

by a Carré ice machine. Two carafes were prepared at a time, and there was plenty of time to keep one constantly at hand.

In order to allow the Miller-Casella thermometers to record the high temperature of 50 fathoms in the last series, they were lowered very rapidly to that depth, and after eight minutes reeled back at the rate of 200 fathoms per minute, so that the minimum side had not time to assume a lower temperature.

The cable was led from a large reel through an 18-inch leading block, and was lowered and reeled in very slowly, and without jerks.

It may be noted in the above Tables that the two instruments gave precisely the same readings at positions of maximum or minimum temperature, but that in intermediate positions the electrical thermometer, in almost every instance, gave a higher reading. This discrepancy may be accounted for, I think, by the circumstance that the electrical thermometer gives the temperature of the water actually surrounding the coil at the moment of observation, whereas the reading of the Miller-Casella instrument must be affected by the maximum or minimum temperatures encountered in its ascent or descent, which may not coincide with that at the points of stoppage. A strong argument in favour of the electrical instrument for geodetic and meteorological purposes has thus been furnished.

V. "On the Coxal Glands of Scorpio hitherto undescribed and corresponding to the Brick-red Glands of Limulus." By E. RAY LANKESTER, M.A., F.R.S., Jodrell Professor of Zoology in University College, London. Received May 25, 1882.

In my essay entitled "Limulus an Arachnid,"\* I have mentioned Dr. Packard's discovery of the "brick-red glands" of Limulus, situated at the junction of the coxæ of the prosomatic limbs with the body in the following terms:—"It is true that Packard has assimilated a brick-red coloured structure occurring at the base of the cephalothoracic limbs of Limulus to a shell-gland or renal organ. In this I cannot agree with him. It is not even apparent, at present, that this brick-red organ, which I have examined, is of a glandular nature at all."

Dr. Packard first described these glands in 1874, and figured them subsequently in his valuable memoir on the "Anatomy, Histology, and Embryology of Limulus Polyphemus," published in the Anniversary Memoirs of the Boston Society of Natural History, 1880.

\* "Quart. Journ. Micr. Sci.," 1881.

Dr. Packard observes—"These glands are quite large and apparently of some physiological importance, and are easily found, as they are conspicuous from their bright red colour, causing them to contrast decidedly with the dark masses of the liver, and the yellowish ovaries or greenish testes, near which they are situated. The glands are bilaterally symmetrical, one situated on each side of the pro-ventricle and stomach, and each is entirely separated from its fellow. Each gland consists of a stolon-like mass extending along close to the great collective vein, and attached to it by irregular bands of connective tissue, which also hold the gland in place. From this horizontal mass four vertical branches arise, and lie between and next to the partitions at the base of the legs, which divide the latero-sternal region of the cephalothorax into compartments. The posterior of these four vertical lobes accompanies the middle hepatic vein from its origin from the great collective vein, and is sent off opposite the insertion of the fifth pair of feet. Halfway between the origin of the vein and the articulation of the limb to the body, it turns at a right angle, the ends of the two other lobes passing a little beyond it, and ends in a blind sac, less vertical than the others, slightly ascending at the end, which lies just above the insertion of the second pair of feet. The two middle lobes are directed to the collective vein. Each lobe is somewhat flattened out, and lies close to the posterior wall of the compartment in which it is situated, as if wedged in between the wall and the muscles between it and the anterior portion of the compartment. Each lobe also accompanies the bases of the first four tegumentary nerves."

I can fully confirm the accuracy of this careful description of the naked-eye appearance and situation of these glands. I am also in agreement with Dr. Packard, when he states that these glands have no opening into the great veins, and, like him, I have as yet been unable to detect the situation of their opening to the exterior.

Dr. Packard's description of the minute structure of these brick-red bodies is such as to have led me to doubt the correctness of his conclusion that they are glands and more especially renal glands. At the time when I wrote to that effect I had only made dissections showing their position and relations in two specimens of *Limulus*. I have since been able to obtain perfectly fresh specimens of the brick-red glands from a *Limulus* killed for the purpose, and having hardened them in absolute alcohol, I have prepared and examined sections demonstrating their minute structure.

