III. *On the Anatomy of Ants.* *By Sir* John Lubbock, *Bart., M.P., F.R.S., F.L.S., D.C.L., LL.D., Vice-Chancellor of the University of London, President of the Entomological Society.*

(Plates XI. & XII.)

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Introductory Remarks.

In conjunction with the observations on the habits of Ants, which the Society has done me the honour of publishing from time to time in the Journal, I have also been studying their anatomy, especially with reference to the muscular system. Of the anatomy of the head I have already given some account in the 'Transactions of the Microscopical Society,' 1877*.

The present paper is devoted to the thorax, with special reference to *Lasius flavus*. Though it is founded on numerous dissections, and on more than 1000 sections beautifully prepared for me by Mr. Newton, of the School of Mines, and Mr. Robertson, of Oxford, it is still very imperfect; and I am only induced to bring it before the Society in its present incomplete state because, while I hope it will be found to add somewhat to our knowledge, I see little prospect of being able to work out the subject as thoroughly as I could wish.

As a general rule, the thorax of insects is considered to consist of three more or less well-marked segments, usually known by the names suggested by Nitzsch—prothorax, mesothorax, and metathorax.

Dr. Ratzeburg, however, published in 1832 a memoir ('Ueber Entwickelung der fusslosen Hymenopteren-Larven, mit besonderer Rücksicht auf die Gattung *Formica*'), in which he maintained that the fifth segment of the larva forms, not the so-called "scale," or first abdominal segment, but the hinder part of the thorax. This view has also been maintained by Audouin and Latreille; while, on the contrary, others, as, for instance, Kirby and Spence and MacLeay, consider the thorax of these insects to be composed of three segments, as usual.

Burmeister, indeed, roundly observes ('Manual of Entomology,' Shuckard's transl. p. 85) that Audouin's assertion is unfounded.

Lepelletier de St.-Fargeau, in his 'Histoire Naturelle des Hyménoptères' (1836), expresses the same opinion. "Il me paraît," he says, "plus simple parler comme voient mes yeux." Westwood also, in his excellent 'Introduction to the Modern Classification of Insects' (1840, p. 227), adopts the same view. It may, he admits, "be asserted that, as the body of the imago possesses two or three segments fewer than exist in the body of larva, we may suppose that the loss of one of these segments takes place at least in this manner, and in this part of the body. This, however, can only be done by admitting that the head and three thoracic segments of the imago are composed of five larva-segments instead of four, an admission negatived by all analogy with pedate larvæ."

* See Quekett Lecture, Monthly Microscopical Journal (1877), vol. xviii. p. 121.

Newport, in his article "Insecta," in the 'Cyclopædia of Anatomy and Physiology,' p. 920, says:—"at first we were inclined to Audouin's opinion, more especially on account of what we shall presently find in Lepidoptera, in which the fifth segment, in its atrophied condition, is as much connected with the thorax as with the abdomen. On further examination, however, we are satisfied that that portion of the metathorax which is posterior to the incisure belongs to the third segment of the thorax."

Fenger, in his "Allgemeine Orismologie der Ameisen" (Arch. für Naturg. 1862, p. 315), treats the thorax as consisting of three segments, and does not even hint at any difference of opinion on the subject. Mayr also, in his excellent 'Die europäischen Formiciden,' p. 4, and Schenck, in his "Beschreibung nassauischer Ameisen-Arten" (Jahrb. des Ver. für Naturkunde im Herz. Nassau, 1852), adopt the same view. Lastly, Forel ('Fourmis de la Suisse,' p. 5) says that the thorax "se divise en trois segments, comme chez tous les insectes: prothorax, mésothorax et métathorax."

It would perhaps hardly be appropriate to refer to more general or condensed works in which the thorax is stated to consist of three segments, as, for instance, by Owen ('Lectures on Invertebrate Animals,' p. 193), Claus ('Grundzüge der Anatomie,' p. 557), Rolleston ('Forms of Animal Life,' p. cix), &c.; for these eminent authors, though expressing no qualification, perhaps only meant to describe a general, and not necessarily an invariable, rule.

Huxley, in the 'Introduction to the Classification of Animals,' p. 58, observes, with his usual care and accuracy, that "three, or perhaps, in some cases, more, somites unite, and become specially modified to form the thorax."

