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# دراسات تشريحية ووظيفية على الجهاز الهضمى للقوقع " بيللاميا يونيكلر"
## ٢- المكونات الداخلية للكتلة الفمية

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يعتبر هذا البحث الجزء الثانى من دراسة متكاملة على الجهاز الهضمى لأحد قواقع المياه العذبة فى بيئتنا المصرية وهو القوقع المعروف باسم " بيللاميا يونيكلر" الذى لم يلق اهتماما سابقا ويتعلق هذا الجزء بدراسة المكونات الداخلية للكتلة الفمية وقد وجد أنها تتميز الى فكين صغيرين وشريط سفن يحمل أسنانا صغيرة وكيس سفن وزوجين من الغضاريف حاملة الأسنان ، ويربط بينهما عضلات كما أن هذه المكونات مزودة بأجزاء تفرز مادة مخاطية تسهل عمل الأسنان والفكين فى قطع المادة الغذائية اللينة ودفعها الى المرئ.

وتعتبر خصائص أسنان السفن والفكين ذات أهمية تصنيفية للنوع والجنس والفصيلة التى ينتمى اليها القوقع وهذه الخصائص لم يسبق توضيحها .

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# ANATOMICAL AND FUNCTIONAL STUDIES ON THE DIGESTIVE SYSTEM OF BELLAMYA UNICOLOR (OLIVIER, 1801)
# II- THE INTERNAL CONSTITUENTS OF THE BUCCAL MASS
(WITH 21 FIGURES)

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## SUMMARY

This paper deals with the internal constituents of the buccal mass of the Egyptian viviparid snail Bellamya uniclor. It is concerned with the functional morphology and taxonomically important characters of the two jaws, dorsal buccal ridges, a postradular ledge, odontophoral mass, radula and subradular organ. Such study may aid in the definition of the diagnostic characters of the species, genus and family to which the present snail belongs. Also it may provide additional evidence for the phylogeny of viviparids and mesogastropods.

## INTRODUCTION

This is the second paper in a series of papers on the functional morphology of the digestive system of the Egyptian viviparid snail "Bellamya unicolor". It deals with the structure and function of the internal constituents of the buccal mass of the present species as a completion of a previous publication on the outer musculature of the same organ in the same snail (BEDDINY and HAMADA, 1981). As mentioned in the first paper of this series, no complete anatomical studies on the buccal mass of a member of the family Viviparidae have been met with in the literature.

Thus, the present paper is a further attempt to elucidate the adaptation of this complicated part to its fucntion and to reveal some of the diagnostic characters of the species, genus and family to which the snail belongs.

## MATERIAL AND METHODS

The specimens of Bellamya unicolor used in the present investigation were collected from the region of connection between the River Nile and Ibrahimia canal at Assiut City. The methods of collection of the specimens, separation and preservation of the soft parts have been recorded in a previous paper on the same species(BEDDINY and HAMADA, 1982 a).

Radula preparations were made by methods as those advocated by MANDAHL-BARTH (1962). The buccal masses of the full grown specimens were dissected, examined and opened to reveal the constituents.

Sections were prepared, for histological studies and for the differentiation of mucus-secreting tissues, by methods mentioned in the first paper of this series (BEDDINY and HAMADA, 1981).

## RESULTS

### The Internal Constituents Of The Buccal Mass

The internal constituents of the buccal mass of B.unicolor will be dealt with in the following manner:

1- The jaws.
2- Dorsal buccal ridges.
3- The postradular ledge.
4- The odontophoral mass.
5- The radula and radular sac.
6- The subradular organ.

1- The Jaws:

There are two small chitinous jaws hanging from the roof of the buccal cavity, one on each side, a little behind the oral aperture. (PL. I, Fig. 1 & PL. II, Fig. 6).

Each jaw has a more or less cone shaped outline, with a relatively broad, thin base of attachment (about 600 u in breadth) and a narrow thick free cutting edge (about 400 u in breadth). The thickness of each jaw decreases gradually from the free edge (about 25.2 u thick) towards the base of attachment (about 13.2 u thick). The cutting edge, which is medially convex and laterally concave, carries numerous minute serrations and is yellow in colour. The rest of the jaw is pale yellow in colour.

Microanatomical study (PL. II, Figs. 7&8) shows that each jaw is secreted by the epithelial cells underlying it. These cells are taller than the neighbouring ones; being about 30 u in length, have basally located nuclei and granulated terminal parts. The matrix of the jaw can be differentiated into a central region of narrow regularly arranged vertical columns from 8.4 to 19.2 u long and a peripheral thin layer of laminae, arranged parallel to the surface and about 4.8 u thick. The major parts of the column acquire a yellow colour, with eosin, while the laminae acquire a bright red colour.

2- The dorsal buccal ridges (PL. II, Figs. 6&9).

When the buccal cavity is cut opened by a median longitudinal incision within its dorsal wall, two pad-like somewhat semilunar ridges are seen projecting down from its roof, one on each side of the median plane. Both ridges form the lateral borders of the dorsal food channel, which runs between them from the position of the jaw to the oesophageal opening. On the inner aspect of each ridge a shallow longitudinal groove is present, dividing the ridge incompletely into two portions; a wide upper portion and a narrow lower one.

The length of the dorsal buccal ridge is about 2.25 mm, and its width is about 0.75 mm anteriorly and 0.50 posteriorly. The microscopical study shows that the dorsal buccal ridge has a core of connective tissue with scattered groups of longitudinal muscle fibers. It is covered by a simple epithelium consisting mostly of ciliated tall columnar cells with interspersed mucous cells. The apical part of each tall columnar cell is more acidophilic than the basal one. Each cell has a basal, oval nucleus. Some of the mucous cells are goblet while others are flask shaped with narrow apical part. The mucous cells are greater in number in the epithelium of the broad upper part of the ridge than in that of its narrow lower one.

