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XI.—*Anatomy and Physiology of* Hæmatopinus tenuirostris, *Burm.* By Oscar Ströbelt*.

[Plate III.]

It is only of late that some considerable attention has begun to be paid to the Pediculina. Among the more important works upon this group of animals we must here mention those of Denny (10)†, Giebel (13), and Piaget (15). The last-

* Inaugural-Dissertation zur Erlangung der Doctorwürde einer hohen philosophischen Facultät der königlichen Akademie zu Münster. Düsseldorf, 1882. Translated by W. S. Dallas, F.L.S.

† The numbers in parentheses refer to the works of which the titles are given below :—

1. Linné, C. Fauna Suecica. Holmiæ, 1761.
2. Linné, C. Systema Naturæ. Vindobonæ, 1770.
3. Fabricius, J. C. Systema Entomologiæ. Flensburgi, 1775.
4. Berkenhout, John. Synopsis of the Natural History of Great Britain and Ireland. London, 1789.
5. Turton, W. A General System of Nature. London, 1806.
6. Stewart, C. Elements of the Natural History of the Animal Kingdom. London, 1817.
7. Nitzsch, C. L. "Die Familien und Gattungen der Thierinsekten (Insecta epizoica)," Germar's Magazin der Entomologie, Band iii. Halle, 1818.
8. Stephens, J. F. A Systematic Catalogue of British Insects. London, 1829.
9. Burmeister, H. "Handbuch der Entomologie," Band ii. Abth. 1 & 2. Berlin, 1835 and 1838.

named naturalist especially, by the exact descriptions and correct and elegant figures in his classical work, has gained great credit in connexion with these animals, which have hitherto been under the ban of a deeply-rooted aversion, and therefore have long been neglected. It is to him that we are by no means least indebted for the present extent of our knowledge of the Lice, of which far more than a thousand species are known.

But however much our knowledge of the external form of these animals has been advanced by the labours of the above-mentioned and many other naturalists, little attention has hitherto been paid to their internal anatomy. Upon the anatomical structure of the Pediculina information has been given by Swammerdam (16) among the older writers, and by a few more recent ones, such as Simon (17), Landois (23–25), and

10. Denny, H. Monographia Anoplurorum Britanniæ, or an Essay on the British Species of Parasitic Insects belonging to the Order Anoplura of Leach. London, 1842.
11. Gurlt, E. F. "Ueber die auf den Haussäugethieren und Hausvögeln lebenden Schmarotzer-Insekten und Arachniden. Zweiter Aufsatz," Magazin für die gesammte Thierheilkunde, Jahrg. ix. Berlin, 1843.
12. Simonds. Journal of Agricultural Science, ser. 2, vol. i.
13. Giebel, C. G. Insecta Epizoa, die auf Säugethieren und Vögeln schmarotzenden Insekten nach C. L. Nitzsch's Nachlass bearbeitet. Leipzig, 1874.
14. Taschenberg, E. L. Praktische Insektenkunde. Band v. Die Schnabelkerfe. Bremen, 1880.
15. Piaget, E. Les Pédiculines: Essai monographique. Leyden, 1880.

16. Swammerdam. Bibel der Natur. 1752.
17. Simon, G. Hautkrankheiten. 1851.
18. Leuckart, R. "Ueber die Micropyle und den feineren Bau der Schalenhaut bei den Insekteneiern," Müller's Archiv, 1855.
19. Leydig, F. "Zum feineren Bau der Arthropoden," Müller's Archiv, 1855.
20. Landois, H. De systemate nervorum transversorum in septem Insectorum ordinibus. Gryphiswaldiæ, 1863.
21. Grimm, O. von. "Zur Embryologie von *Phthirius pubis*," Bull. Acad. Imp. de St. Pétersb. tome xiv.
22. Murray, A. On the *Pediculi* infesting the different Races of Men. Edinburgh, 1864.
23. Landois, L. "Anatomie des *Phthirius inguinalis*," Zeitschr. für wiss. Zool. Bd. xiv. 1864.
24. ——. "Anatomie des *Pediculus vestimenti*," ibid. Bd. xv. 1864.
25. ——. "Zur Anatomie des *Pediculus capitis*," ibid. Bd. xv. 1865.
26. Graber, V. "Anatomisch-physiologische Studien über *Phthirius inguinalis*," Zeitschr. für wiss. Zool. Bd. xxiii.
27. Darwin, C. Die Abstammung des Menschen. Deutsche Ausgabe, von Victor Carus. Stuttgart, 1875.
28. Krancher, O. "Der Bau der Stigmen bei den Insekten," Zeitschr. für wiss. Zool. Bd. xxxv. 1881.

Graber (26); but all these have treated only of the lice parasitic upon man.

With the purpose of filling up this gap in our literature, which, with the lapse of time, is becoming very sensible, and at the suggestion of my honoured teacher, Prof. H. Landois, I made the internal anatomy of the Pediculina, and especially of those which live upon our domestic mammals, the objects of a special study; and in the present work I communicate the results which have come from my investigations on the *Hæmatopinus tenuirostris*, Burm., parasitic on *Bos taurus*.

But before I proceed to the exposition of these, I may be permitted to preface them with something upon the history of this louse.

Historical.

We know at present three Pediculina which live upon the domestic ox (*Bos taurus*, Linn.)—namely, *Trichodectes scalaris*, Nitzsch, *Hæmatopinus eurysternus*, Nitzsch, and *H. tenuirostris*, Burm. Whilst authors agree in the description of the first two species, singularly enough the existence of the last-named species has had doubt cast upon it by Piaget. In his great work he says *, "Since Linné, authors speak of a second species of *Hæmatopinus* likewise living upon *Bos taurus*. Notwithstanding my researches, I have not succeeded in meeting with this species, and some doubts have arisen involuntarily in my mind." In support of his doubts he relies upon the defective descriptions and the inaccurate figures of different authors.

As regards the father of scientific classification, Linné, in the first place, he cites two species as living upon *Bos taurus*:—

"1. *Pediculus Tauri* Bovis: abdomine lineis transversis octo ferrugineis.

"Suecis Koe-luus.

"Habitat in Vaccis; hæc minor est species, datur et altera, quæ major et insequens.

"*Descr.* Totus albus, minimus. Caput testaceum. Pedes testacei, apice albidiores. Abdomen album, lineis octo testaceis transversis in dorso; quinque fasciis transversis in ventre; quæ omnes lineæ non tangunt marginem seu latera; latera tamen obscuriora reliquo corpore sive punctis octo ferrugineis notata."

This is undoubtedly, and according to the concurrent opinions of authors, our present *Trichodectes scalaris*, N.

* *Loc. cit.* p. 650.

Linné mentions as a second species:—
"2. *Pediculus Vituli* Bovis: abdomine plumbeo.
"Suecis Blaluus.
"Habitat in Bobus.
"*Descr.* Præcedenti maior: abdomine ventricoso, acuminato, cæruleo-fusco; pedibus brevibus, crassis, griseis, ut et capite et thorace griseis."

The question now is, whether this *Pediculus vituli*, Linn., is identical with *Hæmatopinus eurysternus*, N., or with *H. tenuirostris*, Burm.

Piaget says, "Linné does not cite the other species, the *eurysternus*, and seems to have been acquainted only with the *vituli*;" but this statement can by no means serve in support of his doubts as to the existence or specific right of *Hæmatopinus tenuirostris*. Linné actually knew only this one species; but whether it is *H. eurysternus* or *tenuirostris* must be ascertained by the comparison of the animals with his description. All other authors agree in regarding *Pediculus vituli*, Linn., and *Hæmatopinus tenuirostris*, Burm., as one and the same species. Once, indeed, Nitzsch* seems inclined to identify *Pediculus vituli*, Linn., with his *P.* (*Hæm.*) *eurysternus*, as appears from the query, "An huc *Ped. vituli*, Linn?" Linné's description is certainly any thing but exact; but from the words "Abdomine cæruleo-fusco, et capite et thorace griseis," it appears clearly and distinctly that *P. vituli*, Linn., is identical only with *Hæmatopinus tenuirostris*, Burm.

Piaget says further, "Denny and Giebel rarely give sexual differences; it may be that they have described the female of *eurysternus*, without paying any attention to the male. Now this male, which is much narrower, has the head somewhat pointed, and appears to me to be their *tenuirostris*. Must we then admit two different species? Denny had seen only two individuals (♀ or ♂?) obtained from a calf; he never found any on *Bos taurus*. Giebel, however, declares it to be very common, very widely distributed."

Piaget may be perfectly right in saying that Denny and Giebel do not frequently indicate sexual differences; but that both of them have taken the male of *H. eurysternus* for the species *tenuirostris* described by them is, from their descriptions and figures, quite inadmissible. Although, as I readily agree with Piaget, these two authors have certainly not endeavoured too strenuously to attain accuracy in their figures, the difference in the figures is too great to allow us to suppose that the two species are identical. From the figures, defec-

* Germar's Magazin, Bd. iii. p. 305.

tive as they may be, we at once see that we have to do with two separate species. Leaving all other characters out of consideration, this is shown at the first glance by the great difference of the head and thorax in the case of both authors*.

But however different the male and female of *H. eurysternus* may be, we find, if we compare the two species (*H. eurysternus* and *H. tenuirostris*), even without magnifying, that they are typically distinct, and that there can be no ground for the assumption that we have to do with the male and female of the same animal.

Piaget takes as a further ground for doubt Denny's statement that he had only seen two individuals of this species, which were obtained from a calf, whilst Giebel asserts that the species lives very commonly upon the domestic ox and is very widely distributed. Denny says†:—"The only two examples of this species which I have examined were kindly forwarded to me by Rev. L. Jenyns, who found them upon a calf. Mr. J. named them *vituli*; and I have no doubt they are the species so named by Linnæus and Fabricius. It may appear somewhat strange that a young animal should have a distinct species of parasite which is not found upon its parents; but, as far as we are able to judge, such is the fact. I have examined numbers of the lice from oxen, but never detected a single specimen of this species amongst them, though there were of *Trichodectes scalaris*, which lives upon cattle and in society with the *H. eurysternus*." Notwithstanding his endeavours, therefore, he could never find the species upon *Bos taurus*. Giebel, on the contrary, says it is very common and widely distributed. Piaget stumbles over this apparent contradiction; and yet both statements may very well be true.

I have not been much more fortunate than Denny. I have only once found *H. tenuirostris* upon an ox, which came from Hamburg; but in this case it was in great numbers. Subsequently I have never succeeded in procuring this species in the neighbourhood of Münster, but always obtained only *H. eurysternus* and *Trichodectes scalaris*. This circumstance may be explained in two ways: either *H. tenuirostris* is parasitic upon our *Bos taurus*, and we have only not found it hitherto, or the animal is confined to a particular district and perhaps to a particular race. Nitzsch and Giebel obtained their lice from the environs of Halle, while Denny collected in England, and Piaget in Holland. Unfortunately we have no precise observations upon either species. It would certainly

* See Denny, pl. xxv. figs. 5 & 3; and Giebel, Taf. ii. figs. 8 & 9.