Notwithstanding the high authorities who have adopted the opposite opinion, and although the first appearance of the thorax seems to support their view, for my own part I cannot but think that Ratzeburg's opinion was correct. Packard ('Guide to the Study of Insects,' p. 66) has given figures of the metamorphoses of *Bombus*, from which it seems clear that the fifth segment of the larva forms the posterior portion of the thorax of the perfect insect. Lacaze-Duthiers (Ann. des Sc. Nat. 1853, p. 231), Palmen (Zur Morph. des Tracheensystems), and Reinhard (Berl. ent. Zeits. 1865) also advocate the same view.

The position of the spiracles affords also strong evidence in support of the same opinion. It is generally stated in works on the anatomy of insects that there are on the thorax two pairs of spiracles, the first between the pro- and mesothorax, the second between the meso- and metathorax.

According, indeed, to Burmeister ('Handbook of Entomology,' p. 164), this is also the case with the Hymenoptera, which "all possess four (spiracles) in the thorax, two of which are upon the limits of the prothorax, between it and the mesothorax, and the other two lie between the meso- and metathorax. In the Hymenoptera, in which the thorax consists of a hard, horny case, and the segments are closely united together, the posterior pair of spiracles lie upon the metathorax itself, whereby they distinguish themselves from all the other orders." In fact, however, as may be seen from the accompanying figures (Pl. XI. figs. 2, 4, 5), the thorax of Ants possesses, not two, but three, pairs of spiracles.

The two first pairs are situated between the pro- and mesothorax and the meso- and

metathorax, as usual, and evidently correspond with the two pairs of thoracic spiracles of other insects. The third pair is situated at the side of the so-called metathorax; but in no case whatever do we find among insects two pairs of spiracles on one segment. Such an arrangement would be contrary to the whole plan of organization of the Arthropoda. It is obvious, therefore, that the third pair of spiracles corresponds to that which in other insects lies between the thorax and the first abdominal segment. Burmeister, as we have seen, remarks that certain Hymenoptera "distinguish themselves from all other orders" in having a pair of spiracles "on the metathorax itself;" but he supposes that these correspond to the spiracles which are ordinarily situated between the meso- and metathorax, overlooking the fact that these spiracles also exist as usual. It seems clear, therefore, that the portion of the body posterior to the third pair of spiracles really corresponds to the first abdominal segment in ordinary insects.

Nor are the respiratory organs alone in pointing to this conclusion. The internal chitinous appendages clearly divide the thorax into four portions; and I think it may be said that the thorax contains four ganglia, though the last (Pl. XI. fig. 2, G^4, Pl. XII. fig. 2) is certainly not large.

The Prothorax.

The upper part of the prothorax, or pronotum, is formed in *Lasius flavus* by a single arched chitinous plate (Pl. XI. figs. 1, 4, & 6, *B*), which slopes downwards from its posterior border towards the head, where it forms a sort of keel (Pl. XI. figs. 1 & 2). Seen externally and from the side, its lower border appears to join the upper edges of the propectus; but a transverse section (Pl. XII. fig. 4) shows that this is not so, but that the propectus is continued for some distance beyond the lower margin of the pronotum, and is then connected with it by a membrane which passes from the upper margin of the propectus to the lower one of the pronotum. The propectus tapers in front (Pl. XI. fig. 5), terminating on each side in two teeth, which lock into two corresponding teeth (Pl. XI. figs. 6 & 7, and Pl. XII. fig. 1, *X*) or processes at the back of the head. The propectus is divided into two plates (Plate XI. fig. 2, *C* & *T*), one anterior and one posterior, which, moreover, are divided into lateral regions by a central ridge. The anterior plate of the propectus has in front a deep bay or depression, at the two horns of which are the above-mentioned teeth or processes. Each region of the anterior division of the propectus has therefore roughly the form of a triangle with arched sides. The posterior division of the propectus is elliptic in form, and not so large as the anterior division, to which it is firmly attached.

The propectus is therefore attached to all the surrounding chitinous plates by flexible, though tough, membranes. It hangs, indeed, something like the under body of a carriage; and from the fact that the anterior horns of the prothorax interlock with the posterior processes of the head, if the propectus is turned round it carries the head with it. On the other hand, if the head be retracted, the posterior processes of the head, from their position with reference to the anterior horns of the prothorax, prevent the head of the insect from being turned round against its will.

The posterior surface of the propectus is connected with the anterior edge of the mesopectus by a tough, but flexible, membrane.

