

XXXII. THE ANATOMY OF *MELQ*
INDICUS, Gmelin.

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(Plates xxviii-xxxij).

I.—INTRODUCTORY.

Through the kindness of the authorities of the Indian Museum of Natural History, and of Dr. J. Travis Jenkins, two specimens of *Melo indicus*, Gmelin, were forwarded to me for examination.

The identification was made by Mr. Preston and confirmed by Mr. E. A. Smith. *Melo* is a genus, or subgenus, in the family *Volutidae*, belonging to the *Stenoglossa Rhachiglossa* in Bouvier's classification of the Monotocard Gastropods.

Bouvier makes the following the chief characteristics of the RHACHIGLOSSA:—

1. The central tooth of the radula is nearly always well developed and the radular formula is not above 1. 1. 1.
2. The special unpaired gland of the oesophagus is well developed, but its duct only rarely traverses the nerve collar (pl. xxx, fig. 6, Unp. Gl.).
3. The supra-intestinal ganglion approaches the right pleural ganglion (pl. xxxii, fig. 21, R. Pl. G. and Sp. Int. G.).
4. The visceral ganglion is subdivided (pl. xxxii, fig. 21, V and V¹).

These characters seem to mark them out among the STENO-GLOSSA, which are characterized by Bouvier as follows:—

1. Radular formula 1. 1. 1., often reduced in various ways.
2. A retractile proboscis (pls. xxviii and xxix, figs. 1-4, Pr.), a well-developed pallial siphon (S), a siphonostomatous shell, a large and bipectinate osphradium (Osph.), a penis. Accessory tubular buccal glands (pl. xxx, fig. 6, T. B. G.) may occur, there is one pair in *Halia*, one pair with ducts uniting in *Volutidae*, etc., none are found in *Buccinidae*.
3. A pair of racemose buccal glands with ducts which do not traverse the nerve collar (pl. xxx, fig. 6, R. B. G.).
4. A special unpaired gland of the oesophagus in many forms (pl. xxx, fig. 6, Unp. Gl.).
5. A highly concentrated nervous system without labial commissure or pedal cords. The ganglia of the reduced buccal mass near the cerebrals. Zygoneury

very highly developed on the right side (pl. xxxii, fig. 22, Zy.). Position of supra-intestinal ganglion variable. One otolith in each otocyst.

The Volutidae are a family of the Stenoglossa Rhachiglossa with the following characters, according to Bouvier:—

Externals (pls. xxviii–xxx, figs. 1–5). A fore-roof (Fore-R.) above and in front of the mouth, covering a part of the front end of the foot. On this are the reduced tentacles (t.), and, behind them, at the sides, the oculiferous projections (e.). Innervation shows that this fore-roof is due to concrescence and enlargement of the tentacle-bases. A strong, rather short siphon (S.) with a large thin projection on each side of the siphonal gutter (R.S.T. and L.S.T.). A fairly short proboscis and sheath.

Alimentary canal (pl. xxx, figs. 5–7). A pair of normal, racemose, buccal glands (R.B.G.) forming a mass from which the ducts go far forwards, becoming engaged in the gut-wall on the way. Accessory glands of tubular form (T.B.G.), typically uniting before they reach the gut, the common duct lying in the ventral wall of the radular sac and opening very far forwards, almost into the mouth.

Nervous system (pl. xxxii, figs. 21–22). Cerebral ganglia fused to form a trapezium. Pleurals barely separated from cerebrals. Supra-intestinal ganglion relatively very far from the right pleural (but in thus generalising Bouvier is probably wrong). Subintestinal ganglion almost continuous with left-pleural, zygoneurous (Zy.) connection with the right pleural short and broad.

Pilsbry-Tryon describes the Volutidae as characterized by the radula:—

Tooth formula 0-1-0, the tooth being tricuspid with large lateral points in *Cymbium*, *Melo*, *Voluta*, *Hyria*, etc. In *Voluta musica* the tooth is multicuspid and very transverse. In *Amoria* the tooth is unicuspid with a concave base.

