Appendix: Notes on the Anatomy of Streptostele (Raffraya) horei Smith

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Apart from THIELE's (1912) meagre notes on the anatomy of *Streptostele,* which chiefly concern the radula, and the fuller description of that of *S. buchholzi* v. Mts. by ODHNER (1932), little seems to have been published on any of the organs of the species belonging to this genus except the shell, although PILSBRY (1919) gave some account of certain of the internal organs of *Varicostele bequaertiana* Pils., a species belonging to a nearly related genus, which THIELE regarded as only a subgenus of *Streptostele.* I am therefore glad to be able briefly to describe some of the more important organs of *Streptostele (Raffraya) horei* Smith, based on spirit material from Yanonge in the Belgian Congo kindly submitted to me by Dr. VENMANS, who has dealt with the shell and distribution of this species in the preceding part of this paper.

Skin and foot. — In specimens preserved in alcohol the skin is completely unpigmented, but it is sufficiently transparent for the

black eyes to be clearly seen through it, even when they are deeply withdrawn within the head. The rugae are best developed on the top of the hinder half of the foot, where the furrows between them form oblique grooves sloping down on each side to the horizontal pedal groove. This is well marked, and cuts off a rather broad, clearly defined foot-fringe, which is crossed by small vertical grooves. The footsole is narrow and undivided; and the foot tapers to a point at the hind end, which is usually curved up in spirit specimens. No caudal mucous pore appears to be present.

Pallial organs. — The lobes on the mantle-edge are inconspicuous: the shell-lobes are absent, and the neck-lobes are low, the lower left neck-lobe being apparently rather widely separated from the upper one, although it is not easy to see.

The mantle-cavity or lung is narrow and very long. Its roof is very thin, but shows the main pulmonary vein running back throughout its length until it enters the auricle of the heart. Scarcely any secondary venation is visible.

The kidney, situated far back at the hinder end of the long mantle-cavity, is short and broad, and stretches upwards from the pericardium to the rectum just below the suture. It then extends forwards for about ¾ mm., immediately beneath the rectum, as shown in fig. 3, thus recalling the form it has in the family Ferussaciidae. Its lower edge scarcely extends beyond the front end of the pericardium, but gives rise there to the primary ureter, which runs back for a very short distance, and then bends round to pass forwards as the secondary ureter, at first below the dorsal anterior extension of the kidney and thereafter next to the rectum itself until it at length reaches the mantle-edge. The short and compact form of the lower half of the kidney may be partly due to the fact that the large embryos in the uterine part of the spermoviduct and the long and stout muscular odontophore leave very little room for the development of other organs in the peripheral region of the lower whorls of this slender snail. The excretory epithelium lining the kidney is thrown into irregular folds, which converge from the upper and posterior edges of the kidney towards the opening of the ureter.

Digestive system. — The jaw is absent, as in most of the carnivorous snails. The radula is about 0.3 mm. broad and 1.5 or 1.6 mm. long when spread out, but when it is retracted the anterior third is folded back beneath the middle of the radula, which therefore does not extend through the whole length of the muscular odontophore. The radula comprises almost 45 transverse rows of 23 or 25 unicuspid

teeth, the formulae of two specimens being 11 + 1 + 11 × 44 and 12 + 1 + 12 × 43 respectively. Each row of teeth forms an angle of about 110° or 120° in the centre, on each side of which the row slopes forward. The central tooth is well developed, but is smaller than the adjacent teeth on each side of it, being about 0.023 mm. in length. Its base is relatively broad, with slightly convex sides and a slightly concave front edge, and its cusp is small, narrow, and sharply pointed (see fig. 6). The first five or six teeth on each side of the centre have trilobed bases and powerful pointed cusps, each with a low knob about half way down it. They increase rapidly in size from the first to the fourth tooth, which is about 0.064 mm. long, and then become smaller again. The remaining teeth continue to diminish in size towards the outer edges of the radula, and become simpler in form, their bases becoming more rounded and their cusps becoming shorter and blunter and without a knob. The embryonic radula differs but little from that of the adult, apart from its smaller size. It may be noticed that the radula of this species resembles that of *Varicostele bequaertiana,* as figured by PILSBRY, in the form of the central tooth, but is nearer those of the species figured by THIELE and ODHNER in the number of the teeth in each row.

The muscular odontophore forms a stout, strongly curved cylinder about 1.6 mm. in length, though probably it is less curved when the animal is extended than when it is contracted within its shell. The oesophagus is long and relatively narrow, and opens into the buccal mass above the front end of the odontophore (see fig. 1). Beside it also open the two long and very slender salivary ducts, which pass forward from the front ends of the rather large and well developed salivary glands. These are closely united with each other, forming a single elongated mass situated dorsally further back. The inconspicuous junction between the two glands is oblique, the right gland extending further forward than the left, which extends further back than the right, although the glands overlap in the middle, as may be seen from figure 1. The posterior parts of the digestive system were not examined.