† *Loc. cit.* p. 32.

be not uninteresting, and indeed of great importance, with respect to the opinions of Lamarck and Darwin, to ascertain more precisely the regions of distribution of the two species and their boundaries. Thus, in Darwin's great work on the Descent of Man, he says* :—"In determining whether the varieties of the same kind of domestic animal should be ranked as specifically distinct, that is, whether any of them are descended from distinct wild species, every naturalist would lay much stress on the fact, if established, of their external parasites being specifically distinct. All the more stress would be laid on this fact, as it would be an exceptional one; for I am informed by Mr. Denny that the different kinds of dogs, fowls, and pigeons, in England are infested by the same species of Pediculi or Lice."

A. Murray (22) has investigated the Pediculina collected in different countries from the different races of men, and found considerable differences both in their colour and in the structure of the buccal organs and limbs. How much more important would it be if it were found that different species occur upon different races. We know, indeed, only that different lice are parasitic upon cattle &c.; but in collecting these no one has yet taken the trouble to note the race of the host in each case. It is only when this has been done in numerous cases that fertile conclusions may be drawn from these observations.

After this digression, let us go back to Piaget. He says further (p. 650), "Gurlt figures two species as very distinct, especially in the form of the head, and in the transverse spot of the penultimate segment; but he nowhere gives the sexual differences, which would be decisive."

That Gurlt's figures (11) are very different is easily seen; but they have been drawn so much in miniature that we cannot get very much more out of them. And as regards the non-statement of sexual differences, we need not wonder at this in Gurlt's case; for we do not find such differences noted even by Denny, from whom Gurlt generally translates pretty literally.

From what has been said it would appear that Piaget had no grounds for casting doubt upon the existence or the specific distinctness of *Hæmatopinus tenuirostris*. That we have really to do here with two perfectly different species is sufficiently shown by my figures (1, 2) on Plate III., which I have made from individuals lying before me; and in connexion with this it must be particularly noticed that I possess males and females of both species.

* Vol. i. p. 219.

Thus Piaget's doubts are got rid of. It remains only to examine into a remark of Giebel's. "If Denny's figure is accurate," says he *, "this species is variable; for it [the figure] represents the head less pointed, the thorax longer, the first pair of legs much stronger, and the abdomen less perfectly spindle-shaped than is the case in our specimens." These differences undoubtedly exist in the figure; and to this must be added that Giebel figures *ten* abdominal segments, while Denny represents only *eight*. Nevertheless I am of opinion that we have not to do here with a variable species, but that, by the inaccuracy of both the figures, the dissimilarity has been made to appear greater. If we were to assume, from the figures, that this species varies, we must do the same with many other species which have shared the fate of *Hæmatopinus tenuirostris* in the matter of figuring.

Place in the System, Name, Occurrence, Remedies.

As regards the systematic position of *Hæmatopinus tenuirostris* we may speak briefly as follows:—*H. tenuirostris* belongs to the genus *Hæmatopinus*, established by Leach, and now containing about twenty species, which, again, is referred to the great family of the Pediculidæ or true Lice. The following Table, derived from Piaget †, may serve to characterize its position in the family Pediculidæ:—

Pediculidæ.

1. Antennæ with 5 joints	3.
Antennæ with less than 5 joints	2.
2. Antennæ three-jointed	*Pedicinus*, Gerv.
Antennæ four-jointed	*Echinophthirius*, Gerv.
3. Legs with two unequal claws; head cylindrical (tubular).....	*Hæmatomyzus*, Piag.
Legs with one claw; head rounded or longish.	4.
4. Abdomen with 6 segments with lateral dilatations. Its second segment with 3 closely approximated stigmata	*Phthirius*, Leach.
Abdomen with 7–9 segments, with or without lateral dilatations. Second segment with a single stigma	5.
5. Head narrowed into a neck before its insertion into the thorax. Abdomen with 7–8 segments. Tibia with a distinct thumb	*Pediculus*, Leach.
Head narrowed insensibly into the thorax. Abdomen with 8–9 segments. Tibia simply elevated at the inner angle.....	*Hæmatopinus*, Leach.

All the species of the genus *Hæmatopinus* are parasitic upon mammals.

* 13, p. 43. † *Loc. cit.* p. 618.

As to the specific name Giebel says, "With regard to the name, Denny has adopted the Linnean name, while Burmeister has transformed Nitzsch's Greek name (*oxyrhynchus*) into Latin. As it is certainly inadmissible to name this parasite after its host, Burmeister's denomination, as published before Nitzsch's, must be regarded as having the first right." Burmeister was certainly in the wrong to convert Nitzsch's Greek name into the Latin one, as he ought to have preserved the right of priority for Nitzsch; on the other hand, however, he published his name first, and this name has since taken its place in literature, so that it does not seem advisable to change it again.

The Sharp-headed Ox-louse lives on the neck and head of cattle. It is very sluggish, and moves but rarely from its place; it usually remains quite quiet, with its proboscis buried in the skin, so that it requires some effort to remove it from the ox. Its eggs it deposits near the base of the hairs of its host. They are always attached so that the micropylar apparatus is turned towards the tip of the hair. Moreover there is generally only one nit upon a hair, rarely two, and these attached at some distance from each other. Only once I found three upon one hair, placed immediately over one another, and in different stages of development. It is principally upon badly nourished and young animals that these lice are parasitic. I must not pass without notice the fact that, as in the case of very many lice of the family Pediculidæ, the number of females is considerably in excess of that of the males. Thus among about one hundred females I found only seven males.

The best means of keeping away these visitors, which are so unwelcome to the farmer, are undoubtedly cleanliness, careful currying, and good feeding. But if the parasites make their appearance they may be got rid of, according to Taschenberg (14, p. 102), by combing the infested animals with a close-toothed comb, by washing with a mixture of soap, benzine, and water, or with a decoction of *semen staphysagriæ*, or tobacco in water, by rubbing in Persian insect-powder or grey mercurial ointment, and other remedies. Quite recently Falkenberg's chemical factory at Grünau, near Berlin, has advertised "Parasite neck-rings," by wearing which "any animal may with certainty and without danger be freed from parasites (lice, fleas, &c.) within twenty-four hours, and preserved in a clean state." Nevertheless I cannot help having some little doubt as to the efficacy of this last-named remedy.

Hæmatopinus tenuirostris, Burm.

(*Pediculus vituli*, Linné; *Hæmatopinus vituli*, Stephens and Denny; *Pediculus oxyrhynchus*, Nitzsch; *Pediculus tenuirostris*, Burmeister.)

External Anatomy.

Hæmatopinus tenuirostris, or the Sharp-headed Ox-louse, has a rather elongated and elegant shape (Pl. III. fig. 1). Its colour throughout is a shining brown, "chestnut and shining" as Denny (10, p. 31) correctly calls it, passing into dark brown in the claws. The head and thorax show a light grey tinge, while the abdomen presents a tint which it is difficult to describe, indicated by Linné (1, p. 476) as "cæruleo-fusco," by Giebel (13, p. 43) as "dirty bluish violet." This shimmer is due to the stomach shining through, and varies according to its degree of fulness. Like all the species of the genus *Hæmatopinus*, our animal presents a body distinctly divided into head, thorax, and abdomen.

The head is longish oval. The antennæ, which are articulated to the sides of the head about the middle, divide it into two parts. The anterior, the forehead (*frons*) has a length of 0·214 millim.* Its sides, which are gently curved, converge to a point from the antennæ. At the apex the sheath of the rostrum, 0·027 millim. long, projects as an obtuse process. The hinder part, measuring 0·261 millim. in length, diminishes scarcely perceptibly behind the antennæ, then becomes somewhat wider, and thence to the thorax shows nearly parallel temporal margins, so that the middle head (*synciput*), or the part of the head situated between the temples (*tempora*), appears nearly rectangular. The hind head (*occiput*) penetrates like a wedge into the thorax. The notch on each side at that part of the head where the antennæ are seated (*excisura* or *sinus orbitalis*, or *orbita*) is very small. The head has its greatest breadth, 0·256 millim., a little behind the antennæ; between the antennæ its greatest breadth is 0·203, and in front of them 0·163 millim. In the anterior part of the head are situated the buccal organs, in its hinder part the cerebral ganglion and the very small and not easily perceptible eyes, the position of which, however, is always indicated by a weak bristle placed immediately above them. The whole head is traversed from before backward by the œsophagus and the tracheæ of the head. The antennæ

* The measurements are always taken from the mean, and relate, where not otherwise stated, to the ♀, as the more abundant.

(fig. 7), which are articulated in front of the eyes as already mentioned, consist of five joints (*antennæ præoculares, quinquearticulatæ*); they attain about half the length of the head. At the articulation the first joint is 0·073 millim. in width; the last joint has a breadth of 0·035 millim.; the lengths of the individual joints are as follows:—first joint 0·062, second 0·064, third 0·048, fourth 0·045, and fifth 0·032; total 0·251 millim.

All the five joints are beset with hairs, the length of which shows great differences in the same antenna, while their position seems to be constant in different individuals. The fifth or terminal joint has its apical surface sharply marked and oblique (fig. 7); and from it rise some small peculiar bacilli with rounded ends. There are also on the different joints variously formed chitinous plates and thickenings of the epidermis.

The eye, as in all lice, is simple. It consists of a strongly convex cornea; behind this we find a clear layer, which appears like a number of closely approximated vesicles with gelatinous contents. Immediately behind this follows a reddish-brown pigment-layer. Nothing could be seen of any lens. The size of the eye is about 0·048 millim., and its distance from the sheath [of the rostrum] about 0·305 millim. As regards the position of the hairs on the head, as also upon the rest of the body, the figure (fig. 1) will furnish information.

The thorax is quadrangular, with rounded anterior angles, rather broader than long, and considerably broader than the head (0·329 millim.). The pro-, meso-, and metathorax are closely amalgamated, so that it is impossible to determine their boundaries. On both sides of the thorax, towards the ventral surface, are the sockets (*acetabula*) in which the legs are articulated. These sockets are oval; and in the first two on each side their longer axis is perpendicular to the median line of the whole animal, while in the hinder ones on each side it forms an angle of about 60°. All the three acetabula are united by a chitinous thickening with the chitinous band which, on the underside, runs in a curve on each side from the middle of the thorax to the anterior angles. The first socket is smaller than the other two, just as the anterior pair of legs is also considerably inferior in thickness to the two hinder pairs (fig. 1). The thorax has further, on each side, turned towards the ventral surface, a stigma, placed at the level of the middle pair of legs, and therefore, as in all the species of the genus *Hæmatopinus* which have been investigated, belonging to the mesothorax, while in the genera

Phthirius and *Pediculus* the thoracic stigma is to be referred to the prothorax.

