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دراسات تشريحية ووظيفية على الجهاز الهضمى للقوقع " بيلاميا يونيكلر "

٣ - القناة الهضمية من المرئ الى الاست

عبد الونيس بديني ، منى حماده

يعتبر هذا البحث الجزء الثالث من دراسة متكاملة على الجهاز الهضمى لأحد قواقع المياه العذبة فى بيئتنا المصرية وهو القوقع المعروف باسم " بيلاميا يونيكلر " الذى لم يلق اهتماما سابقا . ويتعلق هذا الجزء بدراسة التركيب التشريحى البين والدقيق لمكونات القناة الهضمية من المرئ حتى الأست وكيفية تلاؤم هذه المكونات مع وظيفتها وظروف التغذية فى هذا القوقع. وقد دلت هذه الدراسة على أن هذا الجزء من القناة الهضمية يتكون من مرئ وجيبين مريئيين غدييين صغيرين ومعدة وأمعاء ومستقيم ينتهى باست تقع على حلمة شرجية وقد نوقشت هذه النتائج مع مثيلاتها فى الأنواع الأخرى من القواقع المعدة للاغتذاء الهدبى فقط والغير معدة لغيره وكذلك قورنت هذه النتائج بما يميز القناة الهضمية فى القواقع أمامية الخياشيم المعدة للاغتذاء على الأجزاء النباتية الكبيرة نسبيا . وقد اتضح من هذه المناقشة أن خاصية الأغتذاء الهدبى فى هذا القوقع موضوع البحث - ثانوية ومما يؤكد ذلك غياب العود البللورى ووجود الجيبين المريئيين الغدييين الصغيرين .

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ANATOMICAL AND FUNCTIONAL STUDIES ON THE DIGESTIVE SYSTEM OF BELLAMYA UNICOLOR (OLIVIER, 1801) III- THE ALIMENTARY CANAL (FROM THE OESOPHAGUS TO ANUS) (WITH 15 FIGURS & IV PLS)

BY
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SUMMARY

The functional morphology of the alimentary canal (from the oesophagus to anus) of the Egyptian viviparid snail Bellamya unicolor has been investigated and discussed in this paper for the first time. It has been found that it consists of the oesophagus, oesophageal pouches, stomach, intestine and rectum. Since there is no crystalline style, the habit of ciliary feeding would seem to be a relatively recent acquisition.

INTRODUCTION

This is the third paper in a series of papers on the digestive system of the Egyptian viviparid snail Bellamya unicolor. It deals with the functional morphology of its alimentary canal from the oesophagus to the anus. As far as can be ascertained, no complete anatomical work on the alimentary canal of the present species or other members of the family Viviparidea has been met with in the literature. Concerning the same tract in other mesogastropods, there is a number of publications. Among those one can mention that of PRASHAD (1925) on Pila globosa, of MEENAKSHI (1954) on Pila vriens and of MICHELSON (1955) on Ceratodes (Marisa).

Therefore, the present study appears to be necessary for the elucidation of the functional adaptation of the alimentary canl of B.unicolor, and for adding further evidence for the problem of phylogeny of viviparids and mesogastropods.

MATERIAL AND METHODS

The place and methods of collection of the specimens of B.unicolor separation, dissection and preservation of the soft parts have been recorded in a previous paper on the same species (BEDDINY and HAMADA, 1982 a).

The dissection of the alimentary canl was carried out under a binocular dissecting microscope and measurements of the different parts were made with the help of an ocular micrometer. All measurements given in the following description are those normal to the average adult snails of about 1.8 and 2.6 mm in shell height for the males and females respectively. Drawings were done with the help of the camera lucida.

For histological studies and for the differentiation of mucus-secreting tissue, methods mentioned in the first paper of this series (BEDDINY and HAMADA, 1981) were adopted.

RESULTS

The alimentary tract of B.unicolor, as that of many other mesogastropods can be differentiated into the following parts:

a- The oesophagus.
b- The oesophageal pouches.
c- The stomach.
d- The intestine.
e- The rectum.

a- The Oesophagus:

The oesophagus (PL. I, Fig. 1), is a yellowish white long dorsoventrally compressed simple tube, starting from the posterodorsal end of the buccal mass and passing downwards and backwards to join the stomach. Its lenght is about 12.8 mm., but its breadth shows a distinct enlargement at its anterior and posterior parts with a median uniform relatively narrow and long one. Therefore, the oesophagus can be easily distinguished externally into three regions; a pro-, mid, and post-oesophagus. In the male specimen, the oesophagus lies on the left side of the prostate gland at a ventral plane with respect to it.

The pro-oesophagus (PL. I, Fig. 1 & PL. II, Fig. 4) is the shortest part of the oesophagus; being about 0.6 mm. long and it appears oval in cross section with the longest axis of about 500 u. Its lumen is relatively narrow and slit like, with few scattered shallow longitudinal grooves. Its wall is about 95 u thick, and is composed of a lining mucosa of simple epithelium about 35 u thick and an outer layer of connective tissue, provided with smooth muscle fibres, about 60 u thick. The epithelial lining is formed of partially ciliated columnar cells, with basal and elliptical nuclei. Dispersed between these cells, there are numerous mucus secreting cells.

The mid-oesophagus (PL. I, Fig. 1 & PL. II, Fig. 6) extends from the pro-oesophagus, below the epitaenia, backwards and passes within the visceral haemocoel to join the post-oesophagus near the cardiac portion of the stomach. It shows an almost uniform diameter of about 0.5 mm. throughout its whole length which is about 10 mm. It has an oval outline in cross section and its lumen is wider than that of the pro-oesophagus due to its relatively thin wall.

Histologically, the wall of the mid-oesophagus is composed of an epithelial lining and an outer connective tissue layer provided with smooth muscle fibres. The first is a simple ciliated columnar epithelium of a nearly regular height about 35 u. Dispersed between these cells there are distinct flask-shaped mucus secreting cells. The outer coat is less in thickness than that of the pro-oesophagus; being about 15 u thick.

