XII. *Notes on the* Thysanura.—Part IV.

By Sir John Lubbock, *Bart., F.R.S., V.-P. Linn. Soc., &c.*

(Plates XLV. & XLVI.)

Read June 3rd, 1869.

SINCE my last paper on the *Thysanura*, which was read before the Linnean Society in 1867, I have met with six more British species, three of which have been already recorded as occurring on the Continent, while the others appear to have been hitherto overlooked. The first three are *Lepidocyrtus curvicollis* Bourlet, *Degeeria domestica* Nicolet, and *Lipura maritima* Guérin; the fourth is a species allied to *D. domestica*, the fifth an Isotoma, which I propose to name *Isotoma grisea*; and the sixth forms the type of a new genus. In placing on record the existence of Nicolet's *Degeeria domestica* as a British species, I must add that I have never found it myself, but have received specimens from Mr. M'Intire, and that, for reasons given below, I cannot regard it as belonging to the genus *Degeeria*, but rather as constituting the type of a separate genus of much interest as being in some respects intermediate between *Templetonia*, *Lepidocyrtus*, and *Degeeria*. It has the hairs and scales of *Lepidocyrtus* and *Templetonia*, and the general form of *Templetonia* and *Degeeria*, from the former of which, however, it differs in its antennæ.

I also add descriptions of the only three British species of Lepismidæ with which I am acquainted.

Lepidocyrtus curvicollis Bourlet.

Lepidocyrtus curvicollis Bourlet, Mém. Soc. R. Lille, 1839; Mém. Soc. Douai, 1842.
Cyphodeirus capucinus Nicolet, Mém. Soc. Helv. 1842.
Lepidocyrtus curvicollis Gervais, Hist. Ins. Aptères.
—— *capucinus* Gervais, Hist. Ins. Aptères.

Bourlet's description of this species is as follows:—

"Thorace gibboso, capite deflexo, corpore toto squamis plumbeis.

"2 millim. $\frac{1}{2}$. Mêmes caractères que ci-dessus. Sous les pierres et le bois pourri, en tout temps, excepté l'hiver".

I have found a few specimens belonging apparently to this species, and have also received some from Mr. M'Intire. In its ordinary position the head is completely hidden by the projecting bars of the thorax. It seems to me to be identical with the *Cyphodeirus capucinus* of Nicolet, whose description I subjoin.

"Entièrement d'un jaune orangé, sauf les antennes, dont les deux premiers articles sont d'un jaune plus pâle, et les deux derniers d'un gris assez foncé. Corps cylindrique, luisant, peu velu, à poils très-courts. Premier segment très-allongé antérieurement, triangulaire, creux en dessous et recouvrant la tête de manière à n'en laisser voir

que le bord antérieur quand on la regarde en dessus (fig. 1*a*). Deuxième segment, du double plus long que le suivant. Le sixième plus long que les trois précédents pris ensemble, et recouvert sur les côtés latéraux par un prolongement angulaire du cinquième. Yeux noirs. Filets de la queue blancs et finement striés transversalement.

"Cet insecte offre un léger reflet métallique produit par quelques écailles; longueur environ 2 millimètres. Se trouve dans les jardins, sur la terre; très-rare: vit solitaire."

Nicolet must, I think, have had before him immature or injured specimens. When full-grown, and unrubbed, this species is very beautiful, and reflects the most gorgeous metallic tints. Its general appearance is most singular; the depressed position of the head, and the gait, give it a ludicrous resemblance to a Hippopotamus; and at the same time the body does not look as if it belonged to the head and legs, but rather as if it were some foreign body being carried on the back.

The head is scarcely seen from above. The fringe of scales on the front of the thorax is turned down; and there are a certain number of long hairs, some of them bent.

The eggs are laid in heaps, and are spherical, with a diameter of about $\frac{1}{130}$ of an inch. They are at first smooth, but after a few days are covered with filaments.

ISOTOMA GRISEA, n. sp.

Dark grey, with a leaden tinge. Eyes on a black spot. Legs and antennæ of the same colour as the body. Second and third segments of antennæ equal in length. The whole body covered with very short, close, white hairs; the posterior part of the abdomen with a few longer ones. Terminal segment of spring straight, or turned slightly outwards. Feet without tenent hairs; the large claw has a single tooth on the inner side.

Length $\frac{1}{12}$ of an inch. Under boards, on a hotbed. Common. September to March.

I long thought this was the young of some larger species; but having watched them in their native haunts, and kept them for some time in confinement, I am satisfied that it is an independent species. My specimens do not exactly coincide with any of those described by Nicolet. The forms of the antennæ and of the spring distinguish it from the species forming his first section of the genus; nor is there any one in the second which it much resembles.

LIPURA MARITIMA Guérin.

Achorutes maritimus Guér. Icon. du Règne Anim. Ex. Ins. p. 11; Suites à Buffon, Aptères, vol. iii. p. 439.

Dark purple. Eyes five in number, two in front and three behind.

Length $\frac{1}{8}$ of an inch.

This species was found by M. Guérin at Treport, in Normandy. He described it as an *Achorutes*; but he expressly says it could not jump, and there can be little doubt that, as M. Gervais has already suggested, his specimens really belonged to the genus *Lipura*.

I have myself found *Lipura maritima* abundant among the rocks, and on pools, at low water, near St. Andrews; and Dr. Allman has kindly sent me specimens from Kinsale.

BECKIA, n. g.

Body scaly. *Antennæ* 4-jointed. *Eyes* wanting. *Thorax* not projecting overhead. *Abdominal segments* unequal.

This is a particularly interesting genus, and forms a link between *Lepidocyrtus* and *Degeeria*. In many respects it resembles *Degeeria*, but differs in the absence of eyes and the presence of scales. It is even more closely allied to *Lepidocyrtus*, from which the principal difference consists in the absence of eyes. *Templetonia* differs from *Beckia* in having the terminal segment of the antennæ ringed, and in the presence of a dark eye-patch, with a single lens. I have dedicated the genus to Mr. Beck.

BECKIA ARGENTEA, n. sp.

Silvery, with bright metallic reflections. No eyes. Third segment of the antennæ rather shorter than the second or fourth. A thick fringe of hairs in front of the thorax. Filaments of the tail scarcely reaching to the ventral tube.

Length $\frac{1}{15}$ of an inch.

I have also a second species of *Beckia*, somewhat broader than *B. argentea*. This is, perhaps, the *C. albinos* of Nicolet. Considering the absence of eyes, the activity of these species is truly remarkable. They make, however, great use of their antennæ in feeling the ground before them.

SEIRA, n. g.

Body scaly. *Antennæ* 4-jointed; terminal segment not ringed. *Eyes* on a dark patch. *Thorax* not projectiug over the head. *Abdominal segments* unequal.

I have proposed this genus for the scaled species which were placed by Nicolet among the *Degeeriæ*, because it seems to me manifestly unnatural to unite in the same genus species with and without scales. Like the preceding genus, *Seira** forms a very interesting link between several genera—a fact which I have endeavoured to indicate in the name. Indeed some of the species approach very closely to *Lepidocyrtus*; and as regards *S. Buskii*, I was long in doubt whether to regard it as a *Seira* or a *Lepidocyrtus*. The form of the thorax, which is the characteristic on which that genus was founded, admits of every gradation, and therefore is not of very easy application.

SEIRA DOMESTICA.

Degeeria domestica Nicolet.

Nicolet's description of this species is as follows:—

"Mêmes antennes que le précédent, mais blanches, ainsi que le dessous du corps, les pattes et la queue. Dessus du corps écailleux, d'un blanc sale très-luisant, avec

* From σειρά, a chain.

quatre bandes transversales et plusieurs taches d'un gris foncé un peu rougeâtre. Tête blanche. Yeux noirs. Poils gris et longs. Sixième segment comme dans l'espèce précédente.

"Longueur : $1\frac{1}{2}$–3 millimètres. Cette espèce se trouve dans les maisons, où elle vit solitaire ; rare."

Mr. M^{c}Intire has found this species occasionally in Millbank and Brixton prisons. It is, however, as Nicolet says, "rare." I have never met with it.

The antennæ are long and slender.

SEIRA BUSKII, n. s.

Dark violet, with metallic reflections. Head, legs, and base of antennæ yellowish. Eyes on a black patch, and connected by a black band. Spines yellowish at base, colourless towards the extremity.

Length $\frac{1}{15}$ of an inch.

The basal segment is rather shorter than the second or third, which, again, are, though very little, shorter than the apical. The hind legs are longest. The feet are all alike. There is one tenent hair, not much swollen at the end. The small claw is without teeth. The large one has three teeth on the inner, and one on the outer margin.