The legs are all constructed upon the same type. The *coxa* is freely movable in the acetabulum, and is a stout joint furnished with powerful muscles (fig. 6, *c*). This is followed by the *trochanter* (fig. 6, *tr*), which is not half so large and not very muscular. Freely movable upon this, next comes the large *femur*, bearing at its extremity the powerfully-developed *tibia* (fig. 6, *f* and *ti*). The latter has not, as in the other lice, a chitinous process directed forwards, but is simply elevated at the inner angle (fig. 6, *e*). At this point, however, the chitinous skin shows a slight thickening, behind which the tibia appears to be excavated. The above-mentioned elevation of the tibia at the inner angle is more considerable on the hinder pairs of legs, reduced to a minimum on the first pair (fig. 1). Moreover the legs of the first pair have a scarcely perceptible chitinous thickening at this point. On all the pairs of legs, however, this process bears a number of hairs. The *tarsus*, which follows the tibia, is two-jointed, the first joint considerably narrower than the tibia, and only about half its length. The second joint consists of a somewhat curved claw, which is narrow and light-coloured and terminated in a point on the first pair of legs, in the other two pairs broad, dark brown, and rounded at the end (fig. 6, *ta*, *k*, and fig. 1).

The abdomen is separated by a distinct furrow from the thorax, and consists of nine segments, which, however, externally are marked off from each other very faintly by indentations. Neither Denny nor Giebel give the number of the abdominal segments; but Denny (10, pl. xxv. fig. 8) figures *eight* of them, having evidently overlooked the ninth, very small segment, while Giebel (13, Taf. ii. fig. 9) represents *ten* segments, the first of which must be referred to the thorax. It is certainly the case that by mere external examination one may very easily be in doubt whether eight or nine segments are present; but the preparation of the muscles (*musculi transversales*) at once shows that the number of segments is nine. The first segment, as also the eighth and ninth, bear no stigmata; the other six have each one on each side, slightly turned towards the ventral surface. The hairiness is in general short and scanty; on the abdomen the hairs are scattered irregularly, and it is only in the vicinity of the stigmata that some regularity appears. Thus beneath each stigma there stand *two* hairs, which, in the case of the first three on each side, do not exceed the other hairs in length, but in that of the three hinder ones attain twice or

three times this length. In the male the terminal segment is blunt, while in the female it is produced on each side into a process which is closely covered with hairs. Between these processes the margin of the segment is straight. From the middle of this straight termination the longitudinally cleft genital fissure extends forward. The two abdominal processes are united by a chitinous ring which bears a number of shorter and longer hairs directed towards the genital orifice. If we make a longitudinal section through the abdomen, so as to divide it into a right and a left half, we see how the last segment seems to be excavated. The epidermis is firm and thick-scaled on both the dorsal and ventral surfaces.

Internal Anatomy and Physiology.

Integument.

Hæmatopinus tenuirostris has a yellowish, translucent, tolerably firm external chitinous envelope, which shows two layers —an outer one, the *epidermis*, and an inner one, the *cutis*.

The *epidermis* shows a different structure at different parts of the body. Thus on the middle part of the back it appears to consist of small rounded scales, pretty regularly arranged in series, lying one over the other like the slates on a roof. Towards the abdominal extremity these little scales gradually become quadrangular, with the sides much curved, and are separated from each other by double-contoured grooves. Thence to the end of the abdomen we see small, triangular, imbricated scutes, which not unfrequently run out into a point. While on the dorsal surface a certain regularity appears in the arrangement of the scales and scutes, on the ventral surface the epidermis is divided by much curved and contorted furrows into multiform irregular sections, which give the whole an exceedingly varied and elegant appearance. The integument of the head is cut up by double-contoured furrows into divisions of very different forms, but which always more or less resemble hexagons, and may be referred to that form. On the other hand, the epidermis of the limbs and antennæ shows no such divisions, but is simple. Besides the elegant furrows, many thickenings are to be observed in the integument. Thus on the dorsal surface a broad thick band passes forward from the middle of the hinder margin of the thorax, divides at about the middle of the thorax, and runs up parallel to the margins of the occiput. Further, the bands which run from the acetabula to the thickening just described, as well as the acetabula themselves, are thickenings of the

epidermis. The legs also show many thickenings of the epidermis, especially in their last two joints. All these thickenings have a dark brown colour. The structure of the epidermis is most peculiar on the antennæ. In general the integument here shows no divisions; but it appears somewhat lighter, which indicates a less firm consistence. But each joint of the antennæ is furnished with two or more chitinous plates. These are thick, firm, and placed parallel to the long axis of the antenna. Their form is different in the different joints. The first and second joints have bacilliform, and the third uncinate plates; the plates of each pair are always united by a somewhat darker chitinous layer (fig. 7). In the fourth and fifth joints the structures in question are particularly noteworthy. In the fourth joint we find two uncinate plates, one of which, however, is surrounded (fig. 7 *c*) by a lighter chitinous pad. The latter, in turn, shows a small circular excentrically placed opening. Below the pad there is another almost rectangular thickening of the outer chitinous layer. The fifth joint has a similar armature symmetrically placed. Here there is, on one side only, a triangular plate; and at the same level with this on the other side there lies a quadrangular chitinous plate, and beneath this a rounded slightly bordered chitinous piece (fig. 7 *d*), showing a small rounded opening near its middle. What purpose these openings serve, whether they lead to the organs of hearing or of smell, could not be ascertained. This, however, is certain: they are connected with the nervous system, as is shown by the course of the two nervous filaments which I was able to trace distinctly to the end of the fifth joint.

Beneath the epidermis lies the *cutis*, a somewhat darker structureless layer of about the same thickness as the epidermis, as is distinctly shown by transverse sections and the abdominal processes of the female.

The *hairs* have still to be mentioned as special structures of the integument. As already stated, these vary considerably in length. They are all of a pale yellow colour, present exactly the same structure, and, like the hairs of the Arthropoda generally, are homogeneous. In the interior they have a cavity which is produced in the form of a tube through epidermis and cutis, and thus connects them with the body-cavity and the nutritive organs.

Quite different from these hairs are the structures which arise from the terminal surface of the fifth joint of the antennæ. These constitute small round-ended bacilli, without any recognizable internal cavity or special structure. I count five upon each antenna (fig. 7 *b*). I could not hesitate a moment

to recognize them as organs of the sense of touch, especially as one of the nerves penetrating into the antennæ can be distinctly traced to them. The name of "tactile papillæ" or "tactile bacilli" therefore appears to me to be very appropriate for them.

Organs of Digestion.

The digestive apparatus (*tractus intestinalis*) comprises the following organs:—the buccal organs, the œsophagus, the stomach, the small intestine, the large intestine or colon, and, further, the Malpighian vessels and the salivary glands.

The *buccal organs* of *Hæmatopinus tenuirostris* are placed in the fore part of the head, not quite in the middle, but approximated to the ventral surface. The fore part of the head has an indentation of the temporal margins before the apex (fig. 8), then becomes a little enlarged, and is produced in front into a fine tube, which shows a small emargination on the ventral side. Out of this tube or "sheath" (*proboscis*) there can be protruded a sucking-rostrum, which attains half the length of the head, and, according to Giebel (13, p. 43), when protruded is moved briskly about like a tactile organ. At its anterior end the sucking-rostrum bears a circlet of small hooks (fig. 9, *d*), which, when in a state of repose, are directed backward and lie close to the rostrum. But when the rostrum is pushed forth, the little hooks become erected so soon as the circlet has issued from the sheath. The tube cannot then be completely retracted again until the hooklets have again bent backwards. How these hooklets are moved it was impossible to ascertain, from the delicacy of the organ under consideration and the difficulty of preparing it. Beyond the circlet of hooks the extremity of the rostrum is arched into a hemispherical form, and terminates at last in a fine point (fig. 9 *f*). The latter is at any rate the termination of the prickle observed by Denny in *Pediculus vestimenti* (see Denny, 10, pl. xxvi. fig. 1, *e–h*). By means of this prickle the animal produces a wound, and fixes its rostrum into this with the hooklets. The rostrum consists of firm clear chitine. Posteriorly it is connected with a "kind of internal chitinous skeleton" as Landois (24, p. 36) very characteristically names it. Thus on each side of the rostrum there is a dark-coloured chitinous band (fig. 8 *a* and fig. 9 *a*). These chitinous bands, except for a small indentation close behind the circlet of hooks, run straight until, a little in front of the antennæ, they turn right and left at an angle of about 135°. Attached to these bands at about their middle, and turned towards the rostrum, are a second pair (figs. 8 and 9 *b*), which are at first closely ap-

plied to the former and run in the same direction, but then bend towards one another, and finally run divergently.

It remains to be shown how this simple mechanism acts to push the rostrum out of the sheath. From the middle line of the dorsal integument of the head, above the point of articulation of the antennæ, four muscles start on each side (figs. 4 and 9 *e*) and attach themselves to the above-mentioned chitinous bands *a a*. If then these muscles contract, the chitinous bands *a a* are approximated to each other, and with them also the bands *b b*, which latter will touch about *c*. By this exceedingly simple mechanism the sucking-tube, which lies folded in the space between *a* and *c* (fig. 9), is pressed forth. The hooklets become erected; the prickle comes into action; and the function of sucking begins. A factor of some importance in the function of sucking has still to be noticed. In the extended state the sucking-tube is twice as long as when retracted. The air which was contained in it is therefore diffused over twice the space during protrusion. As, further, there is a firm closure at *c* (fig. 9), there is produced in the extended sucking-tube a more or less exhausted space, according as the tube did or did not contain air before its protrusion. Consequently, without any thing further, the blood will be forced from the wound into the sucking-tube by the pressure of the external air. The sucking-tube, however, is not inactive in this business, seeing that, as a fine tubule, it carries upwards the fluid blood by capillary action. But when the muscles from the dorsal side cease, and at the same time those of the ventral side, which, springing from the hinder part of the head run forward to the middle part of the sucking-tube (fig. 4, *i*), begin to act, the hooklets lay themselves back and the sucking-tube is retracted into the sheath. The space at *c* (fig. 9) is now reopened. By the pressure of the retracted sucking-tube the inhausted blood is driven through *c* into the œsophagus, and thence by the independent movements of the latter passed further on.

The *œsophagus* follows immediately behind the sucking-tube (fig. 8 *œ*). This is a fine tube which passes through the middle and hinder parts of the head, penetrates into the thorax, and then soon opens into the stomach. The membrane surrounding the œsophagus is clear, and exhibits extremely fine transverse striæ. Besides this transversely striated membrane a structureless one also appears to be present.

The *stomach*, that part of the digestive organs which extends from the œsophagus to the Malpighian vessels, is elongated and not very broad. At its upper end it shows on each side of the insertion of the œsophagus two dilatations, which

extend towards the two sides of the thorax. This is its widest part; it then gradually diminishes, has nearly parallel sides for the greater part of its course, and contracts in a conical form towards the point of entrance of the Malpighian vessels. It is 0·704 millim. long, 0·356 millim. broad at its widest part, 0·274 millim. in the middle, and 0·107 millim. at the entrance of the Malpighian vessels. As in all Pediculina, its structure is simple. It possesses two membranes. The outer of these (*tunica gastri muscularis*), which is clear and structureless, is covered by an extremely fine but regular latticework of delicate muscles. The breadth of these does not exceed 0·0011 millim.; the individual meshes of the net vary greatly in size, their greatest breadth being 0·028 and their least breadth 0·013 millim. Upon this membrane within is the *membrana gastri propria*, in which the gland-cells of the stomach are situated. The latter are small oval cells, enclosed by a delicate, clear membrane, and presenting yellow granular contents. Their size varies between 0·010 and 0·022 millim.