The post-oesophagus (PL. I, Fig. 2) extends posteriorly from the end of the mid-oesophagus for a short distance of about 2.2 mm to join the cardiac portion of the stomach at its anteroventral aspect. It is marked externally by the increase in diameter, being about 0.6 mm and by narrow longitudinal streaks.

In cross sections (PL. II, Fig. 5), the post-oesophagus has a circular outline and a branched wide lumen. Its wall consists of an inner epithelial lining, a median muscular and an outer connective tissue layers. The lining mucosa is formed of a simple ciliated columnar epithelium varying in height from 30 to 60 u, and with ciliated pyramidal interstitial cells. The narrow and tall columnar cells have elongated oval nuclei with clear nucleoli and chromatin granules. The interstitial cells are wedged between the apices of the columnar cells, with their ciliated bases towards the lumen and containing the spherical nuclei. The muscular layer is thin, about 4.8 u thick and its smooth fibres are arranged in a circular direction. The connective tissue coat is of the wide-meshed type with distinct fibrocytes and it is about 4.8 u thick.

b- The Oesophageal Pouches:

Examination of serial sections through the alimentary tract, has shown the existence of two lateral elongated small evaginations arising from a middorsal point in the dorsal wall of the pro-oesophagus, at its junction with the buccal mass (PL. II, Fig. 7). Each evagination, which can be called the oesophageal pouch, extends transversely over the prooesophagus on one side and is connected by connective tissue to the oesophageal wall, the salivary glands and cerebral commissure. It can hardly be differentiated in macroanatomy due to its small size; being about 0.385 mm. long and 0.085 mm wide.

Each oesophageal pouch has a simple central lumen surrounded by a wall about 60 u thick. The epithelial lining of this wall consists of a single layer of tall glandular columnar cells; some of them are granular and slender, while others are swollen and vacuolated. The first type has an elliptical central nucleus and a cytoplasm which is more acidophilic in the apical part of the cell than in its basal one. The second type has an oval basal nucleus and peripheral cytoplasm. It is noticeable, however, that the epithelial cells of the upper wall of the oesophageal pouch, are higher than those of the lower one; being about 45 & 30 u respectively. The secretion of these cells acquires a violet colour with toluidine blue, indicating its mucoid nature. Outside the epithelial lining, there is a thin layer of circular muscle fibres which is followed by a vacuolated vascular connective tissue richly provided with circular muscle fibres and about 25 u thick. The structure of the oesophageal pouches in B.unicolor, showed that they pour their secretion into the pro-oesophagus to be probably used in collecting, and softening the fragments of the food material.

c- The Stomach:

The stomach of the species under investigation (PL. I, Figs. 1&2) has, in its natural position, a nearly J-shaped form, with its broad posterior part partially embedded in the digestive gland, and its terminal tubular part passing anteriorly into the mantle cavity, to join the intestine. Its lateral and ventral aspects are closely related to the digestive gland in the main whorl of the visceral mass, while its dorsal surface is only covered by the thin general integumentary covering of the visceral mass, known as 'tunica propria. The stomach can be externally differentiated into a posterior broad curved cardiac part about 2.6mm in breadth, and an anterior narrow long pyloric part about 3.2 long and 1 mm. broad. The proximal limb of the cardiac portion receives the end of the post-oesophagus at a point on the right side of its anteroventral edge. The stomach is yellowish white in colour and about 6.3 mm. long. The pyloric portion lies on the right side of the postoesophagus and is marked out from the prointestine by its distinctly great breadth and its colour.

Internally, the stomach (PL. I, Fig. 3) has a roughly quadriangular lumen which is lined by a yellowish cuticularised epithelium. The proximal or left limb of the cardiac portion of this organ is characterised by a distinctly high floor and narrow lumen. Also, its lining shows close numerous, transverse small folds with a midventral longitudinal groove-like, narrow depression about 0.6mm broad. The post-oesophageal opening into this part is wide and leads imperceptibly into its median depression. The distal or right limb of the cardiac stomach, on the other hand, is distinguished by a considerably deep bottom and spacious lumen. Also, there is a narrow shallow longitudinal groove along the left side of its floor. This groove which is about 0.3 mm broad, and 0.24 mm deep, is at a lower level than that of the proximal part and it is bordered by a right broad fold and a left narrow one. The two grooves are continuous with each other across a median depression in the common ventral partition between the two limbs. There is, however a distinct oval pit on the bottom of the right limb close to the common partition and the groove. This vertical partition is formed due to the fact that the inner and medial walls of the two limbs of the cardiac stomach approach each other and become connected.

It is likely to assume that the relatively higher level of the floor of the proximal limb of the cardiac stomach may facilitate the passage of the food fragments from that limb to the distal one.

The opened stomach shows also that the lumen of the distal limb of the cardiac stomach, leads imperceptibly into that of the pyloric part which is relatively narrow with somewhat elevated bottom. There is a longitudinal narrow and shallow groove on the left side of its floor extending from that of the distal limb of the cardiac stomach till it reaches the prointestine. The pyloric groove is bordered by a right broad or major fold and a left narrow or minor one.

In cross sections, the proximal or left limb of the cardiac portion of the stomach (PL.III, Figs.8 & 9) has a somewhat oval outline about 500 u in the long axis, with a clear lumen occupied by fine granules of food particles of acidophilic nature. The lining mucosa is composed of a simple cuticularized columnar epithelium, forming a large number of prominent regular folds which are nearly of the same height. The columnar cells range from 20 ot 70 u in height. They are narrow with mostly elliptical nuclei, at different levels and containing clear nucleoli and chromatin granules. Their cytoplasm can be differentiated into a distal short granulated and acidophilic zone, a central tall vacuolated nearly colourless one and a basal, short, granulated or provided with threads, acidophilic one. The contents of these cells do not include mucus secretion. Just outside the apical cell membrane, there appears a thin layer of vertical fine threads, about 4.8 u thick. This is followed towards the lumen by a cuticular layer formed of closely packed lamellae about 5.4 u thick, extending in a direction parallel to the surface of the epithelium. The first adherent layer, which presents vertical striations, acquires faint blue colour, while the second attains relatively dark blue colour with Mallory's triple stain.

