

XII. *On the Testis of Limulus.* By W. B. S. BENHAM, Esq. (*Communicated by*  
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(Plate XXXVIII.)

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WHILE working in the laboratory at University College, last October, as one of Prof. E. Ray Lankester's assistants, he suggested that I should examine the testis of the King-Crab. By his kindness (here I will take the opportunity of thanking him for his kind help and suggestions) I was fortunately able to work on the fresh animal. Owing to the difficulty, and the time taken, in removing the carapace, not much could be done in a day; and though it kept fresh till the next day, after that it had to be placed in spirit; in this state the finer networks are easily broken, and the finer blood-vessels may be mistaken for the ducts, though the mistake is soon discovered, owing to the absence of networks in the former. The testis is packed by the ramifications of the gastric gland (the so-called liver), and lies almost superficially.

The only description of the generative organs of the King-Crab appears to be that by Prof. Owen, which was published in the *Linnean Transactions* for 1873. He there describes and figures a portion of an ovary; his description opens thus:—"The ovarium is a system of ramified tubes and cavities, occupying chiefly the dorsal region of the body; it extends along the median part of the thoracetron" (=abdomen), "and expands laterally in the cephalotron" (cephalothorax). His figure shows rather thick ducts; and the network represented is not extensive, but, so far as it goes, corresponds roughly with the distribution of the testis. It may be said that the testis forms a reticulated tube all over the dorsal portion of the thorax and abdomen, mixed up with the liver. Owen divides the ovary into anterior and posterior median lobes, with anterior, lateral, and postero-lateral branches and networks proceeding from the former lobe.

We can scarcely, as will be seen, divide the network of the testis into such lobes, though roughly there are anterior (thoracic), posterior (abdominal), and lateral (thoracic) networks. As in the ovary, the main duct of the testis, from the external aperture, divides, on reaching the surface of the liver, into three main branches, having about the same course as in the female organ.

Professor Owen's figure represents the branches as symmetrical on each side; such is not the case with the network of the testis, as will be seen. He suggests as a cause for the posterior median lobe of the ovary dividing into two branches, at the junction of abdomen and thorax, which run forward to the anterior median lobe, that the pressure on it, between heart and intestine, which would take place on flexion of the abdomen on the thorax would be too great if median, and hence there is a branch on each side, outside the pericardium. In the case of the testis, the ducts are much smaller than those

represented in his figure of the ovary, so that they occupy but little space between the pericardium and intestine, and the pressure on it would be very slight. The *external aperture*, both of oviduct and sperm-duct, is similarly situated on the posterior face of the VII. appendage, about one third of the distance from its attachment, near the middle line on each side (as shown in fig. 2).

*The course of the spermatic network.*—The sperm-duct rises from the external aperture on the VII. appendage, upwards and outwards, parallel to the “anterior lamellar” muscle of this appendage. It reaches the surface of the liver, through which it runs, just within the muscle attached to the sixth thoracic limb (fig. 1,  $D^l$   $D^r$ ).

*Lateral network.*—Here it breaks up into three branches; one runs backwards and outwards, behind this large coxo-tergal muscle, giving off branches, which anastomose with one another, forming a network, which includes in its meshes some of the smaller muscles of the sixth coxa; the ducts get finer as they recede from the main duct (they are drawn too thick in the figure), and they run to the side and to the posterior corner of the thorax.

Just after passing the large muscle, an anterior duct is given off, passing along the outer edge of the coxo-tergal muscles, forming a network, which probably runs right away to the front; but I was unable to follow it further than is represented in the figure, as here the ducts get very fine and easily break. The second main branch from the duct runs inside the coxo-tergal muscles, forwards, giving off networks between the various muscles, some of the smaller ones being included in the meshes; these networks pass outwards, and probably anastomose with that on the outer side of the coxo-tergals. However that may be, inside it runs right away in front of the muscles, and on its inner side gives off branches to a median network.

*The median network.*—The third principal branch is represented on the right side, and does not appear on the left, so that there is a certain amount of asymmetry. This runs inwards at first, behind the branchio-thoracic muscle, then forwards along its inner border, where it gives off a network across the middle line, lying between the pericardium above and the alimentary tract below. This network ( $A$ , fig. 1) was removed, and cleaned, as far as it could be, from liver and connective tissue, and mounted; it is represented in fig. 3, where  $A$   $A$  represent the lateral boundaries; on the ducts are seen the sperm-sacs, which are usually in groups, one of which opens into the duct, and the others into one another.

In front of this network is another continuous with it, but separated from it in the figure, owing to the rupture of some of the finer ducts. The anterior lateral boundary of the left side is formed by a duct running from the front of the left branchio-thoracic obliquely forwards to the right side. The network alongside the second coxo-tergal muscle, the most anterior of the large muscles, sends small branches forwards, but not very far, and backwards a larger duct, whence branches and networks pass between the muscles, probably to join a similar lateral network on the right, as was described for the left side.