Central nervous system. — The cerebral ganglia are large and are situated close together on the top of the buccal mass in front of the opening of the oesophagus. Their anterior ends are well developed and slightly divergent; further back they are united by an extremely short and thick cerebral commissure. Each ganglion is almost twice as long as it is broad (see fig. 2).

The rounded buccal ganglia are situated on the top of the odontophore a short distance behind the opening of the oesophagus.

They are united to each other by a short buccal commissure, and to the cerebral ganglia by long and narrow cerebro-buccal connectives.

The ganglia beneath the buccal mass form two groups: an anterior one comprising the pedal and pleural ganglia, united to the cerebral ganglia by rather long cerebro-pedal and cerebro-pleural connectives, and a posterior group consisting of the parietal and abdominal ganglia, united to the anterior group by relatively long pleuro-parietal connectives. On the other hand, the small pleural ganglia are united by extremely short pleuro-pedal connectives to the rather large, oval pedal ganglia, which lie close together. Similarly the right parietal ganglion is closely joined to the abdominal ganglion by an extremely short right parieto-abdominal connective, although the two ganglia are separated by a groove; whereas the small left parietal ganglion is completely absorbed into the abdominal ganglion and cannot be separated from it.

Principal retractor muscles. — The columellar muscle gives off near its origin a broad, ventral, pedal retractor, passing down to the foot, and a narrower, dorsal, rather long, penial retractor, passing forward to the posterior end of the withdrawn penis. Between them the muscle continues forward to form the cephalic retractor, of which the main branches are the powerful buccal retractor, which is inserted in the hinder end of the muscular odontophore, and the tentacular retractor, which divides further forward into the retractors of the right and left tentacles, in the manner shown in figure 1.

Genital ducts. — The hermaphrodite gland and duct, and the albumen gland, were not examined in detail. The spermoviduct usually has its female or left side greatly swollen to accommodate about three large embryos. These develop thin, smooth and glossy, oval, embryonic shells of about 2½ whorls and up to 1.3 × 1 mm. in size. They can be clearly seen through the very thin walls of the spermoviduct, as they are not enclosed in calcareous egg-shells, such as are commonly found in the ovoviparous genera of the Subulinidae, for example. The male or right side of the spermoviduct is furnished with a well developed prostate gland, of which figure 1 only shows the front end.

After the separation of the vas deferens the free oviduct runs forward for a short distance and then unites with the anterior end of the narrow and very long receptacular duct arising from the oval spermatheca, which is situated near the albumen gland and liver. The female duct then continues forward as the vagina, which is moderately long and somewhat swollen towards its front end, where

it opens into the genital atrium. This slightly swollen anterior part of the vagina is clearly separable from the posterior part externally, and differs from it in containing numerous, very minute, thorn-shaped spines, with hollow, rather broad bases, and slender, curved points, as shown in figure 4. They vary in length from about 0.015 to 0.0225 mm., and tend to be arranged in longitudinal rows, with their points usually directed forwards towards the genital atrium. Their function is not very clear, but it is possible that this part of the vagina may be everted with or through the atrium in copulation, causing the points to be directed backwards, although the atrium is not very short in the present species.

The vas deferens is long, and is narrow throughout its length. It winds around the vagina, as shown in figure 1, before passing back again to enter the apex of the penis beside the insertion of the penial retractor muscle. The penis is a long, subcylindrical, muscular organ, sometimes attaining a length of nearly 2 mm. It appears to be completely invaginated when retracted, no penis-papilla being found. Not far from its hinder or apical extremity it bears a short, but stout and conspicuous, lateral appendix, rounded at the end. This is usually directed backwards, but in one specimen it was curved forwards. The outer layer of the wall of the retracted penis is composed of muscle-fibres running in a circular direction, but this does not form a separate penial sheath but adheres to the underlying part of the wall. When the penis is retracted the epithelium lining it forms a number of narrow longitudinal folds in the apical part between the entrance of the vas deferens and the base of the penial appendix; but in the rest of the organ these narrow folds are replaced by not more than two or three broad pilasters, which have the appearance of being finely papillate. In a specimen of the retracted penis examined microscopically, however, only three or four minute thorn-

Explanation of figures 1—6.

Anatomy of *Streptostele (Raffraya) horei* Smith, from Yanonge, Belgian Congo.

Fig. 1. Principal retractor muscles and anterior parts of digestive organs (with oesophagus cut short) on the left, and anterior parts of genital ducts on the right, with the spermatheca displaced towards the left at the foot of the figure; × 35.

