ANATOMY OF *PALUDOMUS TANSCHAURICA* (GMELIN).

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INTRODUCTION.

The family Melaniidae, as usually constituted, consists of diverse forms whose anatomical relationships are imperfectly known. Moore (17) in his studies of the Molluscs of the Great African lakes described the anatomy of archaic forms like *Nassopsis* and *Bythoceros*. In the monographs of Bouvier (8), Bernard (7) and Perrier (20), anatomical accounts of particular systems of organs of some of the Melaniidae are referred to. Of no typical member of the family, however, whether foreign or Indian, a complete anatomical account has so far been published. For the Indian forms the only references available are the contributions by Annandale (2, 3) and Rao (26), and relate only to the radular or conchological features.

For the genus *Paludomus*, Ramanan (25) described briefly the habits of *P. tanschaurica*, and Annandale (2) figured the radula of *P. obesa* and commented on the distribution of the genus in India. The present paper gives a complete account of the anatomy of *P. tanschaurica*.

The genus *Paludomus* occurs in Ceylon, India, Malay Peninsula and Borneo. Preston (24) records thirty five species from the Indian Empire. *Paludomus tanschaurica* is found generally in clear, slow moving, shallow streams with a sandy bottom. The animals usually come towards the water-edge of the stream and extend the anterior part of the body out of water. The animals feel quite at home out of water for some length of time, and even crawl about outside water. When placed in a basin of water in the laboratory, they invariably climb the sides of the vessel and come to the water-edge with the anterior part of the body extended out of the shell, and some even crawl out of the water and lie outside. Fully grown specimens are met with in abundance usually in November and December. The shells in the adult specimens are usually found coated with encrustations of mud and algae and are then not easily distinguished from the surrounding algae that may be present in the water around them. In the hot season, when the stream dries up, the animals burrow into the mud. In the laboratory, specimens that had been kept outside water for two months easily revived when placed in water.

Ramanan (25) states that the species is 'oviparous' and I believe it is so, as I have not come across any evidence of vivipary in the animal.

THE ANIMAL.

The body of the animal, which consists of two and a half whorls, shows the usual divisions of the Gastropod body, head, foot and visceral mass. The head, foot and the mantle edge with its processes can be protruded out of the shell. When the animal actively moves about in water, the mantle processes are fully extended into the water and project forwards, but do not rest on the upper surface of the shell as in the

case of *Melanoides*. When the animal is out of water, the tips of the mantle processes project a little beyond the shell.

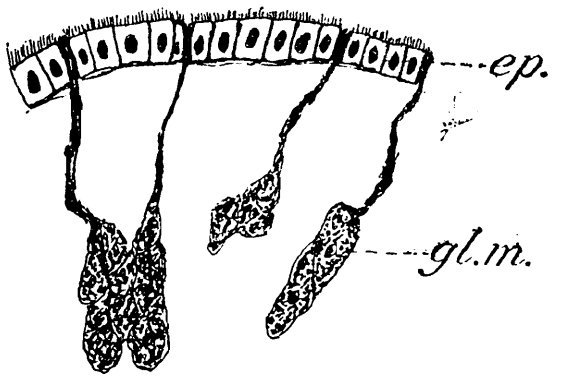
In the male the first and the second whorls have an orange brown colour, due to the presence of the testis on the dorsal and right lateral aspects. In the female specimens, the corresponding whorls are occupied by the ovary which is grey with interspersed yellow patches. On the convex side of the lower part of the second whorl the stomach is conspicuous. At the lower or anterior end of the penultimate whorl, to the left, is the pericardium,and behind it, the termination of the style sac is noticed as a circular translucent spot surrounded by glistening white connective tissue. Commencing at the apex of the body and extending to the right, and then alongside of the style sac, is the renal organ which is yellowish white in colour.

The mantle varies in colouration in the different parts. In the adult male the right side of the mantle enclosing the lower part of the genital duct is of an orange brown colour, while in the female the corresponding region is greyish white to creamy white in colour due to the conspicuous lower part of the oviduct. The mantle over the ctenidial region has a bluish-green appearance and the dorsal part of the stomach region also shows the same colour.

The Head.—The head projects forwards as the partly contractile snout, which, in the fully extended condition, measures about 3 mm. The head and snout are dark brown in colour with interspersed yellow spots arranged in transverse rows. The oral aperture is vertical and slit-like and situated at the anterior end of the snout. The tentacles measure about 6 mm. when fully extended, and are cylindrical and tapering at the tips. They bear the eyes on the outer side on slight lateral prominences. The tentacles are of the same colour as the snout.

The snout, in cross-section, is roughly semicircular in outline. The integument over the snout and the head consists on the outside of a layer of columnar cells with deep staining cytoplasm and round nuclei. The cytoplasm towards the distal ends of the cells is densely filled with brown pigment. Beneath the outer epithelium is a thick layer of transverse muscle fibres containing connective tissue between them. Underneath the transverse fibres are longitudinal fibres. On the sides of the head the longitudinal fibres are not confined to the lower part of the head but are present higher up also. Below the longitudinal fibres a few transverse fibres are again present. These different muscles bring about the elongation and contraction of the snout. The tentacle is covered by a columnar epithelium with unicellular mucous glands between the epithelial cells. The cells contain pigment and are similar to those found in the integument of the snout. The central part of the tentacle shows a more densely arranged connective tissue than that in the peripheral part lying under the epithelium, and contains several lacunae. The tentacular nerve and the tentacular blood vessel are seen in the centre. Underneath the general epithelium are circular muscles, and then come longitudinal muscles. Muscle fibres running across the tentacle from one side to the other are also present. The connective tissue cells are heavily pigmented like the epithelial cells.

The Foot.—The foot in its fully expanded condition measures about 12 mm. by 8 mm., and is somewhat triangulr in shape, but owing to its contractility, it often assumes an oblong or quadrate shape. On the ventral surface, near the anterior margin it shows a shallow transverse groove. The sole is of a light grey colour with interspersed yellow spots. The central region of the foot is of lighter hue than the peripheral. The operculum is carried by the foot dorsally about its middle, and the shell rests on the operculum when the animal is in progression. The foot, in its general structure is in no way specially modified. It is covered by columnar epithelium, which on the ventral surface is ciliated, while the main mass of the foot is composed of connective tissue and muscles, including longitudinal, transverse and vertical or dorso-ventral fibres. In the region of the anterior groove the cilia are longer. The pedal gland which is well developed is situated beneath the ventral epithelium and is composed of ovoid masses of gland cells with oval nuclei and long necks opening on the ventral surface. Each gland mass has the appearance of a multicellular gland of the saccular type, but is really a compact collection of unicellular gland cells. The narrow necks of the cells, as they develop and press forward to the epithelium, simulate the appearance of ducts. Anterior to the groove are more deeply staining, roundish cells with round nuclei and with their cell-details usually obliterated by the deep stain which they take up. As the cells develop they come up to open into the groove.



TEXT-FIG. 1.—The pedal gland-masses. *e. p.* ventral ciliated epithelium of the foot; *gl. m.* mass of gland cells.

The columellar muscle does not call for any remarks. A pseudo-epipodial flap forming a siphon, as in forms like *Viviparus*, *Pila* and *Mysorella*, is not present in *Paludomus*; but, the right side of the mantle opposite the terminations of the rectum and genital duct is produced into a short broad triangular spout-like structure.

THE MANTLE AND MANTLE CAVITY.

The mantle has the usual relationship to other organs and is better developed dorsally. Ventrally it unites with the foot leaving free a narrow fringe of about 0·5 mm.

The anterior part of the mantle is of interest in several respects. Immediately anterior to the termination of the ctenidium a vein runs transversely. This is the circum-pallial vessel or vena circularis. When the mantle is examined fresh, there is seen a heavily pigmented area in front of this vessel, extending for a distance of about 0·8 mm., and beyond it is a broad greyish white area appearing to be slightly thicker than the rest of the mantle edge. This corresponds in position to the supramarginal ridge of forms like *Viviparus*. Anterior to this greyish band, lies the free edge of the mantle or the mantle margin. The mantle

margin is ciliated and is about 0·2 mm. in width and slightly translucent in appearance in the living animal. In the position corresponding to the supramarginal ridge is a shallow groove, the supramarginal groove, but as will be shown later on, the differentiation of the mantle into a supramarginal ridge with a supramarginal groove in front of it, as seen in the Viviparidae, Ampullariidae and many other groups, is not properly discernible in the case of *Paludomus*. Blood vessels are seen ramifying in the pigmented area and communicating with the circum-pallial vessel.

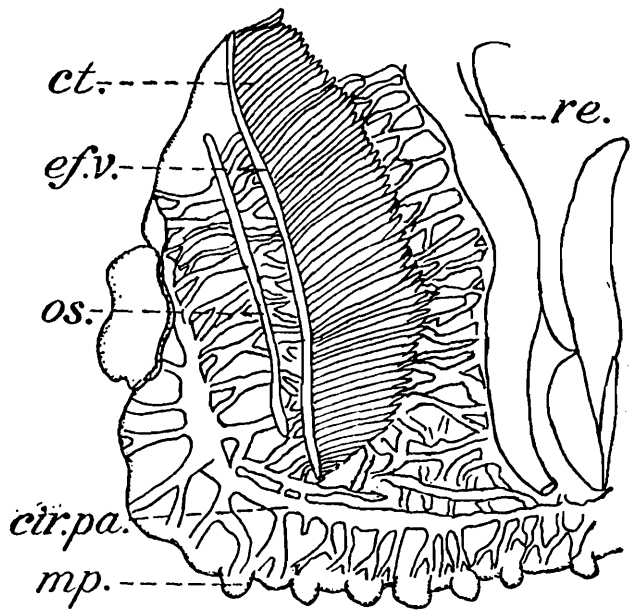
The most conspicuous feature of the mantle is the presence of the mantle processes. In very young specimens nine to twelve may be noticed, and in the adult specimens there are usually fifteen to twenty but the number sometimes goes up to twenty-three. The processes on the right side are usually closer to one another than those of the left side. They are of more or less uniform size unlike those of *Melanoides*. In the absence of grooves communicating with the supramarginal groove they differ from those of the Viviparidae. They differ also from the mantle processes of *Turritella*, which are grooved dorsally and are arranged in two rows.