I have only found this species in greenhouses and hothouses ; perhaps, therefore, it is not an indigenous British species.

[24th May, Thun.—Since the above paper was sent in to the Society, I have paid a visit to Switzerland for the purpose of collecting Nicolet's species, and comparing them with those of England. The Thysanura would probably have been much more frequent during the autumn months ; still I succeeded in finding a good many species, on some of which it may be worth while to say a few words*.]

TEMPLETONIA NITIDA.

I had already come to the conclusion that *Podura nitida* of Templeton, one of our commonest as well as prettiest English species, was identical with the *Degeeria margaritacea* of Nicolet, as well as with the *Heterotoma crystallina* (=*Ætheocerus crystallinus*) of Bourlet. In this view I was confirmed by finding it common in Switzerland.

ORCHESELLA MELANOCEPHALA.

Like Nicolet, I found *Orchesella melanocephala* very common in the woods of Chaumont above Neuchatel. The longitudinal lines, however, in the great majority of specimens were so much more distinct and striking than in Nicolet's figure, as to give the insect a very different aspect. I should not have called the fourth segment of the antennæ "violet" in any of the specimens I found. Lastly, the terminal segment of the antennæ was, like the preceding, pale at the base.

SMYNTHURUS AUREUS, mihi.

I found this species sparingly.

* *Pauropus* I found repeatedly at Grindelwald ; and as it has also been discovered in Sweden, there can no longer be any doubt that it is an indigenous European species.

S. LUTEUS, mihi.

This species also was abundant. Yet it seems to have been overlooked by Nicolet. Perhaps he took it for the young form of *S. viridis*.

I also met with a very pretty little species of *Smynthurus*, which differs from any of Nicolet's species. It is white, with two broad transverse purple bands, one occupying the whole of the front part of the body, the other occupying the middle of the abdomen; the antennæ are yellow, and connected at the base by a line of yellow passing into purple; the eyes are on a black patch, and behind each is a purplish band; underneath, the body is altogether white, with two opaque round spots on each side of the spring. This pretty species cannot be confounded with any other; the dorsal surface is divided into five subequal parts—the first, third, and fifth being white, the second and fourth purple, or to the naked eye black.

I hesitate, however, to describe it as a distinct species, because in the form of the antennæ, the feet, and the spring it so very closely resembles *S. luteus*, from which, on the contrary, it differs so much in colouring.

PAPIRIUS.

I found three species of this genus namely, *P. cursor* mihi, *P. Saundersii* mihi, and *P. nigromaculatus*. As far as colouring goes, these three species agree very closely with the three species named respectively by Nicolet *Smynthurus fuscus*, *Smynthurus ornatus*, and *Smynthurus Coulonii*. In all these cases, however, he distinctly figures the antennæ as having the characters of *Smynthurus*. It would therefore be very desirable to ascertain whether there are really any species of the true genus *Smynthurus* answering to Nicolet's description, or whether perhaps he omitted to notice the difference in the antennæ.

MACHILIS POLYPODA.

Lepisma polypoda Linn. Syst. Nat. ii. 1012; Fabr. Ent. Syst. p. 62.
Machilis brevicornis Latr. Nouv. Ann. Mus. i. 79.
Forbicina polypoda Temp. Trans. Ent. Soc. vol. i. p. 92.
Machilis polypoda Gervais, Hist. Nat. Ins. Apt. vol. iii. p. 448; Nicolet, Ann. Soc. Ent. France, 1847, p. 345.

Brown, with metallic reflexions.

Length $\frac{1}{2}$ an inch.

Woods and dry places.

I have only met with one specimen of this species. In Ireland, according to Templeton, it is very common. The head is small; the thorax is not distinct from the abdomen; the prothorax cylindrical; the mesothorax is enlarged and elevated; the metathorax is less raised, short and broad.

The abdomen is 10-jointed and tapers gradually backwards.

The eyes are large, compound, black, and meet in the middle line.

The antennæ are shorter than the body, but in my specimen were imperfect at the ends; they differed, however, considerably from Templeton's figure 1 *c*. The terminal

whip-like portion is divided into much more numerous subsegments, which towards the end become moniliform, have each a whorl of hairs, and fall into groups of seven, each group separated by a well-marked division.

The larger palpi are six-jointed, the three basal segments point forwards, the third being smaller than the other two; the three terminal ones are recurved, and about as long as the two basal. In Templeton's figure only the first two segments point forwards; and they are succeeded by a recurved many-jointed "whip." This does not at all agree with my specimen.

The lesser palpi are three-jointed; the basal segment is shorter than the other two, which are nearly equal in length, the terminal one being somewhat swollen, though not so much so as in Templeton's fig. 1 *d*.

Geoffroy describes the corresponding organs of his *Forbicina teres saltatrix* as two-jointed, another point in which it differs from *M. polypoda*.

The feet are biunguiculate.

I do not find it observed by previous writers that each of the four posterior legs bears an appendage on the basal segment, closely resembling the eight anterior ventral appendages. Their presence appears greatly to strengthen the argument of those who regard these appendages as rudimentary legs. It is moreover peculiarly interesting, if we remember that the peculiar genus *Scolopendrella* has a very similar pair of appendages attached between each pair of legs except the first.

In *M. polypoda* the anterior abdominal segment appears to want these appendages. In the following eight segments they are attached near the posterior margin, and are about equal in size, except the last, which is considerably larger than the rest. Between this last pair is a strong, straight, stiff appendage, which gradually tapers from the base, ending, however, abruptly. It is divided into about thirty subsegments, each with a whorl of stiff, short hairs.

LEPISMA SACCHARINA Linn.

Lepisma saccharina, Fauna Suec. ed. 2, No. 1925; Guérin, Icon. Ins. plate ii. fig. 2.
Forbicina plana Geoff. Ins.
Lepisma saccharina Gervais, Ins. Apt. iii. p. 451.
Lepisma saccharina Temp. Trans. Ent. Soc. i. p. 92.

Silvery white, with a yellowish tinge about the antennæ and legs.

Length $\frac{1}{3}$ of an inch.

Head free. Mesothorax and metathorax somewhat wider, but shorter, than the prothorax. Abdomen gradually tapering.

Eyes black, remote. Antennæ long, tapering; basal segment short, others numerous and still shorter; at some little distance from the base they become rather longer, and gradually divide into two subsegments. They are about two-thirds as long as the body, but are generally imperfect.

The longer palpi are five-jointed. At the base are several stiff spines, bifurcate at the extremity. The mandibles consist of three parts:—1st, a fleshy rounded lobe; 2nd, a pointed process, horny at the extremity; and, 3rd, the main part, provided with four strong teeth and a molar surface.

The smaller are three-jointed, much expanded at the apex. The lower lip is four-lobed; but the lobes are rounded, not pointed as in Treviranus's figure *.

The legs are five-jointed, and the feet biunguiculate. The two basal segments bear a number of stiff spines with bifurcate extremities, like those on the larger palpi (in addition to ordinary hairs). On the underside of each thoracic segment is a sort of flap, beautifully covered with scales. That of the prothorax is very large; the other two are smaller, particularly the one belonging to the metathorax.

The abdominal appendages are confined to the two posterior segments. They are represented, however, on the anterior ones by a group of stiff yellow setæ. There is moreover a second, similar group nearer to the median line, which appears to represent a second process, formed by a prolongation of the ventral margin of the penultimate segment.

Gervais † considers that these appendages should be compared to the branchial appendages in Neuroptera rather than to true legs; he observes, "Cette manière de voir, que nous avons proposée peu de temps après, rend également compte de l'absence de trachées déja constatée par plusieurs observateurs chez les véritables Thysanoures, c'est à dire, chez la famille des Lépismes." The branchial appendages of Neuroptera, however, are dorsal, while those of the Lepismidæ are ventral; moreover, in opposition to the above assertion, the Lepismidæ undoubtedly have tracheæ, although the system may not be very largely developed. It seems to me curious that there should be any difference of opinion on this point, because, from the transparency of the creature, the tracheæ in the legs are visible without dissection. It is true that Treviranus ‡ was unable to satisfy himself as to the presence of tracheæ; but I can only account for this on the hypothesis that he did not examine freshly killed specimens.

The egg-tubes and the formation of the ovum resemble those of Petrobius, as described by me in the 'Philosophical Transactions'*.

The posterior dorsal plate has a squarish termination.

Reproduction of lost Parts.

