal groove on their inner surface, and a somewhat sunken eye in a slight elevation or gibbosity at the outer side, near the base.

"The animal is furnished with a retractile proboscis of considerable length; and when retracted, the external aperture is quite round and so small as to be scarcely perceptible. The anterior border of the foot is dilaminated, the plates or lips being separated by a deep transverse recess, which appears to have some communication with the sinus of the foot. The creeping-disk or mesopodium is well developed, and the lateral borders, which are produced into a simple lobe, are probably confluent with the epipodia. Its posterior extremity is very thin, but rounded, and surmounted by the metapodium, which is a sub-cylindrical mass of muscular fibres, continuous with those of the great retractor, and abruptly truncated posteriorly, where it presents a subcentral recess, which lodges the internally produced nucleus of the paucispiral operculum.

"The oral teeth form a narrow circular band consisting of a pavement of sharp dental cells, whose points, as in other cases, are directed forwards.

"The lingual pavement is small, but elongated in form and divided into two lateral areas, supporting several series of long and gracefully curved uncinat teeth, which seem to decrease in length from within towards the lateral borders of the membrane, where they also become bifid in the vertical direction.

"The auditory sacs are of comparatively large size, containing *otoconia*.

"*Torinia* (Gray). The anatomical characters of this genus (distinguished by the peculiar gun-screw form of the operculum, so much resembling that of *Siliquaria*) agree in every essential particular with the foregoing.

"*Scalaria*. From a critical examination of the anatomy of *Scalaria*, I have no hesitation in placing it in the same family with *Solarium*. Its principal characters are as follow:—Proboscis long, retractile, with stout muscular walls; the oral aperture furnished with lateral plates, composed of small dental cells with their points directed forwards. Lingual membrane supporting a double pavement of tenaculiform teeth, rather stout, but still very similar to those of *Solarium*, and not, as has been supposed, like those of *Bulla*. Thus the outer teeth present one or two secondary prongs, while the inner remain simple. The eyes are placed at the outer side of the base of broadly conical tentacula; and the auditory sacs contain vibrating *otoconia*.

"The foot is dilaminated in front, and in general configuration resembles that of *Solarium*."

From the above facts I think it may be affirmed that it is a violation of the simplest anatomical principles to place *Scalaria* with the *Turritellidæ*, and *Solarium* with the *Litorinidæ*, the genera in both of which families, as now received, are otherwise heterogeneous enough.

The vermetiform character of the animal of *Torinia* on the one hand, and the peculiar structure of the operculum of *Siliquaria* on the other (so closely aping that of the former genus), afford some indication that both may belong to the same family. Moreover the groove in the outer lip of *Solarium* would appear to represent the branchial slit of *Sili-*

quaria; but until something more is known of the anatomy of the latter, I cannot hazard any further speculations on the subject of its natural position.

It may now be asked, what is to be done with the *Pyramidellidæ*, in which the lingual membrane is quite unarmed and consequently can afford us no guide in classification. The legitimate course in such a case as this would be to compare the whole tenor of the anatomy with that of other families, whose position has been better determined. With the hope of arriving at some successful result in this respect, I separately passed in review the anatomy of *Pyramidella*, *Odostomia*, and *Eulima*, all of which genera are rightly referred to the same family. But as the species of *Pyramidella* are usually more suited for examination, their study has given me the chief grounds for the conclusion I have formed, namely, that in their general anatomy they accord more closely with *Solarium* and its allies than with any other family that I can suggest. From these, however, they differ in two striking particulars, viz., the presence of minute *otoliths* in the ear-sacs instead of *otoconia*, and the absence of dental organs both labial and lingual. In these conditions, nevertheless, if my determination be correct, *Pyramidella* permanently represents the early state of *Solarium*. It is therefore not improbable that, if by any change in the routine of nature dental organs were to make their appearance in *Pyramidella*, they would assume the pavimental arrangement. However this may be, there can be little objection to the position chosen for the *Pyramidellidæ*, immediately succeeding the *Solariidæ*, while there is much to sustain it.