The position and structure of the dorsal buccal ridges show that they most probably serve in keeping the food stream within the limits of the food channel and in directing it by the action of cilia towards the oesophagus. Also the mucous material produced by their glandular cells may help in the collection of the food particles. Furthermore, their lateral inner grooves may provide a place for the collection of the saliva and its action on the food.

3- The post-radular ledge (PL. II, Fig. 6 & PL. III, Fig. 10).

In the floor of the buccal cavity, there is a distinct transverse, creamish soft fold. It extends as a ledge in front of the oesophageal opening and passes anteriorly for a short distance above the lateral odontophoral cartilages to end at the posterior end of the exposed radular ribbon. Thus this fold can be termed the postradular ledge as it is the case in Marisa cornuarietis (DEMIAN, 1964). The post radular fold of B.unicolor has a posterior attached edge and an anterior free one. Its two lateral edges are connected to the sides of the buccal cavity epithelium. Its transverse axis is longer than the longitudinal one; being about 1.8 and 0.9 mm. respectively, and its thickness is about 0.27 mm. The upper surface of the ledge is impressed by few transverse furrows.

In sections, the post-radular ledge is composed of an upper and a lower epithelial layers, connected togehter by connective tissue. The epithelial layer consists of simple columnar cells, about 30 u in height, with a large number of flask shaped mucus secreting cells. The normal columnar cell is characterised by a slender median nucleus and by the fact that the cytoplasm of its apical part is more acidophilic than that of its basal one. The nucleus of the mucus-secreting cell, on the other hand, is rounded and basal in position.

It is reasonable to assume that the post-radular ledge of B.unicolor, allows for the forward movement of the odontophoral cartilages. Also its mucoid lubricative secretion aids in facilitating the complex movements of the radular ribbon and the odontophoral cartilages during feeding.

4- The Odontophoral Mass (PL. I, Figs. 2,3 & PL. III, Fig. 11).

Macro and microscopical studies of the buccal mass of B.unicolor have shown the presence of two pairs of odontophoral cartilages; one lateral and one superior in position. Therefore, according to their relative positions, these cartilages can be termed, after PRASHAD (1925) the lateral and superior cartilages.

The two lateral cartilages are disposed in the posterior half of the buccal mass, in such a way that their long axes, at rest, extend almost in a dorsoventral direction. Their upper medial portions gape widely from one another, while their ventral apices overlap; the right one lies in front of the left. Each lateral cartilage, which is much bigger than the superior one, is a whitish cartilaginous plate with a somewhat rectangular outline in a dorsal view. Its posteroventral angle is tapering and acute, but the three other angles are rounded. The posterior margin of each plate is concave at its ventral half while its anterior one is convex.

Each of the lateral cartilaginous plates is not quite flat dorsoventrallly, because its outer lateral portion is much thicker (about 500 u thick) than its median one (about 197 u thick). It measures about 1.5 mm in length and 0.75 mm in its greatest breadth.

Sections through the lateral cartilages show that their major central parts consist of a cartilaginous tissue, being differentiated into lacunae enclosing chondrocytes. Each cartilage cell has a relatively small rounded central nucleus. The lacunae are separated from each other by thin films of intercellular substance or cartilage matrix. It is remarkable that the chondrocytes are large in size in the core of the plate and become clearly small at its periphery, where they are surrounded by a thin film of condensed fusiform cells, with their long axes parallel to the external surface of the plate. Outside this envelope, there is a thin coat of circular muscle fibres.

The superior cartilages (PL. I, Fig. 2 & PL. III, Fig. 12) are in the form two small thin triangular plates lying one on either side of the anteriormost portion of the lateral odontophoral cartilages. The apex of each superior cartilage is directed posteriorly, while its base is directed anteriorly. The same cartilage has a dorsal convex surface and a ventral concave one which lies, at rest, on the opposing lateral cartilage.

The histological structure of the superior cartilage is basically similar to that of the lateral one. The first is distinguished by the relatively small and numerous chondrocytes and by the great amount of the cartilage matrix.

The two pairs of odontophoral cartilages (PL. III, Fig. 12) are surrounded by a muscular coat which is clearly thick dorsolaterally (about 67.5 u thick). The coat consists of bundles of smooth circular muscle fibres.

The odontophoral cartilages are connected together and with other parts of the buccal mass by a complicated muscular system which enables the radular sac and radula to perform their function during feeding (PL. I, Fig. 2 & PL. IV, Fig. 14). Of these muscles one can distinguish a long muscular band arising from the anterolateral margin of each lateral cartilage, near its dorsal thick end, and passing transversely to become inserted into a similar part on the muscular coat of the other cartilage. Also the apices of the two lateral cartilages are connected together by a relatively thin muscular band. Similar muscular bands connect the two superior cartilages together and with the lateral cartilage of the same side.

There is a nubmer of pairs of muscular bands connecting the muscular coat of the lateral and superior cartilages with the radular sac. The first of these,is a pair of two distinct bands which can be easily exposed by macroanatomy. Each one arises from the ventral surface of the outer side of the posterior part of the lateral cartilage. It passes backwards to reach a point nearly ventral to the posterior end of the buccal mass, where it is reflected upon itself forming a loop and passes forwards to be inserted into a ventrolateral region of the posterior third of the radular sac. In sections, these muscles appear consisting of bundles of circular muscle fibres. They can be termed the posteroventral radular tensors ( BEDDINY & HAMADA, 1981, Fig. 4 ) according to their positions and to the assumption that they are probably used for the retraction of the radular sac and radular ribbon after the backward stroke of the radula.