In the species under investigation,however, the careful examination of the lining of the two limbs of the cardiac stomach supports the suggestion of FRETTER and GRAHAM (1962) with regard to the cuticular nature of the vertical striations emerging from the epithelial cells of the cardiac stomach of some other prosobranchs. But it has been noticed in the present study that there is also cuticular secretion between these threads and at their apices where it takes the form of spherules. This leads to the suggestion that further cuticular secretion passes from the epithelial cells between these threads and along them to form the second layer towards the lumen. The latter takes the form of a sheet parallel to the surface of the epithelium in the case of the proximal limb and the form of distinguished vertical threads in the case of the distal limb of the cardiac stomach.

The basement membrane of the epithelial lining of the proximal limb of the cardiac stomach is followed externally by a thin layer of smooth muscle fibres, about 2.4 u thick and are arranged mostly in circular and rarely in oblique directions. This layer is covered by thick widely meshed connective tissue which is continuous with that of the common integumentary covering of the visceral mass. The muscular and connective tissue layers fill the core of the numerous folds of this part of the stomach.

In sections, (PL. III, Figs. 8 & 10) the distal limb of the cardiac stomach appears oval in shape, large in size; being about 1.5 mm in the long axis and with relatively spacious lumen and thin wall about 60 u thick. Its lumen appears usually in normal specimens filled with food granules and fragments mixed with the secretion of the digestive gland. Its wall consists of the same layers of the wall of the proximal on left limb, with certain differences in the detailed structure of the inner cuticularized lining mucosa and the outer muscular layer following it. The simple columnar epithelial lining has nearly a uniform height of about 48 u, with almost oval basal large nuclei containing distinct nucleoli and chromatin granules. The cytoplasm of the columnar cells is acidophilic with central vacuolated zone and apical and basal granulated regions. These cells are devoid of mucus secreting elements. The cuticular secretion, lining the whole mucosa, is differentiated into two layers of vertical threads which are about 12 u thick, the layer, connected to the epithelial cells, acquires a plaer blue colour than the apical one. The occurrence of the apical cuticular layer in the form of vertical threads may give a further support to the suggestion that the threads attached to the columnar cells may be also cuticular in nature and not microvilli. The outer muscle layer consists of a very thin film of smooth circular muscle fibres about 4.8 u thick.

It is worth mentioning that the vertical partition between the two limbs of the cardiac stomach has the same histological structure and cuticular lining as that of the distal limb of the cardiac stomach.

Cross sections of the pyloric portion of the stomach, (PL. III, Fig. 11), show that it has a somewhat oval outline with wide lumen about 1.1 mm in the long axis and a relatively thin wall about 50 u thick. Its wall consists essentially of the same layers forming the wall of the cardiac stomach with the absence of the cuticular secretion. The simple epithelial lining shows few folds, the most prominent of them are the two major and minor folds bordering the groove on the left side of the bottom of the pyloric stomach. It is composed of narrow columnar cells mostly containing shiny brown or red granules, when treated with Mallory's triple stain, and narrow vacuoles. Scattered between these cells, there are cells full of globules acquiring blue colour with the same previous stain. Few cells, having colourless vacuoles appear discharging their secretion into the lumen. The secretion of most cells is acidophilic, while that of the few scattered cells especially on the major and minor folds, is mucoid in nature. The epithelial cells have a nearly uniform height of about 45 u and almost basal elliptical nuclei with shiny chromatin granules. Most of these cells have cilia especially those on the major and minor folds and the groove lying in between. It is likely to assume that the vibrations of these cilia may aid in migrating the partially digested food material together with the secretion and the brown spherules of excretory products, coming from the digestive gland, to the prointestine within the pyloric groove.

The pyloric mucosa is followed by a basement membrane and a thin circular muscle layer 3.6 u thick and the widely meshed vascular connective tissue.

d- The INtestine:

The intestine (PL. I, Fig. 1) begins at the distal end of the pyloric portion of the stomach, where it bends backwards and extends, in contact with the sotmach on the left side and the rectum in the case of the male specimen or the albumen gland in the case of the female one, till it reaches the end of the penultimate whorl, then bends forwards to join the rectum. Therefore, the intestine takes an inverted S-shaped structure which is about 9.2 mm. long. Its proximal end is marked by a slight constriction between it and the pyloric end. Its diameter at the proximal end is about 1 mm, but it decreases gradually till it reaches about 0.6 mm at the distal end. It is a yellowish white smooth tube with a ventral greyish yellow, longitudinal slightly depressed band along its proximal part indicating the place of the typhlosole of the prointestine. The intestine, however, can not be easily differentiated from the dorsal view into parts.

The intestinal lining (PL.I,Fig.3),shows two different regions,a pro and post-intestine. The first is the longest one, being about 6.2 mm. long, and characterised by a prominent internal ventral fold or the prointestimal typhlosole, which runs the whole length of this part and diminishes gradually towards the distal end where it abruptly disappears as the postintestine begins. The prointestinal typhlosole delimits a narrow ventral and somewhat deep groove on the right side of the floor of the prointestine and a relatively broad and shallow one on the left side. Sections show that the digested and undigested red shaped food materilas are accumulated in the two grooves and they take blue or bluish red colour with Mallory's triple stain.

The post-intestine is about 3 mm long and 0.8 mm broad at its proximal end. In macroanatomy, the postintestine is characterised internally by the presence of a ventral narrow and shallow groove, extending along its whole length. Sections show that the coarse undigested and fine digested food particles occupy its whole lumen and acquire a blue colour after Mallory's triple stain.