The *intestinal canal* in our animal is of moderate length, and describes various ∫-like bends in its course. The first of its two parts, which are separated from each other by a strong dilatation, the *small intestine* (*ileum*, fig. 12, *i*), considerably exceeds the second, the *large intestine* (*colon*, fig. 12, *a–d*) in length, while it yields to it in width. Beyond the above-mentioned dilatation the intestine decreases in width to one half. Throughout its length the intestinal canal allows three membranes to be clearly distinguished. The innermost (*membrana intima*, fig. 12, *c*) consists of a clear chitinous substance presenting a series of longitudinal fibres or longitudinal layers; in the middle one (*membrana media*, fig. 12, *b*) we recognize a number of small closely approximated cells; lastly, the outermost (*membrana muscularis*, fig. 12, *a*) consists of a great number of strong closely adpressed muscular bundles.

Besides these two parts of the intestine, the above-mentioned dilatation has to be considered. Such a dilatation was noticed by Swammerdam*, as a "Verwijding der Darmen" in *Pediculus capitis*. In the present species it has the form of a funnel, of which the narrow end is turned forward. In this dilatation we distinctly recognize six large oval glandular bodies, with dark granular contents (fig. 12, *e*). These are 0·084 millim. long and 0·055 millim. broad. They are imbedded in the *membrana intima*, are separated from each other by grooves, and surround the lumen of the intestinal

* 16, i. p. 76, tab. ii. fig. 3.

canal (fig. 12, *d*) in a circle. They are the six *rectal glands* of the animal. The whole intestinal canal is accompanied by two strong tracheal stems, one on each side, the ramifications of which go to the wall of the intestine, and run along the grooves which exist between the rectal glands.

As regards the accessory organs of the *tractus intestinalis*, the *Malpighian vessels* have first to be mentioned. These, which are four in number, are inserted into the lower end of the stomach, or into the upper end of the intestine (for no definite boundary can be drawn between the two), and remain isolated throughout their course. They are narrow (0·028 millim.), but attain the considerable length of 1·287 millim., and present a hyaline structureless membrane and finely granular pale yellow contents.

We find two kinds of *salivary glands* in *Hæmatopinus tenuirostris*, elongated and globular, situated on both sides of the upper wall of the stomach. Landois also describes two pairs in *Phthirius inguinalis* and *Pediculus vestimenti*, and names them "bean-shaped" and "horseshoe-shaped" (23, p. 9, and 24, p. 39). The former represent our *globular*, and the latter our *elongated* glands. As regards the latter, they always appear horseshoe-shaped *in situ*, and are 0·473 millim. long and 0·041 millim. broad. The efferent duct, however, is not situated, as in *Phthirius inguinalis*, at the curvature of the horseshoe, but at the end of the gland, so that the whole has the form of a thread thickened and bent back at its upper end. The gland itself is enclosed by a clear structureless membrane; the dark yellow contents show no differentiation. The efferent duct has also a structureless envelope, which forms the continuation of the membrane of the salivary gland; its contents, however, are pale yellow and but slightly granulated. The outer envelope of the *globular* salivary glands is likewise structureless, as also the membrane of their efferent ducts; their contents, however, differ essentially from those of the preceding in so far that they are of a lighter colour and show distinct round cells. The diameter of the glandular ball is about 0·090 millim. The efferent ducts of both are throughout uniformly narrow (about 0·015 millim.), and attain a considerable length. Both pairs of salivary glands are placed close to the upper margin of the stomach, and from this point send forth their efferent ducts parallel to the œsophagus to the mouth.

There remains to be mentioned an organ which was named "liver" by Hooke, and "buik-klier" or "ventral salivary gland" by Swammerdam, but to which Landois gives the indifferent name of the "stomachal disk" ("Magenschiebe").

This is an organ inserted into the upper part of the wall of the stomach, on the ventral surface, and surrounded by a special enveloping membrane, which was observed by the last-mentioned naturalist in *Phthirius inguinalis* and *Pediculus vestimenti* (23, p. 7, and 24, p. 38). Notwithstanding all my endeavours, I have not succeeded in detecting an analogue of this in our animal; so that I think I am justified in supposing that this stomachal disk is wanting in *Hæmatopinus tenuirostris*.

Adipose Body.

The adipose body of *Hæmatopinus tenuirostris* consists of a very great number of separate cells. These are of an elongate oval form, often somewhat pointed at one end, by which means they acquire a pyriform appearance. A fine and delicate membrane envelopes the yellowish green, finely granular contents, which readily allow two nuclei to be recognized. At one end of the oval cell, sometimes the pointed, sometimes the obtuse one, is attached an exceedingly fine pedicle, which connects the fatty body with the great tracheal stems. Thus, especially between the tracheæ and the integument of the body, there is interposed a considerable number of fat-cells. The length of an individual cell is on the average 0·110 millim.; their average breadth is 0·057 millim. Besides these there are, especially in the abdomen, small globular cells which attain only half the size of those first mentioned. These also present a clear envelope, finely granular, but darker-coloured contents, and a pedicle. In the arrangement of the cells of the adipose body there appears to be no regularity; they lie sometimes singly, sometimes united into a mass, sometimes in the neighbourhood of the stomachal wall, sometimes close to the integument of the body. As regards the function of this body, Malpighi, and, following him, especially Leydig, regard it as the "analogue of the omentum of the higher animals." I would rather, however, accept the opinion of Landois, who expresses himself decidedly opposed to the above view, "as the adipose body fundamentally considered will not bear comparison in any single particular with the omentum" (23, p. 10).

Dorsal Vessel.

For a long time I tried in vain to get a sight of the dorsal vessel of *Hæmatopinus tenuirostris*. By the dissection of fresh animals I could not succeed in preparing it. The extremely simple method recommended by Landois, of placing the living animal without any preparation under the microscope, could

not be employed in this case, on account of the opaque epidermis. Finally I succeeded in preparing it from specimens which had lain for months in dilute alcohol.

The *dorsal vessel* (*vas dorsale*) consists of a fine tube which stretches, in the direction of the middle line of the animal, close to the integument of the back, about from the extremity of the abdomen to the middle of the anterior margin of the thorax. So far I could trace it; but it is certain that it does not terminate there, but passes further up into the head (fig. 13, *a*). The tube presents on both sides a great number of appendages, some of which adhere to it by broad surfaces, while others are connected with it only by narrow tubes (fig. 13, *c*). These appendages run in multifarious convolutions, with frequent constrictions, parallel to the sides of the animal to the belly, where they seem to terminate cæcally. At its posterior extremity the tube widens into a peculiar vesiculiform organ, presenting numerous muscular bundles, which lie annularly around it. We also observe in it many elongated fibres running from in front backwards, probably longitudinal muscles. A little before its posterior termination this organ shows on each side a strong muscular bundle, by which it is attached to the integument of the back. We also observe further in the middle and at the upper end of the vesicular structure several strong muscular bundles on both sides, which serve the same purpose as those above mentioned. But as regards the tube itself in its further course, I have nowhere observed upon it any trace of muscles which could effect its attachment to the dorsal integument. It is therefore to be supposed that in this case the whole dorsal vessel is not, as in other insects, attached to the integument of the body by means of numerous muscles which at the same time produce the pulsating movement, but is connected therewith by muscles only at its posterior, and perhaps at its anterior extremity, and otherwise hangs down freely into the body-cavity. The tube itself, as also the vesicular organ at its hinder extremity, appears much darker than the above-mentioned appendages, the colour of which is a dingy grey. The walls of the tube are closed throughout their length, and only give off small narrow canals into the appendages (fig. 13, *b*). The contents of the tube are finely granular; as to the structure of its walls I can say nothing. The appendages, on the other hand, present a fine clear membrane, which is perforated by numerous quadrangular, pentagonal, and hexagonal apertures. Over these is stretched a second layer, which exhibits innumerable extremely fine granules. Upon the appendages we also detect numerous irregular longitudinal and

transverse grooves. In the interior of the space enclosed by the above two membranes we easily observe a number of pale-coloured blood-corpuscles furnished with a thin membrane and a distinct nucleus. They are round and have a diameter of about 0·013 millim. As already stated, the vesicular organ is darker and also furnished with thicker walls than the appendages of the tube. It also presents two membranes—an inner one containing fine granules, and an outer one perforated by small roundish apertures. In its interior also there are numerous blood-corpuscles.

As regards the mode of circulation of the blood in the body of our animal, the following statement may be made. The movement of the dorsal vessel takes place, as in all insects, from the posterior extremity of the tube. The muscles surrounding the vesicular organ, which is an analogue of the heart in the higher animals, contract, and by this means the organ becomes narrowed, and the blood which is pressed out of it, in part directly, but for the most part into the tube, passes out of the latter into its appendages, and comes into contact with the organs of the body through their apertures. That other muscles may not cooperate in this movement is by no means certain. When the tension of the muscles ceases again, the vesicle enlarges to its original size, and the blood goes back into it by the same way that it issued.

The whole circulatory apparatus is accompanied by the finest ramifications of the tracheæ, which convey the oxygen of the air to the blood.

Finally, I have to confirm an opinion of Landois's, which he has expressed with regard to the dorsal vessel. In his 'Anatomy of *Pediculus vestimenti*' (24, p. 40), he says:—"Hitherto my endeavours to prepare the dorsal vessel of the body-louse have been without result, which is explicable by the certainly extraordinary delicacy of the organ. Nevertheless we cannot but ascribe a dorsal vessel to the insect. In favour of the existence of such an organ we have not only the analogy of other insects, but the connecting tubes of the ovaries and testes also indicate it. With regard to these I have convinced myself that the tips both of the strings of ova and of the testes give origin to vessels which possess very fine transversely striated muscular fibres, of which I could especially recognize circular ones, perhaps because they lie outermost. It is these vessels, as we know from insects that have been investigated, which stand in connexion with the dorsal vessel. From the existence of these, therefore, we may deduce the presence of a dorsal vessel." This conclusion, arrived at by Landois, is perfectly correct. I have been

able to trace the vessels which originate from the extremities of the strings of ova to their opening into the appendages of the tube. They originate at *c* in fig. 11, and, after a short course, open into one of the appendages (shown *in situ* in fig. 13, *d*).

Nervous System.

Hæmatopinus tenuirostris has a cerebral ganglion and three thoracic ganglia placed close behind one another. The large cerebral ganglion is situated in the hinder part of the head; in the margin directed towards the forehead it has a small emargination which divides it into two parts, right and left lateral halves. The whole thus acquires the form of a bean. Its length is 0·128, and its breadth 0·190 millim. In front there issue from it on each side to the antennæ two nerves in the form of thin delicate threads. Their course has been already particularly noticed (p. 85). Not far from these there starts on each side a somewhat stouter but shorter nerve, which is appropriated to the eye, the *optic nerve*.