The second pair of these muscular bands can be termed the ventrolateral radular tensors (v.l.r.t. ) ( PL. IV, Fig. 15). Each band appears in macroanatomy as a thick broad strand originating from the posterior surface of the lateral cartilage and extending anteriorly close to the ventrolateral inner edge of the same cartilage to reach the superior cartilage of the same side where it becomes inserted into it and into the overlying subradular epithelium. On contraction, these muscles apparently tend to pull the two superior cartilages and the overlying subradular epithelium backwards and outwards to cause the stretching and spreading of the radula over the lateral cartilages. Such mechanism may aid in the fixation of the radula and in keeping its teeth in a position, suitable for rasping food.

A third pair of these muscles is that which can be designated the supraradular flexors, (BEDDINY & HAMADA, 1981, Fig. 3). Each of these muscles originates as a broad flat band from the posteromedian border of the lateral cartilage and passes obliquely inwards and forwards over the dorsal surface of the same cartilage, till it reaches the anterior third of the ventral surface of the radular sac, where it is inserted. Each band can be differentiated into few bundles of circular muscle fibres. These muscular bands apparently aid the posteroventral tensors in pulling the radular ribbon backwards during the retractor stroke of the radula.

The fourth pair of these muscles can be called the suspensors of the radular sac, (BEDDINY & HAMADA, 1981 Fig. 3). In anatomical study of the buccal mass of B.unicolor, they originate as two broad strands from two dorsomedian regions of the muscular coat of the lateral cartilages. Each strand has the form of interconnected parallel muscle fibres which extend from their origin, obliquely backwards towards the radular sac to reach a point on the supraradular wall where they become inserted. At this point of insertion, which is nearly at the end of the anterior third of the radular sac, the muscle fibres of the two strands intermingle. These muscles probably serve to attach the dorsal wall of radular sac to the odontophoral mass and to keep it in position during the forward and backward movement of the radular ribbon.

Such muscular connections show the complete cooperation between the odontophoral cartilages and the radular sac with its radular ribbon, during the rasping action of the radular teeth. Also the structure and position of the odontophoral mass elucidate its supproting function for the radula and its action as a seat for the attachment of the buccal muscles that move the radular teeth.

5- The Radular Sac And The Radula.

The radular sac of B.unicolor, (PL. II, Fig. 6) as those of other gastropods, arises as a median ventral evagination of the floor of the buccal cavity near the middle of its longitudinal axis. The radular sac passes posteroventrally as a dorosventrally compressed cylinder, behind the odontophoral cartilages, till it reaches a point posterior to the buccal mass and below the prooesophagus. In the freshly dissected snail, it has an almost reddish yellow colour, with a deep red posterior end due to the accumulation of blood. Its length is about 3.25 mm, but its breadth increases slightly towards its posterior end to become about 0.25 mm. Within the sac, the radular ribbon extends and emerges from its anterior opening into the buccal cavity.

In sections, the wall of the radular sac consists mainly of an epithelial lining surrounded externally by a layer of connective tissue supplied with circular muscle fibres. The epithelial lining can be differentiated into an upper part lying above the radular teeth and thus known as the supra-radular epithelium and into a lower part, lying below the radular ribbon, and thus designated the subradular epithelium, (PL. I, Fig. 4).

The supraradular epithelium (PL. IV, Fig. 16) is a simple layer of cells which differ greatly in height (ranging from 3.6 to 6 u in height), forming processes extending between the apices of the radular teeth. Each cell contains a basal oval nucleus with one or two nucleoli. In haematoxylin-eosin preparations, the apical regions of the cells appear more acidophilic than the rest of the cytoplasm and possess a number of vacuoles indicating their secretory function.

The subradular epithelium, (PL. IV, Fig. 16) is composed mostly of a single layer of columnar cells which show considerable variation in height(10.8 to 16.8 U high)and lie on a distinct basement membrane. These cells reach their maximal increase in height at the distal end of the radular sac, where the subradular epithelium takes a horse-shoe-shape and its cells become narrow, tall and highly glandular. Such cells secrete the matrix of the cenral core of the tooth and that of the radular membrane to which the bases of the newly secreted teetn become fixed. Therefore, such cells can be designated as the odontoblastic cushion. Anterior to and above the newly formed teeth, the cushion becomes continuous with the supraradular epithelium. The cells of the subradular epithelium are mostly characterised by ovoid basal nuclei and vacuolated cytoplasm showing its secretory function.

Above the supraradular epithelium and in the centre of the dorsal wall of the cylindrical radular sac, there is a remarkable supportive tissue, corresponding to that designated in Lymnaea stagnalis (CARRIKER, 1946) and Marisa cornuarietis (DEMIAN, 1964), as radular collostyle (PL. I, Fig. 4 & PL. IV, Fig. 17). This term is adopted in the present investigation. The radular collostyle of B.unicolor consists of a mass of relatively large cells with distinct nuclei and embedded in a ground matrix with few smooth muscle fibres extending in various directions. The remarkable cells of the collostyle can be differentiated into two types. The first is ventral in position and marked by relatively small and closely packed cells. The second type occupies the median and dorsal parts of the tissue and its cells are relatively large in size and polygonal in shape. The cytoplasm of both types of cells is clearly vacuolated and the nucleus has one or two clear nucleoli.

At the opening of the radular sac, the supraradular epithelium becomes reflected backwards over itself and the top of the radular collostyle, forming an epithelial cap which is termed the " collostyle hood " after CARRIKER (1946). The end of the collostyle hood becomes continuous with the epithelium of the floor of the buccal cavity.

The radular ribbon can be divided, for study, into two parts; the first lies within the radular sac and the second is the functional part emerging from the sac and extending forwards on the floor of the buccal cavity, passing over the odontophoral mass.

