

APPENDIX.

THE ANATOMY OF THE COMMON SOLEN OF THE CHILKA LAKE.— ? A DWARFED FORM OF *S. FONESI* DUNKER.

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The anatomy of *Solen fonesi* has been described briefly by Bloomer¹, but he gives few details of the internal structure and does little more than compare the foot, mantle, etc., with those of *S. vagina*. No detailed account of *S. vagina* is available in Calcutta and there are no specimens in spirit in the Indian Museum. It has therefore seemed best merely to describe the different organs of the form from the Chilka Lake and leave it to other malacologists more favourably situated as regards literature and material to decide whether the identification is correct.

In one point this form differs markedly from that described by Bloomer, *viz.*, in the entire absence of pigment on the external surface of the foot and mantle.

SHELL.

Shell thin, translucent, very brittle, with a brownish epidermis, corroded in its upper anterior portion (upper anterior quadrant), length about three and a half times the breadth; anterior margin straight and directed from above a little forwards, with a rounded antero-inferior angle; posterior margin straight and nearly vertical; a single narrow elongated umbonal tooth just behind the antero-superior margin in the right valve.

Anterior adductor impression elongately triangular, with the base oblique and directed in front; anterior retractor impression small, rounded and just below the anterior end of the anterior adductor impression. Posterior adductor impression small, rounded, just a little in front of the postero-superior angle; posterior retractor impression rounded, of the same size as that of the posterior adductor and placed just in front of the latter.

ANATOMY

In preparing the following description I have had recourse to the following methods:—

- (1) Two relatively large specimens have been dissected; the structures have been followed with the naked eye and with the help of the dissecting microscope.
- (2) Three medium-sized specimens, taken out of their shells, have been dehydrated in absolute alcohol, and cleared in clove oil. The mantle-lobes, gills, and the

¹ *Journ. Malac. Soc. London*, VII, p. 18 (1906).

labial-palps of one side were then removed and the animal was examined under a low power. The coils of the intestine, the ganglia, some of their commissures, and the general outline of the kidneys were well made out by this method.

(3) Lastly, a complete set of serial sections was cut by the paraffin method from one end of the animal to the other, and stained as usual. The arrangement and the relation of the various structures made out in the serial sections were compared with the results obtained by other methods.

I. MANTLE-LOBES.

The anterior margins are thick and straight and run a little forward from above; they are separate from one another in their full lengths so as to leave an oval gap for the foot. The separation extends beyond the antero-ventral corner for a short distance as a rounded notch. The ventral margins are united and thickened, although less so than the free anterior borders. The posterior margins are thickened and united to form a single siphon containing both the inhalent and exhalent canals.

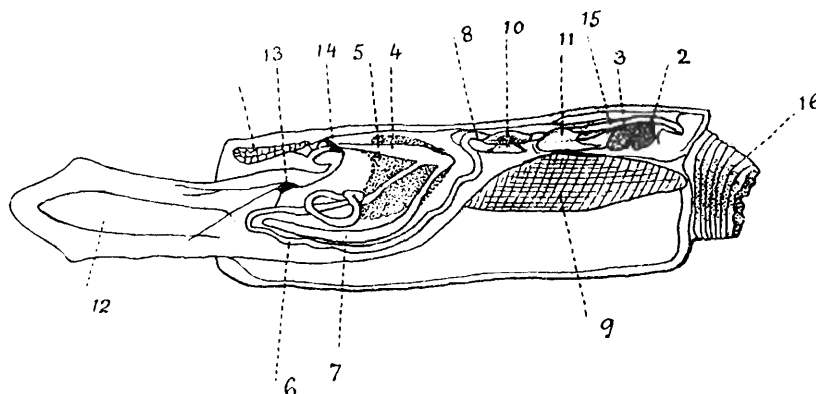


FIG. 1.—*Solen ? fonesi*, Dunker.

1. anterior adductor muscle; 2. posterior adductor muscle; 3. posterior retractor muscle; 4. stomach; 5. liver; 6. intestine; 7. pyloric caecum; 8. rectum; 9. gill (inner); 10. heart; 11. kidney; 12. pedal sinus; 13. pedal ganglion; 14. cerebral ganglion; 15. visceral ganglion; 16. remains of siphons after autotomy.

II. SIPHON.

The siphon consists of the fused inhalent and exhalent canals. When complete it consists of at least ten segments, each of which is wider at the base than at the apex. Each segment is at its distal border fringed with small conical tentacles, about 20 in number and arranged in a single row (see text-fig. 5, p. 354). When complete and fully extended, the siphon reaches a length nearly equal to that of the animal in the shell. When fully retracted and when a part has been thrown off the siphon lies very slightly protruded from the posterior border of the mantle-lobes. In the retracted state, the distal segment is less contracted than the others, forming a tumid rounded border bounding the inhalent and exhalent apertures. The tentacles are retracted and turned inwards towards the apertures.