In *Paludomus* the processes arise from the ventral surface of the mantle edge, and are, generally speaking, finger-like in outline. In the contracted condition they measure about 0·2 to 0·3 mm. and appear as oval structures with their long axes parallel to the mantle margin and are attached by stalk-like bases. When fully extended, they assume a more or less lanceolate shape. Observed in the living condition under the microscope, the mantle processes show a pellucid, peripheral portion and a densely pigmented central part. The pigment is light yellow in colour, seen by incident light under the binocular dissecting microscope. It is not uniformly dense in all processes; in some a few splashes are seen, sometimes none, while in others very dense lumps may be seen. The pigment is usually continuous with that of the basal part of the processes and that in the mantle also, but in some it may be discontinuous. Sometimes similar pigment is noticed in the mantle between the processes. Under high power the pigment appears in the form of a network of granules.

The Circulation in the Mantle.—The circum-pallial vessel receives small veins anterior to it. Posteriorly also there is a network of vessels communicating with it, and here and there are small veins having a course somewhat parallel to the circum-pallial vessel and communicating with it. Sinuses are present in the mantle processes also and they communicate with the circum-pallial vessel. Further details are dealt with under the circulatory system.

Histology of the Mantle processes.—In a vertical section passing through the mantle and the mantle process, the mantle process is seen as an anteroventral prolongation of the mantle. Its epithelium is continuous on the one hand with the epithelium of the ventral surface, and on the other with the epithelium of the mantle margin. It is composed of narrow columnar cells with prominent, elliptic to oval nuclei showing granular chromatin. The cells, especially towards the sides and the base, are ciliated. The distal ends of these cells show fine

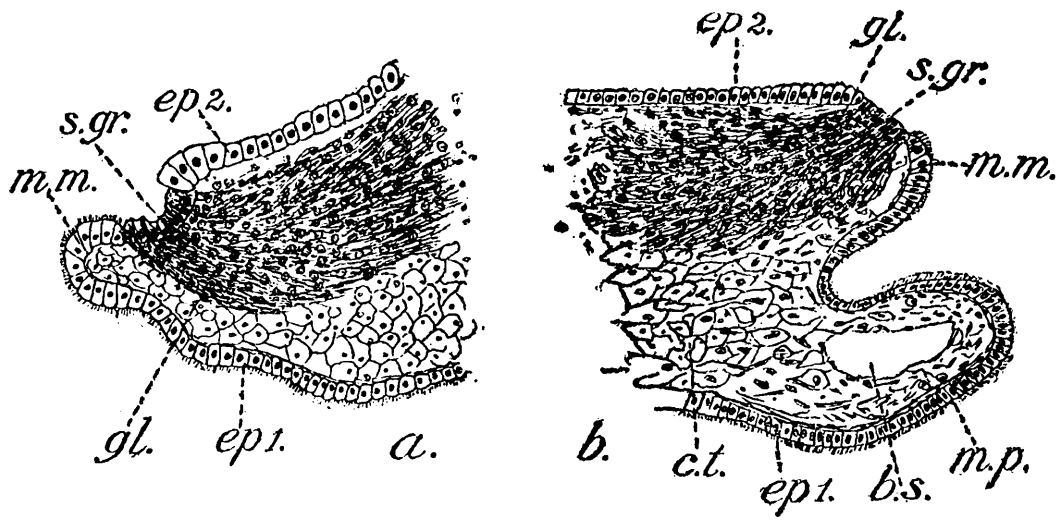
granules. Between the epithelial cells a few unicellular gland cells are seen. Each gland cell has a long narrow neck opening on the surface and a round swollen base containing an oval nucleus. The gland cells appear to be the same as those of the ventral epithelium of the mantle edge, and stain homogeneously. The thickness of the mantle process is composed of connective tissue and one or more sinuses. The pigment which is conspicuous in the living condition is not seen in sections.



TEXT-FIG. 2.—Circulation in the mantle. *cir. pa.* circum-pallial vessel; *ct.* ctenidium; *ef. v.* efferent ctenidial vein; *mp.* mantle process; *os.* osphradium; *re.* rectum.

The Histology of the Mantle.—The inner surface of the mantle in the anterior region is composed of columnar ciliated cells, among which are found unicellular mucous glands. The upper surface which is considered responsible for the secretion of the nacreous layer is composed of cubical or shortly columnar cells with large or rather oval nuclei. The anterior part of the mantle comprising of the mantle margin and the region of the supramarginal groove, in very young specimens differs to some extent from that of adult specimens. In the former, behind the mantle margin, there is a distinct groove and the epithelium behind it is slightly raised, being composed of cells a little taller than those of the remaining part of the outer epithelium of the mantle. The cells in the supramarginal groove are columnar and slightly compressed with large round, basally placed nuclei. They are similar to the outer epithelial cells of the mantle. Situated in the connective tissue of the mantle and extending a little backwards under the outer epithelium is the shell gland which is composed of elongate cells with large round nuclei containing granular chromatin. Generally, in the different families (Viviparidae, Ampul-lariidae) similar gland cells open behind the groove on the supramarginal ridge, but in *Paludomus* they distinctly open into the supramarginal groove. As in *Pila* and *Viviparus*, the gland consists of a mass of cells having narrow necks which reach out to the groove but are shorter than those in the Viviparidae.

In adult specimens, the region of the groove is very shallow and is not clearly seen. Its position is indicated usually by the break in the



TEXT.-FIG. 3.—*a*. Section through the mantle edge of an young specimen. ep_1. inner epithelium of the mantle; ep_2. outer epithelium; *gl.* shell gland; *m. m.* mantle margin; *mp.* mantle process; *s. gr.* supra marginal groove.

b. Section through the mantle edge and mantle process of an adult. *b. s.* blood sinus; *c. t.* connective tissue; ep_1. inner epithelium of the mantle; ep_2. outer epithelium of the mantle; *gl.* shell gland; *m. m.* mantle margin; *m.p.* mantle process; *s. gr.* region of the supra-marginal groove.

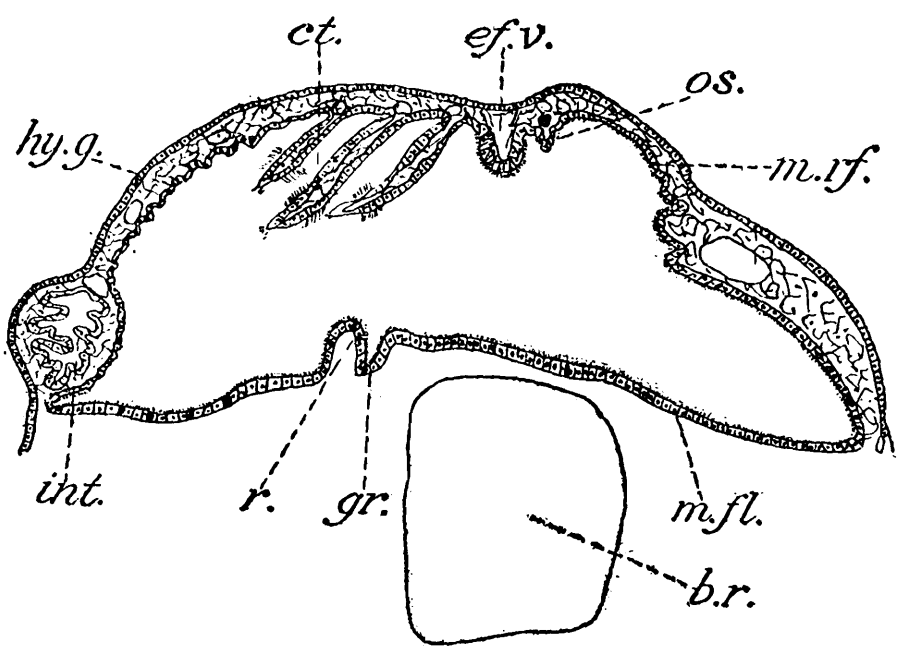
continuity of the dorsal epithelium and sometimes by a slight depression. Into this region the fibre-like necks of the shell glands open. The cells of the supramarginal groove, as seen in young specimens, are hardly distinguishable in the adult. In a large series of sections of the mantle edges of the adult examined by me, I found the shell gland present in a more or less well developed condition. The region immediately in front of the supramarginal groove is the mantle margin and consists of ciliated columnar cells.

The thickness of the mantle is composed of connective tissue, blood vessels and muscle fibres. The latter consists of longitudinal fibres beneath the epithelium, transverse muscle fibres and a few fibres running across the thickness of the mantle. The connective tissue cells are large and irregularly round and some of them contain calcareous concretions.

As to the function of the mantle processes, it is certain that they do not mould the sculpture of the shell as in the Viviparidae, the structure between the two being quite different. Further in *Paludomus* the processes are not embryonic structures as in many Viviparidae, but increase in size and number as the animal grows. In '*Melania*,' Benson (6) states that the processes clasp the right lip of the shell while the animal is crawling, and thus perhaps occasion the transverse furrows observable on the shell. In *Paludomus*, as seen already, the processes are more uniform and do not clasp the shell in the same manner as in *Melania*. But in the living animal they project beyond the shell and are turned up against the edge of the shell. If at all they can have any share in the formation of the sculpture of the shell, it can only be that, by frequent pressing against the edge of the shell as it is secreted, they

cause the lines seen on the shell, which, when examined under the lens, appear to consist of a series of minute elevations; but there is no exact correspondence between the mantle processes and the spiral lines which are about fourteen, the three central ones being prominent. The presence of definite sinuses in the processes in communication with the circumpallial vessel would show that the processes may function to some extent as accessory respiratory organs.

The Mantle cavity and the Pallial complex.—The floor of the mantle cavity shows on the right side a low ridge bounding on one side a slight depression or groove and extending from the apex of the mantle cavity to the region below the right tentacle. This ridge and groove are present in both the sexes and have no connection with the reproductive system like the genital grooves of the type which Moore (16)



TEXT-FIG. 4.—The mantle cavity (diagrammatic). *b. r.* buccal region; *ct.* ctenidium; *ef. v.* efferent ctenidial vein; *gr.* groove on the mantle floor; *hy. g.* mucous gland; *int.* intestine; *m. fl.* mantle floor; *m. rf.* roof of the mantle cavity; *os.* osphradium; *r.* ridge on the mantle floor.