When newly formed, the radular teeth lie close to the radular membrane and their apices are surrounded by peripheral cover secreted by the supraradular epithelium. RÜCKER (1883) and RÖSSLER (1885) stated that this outer cover is enamel and it is secreted by the supra-radular epithelium. The fully formed tooth is thus composed of a central core and a peripheral cover. Unstained radular teeth are generally colourless, except the oldest ones, which are found in the functional part of the radula, since they show a yellow band at their bases. With Mallory's triple stain, the central core of the radular tooth acquires a deep red colour which fades gradually towards the periphery where it becomes yellow. With toluidine blue, on the other hand, the outermost part of the tooth becomes deep blue in colour while the central part is pale blue in colour, (PL. V, Fig. 18).

The functional part of the radula can be differentiated into a median denticulate ribbon forming the radula proper and two lateral curved edentate smooth plates, lying on the odontophoral cartilages on both sides. These two lateral plates correspond to the alary processes of the radular membrane mentioned by SCOTT (1957).

The radular ribbon of the snail under investigation appears, in the resting phase, as an elongated colourless band with an upper concave surface due to the slight elevation of its two lateral edges. It measures about 1.9 mm. in length and 0.34 mm in its maximum anterior breadth. The teeth are arranged on the radular membrane in successive transverse rows, that are 87 in number, in the average.

Examination of sections through the radula shows that it consists of the teeth, the radular membrane, the subradular membrane and the subradular epithelium. It is worth mentioning that the subradular membrane is found only in the radula proper. According to the teeth, ( PL. I, Fig. 5 ) the radula of B.unicolor, as that of any other mesogastropod, is of the taenioglossate type. It has the formula 1.1.1.0.1.1.1.

The central or rachidian tooth (a) is much broader than long, and has a proximal almost rectangular basal disc or base of attachment and a free lobe carrying the cusps. The base of attachment has a superficial, a deep and two lateral borders. The superficial border carries the free lobe. The deep border is convex and longer than the superficial one. The two lateral borders are of the same length. The free lobe of the central tooth is strongly reflected backwards and carries a central broad, blunt cusp, on each of its sides there are four lateral cusps. The central cusp is the largest one with a semicircular smooth free edge near the base of attachment. The lateral cusps are much smaller, their pointed free ends are directed towards the central cusp and they decrease gradually in size towards the lateral edges of the tooth.

The lateral tooth (b) has a distinctly long wedge-shaped base of attachment which is greatly longer than that of the central tooth. The superficial border of its base of attachment is broad and attached to its free lobe, while the deep border is narrow and pointed. The free reflected lobe carries nine cusps which are nearly of the same shape and arrangement as those of the central tooth. However, the central cusp or the mesocone of the lateral tooth is larger than that of the central tooth, while the lateral cusps of both teeth show a reverse relation; those of the first are smaller than those of the latter The tips of the cusps of the lateral tooth lie very far from the deep pointed end of the base of attachment.

The intermediate tooth (c) (on the outer side of the lateral tooth) has a general pattern similar to that of the latter. The first has a mesocone or a central cusp which is clearly smaller than that of the latter.

The marginal tooth (d) has also a wedge-shaped base of attachment, with a superficial broad border carrying the free backward reflected lobe. The latter carries almost eleven pointed small cusps, lying close to each other and giving it a serrate appearance. The central five cusps are longer than the peripheral ones.

The radular membrane (PL. V, Fig. 18) appears in sections as a thin chitinous wavy plate, lying above the subradular epithelium. The bases of the teeth are firmly attached to this membrane at points which are thicker than those lying between them. It is acidophilic; acquiring red colour with eosin and blue colour with Mallory's triple stain.

The subradular membrane (PL. I, Fig. 4 & PL. V, Fig. 19) lies between the radular membrane and the subradular epithelium in the radula proper only. It is apparent that this membrane is secreted by the cells of the underlying subradular epithelium. By high magnification, one can observe that the subradular membrane consists of a large number of thin threads, found in a ground substance and running from the radular epithelium to the radular membrane. In most cases the threads occur in pairs or in small groups, leaving spaces in between. The ground substance, found between the threads, shows acidophilic affinity when stained with Mallory's triple stain. A large number of dark granules of various sizes are dispersed in the ground substance and some of them are present on the surfaces of the threads. It is reasonable to suggest that the presence of the subradular membrane in the radula proper only is probably to facilitate its movements during the process of feeding.

The subradular epithelium of the functional part of the radula, in the species udner investigation (PL. I, Fig. 4) is considered as a direct extension of the subradular epithelium of the radular sac as both have the same structure.

The two alary processes of the radula (PL. II, Fig. 6) are translucent chitinous plates, roughly triangular in outline and with rounded angles. They extend on both sides of the radula proper, over the odontophoral cartilages. Each process is formed of a somewhat thick layer of chitinous material. Its thickest part is the inner edge, close to the radula proper (about 22.5 u thick), but it gradually thins out laterally till it ends in the lateral recess of the buccal cavity, where it is about 10 u thick (PL. V, Fig. 20).

6- The Subradular Organ:

Below the anterior part of the radular ribbon, there is a yellowish highly folded mass. At rest, the tips of the folds project into the buccal cavity between the jaws (PL. II, Fig. 6). In sections, the epithelium covering this mass appears folded and formed of a single layer of columnar cells, most of them are highly vacuolated and mucus secreting. They have basal oval, relatively small nuclei. This epithelium is followed by a relatively thick layer of conective tissue which passes between the epithelial folds (PL. V, Fig. 21). Such mass can be termed the subradular organ as proposed by PRASHAD (1925).

The function of this organ in B.unicolor, as in other snails, is the production of mucus secretion. It is likely to assume that this secretion probably helps in lubricating the lining of the buccal cavity and the jaws. Such lubrication may facilitate the forward and backward movments of the odontophoral cartilages and protect the epithelial lining of the buccal cavity from being injured by the jaws and sharp cusps of the radular teeth.