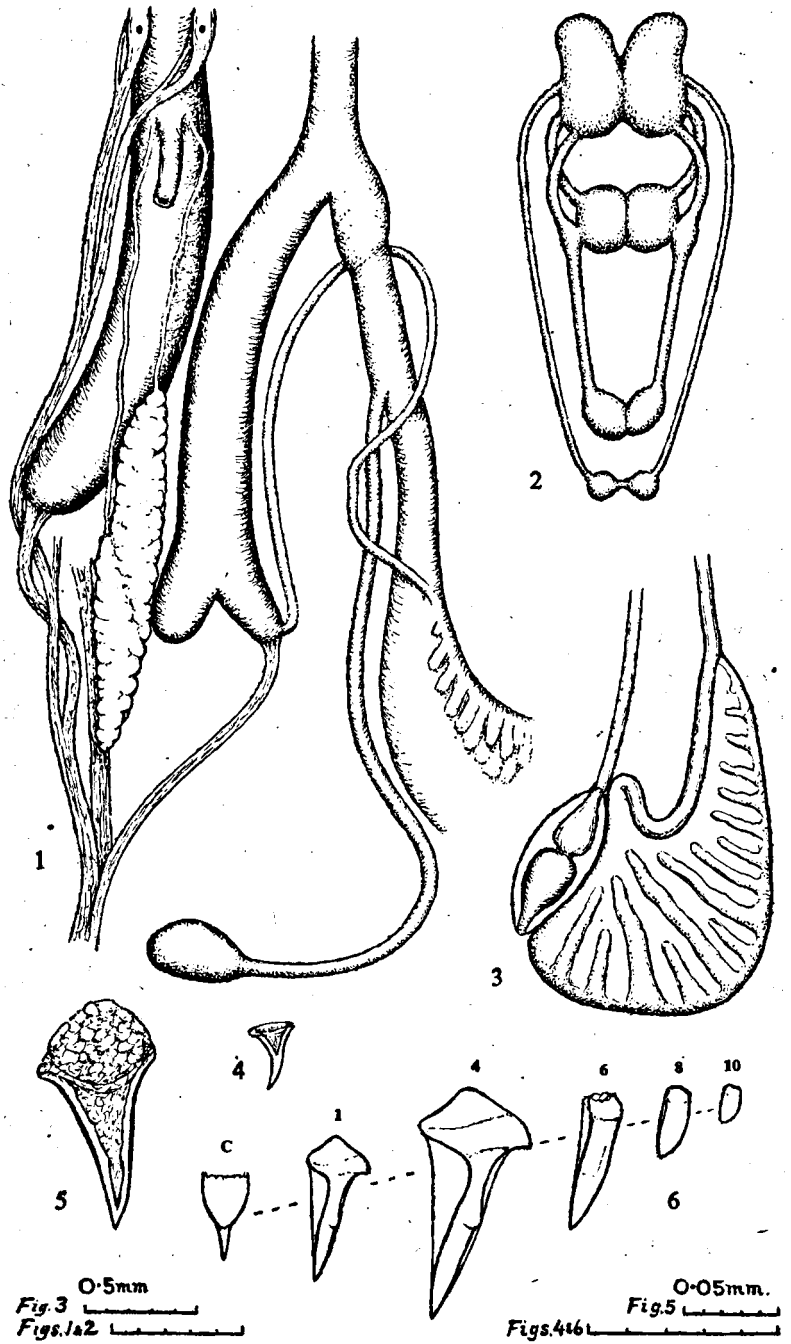
Fig. 2. Central nervous system, seen from above and slightly spread out, with the nerves that radiate from the ganglia omitted; × 35.

Fig. 3. Kidney and posterior part of ureter on the left, and heart (in the pericardium) and posterior part of pulmonary vein on the right, seen from the outer side through the transparent roof of the mantle-cavity; × 30.

Fig. 4. Minute spine from near the front end of the vagina; × 500.

Fig. 5. Larger type of spine from the penis; × 250.

Fig. 6. Representative teeth from the radula; × 500.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Figs. 4 & 6

shaped spines were found close to the entrance of the penis into the atrium, and of exactly the same type as the more numerous little spines in the adjacent lower part of the vagina; and, in addition to these, two rather similar, but very much larger, thorn-shaped spines were present a little further back within the penis, about three-quarters of the distance from the entrance of the vas deferens into the penis to the opening of the latter into the atrium. This larger type of spine is shown in figure 5, which is only magnified half as much as figure 4, one spine measuring about 0.1 mm. and the other 0.12 mm. in length. Both of them pointed forwards towards the atrium, and would therefore point backwards on the everted penis and might serve for retention.

In the Streptaxidae the penis is known to be often furnished with these small spines or hooks, and although neither PILSBRY nor THIELE state that they are present in the species of *Varicostele* and *Streptostele* that they dissected, ODHNER says that they are numerous in the penis of *S. buchholzi* v. Mts. and figures them. PILSBRY, however, showed that *Varicostele bequaertiana* differs from *Streptostele (Raffraya) horei* in having a much longer and more elaborate penial appendix, arising close to the base of the penis instead of near its apex, as well as in the salivary glands being separate and the radular teeth more numerous; and while THIELE stated that the male organs of *Streptostele buchholtzi* v. Mts. are, on the other hand, simple, ODHNER has shown that this species has a short penial appendix, not unlike that of the present species, but both he and THIELE have figured the central tooth of its radula as of a different shape. Moreover none of these authors said that the forms they dissected were viviparous. But until more species have been carefully examined anatomically, the precise systematic value of these differences cannot be rightly judged.

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