

ON A NEW SPECIES OF THE OLIGOCHAETE GENUS
AULODRILUS BRETSCHER.

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(Plate X.)

The present paper deals with the anatomy of a new species of the genus *Aulodrilus*. Four species of this "aberrant" Tubificid genus have already been recorded from Indian territory. These are *Aulodrilus remex* Steph. from the Central Provinces (5) and Travancore (1). *A. kashi* Mehra and *A. stephensoni* Mehra from Benares (4), and *A. trivandranus* Aiyer from Travancore (1 ; 6).

***Aulodrilus pectinatus*, sp. nov.**

Specimens of the present interesting species were obtained from the mud at the bottom of a fresh water lake (Vellayani Lake) six miles S. E. of Trivandrum. The sample of mud was taken from the lake on 1st November 1927 and was kept in the College laboratory till the middle of January, 1928. A number of non-sexual specimens developed and were available for examination. Sexual individuals were first observed in the culture about the end of November and continued to be collected till the beginning of January.

External characters.

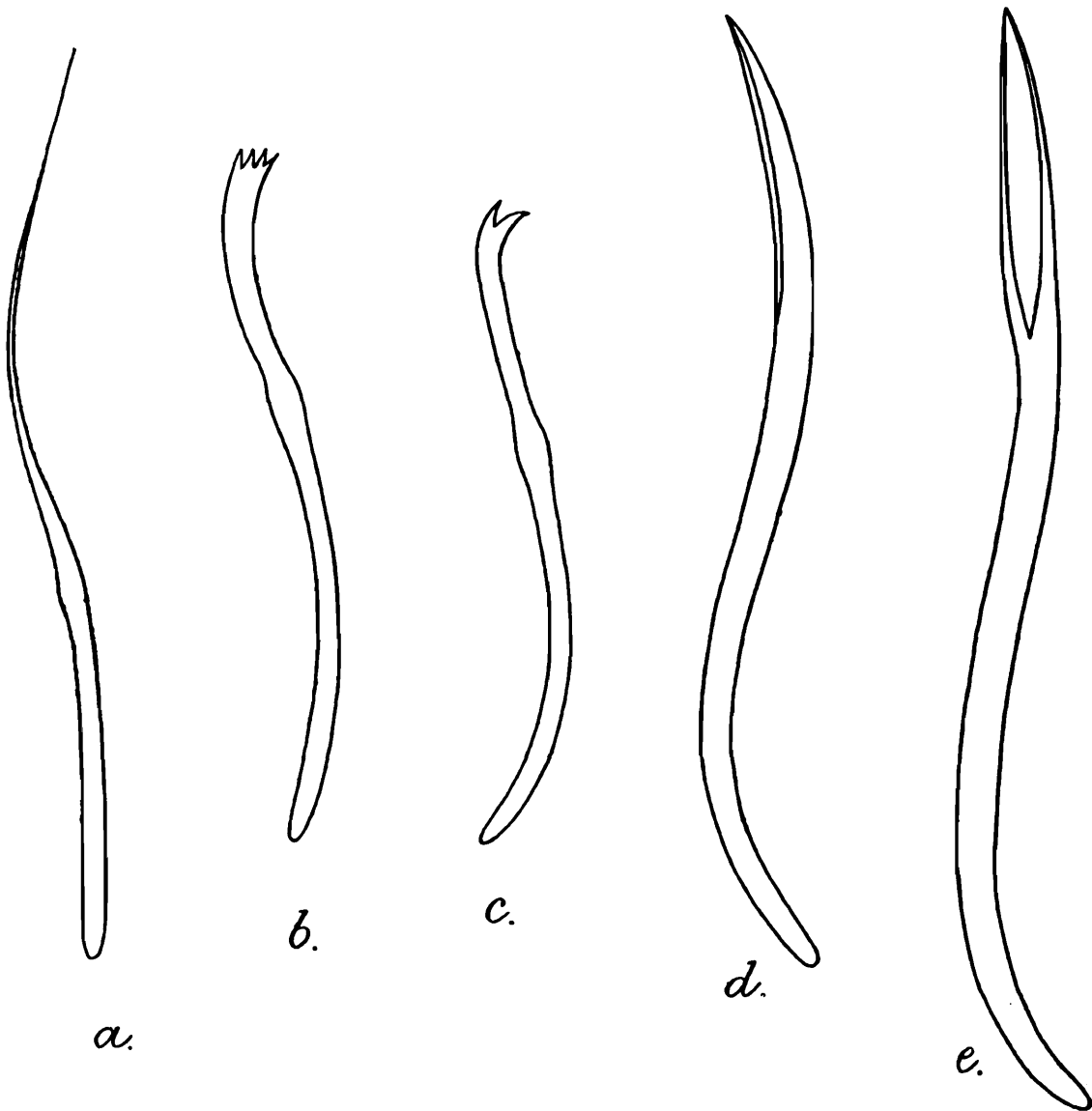
The length of fully grown specimens varies from 5.0—6.5 mm. The body is very slender and tapers gradually to the posterior end.