I have found it difficult to understand the descriptions given of the interior skeleton of the thorax by previous writers, nor do their figures give much assistance. In the normal insect-thorax there appear to be seven principal processes—four springing from the back, and called by Kirby and Spence the phragma, prophragma, mesophragma, and metaphragma; and three from the sternum, named by the same authors profurca, mesofurca, and postfurca. In the worker Ants the four superior processes are not developed, but the furca, mesofurca, and postfurca are very important; they give attachment to various muscles, and serve also to protect the nervous system. Kirby and Spence, however, dismiss them very summarily, and, as regards the processes of the endosternum, state that they "are not sufficiently remarkable to require particular notice" *. Burmeister† says that in the prothorax (of the Hymenoptera) "there are two strong pointed processes, each of which has a double root. The exterior one comes from the margin of the prosternum, and the interior one from the central ridge of the same part. Between these roots the muscles of the coxæ pass, and between the processes themselves run the pharynx and the nervous cord; and it is to these processes that the connecting muscles of the pronotum and prosternum are attached. In the mesothorax we first find the prophragma, a small, not very high, horny partition, which descends from the anterior margin of the mesonotum; and we next find a delicate ridge, which encompasses the whole distinctly separated mesonotum. The mesosternum and scapulæ are closely joined in a half-ring, and from the central carina of this ring springs a broad strong ledge, which at its upper margin is furnished on each side with a strong process; they form with the ledge a rectangular cross, and serve as points of insertion for the muscles of the coxæ of the middle legs, lying on each side contiguously to the central ridge." As regards the metafurca, all he tells us is, "between the metanotum and metaphragma the two large side pieces and their auxiliaries lie, separated from each other by furrows, from which, internally, strong ridges spring, and to which the muscles of the posterior legs are attached."

Graber, in his admirable 'Die Insekten,' truly observes that the endoskeleton has been almost entirely neglected by recent entomological writers. I trust, however, that the following description and the accompanying figures may give some idea of the endoskeleton as it exists in the workers of *Lasius flavus*.

The hinder plate of the propectus turns upwards at approximately a right angle, and is produced into the antefurca (Pl. XI. figs. 1, 2, 5, & 6; Pl. XII. fig. 8), a chitinous process which extends more than halfway up the dorsum, leaving, however, a central orifice (Pl. XII. fig. 4) through which the nervous chords penetrate, while the œsophagus and the heart pass between the upper edge of the antefurca and the dorsum.

As seen from behind (Pl. XII. fig. 4) it has the form of a cross with four arms. In the middle of the centre piece is an oval orifice, the wider end below, through which the nervous system passes. The centre of the upper part sends out a process both anteriorly and posteriorly, as shown in Pl. XI. fig. 2; in fact it forms a sort of case for the protection of the ganglia.

* 'Introduction to Entomology,' vol. iii. p. 587. † *Op. cit.*

The medifurca (Pl. XI. fig. 2; Pl. XII. fig. 5, *Med*) rises from the medipectus. It is much more elongated and slender than the antefurca, and has the form of a Y, the upper arms of which, however, are connected by a cross bar, thus leaving a triangular orifice with rounded angles, through which runs the nervous chord. To a process of the cross bar is attached the muscle which elevates the prothorax.

The postfurca (Pl. XI. fig. 2 and Pl. XII. fig. 6) also has somewhat the form of a Y. The stem, however, is much shorter, the branches are curved, and the cross bar is absent. The postfurca arches forwards, so that the upper part of the arms approach those of the medifurca, with which they are connected by tendinous fibres. Between the medifurca and the postfurca lies the third thoracic ganglia.

Muscles of the Head.

There are two elevators of the head on each side (*a* & a^1). The first (Pl. XI. figs. 1, 2, & 5, *a*) is a thin muscle, which rises from the back near the middle line, at the junction of the pro- and mesothorax, and, passing forwards, is inserted at the upper margin of the occipital foramen, where the posterior margin of the head joins the intersegmental membrane. The second is more powerful. It (Pl. XI. figs. 1, 2, a^1) rises from the anterior surface of the upper part of the antefurca, and, passing forwards and slightly upwards, is inserted close to the preceding. The heads of attachment of this muscle reach almost across the segment.

The first depressor of the head (Pl. XI. figs. 1, 2, *b*), like the second elevator, is attached to the anterior face of the antefurca, but at a lower level, and, passing over the prothoracic ganglion, is attached to the inferior margin of the occipital foramen.