As regards the connexion of the cerebral ganglion with the thoracic ganglia, I was able certainly to distinguish two nerve-filaments at the hinder border of the former and the anterior margin of the first thoracic ganglion; but from their delicacy and the solidity of the integument of the head and thorax, I could not ascertain their further course and the mode of their union; and I see that in this respect I have fared no better than Landois. The supposition, however, seems to be justified that these two nerves establish a connexion, like the commissures in other insects.

The three thoracic ganglia lie close together towards the ventral surface; and the first of them does not extend beyoud the middle pair of limbs. The anterior one has a quadrangular form with rounded anterior and posterior angles; its greatest breadth is in front, as is also the case with the other two ganglia of the thorax. In its anterior margin there is a faint scarcely perceptible emargination. The second is more oval, whilst the last decidedly acquires a quadrangular form. The anterior thoracic ganglion is 0·124 millim. broad and 0·093 millim. long; the intermediate one 0·115 millim. broad and 0·091 long; and the posterior one 0·190 millim. broad and 0·128 millim. long. From the three ganglia of the thorax there start on each side in front three nerves, one of which in each case enters into a limb. I have been unable to trace the course of the other two; possibly, as Landois supposes, one of them is a sensitive nerve, while the other is appropriated to the muscles of the body. The first two ganglia have only

these three nerves on each side; the last one, however, possesses several more. In the first place two nerves on each side issue from the middle of the lateral parts of the posterior thoracic ganglion; these were also observed by Landois in *Phthirius inguinalis* and *Pediculus vestimenti*, and regarded by him as "transverse" nerves, "the function of which is to supply the dorsal vessel and the tracheal stems." Besides these, nerves are attached to the hinder part of this last ganglion, five on each side, forming the so-called "cauda equina." These are elongated nerves, which soon divide up into fine threads, and the extremities of which run to the intestines as well as to the generative organs.

The colour of the ganglia is "dark granular." Each ganglion is surrounded by a special, tolerably thick, structureless envelope. The cerebral ganglion and the first two thoracic ganglia show two probably amalgamated lateral halves, while the last thoracic ganglion consists of three parts, two lateral anterior ones and a narrow hinder one. For the rest I would adopt the views of Landois (24, p. 25), who says:—"The two anterior ganglia and the anterior halves of the third evidently correspond to the three thoracic segments; the hinder part of the third I regard as the contingent belonging to the abdomen."

Female Sexual Organs.

The female generative organs consist of the *ovaries*, the *tubæ*, the *uterus*, the *vagina*, and the *cement-glands*.

Upon the diverticula of the bicornute uterus five *ovarian tubes* arise on each side. In our animal these are bilocular. Whether this is the case throughout the genus *Hæmatopinus* I cannot say, as I have hitherto only examined a few species of the genus in this respect. In those examined (*H. suis*, *H. eurysternus*, and others), however, I have always found bilocular ovarian tubes. But in the structure of the ovaries in general there is a great difference, the importance of which in the classification of the Lice must not be underestimated. Thus in *Phthirius* Landois found *unilocular*, and in *Pediculus septemlocular* ovarian tubes. Should we, therefore, find in animals of the genus *Hæmatopinus* ovarian tubes possessing more or less than two chambers, this would be a reason for grouping the species in question in another genus. However, at present we know so little about the internal anatomy of the Pediculina, that we must content ourselves with the existing arrangement in accordance with purely external characters. We should, however, act very one-sidedly if we were to found a classification of the Lice

upon this single character. A rational classification must be founded upon other equally important characters, such as especially the buccal organs, but not only their external structure, as we already distinguish lice with suctorial from those with biting buccal organs, but also the internal constitution of the organs in question.

The above-mentioned bilocular ovarian tubes are connected with the uterus by shorter or longer *tubæ*. The average length of these tubæ amounts to 0·058 millim., while the greatest observed by me was 0·176 millim. According to the development of the ova contained in them the ovarian tubes present a difference of size and thickness. The lower chamber, nearest to the uterus, is always the largest. In it a single egg attains its development. As soon as this has become mature it is expelled. Then the walls of this chamber shorten, by which the second or upper chamber is brought nearer to the uterus. It is only then that the ovule in this chamber can become developed to its maturity. Thus we find the view expressed by Landois (24, p. 51) confirmed in this case also:—"The ova arrive at their full development in the chamber in which they are placed at first; they do not pass into the immediately underlying emptied chamber in order to become developed." When the ovum has attained its full maturity in the second chamber and been expelled therefrom, the course of development has come to an end in that ovarian tube. In this way the Sharp-headed Ox-louse, if it does not perish previously, may deposit *twenty* eggs. In connexion with this it is to be remarked that in the same individual several eggs may arrive at maturity at the same time, and these are then expelled soon after one another. Most frequently I found in each ovary one ovum approaching maturity; but the presence of *two* in the same ovary was not a rarity. In the latter case, however, the other ovary had only *one* ovum in an advanced state of development. Indeed more than three would not find room in the body-cavity; for a single mature ovum fills nearly one fourth of the abdomen. As regards the size of the different chambers, this is very variable in the case of the lower one, according to the stage of development of the ova, while in the upper one it is more constant. Thus the length of the lower chamber varies from 0·509 to 0·929 millim., and its width from 0·092 to 0·396 millim. The second chamber, on the contrary, which is separated from the former only by a constriction, is 0·156 millim. long and 0·049 millim. wide. It is continued upwards into a tubular structure of 0·078 millim. length (fig. 11 *c*), which unites with the analogous vessels of the other ovarian tubes of

the same ovary, and is connected with the dorsal vessel as already described. The ovarian tubes are enveloped by a clear, structureless, tolerably strong membrane. Landois was the first to make an accurate investigation of the course of development in the chambers in *Pediculus vestimenti*, tracing it step by step in the seven chambers. In that species this was attended with less difficulty, because the most different stages of development occur at the same time in the same ovarian tube; in the present case, on the contrary, I had to examine a whole series of ovaries in order to obtain a clear idea of the gradual progress of the development. I have, however, arrived at exactly the same results as Landois, and may therefore refer to them. I will here cite only one of his principal statements (24, p. 50) :—"The cell situated in the centre," he says, "is the germinal vesicle (fig. 11, *kb*), and its nucleus the germinal spot; the surrounding granular fluid, containing small fat-molecules in suspension, is the vitellus (fig. 11, *d*); the rounded cells, already containing large nuclear structures, placed in the upper part of the chamber are the vitelligenous cells (fig. 11, *db*), and the bacilliform cells lying below them the epithelial layer of the germinal chamber (fig. 11, *estr*)." In the further progress of the development more and more of the vitelline mass is secreted, the vitelligenous cells become smaller, the epithelium becomes more coarsely cellular, and "at the approach of the maturity of the ovum acquires the character of a rounded unistratified layer, whereas it was previously cylindriform." The whole vitellus becomes surrounded by an extremely fine and delicate envelope, the so-called vitelline membrane. Last of all is formed the external envelope of the ovum, the chorion, and, indeed, from the epithelial cells by deposition externally. The chorion is of considerable thickness and of firm consistence. It is not textureless, like the vitelline membrane, but exhibits on its surface numerous hexagonal areas, separated from each other by grooves. Beneath these there is an inner homogeneous layer of the chorion, which exceeds the outer one in thickness. At the upper pole of the ovum, *i. e.* at the end which is furthest from the uterus, when the ovum has attained a certain stage of development, the *operculum* is formed. Upon its production Leuckart (18) says, "According to my observations the operculum is produced in this way. At a certain distance from the anterior pole of the ovum an annular groove makes its appearance, which gradually penetrates deeper and deeper, and finally cuts through almost completely to the vitelline membrane." The complete separation of the operculum, marked off by the groove in question, from

the rest of the chorion, only takes place outside the maternal organism, when the embryo is so far developed that it will soon quit the egg-capsule. Upon the operculum arise some small hemispherical cells, from sixteen to eighteen in number, which form the micropylar apparatus. They occur only on the middle part of the operculum; so that a broad margin remains which shows exactly the same superficial structure as the rest of the chorion. Between the micropylar cells the surface of the operculum is uneven and finely granular. In the middle of each cell of the micropylar apparatus we see a round aperture, the true micropyle. Round this, at some little distance, runs a circular elevation, towards which radiating grooves run from the orifice. From the true micropyle a fine canal passes through the chorion into the cavity of the egg. The micropylar apparatus is only developed on the ovum after all the previously described structures have been produced. It seems to me that the small rounded cells placed above the vitelligenous cells (fig. 11, *m*) take part in its formation. The vitelline membrane is separated from the chorion throughout its whole extent, except at the periphery of the operculum, where the two are firmly united. It has only a *temporary* existence, and disappears during the development of the embryo. At the posterior pole of the egg—that is, at the end which lies nearest to the uterus, there is a peculiar structure, which was also found by Leuckart in the eggs of *Pediculus capitis*, and by Landois in those of *Phthirius inguinalis*. The latter describes it characteristically as a "conical organ which appears as if composed of a tuft of very fine aciculi, springing from a rather dark round space, much like the individual florets in the flower of a composite plant." Whether Leuckart's supposition that this structure is an apprratus of attachment is correct must remain undecided. It is certain, however, that this apparatus is connected with the vitelline membrane, which becomes contracted below into a fine tube, which I could trace distinctly to the structure now under consideration.

The ovarian tubes are connected with the uterus by the *tubæ*. These are slender thin-walled tubes filled with a yellowish cell-mass. The *uterus* is bicornute (*uterus bicornis*); that is to say, it presents two nearly globular diverticula. These open below into the upper broad part of the vagina. Both uterus and vagina have an outer tolerably firm textureless membrane and dark granular contents. The *vagina*, which is surrounded by a network of fine circular and longitudinal muscles, receives the two *cement-glands* before it opens into the cloaca. These are lobulate bodies with an external en-

velope which exhibits numerous longitudinal and transverse grooves, and an inner layer with many dark granular gland-cells. The latter secrete the cement-mass by means of which the egg is attached to the hair of the host.

The fully developed egg has an oval form (fig. 10), and shows two opposite surfaces, which differ considerably in their curvature. Leuckart calls the convex, more strongly curved surface the *ventral*, and the opposite but slightly curved one the *dorsal surface*. He says, "The convex surface corresponds to the ventral surface of the young larva. During the sojourn in the ovary the convex surface seems to be generally turned outward towards the lateral parts of the maternal body." As regards the latter part of this statement Leuckart is perfectly right. But it is not the convex but the opposite slightly curved surface that corresponds to the ventral surface of the embryo. The latter lies in the egg so that its head is placed at the upper or anterior pole of the egg, which bears an operculum, and its back on the convex side of the egg, called the ventral surface by Leuckart (fig. 10); so that here the denominations dorsal and ventral surface must be reversed. A longitudinal section perpendicular to the above-mentioned two surfaces is the only one that divides the egg into two symmetrical halves. The egg is always attached to the hair so that the ventral surface of the embryo is turned towards the hair, by which it is enabled, on quitting the egg-capsule, to climb up on the hair immediately.