The fore part of the head (or the muzzle) of Gasteropods presents at least three different modifications which may be of service in classification. Thus, 1st, it may be simple, incapable of retraction beyond what is distinguished as mere contractility; 2ndly, probosciform or retractile from the apex, invaginating itself with one simple fold; or, 3rdly, it may be a true proboscis, retractile from or near the base, with two resulting folds. The latter form is present in all unisexual Gasteropods having a lingual ribbon with three rows of teeth and under, and in some few families in which this organ presents seven rows. The 2nd occurs in the *Cypræidæ*; and all the rest, with one or two questionable exceptions, have simple muzzles with a dental armature of seven series and upwards. *Pileopsis Hungaricus* is figured and described as possessing a retractile proboscis of considerable length; while the other members of *Calyptræidæ* have plain though more or less produced muzzles; and it is very doubtful whether the animal in question properly belongs to this family, there being much in favour of its affinity to *Velutina*, as suggested by Mr. Woodward. I must say that I have never discovered a true proboscis in the animals of the numerous *Pileopsis*-like shells which I have examined from time to time. The importance of the distinctions here indicated is also exhibited in the case of the genus *Erato*, which is admitted on all hands to belong to the *Cypræidæ*.

Erato is anatomically related to *Triton*, or probably to *Cassis*, rather than to *Cypræa*, as the inspection of its labial and lingual dental organs will at any time prove. Its lengthy proboscis is retractile from the base; and the extremity of the tongue-sac can therefore never lie freely in the visceral cavity—one of the most essential characters of the *Cypræidæ*, though not peculiar to this family.

The last case which I have to notice in this connection is that of *Triforis*. In a dextral

example of this genus*, which I collected myself on the Wreck Reef, I found that all my previous remarks on its anatomy were correct, save that the lingual membrane was stated to support a "multiserial pavement of minute teeth." Employing a one-sixth-of-an-inch objective (Ross), I discovered my mistake with regard to this very small strap; and I think I may now very safely say that it is septiserial; and so far, indeed, *Triforis* agrees with *Cerithium*. But when we take its otoliths, retractile proboscis, and lateral labial plates (composed of amber-tinted rhomboidal cells) into consideration, a place near *Triton* or *Ranella* can scarcely be denied to it. I am still convinced that the early state of its shell affords only an apparent mark of affinity to *Cerithium*. On the other hand, three openings homologous with those of *Triforis* are strikingly apparent in some *Ranellidæ*.

Having made one flagrant mistake, however, with regard to *Triforis*, I feel now rather disposed to leave the determination of its true status to more able malacologists, throwing out one hint—that its operculum is pointed, with an apical nucleus, as in *Cerithiopsis* (Forbes), which also possesses a retractile proboscis.

An error of observation is far more unpardonable than the false determination of the genus to which any particular shell may appear to belong; for it often happens that in the short but indefinite descriptions of the shell-characters given by authors, perspicuity is sacrificed in the attempt to attain conciseness. On this account I fell into another mistake, confounding a short and stumpy *Fasciolaria*, having very obscure plates on the pillar, and a crenulated outer lip, with Swainson's *Tritonidea*, which has now become synonymous with *Pisania*. The operculum in both genera is stout and claw-shaped, and the animals themselves are not at all unlike each other.

The lingual dentition of *Fasciolaria*, *Fusus*, and *Clavella*, however, may be at once distinguished from that of *Pisania*, which I believe to belong properly to the *Buccinidæ* and not to the *Muricidæ*, if the *Buccinum cinctum* of Quoy, and *Pusiosterna* of Swainson may be taken as true examples.

So far as I have been able to discover, besides *Murex* itself, *Hemifusus* (Sw.) is the only genus, in the whole of the *Muricidæ*, having an operculum with an approach to an apical nucleus, which is essential to *Pisania*.

The family-difference observable in the dentition of the *Buccinidæ*, *Fusidæ*, and *Muricidæ* is so distinctive, that, when once recognized, no confusion of the species of one family with those of another can possibly occur; and thus an unfailing guide is afforded in the determination of doubtful cases, which may be more or less conformable with the definition of *Pisania* or any other ambiguous genus.

I leave the case of the *Aciculidæ*† an open question until I shall have the opportunity of comparing the anatomy of *Geomelania* and *Acicula* with that of *Egea* (Benson?), which I think may possibly be identical with the former genus; and if so, it will bring along with it some freshwater and littoral genera, viz., *Hydrobia*, *Syncera*, and a number of beautiful little *Paludina*-like shells now placed in the *Rissoïdæ*.

Truncatella is doubtless close at hand, though perhaps sufficiently distinct to form the

* Having obtained a second dextral *Triforis* at Moreton Bay, it may be safely stated that the shell is not invariably sinistral, though commonly supposed to be so by conchologists.

† As accepted by Mr. Woodward.

type of a separate family, with some more truly marine examples of which I am well acquainted. Many *Truncatellæ* live far inland, exhibiting a terrestrial habit as obviously as any of the operculate Pulmonifera; and their anatomical characters are well worthy of a rigid comparison with those of *Acicula*.