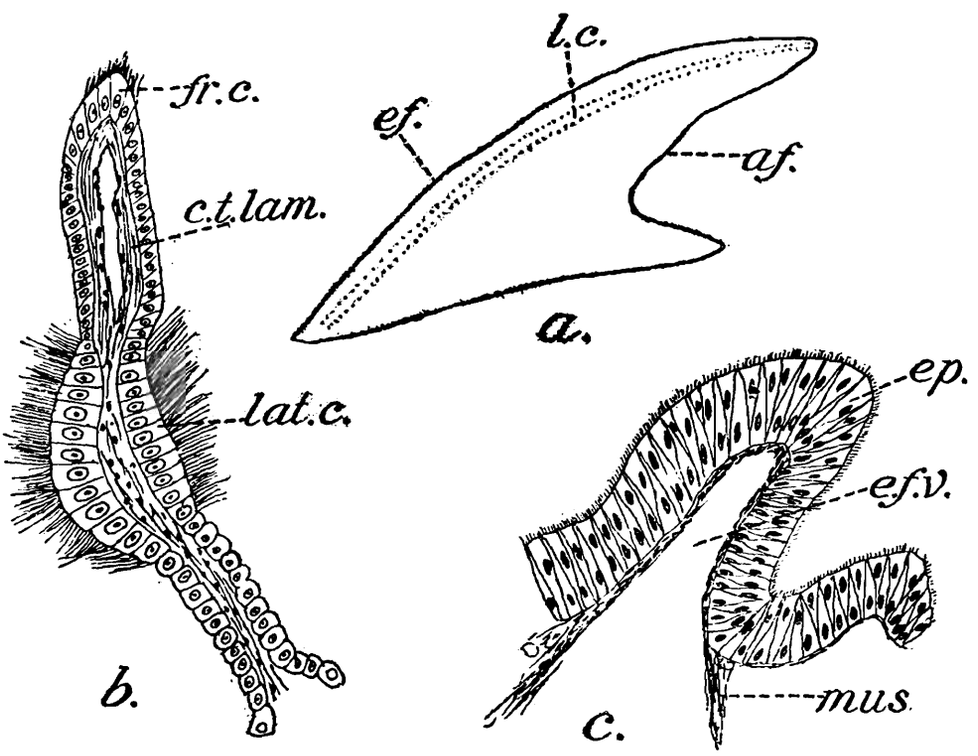
described in some of the Melaniidae. The position of the ridge and groove is similar to that of the food groove noticed by Yonge (33) in forms with ciliary feeding mechanism, but, as will be shown later on, there is no ciliary feeding in *Paludomus*. Sections through this region show the ridge to be a small, simple elevation of the mantle floor. In conjunction with the special ciliated epithelium at the base of the ctenidum, which will be described below, this ridge and groove may play some role in directing the water currents in the mantle cavity.

The pallial complex, as usual, consists of the osphradium, the ctenidium, the hypobranchial gland, and the lower part of the genital gland.

The osphradium is situated on the left side of the mantle cavity and is in the form of a simple, narrow ridge of more or less uniform width, and measuring about 3 mm.

The ctenidium is monopectinate and measures about 10 mm. It consists of about 200 lamellae. The lamellae in the middle region of the ctenidium are, as usual, of greater width than those towards either end of the ctenidium. Each lamella is attached to the roof of the mantle by its base and has a concave afferent side. The efferent side is longer than the base and measures about 2·4 mm., while the base measures only 1·8 mm. The region of specially well-developed cilia *i.e.* of the lateral cells is parallel to the efferent side.

A ctenidial leaflet is composed of a double layer of epithelium enclosing a blood space and a connective tissue lamella. In the latter, nuclei and muscle fibres are seen. At the apex of the leaflet the frontal cells are shortly columnar and ciliated, with large round nuclei. These gra-



TEXT-FIG. 5.—*a*. A single lamella of the ctenidium. *af*. afferent side; *ef*. efferent side; *l. c*. region of lateral ciliated cells.

b. Section through a single ctenidial lamella. *c. t. lam*. connective tissue lamella; *fr. c*. frontal ciliated cells; *lat. c*. lateral ciliated cells.

c. The mantle epithelium over the efferent ctenidial vein. *ef. v*. efferent ctenidial vein; *ep*. ciliated and glandular epithelium; *mus*. muscles.

dually pass down into the next part of ctenidium composed of shorter cells enclosing the efferent blood space. Below this is the region of the lateral cells with well-developed cilia. The cells are tall and columnar with large oval nuclei and the cilia are as long as the cells. The rest of the ctenidium is lined uniformly by somewhat cylindrical cells having among them ovoid gland cells.

The epithelium over the efferent ctenidial vessel is high and consists of columnar ciliated cells with rather distally placed nuclei. Between them are narrow gland cells with basally placed nuclei, and granular cytoplasm. Beneath the epithelium, longitudinal muscles and vertical muscles passing to the mantle roof are present. The contraction of these muscles probably helps the flow of blood. As to the function of the

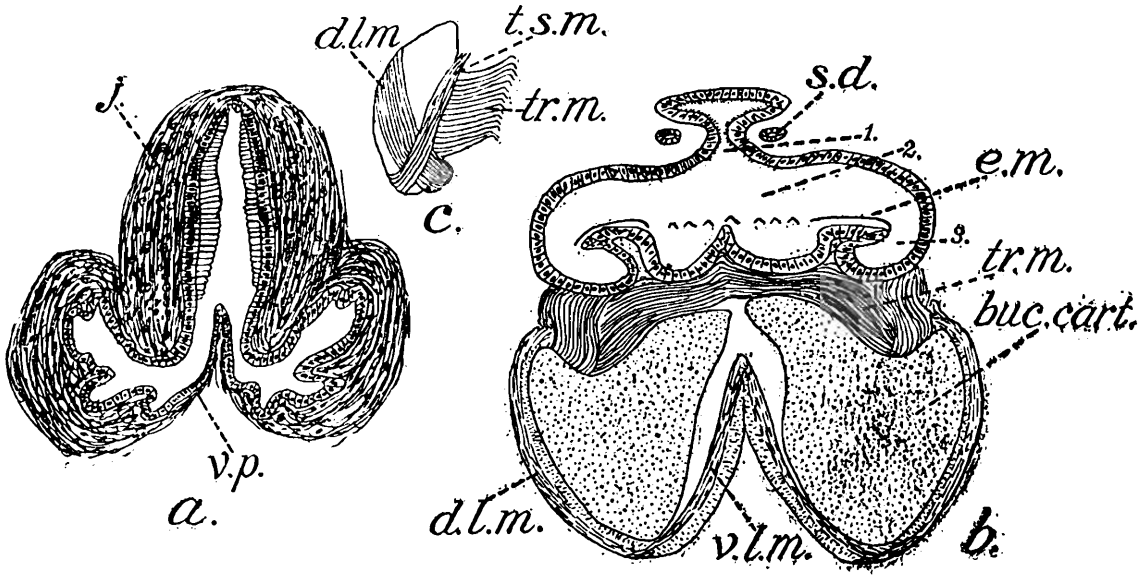
epithelium, it may be serviceable in directing the flow of the incurrent water. The mantle epithelium between the rectum and the ctenidium shows slight transverse folds and constitutes the mucous or hypobranchial gland. In this region the gland cells are numerous and globose and the depth of the staining they take depends on the amount of secretion in the cells. Between the mucous cells are columnar epithelial cells.

The general inner epithelium of the mantle is composed of short columnar ciliated cells with unicellular mucous glands between them. The gland cells are goblet shaped and differ from those of the hypobranchial gland in being of smaller size.

THE DIGESTIVE SYSTEM.

The food of the animal consists of diatoms and filamentous algae like *Spirogyra*. The feeding is by the radular mechanism.

The mouth is in the form of a vertical slit placed at the end of the snout. Bounding the mouth on either side there is an oval greyish coloured area which is smooth and cushion-like. The mouth is lined by columnar cells with oval nuclei and leads into the oral cavity or vestibule.



TEXT-FIG. 6.—*a*. Section through the region of the jaw. *j*. jaw; *v. p*. process of the ventral epithelium.

b. Transverse section of the buccal mass. 1. 2. 3 The three portions of the buccal cavity; *buc. cart*. buccal cartilages; *d. l. m*. dorsolateral muscles; *e. m*. elastic membrane; *s. d*. salivary ducts; *tr. m*. transverse muscle connecting the buccal cartilages; *v. l. m*. ventrolateral muscles.

c. Dissection to show the muscles of the buccal cartilages. *d. l. m*. dorso-lateral muscles; *t. s. m*. tensor superior muscle; *tr. m*. transverse muscle connecting the cartilages.

The oral cavity is surrounded by circular muscle fibres with connective tissue between them. The connective tissue is of the type found in the oral region of other Taenioglossates and which Bregenzer (9) termed labial cartilages in *Bythinella*. Muscle fibres run from the oral region to the dorsal and lateral regions of the snout. The appearance of the oral cavity as seen in section differs in the different parts. A little behind the mouth, the " vestibule " is seen to comprise of a central cavity produced into a dorso-median diverticulum and two ventro-lateral diverticula

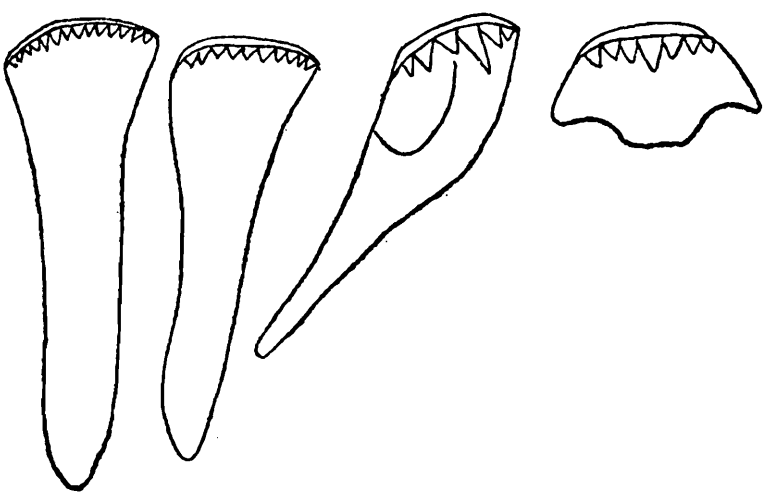
which are separated by a conical projection of the floor of the vestibule. A little further behind, about the commencement of the jaws, the ventro-lateral prolongations become reduced, while the conical projection of the floor assumes a dagger-shaped form in transverse section. The dorso-median chamber becomes prominent and its epithelium develops on its inner edge thick, cuticular plates which are continued into the jaws behind. The cells underlying the cuticular plates are columnar with elliptic nuclei, and show brown granules towards their free ends. In the region of the jaws the elevation on the floor of the cavity becomes still more pronounced and assumes a villus-shaped structure projecting half way into the dorsal diverticulum and the central cavity is drawn out laterally on either side. The jaws appear in transverse sections as chitinous rods in continuation of the underlying cells and are as long as the cells. Behind the jaws, the dorsal cavity becomes shorter and the oral cavity passes into the buccal cavity. In this region one can distinguish (i) a short median or dorsal unpaired cavity which is the continuation of the dorsal diverticulum of the oral cavity. Its roof shows two small lateral prolongations and its epithelium is ciliated throughout. (ii) The central cavity which has lateral expansions is flattened over the cartilages. (iii) In the posterior part of the buccal mass the ventro-lateral expansions of the buccal cavity dip beside the buccal cartilages. The floor of the central cavity shows two lateral elevations, one on either side, which are directed inwards and over which the elastic membrane is spread. The dorsolateral epithelium of the central cavity is composed of columnar cells with gland cells between them.