The worm lives in a thin unbranched tube formed of mucus to which fine particles of sand adhere. When the tube is placed in water in a watch glass the worm slowly wriggles out. On coming out of the tube it alternately coils itself into an irregular spiral and immediately straightens itself, throwing out the two ends of the body violently, very much as an earthworm would do when its body is touched with a drop of irritant like alcohol or formalin. This goes on for a minute or two, after which the worm slowly begins to move about. The body is very sticky owing to the mucus secretion of the gland cells, and the transference of the animal from the watch glass to the slide is often a matter of difficulty, as the creature sticks fast to the pipette and the needle.

The number of segments in the specimens examined varies from 32-43. There is a short unsegmented seta-less transparent region at the posterior end which, as in the other species of the genus, functions as a gill. During life the anus dilates giving rise to a branchial fossa.

The prostomium is almost rounded and is devoid of sensory hairs or eyes.

The dorsal bundles of setae commence in segment ii and consist of hair setae and needles. The hair setae (text-fig. 1, *a*) are present from segment iv but are as a rule absent in segments ii and iii. They are 52μ long and have a sigmoid curve. At the commencement of the distal hair-like portion the seta presents a slight swelling not unlike an indistinct nodulus.



TEXT-FIG. 1.—Setae of *A. pectinatus*, sp. nov. *a*. Hair seta, $\times 1700$. *b*. Pectinate needle, $\times 1700$. *c*. Ventral seta, $\times 1700$. *d*. Penial seta lying on its side, $\times 1420$. *e*. Penial seta showing the boat-like excavation, $\times 1420$.

The needle setae of the anterior segments are double-pointed with the two prongs equal in length. These setae have a length of 39μ . From segment iv backwards the nodulus is distinctly distal to the middle of the shaft, the proportion of the distal and proximal parts of the seta being 12 : 17. From about the seventh segment the distal end of the needle seta becomes crenate with two or three and rarely four intermediate prongs (text-fig. 1, *b*). All the prongs are equally developed and are of the same length. The pectinate setae, which begin in segment vii or viii, continue to the posterior end of the body, the last four or five segments having one pectinate and one hair seta per bundle.

The ventral setae (text-fig. 1, *c*) are double pointed crotchets. The outer prong is slightly thinner than the inner but is almost equal to it in length. The ventral setae are 39μ long and the nodulus is distal to

the middle of the shaft except in segments ii-iv in which it is at the middle or very slightly distal.

The setal arrangement in the anterior segments of three individuals is given below.

Specimen 1 (non-sexual).

Segment.	Dorsal bundle.	Ventral bundle.
ii	3n	3c
iii	3n	4c
iv	3n+2h	4c
v	3n+1h	4c
vi	2n+1h	4c
vii	3n+1pn+3h	4c
viii	3pn+2h	5c
ix	3pn+2h	5c
x	3pn+2h	5c

Specimen 2 (non-sexual).

Segment.	Dorsal bundle.	Ventral bundle.
ii	3n	3c
iii	4n	4c
iv	4n+2h	4c
v	3n+2h	5c
vi	3n+2h	4c
vii	2pn+1n+2h	4c
viii	3pn+2h	5c
ix	3pn+2h	5c
x	3pn+2h	4c

Specimen 3 (sexually mature).