The *Patellidæ* exhibit many points of affinity to *Fissurella*, *Nerita*, and the series to which they belong. Several members of the family manifest a tendency to deviate from the typical species, in their dental formula in particular; and indeed the whole lingual armature in *Patella* appears but to represent the rachidian area of *Turbo* or *Nerita*,—the pleural teeth being suppressed, as in the mooted cases of *Elysia*, *Eolis*, &c., noticed in the first part of the paper.

The affinity here advocated is still further suggested by the peculiar sculpturing, olivaceous colouring, and nacreous lining of the shell, in some species of *Acmaea*.

The *Patellidæ* and *Dentaliidæ* have a broad upper-lip mandible, and their ear-sacs contain otoconia, but the resemblance ceases here; while on the other hand in the *Chitonidæ* no upper-lip mandible exists, and I have never been able to detect either visual or auditory organs. I must give up the attempt to class the two latter families; but I think that the *Patellidæ* may be placed provisionally at least as an appendix to the *Fissurellidæ*.

I have no desire to repeat former observations, and therefore refrain from any further comment on the particular families contained in the Table. I can only say that I have endeavoured as much as possible to make the order of their arrangement in strict accordance with their anatomical relations. With all its imperfections, therefore, the scheme is submitted to the judgment of the zoologist, purporting to be merely a help to the attainment of a precise conception of the natural affinities of Gasteropoda.

CLASSIFICATION OF THE GASTEROPODA,

Showing the nature of the Lingual Dentition and of the Auditory Concretions in the principal Families.

Division I.—Sexes combined.

Lingual dentition pavimental, though in a few instances reduced to a single strap-like series.

Ear-sacs containing otoconia in general, but which are reduced to a single particle in several genera.

1.	2.	3.
<i>Pulmonifera inoperculata</i> , breathing in air, with lung-chamber alone.	<i>Bisexual Prosobranchiata</i> , breathing in air and water, with lung-chamber and gill.	<i>Opisthobranchiata</i> , breathing in water alone, with special branchiæ or by the general surface.
<p>Limacidae.</p> <p>Helicidae.</p> <p>Lymnaeidae.</p> <p>Auriculidae.</p> <p>Onchidiidae.</p>	<p>Siphonaria and Amphibola.</p>	<p>Tectibranchiata.</p> <p>Tornatellidae.</p> <p>Bullidae.</p> <p>Aplysiadae.</p> <p>Pleurobranchiidae.</p> <p>Phyllidiidae.</p> <p>Nudibranchiata.</p> <p>Doridæ.</p> <p>Tritoniidae.</p> <p>Phyllirrhoidæ.</p> <p>Elysidae.</p> <p>Eolidæ.</p>

Division II.—Sexes distinct.

Including the unisexual Prosobranchiata and the Pulmonifera operculata.

Section A.

Lingual dentition in the form of a double pavement.

Proboscis retractile.

1.	2.
Teeth uniformly simple, uncinatè, Proboscis short, stout. Ear-sacs with minute otoliths &c. Ianthinidæ.	Outer uncini furnished with one or more supplementary cusps. Ear-sacs with otoconia. Proboscis lengthy, &c. Solariidæ.

Section B.

Lingual membrane wholly unarmed.

Ear-sacs with minute otoliths, but in other particulars resembling Solariidæ.

Pyramidellidæ.

Section C.

Lingual dentition ribbon-like.

1.			
Dental processes directed backwards from the posterior part of the dental plates.			
Ear-sacs with otoliths.			
Strap uniserial.		Strap triserial.	
Teeth straight for piercing.	Teeth gently curved.	Pleural plates broadly attached, fixed.	Pleural teeth uncinatè with lateral motion.
Conidæ.	Pleurotomidæ.	Buccinidæ.	Columbellidæ.
			Costellariidæ.
			Muricidæ.
			Cynodontidæ.
			Mitridæ.
			Fusidæ.
			Lamellaria.
			Planellaria.
			Ranellidæ.
			Naticidæ.
			Strombidæ.
			Cassidæ.
			Cypreidæ.
			Calyptræidæ.
			Vermetidæ.
			Littorinidæ.
			Paludinidæ.
			Melaniidæ.
			Truncatellidæ.
			Egoidæ.
			Planacidæ.
			Cerithidæ.
			Cyclophoridæ.
			Helicinidæ.
			Neritidæ.
			Turridæ.
			Haliofidæ.
			Fissurellidæ.
			Patellidæ.
			Not classed—Dentaliæ and Chitoidæ.