The genus *Melo* is defined by shell characters and Pilsbry thinks the absence of an operculum is not proven for many of them. Adams states that the animal is ovoviviparous, the young ones being arranged in the oviduct of the female in a long string without egg-shells. In *Voluta*, the mantle is not so greatly expanded as in *Cymbium* and *Melo* and the foot is proportionately not so large. Volutid shells are rarely collected with the animal except when accidentally thrown ashore after a storm. The reason is that, like the Naticae, they bury themselves under the surface as soon as the water falls and the sand is left dry by the tide (Gray).

Haller's papers on the Rhachiglossa relate to Buccinids and Purpurids for the most part. Bouvier examined *Voluta neptuni* which is said to belong to the genus *Melo*. Woodward worked at *Voluta (Cymbiola) ancilla*, Sol., *Neptuneopsis gilchristi*, Sby., and *Volutilithes abyssicola*, Ad. and Reeve. My results are in very general agreement with his.

Pace has worked at *Voluta musica*, about the relationships of which there is some doubt. It is a West Indian form, whereas 80% of the species of *Volutes* live within a triangle having its extreme points at Ceylon, Japan and New Zealand. It has a fusoid, narrowly elongated operculum mounted on a distinct pad. This is also found in *Neptuneopsis*, *Volutolyria* and *Lyria*, but no trace of it appears to subsist in *Melo*.

II.—EXTERNAL CHARACTERS AND BRANCHIAL CAVITY.

(Pls. xxviii—xxx, figs. 1—5).

The lack of adequate illustrations of the Rhachiglossa has led me to sketch this type from several points of view, both the specimens used being females.

The foot is large and massive with a long definite anterior edge, grooved (pl. xxviii, fig. 2, Gr.) and glandular as usual. This type of foot can be compared with that of *Natica*, *Bulla*, *Scaphander*, etc., being apparently in every case an adaptation to the burrowing habit. In this connection, too, the compact rolling of the spire above the foot is noteworthy. The disposition of the spire and the columellar muscle makes possible the wide opening of the branchial cavity on the animal's right side (pls. xxviii and xxix, figs. 1 and 4) with the result that the rectum opens well back on that side (pl. xxix, fig. 4, A.), and the other openings are also a good way off from the ctenidium and osphradium. The roof of the cavity between the ctenidium and rectum has the usual mucus gland with oblique ridges in its surface. In one specimen, as also in a part of another sent, but not in the other complete one, there was a well-marked swelling (pl. xxviii, fig. 1) not far in from the edge of the cavity's roof.

The siphon (S.) is short and strong and possesses two tentacles at its base, one above and to the right (R.S.T.) and the other below and to the left (L.S.T.) of the gutter.

The osphradium (Osph.) is situated in the branchial roof and is bipectinate, with its leaflets approximately parallel to those of the ctenidium and somewhat oblique to the incoming stream of water along the siphon. The leaflets are rather thinner and finer than those of the ctenidium.

The monopectinate ctenidium (ct.) and the osphradium both curve round to the left as they go back. The leaflets of the ctenidium are long-based low triangles.

The proboscis (Pr.) is fairly short and pleurembolic. Pl. xxviii, fig. 1 shows it expanded to some extent while pl. xxx, fig. 5 gives it in the completely retracted condition. The great mass formed by the retracted proboscis and the sheathing body wall displaces the oesophagus (pl. xxx, fig. 5). When the proboscis is extended its wall continues back practically without a kink into that of the proboscis sheath.

The lamina or fore-roof (Fore-R.) above the proboscis, mentioned as a characteristic of the *Volutes*, is very well developed

and the small tentacles (t.) occur at the sides of its front edge with an eye (e.) on the outer side of the base of each of the two anterior ones; the additional tentacle is situated at the base of the fore-roof on the right side. The fore-roof may be compared with the analogous developments in *Bulla*, *Scaphander*, etc., and pl. xxviii, fig. 2 shows how it lies over the proboscis. If the siphon is contracted and the anterior edge of the mantle pressed against the fore-roof, the proboscis, etc. being contracted underneath and pressed up by the expansion of the foot in burrowing, the branchial cavity must be fairly effectually closed in front.

