ON THE ANATOMY OF SPECIES OF *CULTELLUS* AND *AZOR*.

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PLATE I.

I desire to express my thanks to Mr. Edgar A. Smith, I.S.O., of the British Museum, for kindly permitting me to examine the following :—

Cultellus cultellus (Linn.).

The specimen examined from the Indian Ocean measures 61 mm. antero-posteriorly by 17 mm. dorso-ventrally. Along the dorsal edge it is straight, except at the anterior end, where it bends upwards. The other edges are curved.

The mantle-lobes are united in front of the anterior adductor muscle and project anteriorly. The pedal aperture occupies nearly the anterior half of the ventral surface, then the pallial edges coalesce. Posteriorly the other openings are only the siphonal ones, there being no fourth aperture. The lobes bordering the pedal aperture carry a minute tentacular fringe on the middle longitudinal fold, the same being a little more evident at the anterior end. The inner longitudinal fold or velum on the ventral surface of the animal is shallow, but becomes deeper anteriorly. The whole of the external surface of the mantle is mottled with small brown markings, which to an extent correspond to, and account for, the mottled appearance of the periostracum covering the shell, the more distinctive feature of this species.

The siphon is nearly all in one piece, the free portions being very short. The siphonal chambers are short, but deep, and their apertures are bordered by a long tentacular fringe, the outer tentacles being much longer than the inner ones. The fringe continues dorsally and ventrally, though in a considerably lesser degree, and gradually disappears. Fig. 1 (*Ex.S.*, *In.S.*) shows the free portions of the siphon to point dorso-posteriorly, but this is probably due to the greater contraction of the muscles controlling the exhalent part.

The foot (Fig. 1, *F.*) is apparently large and muscular, with the distal part pointing anteriorly. Its exact length, however, cannot be determined, as a portion of it is missing.

Musculature. *Pallial Muscles.*—The anterior adductor muscle (Fig. 1, *A.A.*) is a broad muscle, with the anterior part turning sharply upwards, and increasing in depth as it proceeds posteriorly. It is joined at the anterior end with the mantle-lobes, and at the posterior one with the protractor pedis anterior muscles. Compared with the same muscle in *Solen pellucidus* it is neither so broad nor so deep, and at the posterior end the bend ventrally is not so pronounced.

The posterior adductor muscle (Fig. 1, *P.A.*) is large, being both wide and deep, and is much larger than that of *S. pellucidus*. It is flattened dorsally and curved ventrally. Anteriorly it is connected with the retractor pedis posterior muscle, and posteriorly with the mantle-lobes.

The muscular band of the pallial edge does not vary much in depth, but is somewhat shallower at the posterior end, and the transverse muscle-fibres have the usual radial direction. The latter become more developed near the posterior part of the pedal aperture and increase in thickness towards the siphon. The longitudinal muscle-fibres, forming the circumpallial muscles, also increase in number from the same region. The siphon is muscular and compact.

Pedal Muscles.—The protractor pedis anterior muscles (Fig. 1, *P.P.*) are long and connected with the anterior adductor muscle, whilst proximally their fibres lie close to the pedal integument.

The retractor pedis anterior muscles (Fig. 1, *P.R.A.*) are long, flat, very wide, and bifurcated; each bifurcation is divided, the anterior into two and the posterior one into three parts. They extend over the greater part of the anterior adductor muscle with their distal ends inserted into the shell. Proximally they pass inside the longitudinal muscles of the foot in a fan-shaped direction.

The retractor pedis posterior muscle (Fig. 1, *P.R.P.*) is long, but not bifurcated. It is attached to the posterior adductor muscle, and laterally is also inserted into the shell. Proximally its fibres pass longitudinally along the foot.

Alimentary Canal.—The mouth (Fig. 1, *M.*) is on the ventral surface to the rear of the anterior adductor. The œsophagus, which is short, proceeds dorsally with a slight curve, where it joins the œsophageal division of the stomach. This division is separated from the cardiac one, which lies dorsally to it, by a lateral process of the gastric wall from its left side, and extends about half the length of the stomach. The pyloric division is the largest one, and on the postero-ventral side is continued as the cæcum of the crystalline style (Fig. 1, *C. C.*); the latter passes with a curve near to the ventral edge of the foot. The intestine (Fig. 1, *In.*) also leaves the pyloric division in front of the cæcum, but a little to the left. It then passes near to the distal end of the cæcum. There it makes a number of folds, then proceeds below the cæcum, turns dorsally, passing close to the posterior pedal wall to the dorsal part, where it turns posteriorly, going over the posterior adductor muscle into the exhalent siphonal chamber, and ends in a conspicuous anus.

The *branchiæ* along the gill axis are separate from each other. The lamellæ are heterorhabdic and plicate. There are about seventeen filaments to a plica in the inner, and fourteen in the outer demi-branch. The frontal ridge of the principal filaments is sharp.

Nervous System.—The cerebro-pleural ganglia are situated just in front of the mouth, one on each side, and each ganglion gives off anteriorly a nerve which passes to the lateral posterior edge of the anterior adductor muscle; this divides and innervates the muscle and the mantle.