The *cement-mass*, which is on the average 0·336 millim. long and 0·318 millim. broad, consists of a hyaline substance. This presents numerous darker streaks, which, attaching themselves at the inferior pole of the egg, pass round the hair and unite with the streaks coming from the other side (fig. 10, *k*). These streaks resemble so many elastic bands, which, on the one hand, maintain the egg in its position, and, on the other, if it should be displaced by external agencies, draw it back again into its place. The hair with the nit attached to it may be best compared, as regards external form, to a tobacco-pipe. The hair represents the tube, the egg the bowl of the pipe, the cement-mass the receptacle, the operculum the lid of the bowl, and the micropylar apparatus the openings in the lid. The operculum of the egg separates in this way: the part lying furthest from the hair first separates from the rest of the chorion, just as, in order to complete the comparison, the lid of the pipe is attached to the bowl at the point nearest to the tube.

It is a remarkable phenomenon in the literature of the Pediculina that we find the eggs neither described nor figured

by the various authors, although we almost always find the nits on animals on which the lice are parasitic. It is true that these escape the eye more easily than the lice themselves, as they often mimic the colour of the hair or of the skin of the host. Denny alone gives figures of the eggs of *Hæmatopinus lyriocephalus*, Burm., and *H. eurysternus*, Nitzsch. And yet the eggs, with their operculum, their micropylar apparatus, and the mode of their attachment, are of no small importance, both as regards the internal anatomy and developmental history and as regards classification.

Male Generative Organs.

The male sexual organs include the *testes*, the *mucus-organs*, and the *penis*.

The *testes*, as in all Lice hitherto investigated, are four in number; and each pair has an efferent duct. They are situated on the two sides of the body, at a considerable distance apart, and are of an oval form. Their width is 0·154, and their length 0·247 millim. The whole testis is surrounded by a pretty firm structureless membrane. Superiorly this passes into a thin thread-like vessel of 0·013 millim. width, with a fine lumen and pale yellow contents, which connects the testis with the *vas dorsale*. Diametrically opposite to this point the envelope of the testis lengthens out to form the seminal duct, which is 0·048 millim. wide and very long. The two testes are situated quite close together; both are attached without any peduncle to the end of the seminal duct. The latter presents a fine textureless membrane, a small lumen, and clear granular contents. Its length is considerable, equalling that of the abdomen. The seminal elements, developed in the testes, consist of a rounded head and a long thin caudal part. As regards the development of the spermatozoids I can at present say nothing, as only a few males of our animal were at my disposal during the investigation.

Between the seminal ducts are placed the *mucus-organs*, two large structures, 0·340 millim. broad, which exhibit a structureless outer envelope and contents consisting of gland-cells. Below these organs contract into efferent ducts, which cross a little way from their point of union, so that the efferent duct of the right mucus-organ approaches that of the left one from the left, and *vice versâ*. A little before they unite these structures receive the two seminal ducts.

The *penis* is a bacilliform strongly muscular organ 0·186 millim. long and 0·049 millim. broad, into which strong chitinous bands are inserted at the sides. The latter run into four chitinous rods, which attain the length of the penis.

Anteriorly the penis, as well as the above-mentioned chitinous bands, is in connexion with the united efferent duct of the mucus-organs and seminal ducts.

Muscular System and Movements.

In the preparation of the muscles I have in general adopted the method recommended by Landois as the most convenient. He describes his process as follows (25, p. 499) :—" Select individuals as large as possible, and lay them first of all for a time in dilute alcohol, until a moderate hardening has taken place. Then the individual is divided by a frontal incision, by which the dorsal integument is separated from the ventral. The two halves are now laid in water; and when the viscera have become sufficiently soft they are removed by means of fine needles and hair-pencils. The integument, with the muscles, then remains. Staining brings out the picture." I have divided the animals not only by frontal incisions, but also by longitudinal sections into right and left halves, by which means, besides the dorsal and ventral muscles in the abdomen, previously unsuspected lateral muscles were exhibited. Although certainly the preparation and investigation of the musculature of such small animals is not one of the easiest problems of anatomy, I believe that, from the great number of preparations that I have made, I can give a tolerably complete view of the musculature of *Hæmatopinus tenuirostris*.

The muscular bundles of the Arthropoda consist of the sheath (*sarcolemma*) and the transversely striated contents, the true contractile elements. In our animal I could only in a few instances see the sarcolemma, but I could discover no nuclei in it. The individual muscles break up into fibrillæ, the number of which varies according to the thickness of the muscles. The finest presented only two fibrillæ, while stronger ones had fourteen or more. In the fibrillæ we see darker and lighter layers alternate. These layers are sometimes perpendicular to the long axis; sometimes they form with it an angle varying more or less from a right angle (fig. 5). The interstices between the darker layers produce the transverse striation. In Leydig's opinion (19) they are filled with semi-fluid substance. At the extremities the fibrillæ terminate conically. By this means they are slightly separated from each other, and thus the muscle appears to be fringed. All the muscles are transversely striated. Only one, the *flexor tarsi*, has a sinewy termination (fig. 6, *ft*.) The length and thickness of the individual muscular fasciculi vary greatly: thus, for example, in the abdomen their greatest length is

0·340 millim., and their least 0·059 millim.; their greatest width 0·066, and their least 0·001 millim.

Musculature of the Head.—The muscles of the head divide into three groups:—those of the buccal organs; the motors of the antennæ; and the motors of the head itself.

Muscles of the Buccal Organs.—Of these there are two kinds. Those which serve for the protrusion of the sucking-tube are inserted upon the dorsal integument of the head in the vicinity of the middle line and at the level of the antennæ, and pass thence, running obliquely forward, to the chitinous bands which exist on each side of the proboscis. There are four of them on each side (fig. 4 *e* & fig. 9 *e*). Their mode of action has been already explained (p. 87). The second group comprises those which effect the retraction of the sucking-tube. They originate on the ventral surface at the base of the head, at a small distance from the middle line, two on each side, and converging anteriorly, accompany the œsophagus, pass between the antennæ, and reach the sucking-tube in front of them. These are fine and exceedingly long muscles (fig. 4, *i*). Their function has been already mentioned.

Muscles of the Antennæ.—Below the muscles which serve for the protrusion of the rostrum two muscles originate on each side at the dorsal surface of the head; and these run parallel to the above mentioned and go to the antennæ. The two muscles of each side lie close together, and only separate a little before reaching the antennæ. One of them goes to the anterior, and the other to the posterior margin of the first antennal joint; the former is the forward and upward motor, the latter the backward and downward motor (fig. 4, *a*). The first antennal joint exhibits four muscles, two of which are inserted at the anterior and two at the posterior end of the base of this joint. These muscular bundles run converging upwards to the lower margin of the second joint. In each of the second, third, and fourth joints we see two muscles. They originate at the base of the joint in which they are situated, run parallel to the longitudinal axis of the joint, and pass to the basal part of the succeeding joint. The fifth joint also has two muscles, which run together above, and probably are destined to move the tactile bacilli.

To the *third* group I refer all the rest of the muscles contained in the lower part of the head.

Immediately below the point of origin of the muscles which go to the antennæ, and in part coincident with them, there goes off on each side a muscular fasciculus to the right and left (fig. 4, *c*). These muscles run from the dorsal surface of the head towards the ventral surface. By their contraction

they approximate the upper to the lower integument, and thus assist in respiration, as will be explained further on. Lastly, we find two more muscles on each side, which, commencing far back on the dorsal surface of the head, run forward (fig. 4, *b' b*), one of them nearly parallel to the middle line (*b'*), the other more towards the ventral surface (*b*). Upon the last-mentioned pair the cerebral ganglion rests. As to the function of these two pairs of muscles I can say nothing with certainty; but I suppose that they also assist in respiration.

Musculature of the Thorax.—The muscles of the thorax may also be divided into three groups—the muscles of the legs, the muscles which serve for the constriction of the thorax, and the motors of the head.

Muscles of the Legs.—These muscles are all attached to the chitinous pad, already repeatedly mentioned, which originates in the middle of the posterior margin of the dorsal surface of the thorax, runs forward in the direction of the median line, then divides and runs towards the anterior angles of the thorax (fig. 4, *l*). These muscles penetrate into each leg. Those going to the first pair originate a little before the point where the above-mentioned chitinous band forks, form with this an angle of about 45°, and are inserted upon the anterior and posterior margins of the base of the coxa; these move the legs forward and backward (fig. 4, *v'*). Immediately behind these the forward and backward motors of the succeeding pairs of legs take their origin, starting from the chitinous band nearly at a right angle (fig. 4, *m'* & *h'*). The musculature is exactly the same in all three pairs of legs, except that the muscles of the first pair are much more delicate than those of the two posterior pairs, as the legs of the first pair are far less powerful than the others. At the base of the coxa originate four muscles which converge forwards, and are inserted upon the lower margin of the trochanter (fig. 6, *c*). The short trochanter exhibits only two muscles, which are tolerably broad at the posterior end, but become considerably narrowed anteriorly and run divergently. They have their origin at the base of the trochanter, and terminate at the lower margin of the femur (fig. 6, *tr*). The musculature of the femur is of a somewhat different type. One muscle traverses the femur from behind forwards, parallel to the long axis of the leg. Two pairs are inserted on each side at some height on the posterior margin of the femur, and run obliquely through it to the anterior margin of the basal part of the tibia (fig. 6 *f*). The three muscles just mentioned are flexors of the tibia. Besides these the femur shows two more muscles, which are inserted on each side above those last named, penetrate into the tibia, and then

unite with the motor of the tarsus (fig. 6, f^1). The *flexor tarsi* has a triple origin. Its principal portion originates in the sinuosity of the tibia which is directed backwards, and runs forwards thence, gradually becoming narrower (fig. 6, *a*); a second part is inserted upon the anterior basal margin of the tibia (fig. 6, *b*), unites, after a short course, with the muscle (f^1) coming from the femur, and both combine with the principal part after they have become considerably narrowed. At its extremity the flexor of the tarsus passes into a fine clear sinew (fig. 6, *ft*). The latter is attached to a finely ribbed chitinous plate (*d*), which is connected with the claw of the tarsus. If then the *flexor tarsi* contracts, the claw is approximated to the chitinous process (*e*) on the anterior margin of the tibia, by which means the animal is able to clasp the hairs of its host.

There are several muscles which serve for the *constriction of the thorax*. The first of these originates above the muscles which run to the first pair of legs, and is inserted upon the anterior margin of the first acetabulum on each side (fig. 4, *x*). The second is inserted between the muscular fasciculi which run to the first and second pairs of legs, and terminates between the first and second acetabula (fig. 4, *z*). The third originates between the muscles going to the second and third pairs of legs, and terminates between the middle and posterior acetabula (fig. 4, *y*). Besides these there is yet a fourth strong muscular bundle, which serves the same purpose. This, which forms a broad band adhering to the dorsal integument, runs from one side to the other at the hinder margin of the thorax (fig. 4, *t*). By the contraction of all these muscles, or of a portion of them, the dorsal integument of the thorax is approximated to the ventral.