## DISCUSSION

The buccal mass of B.unicolor is marked by the relatively short radular ribbon, small radular teeth and reduced jaws which are suitable for scraping up soft food particles and the withdrawal of fine fragments. Fine food particles can also be obtained from the current of water entering the mantle cavity. Both methods of feeding accomodate the existence of the snails on the bottom of the slow running rivers and streams. COOK (1949) referred briefly to the reduced radula and jaws of Viviparus viviparus and their usage for scraping up loose particulate matter. However, he did not describe the structure of its buccal mass. The basic anatomical structure of the constituents of the buccal mass of the present species is generally similar to that of other mesogastropod herbivors as Marisa cornuarietis (DEMIAN, 1964 and LUTFY & DEMIAN, 1967).

## REFERENCES

Beddiny, E.A.M. and M.I. Hamada, (1981): Anatomical and functional studies on the digestive system of Bellamya unicolor (Olivier, 1801), I- The outer musculature of the buccal mass. Assiut Vet. Med.J.Vol.8(15&16) 83-86.

Beddiny, E.A.M. and M.I. Hamada, (1982) a): Notes on the Egyptian snail Bellamya unicolor, with reference to its taxonomic status. Ibid. Vol. 9 (17&18): 73-76.

Carriker, M.R. (1946): Morphology of the alimentary system of the snail Lymanea stagnalis appressa Say. Trans. Wisconsin Acad. Sci. Arts. Lett., 38: 1-88.

Cook, P.M. (1948): A cliliary feeding mechanism in Vivipaurs viviparus (L) Proc. Malac. Soc. Lond. 27: 265-271.

Demian, E.S. (1964): The anatomy of the alimentary system of Marisa cornuarietis (L). K.Vet. O. Virrerh. Samh. Handl. F. 6. Sep. B. BD 9. No: 7.

Lutfy, F.G. and Demian, E.S. (1967): The histology of the alimentary system of Marisa cornuarietis. Malac., 5 (3): 375-422.

Mandahl-Barth, G. (1962): Key to the identification of East and Central African freshwater snails of Medical and Veterinary Importance. Bull. Org. mond. Sante (Bull. Wld. Hlth. Org.) 27, 135-150.

Prashad, B. (1925): Anatomy of the common Indian apple snail Pila globosa Mem. Ind. Mus. VIII, 3, pp. 91-152.

Rücker, S. (1883): Uber die Bildung der Radula bei Helix pomatia. Ber. Oberhass. Ges., 22: 209-229.

Scött, M.I.H. (1957): Estudio morfologicoy taxonomico de les Ampullarides de la Republica Argentina. Rev. Mus. Argentino Cien. Nat. "Bernardino Rivadavia" Cien. Zool., 3 (5): 231-333, Pls. I-XXIII.

### EXPLANATION OF PLATES

PL. I

Fig. 1: Diagrammatic drawing of the dorsal aspect of the jaw.
Fig. 2: Diagrammatic drawing of the two lateral & two superior cartilages in situ.
Fig. 3: Diagrammatic drawing of the lateral aspect of an isolated lateral cartilage.
Fig. 4: Diagrammatic drawing of a longitudinal section of the radula and radular sac.
Fig. 5: Drawings of the separate teeth on half of a transverse row of the radula:
a) central tooth b) lateral tooth c) intermediate tooth d) marginal tooth.

PL. II

Fig. 6: Dorsal view of the interior of the buccal mass after making median longitudinal cut along its dorsal wall and raising the tip of the radular ribbon to expose the subradular organ.
Fig. 7: Photomicrograph of a T.S. of the buccal mass passing through the jaw.
Fig. 8: Photomicrograph of a T.S. through the jaw.
Fig. 9: Photomicrograph of a T.S. of the buccal mass, showing the dorsal buccal ridge and muscles between the odontophoral cartilages and the radular sac.

PL. III

Fig. 10: Photomicrograph of a T.S. of the buccal mass showing the post-radular ledge.

Fig. 11: Photomicrograph of a part of T.S. through the buccal mass showing the structure of lateral and superior cartilages.

Fig. 12: Photomicrograph of a part of T.S. through the buccal mass showing the muscular envelope of the lateral and superior cartilages.

Fig. 13: Photomicrograph of an oblique section passing through the lateral cartilage and the radular sac.

Fig. 14: Photomicrograph of a cross section through the buccal mass showing some muscles of the odontophoral cartilages.

Fig. 15: Photomicrograph of a post of a cross section through the odontophoral cartilages and the radular sac, showing the attachment of the muscles.

Fig. 16: Photomicrograph of an oblique section of the radular sac showing the supra-and subradular epithelia.

Fig. 17: Photomicrograph of a magnified part of a section through the radular collostyle.

PL. V

Fig. 18: Photomicrograph of a part of L.S. of the radular sac showing the newly formed radular teeth and radular membrane.

Fig. 19: Photomicrograph of a part of T.S. of the buccal mass showing the subradular membrane.

Fig. 20: Photomicrograph of a part of T.S. of the buccal mass showing the alary process of the radula.

Fig. 21: Photomicrograph of a part of L.S. through the buccal mass showing the subradular organ.

KEY TO LETTERING OF FIGURES

c.m.f.= Circular muscle fibres, col.j. = columns of jaw, cut.eg. = cutting edge, d;b;r; = dorsal buccal ridge, ep.l. = epithelial layer, j.= jaw, l.ce. = large cell of radular collostyle, l.ct. = lateral cartilage, l.m.f. = longitudinal muscle fibres, lm. j. = laminae of jaw, ms.b.= muscle band, ms.f. = muscle fibres. odb.c. = odontoblastic cushion, pig.l. = pigmented layer, pro.oes. = prooesophagus, prd. l.= postradular ledge, rd.= radula, rd.al.= alary process of radula, rd.cl. = radular collostyle, rd.mb. = radular membrane, rd.s. = radular sac, of radula, sec. ce. = secretory cell, s.ce. = small cell of radular collostyle, sb.rd.e.= subradular epithelium, srd.mb. = subradular membrane, srd.o. = subradular organ, s.ct. = superior cartilage, sp.rd.e. = supraradular epithelium, te. = teeth, v.l.r.t. = ventrolateral radular tensors.