Histologically, the intestinal wall consists basically of an inner simple epithelial lining of columnar cells, a median thin layer of circular and few longitudinal muscle fibres and an outer thick widely meshed connective tissue layer, rich in blood spaces, continuous with that of the mantle wall.

In the case of the prointestine (PL. IV, Figs.12 & 13) the columnar cells of the mucosa are mostly ciliated, narrow, and showing abrupt decrease in height at certain small areas, far from the typhlosole, leading to the appearance of shallow longitudinal small grooves. The columnar cells range from 35 u to 55 u in height and can be differentiated into thin granulated or globulated cells nearly alternating with vacuolated colourless ones. Most of these granules and globules include mucous constituents. The vacuolated cells, on the other hand may be flask-shaped or of the goblet type and few of them appear opening into the lumen. Their scant cytoplasm and elliptical nuclei occupy the periphery. It is clear, in sections, that the apical parts of both types of cells are occupied by homogeneous weakly acidophilic granules or fine filaments. The elliptical nuclei of both types of cells are usually found at different levels in the basal halves of the cells. The epithelial cells rest on a distinct basement membrane, followed by the circular and longitudinal muscle layer which is about 6 u thick. The connective tissue layer is distinguished by scattered circular and oblique muscle fibres. It is remarkable that the wall of the prointestinal typhlosole is devoid of the muscular layer, but the globulated cells are numerous in its epithelial lining.

The post-intestine(PL. IV, Fig. 14) is somewhat ovoid in cross sections and the epithelial lining is characterised by three or four grooves due to the abrupt shortening of the columnar cells of these regions. The deepest of these grooves is the ventral distinct one which is lined with short, ciliated, columnar cells about 20 u high. The mucosa of the postintestine, shows nearly the two types of cells encountered in that of the prointestine. However, the ciliated columnar cells of the first, ranging from 50 to 90 u in height, differ from those of the latter in the rarity of the mucus secreting cells and the ovoid nuclei found at different levels. The muscular and connective tissue layers of the two intestinal parts are nearly similar.

The sturcture of the intestine of B.unicolor leads to the assumption that the partially digested and the undigested food particles pass from the pyloric stomach within the two grooves of the prointestine by the aid of the current created by cilia and by muscular contractions. In the latter, the digestion of ceratin partially digested food particles may take place by the secreted enzymes and absorption of the food fluid is likely to occur. The undigestible residue is mixed with mucus and compacted into the beginnings of faecal rods. In the postintestine the digestible fine food particles may pass within the grooves especially the ventral one where digestion and absorption probably proceed. The faecal rods become however more compact and accumulate in the centre of the eumen. This may take place by the small amount of mucus, the ciliary beating and the contractions of the muscle layer of the postintestinal wall.

e- The Rectum:

The posterior or distal portion of the postintestine reflects forwards to pass into the rectum. The latter (PL. I, Figs. 1 & 3) begins from a point opposite to the cardiac stomach and runs longitudinally along the right side of the body whorl, parallel to and on the left side of the pallial gonoduct. It passes forwards attached to the dorsal mantle wall, till it terminates a little behind the free anterior mantle edge in a short smooth finger-like anal papilla, that carries the anal opening at its free tip. The rectum is a dorsoventrally compressed ovoid yellowish white tube which is externally distinguished by regular transverse lateral wrinkles. It measures about 12 mm in length and 5 mm in the greatest diameter. The anal papilla about 1.3 mm. long and 0.3 mm. in diameter, and protrudes into the mantle cavity showing ability to surge and change its length in the living specimen.

In cross sections, the rectum (PL. IV, Fig. 15) has an ovoid outline, wide lumen and relatively thin wall, its wall consists of an inner epithelial lining, followed externally by a thin circular muscle layer,about 2.4 u thick, which is surrounded by the vacuolated connective tissue of the mantle wall, connecting the rectum with the neighbouring gonoduct. The epithelial lining is thrown into a number of small folds enclosing inner longitudinal grooves. It is formed of a simple layer of nonciliated columnar cells which vary considerably in height, being from 27.6 to 39.6 u high,and leading to the formation of shallow superficial grooves. Most of the columnar cells have apical granular homogeneous weakly acidophilic parts with brush free borders. The central regions of these cells are mostly occupied by vacuoles containing coarse granules which acquire pale red colour with haematoxylin - eosin stain. The acidophilic cytoplasm usually lines the periphery of the cells and surrounds the oval nuclei usually found at different levels, in the basal halves of the cells. There are few scattered narrow granulated columnar cells with mucoid secretion. The histological structure of the anal papilla is basically similar to that of the rectum except the increase in thickness of the circular muscle layer, being about 9.6 u thick.

The contents of the rectum takes the form of spherical masses. Each mass consists mostly of rod like or coarse irregular particles which are refractive and pale yellowish or greenish in colour, after treatment with the commonly used stains. It is noted, however, that there are few scattered mucoid bodies among these contents.

It is likely to assume that the epithelial lining of the rectum may have an absorptive function. Also the circular muscle layer and the folded mucosal lining with its mucus secretion may be used for dividing the undigested food particles into compact rod-like fine fragments to be ejected to the outside via the anal opening.

DISCUSSION

It is clear however, that there is no crop in the alimentary canal of B.unicolor. In this regard, COOK (1949) has briefly reported that Viviparus viviparus has a narrow thin walled oesophagus leading into the stomach, without describing its structure or refereing to its pouches. It is worth mentioning that other mesogastropods, as ampullariids (AMAUDRUT, 1898; SCOTT, 1957 and DEMIAN, 1964), feeding on coarse food particles, have dilated portions of the oesophagus or crops for food storage and large distinct glandular oesophageal pouches, apparently for secreting substances necessary for digestion. The small size of the glandular oesophageal pouches of B.unicolor can be attributed to its dependence in feeding upon the fine soft fragments, needing few enzymes for digestion. Such suggestion is supported by the fact that they are well developed in mesogastropods feeding on coarse food particles, as Marisa cornuarietis (LUTFY and DEMAIN, 1967). As reported by GRAHAM (1939), the presence of these pouches is an index of extracellular digestion taking palce in more posterior parts of the alimentary canl, since they are absent in molluscs adapted for intracellular digestion.