The buccal mass is pyriform and measures about 2 mm. Dorsally several fine strands of muscles arise from the anterior part of the oral tube and run to the dorsum of the snout. Some of these are median and others lateral. The anterior dorso-lateral muscles are represented by slightly thicker strands that arise laterally from the buccal mass about the region of the jaws. The posterior dorso-laterals are represented by two thick white strands arising from the sides of the buccal mass and several thread-like muscles arising more dorsally. The sphincter muscle, as usual, is developed in the anterior region of the buccal mass. The retractors of the buccal mass are club-shaped and arise laterally in the posterior part of the buccal mass about the level of the hind ends of the buccal cartilages. Ventrally a pair of ventro-median protractors are present arising at the hind end of the oral tube. A little behind these, the depressors of the radula arise and run down towards the region of the pedal ganglia.

The buccal cartilages are two in number, and viewed from the ventral surface, appear roughly oval in outline, but owing to a dorso-lateral depression in the anterior part, they appear as V-shaped structures in transverse sections of the anterior part. In the posterior part, the cartilages overlap each other partially. The structure of the cartilage is of the usual type, being composed of irregularly polygonal cells with faintly-staining, homogeneous ground substance, and with round deep staining nuclei situated close to the cell limits. The cell limits are distinctly stained. Towards the peripheral part of the cartilages the cells are small, and some of them possess two nuclei.

As for the muscles of the buccal cartilages, the condition presented by *Paludomus* differs from what has been described in forms like *Pila*, *Mysorella*, *Bythinella* and *Paludestrina*. Amaudrut (1) did not include the Melaniidae in his studies of the anterior part of the digestive tube of the gastropods. In a dissection of the buccal mass from the dorsal surface, after removing the superficial muscles, the radula and the elastic membrane, the buccal cartilages will be seen. Passing obliquely on the dorso-lateral surface of each cartilage is a band of muscle which runs forwards and inwards, and is attached to the elastic membrane. This corresponds to the tensor superior muscle. Underneath it is an oblique muscle, the dorso-lateral, running forwards and outwards from the posterior end of the cartilage. Posteriorly these muscles turn round to become continuous with those seen on the ventral surface, the ventro-lateral muscles. The ventral muscles run forwards on the inner surface of the cartilage. The transverse muscle connecting the two cartilages is a broad muscle arising from the dorso-lateral concavity of one cartilage and runs to that of the other and is therefore dorsal in position, though ventral to the dorsal muscles described above. In forms like *Pila* the muscle connecting the two cartilages is ventral in position.

The radula measures about 2·75 mm. It has the typical Taenioglossid formula 2. 1. 1. 1. 2 and bears about 130 transverse rows of teeth. The central tooth has a trapezoid outline, the anterior edge measuring 0·06 mm. and the posterior 0·09 mm., while the length in the antero-posterior axis is about 0·05 mm. The anterior margin, which is slightly reflexed downwards, bears one pointed conical, central denticle and three, sometimes four, smaller denticles on either side. The central denticle is stouter and more conspicuous than the lateral ones. The base of the



TEXT-FIG. 7.—The teeth of the radula showing the central, lateral and two marginals of one side.

central tooth is not straight but protrudes in the middle. The lateral tooth consists of a quadrilateral portion with its base prolonged on one side. The cutting edge bears one large denticle and three or more smaller denticles on either side. The outer and inner marginals are more or less similar, being somewhat spathulate in shape. The inner marginal bears ten small conical denticles. The outer marginal is slightly narrower than the inner marginal and bears twelve to sixteen denticles, sometimes even more.

In *Paludomus obesa,* the radula of which was figured by Annandale (2), the marginals have fewer denticles. The radula of *Paludomus tanschaurica* bears a closer resemblance to that of *Melania tuberculata,* the figure of which also was given by Annandale (2), in the marginals having small uniform denticles. The radula of *Paludomus* differs from that of *Acrostoma* in which the radular teeth are relatively shorter with fewer and blunt denticles. It differs also from that of *Nassopsis,* and less so from that of *Bythoceros* in which the shape of the central is different and the lateral has a shorter prolongation than in *Paludomus.*

The salivary glands are two long tubular and somewhat coiled structures. In preserved specimens they are usually found to extend as far as the region of the supra-intestinal ganglion. They lie close pressed to the sides of the oesophagus and in the region of the cerebral commissure lie under it. As they reach the buccal mass, the salivary glands pass into the salivary ducts which are narrower than the glands, and which taper towards their openings into the buccal cavity. The two ducts open on the dorsal surface into the buccal cavity, one on either side, about the middle of the buccal mass. The histological structure of the salivary glands of *Paludomus* agrees with that of Hydrobiidae, in having gland cells with support cells between them.

The oesophagus, on leaving the buccal mass, descends down to pass through the cerebral commissure, and is about 9 mm. long. The oesophageal epithelium has the usual histological features and is longitudinally folded. It has an investment of muscle fibres on the outside.

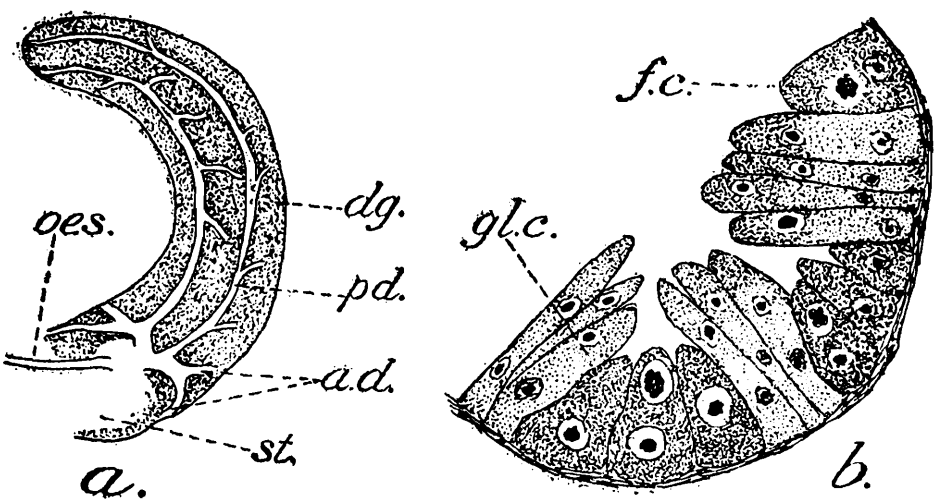
The oesophagus and the style sac are surrounded by a dense coating of a glistening-white connective tissue which shows effervescence on the addition of a drop of acid. The tissue consists of irregularly polygonal cells with feebly staining cytoplasm and deep-staining laterally placed nuclei. Some of the cells are large and possess calcareous concretions. When these are dissolved out as in the course of ordinary acid fixation, the cells appear full of of lacunae with thick walls.

The first part of the intestine has a well formed dorsal typhlosole besides finger-shaped processes. It has an investment of longitudinal and circular muscles. The rectum is much wider than the upper part of the intestine and its walls are thrown into prominent, longitudinal folds. A characteristic feature of the rectal epithelium is the abundance of goblet-shaped gland cells. After osmic fixation followed by iron haematoxylin, the cells show spherical basal nuclei and rows of dark spherical granules in the distal part. With ordinary stains the gland cells become deeply stained.

The disposition of the digestive gland has been described elsewhere. It consists of branched tubules or diverticula, from which small ducts arise. Those from the posterior part unite to form two long ducts running more or less parallel to each other from the apex of the body to the stomach. The main ducts from the anterior part are shorter and each posterior duct is joined by the anterior, so that there are ultimately two openings of the digestive gland into the stomach.

The tubules of the digestive gland, in cross section are roughly circular in outline and are bound together by connective tissue containing blood vessels. The tubules are composed of cells, which, by their

staining reaction and size, appear to be of two distinct kinds, the ferment cells and the gland cells. The ferment cells are ovoid, shorter, stouter



TEXT-FIG. 8.—*a*. The ducts of the digestive gland. *a. d.* anterior ducts ; *d. g.* digestive gland ; *oes.* oesophagus ; *p. d.* posterior ducts ; *st.* stomach.
b. Portion of a transverse section of the digestive gland. *f. c.* ferment cells ; *gl. c.* gland cells.

and crowded between the gland cells, and do not usually reach the cavity of the tubule. They are deep-staining and have a cytoplasm showing a vacuolated appearance in osmic fixed material followed by staining in iron haematoxylin ; the nucleus is spherical with a distinct nucleolus and is placed in the lower part of the cell. The gland cells are greyish and have a granular structure, the granules being abundant towards the free ends. They are cylindrical in shape, narrower and longer than the ferment cells and the nuclei are smaller. Both kinds of cells often show a large vacuole in the distal part. In the ferment cell the vacuole, when present, contains a number of small spherical bodies crowded together and dark brown in colour. In the gland cell the vacuole contains bodies which are light greyish brown and often in a state of disintegration or digestion. In some specimens especially in those infected with Trematode parasites, the cells of the digestive gland were found to be practically of uniform appearance, being of the type of the ferment cells. The nucleus, in almost all the cells, consisted of a clump of chromsomes and mitotic phases could be observed. Yonge (32) has shown that in Lamellibranchs the ferment cells are really the earlier stages of the gland cells and that they undergo division in the tubules. The same seems to be the case with the digestive gland of *Paludomus*.

THE CIRCULATORY SYSTEM.