This does not agree with the description given by Dr. Packard, whose account of the minute structure of these bodies led me to doubt their glandular nature.

Dr. Packard states that "the four lobes end in blind sacs and have no lumen or central cavity," and in the next paragraph somewhat

inconsistently remarks "each lobe when cut across is oval, with a yellowish interior and a small central cavity." He states that the gland is "dense though yielding, and on this account hard to be cut with the microtome," and appears to have confined his observations accordingly to preparations of the fresh gland teased. Various kinds of cells, from a "cortical" and a "medullary" substance of the gland, are described and figured, but it does not seem to be possible to bring these results of "teasing" into relation with what I have observed in sections taken in various directions across the lobes of the gland, and stained and mounted in the usual way in balsam.

I find that each of the quadrilobate glands, which I should propose to call the right and the left "coxal glands," is essentially a sac, lined with a characteristic glandular epithelium, the lumen of the sac being cut up into a number of inter-communicating passages by the production of the inner surface of the sac into very numerous and far-reaching trabeculae. The gland-cells which clothe these trabeculae are remarkable for their round, well-defined nuclei, and for the possession of a peculiar differentiation of the substance of the cells near their free surface, which has at first sight the appearance of a very thick cuticle.

A more detailed account of the structure of these cells may be deferred for the present. My object now is to point out that in the Scorpions there exists a similar pair of large coxal glands, having essentially the same structure and position as the coxal glands of *Limulus*. I was led to look for the existence of such glands by the hypothesis that *Scorpio* and *Limulus* are very closely related members of the class *Arachnida*; and it will, I think, be conceded that the discovery of the existence of such corresponding organs goes a long way towards confirming the conclusion as to the close affinity of the two animals, to which I had been led by the observation in them of numerous other structural coincidences.

The coxal glands of the Scorpions are very large and prominent structures, each attaining the size of a dried pea in a large Indian scorpion of five inches in length. They are placed as in *Limulus* at the junction of the coxae of the ambulatory limbs with the body (fig. 1. B.). They do not send lobes forward corresponding to the second, third, and fourth of the six limbs of the prosoma, but are oblong white bodies resting upon the sternal prolongations of the hinder limbs (fifth and sixth) on each side. Posteriorly each gland rests against the ingrowing chitinous wall (fig. 1. C.) of the coxa of the last limb of the prosoma which forms the posterior cornu of the entosternite, but the mass of the gland lies in the hollow of the sternal prolongation of the fifth limb, and is attached to it by a triangular outgrowth which I shall provisionally speak of as a duct, though I have not at present succeeded in finding any external aperture corre-

sponding to these coxal glands of the Scorpion, any more than I have in the case of the similar glands of *Limulus*.

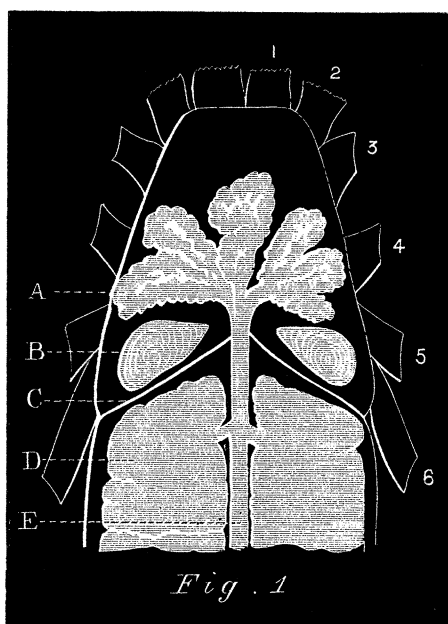


Diagram of the anterior portion of a Scorpion's body, to show the position of the coxal glands.