The stomach of B.unicolor is characterised by a U-shaped cuticularized cardiac portion and a tubular non-cuticularized pyloric one, and by the absence of crystalline style and gastric pouches. The absence of the crystalline style and the presence of the glandular oesophageal pouches support the statement of GRAHAM (1939), that it appears that in the case of the herbivorous prosobranchs, a style and a series of glandular oesophageal pouches are alternative mechanisms. Also, according to YONGE (1932) and GRAHAM (1939), the absence of the crystalline style in the present species can be correlated to its way of feeding and to the habitat in which it dwells. Such habitat appears to be unsuitable for continuous feeding which has been considered by YONGE (1932) necessary for style-bearing molluscs. Similarly, COOK (1949) has noticed the absence of the crystalline style in the stomach of Viviparus viviparus. The structure of the stomach in the present viviparid snail as in other herbivorous prosobranchs (GRAHAM, 1938 & 1939) in which digestion is predominantly extracellular is simple in comparison with that of style-bearing prosobranchs.

The intestine with its typhlosole, grooves, ciliated, absorptive and secretory cells of the mucosal lining, together with the muscle coat, shows, that it is engaged in digestion, absorption and preparation of compressed faecal rods. It also pushes these rods to the rectum where they are further mixed with mucus, divided into fine threads which can be ejected to the outside via the anal papilla. Furthermore, the rectum performs an absorptive function. The intestine and rectum of Marisa cornuarietis (LUTFY and DEMIAN, 1967) differ from those of B.unicolor due to the presence of midintestine and a well developed anal gland with mucus-secreting cells in the first species. Such additional parts can probably be related to the type of food, the first snail feeds on.

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EXPLANATION OF PLATES

PL. I

Fig. 1: Illustration of the dorsal aspect of the digestive system.

Fig. 2: Illustration showing the two limbs of the cardiac and pyloric portions of the stomach after removal of the covering integument of the visceral mass.

Fig. 3: Illustration showing the interior of the stomach, intestine and rectum after making a mid-dorsal incision along their whole length and turning the two flaps aside.

PL. II

Fig. 4: Photomicrograph of T.S. through the prooesophagus.

Fig. 5: Photomicrograph of a part of T.S. through the post-oesophagus.

Fig. 6: Photomicrograph of a part of T.S. through the mid-oesophagus.

Fig. 7: Photomicrograph of a part of L.S. through the oesophageal pouch.

PL. III

Fig. 8: Photomicrograph of T.S. of the visceral mass, passing through the two limbs of the cardiac portion of the stomach.

Fig. 9: Photomicrograph of a part of T.S. of the proximal limb of the cardiac portion of the stomach.

Fig. 10: Photomicrograph of a part of T.S. of the distal limb of the cardiac portion of the stomach.

Fig. 11: Photomicrograph of T.S. of the pyloric portion of the stomach.

PL. IV

Fig. 12: Photomicrograph of T.S. through the prointestine.

Fig. 13: Photomicrograph of a magnified part of T.S. through the prointestine.

Fig. 14: Photomicrograph of T.S. through the postintestine.

Fig. 15: Photomicrograph of T.S. through the rectum.

KEY TO LETTERING OF FIGURES

b.m. = buccal mass, cd. gr = cardiac groove, ci.co.c. = ciliated columnar cell, ci.co.ep.= ciliated columnar epithelium; c. & l.m.f. = circular and longitudinal muscle fibres, co.c. = columnar cell, co.ep. = columnar epithelium, c.t = connective tissue, c.t. & m.f. = connective tissue & muscle fibres, cut. co.ep. = cuticularized columnar epithelium, di.g. = digestive gland, d.l.c. st. = distal limb of cardiac stomach, gr.c. = granulated cell, int. gr. = intestinal goove, lu = lumen, mj.py.f. = major pyloric fold, mi. oes. = mid oesophagus, mn. py.f. = minor pyloric fold, m.c. = mucous cells, pt. oes. o. = opening of post-oesophagus into the cardiac stomach, pt.int. = post-intestine, pt.oes. = post-oesophagus, pr. int. = prointestine, pr.int.typh.= prointestinal typhlosole, pr. oes. = prooesophagus, p.l.c.st. =proximal limb of cardiac stomach, py.gr. = pyloric groove, py.st. = pyloric part of stomach, rec.=rectum, rct.gr. = rectal groove, s.gl. = salivary gland, s.gl.d.= salivary gland duct, vc.c; = vacuolated cell, we.c. = wedge cell.

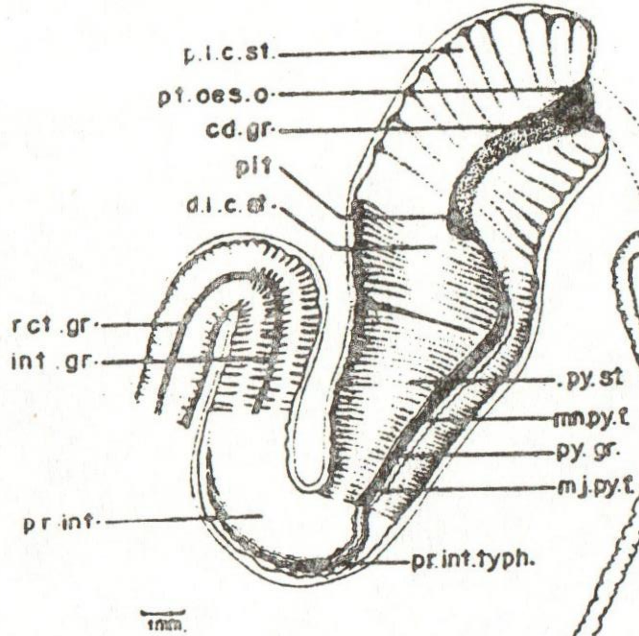

FIG. (3)