The position of the pericardium has already been described. It is a triangular cavity bounded by the apex of the mantle cavity, the kidney and the style sac. There are no pericardial glands. The heart consists of a single conical ventricle and a somewhat oval auricle. The ventricle is thick and muscular, the muscles running from the base to the apex, from side to side, and obliquely as well as from back

to front. It has consequently a spongy appearance with a much diminished cavity. The auricle, as usual, is thin walled and less muscular and has a wider cavity. The muscles arising from the base of the ventricle are disposed to form a kind of valvular arrangement allowing blood to pass from the auricle to the ventricle but not the other way. The ventricle gives rise to a short truncus arteriosus which divides into an anterior artery and a posterior or visceral artery. At the base of the truncus arteriosus also, the muscle fibres are disposed to form a kind of valvular arrangement. The anterior aorta, after giving off a small artery, soon after its orgin, passes forward to supply the anterior part of the body and the foot. In its course it lies dorsal to the oesophagus, and anteriorly it gives off a branch to the foot, while the main branch passes beneath the radula to the buccal mass. The pedal artery runs dorsal to the pedal ganglion. The visceral artery runs on the dorsal side of the style sac, and proceeding further, gives off a branch to the digestive gland and another to the genital organ.

The venous system consists of a system of lacunae and is difficult to trace satisfactorily. The following appears to be the general course of the venous circulation. The genital gland and the digestive gland are situated in sinuses and the venous blood from the posterior parts of the body passes into the posterior sinus. Anteriorly the oesophagus and the anterior part of the alimentary canal lie in a sinus. The sinuses in the tentacles have been referred to already. The pedal sinuses run ventral to the pedal ganglia. The sinuses from the anterior parts of the body all unite into the anterior sinus. The anterior and the posterior sinuses unite ventral to the stomach to form the abdominal sinus. From the abdominal sinus some of the blood flows into the kidney from which a distinct renal vein passes to the base of the auricle into which it opens. The blood from the upper part of the intestine also passes through the abdominal sinus into the kidney.

The remaining part of the blood flows into the rectal sinus. The genital duct has under it a sinus into which also, some blood from the ventral or abdominal sinus seems to flow. From this sinus the blood flows into the rectal sinus surrounding the lower part of the intestine and the rectum. From the rectal sinus the blood flows along the roof of the mantle cavity into the ctenidial lamellae by a number of ramifications and from the ctenidium into the efferent ctenidial vessel. The efferent ctenidial vessel opens into the auricle at its base.

The pallial circulation, as stated already, is interesting. Bernard (7) did not study the Melaniidae, and of the forms he studied, *Natica* resembles *Paludomus* in the possession of a circum-pallial vessel but in other respects *Paludomus* is different. An examination of the fresh mantle or one fixed in formaline will show the distribution of the vessels. Arising from the lower part of the rectal region of the mantle is the circum-pallial vessel whose course has been described already. A number of sinuses are connected with it both in front and behind. Some of those in front communicate, as has been described above, with the sinuses in the mantle processes. The vena circularis or circum-pallial vessel runs to the left side and turns up where a number of sinuses from the left side of the body open into it. In this region a network of sinuses

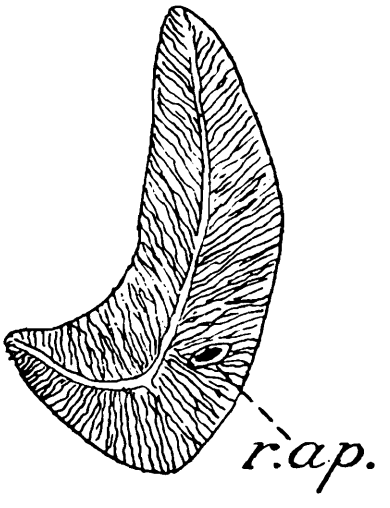
can be seen connecting the vena circularis with the efferent ctenidial vessel. Thus the blood from the circum-pallial vessel flows into the efferent ctenidial vessel. The appearance of this part of the pallial circulation is like that seen in the case of the Pulmonates. The habit of *Paludomus* in coming to the water's edge and keeping the anterior part of the body out of water is probably correlated, to some extent, with these peculiarities of circulation.

Several parts of the body, as noticed before, have a bluish green appearance and in the course of dehydration of fixed material, the alcohol is turned bluish-green, probably due to the presence of haemocyanin in the blood.

THE KIDNEY.

Perrier (20) made a passing reference to the kidney of *Melania* and said that it is a simple sac-like structure with its cavity obliterated by septa.

The renal organ of *Paludomus* is greyish or whitish yellow in the living condition. It is situated at the apex of the body whorl. Starting from the apex of the body whorl in front of the anterior end of the style sac, it passes up on the right side of the style sac as far as the posterior chamber of the stomach. Its anterior end projecting into the mantle cavity is roughly triangular in shape. The total length of the kidney is about 4 to 5 mm. and its greatest width is 2 mm., while in the narrow part extending alongside of the style sac it measures 1 mm.



TEXT-FIG. 9.—The kidney viewed from the ventral surface. *r. ap.* renal aperture.

The renal aperture into the mantle cavity is situated quite at the apex of the mantle cavity, more posteriorly than is usually the case. It is placed on the right side, on the ventro-lateral aspect of the ascending part of the kidney, close to the intestine. It is slit-like, and elliptic in outline. The pericardial aperture is much smaller than the pallial aperture and is placed on the pericardial aspect of the kidney. The intestine is placed dorsal to the kidney and is pushed down into it. In sections, this gives the appearance of the intestine being almost surrounded by the kidney.

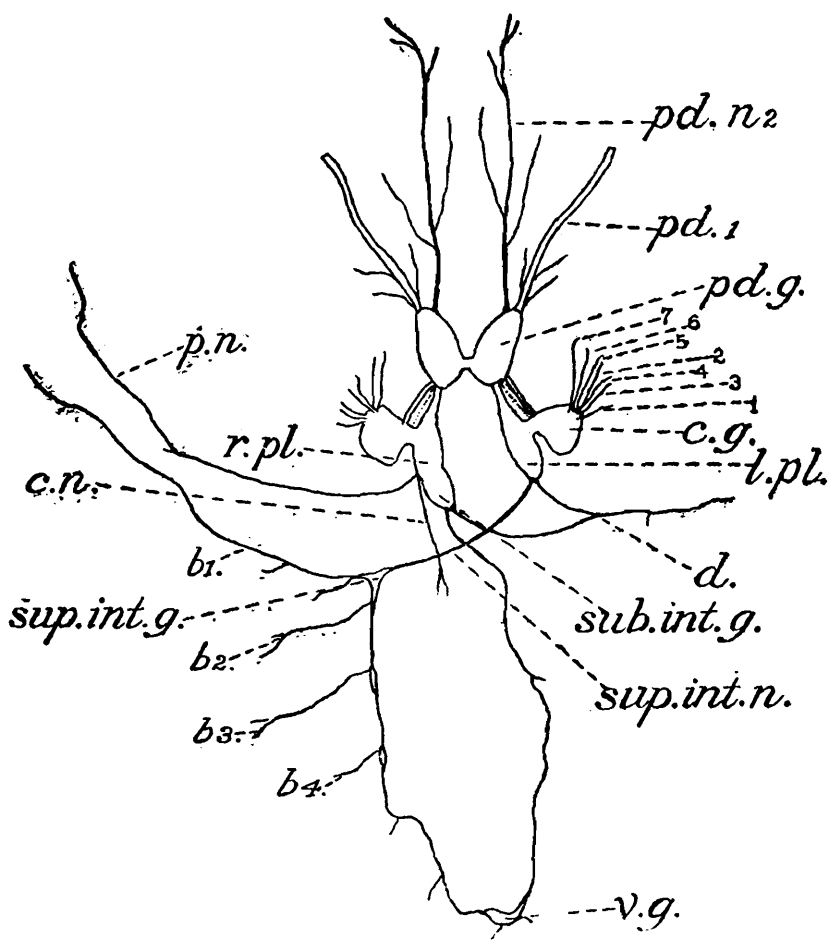
Internally the cavity of the kidney is traversed by numerous transverse septa. In a transverse section, the posterior part of the kidney lying between the style sac and the intestine appears roughly triangular in outline with the base being dorsal and the apex being near to the style sac. Running from the dorsal wall to the ventral are lamellae between which are blood spaces. Each lamella is composed of a double layer of renal epithelium enclosing a blood space. The renal cells are cubical with a homogeneous cytoplasm and usually vacuolated in the distal part. The nuclei are round and possess distinct, round nucleoli. In some of the cells, the nuclei are not seen.

The blood spaces in the lamellae communicate with the abdominal sinus surrounding the upper part of the intestine. The renal vein leaves the kidney ventrally in the anterior part. A blood-gland is absent.

The renal opening into the mantle cavity is lined by ciliated and gland cells and beneath the epithelium a well developed layer of muscles is seen. The reno-pericardial passage is lined by ciliated cells.

THE NERVOUS SYSTEM.

In the family Melaniidae, Bouvier (8) studied the nervous system of *Melania*, *Faunus* and *Melanopsis*. The study of the nervous system of *Paludomus* shows that it comes very close to that of *Melania* in all important features.



TEXT-FIG. 10.—The nervous system. 1 to 7. cerebral nerves; b_1. anterior branchial nerve; b_2, b_3, b_4, branchial nerves; *c. g.* cerebral ganglion; *c. n.* columellar nerve; *d.* dialyneury; *l. pl.* left pleural ganglion; *p. n.* pallial nerve; *pd. g.* pedal ganglion; pd_1 *n.*, pd_2 *n.*. dorsal and ventral pedal nerves; *r. p.* right pleural ganglion; *sub. int. g.* sub-intestinal ganglion; *sup. int. g.* supra-intestina ganglion; *sup. int. n.* supra-intestinal nerve; *v. g.* visceral ganglion.

The cerebral ganglia have a thick investment of connective tissue which has to be removed carefully in exposing them. They are oval in shape and their broad inner ends are united by a very short broad commissure. Each cerebral ganglion gives rise to seven nerves besides the nerve to the statocyst. The number, mode of origin and distribution of these nerves differs to some extent from what was described by Bouvier (8) for *Melania*.