Segment.	Dorsal bundle.	Ventral bundle.
ii	5n	5c
iii	6n	6c
iv	3n+3h	7c
v	3n+3h	7c
vi	3n+2h	Absent
vii	3n+2h	Penial Setae.
viii	3pn+2h	5c
ix	3pn+2h	5c
x	3pn+2h	5c

(n=bifid needles ; pn=pectinate needles ; h=hair setae ; c=crotchets.)

Internal Anatomy.

The pharynx extends through segments ii and iii. It is lined by strongly ciliated columnar epithelium and is attached to the body-wall by radiating muscle-fibres. Surrounding the pharynx are groups of large gland cells with prominent rounded nuclei. The oesophagus is narrow and occupies segments iv-vi. In segment vii it suddenly dilates to form the wide intestine which practically fills the whole body cavity

in segments vii to ix and narrows slightly from segment xii onwards. The intestine in segment vii becomes greatly narrowed during sexual maturity.

The dorsal vessel is at first ventral in position and rises over to the dorsal side of the oesophagus in segment vi. In this segment are a pair of stout contractile hearts connecting the dorsal with the ventral vessel. There are no supra-intestinal or sub-intestinal vessels.

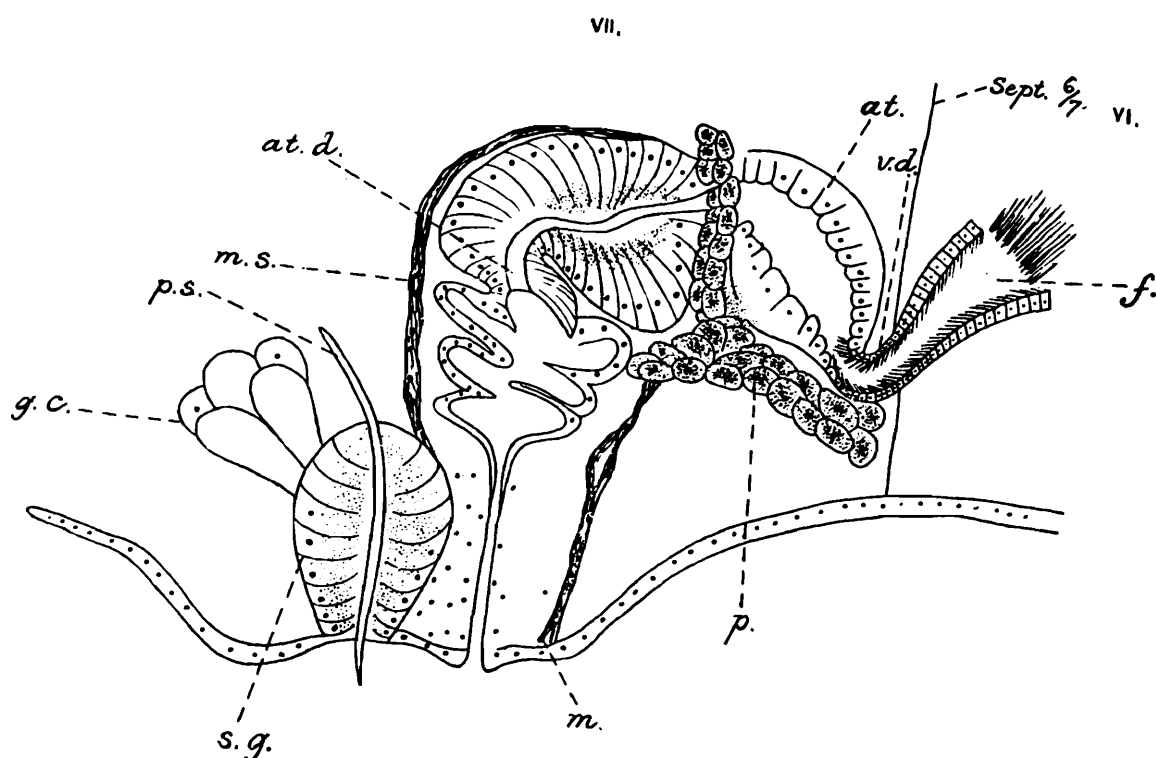
The first nephridium is in segment viii.