The viscero-parietal ganglia are situated at the antero-ventral edge of the posterior adductor muscle, and each ganglion gives off posteriorly a nerve, the branchial nerve, which passes directly to the gill, and another nerve which goes obliquely across the muscle, innervating it, the siphon, and the mantle.

SOLECURTUS (AZOR) ANTIQUATUS (Pult.).

The one specimen examined from the English Channel is imperfectly preserved, and is much swollen laterally. The measurements, from the shell, are 47 mm. antero-posteriorly by 21 mm. dorso-ventrally. There is a slight lateral constriction towards the centre of the ventral surface. The mantle is muscular and strongly formed.

The pedal aperture extends from the anterior adductor muscle about half-way along the ventral surface of the mantle. The inner longitudinal fold or velum is short and not so well developed as the middle longitudinal fold which prominently projects ventrally. The union of the two velar processes, terminating the pedal aperture, encloses the posterior portion of the mantle-cavity, and is also continuous with the ventral wall of the siphon. Similarly, the mantle covering the dorsal surface of the posterior adductor muscle is continuous with the dorsal siphonal wall.

Ventrally to the posterior adductor muscle (Fig. 2, *P.A.*) lies the musculus cruciformis, and near it commences the fusion of the proximal portion of the siphon with the mantle; still, from that position the mantle-lobes extend some distance posteriorly.

The siphon is very muscular, with its proximal part (Fig. 2, *Ex.S.*, *In.S.*) extending a considerable distance rearwardly beyond the fusion of its lateral walls with the mantle. Internally from the junction of the tubes with the proximal portion is on each side a process of the lateral wall (Fig. 2, *S.R.*), which runs just above the siphonal retractor muscle to the posterior adductor muscle. To the free edge of this process is attached the basal portion of the gills, thus completing the division of the inhalent from the exhalent chamber. The siphonal tubes are likewise large and long. The edge of the mantle carries a minute tentacular fringe; it is, however, a little more distinct near the anterior adductor muscle, whilst there is no sign of it on the siphon or at the free end of the tubes.

MUSCULATURE. *Pallial Muscles.*—The muscles of the mantle (Fig. 2, *M.L.*) consist of the radial fibres and the circumpallial or longitudinal ones nearer the edge, but the latter are more numerous in the part supporting the velum. The anterior adductor muscle (Fig. 2, *A.A.*) spreads out somewhat towards each end, where it is moderately deep and wide, but is much longer ventrally than dorsally owing to the convexity of the shell. The posterior adductor muscle (Fig. 2, *P.A.*) is large and, like the anterior one, spreads out towards each end, and is also longer ventrally than dorsally. The musculus cruciformis (Fig. 2, *M.C.*) is situated on the inner surface of the mantle ventrally to the posterior adductor muscle, and its two branches on each side gradually diverge, the one going anteriorly and the other posteriorly. Both are then inserted into the shell. The siphon is characterized by the rearward prolongation of its proximal portion (Fig. 2, *Ex.S.*, *In.S.*), the same being all in one piece. On each side the muscle-fibres of its walls are drawn together into a round and powerful muscle (Fig. 2, *S.R.M.*), which afterwards penetrates the mantle and, spreading out into a large ovoid-shaped disc, becomes

attached to the shell. The siphonal tubes (Fig. 2, *Ex.S.'*, *In.S.'*) are also muscular and externally are transversely ribbed, whilst internally they present evidences of slight longitudinal ribbing.

Pedal Muscles.—The retractor pedis anterior muscles are inserted into the shell on the dorsal surface.

The protractor pedis anterior muscles are attached to the shell and to the anterior adductor muscle close to the lateral edge.

The retractor pedis posterior muscle (Fig. 2, *P.R.P.*) is short and thick, with its bifurcations resting upon the antero-dorsal edge of the posterior adductor muscle.

The attachment to the shell of the pedis elevator and branchial retractor muscles cannot be traced with certainty.

Alimentary Canal.—The mouth (Fig. 2, *M.*) is wide with the lips lying in an anterior direction. The œsophagus passes with a curve to the stomach (Fig. 2, *St.*); the latter is long, but internally its shape is not plainly discernible. It appears to be divided into three parts, the œsophageal and cardiac ones being long and shallow, and separated from each other, on the left side, by a lateral process of the gastric wall, whilst the pyloric division is much larger, and on the ventral surface is continued as the cæcum of the crystalline style (Fig. 2, *C.C.*) which extends to near the ventral part of the foot. The intestine (Fig. 2, *In.*) has the aspect of being only a groove on the left side of the cæcum, but becomes quite separate at the distal end of the cæcum, where it turns rearwardly, and passes dorsally to near the posterior part of the stomach; there it makes a number of folds and goes posteriorly, as the rectum, over the posterior adductor muscle to the anus (Fig. 2, *A.*), situated at the postero-ventral edge of the latter muscle.

It is not possible to make out the nervous system except the position of the viscero-parietal ganglia, situated at the antero-ventral edge of the posterior adductor muscle.