The second depressor of the head (Pl. XI. fig. 1, Pl. XII. fig. 1, b^1) is attached to the central and hinder part of the propectus, and, passing directly forwards, is also attached to the lower edge of the occipital foramen.

The rotators of the head are five in number on each side. The first (Pl. XI. figs. 1, 2, & 4, *c*) rises from the middle of the lateral wall of the pronotum, and, passing downwards and inwards, is attached to the anterior toothed process of the propectus. The second rotator passes from the middle of the lateral wall of the propectus (Pl. XI. figs. 4, 6, & 7, c^1), and is attached to the outer anterior toothed process of the prosternum. The third rotator (Pl. XI. figs. 4, 6, 7, c^2) lies rather nearer the middle of the segment. In front it is attached to the inner toothed process, and posteriorly to the lateral and posterior wall of the propectus, a little behind the preceding. The fourth rotator (Pl. XI. figs. 1, 2, 6, *d*) commences at the anterior process of the propectus, close to the preceding, and, passing backwards and slightly inwards, is attached to the anterior central process of the antefurca. The fifth rotator (Pl. XI. figs. 1, 2, & 6, d^1), rises with the preceding, but passes diagonally across the segment to be attached to the lateral edge of the antefurca.

Although the muscles of the head of Coleoptera, as described by Straus-Durckheim in *Melolontha*, and as given generally by Burmeister in his 'Handbook of Entomology,' are more complex than those which are found in Ants, yet neither of these authors describe any muscle exactly comparable to the following.

This muscle (Pl. XI. figs. 1, 5, *e*) differs from the preceding in that, while they taper

as they pass forward, it, on the contrary, rises from the anterior surface of the pronotum by several, somewhat diverging heads, and, passing backwards and slightly downwards, is attached to the upper part of the antefurca. It would therefore seem to draw the propectus, and consequently to push the head, forwards. It is obvious that if the head is projected forwards, and the propectus then retracted, so that the head could move freely towards each side, it would be easily turned by the rotators above described. On the contrary, if it be retracted, or if the propectus be thrown forward, so that the posterior process of the head interlocks with the anterior processes of the propectus, the head would be so situated as to retain its position even against a considerable force.

The next muscles to be mentioned are the elevators of the antepectus; these are two in number. The first (Pl. XI. figs. 1, 2, 4, 5, and Pl. XII. fig. 4, *f*) rises from near the middle of the pronotum, and, passing downwards, is attached to the anterior process of the antepectus. The second is weaker; it is attached to the side of the pronotum, and, passing downwards (Pl. XI. fig. 5, f^1) and slightly inwards, is also attached to the anterior process of the antepectus, close to the preceding. The attachment of the first large rotator of the head (*e*) lies between those of these two muscles, as may be seen in Pl. XI. fig. 5, where *f* and f^1 represent the heads of these two muscles, which, when they contract together, would tend to elevate the antepectus.

The depressor of the antepectus is smaller. It commences (Pl. XI. figs. 5, 6, 7, *g*) at the lower edge of the pronotum, and, passing upwards, is attached to the upper edge of the antepectus, which therefore, on contracting, it draws downwards.

Front Legs and their Muscles.

The legs consist of the following segments:—1, coxa; 2, trochanter; 3, femur; 4, tibia; and 5, tarsus, this latter being composed of five segments.

The description given by Straus-Durckheim of the muscles by which the legs are moved has been adopted by most subsequent writers. According to him, the anterior legs have five muscles, four flexors and one extensor. The first flexor rises from the superior lateral and anterior surface of the prothorax, and is attached to the posterior border of the coxa. The second and third flexors rise from the superior and posterior surface of the prothorax, and are attached to the coxa just outside the preceding. The fourth flexor rises from the external portion of the posterior surface of the "rotule," and is attached to the posterior edge of the coxa. Lastly, the extensor rises from the pronotum, near the first flexor, and acts immediately in opposition to the preceding.

The number of muscles in the Ant appears to be greater than in *Melolontha*, and the disposition is in many respects dissimilar.

The first muscle of the leg (Pl. XI. figs. 4, 7, and Pl. XII. figs. 1, 4, *h*) rises from the anterior lateral wall of the prothorax, and, passing downwards and backwards, is attached to the upper anterior angle of the condyle of the coxa, which, therefore, it would tend to draw forwards and inwards.