The left border of the median network is formed by two very fine ducts parallel with one another, on the inner side of the branchio-thoracic muscle. These two ducts anastomose here and there, and join a network in the abdomen, across the middle line, beneath

the pericardium; the ducts then become excessively fine, and the network, at any rate the sides of it, ends at about the xi. appendage. The network was here incomplete, as I had removed the portion *A* previously to noticing these fine posterior ducts.

The lateral network of the right side is doubtless similar to that on the left; but I did not follow it throughout its extent.

Thus there is a continuous network of ducts more or less all over the body, lying, in the median line, below the pericardium and above the intestine; this median network runs throughout the abdomen and thorax, though the ducts are larger more anteriorly. This corresponds to Prof. Owen's "anterior and posterior median lobe" of the ovary; the lateral lobes or branches of this are represented by the lateral networks outside the coxo-tergal muscles of the thorax.

That the testicular network does thus extend everywhere is shown by the fact that, when the carapace is cut off, a white viscous fluid flows out, which consists of blood mixed with spermatozoa; this soon coagulates.

The *spermatozoa* consist of a small rounded head about  $\frac{1}{1000}$  inch in diameter, with a flattened wide "neck" and a long mobile tail (fig. 4). The mobility of the spermatozoa of *Limulus* was discovered and recorded by Prof. Lankester in 1881 (Quart. Journ. Micr. Science, vol. xxi.).

The *sperm-sacs* are seated in groups upon the sides of the ducts; two or three, sometimes more, are in connexion with one another, one of which opens into the duct (figs. 3 & 5). These sacs are subglobular in shape, and are surrounded by a delicate membrane. These are filled with groups of spermatozoa without tails, their further development apparently taking place in the ducts as they approach the aperture. Sometimes sperm-sacs are seen at some distance from a duct, and I could, in many cases, trace no ductule from them (as at *B*, fig. 5). Perhaps it is here that the sperm-cells are produced, and by continual enlargement of the sperm-sacs, by subdivision of the sperm-cells, and stretching of membrane round them they reach the ducts.

All these structures, as well as the cæca of the great gastric gland, are packed by a fibrous connective tissue, which is very loose (fig. 5, *C*).

The *wall of the duct* (fig. 6) is made up of interlaced tendinous-looking fibres; by tendinous I mean that they are more or less highly refractive and parallel to one another. These are arranged longitudinally, circularly, and obliquely, while the inner surface is lined by columnar cells. The duct is often filled with the unripe spermatozoa, which, here and there, have aggregated into rounded masses near the walls (fig. 5, *S*).