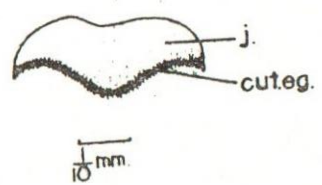



Fig. 1

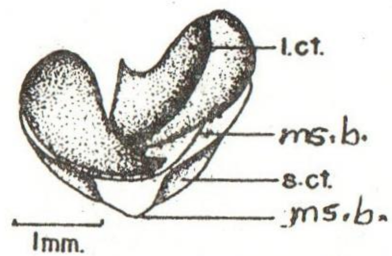
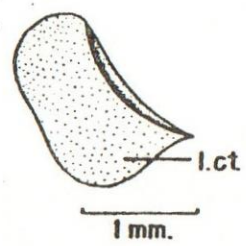



Fig 2

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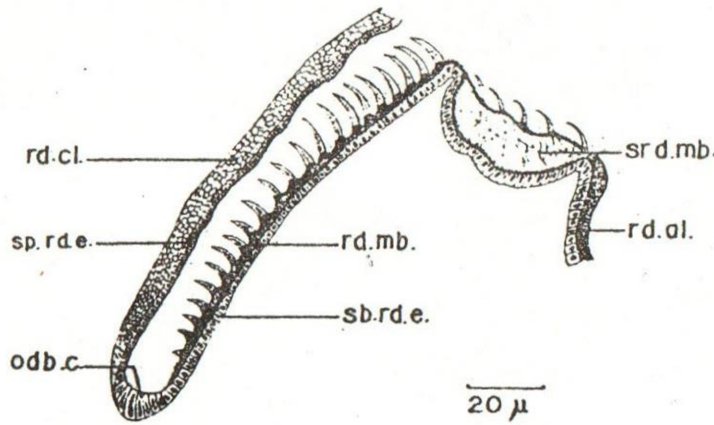


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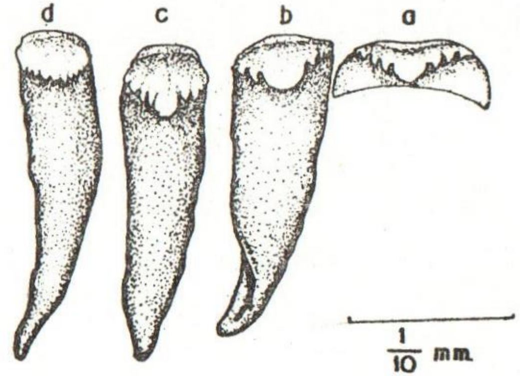