Three of these pairs of muscles effect the *movement of the head*. One of them originates on the chitinous pad at the point where this divides, and runs forward to the lateral margin of the head (fig. 4, *r*). The second is inserted above the fork of the chitinous band, and runs perpendicularly to the boundary of the first and second acetabula (fig. 4, *q*), where it meets with the third pair, which commences at the lateral margin of the head, and thence goes obliquely downwards (fig. 4, *p*). All these muscles serve to move the head sideways and downwards. I have been unable to discover any special upward motors of the head, and therefore assume that the chitinous fork which has been repeatedly mentioned acts at the same time as an elastic band which draws the head upwards.

Musculature of the Abdomen.—As in the case of the

muscles of the head and thorax, we shall here also distinguish three groups—the muscles which move the individual abdominal segments, the respiratory muscles, and the muscles of the generative organs.

Motor Muscles of the Abdominal Segments.—At the dorsal surface we find in each segment on each side of the median line five longitudinal muscular fasciculi. The fasciculi placed on the two sides of the median line are distinctly separated from each other by an interspace, which widens towards the middle of the body and narrows again towards the extremity of the abdomen. In the first segment the muscles originate at the posterior margin of the segment, and run, somewhat converging, to the hinder margin of the thorax. These are the elevators of the thorax. The muscles of the other segments are always inserted at the hinder margin of the segments in which they are situated, and run to the hinder margin of the next preceding segment. Besides these we find in the third segment another muscle on each side, which originates close to the other five, but runs outwards and forwards to the hinder lateral margin of the second segment. The length of the muscles in the respective segments is as follows:—

	millim.
In segment 1	0·166
,, ,, 2	0·178
,, ,, 3	0·228
,, ,, 4	0·269
,, ,, 5	0·288
,, ,, 6	0·329
,, ,, 7	0·340
,, ,, 8	0·155
,, ,, 9	0·059

The ventral surface shows five longitudinal muscles on each side in each of the first seven segments, three on each side in the eighth. Those of the first segment are the depressors of the thorax, the others the flexors of the ventral rings of the abdomen. Their insertion and course in the respective rings is exactly the same as with the muscles of the dorsal surface. In the first segment three more muscles on each side originate near the longitudinal muscles, run outwards and forwards, and are inserted upon the hinder lateral margins of the thorax. These are the lateral motors of the thorax.

To the motor muscles of the abdomen we have further to reckon some longitudinal muscles which pass at the lateral margins through the segments from the second to the seventh. There are two pairs of these in each of the above-mentioned segments. Those of the second segment are inserted upon

the hinder margin of the first segment near the dorsal muscles towards the ventral side, and run thence obliquely downwards towards the ventral surface to about the middle of the hinder lateral margin of the second segment. Opposite to their terminations originate the lateral longitudinal muscles of the third segment, which, like those of the other segments, run more parallel to the median line of the whole animal. While the muscles of the dorsal and ventral surfaces by their contraction effect the contraction of the dorsal and ventral integuments, the lateral longitudinal muscles serve for the contraction of the lateral integument.

Respiratory Muscles.—In opposition to the muscles of the first group just described, these traverse the abdomen transversely. They consist of from one to three fasciculi in the respective segments. The first is situated in the middle of the sides of the second segment. It originates near the lateral muscles of this segment and runs towards the ventral surface. In the third segment the respiratory muscle is inserted near the dorsal muscles towards the ventral side, stretches over the lateral longitudinal muscles, and terminates between the latter and the ventral muscles. We also find a muscle of this kind, which, however, is considerably smaller, in the middle of the fifth segment. The other respiratory muscles are situated on the boundaries of segments three to eight. They all originate on both sides of the dorsal muscles, and pass over the lateral longitudinal muscles into the neighbourhood of the ventral muscles. The action of these muscles will be noticed hereafter.

Muscles of the Generative Organs.—In the *female* sexual organs the muscular apparatus is as follows. As already stated, the vagina is surrounded by a number of circular (*c*) and longitudinal (*l*) muscular fibres. From the seventh segment come two muscular fasciculi, which, running obliquely downwards, traverse the eighth abdominal segment, and attach themselves to the vagina in the upper part of the ninth segment. They are long muscular fasciculi, consisting of a great number of fibrillæ. (They may be called *aa*.) On the anterior lateral margins of the ninth segment two shorter and thinner fasciculi are inserted, which stretch somewhat upwards and attach themselves to the vagina a little before the first mentioned (*bb*). At the bottom of the last segment we see on each side a powerful but short muscular bundle, which runs from the sides towards the genital cleft, and has for its office to dilate the latter (*cc*). All these muscles are of great importance in the act of parturition. When the egg has got out of the uterus into the vagina, the longitudinal muscles of

the latter contract; at the same time the muscles *aa* and *bb* also contract. By this means the upper part of the vagina is shortened and the lower part dilated, and the egg is pressed through the abbreviated vagina into its lower dilated extremity. The circular muscles (*c*) now come into action, and force the egg lower down; the muscles *cc* contract and enlarge the genital cleft, and the egg is completely pressed out of the genital aperture.

The muscular apparatus of the *male* sexual organs is much more simple, as indeed lies in the nature of the case. Here we have only two muscles, which originate in the last abdominal segment, and are inserted at the base of the penis. One of them serves to push it forth, the other to retract it after protrusion.

Anatomy and Physiology of the Respiratory Organs.

The respiratory organs of *Hematopinus tenuirostris* consist, as in all insects, of stigmata and tracheæ. Seven pairs of *stigmata* are present. These are placed, as in most Pediculina, somewhat towards the ventral side, and always symmetrically on the two sides of the segments, whereas in other insects they are for the most part situated towards the back. They advance to the middle of the segments, which is also the case in the Pulicidæ and Acanthiadæ. In the other Hexapods, on the contrary, we generally find them between two segments. The first pair is in the thorax at the base of the second pair of legs, and therefore in the mesothorax. This appears to be the case throughout the genus *Hæmatopinus*, in contradistinction to *Pediculus* and *Phthirius*, in which the thoracic stigmata belong to the prothorax. The remaining six pairs are situated in the abdominal segments from the second to the seventh. Besides its size the thoracic stigma is distinguished by its form from the abdominal stigmata. The latter resemble a closed flower-bud (fig. 3), whereas the former rather resembles an open flower. The different stigmata have a small circular aperture surrounded by a chitinous ring (fig. 3, *b*). Parallel to the latter, three other chitinous rings surround the globular stigma. The space between the first ring placed immediately round the aperture and the second, and in the stigmata of the thorax that also between the second and third, are divided into regular areas by radiating grooves. In the bottom of the stigmata, opposite to the external aperture, we observe a number of fine hairs directed outwards. These serve to prevent the entrance of foreign bodies into the air-passages. Below the stigma narrows and passes into the *tunica adventitia* (fig. 3, *d*), on which the tra-

chea abuts. Immediately before this spot the passage between the trachea and stigma is narrowest. Here there is an extremely fine, somewhat curved rod, thickened at its upper extremity, the closing lever of the stigma (fig. 3, *e*). The superior thickened end of this rod is connected in the abdomen with the lateral longitudinal muscles, in the thorax with the median constrictor of the thorax (fig. 4, *x*). Then, as soon as the above-mentioned muscles contract, the lever is set in motion and closes the trachea. When the contraction ceases it opens again in consequence of its elasticity, and the little rod goes back into its position of repose.

The tracheæ exhibit an exterior nucleated membrane, the peritoneal envelope, and an interior chitinous spiral membrane. They are divided into principal and subordinate stems, of which the latter run out into the finest ramifications and go to all the organs of the body. The connexion of the individual stems by the tracheæ is in this case a peculiar one, such as, so far as I know, has hitherto been observed in no insect. From the last abdominal stigma a tracheal stem runs inwards and forwards (fig. 1, *a*). This is united with the corresponding trachea of the opposite side by a transverse stem (*b*). At the point of union the trachea bends suddenly towards the side of the body (*c*). The trachea starting from the penultimate abdominal stigma divides, after a short course, into two branches. One of these (*d*) runs straight forwards, the other (*k*) inwards to the viscera. Into the latter the tracheal stem coming from the last stigma opens. This arrangement is repeated through the whole of the abdomen, so that in each case the main stem of the trachea of the posterior stigma joins the subordinate stem of the trachea of the next anterior stigma. The tracheal branch starting from the first abdominal stigma alone unites directly with the main stem from the thoracic stigma. From the latter a branch goes to the anterior legs; the main stem itself passes into the head, and ramifies there. The trachea which starts from the first abdominal stigma and passes into the thorax emits a branch to each of the intermediate and posterior legs. The tracheæ serve, as Landois justly pointed out, both to convey the oxygen of the air to the internal organs of the animal's body, and also to fix the respective organs in their places relatively to the chitinous skeleton and to each other.

In respiration we distinguish expiration and inspiration. Expiration takes place as follows:—When the respiratory muscles which we have found in the head, thorax, and abdomen contract, the body-cavity will be diminished, the interior organs, and especially the cells of the adipose body, will press

upon the tracheæ, by which these are themselves compressed and squeeze out the air contained in them. Expiration is therefore of an active nature. When the air is driven out through the stigmata, the contraction of the respiratory muscles ceases, the body-cavity dilates again, the pressure of the organs upon the tracheæ ceases, the latter expand again by the agency of the spiral thread, and fresh air flows in through the stigmata. Landois thinks that the inspiration is entirely passive. Up to this point certainly; but now the air that has penetrated into the tracheæ has to be driven into the finest capillaries. For this purpose another narrowing of the tracheæ is necessary; but this can be effected only by a constriction of the body, and therefore by the contraction of the respiratory muscles. In inspiration the above-mentioned closing apparatus of the tracheæ is of great importance as Krancher has ascertained. He says (28, p. 516):—"If this were wanting the animal could not breathe at all, and would consequently be incapable of living. Without the closure of the tracheæ the animal, if it wished to breathe, would always expel again the air which is drawn into the body by the corresponding opposite movement, it would never penetrate into the finest ramifications. But when the tracheal closing apparatus comes into action and the tracheæ are full of air, the contraction of the body and the narrowing of the tracheæ consequent upon it presses the air more or less into their finest extremities, where the exchange of gas may take place in the most favourable manner." From what has been said we see that in the Lice both inspiration and expiration are of an active nature.

EXPLANATION OF PLATE III.

Fig. 1. Adult female of *Hæmatopinus tenuirostris*, Burm., seen from the ventral surface, showing the tracheal system, the ganglia, and the hairs.
Fig. 2. Head of *Hæmatopinus eurysternus*, Nitzsch.
Fig. 3. Abdominal stigma of *H. tenuirostris*.
Fig. 4. Head and thorax, seen from the side, showing the muscles and the cerebral ganglion (*d*).
Fig. 5. Upper extremity of a single muscle, greatly magnified.
Fig. 6. Intermediate leg, with the muscles and chitinous thickenings, seen from the side.
Fig. 7. Antenna, showing the chitinous plates, the thickenings and the hairs, and the terminal surface with tactile bacilli.
Fig. 8. Head, with the buccal organs (*a*, *b*), œsophagus (*œ*), and eyes (*f*).
Fig. 9. Buccal organs and muscles, more highly magnified.
Fig. 10. Attached egg, with embryo (*e*) and vitellus (*d*).
Fig. 11. Upper chamber of an ovarian tube.
Fig. 12. Ileum, rectum, and colon, with their membranes.
Fig. 13. Upper part of the dorsal vessel. *a*, tube; *c*, appendages; *b*, efferent duct from the tube into the appendages; *d*, appendage connected with the ovaries.