Minute structure (figs. 2, 3).—In a transverse section, the siphon consists of a thick wall with a transverse band separating the apertures (text-fig. 2).

The wall consists of the following layers :—

- (1) An outer layer of columnar cells situated on a distinct basement membrane.
- (2) A thick layer of connective tissue with many elastic fibres and connective tissue corpuscles. The fibres are mostly arranged circularly and radially in narrow bundles at regular intervals. They are continued into the next layer.

- (3) A thick longitudinal layer of muscles fibres grouped into radial bundles by radial and longitudinal partitions of connective tissue which extend from the second layer to the next. The muscular layer is divided into an outer and an inner portion by a thin circular layer of connective tissue

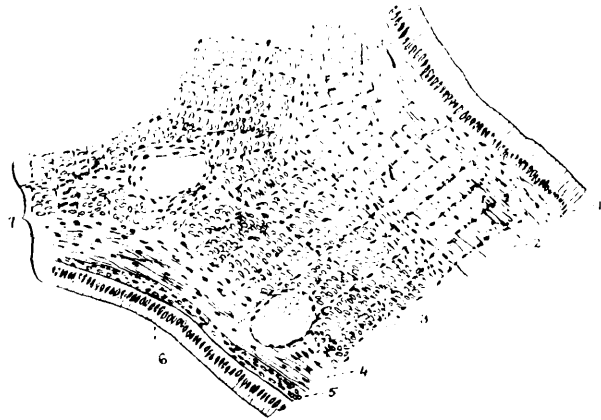


FIG. 2.—*Solen ? jonesi*, Dunker.

Transverse section of the wall of the siphon.

1. outer epithelial lining; 2. outer layer of connective tissue; 3. longitudinal layer of muscles; 4. transverse layer of muscles; 5. longitudinal layer of muscles; 6. epithelial lining of the inhalent tube of the siphon; 7. part of transverse partition.

fused with the radial ones at their points of crossing. This thin layer of connective tissue is united on both sides by a thin layer of the same tissue, which forms the middle of the thick transverse partition between the inhalent and exhalent canals. At the junction of the two lie two blood-sinuses, one on either side. On either side of this median layer lies a narrow longitudinal layer of muscular tissue continuous with the inner portion of the longitudinal layer of muscular fibres in the wall of the siphon.

- (4) A thin layer of connective tissue which is interrupted at the junction of the outer wall of the siphon with the transverse partition. In this layer and abutting on the next outer muscular layer are blood-sinuses and nerves disposed in the following manner :—The blood-sinuses are 4 in number—two lateral already referred to, and one in the mid-dorsal and one in the mid-ventral line. The nerves are 12 in number, three on each side of the inhalent and three on each side of the exhalent aperture.

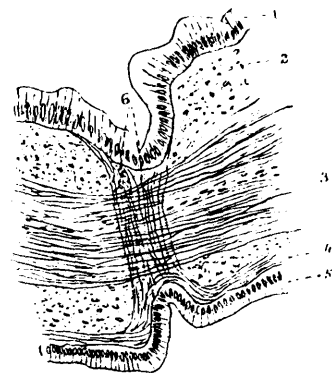


FIG. 3.—*Solen ? jonesi*, Dunker.

Longitudinal section through wall of siphon at junction of two contiguous segments.

1. outer epithelial lining; 2. outer layer of connective tissue; 3. longitudinal layer of muscles; 4. inner longitudinal layer of muscles; 5. inner epithelial lining; 6. radial layer of muscles.

- (5) A thin layer of transverse muscle-fibres surrounding the inhalent and exhalent canals. This layer is much thicker in the situation of the transverse partition than in the wall of the siphon.
- (6) A thin layer of longitudinal muscle fibres.
- (7) A thin layer of transverse muscle fibres.
- (8) A layer of columnar epithelial lining of the inhalent and exhalent canals.

The structure of the wall of the siphon at the junction of the contiguous segments (text-fig. 3) differs from that of the wall of the segments themselves in the following particulars:—

- (1) The wall is much narrowed down.
- (2) The connective tissue layer beneath the outer epithelial lining has disappeared.
- (3) The inner thin transverse layer of muscles is absent.
- (4) A radial layer of muscle fibres pass from beneath the outer epithelial lining inwards to the epithelium lining the apertures.

The process of autotomy which occurs in the siphonal tube between the contiguous segments thus seems to be due to the voluntary contraction of the radial muscles which cut through all the other layers of the body-wall, thus separating one or more distal segments from the proximal portion of the siphon. Even in the case of spirit specimens the segments can be easily separated from one another.