III.—ALIMENTARY CANAL. (Pl. xxx, figs. 5—7).

The actual entrance to the food canal found on dissection will vary a little according to the state of protraction or retraction but there is always a short conjoint section of the canal which then divides giving fore-gut above and radular sac below. The cavity of the latter is practically nil except just in front.

There is a cushion for the radula, a membrane with thickening on either side, *i.e.*, one may speak of a pair of cartilages which are long and narrow, lath-like in fact. They are bound together by the membrane in which they develop and by muscle-fibres joining them. There are also muscle-fibres around them and at the sides, joining them to the proboscis wall. Some of the fibres run forwards and protract the cushion and others run backwards and serve for retraction. The fact that the radula is in an organ (the proboscis) which moves back and fore, however, makes the separate movement of the radula less important and the odontophore and its musculature are therefore less complex than in Gastropods without a long retractile proboscis.

The radula has been described elsewhere. It is reduced to one tooth, the median or Rhachis tooth, in each row; the tooth is powerful and tridenticulate. The whole radula rests on a strong membrane, the front end of which, bent down over the cushion, is held by a strong pair of ventral-stretching muscles going back in the middle line.

Muscle-fibres arise also from the sides of the subradular membrane and go to join the sheath; they keep the main part of the radula tense, pulling it backwards and outwards on either side.

The glands of importance to the mouth region of the gut have their ducts much elongated as they are necessarily massed behind the proboscis region. They are:—

- (a) One pair of ordinary acinous buccal glands (R.B.G.). The ducts run alongside the fore-gut and get involved in its wall, ultimately opening near the junction of gut and radular sac.
- (b) One pair of glands (T.B.G.) formed of long, much bent, folded tubes. These tubes ultimately unite and the united duct curls along in the ventral wall of the radular sac to open near the junction of the sac with the fore-

gut. The distal ends of the tubes are much longer than the ends which unite.

Behind the proboscis, the gut lies in the general anterior cavity suspended by many fibrous strands. Just behind the proboscis is a short section of somewhat increased diameter (Ph. L., pl. xxx, fig. 6) corresponding with the "Pharynx de Leiblein" noted by French observers in some other Rhachiglossa. Behind this, the nerve-collar gathers round the gut, and, some distance behind this, the great median or unpaired gland of the fore-gut stands out above it. The duct of the latter goes forward in the gut wall and opens near the level of the nerve-collar. Bouvier thought the gland was usually small in Volutids but large in *Melo neptuni* which he studied. Woodward thought the gland longer in Volutids than in the Rhachiglossa in general. Pace found a very large gland in *V. musica*. It is certainly large in *M. indicus* and the other observations make it probable that Woodward is right.

The oesophagus is continued back as a cylindrical tube which widens suddenly at a certain level. The lining of the wider section is strongly ribbed by longitudinal folds (pl. xxx, fig. 7a) and this section goes back into the visceral mass where it opens into a stomach which is of a U, or, rather, a V-shape with a caecal outgrowth on one side. The digestive gland occupies the upper part of the spiral and communicates, so far as I have been able to trace it, with the caecal outgrowth of the stomach by two openings (see pl. xxx, figs. 6—7). Following upon the stomach is the short intestine overlying the oviduct and wrapped around to a considerable extent by the right (or posterior) portion of the excretory organ. The anus (pl. xxix, fig. 4, A.) is deeper in the branchial cavity than the oviducal opening. Both lie, as already stated, well back on the right side and thus out of the way of the ctenidium and osphradium and the arrangements which, it has been suggested, secure the closing of the front margin of the branchial cavity.

IV.—NERVOUS SYSTEM. (Pl. xxxii, figs. 21 and 22).

The nervous system has been described more thoroughly than any other, and Bouvier's observations are established and confirmed, as usual, by subsequent workers. A detailed account of the system is therefore superfluous though reference may be made to the interesting question of the supra-intestinal ganglion.