M. l'Abbé Bourlet, who was unfortunately ignorant of Mr. Templeton's memoir, gave as a character of his genus *Heterotoma* (a name which he subsequently changed for *Ætheocerus*), and which is composed of the species forming Templeton's genus *Orchesella*, that the segments of the antennæ varied from 2 to 5, those even of the same individual being often dissimilar in the number of their segments. He was aware that M. Macquart regarded these differences either as abnormal or accidental; but he rejected this explanation because:—1°. Dans le cas où les antennes sont inégales, le dernier article de la plus courte, quel que soit son rang numérique, n'est jamais conforme à l'article correspondant de l'autre antenne; 2°. il affecte constamment une forme analogue à celle de l'article terminal, ou le cinquième; 3°. il en est de même pour les antennes égales, mais ayant moins de cinq articles; dans ce cas, le dernier est toujours plus gros et plus

* Vermischte Schriften, Tab. ii. fig. 4.

‡ Vermischte Schriften, vol. i. p. 16.

† Suites à Buffon. Insectes Aptères, vol. iii. p. 446.

§ Phil. Trans. 1861, p. 619.

long que le terminal de l'antenne normale, quoique ayant une forme analogue et la même couleur; 4°. on n'aperçoit à l'extrémité de l'article aucune trace de fracture; 5°. plusieurs jeunes Podurides et un grand nombre d'adultes ont été trouvées ainsi conformées; le nombre de celles-ci était, à l'egard des *Ætheocerus* à antennes de cinq articles, comme cinq est à huit; 6°. cette conformation des antennes ne se rencontre que rarement dans les autres Podurides; 7°. toutes les fois que dans les autres genres on trouve des Podurides dont les antennes ont été brisées, la cicatrice est toujours visible et la forme des articles n'a pas varié; 8°. j'ai renfermé dans des vases une certaine quantité d'Ætheocerus dont les antennes offraient les différentes conformations observées par moi; j'y ajoutai plusieurs congénères qui avaient ces organes brisés au moment où elles furent trouvées, ou à qui je les avais moi-même mutilés; au bout de trois mois elles furent retrouvées toutes exactement dans le même état."

Two years later he repeated this argument in the same words in the Transactions of the Soc. d'Agricult. du Départem. du Nord, at Douai, 1841–2.

Yet it is, I think, certain that the antennæ of the species forming his genus *Ætheocerus* (or *Heterotoma*) are normally six-jointed, although they are very frequently mutilated. It is true that in antennæ possessing less than six segments, the terminal one does to a certain extent resemble the terminal segment of an unmutilated antenna; but this is the case, as I have satisfied myself by repeated experiments in artificially mutilated specimens. It is also quite true that the antennæ which are composed of less than six segments show no trace of fracture; but it is equally certain that this is also the case in mutilated specimens after a change of skin. If one removes part of the antenna of an *Orchesella*, the injury is very apparent until the creature moults, after which the end of the antenna becomes more or less regular, according to the time which has elapsed between the wound and the moult. M. Bourlet states that this condition of the antennæ occurs only among the *Heterotomæ*; this, however, is by no means the case. Most of the other genera, indeed, having shorter antennæ, are less liable to injury; and mutilated specimens are therefore much less frequent among them than in the genus *Orchesella*.

Choreutes, however (*Macrotoma* Bourlet), also has long antennæ; and here the mutilations are so frequent that Bourlet actually describes the genus as having three-jointed antennæ, four being the right number. I myself, though I have found hundreds of specimens, have never found a full-grown *Choreutes plumbea* with perfect antennæ. This almost invariable mutilation is an extremely curious fact.

M. Bourlet affirms that really mutilated specimens always show the "cicatrice." The term is scarcely correct; and, as I have already observed, the mark only remains until the next moult. Lastly, M. Bourlet states that, having mutilated the antennæ of several specimens, and placed them with others in which the antennæ were unsymmetrical, he found them at the end of three months exactly in the same condition. This statement is quite contrary to my invariable experience, and, unless he tried it in very cold weather, he must, I think, have made a mistake. In summer the moults always follow one another at comparatively short intervals; and at the first moult after mutilation I have always found a considerable tendency to reparation, which becomes still more manifest after two or three changes of skin.

The explanation of M. Bourlet's mistake, however, is to be found in the fact that an antenna once seriously mutilated never regains its normal number of segments. Such, at least, has been my experience. It is possible that very young specimens may have more complete powers of reparation. I doubt very much, however, whether it is so, because I have observed in *Chloëon* (*Ephemera*) that the terminal segments of the antenna, if once removed, are never replaced (although the antenna continues to grow), so that not one specimen in twenty of those which I examined had perfect antennæ when the insects were half-grown.

As illustrating the partial recovery which takes place, I will take the following cases from my note-book

On the 11th of April, I removed the terminal portion of the right antenna of a pale *Orchesella cincta*, at the middle of the second segment, as shown in Pl. XLV. fig. 1. On the following day the animal moulted, and the mutilated antenna was as in fig. 2, the second segment being a little elongated, but not much altered, probably on account of the short time which intervened between the mutilation and the moult. On the 19th of April the antenna was as in fig. 3, and consisted of three segments. The second and third were quite unlike those of normal specimens, the second being unusually large, and the third, which is normally quite short, being elongated and somewhat club-shaped. Subsequently both these segments, and especially the third, elongated somewhat (fig. 4), but they made no further approximation towards the normal form.

Again, on the 5th June, I treated another specimen in the same manner, leaving the antenna in the state shown in Pl. XLV. fig. 5. On the 17th June it had moulted, and was as in fig. 6. Here, the mutilation having taken place near the extremity of the segment and some days before the moult, it will be seen that more change has taken place than in the preceding case. The antenna is three-jointed, the two apical segments presenting the same peculiarities as in the preceding specimen. Subsequently the terminal segment elongated as in fig. 7; but no further change took place.

I made a few more similar experiments with similar results, but was reluctant to multiply them too much, being unwilling to cause unnecessary pain, and seeing no reason to expect any materially different results.

It is remarkable that in all these cases the terminal segment acquires a length even greater than that which it possesses in normal specimens. This is well shown also in *Choreutes*. In this genus I have satisfied myself, both by direct experiment, and also by watching specimens which I had met with accidentally, that if the terminal segment is removed it is never replaced, though the third segment acquires an unusual length. I have even seen specimens, under these circumstances, in which the third segment acquired a length almost equal to that of the third and fourth segments of a normal antenna.

Anatomy.

Intestinal Canal.

According to Nicolet (*l. c.* p. 46), the digestive organs of the *Thysanura* consist of six parts—namely, l'ésophage, le jabot, le ventricule chylifère, les vaisseaux hépatiques, l'intestine grèle, et le cæcum." By the "cæcum" he evidently means the rectum. Nicolet gives his description of these parts as applicable to the order generally, and does not mention which genus or genera he particularly examined. In those which I have dissected, and particularly in *Tomocerus*, *Orchesella*, and *Smynthurus*, the digestive organs pass straight through the body without any circumvolutions from the head to the tail, and fall into three divisions, the œsophagus, the stomach, and the rectum. I think there are no Malpighian vessels.

Von Olfers, the only naturalist who has, since my paper in the 'Linnean Transactions' (which, however, he does not appear to have seen), occupied himself with the anatomy of the *Thysanura*, also describes and figures the intestinal canal, at least in *Orchesella*, as a straight tube passing directly from one end of the body to the other, and falling into three divisions, the œsophagus, the ventriculus, and the rectum.

The œsophagus is rather long, narrow, and composed of an inner chitinous membrane, thrown more or less into folds, and a cellular envelope, outside which, again, is a loose and very delicate membrane. Nicolet describes a crop as existing between the œsophagus and the intestine stomach; but he admits that it is only "une simple dilatation de l'ésophage, dont le diamètre varie selon que l'insecte a plus ou moins mangé."

Von Olfers was, I believe, the first to observe that from one side of this swelling, which is somewhat thickened, rises an elongated membranous tube. This he regards as the salivary gland; and he considers that it really rises immediately behind the mouth, passing backwards along the œsophagus, to which, however, it is so firmly attached that "ne vi quidem separari possint" (they can hardly be separated even by force). In fact, if the "salivary gland" and the stomach be pulled in opposite directions, as far as my experience goes, the former gives way.

The stomach is capacious, and extends in a straight line from the posterior end of the œsophagus to the commencement of the intestine. It is of even width throughout. Externally it is provided with both longitudinal and transverse muscles, which give it a pretty reticulated appearance (Plate XLV. fig. 13). The transverse series is the most numerous, the spaces between the muscles being something less than twice the width of the muscles themselves. In some places, as in Plate XLVI. fig. 15, they anastomose frequently. This appeared to me to be more the case in some specimens than in others. The distances between the transverse muscles are much larger. The stomach contains, besides the food, a large number of clear round cells containing smaller cells or vacuoles. It is, moreover, often occupied by a number of Gregarinas.