Fig. 5

PL. I

PL. II

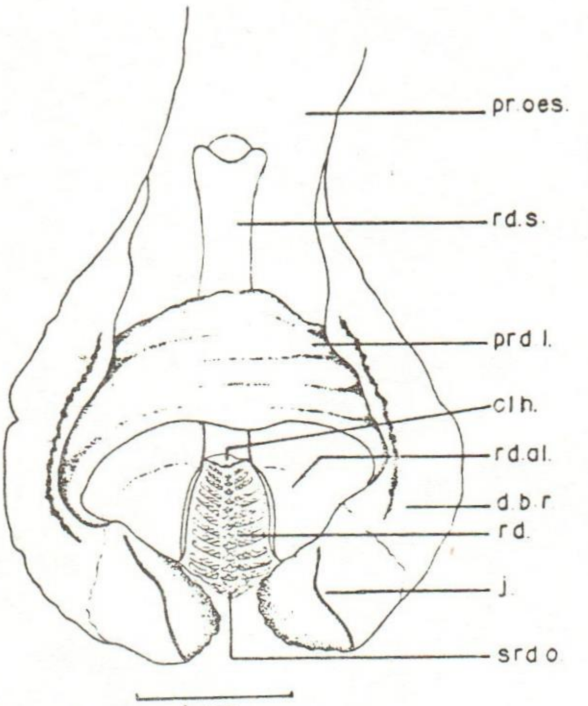


Fig. 6

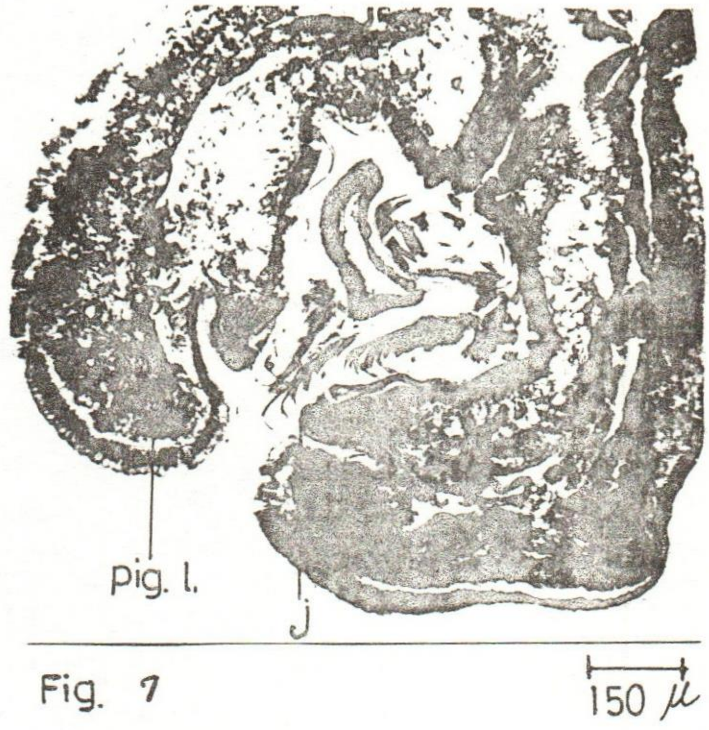


Fig. 7

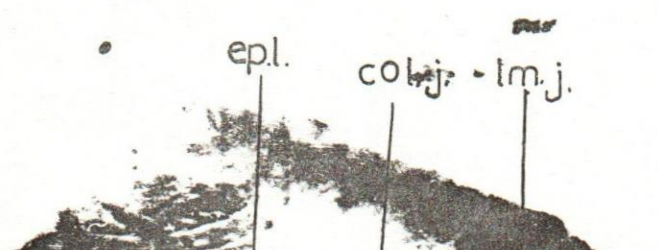


Fig. 8


Fig. 9

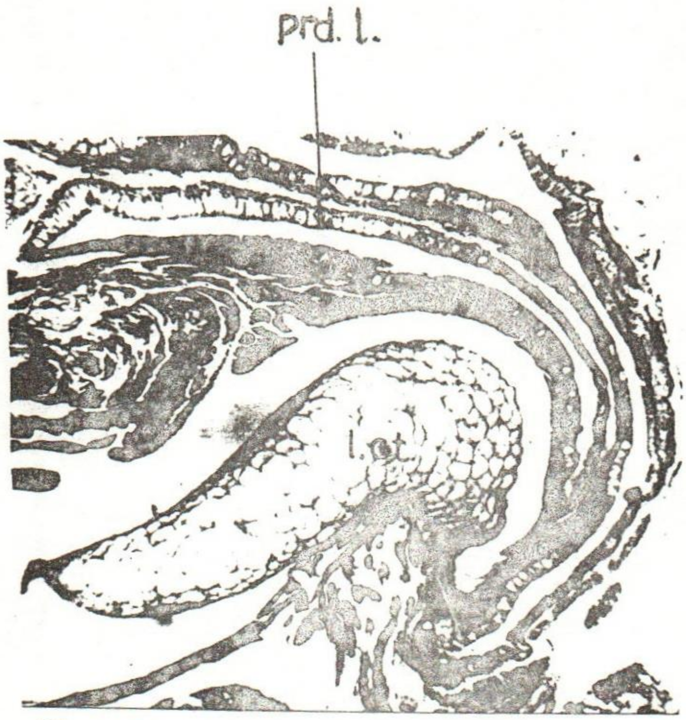


Fig. 10 165 μ

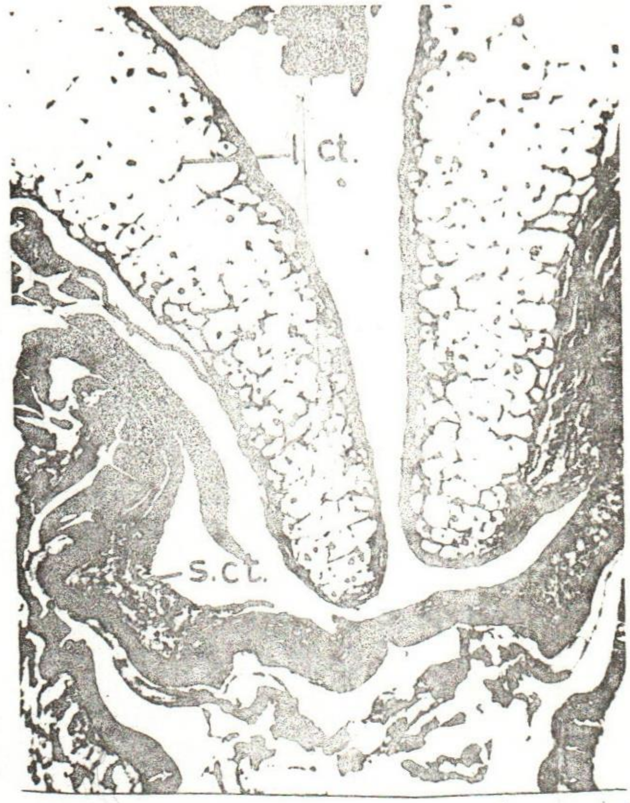


Fig. 11 110 μ


Fig. 12 55 μ