Cerebral, pleural and pedal ganglia are intimately united in pairs and the cerebrals are closely fused with the pleurals to form a trapezoidal mass. From this mass are given off, as Bouvier found,—

- (a) Two large nerves to the proboscis on each side.
- (b) Nerves to the fore-roof above the head.
- (c) Nerves to the anterior part of the body wall.

The above are from the cerebral ganglia.

- (d) Parietal nerves from the pleural ganglia.

- (e) The short connective, so short as to be almost non-existent, to the supra-intestinal ganglion (pl. xxxii, fig. 21, Sp. Int. Gl.).

This ganglion is similarly near the cerebropleural mass in the Volutids examined by Woodward, in *Voluta (Cymbiola) ancilla* (Sol.), *Neptuneopsis gilchristi* (Sby.), and *Volutolithes abyssicola* (Ad and Rve). Pace examined *Voluta musica* and found that this form has the supra-intestinal ganglion separated from the cerebropleural mass by a considerable length of visceral connective. Bouvier's type was *Voluta neptuni*, Gmelin, which is referred by Pace and Woodward to the section "*Melo*," but is grouped by Pilsbry-Tryon with *Cymbium*; he found the connective between the pleural and the supra-intestinal ganglion long. This seems to indicate that the type now under discussion, *Melo indicus*, Gmelin, can hardly be in the same section of "*Voluta*" as Bouvier's species.

The supra-intestinal ganglion gives rise to three chief trunks, not so many as in Bouvier's type which had eight to ten nerves arising here. The two anterior trunks branch and supply the body-wall and the ctenidium and osphradium. There seems to be an anastomosis between one branch nerve to the body-wall and siphon from this ganglion and a nerve from the left pleural ganglion.

The third of the trunks is the visceral loop (V.L. sp.).

The sub-intestinal ganglion is, as usual, close to the pleural, but is more closely bound up with the right pleural than in Bouvier's type, the zygoneurous connection (Zy.) being very short and thick. The zygoneurous connection, it will be remembered, is formed by a great parietal nerve of the right-side passing through the subintestinal ganglion. The subintestinal ganglion therefore appears to give off this parietal nerve (R. par.) and also the visceral loop.

The visceral loop is quite normal, with two ganglia (v and v¹) at the back, the supplementary ganglion being to the left of the principal one. From the supra-intestinal part (V.L. sp.) of the commissure, near the point when it passes over the oesophagus, a nerve seems to branch off to the branchial region. The supplementary ganglion is situated on the loop just after it has crossed the intestine, and from it a nerve runs up towards the heart and visceral mass. The principal ganglion is a short distance to the right and it gives off various nerves including one to the heart, etc. and one to the rectum and neighbouring parts.

The buccal ganglia are close below the cerebrals and are connected by a commissure. The pedal ganglia are connected closely with the cerebropleural mass and with one another and give off numerous nerves which I have not further studied.

V.—CIRCULATORY SYSTEM.

The heart is slung in the pericardial cavity (pls. xxix & xxxi, figs. 3 and 8) by the connection of the efferent ctenidial vein with

the auricle above (technically forwards and to the left) and by the base of the aortæ below. The pericardial cavity is fairly spacious and its connection with the renal organ is on the posterior or right side of its floor. The pericardial lining does not seem to possess glandular specialisation though my specimens were not in a condition for histological examination. The ventricle is strongly muscular, with the muscle internally in longitudinal bands, the bands being radially arranged. The auricle was strongly contracted in the specimens examined, but a valve seems to exist between it and the ventricle.

The base of the aortæ is guarded by a pocket valve on the side towards the anterior aorta and the wall projects inwards from the side towards the posterior aorta; these arrangements must be effective against back-flow.

There are as usual two aortæ.

The anterior aorta is strongly walled and follows the oesophagus for some time (pl. xxxi, fig. 9), giving off several branches to bodywall, columellar muscle and foot across it. A large branch goes to the siphonal region, and the anterior region generally.

The visceral aorta is also strong and it divides as shown in fig. 9.