SOLECURTUS (AZOR) COARCTATUS (Gmel.).[1]

The specimen described from Japan in 15 fathoms differs considerably from *A. antiquatus* from the English Channel.

The Japanese shell, measured antero-posteriorly, is shorter than the English species, the difference being chiefly in the part posterior to the umbonal region, whilst the posterior edge is a little more angular. Measured dorso-ventrally it is deeper than the English species. From the umbonal region of both specimens, and passing in a slightly postero-ventral direction, is on each side a constriction of the shell. This is, however, more pronounced in *A. coarctatus.*

The animal itself is in a far better state of preservation than the one previously described, though more contracted. The muscles of the mantle border are well developed and much deeper at the anterior part. The chief difference, however, is in the proximal portion of the siphon, which is very prolonged in the English species, but the

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[1] See Smith, *Challenger Lamellibranchiata*, 1885, p. 79.

anterior part is folded upon itself in a somewhat similar manner as in *Solecurtus strigillatus*.

The anterior adductor muscle (Fig. 3, *A.A.*) is similar, but smaller. The posterior adductor (Fig. 3, *P.A.*) is deeper, angular on the antero-dorsal surface, and is situated more ventrally. The siphonal tubes (Fig. 3, *Ex.S.'*, *In.S.'*) are more compact, though very muscular.

In transverse section the arrangement of the muscles of the inhalent siphonal tube appears to be very similar to that of *Solecurtus strigillatus* and *Tagelus gibbus*; it is also akin to that of *Psammobia vespertina*, as described and illustrated by Rawitz in *Der Mantelrand der Acephalen*, and by myself *On the Anatomy of the British Species of Psammobia*, whilst in the distribution of the nerves there is still a closer resemblance. A tentacular fringe is present all round the ventral portion of the mantle from the anterior adductor to the posterior adductor muscle, but it is more pronounced at the anterior and posterior ends. What, however, is the chief characteristic, in fact a striking feature of the animal, is the mass of tentacular processes, which covers the entire external surface of the siphonal tubes. This is in great contrast to the British and Mediterranean species of *A. antiquatus*, which are quite bare. The bifurcations of the retractor pedis posterior muscle (Fig. 3, *P.R.P.*) are longer, and their terminal parts are situated on the dorsal, instead of the dorso-anterior, surface of the posterior adductor muscle.

The alimentary canal also varies. The œsophagus is a little shorter, the stomach more compact, being shorter and deeper, and the intestine makes a larger number of folds before turning posteriorly.

From the foregoing description of the British specimen of *A. antiquatus*, the type of the subgenus *Azor*, it will be observed that it differs considerably from the genus *Psammosolen*, Risso, type *S. strigillatus* (Linné),[1] and more so from the genus *Solecurtus*, Blainville, type *Solen legumen* (Linné),[1] consequently *Azor* should be raised to the position of a genus; further, the Japanese is quite distinct from the English species and bears out the justification of treating it as a separate species, but whether it agrees in its structure with the animal of the Nicobar shell described by Chemnitz, the type of *coarctatus*, I have as yet been unable to determine, as I have not succeeded in obtaining a specimen from that locality. At the same time I shall not be surprised to learn later that the Japanese specimen, owing to the peculiarity of the mantle fringe and the siphonal tentacular processes, is only local, and consequently will have to be made a distinct species.

In the work of Dr. Dall just referred to he states " The Solenidæ form a compact group after the elimination of the soleniform Psammobiidæ such as *Novaculina* and *Tagelus*", but to this exclusion must be added the genera *Azor* and *Psammosolen* (in the latter as far as *S. strigillatus*, *S. candidus*, and *S. Philippinarum* are concerned).

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[1] Dr. W. H. Dall, "Tertiary Fauna of Florida": Trans. Wagner Inst. Phil., vol. iii, pt. ii, p. 951, 1900.

EXPLANATION OF PLATE I.

FIG. 1. *Cultellus cultellus.* View from the right side, showing internal
structure, etc. Nat. size.

,, 2. *Azor antiquatus.* View from the right side, showing internal
structure, etc. Nat. size.

,, 3. *Azor coarctatus.* View from the right side, showing internal
structure, etc. Nat. size.

A. anus ; *A.A.* anterior adductor muscle ; *C.C.* cæcum of the crystalline
style ; *D.G.* digestive gland ; *Ex.S.* proximal portion of the exhalent siphonal
chamber ; *Ex.S.'* exhalent siphonal tube ; *F.* foot ; *In.* intestine ; *In.S.*
proximal portion of the inhalent siphonal chamber ; *In.S.'* inhalent siphonal
tube ; *M.* mouth ; *M.C.* musculus cruciformis ; *M.L.* mantle-lobe ; *P.A.*
posterior adductor muscle ; *P.P.* protractor pedis anterior muscle ; *P.R.A.*
retractor pedis anterior muscle ; *P.R.P.* retractor pedis posterior muscle ;
R. rectum ; *S.R.* ridge dividing the inhalent from the exhalent chamber
of the proximal portion of the siphon, and to which is attached the basal
part of the gill ; *S.R.M.* siphonal retractor muscle ; *St.* stomach.