Fig. 1.

Fig. 2

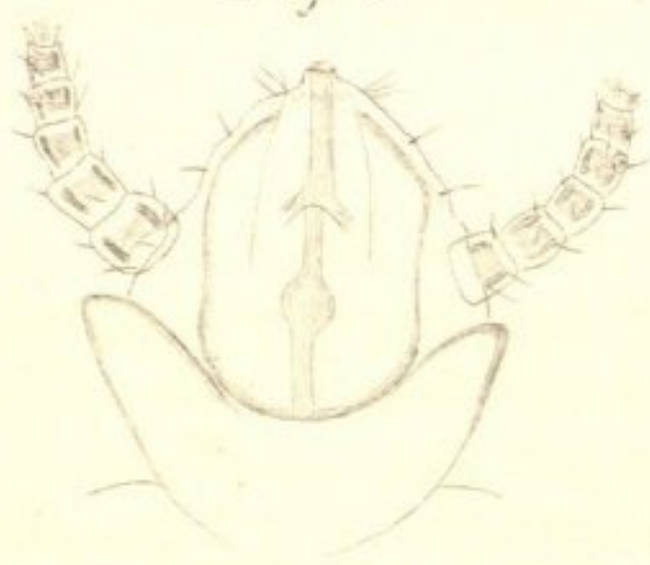


Fig. 3.

Fig. 4.

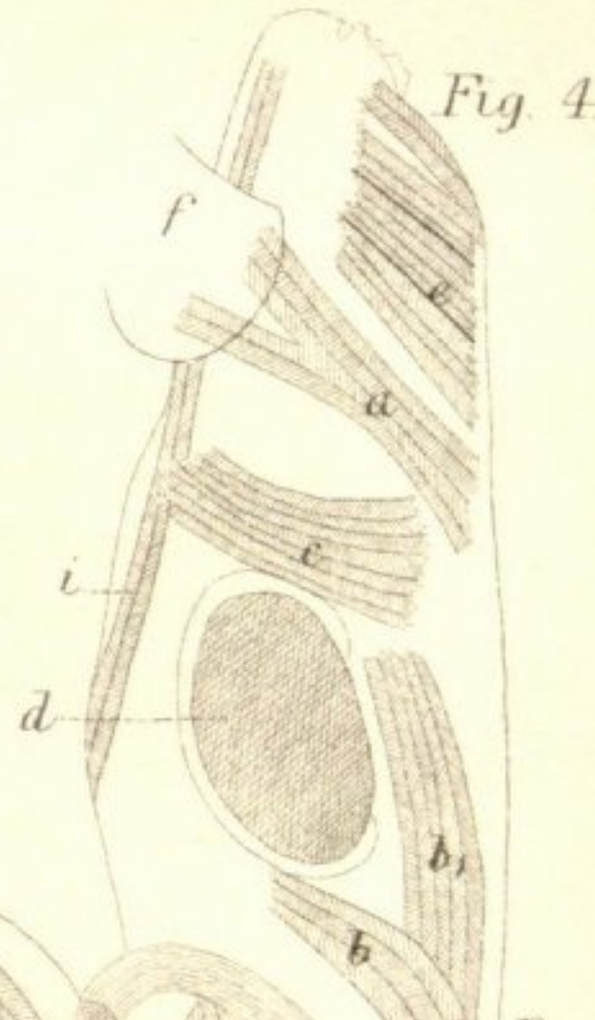


Fig. 5.

Fig 6.

Fig. 11.

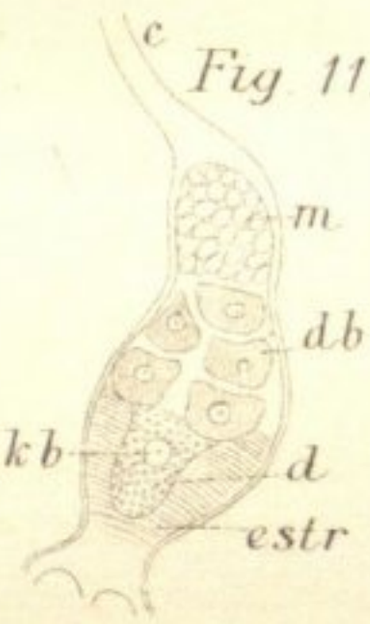


Fig. 12.

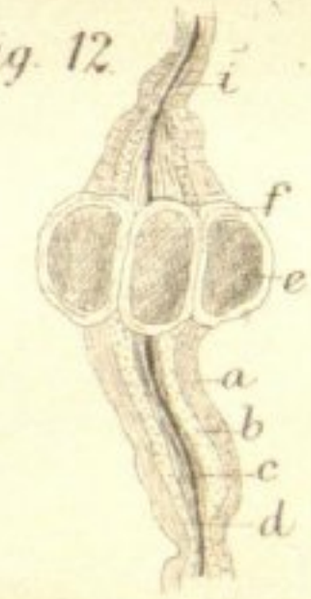


Fig. 9.

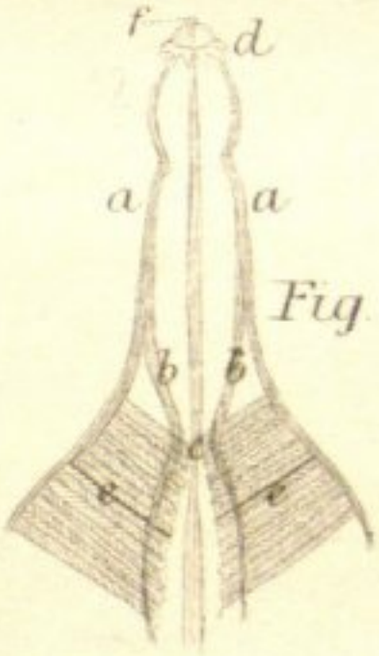


Fig 10.

Fig 7

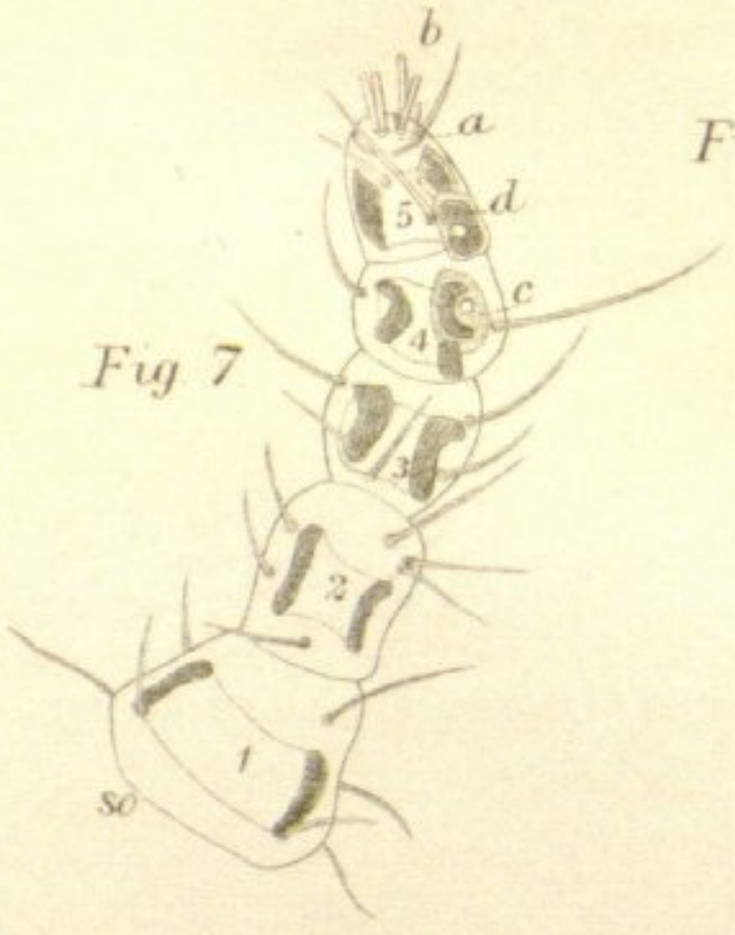


Fig 8

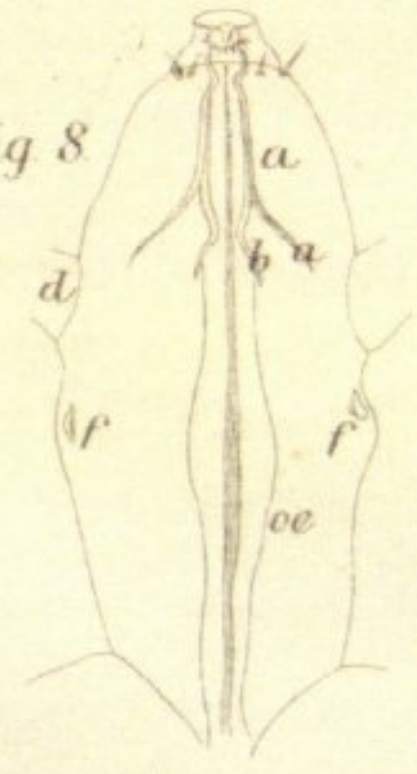
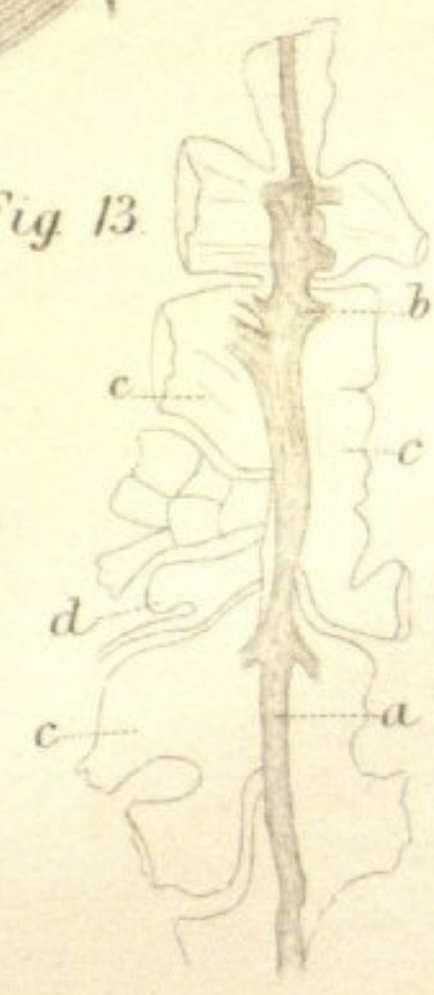


Fig 13.



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