Sexual organs.

About a dozen sexual specimens were obtained on different occasions between the end of November and the beginning of January. Three specimens were successfully sectioned and a few were examined alive under the microscope.

The clitellum extends from the level of the spermathecal apertures in segment vi to the level of the setae in segment viii (=2 segments).

The testes are one pair in segment vi on the hinder face of septum 5/6. The organs disappear in fully mature specimens.



TEXT-FIG. 2.—Entire male deferent apparatus of *A. pectinatus*, sp. nov., semidiagrammatic, compiled from a number of sections

at. = atrium ; *at. d.* = atrial duct ; *f.* = male funnel ; *g. c.* = gland cells ; *m.* = muscle ; *m. s.* = muscular sac ; *p. s.* = penial seta ; *s. g.* = penial setal gland ; *p.* = prostate ; *v. d.* = vas deferens.

Sperm morulae and bundles of ripe spermatozoa are abundant in segment vi. A small narrow sperm sac is present in segment vii, formed as a backward pouching of septum 6/7, but the greater portion of the developing sperms is seen in segment vi. From the small size of the sperm sac and the fact that the coelomic space in segment vi is almost filled with developing sperms, it would appear that the sperm sac is slowly degenerating and that its function is being taken by the body cavity of segment vi.

The male funnels (*f.*, text-fig. 2) are in segment vi in front of septum 6/7. They are simple, funnel-shaped structures, 27μ in height and 25μ wide at the mouth. The wall of the funnel is composed of a single layer of cubical ciliated cells with centrally situated, oval or rounded nuclei. Bundles of ripe spermatozoa are seen at the mouths of the funnels.

The vas deferens (*v. d.*) is an extremely short tube ciliated internally. It is 12μ thick and has a lumen 6μ in diameter. Close behind septum 6/7 it opens into the atrium (*at.*). (In the account that follows I have adopted Mehra's terminology for securing uniformity of description.)

The atrium (*at.*, text-fig. 2 and plate X, figs. 1, 2) is an ovoid chamber lying longitudinally in segment vii and is 45μ in length. The middle part of the chamber is 30μ wide with a lumen of about 9μ in diameter. The wall of the atrium is composed of three layers; an extremely thin outer layer of peritoneal cells seen only indistinctly in sections, a middle muscular layer and an inner layer of large oblong columnar cells. These large cells have distinct boundaries and their cytoplasm is finely granular. The small inconspicuous nuclei are centrally situated and are only made out with difficulty. These cells are not stained with haematoxylin. In two fully mature specimens examined alive under the microscope the entire male deferent apparatus was got out by rupturing the body-wall by gentle pressure on the cover slip. In these the lumen of the atrium was found to contain ripe spermatozoa but in sections the lumen appears to be empty.

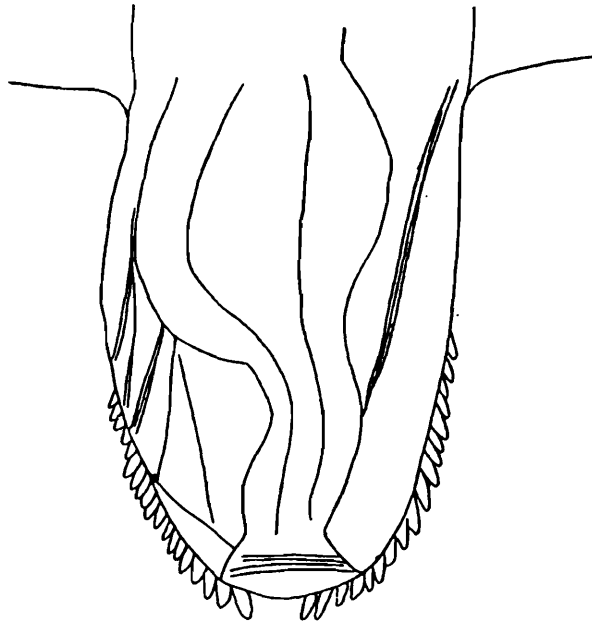
The prostate (*p.*) is a lobed mass lying between the vas deferens and the muscular chamber of the atrial duct (described below). The lobes are finger-shaped and are three in number, one extending backwards as far as the muscular sac of the atrial duct, one lying transversely over the narrow hinder end of the atrium and one extending forwards and lying close to the side of the atrium. The prostate is composed of large oval cells with granular cytoplasm and large centrally situated rounded nuclei. The cytoplasm and nuclei are deeply stained with haematoxylin. The prostate communicates with the atrium at its widest part in the middle and at this point "the peritoneal and muscular layers of the wall of the atrium are interrupted so that the cells of the prostate and those of the inner-most layer of the atrium are intimately connected with one another" as described by Dixon in the case of *Tubifex rivulorum* (3).