III. FOOT.

The foot is elongated and cylindrical, and is a little flattened from side to side; it is incapable of retraction within the mantle-lobes. The organ is stouter towards the apex than towards the base, where it forms a distinct rounded annular swelling and still further a conical process at the tip. When fully protruded, the foot has its length a little less than that of the body (mantle-lobe). There is a wide pedal-sinus along the middle of the foot.

IV. LABIAL PALPS.

The labial palps are shaped like an obtuse-angled triangle, the longest side of which is a little curved and forms the lower border of the organ. The shortest side of the triangle is attached to the side of the visceral mass at its junction with the mantle-lobe. The measurements of the palp-margins (in a specimen 2.5 cm. in length) are 0.45, 0.3, and 0.2 cm., respectively.

V GILLS.

The gills are narrow and elongated; their posterior ends are slightly prolonged into the base of the inhalent canal. The outer gill extends from the postero-inferior angle of the labial palp; the inner gill extends further forwards, and begins from behind the postero-superior angle of the palp. This anterior portion of the inner gill is overlapped by the palps.

The attachments of the gills are best described in a table:

Outer gill.

| | | |
|---------------|---|---|
| Outer lamella | } | Attached to the mantle-lobe, the non-glandular portion of the kidney and to the glandular portion behind the visceral mass; to the non-glandular portion at the level of the visceral ganglia, and lastly to the mantle-lobe again. |
| Inner lamella | | |
| Inner gill. | } | Attached to the under-surface of the non-glandular portion of the kidney, and to the glandular portion posteriorly. |
| Outer lamella | | |
| Inner lamella | | |
| | | Free; beyond the visceral ganglion attached to the inner lamella of the opposite inner gill. |

VI. DIGESTIVE SYSTEM.

The transverse slit-like *mouth* lies just behind and towards the ventral aspect of the anterior adductor muscle.

The *oesophagus* passes horizontally backwards to end in the stomach. Beneath the ventral aspect of the anterior two-fifths of the oesophagus is a space bounded below by the base of the foot, laterally by the labial palps, and behind by the visceral mass. Just behind the upper and lower lips of the mouth the oesophagus has a cuticular lining continuous with a similar, but less prominent, lining of the stomach.

The *stomach* is elongately pyriform in shape, and is rounded posteriorly. Behind and from its ventral aspect is given off a hollow tubular structure, the *pyloric coecum*, which descends into the visceral mass. The pyloric coecum passes to the right side lying on the inner side of the right wall of the visceral mass. It then curves forwards and passes to the front, lying still on the right side and parallel to the coil of the intestine. It then crosses the middle line and passes to the left side where it ends blindly at a point about midway between the junction of the two anterior loops of the intestine and the junction of the foot with the visceral mass. The position of the pyloric coecum varies slightly with the condition of the foot as regards its contractility. When the foot is fully extended, the coecum lies at the same level with the lowest loop of the intestine, but when it is more or less retracted, it lies above the loop.

The *intestine* begins from the ventral aspect of the stomach just in front of the origin of the pyloric coecum. It passes forwards and a little downwards along the right side of the middle line and curves downwards and then backwards in front of the base of the foot. It then runs backwards along the left side of the middle line and then bends upwards lying on the inner side of the first loop. It then takes another curve and passes a little forwards and then suddenly turns backwards and again downwards and forwards, and passes on straightly forwards crossing the middle line to the right side into the foot to the junction of its anterior two-thirds and posterior one third, where it bends downwards and backwards beneath the pyloric coecum. Lastly the intestine curves round the posterior end of the stomach to reach the posterior portion of the dorsal aspect of the latter and then curves out of the visceral mass to enter the pericardial chamber and form the rectum.

The *rectum* as usual passes through the ventricle in the pericardial chamber over the posterior adductor muscle to end in the anus.

The *liver* surrounds the stomach. Ventrally it extends beyond the first loop of the intestine to the dorsal aspect of the pyloric coecum. Anteriorly it extends to the close coils of the intestine.

VII. NERVOUS SYSTEM.

The *cerebral ganglia* are fusiform in shape, and are placed obliquely on the side of the gullet, the posterior lower end lying just behind the groove at the base of the foot. Each ganglion lies just above the junction of the inner and outer lamellae of the outer and inner labial palps.

The cerebral ganglia are joined to one another by an *intercerebral connective* lying transversely over the oesophagus as usual.

The *cerebro-pedal commissure* passes downwards just behind the junction of the foot with the visceral mass and joins the pedal ganglion of the same side. The direction of the cord varies according to the condition of the foot; when the foot is fully extended, the cord is directed downwards and forwards from the cerebral ganglion, but it is directed downwards and backwards when the foot is retracted.