The second (*i*, Pl. XI. figs. 1, 2, 4; Pl. XII. figs. 1, 3, & 4) lies transversely in the lower and posterior portion of the antepectus. In Pl. XI. figs. 1 & 2 it is seen in section. In Pl. XI. fig. 4 it is severed close to its attachment. It rises from the central ridge

of the antepectus, and, passing transversely across the segment, is attached to the posterior and outer edge of the leg, at the summit of the projecting head or condyle. It would tend to extend the leg laterally.

The third (*i*', Pl. XII. fig. 4) is attached to the antefurca, and, passing downwards and outwards, is attached close to the preceding.

The fourth and fifth muscles of the fore legs are of a different character, penetrating into the coxa. The fourth rises from the upper edge of the antepectus in front of the antefurca (Pl. XI. fig. 4, and Pl. XII. fig. 4, *k*), and passes downwards into the coxa.

The fifth rises partly from the hinder wall of the antefurca, partly from its posterior spur (Pl. XI. figs. 1, 2, 4, & 7, *l*), and, like the preceding, passes down into the coxa. The upper part of the muscle is joined by some fibres, which pass round the posterior process of the antefurca and are attached to the pronotum.

The seventh is attached to the outer and posterior edge of the coxa, and, passing backwards and inwards, is attached to the anterior surface of the medifurca. It is not, however, well shown in any of my sections.

In addition to these muscles, the coxa contains two others, one of which rises from the upper and outer wall and passes downwards and inwards, while the other, rising from the upper and inner wall, passes downwards and outwards.

The small trochanter (Pl. XII. fig. 1, *tr.*), in addition to the above-mentioned fibres of the flexor of the femur, contains only a short single muscle, which at its lower end is attached to the thigh.

The femur (Pl. XII. fig. 1, *fm*) contains two muscles. The extensor is attached to the upper surface of the segment, the fibres being attached to one side of a long tendon, which at its lower end is attached to a chitinous piece at the upperside of the head of the tibia. The flexor is situated rather on the lower side of the segment; but the fibres diverge from both sides of the tendon, and some of them cross those of the extensor muscles. Some of the central fibres pass into the trochanter, and are attached to its inner margin. The lower end of the tendon of the flexor is attached to a chitinous process.

The tibia presents some very remarkable points, with reference to which I may perhaps be permitted to quote a passage from a paper of mine published in the 'Microscopical Journal,' 1877.

Remarks on the Tibial Organ.

In the year 1844 Von Siebold* described a remarkable organ which he had discovered in the tibiæ of the front legs of *Gryllus*, and which he considered to serve for the purpose of hearing. These organs have been also studied by Burmeister, Brunner, Hensen, Leydig, and others, and have recently been the subject of a monograph by Dr. V. Graber†, who commences his memoir by observing that they are organs of an entirely unique character, and that nothing corresponding to them occurs in any other insects or, indeed, in any other Arthropods.

* "Ueber das Stimm- und Gehör-Organ der Orthopteren," Wiegmann's Arch. f. Natur. 1844.

† Die tympanalen Sinnes-Apparate der Orthopteren, von Dr. Vitus Graber, 1875.

I have therefore been very much interested by discovering in Ants a structure which seems in some remarkable points to resemble that of the Orthoptera. As will be seen from a glance at Dr. Graber's memoir, and the plates which accompany it, the large trachea of the leg is considerably swollen in the tibia, and sends off, shortly after entering the tibia, a branch, which, after running for some time parallel to the principal trunk, joins it again. See, for instance, in his Monograph, pl. ii. fig. 43, pl. vi. fig. 69, pl. vii. fig. 77, &c. Now I have observed that in many other insects the tracheæ of the tibia are dilated, sometimes with a recurrent branch. The same is the case even in some mites.

I will, however, reserve what I have to say on this subject, with reference to other insects, for another occasion, and will at present confine myself to the Ants. If we examine the tibia, say of *Lasius flavus*, we shall see that the trachea presents a remarkable arrangement, which at once reminds us of that which occurs in *Gryllus* and other Orthoptera. In the femur it has a diameter of about $\frac{1}{3000}$ of an inch; as soon, however, as it enters the tibia it swells to a diameter of about $\frac{1}{500}$ of an inch, then contracts again to $\frac{1}{800}$, and then again, at the apical extremity of the tibia, once more expands to $\frac{1}{500}$. Moreover, as in *Gryllus*, so also in *Formica*, a small branch rises from the upper sac, runs almost straight down to the tibia, and falls again into the main trachea just above the lower sac. The remarkable sacs at the two extremities of the trachea in the tibia may also be well seen in other transparent species, such, for instance, as *Myrmica rugi-nodis* and *Pheidole megacephala*.