- A. Anterior glandular cæca of the alimentary canal (salivary glands of Newport and Blanchard, *not* of Dufour). These are drawn of smaller size than natural, and are turned forward so as to expose the coxal glands.
- B. The coxal gland of the left side.
- C. Fibrous septum (diaphragm of Newport) formed by the posterior cornua of the entosternite.
- D. Glandular cæca of the alimentary canal (so-called "liver").
- E. Axial portion of the alimentary canal.
- 1 to 6. The six pairs of limbs of the prosoma.

These oblong, almost egg-shaped, glistening white bodies have not altogether escaped the notice of previous students of the anatomy of Scorpions; but owing to the fact that spirit-specimens have been used by most naturalists who have dissected Scorpions, and that spirit fails to preserve the softer tissues of a whole Scorpion in a fit state for observation, the nature of these glands has been misunderstood.

I have been enabled to dissect freshly-killed specimens of the large Indian scorpion, *Sc. cyaneus* (allied to the species called *Buthus*\*

\* Not the genus *Buthus* of Leach, but of Gervais, identical with *Heterometrus* of

*Kochii* and *Buthus afer* by some authors), through the kind exertions of my friend Dr. Henry Trimen, Director of the Royal Gardens at Peridenya, Ceylon, also of the fine North African *Androctonus funestus* (Ehrenberg spec.), of which I received specimens in a living state from Algeria through the courteous intervention of Professor Carl Vogl, of Geneva; and, lastly, of *Scorpio Italicus*, Roessel, and *Sc. Carpathicus*, Linn., the common little Italian scorpions (not to be confused with the larger yellow Spanish *Sc. Europæus* of Linnæus, which is an *Androctonus* closely allied to *A. funestus* and often called *A. occitanus*), for which I have to thank Mr. Gibson Carmichael. When the prosomatic carapace is removed from one of these Scorpions recently killed, the white oviform coxal glands are seen in the position described, right and left of the alimentary tract. The anterior glandular cæca (fig. 1. A.) of the alimentary tract, called salivary glands by Newport, rest upon the coxal glands and hide them to a certain extent. This proximity has led to the notion that the coxal glands are connected with the alimentary canal.

Newport in the plates illustrating his masterly description of the circulatory and nervous system of the Scorpion, published in the "Phil. Trans." nearly forty years ago (1843), has figured these bodies, but has not described them in the text of his work. In the description of the plate they are spoken of as "lateral appendages of the thoracic portion of the canal, (?) gizzard (?)." The accuracy and completeness of Newport's account of the vascular and nervous systems is worthy of profound admiration, when it is remembered that he had only specimens preserved in alcohol to deal with. At the same time this condition of his specimens accounts for the incorrectness of his conclusions as to the very soft and decomposable glandular structures.

Leon Dufour ("Mémoires de l'Institut," Tom. 14, 1856) has also described and figured the coxal glands in *Androctonus occitanus* (*Scorpio Europæus*) the large yellow scorpion of southern France and Spain. Dufour had the advantage of using freshly-killed specimens, but his account of the anatomy of this species appears to me to be, nevertheless, curiously inaccurate in many important particulars. He very properly does not consider the glandular cæca of the most anterior portion of the alimentary canal as "salivary glands" as did Newport, but recognises the identity of their structure with that of the large glandular masses filling up the mesosoma which have been termed "hepatic," and accordingly describes the "salivary glands" of Newport as the anterior or cephalothoracic lobes of the liver.

He, however, describes the pair of coxal glands as "salivary Ehrenberg. The confusion of nomenclature among the Scorpions is very great. Peters ("Berlin Monatsbericht," 1861, p. 510) has given the best systematic arrangement of the sub-genera.

glands," and this, notwithstanding that he has accurately recognised the absence of any duct connecting them with the alimentary canal. He *figures* such a duct, but remarks in the text of his memoir, that these apparent ducts are really ligaments.

He further figures and describes the broad triangular offset from the anterior and inferior margin of the gland which appears to me to be in all probability its true duct,\* and gives to this the name of "fleshy pedicle."