According to Nicolet, the Malpighian vessels are probably six in number. He says, "Les vaisseaux hépatiques, dont je n'ai pu au juste reconnaître le nombre, mais que je crois être de six, sont tubuleux et filiformes ou du même diamètre dans toute leur

longueur; ils sont insérés immédiatement au-dessus du rétrécissement pylorique; leur longueur égale à peine la moitié de celle du ventricule chylifère; du reste, leur extrême ténuité et leur peu de consistance ne m'ont pas permis de les étudier en détail" *. Von Olfers also describes them as "filiformia, tenerrima;" but he only saw four. When the Malpighian vessels are very numerous, it is naturally difficult to count them; but as they are in this group so few, Nicolet can certainly not have seen them very distinctly when he remained in doubt as to the number.

For my own part I have examined *Orchesella fastuosa*, the species in which they are figured by Von Olfers, as well as *Tomocerus plumbeus*, *Smynthurus*, and other species, but have never been able to satisfy myself that any such organs really exist.

The intestine has, in *Tomocerus*, a length of about $\frac{1}{35}$ of an inch. It is straight, and of even diameter. It is strongly muscular, being provided throughout its whole length with transverse muscles, which lie close together, and are about $\frac{1}{1500}$ of an inch in diameter.

Respiratory Organs. (Plate XLV. figs. 7, 8.)

The condition of the respiratory system of the *Thysanura* is a question of much interest.

Nicolet describes a series of spiracles situated at the sides of the superior arches of the abdomen. The tracheæ extend, according to him, in an undulating line from the head to the tail, each undulation corresponding to a segment, and sending out on the one side a short branch to the corresponding spiracle, and on the other a number of branches which ramify over the different organs of the body. There are also on each side six pneumatic sacs which lie longitudinally, communicate by a short duct with the main tube, and give out from the posterior end two branches, one of which goes to the side of the body, passing under the principal trache a. He figures the tracheæ arranged in this manner in *A. fimetarius*, and, though not expressly saying so, appears to regard the description as applicable to all the *Podurelles* (Thysanura).

In my first memoir in the 'Linnean Transactions' (vol. xxiii. p. 429), on the contrary, I have described the tracheæ of *Smynthurus* as opening by two spiracles in the head, opposite the insertion of the antennæ—that is to say, on the lower side of the head, if it is placed with the antennæ and eyes upwards, or on the back part when it is in its natural perpendicular position.

As regards *Achorutes* and the allied genera, Von Olfers repeats the statements of Nicolet. His own observations were made on *Smynthurus oblongus*, *Tomocerus plumbeus*, and *Orchesella fastuosa*. In these he found the respiratory system formed on one plan. They have two spiracles only; and these are situated on the inferior side of the thorax, close to the first pair of legs. From each spiracle start three principal trunks, one of which goes forwards, one upwards, and one backwards. The first two are immediately divided into a great number of branches, which are extremely narrow. The other passes to the middle line, lies close to the corresponding trachea of the other side, without, however apparently uniting with it, and then also breaks up into a number of fine branchlets.

I have again examined *Smynthurus*, and can only confirm my previous statements. Von Olfers, without being acquainted with my memoir, agrees with me, as we have

* *L. c.* p. 47.

seen, that there is only one pair of spiracles. He considers, however, that they are situated in the thorax, close to the place of insertion of the anterior legs, while I think they are in the head.

I will not be so bold as to say that there certainly is no spiracle in the place indicated by Von Olfers; the animal is so small and so inconvenient for dissection, that I will not venture to make a positive assertion in opposition to one who has evidently worked with much care and skill. Nevertheless I think he has been misled by the fact that at this part the tracheæ are held in place by the rather large branch given off to the anterior leg. I think I have traced all the tracheæ up into the head, and that the only spiracles possessed by *Smynthurus* are situated in the head, at the place where it is attached to the body.

As regards the other species, I differ still more from M. Nicolet and Von Olfers. I have examined *Tomocerus plumbeus*, as well as species of *Achorutes*, *Lepidocyrtus*, *Isotoma*, *Lipura*, and am satisfied that they do not possess any tracheal system answering to the descriptions either of Nicolet or of Von Olfers.

The Generative Organs.

I have already described the generative organs of the *Smynthuridæ* in my first paper. Those of *Tomocerus*, which may be taken as representing the *Poduridæ*, are very simple, and in both sexes consist of two tubes, commencing near the anterior end of the abdomen. They widen gradually as they pass back, and open on the ventral side of the posterior segment behind the base of the spring.

Nervous System.

Tomocerus.

In the head are two ganglions, the supra- and infraœsophageal, which are connected by two short commissures, between which the œsophagus passes as usual.

The remainder of the nervous system consists of three ganglia, lying in the thorax and first abdominal segments. The posterior ganglion is much the largest and is double. The hinder portion is somewhat square-shaped, and sends off several strong nerves backwards.

Smynthurus.

Nicolet was unable to discover the nervous system in the linear Thysanura while that of the globular species appeared to me much more difficult to make out. As described by him, *Smynthurus* has, like *Tomocerus*, two ganglia in the head, and three in the thorax. The supraœsophageal ganglion is large, and gives off the nerves for the eyes and the antennæ.

Muscular System.

Smynthurus.

Muscles of the Caudal Appendage. (Plate XLV. figs. 9–11.)—So far as I am aware, no naturalist has hitherto given any account of the muscular system in the Thysanura.

With patience and spirits of wine, however, I have been able to make out the principal muscles pretty clearly.

Muscles of the Spring.—These muscles (Plate XLV. figs. 9–11) are nine in number on each side of the body. The stoutest of all (Plate XLV. fig. 10, *a b*) rises on the ventral side of the body, close to the middle line, and immediately in front of the reversible base of the saltatory apparatus. It passes upwards, expanding gradually, and is inserted by two heads on the side-wall of the body (Plate XLV. fig. 10, *b*).

The second muscle, which is much smaller (*c d*), rises behind the first, and somewhat further from the middle line, being separated from the corresponding one on the other side by the central thickened part of the reversible base of the spring. It passes straight upwards, without altering in diameter, and is attached to the skin at *d*, behind but on the same line as the preceding muscle.

The third muscle (*e f*) rises close to the preceding, but a little outside it, and, passing upwards and forwards, is attached close to the posterior branch of the first muscle, by which, therefore, in Plate XLV. fig. 10, it is necessarily concealed.

The fourth (*g h*) lies parallel to, and rather behind the second; it is, however, rather shorter, and consequently does not reach so far up towards the back.

The fifth (*i j*) rises close behind the last three. It is shorter and broader, and passes straight backwards to the posterior wall of the body, where it is inserted between the spring and the small terminal abdominal segment. The other four muscles belong to a different group altogether. The first of them (Plate XLV. fig. 10, *k l*) rises rather behind and outside the ventral attachment of the muscle *a b*. It then passes upwards and forwards and is inserted on the lateral wall of the body immediately above the ventral tube, and about halfway between it and the central line of the back.

The sixth muscle (*m n*) rises close to the preceding, between it and the first, and has the same general direction, but is inserted higher up.

The seventh (*o p*) rises close to *c*, and consequently further back than either of the preceding, nor does it pass quite so far forward. It is attached not very far from *k*, but behind it.

The last of this group (*q r*) rises close to *n*, and is inserted below *o*.

Plate XLV. fig. 10, *s t*. This is a small muscle which moves the second segment of the spring.

There are also several other small muscles in the posterior part of the abdomen, and belonging either to the terminal abdominal segment or to the rectum.

If a *Smynthurus* be examined after death, the tail will almost invariably be found extended as in Plate XLV. fig. 11. If, moreover, we consider the mode in which the muscles just described act on the spring, we shall see that the most powerful of them tend to draw it forward, and not to extend it.

When, indeed, we see a *Smynthurus* leap, one is apt to be surprised at the muscular force which it must possess. It would appear, however, that its power of jumping arises from the elasticity of the spring, and not from direct muscular action. I presume that this is a more economical arrangement of force. It certainly may require less strength to pull the spring gradually forwards into position than it would to strike it

against the ground with force enough to throw the *Smynthurus* so high up into the air. We see the difference very well in a crossbow; the muscular effort required to set the bow is much less than that which would be necessary to project the arrow as far if applied directly. One might suppose that though the force required to pull the spring forward might be much less than that necessary to move it backwards, still, as the spring is habitually carried with the points forward, there would be a constant strain in the one case, and only an occasional effort wanted in the other.