(i) Arising dorsally from the outer lateral surface of the cerebral ganglion is a short slender nerve which proceeds to the side of the snout in front of the posterior retractor of the buccal mass. Bouvier (8) does not mention any such nerve in the case of any of the species of *Melania.* (ii) Anterior to this, arising dorsally from the anterior border of the cerebral ganglion, is a slender nerve, which, running forwards, divides into two branches and finally proceeds to the integument of the snout, in front of the tentacle. (iii) and (iv) Slightly posterior to the above nerve, arise the tentacular and ocular nerves which run more or less parallel to each other. The tentacular nerve is thicker than the ocular nerve and after passing into the tentacle, gives off a branch. (v) Slightly ventral to these, arises what may be called the proboscidian nerve which runs forward and divides into two branches proceeding to the dorsal part of the oral region. (vi) The next one is the labial nerve proceeding to the oral region. (vii) The ventral-most or innermost one is the buccal nerve which is well developed and fairly long. It gives off a labial nerve while the main nerve enters the buccal mass in front, and after giving off a small nerve to the anterior part of the buccal mass, runs backwards under the superficial muscles of the buccal mass and arrives in the buccal ganglion. The buccal ganglia are oval with their narrow ends connected by a fairly long commissure, and situated ventrally one on either side of the posterior part of the buccal mass. Each buccal ganglion gives off two nerves. The arrangement of the buccal connective is similar to the condition obtaining in *Melania* and *Cerithium.* (viii) The nerve of the statocyst arises close to and inside of the orgin of the cerebro-pedal connective. It is free throughout its course and runs between the crebro-pedal and pleuro-pedal connectives.

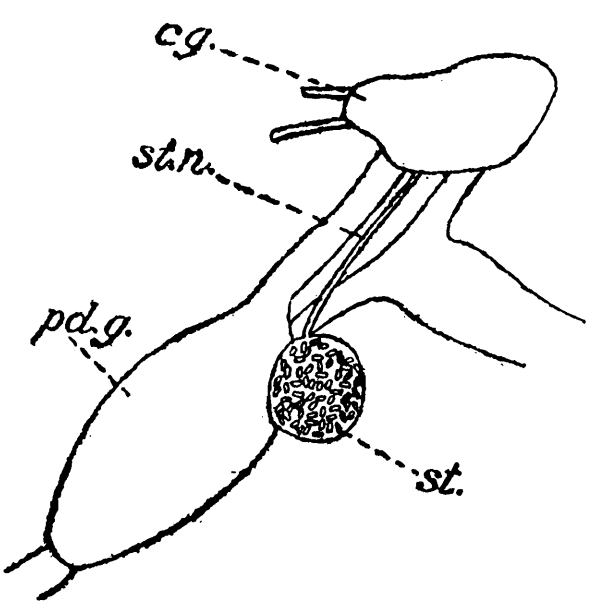
In the arrangement of the lateral centres *Paludomus* shows very close resemblance to *Melania.* The pleural ganglia are approximated to the cerebral, being connected to them by very short connectives, unlike the condition seen in *Melanopsis.* The right pleural ganglion is a somewhat spindle-shaped ganglion which gives rise to the supra-intestinal nerve and the right pallial nerve. The supra-intestinal nerve is a thick nerve which proceeds to the supra-intestinal ganglion. The left pleural ganglion is oval in shape and gives rise to two nerves (*a*) the left pallial nerve which proceeds to the anterior part of the mantle and (*b*) a slender nerve which runs down to the columellar muscle.

The sub-intestinal ganglion is in contact with the left pleural. Besides the right visceral nerve, it gives off a pallial nerve which proceeds to the right and joins the right pallial nerve from the right pleural ganglion, thus presenting a dialyneurous condition. The common nerve thus formed passes into the mantle on the right side and after giving off a branch proceeds to the genito-rectal region. This anastomosis differs from that seen in *Melania costata* and *M. tuberculata* in being much shorter and approaches the condition described for *M. amarula.* In fact, the anastomosis can be seen on opening the animal without much dissection.

The right visceral nerve has a slightly wavy course and in its course gives off one nerve. The supra-intestinal ganglion is triangular in outline and gives rise to two chief nerves, the 'anterior branchial' nerve

and the left visceral nerve. Close to its origin the anterior branchial nerve gives a fine branchial nerve and further on another slender nerve. After passing into the mantle it turns forwards and a fine nerve from the left pallial nerve runs towards this, but I have not been able to observe any anastomosis. The left visceral nerve is thinner than the right one and gives off three branchial nerves, the first one arising from it close to its origin from the supra-intestinal. Usually two small ganglia are seen in the course of the left visceral nerve. The visceral ganglion is slightly curved and situated close to the region of the renal aperture. It gives off two nerves one of which proceeds to the kidney.

The pedal ganglia are somewhat elongate and oval in shape and longer than the cerebral ganglia. The pleuro-pedal and the cerebro-pedal connectives are of moderate length, being much shorter than those of *Melanopsis* and slightly shorter than those of *Melania costata*. The two pedal ganglia are connected by a short narrow commissure situated in the upper part. The pleuro-pedal connectives are thicker than the cerebro-pedal. The pedal ganglia are produced into two thick ventral pedal cords which run to the posterior part of the foot. Close to its origin each pedal cord gives rise to two nerves, one on either side, and another nerve arises on the outer side a little further on. Arising dorsally and towards the inside of each pedal ganglion a thinner cord arises and runs parallel to its fellow. Each of these dorsal cords gives off a number of nerves but does not anastomose with its fellow. From the outer, lateral surface of each ganglion arises a short nerve to the sides of the foot. The pleuro-pedal cord close to its junction with the pedal ganglion, gives off laterally a short nerve.



TEXT-FIG. 11.—The statocyst and its nerve. *c. g.* cerebral ganglion; *pd. g.* pedal ganglion; *st.* statocyst with statoliths; *st. n.* nerve of the statocyst.

The statocysts are spherical and are situated in the upper part of the ventral surface of the pedal ganglion. The course of the nerve to the statocyst has already been described. The statocyst is spherical being about 0·3 mm. in diameter and is filled with numerous more or less oblong statocysts, the sides of which are slightly convex. The number

of statoliths varies in the family Melaniidae, as stated by Bouvier (8). In *Melania tuberculata*, *M. costata* and *M. amarula* according to Bouvier (8) the statocyst contains a single, round statolith. In *M. asperata* the statoliths are said to be numerous and so is the case with *Melanopsis*. In *Nassopsis* and *Bythoceros* also, the statocysts contain numerous statoliths. The statocyst in *Paludomus* is surrounded by connective tissue. Immediately outside the epithelium of the statocyst is a layer of muscle fibres. The epithelium consists of short cubical cells with large nuclei. Cilia could not be made out ; however, some of the cells appeared to have short processes.

The structure of the eye is of the usual type and does not call for any remarks. The tentacles have already been described.

The general shape and position of the osphradium have been described already. The osphradium is placed over a nerve and consists of (i) sensory cells, (ii) gland cells and (iii) ciliated cells. The sensory cells are columnar and possess oval nuclei. The gland cells are of the usual type and found between the sensory cells. The ciliated cells are found towards the base of the osphradium on the lateral edges.

It now remains to consider whether the nervous system of *Paludomus* shows any relationship at all to that of the African Melaniidae described by Moore (17). There is practically no resemblance to the archaic condition seen in *Nassopsis*. As for *Bythoceros*, *Paludomus* shows some resemblance in the disposition of the cerebral ganglia, in the dialynerous condition and in the approximation of the left pleural and the subintestinal ganglia. But the pleuro-pedal and the cerebro-pedal are shorter in *Paludomus* and the recurrent part of the buccal nerve passing to the buccal ganglion at the posterior end of the buccal mass is longer than in *Bythoceros*.

THE REPRODUCTIVE SYSTEM.

The reproductive system of *Paludomus* is peculiar among the Melaniidae and differs from what has been described in the other genera *Melania*, *Bythoceros*, *Nassopsis* and *Faunus*.

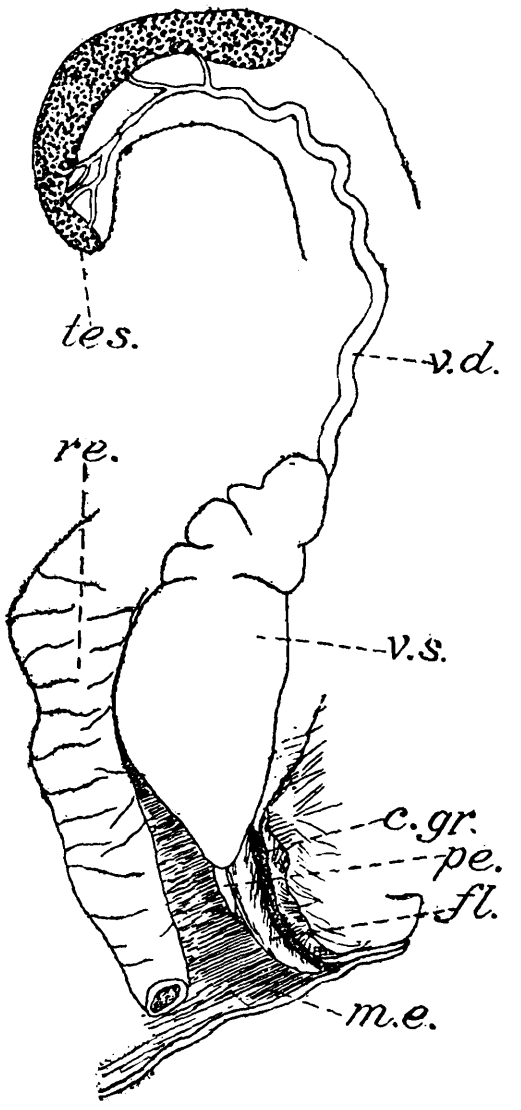
The animal is dioecious, but except for the slightly larger size of the body-whorl in the female, there is nothing to mark the sexes externally.

The Male Reproductive System.—The male reproductive system consists of the testis, the vas deferens, an enlargement of the vas deferens and the penis.

The testis is of an orange colour and occupies the dorsal and right lateral aspects of the first and second whorls of the animal and overlies the digestive gland. Anteriorly it extends very nearly to the posterior end of the stomach. It measures about 7 mm. in length and consists of tubular follicles. From these a few chief ducts arise and lead into the vas deferens which runs on the columellar side of the apical whorls. In its lower part which lies below the stomach, the duct becomes stouter and somewhat coiled.