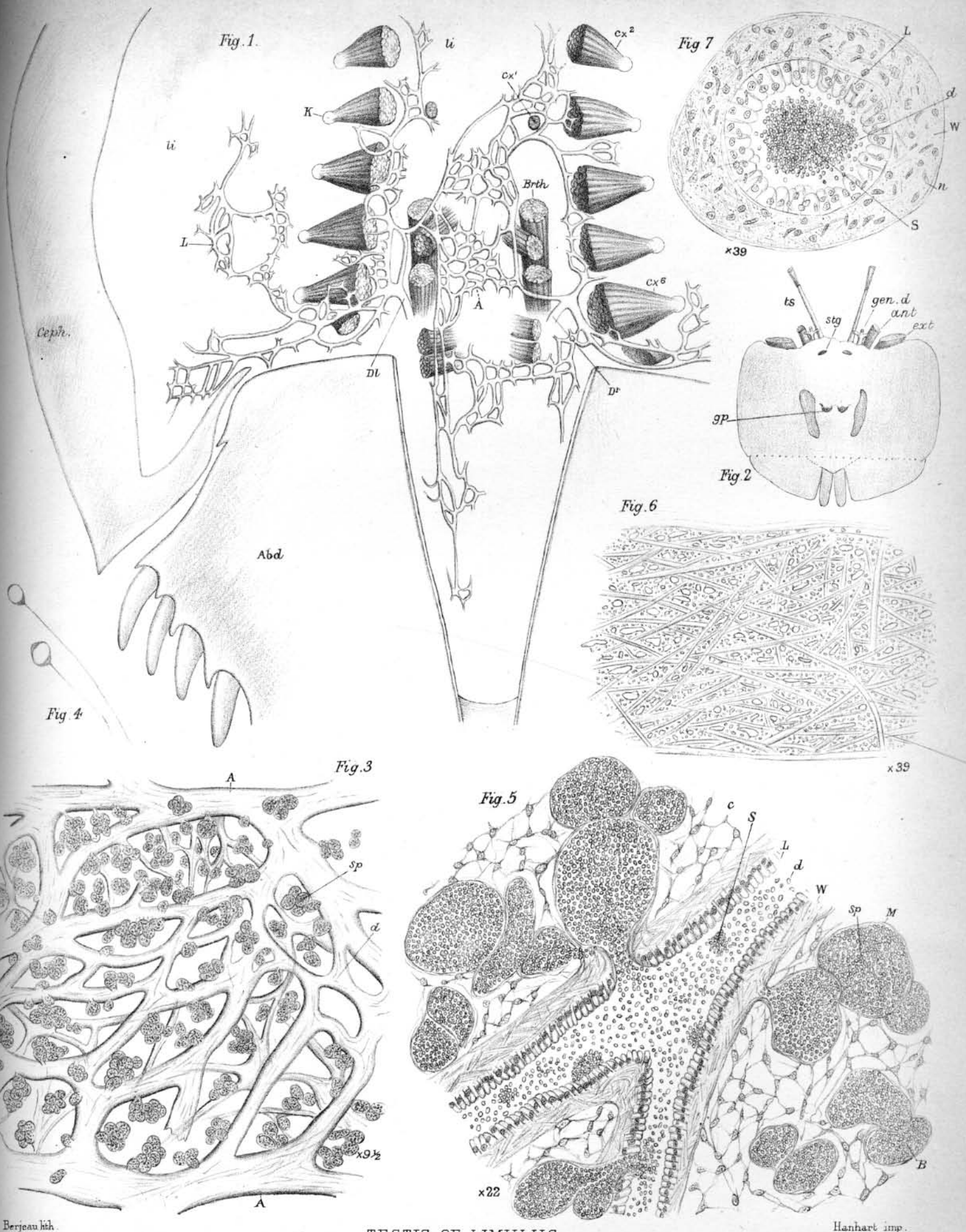
*Significance of the above observations.*—The importance of the observations thus recorded depends upon the fact that in no crustacean do the ducts of the generative glands form a network, whereas in the Scorpion (and other Arachnids), as in *Limulus*, they do. Hitherto the fact that the ovarian ducts of *Limulus* form a reticulum was the only information which we possessed as to the form of the generative organs in *Limulus*. The observations recorded in the present paper show that the duct of the male organ in *Limulus* also has the form of a reticulum. Thus a new and important confirmation is afforded to the proposition maintained by Prof. Lankester in his essay

"*Limulus* an Arachnid," viz., that the organization of *Limulus* is closely similar to that of the Scorpions, and has no special agreement with that of any Crustacea.

A second point of considerable interest is the apparent isolation of many of the spermatic sacs, and the probability that they are *not* diverticula of the spermatic duct, but, secondarily, in the course of their ripening acquire a connexion with it, the two structures having developed independently. This is in accordance with what is known as to the essential nature of the genital ducts of Arthropoda, although it cannot be said that we have, at present, a sufficient series of observations upon their development to warrant a generalization.

### DESCRIPTION OF PLATE XXXVIII.

- Fig. 1. The carapace has been removed from the cephalothorax (*Ceph*), and the tergum from the abdomen (*Abd*), to show the course of spermatic network amongst the liver (*li*), which is not indicated: *A*, median network; *L*, lateral network; *Cx*<sup>1</sup>–*Cx*<sup>6</sup>, coxo-tergal muscles, the rounded knobs (*k*) to which these are inserted are parts of the entocoxites of the appendages; *Br.th*, branchio-thoracic muscle; *D*<sup>l</sup>, *D*<sup>r</sup>, the left and right main sperm-ducts, dipping down to the external aperture in appendage VII.
- Fig. 2. *Genital operculum*, half nat. size. Posterior face, to show the papillæ in which the external apertures of the genital duct are situated; *gen. d*, sperm-duct dividing into three main branches; *g.p*, its external aperture; *Stg*, stigma; *t.s*, tendinous stigmata; *ant.*, anterior lamellar muscle; *ext.*, external branchial muscle.
- Fig. 3. Portion of the median network *A* (fig. 1), magnified about 9½ times; *AA*, lateral boundaries of this portion; *d*, duct; *sp*, sperm-sacs.
- Fig. 4. Mature spermatozoa.
- Fig. 5. Portion of a section showing sperm-sacs, × 22: *d*, sperm-duct; *W*, wall of duct; *L*, epithelium of duct; *S*, aggregations of spermatozoa; *c*, surrounding connective tissue; *M*, membrane of sperm-sac; *B*, sperm-sac with no apparent connexion with duct.
- Fig. 6. Portion of wall of sperm-duct, seen from without; enlarged about 39 times.
- Fig. 7. Transverse section of duct, × 39: *d*, lumen of duct; *L*, epithelium; *n*, nuclei; *W*, wall; *S*, spermatozoa within the duct.



TESTIS OF LIMULUS.

Hanhart imp.