When, however, the spring points straight forwards, there is perhaps little strain on it; moreover there is a little catch (Plate XLV. figs. 10 & 11), which is an organ homologous with the spring itself, but situated on one of the anterior segments; this passes between the two arms of the spring, and keeps them in place. It answers in fact to the catch in a crossbow, and as soon as it is drawn forwards, the muscle pulls the spring downwards, and its own elasticity does the rest.

A priori it might have been supposed that a position of rest was one of relaxation, in which the muscles were, so to say, at ease, but ready to spring up to attention in a moment if necessary. On the contrary, however, we find very often that a position of rest is a state of opposite tensions.

Take, for instance, our own case. The upright position which seems so easy and natural to man, is, says Prof. Huxley, in his excellent lessons in elementary physiology, "the result of the contraction of a multitude of muscles which oppose and balance one another. Thus, the foot affording the surface of support, the muscles of the calf must contract, or the legs and body would fall forward. But this action tends to bend the leg; and, to neutralize this and keep the leg straight, the great muscles in front of the thigh must come into play. But these, by the same action, tend to bend the body forward on the legs; and if the body is to be kept straight, they must be neutralized by the action of the muscles of the buttocks and of the back."

I will take one more illustration from a very different part of the organized kingdom.

In most of the Orchids, as Mr. Darwin has shown us in his excellent work on that order of plants, the pollen from one flower is carried by insects to another; and if this is not done, the flower is not fertilized and the seed is not developed. Now, in our own small Orchids, when an insect lights on the flower the sticky end of the pollinium adheres to the insect, and is thus carried away; in some of the large tropical Orchids, however, the part of the flower which insects visit is so far from the pollen-masses that a different arrangement is necessary. In *Catasetum*, for instance, there is a long sensitive process, or antenna, which hangs over the part on which insects alight, in such a manner that they can scarcely fail to touch it. Directly they do so, the flower throws its pollen-masses in the direction of the insect, and with such force that they will fly two or three feet. I have myself seen a flower, when its antenna was touched, throw the pollen-masses for about two feet, across a small table and to a window, on which they stuck.

This is not effected by muscular action; but the stalk on which the pollen-masses stand is bent round a protuberance, and held in position by a delicate membrane. When the sensitive antenna is touched, this membrane gives way, and the elasticity of the pollen-stalk throws it forwards with much force, as just described.

Ventral Tube. (Plate XLV. figs. 10, 11, 12.)—I have already described the arrangement of the muscles belonging to this curious organ in my previous paper; but I refer to it again because I think the figures now given will make the mechanism more clear.

As I have there pointed out, it is evident that the protrusion of the two filaments could not be effected by muscular influence, excepting, indeed, by the indirect effect of those muscles which contract the cavity of the body, and thus, intensifying the general pressure, squeeze out as it were the two filaments.

For retraction, however, there are two muscles, *a' b'* and *c' d'*. The first is attached to the extreme end of the filament (which in Plate XLV. fig. 12, is represented as partially retracted); it passes all along the filament, and then close to the walls of the body, between them and four lateral muscles, which tend to keep it in place, and is then attached to the back, not far from *m*, and near the median line. The other muscle (*c' d'*) is attached to the middle of the filament; it runs parallel to the preceding, also passes between the four lateral muscles and the skin, and divides into two ends, which terminate near one another, and still close to the central line of the body. One of the filaments, in a state of almost complete extension, is represented in Plate XLV. fig. 11. In Plate XLV. fig. 10 are seen the same parts during retraction: *e'* is the filament, turned, of course, inside out; and the muscles are lettered as before.

The presence of two muscles instead of one is necessary, owing to the length of the organ. It is evident that by itself the muscle *a b* would be able only partially to withdraw the filament, the length of the latter being greater than the distance from the insertion of the muscle to the end of the ventral tube, *e'*; the terminal portion of the filament would therefore still be left outside, if it were not for the muscle *c' d'*. Moreover, when the organ is about to be protruded, it is probable that the muscle *c' d'* relaxes first, and thus the filament passes out regularly, whilst, if there were only one muscle, it might from its length, get into a knot.

Muscular System of Tomocerus.

I will now pass to the abdominal muscles of *Tomocerus*, and will more particularly describe those of the 3rd and 4th abdominal segments, as these are specially concerned in the mechanism of the spring.

Fourth Abdominal Segment. (Plate XLVI. figs. 18, 19, 20.)—If we commence the description of the abdominal muscular system from the dorsal line, the first muscle we shall meet with is a straight wide muscle (1), which lies on each side of the dorsal vessel, rises at the front margin of the segment, and passing directly backwards, through the segment and over the intersegmental membrane, is attached to the anterior margin of the following segment. In several cases I have found it continuous with the corresponding muscle of the preceding segment.

2. This muscle lies outside the preceding, and therefore, in Plate XLV. fig. 7, is under and hidden by it. In some specimens it is straight, in others, as in the one figured, it lies a little diagonally.

3 crosses under, or rather outside, no. 2. Like the two preceding, it rises at the anterior margin of the segment, and passes to that of the penultimate one.

4. This muscle is one of those that move the tail. It rises close to, but at the side of the preceding, and passes diagonally backwards and downwards, curling round no. 5, which will be described next, and eventually reaching its posterior attachment at the dorsal side of the root of the tail.

5. This muscle rises with a double head immediately below the preceding, and, passing backwards, twists as it were round it, and is also attached to the posterior margin of the following segment.

6, 7. This is a transverse muscle. Its upper end is double, and is attached not far from, but rather in front of, the middle of the segment. It passes straight down, and is inserted into the central ventral piece.

8 is inserted close to the anterior end of no. 5, and passes diagonally backwards and downwards, outside no. 6, and is attached to the lower side of the penultimate segment.

9 lies immediately outside no. 4, but is somewhat straighter, as it is not affected by no. 5.

10 rises nearly in the centre of the side-wall, opposite the middle part of no. 6, and, passing backwards, is attached close to the posterior end of no. 4.

11 lies just outside no. 10, and has the same direction and attachments. In some specimens these two muscles seemed to form one only.

12. This powerful muscle is the principal extensor of the tail, and passes forwards along the ventral surface, through the antepenultimate segment, and is attached at the anterior end of the third abdominal segment.

Third Abdominal Segment.—1. This muscle corresponds to the muscle, no. 1, of the fourth segment, immediately in front of which it lies, and with which, in some specimens, as already mentioned, it even forms one continuous muscle. It generally, however, commences near the middle line of the back, on the side of the dorsal vessel, and directly in front of the anterior end of the corresponding muscle of the following segment, and, passing straight forwards, is attached to the anterior margin of the segment.

2. This muscle, as in the fourth segment, is smaller than, and lies under, or rather outside of, the preceding.

3 rises at the anterior end of the segment, partly under and partly at the side of no. 1, and passes rather diagonally backwards under no. 2.

4 runs at the side of, and parallel to, no. 3.

5 rises at the side of no. 1, and passes forward parallel to it, but, instead of being attached at the anterior end of the segment, passes forward, completely through it, to the anterior edge of the second, where it is inserted, partly below, and partly at the side of, the muscle no. 1 of that segment.

6, 7. These two muscles correspond to those which I have indicated by the same numbers in the fourth abdominal segment. They rise, side by side, at the lateral edge of no. 5, and not very far from the anterior margin of the segment. They are largest at their dorsal extremity, and pass straight downwards.

8. This powerful muscle rises at the anterior margin of the antepenultimate segment, at the side of no. 5, and passes downwards and forwards, dividing into two branches, which, at their lower and anterior extremity, are intimately connected with the neigh-

bouring portions of nos. 6 and 7, as well as of the muscle no. 16, which has not yet been described. The lower branch terminates in the third segment before arriving at its anterior margin; but the upper branch is longer, and penetrates into the next segment.

9 rises below, and close to, no. 8. It has the same general course, but diverges somewhat, and ends at about the middle of the segment. It will be seen, from my drawing, that the end lies under the muscle marked no. 16, and over that marked no. 15. It cannot, therefore, be directly attached to the skin in this position, because the muscle no. 15 comes directly in the way. The true attachment of this end of the muscle, like that of nos. 6 and 7, and the posterior branch of no. 8, with all of which it is closely connected, is not easy to make out. I believe, however, that a delicate membrane passes from its lower extremity, both backwards and forwards, over no. 15, and that, by thus acting on the centre of that membrane, the same effect is produced as if the muscle were actually attached to the skin at the point where it terminates.