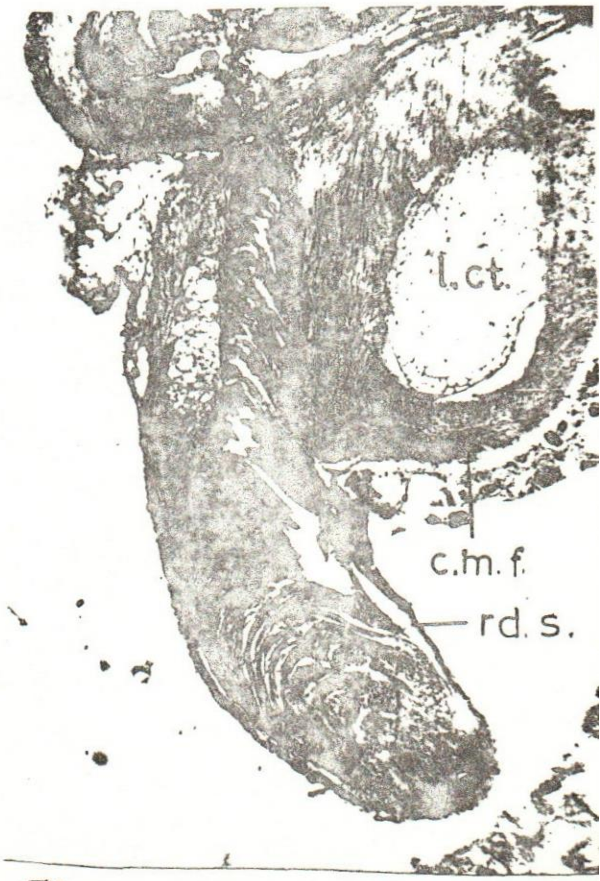


Fig. 13 200 μ


Fig. 14 375 μ

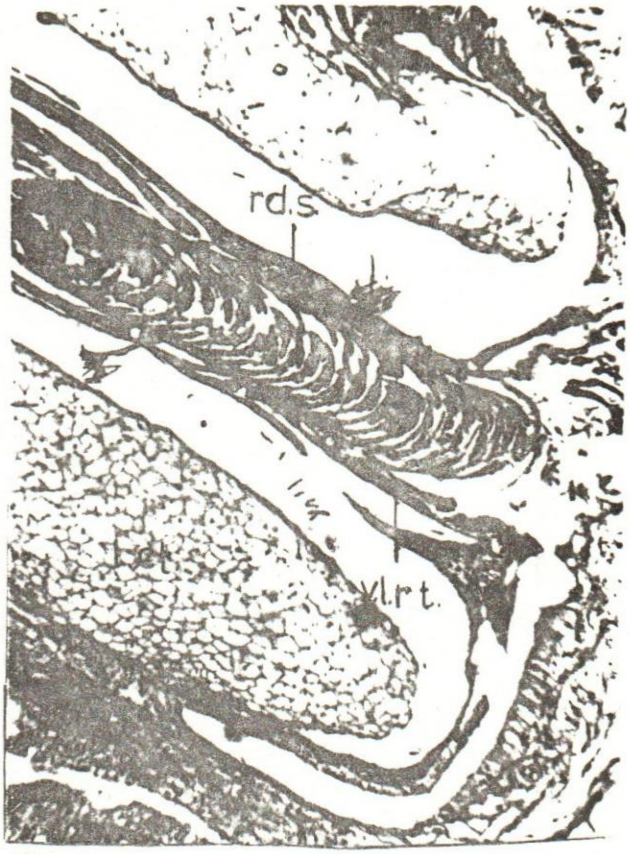


Fig. 15 200 μ

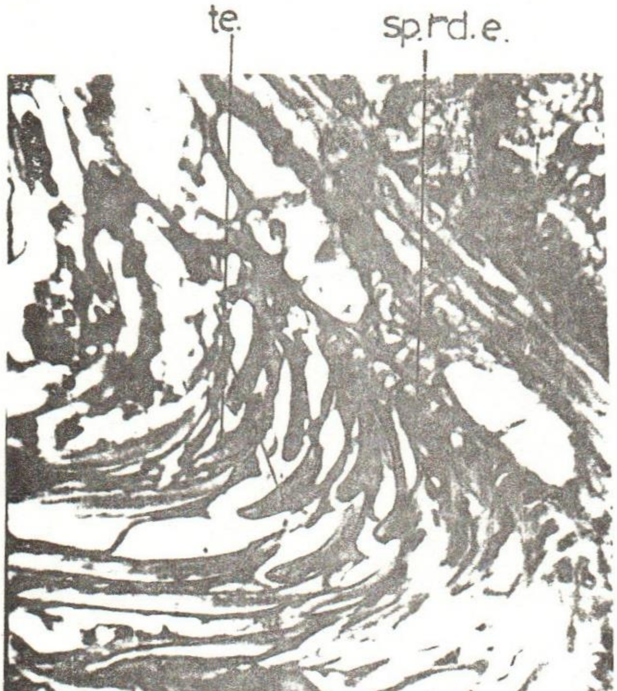


Fig. 16 60 μ

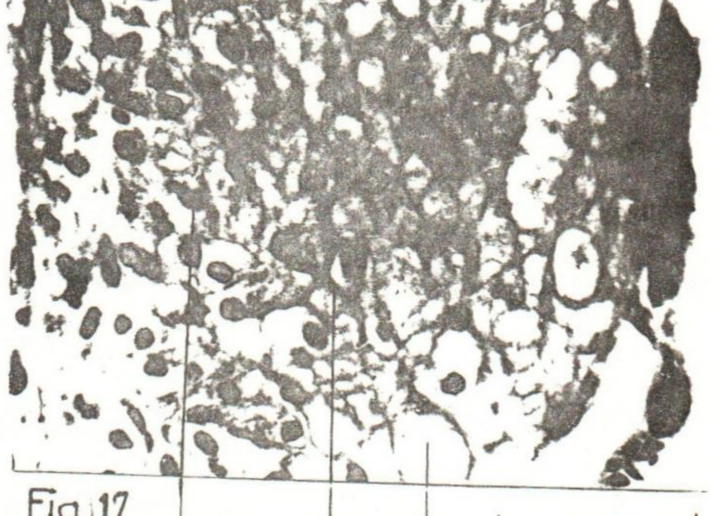


Fig. 17 35 μ

PL. V

Fig. 18

Fig. 19

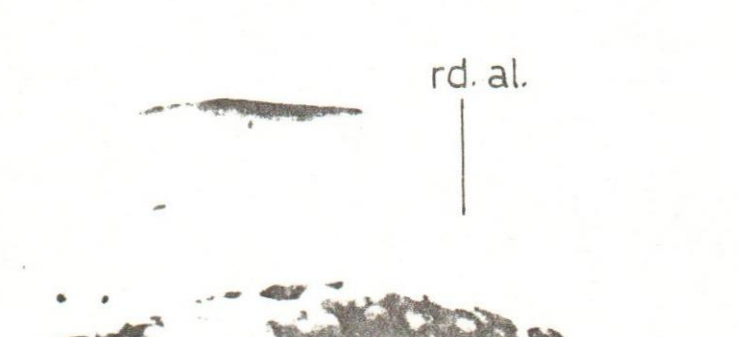

Fig. 20

Fig. 21