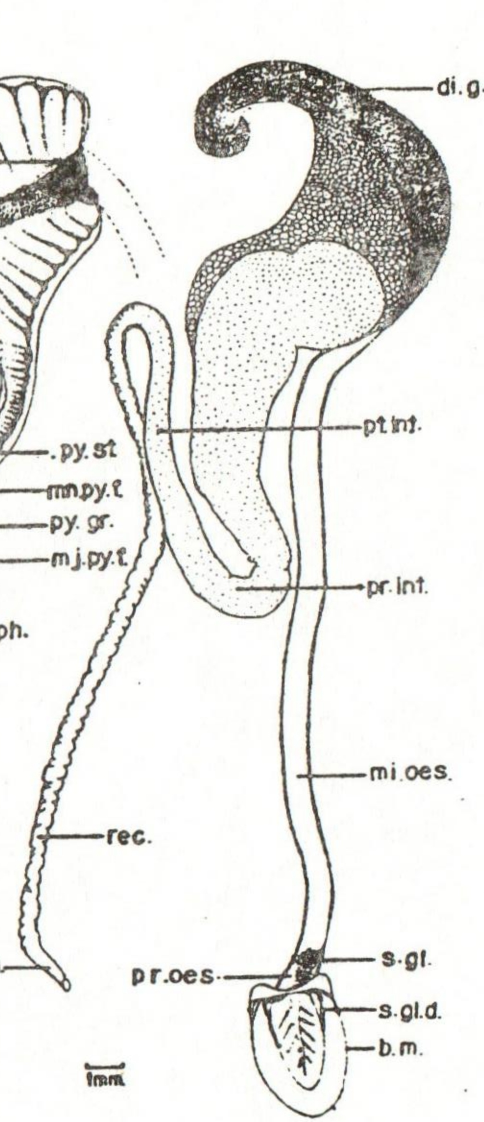

FIG. (1)

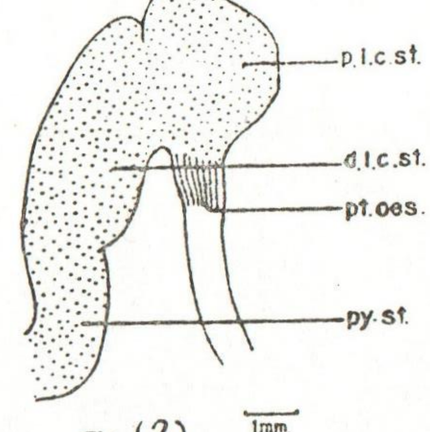

Fig. (2)