10 rises under the posterior terminations of nos. 5 and 8, and passes forwards with a slight inclination downwards. It passes on the outer side of nos. 6 and 7, and is attached, in the ordinary way, to the anterior margin of the segment.

11 lies outside the preceding. Some of the upper fibres did not, in the specimens I examined, reach so far as the margin of the segment.

12. No. 12, which belongs partly to this segment and partly to the antepenultimate, has already been described.

13. This powerful muscle rises by a double head. One portion lies under no. 12, which is cut away at that part in Plate XLVI. fig. 19, in order to show no. 13; the other and larger portion is attached by a broad base to the gently curved arch, which here runs along the segment. Both branches soon unite, and pass straight forward completely through this segment, to the anterior margin of the second.

14. This and the following are short, but powerful, transverse muscles. The present one rises under no. 13, but extends somewhat in front of it, and passes downwards and a little forwards to the ventral part of the segment.

15. This muscle is attached, like the preceding, which it crosses, to the gently curved arch already mentioned. It is attached above, in front, and below behind the preceding muscle, outside of which it runs. These two muscles are fan-shaped; and though their ventral ends are of moderate size, their dorsal extremities are so wide that between them they extend over the whole length of the segment.

16 also rises by two heads, and lies outside no. 15; it passes forward, straight into the thorax, and is attached close behind the head.

Second Abdominal Segment.—In this segment the dorsal muscles are much weaker than in the preceding. In several cases I even found nos. 1, 2, 3, and 4 entirely deficient. No. 5, on the contrary, seems to be always present. There are, indeed, two muscles marked thus. The one rises in the third abdominal segment, as I have already mentioned, and passes forwards, dividing into two heads, which are attached to the anterior margin of this segment. The other, which corresponds with it, rises at the posterior end of this segment, at the edge of the muscle just described, and, passing through the present segment, is attached to the anterior margin of the first abdominal segment.

On the Classification of the Thysanura.

Linnæus placed his genera *Lepisma* and *Podura* immediately after the Diptera, and at the head of the Aptera, followed by *Termes*, *Pediculus*, *Pulex*, *Acarus*, *Phalangium*, *Aranea*, *Scorpio*, *Cancer*, *Monoculus*, *Oniscus*, *Scolopendra*, and *Julus*, in the above order.

The system adopted by Geoffroy was very similar. He classed *Podura* and *Lepisma*, however, between *Pediculus* and *Acarus*.

Fabricius, on the contrary, on account of the structure of their mouths, united them with the Neuroptera in his order Synistata; and in this view he was followed by Blainville.

The order Thysanura was established in 1796 by Latreille, who placed it between Pulex and the Parasita. In the 'Considérations Générales' (1810), he arranged it with the Myriopoda, and Parasita among the Arachnida.

Lamarck, in his 'Animaux sans Vertèbres,' adopted the group Thysanura, which he united with the Myriopods to form his Arachnides Crustacéennes, constituting the first section of his Arachnides antennées-trachéales. He even regarded the Thysanura as more nearly allied to the Crustacea than to the Insecta; they are, he said, "assurément point des Crustacés et encore moins des Insectes." In separating them thus widely from the other Hexapods, he seems to have been mainly influenced by the absence of metamorphoses.

Cuvier, on the contrary, regarded them as true insects, and arranged them as the second order, preceded by the Myriopoda, and followed by the Parasita.

Burmeister, in his 'Handbuch der Entomologie,' treats the Thysanura as a separate tribus, which he places between the Mallophaga and Orthoptera.

According to Bourlet, the Thysanura follow the Myriopods, and constitute the first order of insects.

Lucas adopts Laporte's name of "Monomorphes" for the Thysanura, and places them between the Myriopods and the Anoplura.

M. Gervais, in the 'Histoire Naturelle des Insectes Aptères,' points out the great diversity which exists between the Lepismidæ and the Poduridæ. Referring to the classification of Fabricius and Blainville, who placed the Thysanura amongst the Neuroptera, he says, "Les Thysanoures ainsi envisagées sont donc des Névroptères frappés d'un arrêt de développement. C'est ce que nous admettons parfaitement pour les Lépismes et genres voisins, mais il nous paraît impossible d'en dire autant, ou du moins dans le même sens, pour les Podures. Le petit nombre des anneaux du corps des Podurelles les rapproche des Insectes épizoïques, et le reste de leur organisation diffère complètement de celle des Lépismes. Il serait donc plus convenable de créer à leur intention un ordre particulier parmi les Insectes hexapodes, dont le corps n'a pas le nombre normal d'anneaux. Nous laisserons à cet ordre des Podures et des Smynthures le nom de *Podurelles*, c'est à dire qui saute avec sa queue, puisque c'est là nu de leurs caractères les plus généraux"*.

Gerstäcker, in the 'Handbuch der Zoologie,' places the Thysanura amongst the Orthoptera, on account of the absence of metamorphoses, and the mandibulated

mouth. Although, however, the Poduridæ and Smynthuridæ certainly do possess mandibles, still their mouth differs very greatly from that of all other mandibulated insects.

The points which we have principally to consider in relation to the classification and position of the Thysanura are:—the absence of metamorphoses; the absence of wings; the presence or absence of tracheæ; the structure of the mouth; the saltatory caudal appendage; and the ventral tube.

The last-mentioned organ, though observed by most of the preceding writers, has not, I think, attracted the attention it deserves. It is, in fact, the true characteristic of the group. The absence of wings and of metamorphoses is not peculiar to the Thysanura; in fact the presence of metamorphoses is closely connected with that of wings. To the tracheæ we must not attach too much importance; for though absent in the great majority of the group, they occur in *Smynthurus*. The peculiar mouth-parts of the mandibulate genera are entirely absent in Anura; and the caudal appendage is wanting in the *Lipuridæ*.

Thus, then, the ventral tube is characteristic as being general to the true Thysanura, and still more so as being peculiar to them; for I know of no similar organ in any other group of Articulata. The presence of tracheæ, the structure of the mouth, and the abdominal appendage, all indicate a wide distinction between the Lepismidæ and the Poduridæ, and, when considered in conjunction with the fact that the ventral tube is absent among the former, force us to the conclusion that the two groups are much less closely allied than has hitherto been supposed.

We must, indeed, in my opinion, separate them entirely from one another; and I would venture to propose for the group comprised in the old genus *Podura* the term Collembola as indicating the existence of a projection or mammilla enabling the creature to attach or glue itself to the body on which it stands.

We now come to consider whether it should be classed among the Insecta, or whether Lamarck was right in separating it from that great class. Taking each of the characteristic points separately, we begin with the absence of metamorphoses. To this we must not attribute too much importance. There are species of Orthoptera and of Neuroptera which are almost in a similar position. So, again, as regards the absence of wings, the same argument holds good: in all orders of insects there are wingless species. Moreover, although it may seem paradoxical to say so, the character of an organ is of greater classificatory value than the absence of it. Thus, for instance, we have cattle and deer without horns, but no cows have deers' horns or *vice versâ*. So the presence of four wings is absolutely peculiar to the Insecta; but some insects have only two wings, and in all the large orders there are species without any wings at all. The absence of wings is therefore no conclusive evidence against classing the Collembola amongst the Insecta.

The absence of tracheæ is more significant. That of wings involves only inability to fly, but that of tracheæ implies that respiration is carried on in a different manner. The importance, however, of the difference is reduced to a minimum, because

L. c. vol. iii. p. 378.

there are no other special organs for respiration, and the process seems to be carried on through the skin. Moreover, while *Papirius*, like most of its allies, has no tracheæ, *Smynthurus* has a well-developed system. I know hardly any other case of species, so closely resembling one another in other respects, differing so entirely as to one of the most important parts of their internal anatomy.

The structure of the mouth, as far as it goes, is unfavourable to the view of those who regard the Collembola as true insects. I quite agree with Dr. Meinert that the mouth differs essentially from both the principal types found among insects, without, however, making any near approach to that of the Myriopoda or the Arachnida*.

The presence of a saltatory caudal appendage must be taken for what it is worth. It is very remarkable that no similar apparatus is possessed by any one of the almost innumerable insects, many of which, however, possess the power of leaping in a high degree. Nor, on the other hand, do any of the Collembola jump like *Gryllus*, *Haltica*, or *Pulex*, by means of their hind legs. The true value of such a character as this, however, is as difficult to estimate as it it is easy to apply.

The same observations apply to the gastric tube, which, as I have already observed, is even more characteristic of the Collembola than the caudal appendage.