On reaching the mantle cavity, the vas deferens presents an enlargement which may be termed the seminal vesicle. It opens anteriorly by a slit-like aperture which is bounded on one side by a flap extending beyond the genital duct for about 2 mm., *i.e.*, as far as the anal region

The area bounded by the flap is in continuation of the genital aperture and represents the vestigial, ciliated groove present in the reproductive

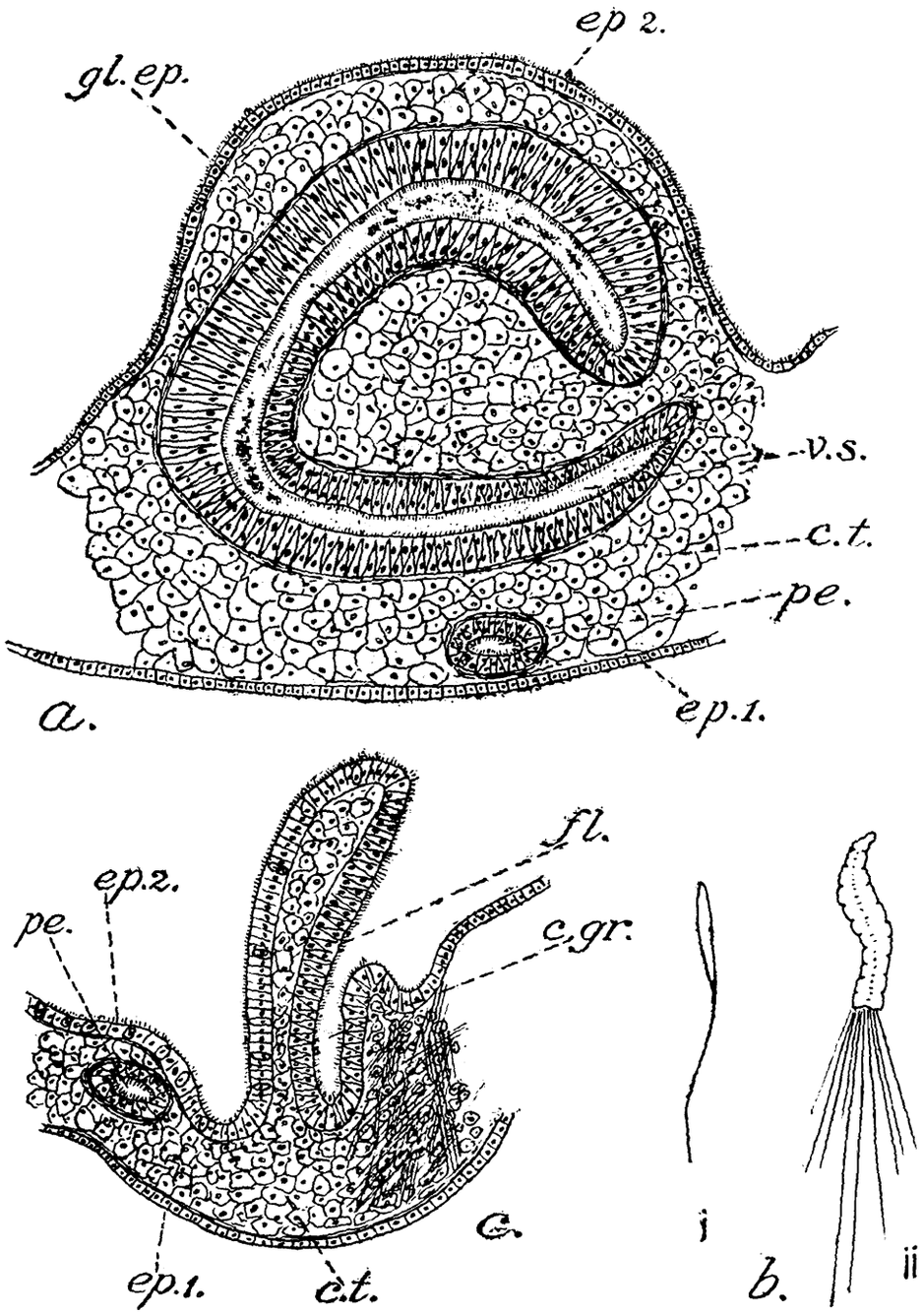


TEXT-FIG. 12.—Male reproductive system. *c. gr.* ciliated groove ; *fl.* flap bounding the ciliated groove ; *m. c.* mantle edge ; *pe.* penis ; *re.* rectum ; *tes.* testis ; *v. d.* vas deferens ; *v. s.* seminal vesicle.

systems of the less specialised forms. The flap arises from the ventro-lateral edge of the enlargement of the vas deferens, or seminal vesicle. In the enlargement of the vas deferens two parts can be made out externally, an upper or posterior, triangular and comparatively thin-walled part measuring about 2 or 3 mm. and a lower thick walled portion about 4 mm. in length. From the posterior part of this enlargement of the vas deferens a long and slender tubular structure, the penis, arises, and after passing on it for some length, runs forward in the connective tissue of the mantle and lies on the rectal side of the genital duct. It tapers at its free end and measures about 4 to 5 mm.

The cavity of this lower part of the vas deferens is rendered crescentic in section owing to its wall being pushed in on one side. In the presence of this curious copulatory organ *Paludomus* differs from the other Melaniidae. Bouvier (8) states that he did not observe a penis in the Melaniidae studied by him, although Fischer had mentioned the presence

of a penis at the back of the tentacles. In *Bythoceros* the male genital duct is enlarged, but not like that seen in *Paludomus*, and the penis is absent. In *Nassopsis* the genital duct is simple and shows no modification in the mantle cavity. In the possession of the penis besides the genital aperture, *Paludomus* resembles *Typhobias*, but in the latter the penis is developed from the mantle and is muscular, according to Moore (15).



TEXT-FIG. 13.—*a*. Section of the male reproductive system through the seminel vesicle and penis. *c. t.* connective tissue; ep_1, ep_2. outer and inner epithelium of the mantle; *gl. ep.* glandular and ciliated epithelium of the seminal vesicle; *pe.* penis; *v. s.* seminal vesicle.

b. (i) eupyrene sperms; (ii) oligopyrene sperms.

c. Section through the male reproductive system in the region of the groove and flap. *c. gr.* ciliated groove; *c. t.* connective tissue; ep_1, outer epithelium of the mantle; ep_2. inner epithelium of the mantle; *fl.* flap; *pe.* penis.

The sperms are of two kinds, eupyrene and oligopyrene. The eupyrene sperms measure about 14μ exclusive of the tail which measures about 26μ. The oligopyrene sperms measure about 20μ and bear a tuft of cilia, about ten in number and measuring about 40μ. The oligopyrene, when examined alive in fresh smear preparations, wriggle about.

The testis is covered by a single layer of cubical epithelium similar to and continuous with the general body epithelium. The investing epithelium consists of cubical cells with large oval nuclei. Beneath the epithelium are muscle fibres running transversely and underneath them lies connective tissue with blood spaces. The tubules of the testis lie in this connective tissue by which they are separated from one another. The tubules have a thin investment of connective tissue and their walls are composed of a protoplasmic layer in which nuclei of the sperm mother cells or spermatocytes are found. The spermatocytes develop into spermatogonia that project into the cavity of the tubule.

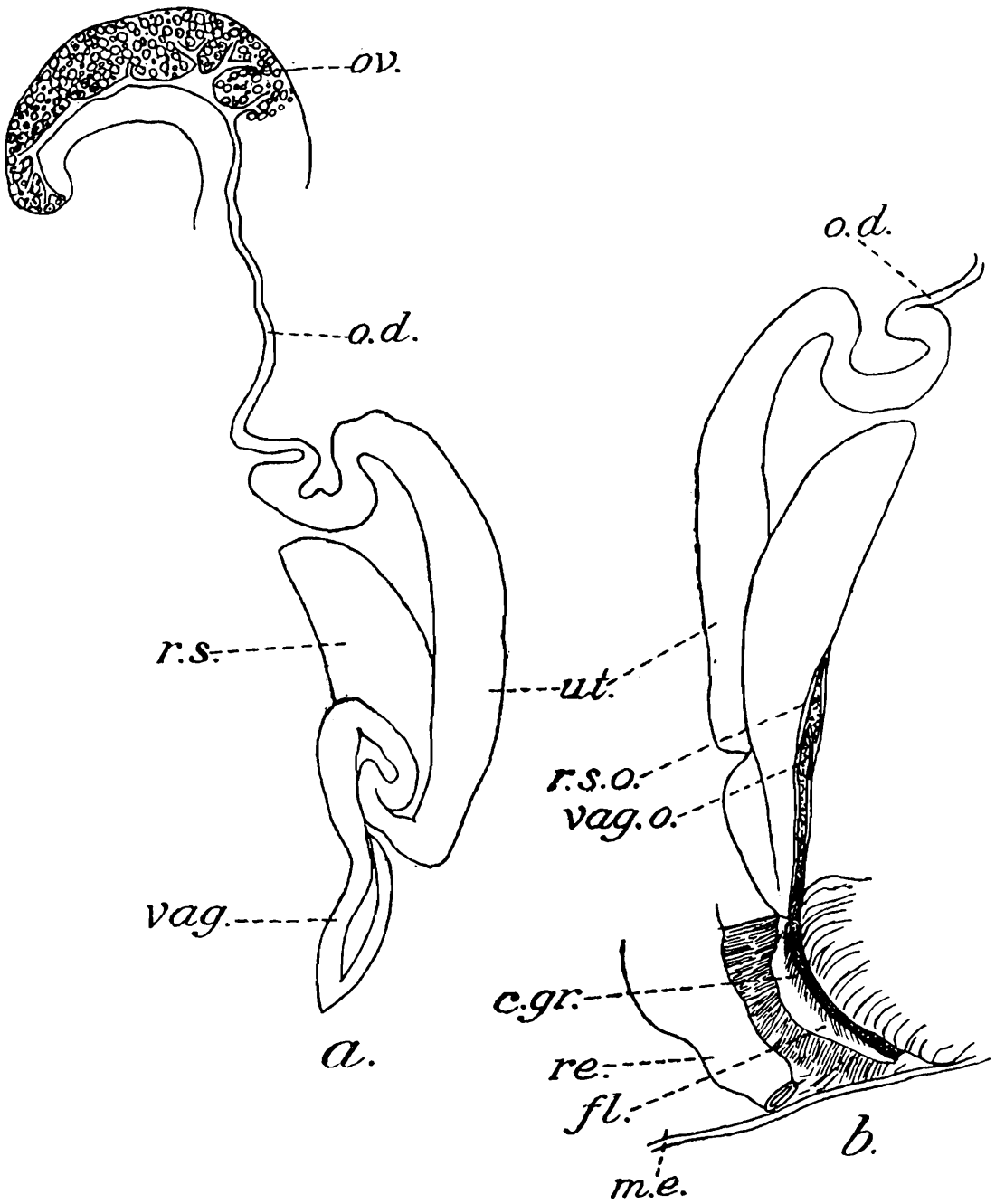
The vas deferens has an epithelium composed of cubical, ciliated cells, and is surrounded by muscle fibres.