Dufour observed and figured something of the minute structure of the coxal (his "salivary") gland. He shows that its smooth white surface is marked by winding lines of a labyrinthine arrangement, but erroneously attributes their existence to a coiled tubular structure.

My own observations on the minute structure of the coxal glands of the Scorpions dissected by me are briefly as follows: the three species agreeing in essentials. Each gland is a sac; the labyrinthine markings seen on the surface being due to the existence of labyrinthine trabeculæ which rise up from the inner surface of the sac, and break up its lumen into numerous narrow passages as is the case in the coxal glands of *Limulus*. An injection of freshly precipitated lead chromate forced into the gland did not escape from it by any duct, but distended the triangular "pedicle," which I consider as probably the duct, though I have as yet failed to find any pore corresponding to it on the outer surface of the coxa or of the sternum.

Coxal glands taken from freshly killed Scorpions and placed in absolute alcohol, and subsequently stained with picrocarmine or hæmatoxylin, and cut into sections in the usual manner, showed that the gland is a sac with its wall folded inwards, so as to form numerous trabeculæ, clothed with a remarkable epithelium. The cells of this epithelium are much larger than those of the coxal glands of *Limulus*, but agree with them in presenting a differentiation of the cortical substance of the cell. Each cell of the epithelium of the scorpion's coxal gland presents in optical section a complete cortical ring of bright dense-looking substance surrounding a transparent protoplasm, in the centre of which is the nucleus. The dense cortical substance of each cell appears to be finely striated; the striæ radiating from the medullary substance towards the surface of the cell. This striated structure recalls to mind the striated structure of the cells of the leech's nephridium, and of the mammalian kidney.

The trabeculæ on which these cells rest are cavernous, being filled with blood. The blood spaces so formed are larger than the spaces

\* *June 24th*, 1882.—I am indebted to the skill of my assistant, Mr. A. G. Bourne, B.Sc., for some complete series of sections through small Scorpions, the study of which has led me to doubt whether these glands have any duct. Their exact nature and function require further investigation, with which I am engaged.

left between the projecting trabeculæ. The latter are the true "lumen" of the gland. The structure of the central portion of the coxal gland of the Scorpions differs from that of its periphery, to which the previous description refers.

*Conclusion.*—It does not seem possible to doubt that the coxal glands of the Scorpions and of *Limulus* are homologous structures. Though no external opening has been found as yet, in either the one case or the other, it is possible that such an opening exists. Though glands in a similar position (at the bases of the limbs or jaws) are found in other Arthropoda, there are none known which agree so closely in position and structure with either the coxal glands of *Limulus*, or of *Scorpio*, as these do with one another. Possibly such coxal glands are in all cases the modified and isolated representatives of the complete series of tubular glands (nephrida) found at the base of each leg in the archaic Arthropod, *Peripatus*.

P.S.—I may add that since writing the above, I have found a similar pair of glandular organs in a large South American Mygale, which I received from the Zoological Society on the day of its death, in the Insect House at Regent's Park. The coxal glands in *Mygale* are elongated and lobed as in *Limulus*. They rest on the dorso-lateral region of the entosternite.

VI. "Note on the Differences in the Position of the Ganglia of the Ventral Nerve-cord in three Species of Scorpion." By E. RAY LANKESTER, M.A., F.R.S., Jodrell Professor of Zoology in University College, London. Received May 25, 1882.

No one who is acquainted with the researches of George Newport can doubt the general accuracy of his description of the nervous system of an "*Androctonus*." Very probably the Scorpion which he made use of for his researches on the nervous system was *Androctonus funestus*, Ehr., the same which I have received in the living condition from North Africa.

The accuracy of Newport's description in a very material point, and one which refers to a very obvious feature, has been called in question by Leon Dufour. Dufour dissected a species closely allied to *A. funestus*, one which is little more than a small European variety of it, namely, *A. occitanus*. Yet he gives an account of the disposition of the ganglia of the ventral nerve-cord, and of the innervation of the four pairs of pulmonary sacs, which is widely different from that of Newport.