As the upshot of all this, then, while the Collembola are clearly more nearly allied to the Insecta than to the Crustacea or Arachnida, we cannot, I think, regard them as Orthoptera or Neuroptera, or even as true insects. That is to say, the Coleoptera, Orthoptera, Neuroptera, Lepidoptera, &c. are, in my opinion, more nearly allied to one another than they are to the Poduridæ or Smynthuridæ. On the other hand we certainly cannot regard the Collembola as a group equivalent in value to the Insecta. If, then, we attempt to map out the Articulata, we must, I think, regard the Crustacea and Insecta as continents, the Myriopoda and Collembola as islands—of less importance, but still detached.

Or if we represent the divisions of the Articulata like the branching of a tree, we must picture the Collembola as a separate branch, though a small one, and much more closely connected with the Insecta than with the Crustacea or the Arachnida.

The Collembola fall into five well-marked families. Two of these (the Smynthuridæ and Poduridæ) have long been recognized. The former, however, must certainly be divided into two, the Smynthuridæ and Papiriidæ, characterized respectively by the presence and absence of tracheæ. It is true that the former family will contain only two genera, the latter only one; but if our classification is to have any scientific value, it is impossible to place in one family species which differ so much in their internal anatomy.

The Poduridæ must be divided into three families—the Poduridæ proper, the Lipuridæ, and the Anuridæ. The two former have mandibulated mouths, the latter suctorial; the former is saltatorial, the two latter do not possess the characteristic spring. The

* I say any "near" approach, because as Mr. Humbert has pointed out to me, the mouth parts of *Scolopendrella* in some points approach those of the Collembola. This genus, indeed, appears to be more interesting and peculiar than either Gervais or Newport supposed. For instance, it has on the underside of each segment a pair of appendages closely resembling those of the Lepismidæ—a fact which suggests doubts whether the subabdominal appendages of that group really represent the legs of Myriopoda.

Lipuridæ and Anuridæ contain at present only a single genus each. The Poduridæ, on the contrary, contain nine genera, which may be distinguished from one another, as in the following table:—

- Body globular..
  - Without tracheæ ..... *Papirius.*
  - With tracheæ
    - Antennæ 4-jointed ..... *Smynthurus.*
    - Antennæ 8-jointed ..... *Dicyrtoma.*
    - Antennæ 6-jointed ..... *Orchesella.*
- Body elongated ..
  - Saltatorial
    - Saltatory appendage long ..
      - Antennæ 4- or 5-jointed ..
        - With scales
          - Terminal segment of antennæ ringed
            - Two terminal segments ringed ....
              - Eyes 7 in each group ..... *Choreutes* (or *Tomocerus*).
              - Eyes absent.. *Tritomurus.*
            - Third segment simple ..... *Templetonia.*
          - Terminal segment of antennæ simple
            - No eyes ..... *Beckia.*
            - With eyes.
              - Head exposed..... *Seira.*
              - Head more or less concealed under thorax ..... *Lepidocyrtus.*
        - Without scales .. Abdominal segments ..... unequal ..... *Degeeria.*; subequal ..... *Isotoma.*
    - Saltatory appendage short .... Foot biunguiculate ..... *Achorutes.*; Foot with one claw ..... *Podura.*
  - Non-saltatorial .... Mouth mandibulated..... *Lipura.*; Mouth suctorial ..... *Anura.*

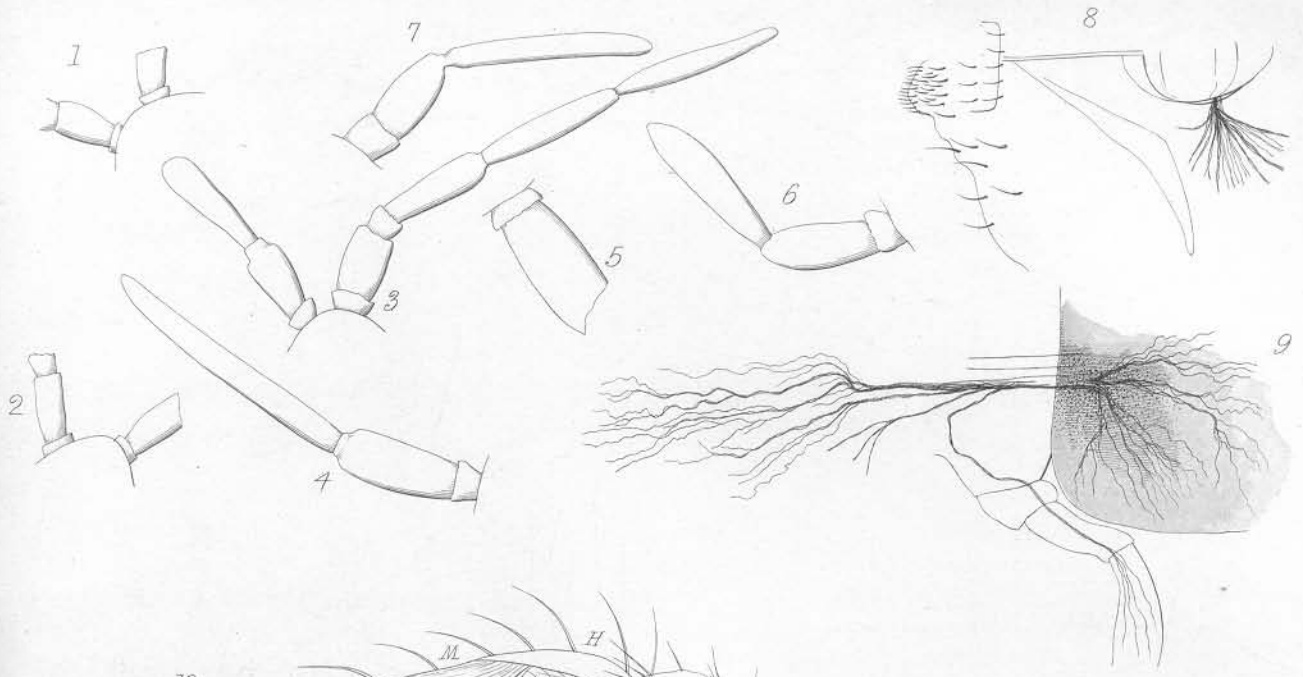
EXPLANATION OF THE PLATES.

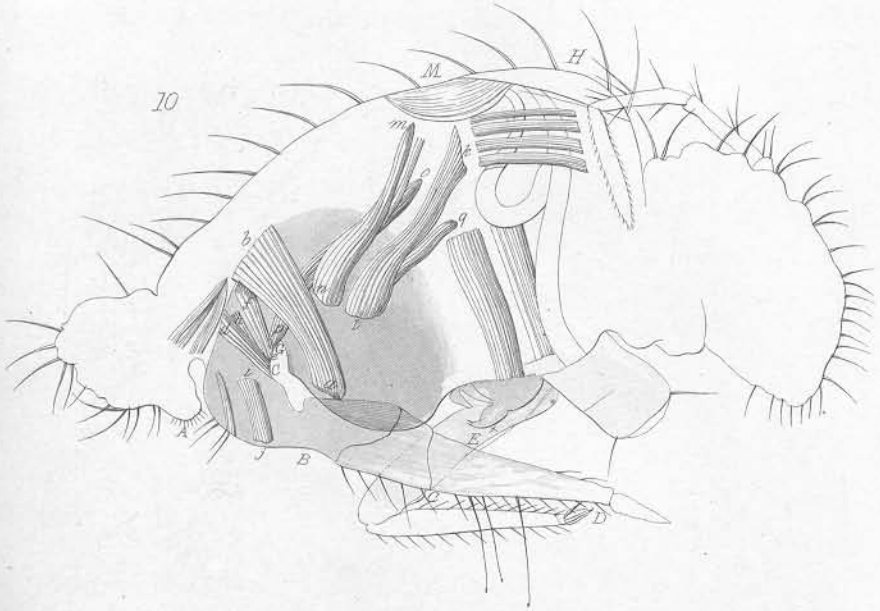
PLATE XLV.