Pl. I

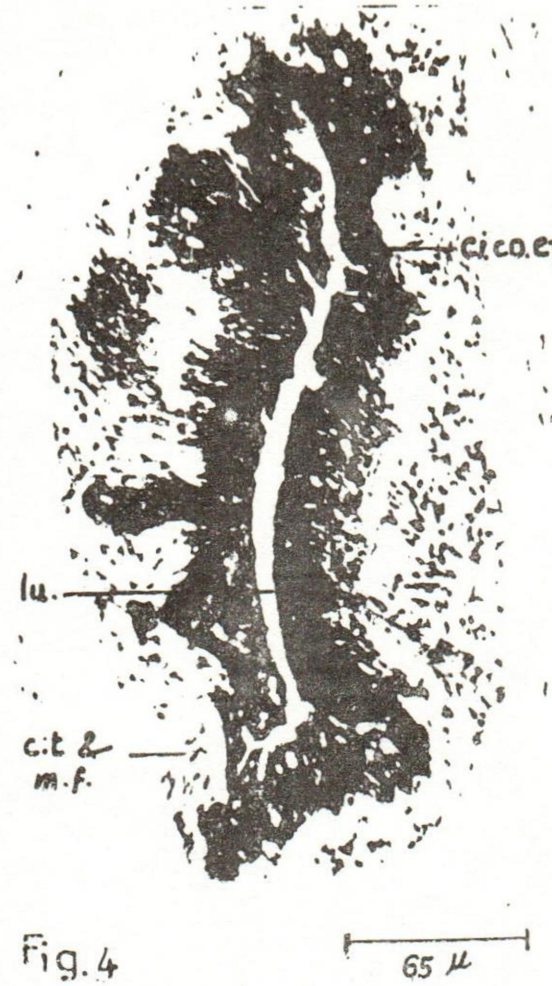

Fig. 4

Fig. 5

Fig. 6

Fig. 7

PL III

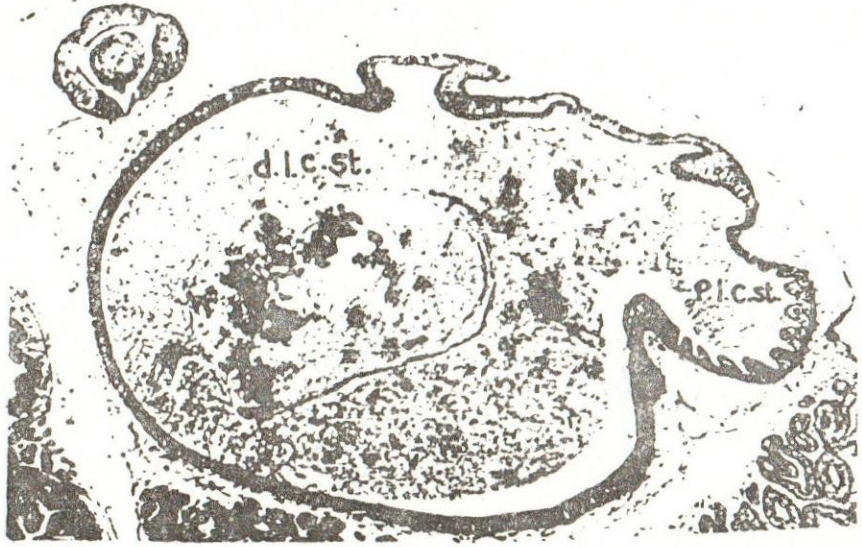

Fig.8

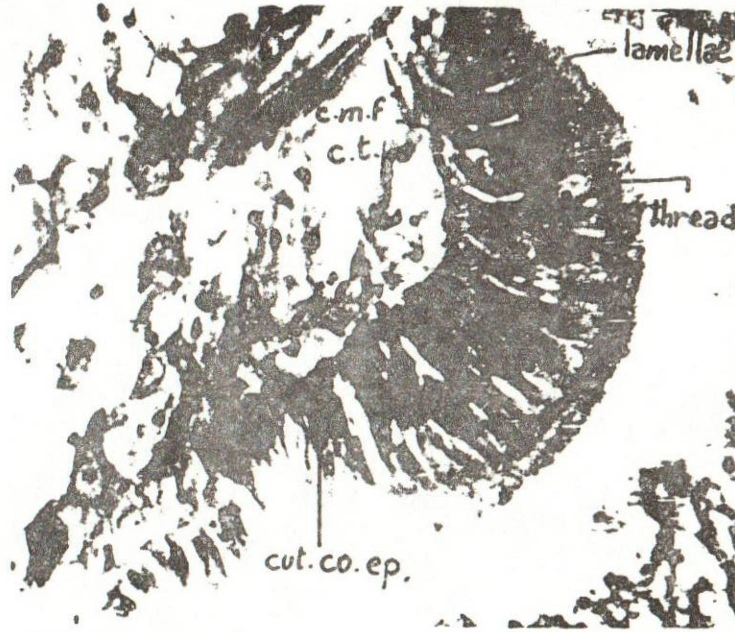

Fig.9

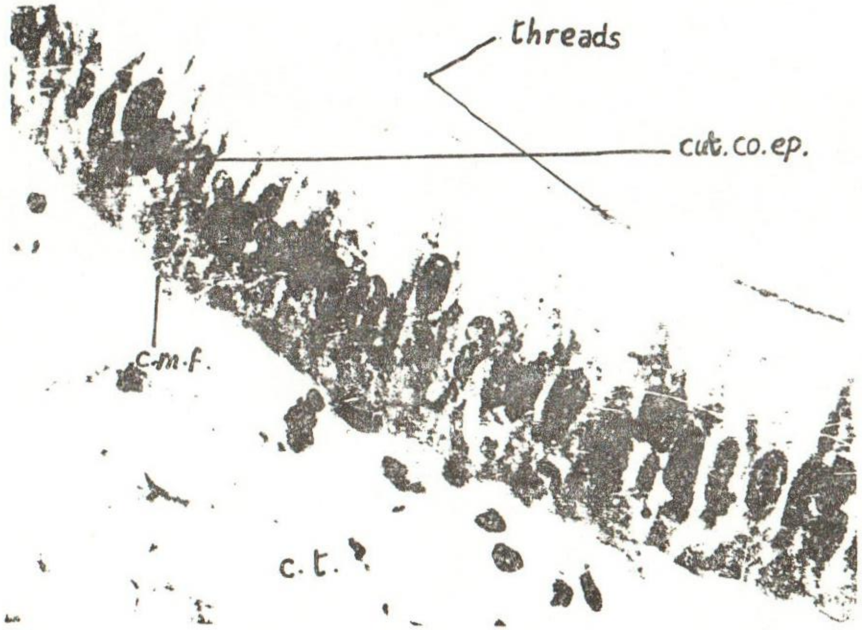

Fig.10

