XVIII.—*Notes on the Anatomy of the Genus Firola.* By JOHN DENIS MACDONALD, R.N., F.R.S., Surgeon of H.M.S. "Icarus." Communicated by Professor MACLAGAN. (Plate IX. fig. 4.)

(Read 5th January 1863.)

In a successful haul of the towing net, off the Island of Sardinia, I obtained a very beautiful *Firola*, which gave me a good opportunity of testing the truth of my former conclusions with regard to the economy of the Heteropoda in general, and of *Firola* in particular; and I have great pleasure in submitting the facts arrived at, with the accompanying enlarged figure of the visceral nucleus and the neighbouring parts, to the Royal Society of Edinburgh, as an appendix to my paper "On the Anatomy and Classification of the Heteropoda," already brought under its consideration.*

I find that the relationship between *Firola* and *Firoloides* is even closer than I had originally imagined, and with the exception of the presence of gills in the former genus, nearly every anatomical point occurring in one may be distinctly traced out in the other, only differing in relative characters.

To avoid unnecessary repetition, I shall simply explain the accompanying figure, and enlarge in passing upon any matters of importance that may suggest themselves.

Explanation of Plate IX. fig. 4.

- a. Integument.
- b. Muscular sheath.
- c. Visceral nucleus, including the stomach, intestines, liver, testis, &c.
- d. Vesicula seminalis. All these organs are invested by an oval capsule, with its long diameter directed obliquely downwards and forwards, having the stomach at the lower end, and the trumpet-like vent above, and in front, lying in relation to the Sinus-system, the heart, great vessel, and œsophagus.
- e. Seminal opening.
- f. Intestine.
- g. Anal orifice, plicated internally, and richly ciliated.
- h. Gills, with their zig-zag folds, giving the organs a pinnate appearance, which is often incorrectly given in figures of the Heteropoda.
- i. Ciliated fossa fronting the gills, the cilia disposed in a circular band, and undulating in the direction of the arrows.
- k. Sinus-system, communicating directly with the auricle of the heart (m), and everywhere intersected with muscular bundles and fibres.
- l. Circular opening, leading into what I have been induced to regard as an inverted mantle-cavity, whose walls are much lobulated and highly contractile, so that the sea-water is ejected through the opening which is guarded by a sphincter. A *vis e fronte* effect

* Trans. Roy. Soc. Ed., vol. xxiii. p. 1.

would appear to be exerted on the blood entering the sinus-system ; for during the contraction of the muscular fibres of the latter, and the systole of the auricle, diastole of the mantle-chamber is taking place. A great deal has been said about vital expansion in human physiology, but the instance just given is one in which the expansion of one chamber is facilitated by the contraction of another, having no internal communication with it ; and this I believe to be the office of the remarkable organ in question, as an appendix to the auricle, which communicates so freely with the sinus-system.

- m. Auricle of the heart, or rather its proper position ; for its limits do not appear to be accurately defined.
- n. Ventricle, with its closely interlaced muscular substance.
- o. Principal vessel.
- p. Œsophagus.
- q. Stomach.
- 1. Long nerve-trunk, extending from the pedal ganglion to No. 2.
- 2. A small nodule of neurine, which, as I imagine, is chiefly respiratory, though it also sends filaments to the great vessel and œsophagus.
- 3. A stout commissural-nerve, connecting No. 2 with
- 4. The cardiac and visceral ganglion.
- 5. A conspicuous nerve, supplying the sphincter and radiating muscular fibres of the mantle opening, arising, as in *Firoloides*, from the ganglion No. 4.
- 6. A large commissural-nerve, passing from No. 2 to
- 7. A large saucer-shaped ganglion, lying immediately below the ciliated fossa (i). I can now safely say, that a body corresponding to this, though much smaller in *Firoloides*, is truly nervous ; but I cannot hazard any theory as to its office, though it is obviously in some way connected with that of the ciliated fossa,—probably with respiration.

In my former paper, I stated my reasons for believing that the sexes are separate in the *Heteropoda*, and I am sure that this point will require no further proof, though, as far as the sanction of authority is concerned, the more general conviction even now is, that the sexes are combined. The uncertainty existing on the subject amongst zoologists, cannot be better represented than by the following quotation, verbatim, of Note 9, p. 264, Dr BURNETT's translation of SIEBOLD's "Anatomy of the Invertebrata" :—

"The penis is double, and at the right side of the base of the visceral sac, with *Carinaria* and *Pterotrachea* (MILNE-EDWARDS, Ann. d. Sc. Nat., xiii. 1840. p. 195 ; xviii. p. 323, Pl. x., fig. 3). QUOY and GAIMARD (Voy. de l'Astrolabe, Mollusq., Pl. xxviii. fig. 10 ; or Isis, 1834, Taf. iii. fig. 10), have figured a long bifid penis, with *Phyllirrhoë amboinensis* ; and so, if with the other Heteropoda, the penis is not retractile, as appears to be the case with *Carinaria*, according to MILNE-EDWARDS this species would be a male ; while *Phyllirrhoë bucephalus*, figured by PERON (Ann. du Museum, xv., fig. 1 ; or KOSSE, De Pteropodum ordine, Diss. fig. 1), apparently without a penis, would be a female, although D'ORBIGNY (Voy. dans l'Amer. MÉR. ; or Isis, 1839, p. 519), regards this genus as hermaphrodite. With *Atlanta*, there is a simple, pointed penis on the right side

of the neck, directly near the arms ; but as RANG (Mém., *loc. cit.*, p. 378, Pl. ix. ; or Isis, 1832, Taf. vii.) has found this penis with all the individuals he has examined, it may be questioned if the sexes are really separate with this Heteropod.

“ The internal genital organs of *Atlanta* and *Phyllirrhoë*, should be thoroughly studied for the elucidation of this point.”

There are a good many references made in this note, but no satisfactory information is derived from any of them. The paucity of female *Atlantæ*, as indicated by M. RANG having only encountered the males, is perhaps the most interesting point. This was for a long time my own experience also, but on several occasions I have been fortunate enough to obtain indisputable females.

Though the position of *Phyllirrhoë* amongst the Nudibranchs and not with the Heteropods, has been long recognised by zoologists, I may make the following remarks in passing, to clear up a desideratum in the note. First of all, the bifid penis of this mollusc is perfectly retractile, and its testicular follicles are included within the sacculæ of the ovaria, so as to form perfect hermaphrodite glands. The primary vas deferens and oviduct are blended together ; and subsequently to the formation of stout fusiform spermatheca, the common tube divides into outer oviduct and outer vas deferens, the one passing into a wide glandular uterus, and the other into one of the limbs of the intromittent organ. The bisexual nature of the animal was known to CUVIER, though he could not have given this interpretation of it.

Having examined some hundreds of recent Heteropoda, particularly the species of *Atlanta*, it struck me as being very odd, that I had never in a single instance succeeded in tracing a vas deferens onwards to the external male organ. This finally led me to believe that the penis was imperforate, and as in *Onchidium*, *Aplysia*, *Melo*, and numerous other Gasteropoda, far in advance of the spermatheca opening, both being held in communication by a ciliated groove, more or less capable of being converted into a canal. Of the truth of this doctrine, I am now fully convinced, for the outlet of the spermatheca, as given in the figure, and which is even quite prominent in *Firoloides*, is so palpable as to admit of no question ; and on closely examining the duplex penis, I find by the simple test of focussing, that the so-called perforation and internal canal are nothing more than an external, deeply-grooved, and ciliated tract, the office of which is obvious enough.