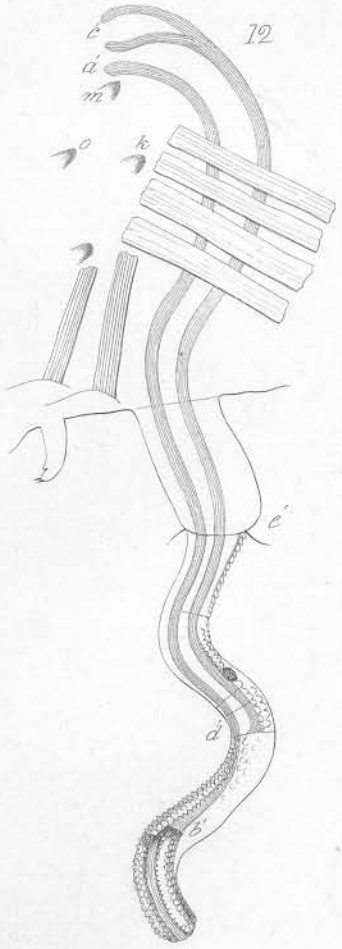
Fig. 1. Outline of a mutilated antenna of *Orchesella cincta*, April 11, × 60.
Fig. 2. The same, April 12, × 60.
Fig. 3. The same, April 19, × 60.
Fig. 4. The same, May 8, × 60.
Fig. 5. Outline of another mutilated antenna of the same species, June 5, × 60.
Fig. 6. The same, June 17, × 60.
Fig. 7. The same, June 24, × 60.
Fig. 8. Part of head of *Smynthurus*, from below, to show the orifice of the tracheæ.
Fig. 9. Part of respiratory system of *Smynthurus*, × 30.
Fig. 10. *Smynthurus*, side view, with the spring retracted, × 125.
Fig. 11. *Smynthurus*, side view, with the spring extended, × 125.
Fig. 12. Ventral tube, partially extended, with its muscles. × 125.
Fig. 13. Muscles of stomach of *Choreutes*, × 125.

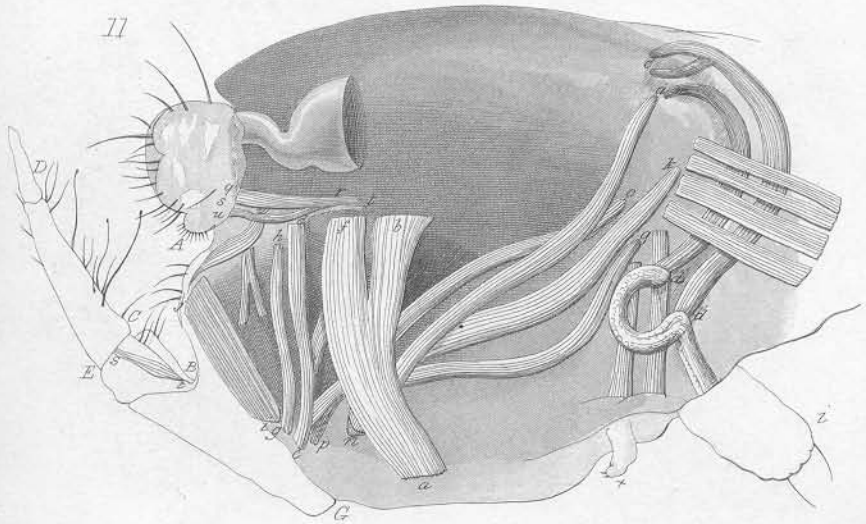
PLATE XLVI.

Fig. 14. Muscles of stomach of *Choreutes*, × 125.
Fig. 15. Underside of posterior end of abdomen of *Choreutes*, × 125.
Fig. 16. Muscles of stomach of *Choreutes*, × 125.
Fig. 17. Portion of skin of *Choreutes*, × 125.
Fig. 18. Side view of abdomen of *Choreutes*, to show the muscles (inner layer), × 125.
Fig. 19. Side view of abdomen of *Choreutes*, to show the muscles (outer layer), × 125.
Fig. 20. Arrangement of muscles on the ventral surface of the posterior abdominal segments of *Choreutes*.


1
2
3
4
5
6
7
8
9

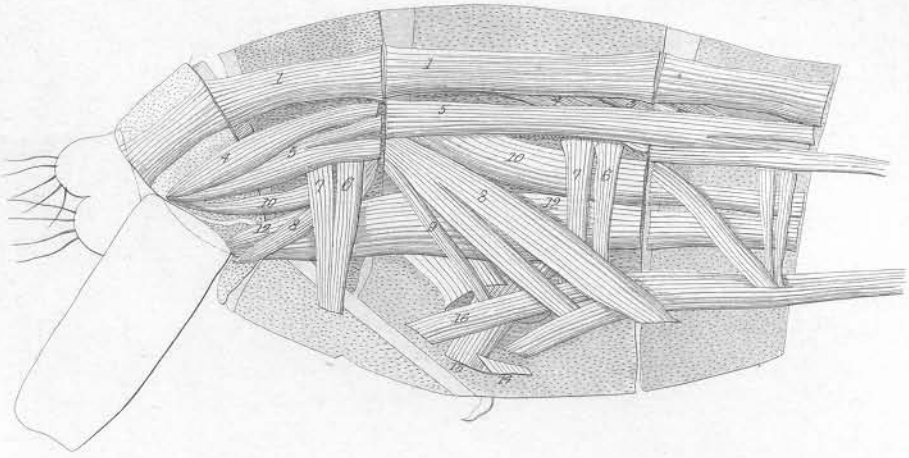

10
M
H
A
B
D
E


12
c
d
m
o
k
c'
d'
b'

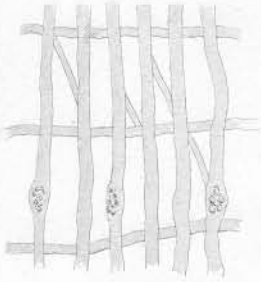

11
A
B
C
D
E
G
a
z

13

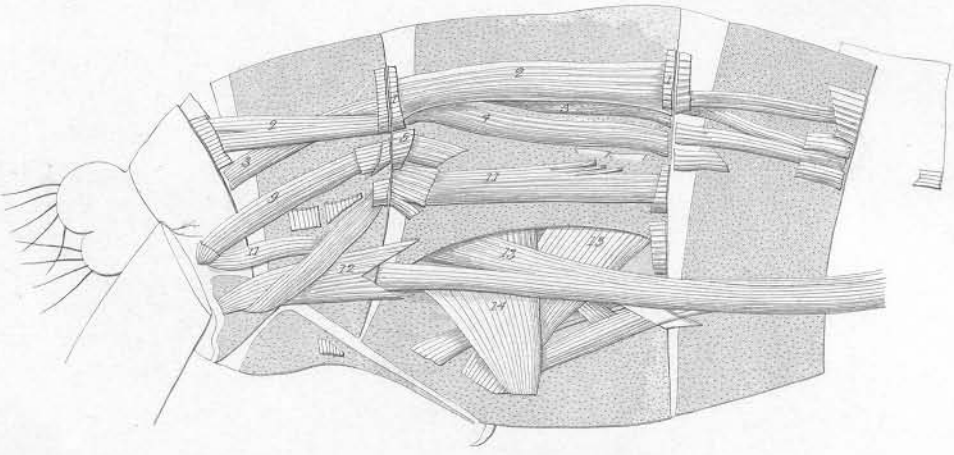
18



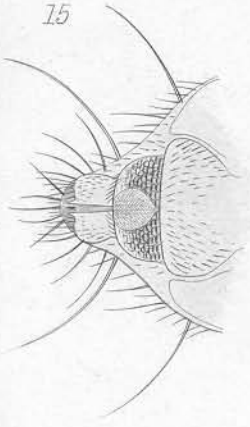
14



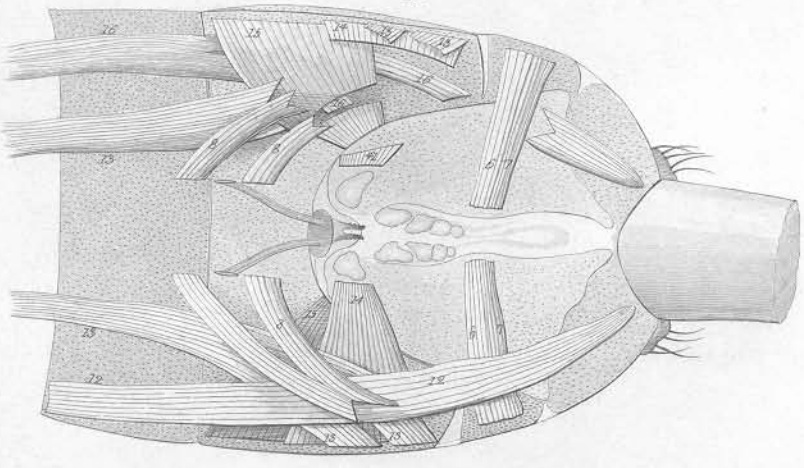
19



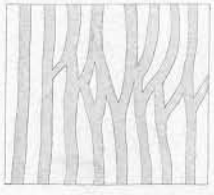
15



20



16



17