Posteriorly the atrium narrows considerably and is only 12μ thick. The narrow hinder end of the atrium leads into a long and convoluted atrial duct (text-fig. 2 and plate X, fig. 3). The atrial duct may, for the sake of convenience, be divided into two distinct parts, an ental part and an ectal part.

The ental part of the atrial duct is roughly ovoid in shape, $36-45\mu$ in length and 45μ wide. The lumen of this part is extremely narrow, being only $2-3\mu$ in diameter. The wall is of considerable thickness and is composed of a layer of much elongated columnar cells with distinct outlines. The cells are about 18μ long and the nuclei are situated about the periphery.

The ectal part of the atrial duct is longer and much thinner than the ental part. It is 12μ thick and has a lumen 7μ in diameter. The wall is composed of a layer of flattened epithelial cells. The duct is convoluted and forms two or three loops, one above the other. The distal end of the duct is almost straight and opens to the outside on the ventral surface of segment vii.

The whole of the atrial duct is enclosed in a muscular chamber (plate X, fig. 3) composed of bundles of muscle-fibres loosely joined together. The chamber has its origin in the ventral body-wall and the basal portion of the sac surrounding the distal end of the duct is very thick.



TEXT-FIG. 3.—Everted penis of a living specimen of *A. pectinatus*, sp. nov.

The entire ectal part of the duct is eversible as a penis. The everted penis (text-fig. 3) was observed in mature specimens when examined alive under the microscope. When fully everted the outer surface of the penis presents several rows of minute teeth-like projections borne on what appears to be a cuticular layer. These serrations are faintly visible in the sections on the inner surface of the upper portion of the ectal part of the atrial duct. I am unable to say definitely whether the projections are really cuticular or only the free ends of the epithelial cells projecting separately into the lumen. The probability seems to be that the epithelial cells secrete a thin chitinous layer and that the serrations are formed on it.

The ovaries lie in segment vii and are present even in fully mature specimens. In a section of a mature individual the ovary is a long flattish band about 90μ in length and $18-27\mu$ in width and composed of a few longitudinal rows of minute rounded ova. The anterior end of the ovary is narrow and stalk-like.

The ovisac is in segment viii and is formed as a backward pouching of septum 7/8. It is occupied by a single large ovum loaded with minute rounded yolk-granules and having a conspicuous oval nucleus in the centre with a distinct rounded nucleolus.

Female funnels and duct are not recognisable in the specimens examined.

The spermathecae (plate X, figs. 4 and 5) comprise one pair in segment vi and consist of a distinct ampulla sharply marked off from the duct. The spermathecal duct is more or less pear-shaped, 65μ in height and about 36μ wide at the middle. The ectal end of the duct is greatly narrowed being only 9μ thick. The openings of the ducts are on a level with the setae of segment vi. The ventral setae of this segment are lost during sexual maturity. The inner surface of the wall of the duct is irregular as in *A. trivandranus* (6), due to the varying height of the epithelial cells. Investing the duct is a distinct muscular layer which on passing on to the ampulla gets thinner and gradually becomes unrecognisable. The ampulla is a cylindrical tube longer than the duct with the ental end slightly swollen and rounded and coiled like the proboscis of a butterfly. The ectal end of the ampulla projects into the broad ental end of the duct. The ampulla has a diameter of 16μ near its ectal end and of 21μ at the swollen ental end. The wall is composed of a single layer of flattened epithelium. A thin muscular layer is discernable round the ectal portion. The lumen is occupied by a tightly packed mass of spermatozoa.