The *cerebro-visceral commissure* passes backwards lying just above the attachment of the inner and outer lamellae of the outer and inner labial palps. As it passes backwards it penetrates the wall of the visceral mass obliquely and comes to lie on the inner side of the wall at the anterior end of the gills. It runs backwards, lying along the attachment of the gills, and is gradually displaced upwards till it comes to lie on the inner side of the kidney between it and the wall of the visceral mass beyond the posterior loop of the intestine. It then comes to lie beneath the kidney towards its outer side. In its further course it is gradually displaced towards the inner side and lies between the kidney and the posterior retractor muscle of the foot. Lastly the two cords lie side by side till they end in the visceral ganglia.

The *pedal ganglia* are closely applied to one another, lying in the middle line towards the dorsal aspect of the foot at its base a little in front of the mouth. When the foot is retracted, the ganglia recede backwards and come to lie considerably behind the cerebral ganglia. Three nerves can be followed from each pedal ganglion:

- (1) Passes horizontally forwards and divides into two branches which can be traced beyond the middle of the foot.
- (2) Passes obliquely forwards and downwards to the middle of the foot.
- (3) Passes downwards and a little forwards towards the ventral aspect of the foot.

The *visceral ganglia* are closely applied to one another and are placed between the two posterior retractors of the foot and beneath the rectum. The ganglia are displaced forwards from the posterior adductor muscles. The two posterior pallial nerves can be traced to the undersurface of these muscles.

VIII. VASCULAR SYSTEM.

The *pericardial chamber* is elongated, and is much narrowed down and compressed posteriorly over the rectum.

The *heart* occupies the anterior half of the pericardial chamber, the *ventricle* corresponding to the posterior end of the last intestinal loop in the visceral mass. The *ventricle* is fusiform in shape. The two *auricles* are trapezoid in shape; of the two parallel sides, the shorter one is attached to the ventricle and the longer one to the base of the gill.

IX. EXCRETORY SYSTEM.

Each *kidney* is U-shaped with the loop placed posteriorly. The *glandular portion*, lying beneath the pericardium, begins at a point behind the middle of the ventricle. In the first part of its course the kidney is tubular and narrow and is placed on the dorso-lateral aspects of the non-glandular portion and the visceral mass just above the attachment of the gills. It then suddenly widens out into a bulbous portion, pushing the gills downwards and outwards and lying on the outer side of the non-glandular sac and on the dorso-lateral aspect of the hindermost portion of the visceral mass and the ventro-lateral aspect of the rectum, both the two latter structures being applied to the glandular sac. Anteriorly the bulbous portion is crescentic in transverse section, the concave side being placed on the dorso-lateral aspect of the hindermost part of the visceral mass and the cerebro-visceral nerve cord. Just before the formation of the posterior retractor muscle of the foot, the bulbous portion widens out more on the inner aspect and communicates with the opposite one through the inter-renal aperture. At this point the bulbous portion surrounds the rectum on its ventral and lateral aspects. Gradually the inter-renal aperture widens out, while the glandular sac surrounds the rectum more closely and completely. The pericardial chamber is much narrowed down and flattened out, occupying the dorsal aspect of the rectum. The glandular sac now recedes from the rectum and is displaced ventral-wise by the interpolation of the two posterior retractor muscles which lie by the side of the middle line, being separated by a median vertical partition extending from below, where two glandular portions meet at their inner borders to the side of the rectum above, to end in the mantle-lobe. Lastly the glandular portion becomes narrowed down again and ends in the non-glandular portion by a small narrow slit.

From the dorsal aspect of each of the two glandular sacs where they communicate with one another at their ventral aspects, a diverticulum is given off, which passes backwards for a short distance surrounding the ventral and lateral aspects of the rectum, the dorsal aspect being occupied by the pericardial chamber.

The non-glandular portion is very wide at its origin at the level of the visceral ganglia, occupying the whole width between the attachments of the gills on either side. It extends a little backwards beyond the posterior end of the glandular sac. As it runs forwards, it occupies the outer side of the glandular sac and is gradually displaced, at first to the ventral and lastly to the inner side of the glandular sac, separated from each other at this place by a wide interval. The non-glandular sac extends a little beyond the glandular sac at its anterior end.

X. REPRODUCTIVE SYSTEM.

The gonads form irregular branching masses beneath the dorsal wall of the foot in its anterior two-thirds and both along the lateral and the dorsal aspects in its posterior one-third ; the lateral group passes upwards to the ventral aspect of the gullet and extends backwards to the anterior end of the liver. The mass extends backwards on the inner side of the lateral walls of the visceral mass in the middle third of its lower half on the outer side of the coils of the intestine. Posteriorly behind the liver and the coils of the intestine, the gonads are more numerous and nearly fill the cavity of the visceral mass.