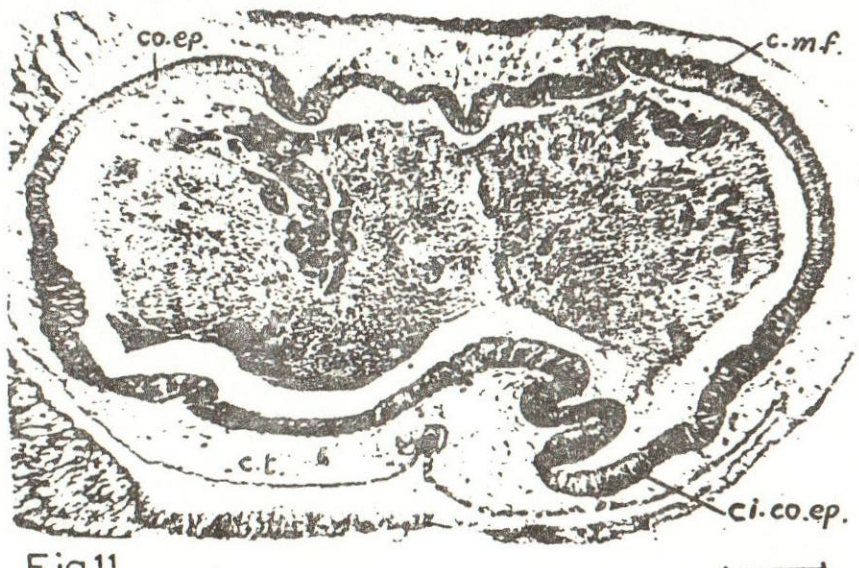

Fig.11

PL IV

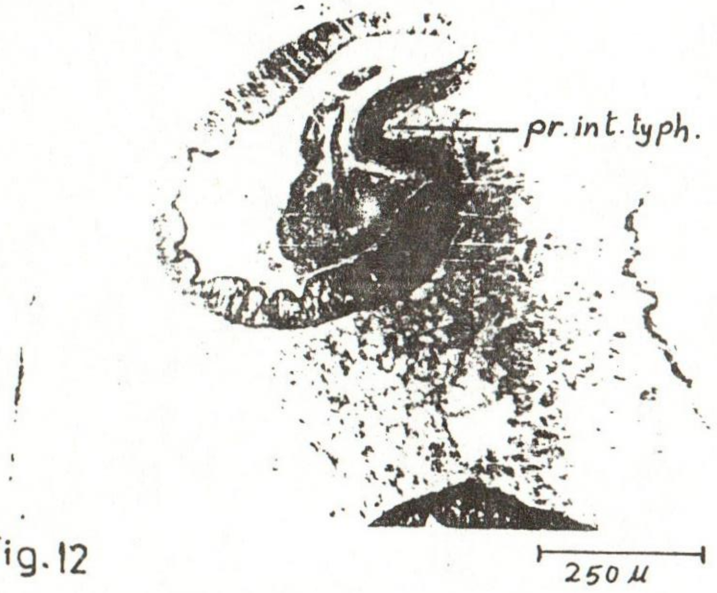

Fig. 12

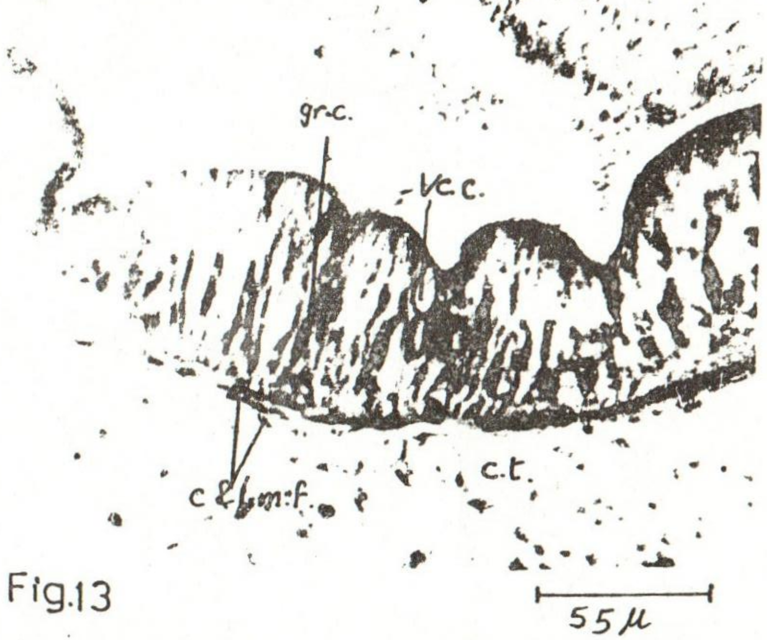

Fig.13

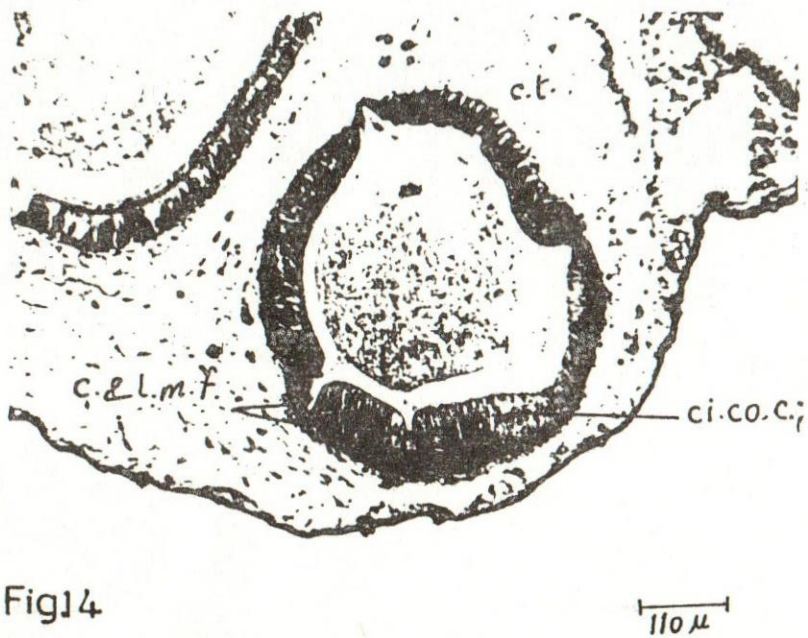

Fig14

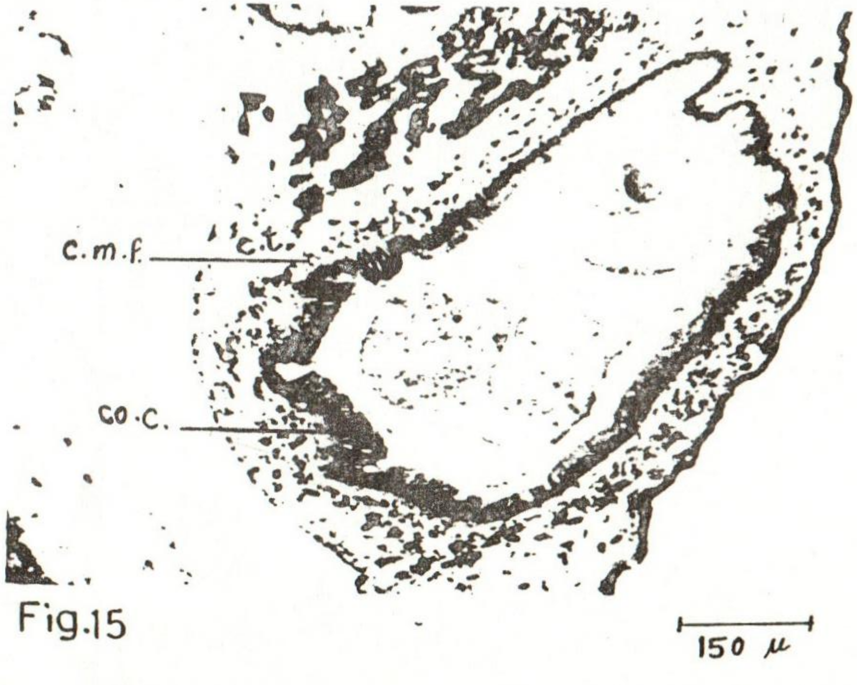

Fig.15