The swollen part of the vas deferens or seminal vesicle lying in the mantle cavity has a thick investment of connective tissue in common with that surrounding the penis. The cavity of this enlargement is narrow and, as already pointed out, crescentic in section. The walls are thick and covered on the outside by muscle fibres. In transverse section the whole structure appears C-shaped and the narrow cavity is lined by ciliated and glandular epithelium. Owing to the presence of two kinds of cells, gland cells and ciliated cells, the nuclei appear at two different levels. The ciliated cells are narrow and possess oval nuclei which are rather distally placed, whereas the gland cells have basally placed nuclei. The penis, in transverse section, appears elliptic in outline. Its cavity is merely a narrow continuation of that of the enlargement of the vas deferens, and its histological structure is the same. The groove also is lined by ciliated and glandular epithelium continuous with that of the seminal vesicle. The flap guarding the groove is lined on the side facing the groove by glandular and ciliated epithelium continuous with that of the groove. The outer side is composed of epithelium continuous with that of the inner surface of the mantle.

The Female Reproductive System.—The female reproductive system consists of (i) the ovary (ii) the oviduct (iii) the uterus (iv) the vagina (v) the receptaculum seminis and (vi) as in the male, a flap guarding on one side a ciliated furrow.

The ovary occupies a position corresponding to that of the testis in the male. The colour of the ripe ovary is grey with interspersed yellowish, circular patches. The ovary is a racemose structure consisting of much branched tubular follicles, from which small tubules arise and lead into about seven or eight larger ducts which finally join the oviduct. The lower or the anteriormost duct is stouter than the others and receives four smaller branches. The oviduct runs on the columellar side of the digestive gland and the stomach, and on entering the mantle cavity, enlarges into the thick walled uterus. The oviduct is about 4 or 5 mm. long and yellowish in colour. The lower part of the female genital duct

lying in the mantle cavity is peculiar. The uterus in its lower part turns up to take a sharp bend and after once more becoming doubled on itself

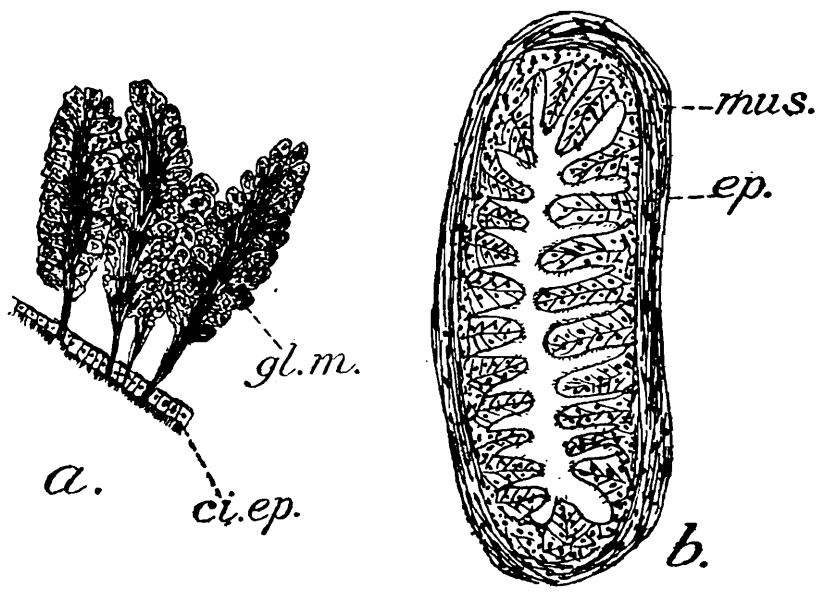


TEXT-FIG. 14.—*a.* Dorsal and *b.* ventral views of the female reproductive system. *c. gr.* ciliated groove; *fl.* flap.; *m. e.* mantle edge; *o. d.* oviduct; *ov.* ovary; *re.* rectum; *r. s.* receptaculum seminis; *r. s.o.* opening of the receptaculum seminis; *ut.* uterus; *vag.* vagina; *vag. o.* vaginal opening.

passes into the vagina. The vagina is oval in outline. Lying in the same plane as the uterus and vagina, there is a roughly triangular thin walled sac which appears to be a receptaculum seminis and not a brood pouch. The internal structure and the absence of any traces of embryos in the numerous specimens examined by me lead me to consider this sac a receptaculum seminis. The receptaculum seminis and the vagina open into a kind of furrow guarded by a flap extending, as in the male, for a length of about 2 mm. in front of the vagina. The flap extends from

the surface of the vagina and is continuous with the spermatheca also. The uterus is about 5 or 6 mm. in length and has thick glandular walls. The walls of the vagina and the uterus develop a creamy-white colour in mature specimens, which is seen conspicuously on the outer surface of the mantle.

The ovary is covered by a thin epithelium which is a continuation of the general body epithelium and underneath this there is connective tissue. The follicles which are roughly oval in section consist of a thin germinal epithelium from which ova in different stages of growth project into the cavity of the follicle. The ripe oogonia are found filled with yolk. The oviduct is lined by columnar ciliated cells. The cavity of the uterus also is lined by columnar ciliated cells. The thickness of the uterine wall in the upper part is composed of elongate saccular gland masses composed of groups of cells with ill defined cell-limits and round nuclei. These glands open between the epithelial cells into the cavity of the uterus. In the lower part of the uterus and the vagina, the walls, as already stated, have a creamy white colour, and the histological structure, though really the same as that of the upper part of the uterus presents often a different appearance. The cavity is roughly U-shaped. One limb of the U-shaped cavity develops in its walls, on either side, glandular tissue similar to that seen in the upper part of the uterus, but deep staining and with cell details obliterated. The gland masses open by narrow necks between the ciliated cells. Each gland mass consists of gland cells arranged round a central lumen and appearing like saccular glands opening into the uterine cavity between the epithelial



TEXT-FIG. 15.—*a*. The gland-masses of the vaginal wall. *ci. ep.* ciliated epithelium; *gl. m.* gland mass.
b. Section through the receptaculum seminis. *ep.* epithelium; *mus.* muscle.

cells. The other limb of the cavity is usually not invested with glandular tissue. This condition is similar to what I described in *Mysorella*. The inner side of the flap, and the groove are lined by an epithelium continuous with that of the vagina.

The receptaculum seminis, has a characteristic appearance in section. It has an investment of muscle fibres and its epithelium is thrown into finger shaped processes and is composed of columnar, glandular and ciliated cells, with basally placed nuclei, and with cytoplasm staining light pink with eosin. The ciliated cells seem to become transformed into the gland cells by the loss of the cilia. A brood pouch, as described for *Melania*, is not found in *Paludomus*. I examined a very large number of specimens in the different seasons of the year and no trace of 'vivipary' could be found. The species seems to be oviparous as Ramanan (25) has recorded.

The above account of *Paludomus* will show that its reproductive system is unlike that of any other genus in the Melaniidae, so far as is known to us. *Paludomus* has to be considered as a specialised form. The open groove present in the less specialised forms like *Melania episcopalis* as described by Moore (16) is indicated in *Paludomus* by the very short furrow, guarded by a flap extending anteriorly for a distance of 2 mm. from the genital aperture.

Summary and Conclusion.

1. The complete anatomy of *Paludomus tanschaurica* is described.
2. The foot possesses a well developed pedal gland.
3. The structure of the mantle and the mantle processes is described.
4. The mantle processes, which are present, do not have the same function as those in the Viviparidae. No function is definitely assigned to them, but the presence of the sinuses would show that they may subserve as accessory respiratory organs.
5. The shell secreting region of the mantle differs from that of the Viviparidae in one respect. The shell gland does not open on a supramarginal ridge but into the supramarginal groove which is found fairly well developed only in young animals.
6. The mantle floor shows a low ridge on the right side bounding a shallow groove and running from the apex of the mantle cavity to the right tentacle. The epithelium over the efferent ctenidial vessel is peculiar in being high and composed of well developed gland cells and ciliated cells. The ridge and this epithelium may be useful in directing the currents of water.
7. The buccal cartilages are connected *dorsally* by a broad transverse band of muscle.
8. The radula resembles in the nature of its marginals that of *Melanoides tuberculata.*
9. The salivary glands are fairly long, coiled, simple tubular structures.
10. The digestive gland shows two types of cells, the gland cells and the ferment cells, according to their staining reaction. The ferment cells undergo division in the tubules, and in some specimens, especially in those infected with parasites, all the cells of the digestive diverticula are uniformly made of ferment cells. It is quite probable that, as in Lamellibranchs, the ferment cells represent a stage in the development of the gland cells.

11. The pallial circulation in the anterior part of the mantle is interesting in the presence of a circumpallial vessel receiving a ramification of vessels in front of, as well as behind it, and communicating on the left side with the efferent ctenidial vessel.

12. The renal organ is a simple sac-like organ with its cavity traversed by transverse septa.

13. The nervous system resembles in general that of *Melania* in being dialyneurous, in the approximation of the sub-intestinal ganglion to the left pleural and in the nature of the buccal nerves.

The general tendency in *Paludomus* is towards greater concentration. The statocyst contains numerous statoliths unlike the statocysts of *Melania tuberculata*, *M. amarula*, which, according to Bouvier (8) have a single statolith.

14. The reproductive system does not resemble that of any other Melaniid described so far. The male reproductive system is interesting in having (*a*) an enlargement or seminal vesicle in the mantle cavity, (*b*) a slit-like aperture and (*c*) a flagellum-like penis. The sperms are of two types, eupyrene and oligopyrene. The female reproductive system possesses a uterus and vagina with glandular walls and a receptaculum seminis. There is no brood pouch as in *Melanoides*. In both sexes there is a short furrow of about 2 mm. guarded by a flap leading from the genital aperture to the mantle edge. This is the vestigial form of the ciliated groove found in the less specialised types of reproductive system.

15. The animals withstand dessication in the laboratory for over two months.

This account of *Paludomus tanschaurica* will show that its resemblances are to *Melania* especially forms like *Melanoides tuberculata* and *Melania amarula*. The resemblances are chiefly with reference to the nervous system. With regard to the reproductive system *Paludomus* stands by itself and shows features of specialisation in both sexes in the development of accessory structures.

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