Penial setae. The ventral setae of segment vii are modified as the penial setae—one seta on each side, though in less mature specimens two setae are sometimes seen in a bundle. The penial seta (text-fig. 1, *d*, *e*) is $70-75\mu$ long. The shaft has a double curve and is without a nodulus. On the broad concave side of the distal third of the seta there is a boat-like excavation extending to the tip. When the seta lies completely on its side the boat-like hollow is liable to be overlooked.

Setal glands. There are in segment vii two setal glands, each surrounding a penial seta. The glands open to the outside a little behind the male pores. Each gland (plate X, fig. 6) is ovoid in shape with the upper part rounded and the lower half narrowing to the base. It is 54μ in height from the surface of the body and 37μ wide at the middle. The gland (*p. s. g.*) is composed of a single layer of large cells filled with loose granules and having their rounded nuclei situated towards the base. The nuclei alone are stained with haematoxylin. There is a central lumen through which the penial seta (*p. s.*) passes. The distal end of the seta may project slightly from the surface of the body, while the proximal part extends beyond the gland into the setal sac for a distance of 27μ . Attached to the proximal end of the seta are the muscle bands (*m.*) of the setal sac which are continuous below with a thin muscular layer investing the gland.

In connection with each setal gland there are present a few conspicuous lobed masses of large pear-shaped cells, such masses of gland cells have been described by Mehra in *A. kashi* (4). The cells comprising each mass are larger than the prostatic cells, and are pear-shaped. The rounded nuclei are situated in the swollen part of the cell and the cytoplasm appears to be highly vacuolated. Both the cytoplasm and the nuclei are deeply stained with haematoxylin. Fine intercellular ductules, joining together to form a single duct from each mass, are faintly seen in certain sections and I am inclined to think that the secretion is poured into the lumen of the setal gland and not into its cells.

Remarks.—This is the third Indian species of the genus *Aulodrilus* in which the sexual organs occupy the anterior position in segments

vi and vii. The present species agrees very closely with the much larger *A. kashi* described in detail by Mehra. The marked resemblances between the two species are due to the presence in both of

- (1) a long and convoluted atrial duct enclosed in a muscular chamber,
- (2) a retractile pseudo-penis,
- (3) penial setae, penial setal glands and masses of gland cells in connection with penial setal glands and
- (4) a solid prostate.

Among minor distinctions may be mentioned the following:—

- (1) The proximal part of the atrial duct in *A. kashi* is very narrow and is not sharply marked off from the distal part. In the present species this portion of the duct forms a distinct part of the efferent apparatus and possesses an extremely thick wall and a very narrow lumen.
- (2) A spermiducal chamber as described by Mehra in *A. kashi* is absent in *A. pectinatus*.
- (3) In the present species the *wide* spermathecal duct is sharply marked off from the long cylindrical ampulla.
- (4) The sperm sac is poorly developed in the present species.

The presence in this species of pectinate needle setae and the almost equal prongs of the ventral crotchets bring the genus *Aulodrilus* closer to *Tubifex*; but the short unsegmented seta-less region at the posterior end functioning as a respiratory organ continues to remain as the chief distinguishing feature of the species described so far.

REFERENCES TO LITERATURE.

1. Aiyer, K. S. Padmanabha.—Notes on the Aquatic Oligochaeta of Travancore, I. *Ann. Mag. Nat. Hist.*, Ser. 9, Vol. XV (1925).
2. Beddard, F. E.—A Monograph of the Order of Oligocheta. (Oxford, 1895.)
3. Dixon, Gertrude C.—Tubifex. *L. M. B. C. Memoirs* (1915).
4. Mehra, H. R.—Two new Indian species of the genus *Aulodrilus* Bretscher. *Proc. Zool. Soc. London* (1922).
5. Stephenson, J.—Fauna of British India, Oligochaeta. (London, 1923.)
6. Stephenson, J.—Oligochaeta from various regions, including those collected by the Mount Everest Expedition 1924. *Proc. Zool. Soc. London* (1925).