The spaces throughout the body are blood spaces. They may be grouped, more or less, into sets:—

- (a) The spaces in the foot, often running along with the nerves.
- (b) The general anterior cavity continued into the cavity of the proboscis. This cavity communicates with the spaces in the foot more especially, though not exclusively, in the neighbourhood of the pedal ganglia.
- (c) The spaces between and amongst the parts of the renal organ, reproductive organs, and intestine, *i.e.*, the lower part of the visceral mass. The connection of these spaces with those of the anterior cavity appears to be regularized into what is practically a vessel (pl. xxxii, fig. 16, Ant. V.) and certainly these spaces are, otherwise, practically completely cut off from those under (a) and (b).
- (d) The spaces amongst the parts of stomach and liver, *i.e.*, in the upper part of the visceral mass, somewhat distinctly marked off from those under (c) with what may be called an anterior visceral sinus.
- (e) The spaces in mantle roof, ctenidium, and siphon. The afferent channel to the ctenidium continues the anterior visceral sinus. These spaces, especially towards the siphon, are also in connection with those of the general anterior cavity (b above). The afferent ctenidial channel is well marked.

The blood channels in connection with the renal organ are regularized to some extent and are discussed in connection with that system.

If one may infer from the arrangement of blood channels, the general course of the circulation would be from the heart *via* the aortae to either the head, foot, siphon, etc., or to the visceral mass. From the former to the general anterior cavity, thence *via* the renal organs to the anterior visceral sinus which presumably also gets the blood from the channels amongst the viscera (*d* above). Thence to the mantle and ctenidium roof and so back to the heart.

The separation of the sets of spaces is perhaps somewhat marked and one gets the idea of a fairly regular system allowing of course for movements of blood due to such other causes as the expansion and contraction of the foot, the protrusion and retraction of proboscis and siphon, and so on.

VI.—EXCRETORY SYSTEM.

The renal organ is treated by Perrier who studied *Voluta neptuni*. It is situated on the right side of (that is, actually, behind) the pericardium (pl. xxix, fig. 3), and is a large massive organ occupying the lower part of the visceral mass and covered by the ovarian tubules. It consists of (1) the massive posterior or right lobe (see R. L., pls. xxix & xxxi, figs. 3, 10—13), which has a spongy structure (pl. xxxi, fig. 15) and opens into the general renal cavity by fissures between some of its projecting lobes (pl. xxxi, figs. 12 and 13). This lobe is wrapped around the rectum on the dorsal side of the latter.

(2) The smaller anterior or left lobe (L.L., pls. xxix & xxxi, figs. 3, 10—13), a band of tissue of a lighter colour than the other lobe. It runs vertically, parallel to the posterior (morphologically right) wall of the pericardium. This band is, as it were, suspended from the roof of the cavity (pl. xxxi, figs. 11 and 12) and is attached to the floor just within the lips of the external openings (see fig. 12). Through this attachment it receives a branch channel (pl. xxxii, fig. 16, L.L.V.) from the great blood channel leaving the general anterior cavity (A.V.). The surfaces of the left lobe are somewhat swollen out, making numerous flat lobes with furrows between them (pl. xxxi, fig. 14).

(3) The so-called nephridial gland (N. G., pls. xxix & xxxi, figs. 3 and 10—13) against the pericardial wall, but not extending over its (morphologically) anterior end. The internal surface is somewhat ridged and grooved and there are pits at intervals (pl. xxxi, fig. 13).

The general renal cavity is partly subdivided by the vertically hanging left lobe as described. Just below the nephridial gland, and towards the right side (morphologically, forwards) the renopericardial canal (Rn. P.P., pl. xxxi, fig. 12) enters. The pericardial canal is short and direct. The circulatory arrangements of the renal

organ were worked out as far as possible. A very definitely walled channel (Ant. V., pl. xxxii, fig. 16) coming from the anterior cavity of the animal (see above) runs just beneath the side of the external opening of the renal organ and, once arrived under the floor of the organ, it gives off branches as follows:—

- (a) A branch to the nephridial gland (N. G. V., pl. xxxii, fig. 16).
- (b) A branch to the left lobe (L.L.V., pl. xxxii, fig. 16).
- (c) A branch to the large part of the posterior or right lobe which lies morphologically in front of and topographically to the right of the external aperture (R.L.V., pl. xxxii, fig. 16).
- (d) A branch which goes along beneath the floor of the renal cavity and gives off branches to the several projecting lobes of the right lobe (R.L.V., pl. xxxii, fig. 16).