I am able to confirm the general accuracy of Newport's account by my dissections of *A. funestus*, and have been in much doubt as to

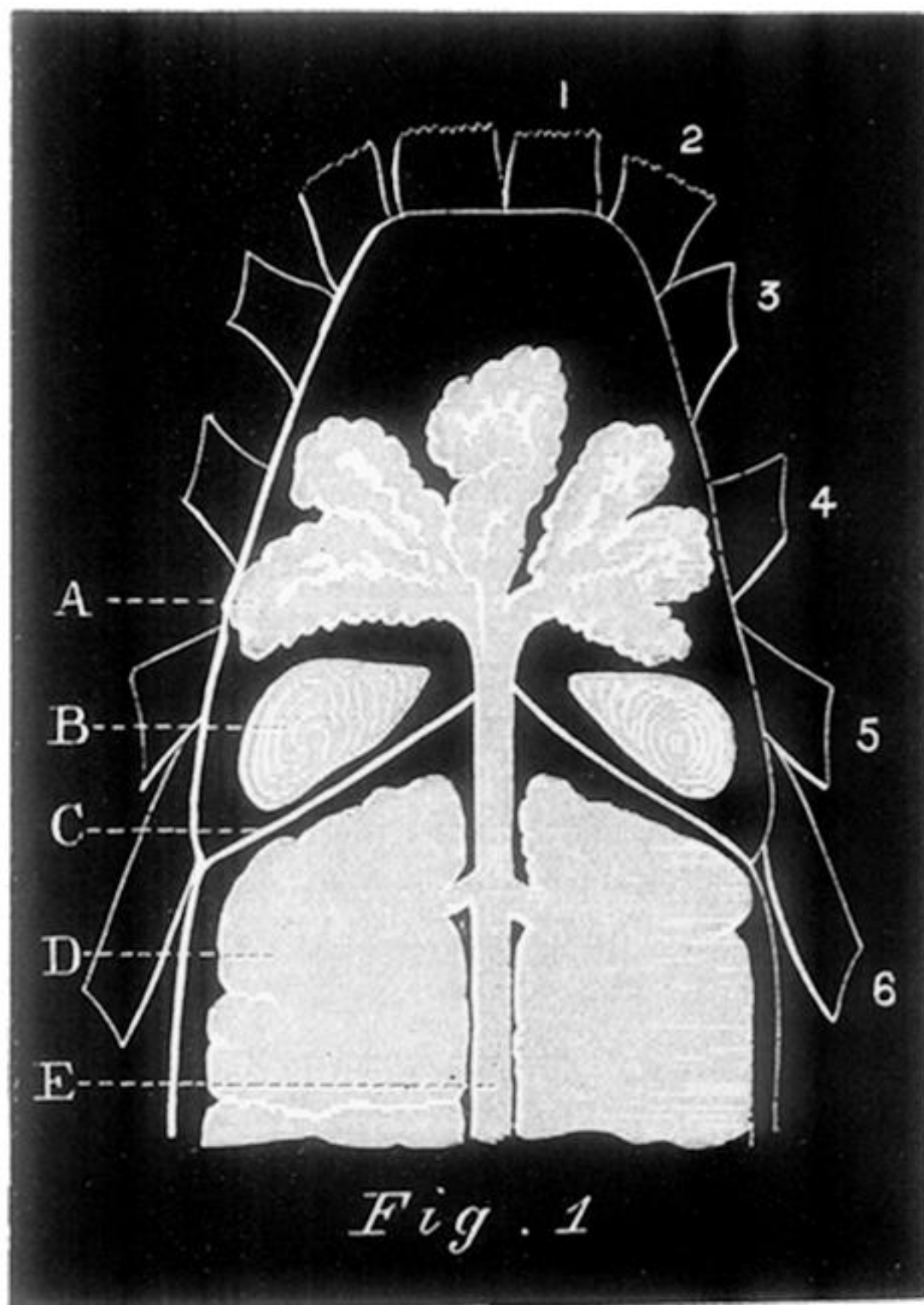


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