The last-named blood channel appears to connect with the anterior visceral or abdominal sinus (A. Abd. S). The latter apparently also gathers blood from sinuses in the body wall and elsewhere around the renal organ, liver, etc.; it is situated between the pericardium and the stomach and communicates with the afferent blood channel of the ctenidium.

VII.—REPRODUCTIVE SYSTEM. (Pl. xxxii, figs. 17—20).

Both my specimens were females so I can only describe this sex and, in connection with it, I have mainly to confirm Haller's results from *Concholepas peruviana* with some additional observations. In other words, the genitalia are very similar in this sex for the two types.

The ovary is composed of a number of long tubules spreading over the surface of that portion of the visceral mass which is occupied by the large posterior or right lobe of the kidney. The tubules form a branched system and lie side by side. As they unite they approach the posterior edge of the upper surface of this portion of the visceral mass and then bend round to its under (posterior) side in the lower part of which they open (after further uniting in pairs) into the common collecting duct which goes forward to open into the large oviduct.

This collecting duct receives a duct from a large bladder-like structure which I shall call, tentatively at least, the albumen sac (Alb., pl. xxx, fig. 7). It is in the position of the receptaculum seminis, so called at any rate, of *Concholepas*, but in the latter the collecting duct from the ovary seems to go into this organ and the channel to the uterus out from it again. The relations are therefore not exactly the same, even if, as seems probable, the name receptaculum seminis is an error.

The oviduct is a large sac-like duct abutting on the posterior side of the branchial cavity narrowing down to a terminal duct-

like portion which projects freely into the branchial cavity (pl. xxix, fig. 4).

Internally the duct portion of what has been tentatively named albumen sac is marked by numerous fine longitudinal ridges, all of which become much weaker as soon as they enter the sac. Most of the sac seems to have a simple membranous wall. The collecting duct of the ovarian tubules is also ridged longitudinally.

The wall of the oviduct internally is evidently glandular almost throughout. Slight ridges and hollows run in transverse lines on the side towards the branchial cavity, being weakest (see pl. xxxii, figs. 18—20) along the line where they are nearest to that cavity (through the wall).

Along the back-line, almost dorsally, a swollen ridge with grooves in its surface projects as an almost horizontal shelf into the cavity along practically its whole length. Sheltering beneath its under side is the main channel which is bounded on its forward and lower side by a thick ridge. This ridge rises up towards the end and finally goes into the roof of the terminal narrow part of the duct. On the anterior side of this ridge the transverse ridges and hollows mentioned above are much higher than elsewhere (pl. xxxii, figs. 18 and 19).

The whole effect is to partially mark off a canal portion of the oviduct, ventral and posterior, from a large chamber, more or less dorsal and anterior. The shelf and the thick ridge already mentioned have not grown sufficiently to meet and fuse so the canal portion and the chamber are connected all along (see pl. xxxii, figs. 18 and 20).

The following are some of the papers referring to Volutidæ :—

Bouvier, E. L.—Le système nerveux des Gasteropodes Prosobranches.—*Ann. Sci. Nat. Zool.*, ser. vii, tome 3, 1887.

Bouvier, E. L.—L'organisation des Volutes.—*Bull. Soc. Philomathique*, ser. vii, tome xii, p. 102, 1886-7.

Gray, J. E.—Observations on Volutids.—*Ann. Mag. Nat. Hist.*, ser. 4, vol. i, p. 310, 1868.

Pace, S.—*Voluta musica*.—*Proc. Malacol. Soc.*, vol. v.

Perrier, R.—Le rein des Gasteropodes Prosobranches.—*Ann. Sci. Nat. Zool.*, 1890.

Pilsbry-Tryon.—*Manual of Conchology*.

Woodward, M. F.—Anatomy of *Voluta*, etc.—*Proc. Malacol. Soc.*, iv, 1900.