At the place where the upper tracheal sac contracts there is, moreover, a conical striated organ (x), which is situated at the back of the leg, just at the apical end of the upper tracheal sac. The broad base lies against the external wall of the leg, and the fibres converge inwards. In some cases I thought I could perceive indications of bright rods, but I was never able to make them out very clearly. This also reminds us of a curious structure which is found in the tibia of Locustidæ, between the trachea, the nerve, and the outer wall, and which is well shown in some of Dr. Graber's figures.

Other Organs of the Prothorax.

The anterior pair of spiracles, as already mentioned, lie (Pl. XI. figs. 4, 5, Sp^1) between the pro- and mesothorax. The tracheal tube immediately behind the spiracle is provided with a short muscle, as already described in other insects by MM. Landois and Thelen*. The ganglion (Pl. XI. figs. 2, 6, & 7, G^1) is of considerable size, and is connected anteriorly with that of the head, and posteriorly with that of the mesothorax, by a double commissure. In the latter case the commissures pass through an orifice in the antefurca, which thus not only serves as a support to the muscles, but also as a protection to the nervous system.

The œsophagus passes straight through the prothorax, and, indeed, does not enlarge into the crop until it reaches the enlarged part of the abdomen. In the upper part of the prothorax lie the large thoracic salivary glands (Pl. XI. fig. 2, *gl*).

A considerable part of the upper and anterior portion of the prothorax is occupied by the thoracic salivary glands, which I have already described in the 'Microscopical Journal.'

* Zeitschr. f. wiss. Zool. 1867, p. 187.

They consist of a number of branched and twisted tubules which gradually unite in a single duct. This duct then swells into a capacious receptacle, after which it contracts again, and after joining the corresponding duct from the other side, passes through the neck into the head, and then, after a meandering course, opens at the upperside of the under lip. The duct consists of an epithelial layer of cells, within which is a structureless membrane, strengthened, as is so often the case with the ducts of glands, by chitinous ridges, which give it very much the appearance of a trachea. Fig. 3, Pl. XI., represents a glandular organ situated in the lower part of the thorax of *Myrmica ruginodis* immediately above the base of the anterior leg.

Mesothorax and Middle Legs.

The mesothorax is much more closely connected with the metathorax than with the prothorax (Pl. XI. fig. 2). Like the prothorax it consists of an upper and lower more or less arched plate. The upper plate or mesonotum (Pl. XI. figs. 2, 5, 6, *Mes*) is oblong, somewhat emarginate behind, the spiracles (Pl. XI. figs. 2, 4, Sp^2) being situated at the posterior angles. In front the mesonotum projects some way over the sides of the prothorax; and as the middle legs are attached quite at the posterior end of the metapectus, they, as well as the posterior legs, lie under the metanotum, and seem at first sight as if they belonged to the hinder division of the thorax.

The depressor of the prothorax (Pl. XI. figs. 2, 4, 5, *m*) arises from the junction of the meso- and metathorax, beneath the spiracle, and passing down and forwards is attached to the lower posterior edge of the prothorax, which therefore it would tend to draw downwards.

On the other hand, the elevator of the prothorax (Pl. XI. figs. 2, 5, *n*) rises from the upper part of the antefurca, and passes backwards and downwards to a spur of the medifurca just above the mesothoracic ganglion.

The second pair of legs has, according to Straus-Durckheim's description of *Melolontha*, three flexors and two extensors. The arrangement, however, is very different from that in the Ant.

Graber, in his excellent work, refers specially to four muscles; the first (*ulm*, in his fig. 61) rises from the central ridge of the sternum, and, passing directly outwards, is attached to the inner edge of the coxa, which therefore it would draw inwards and downwards. The next two (*shm* 1 and 2, in his fig. 61) rise one behind the other from the side of the thorax, and would, on the contrary, draw the leg outwards and upwards. The fourth also lies behind the other two, but would specially draw the leg upwards.

As regards the Ant, the principal muscles which move the middle legs are shown in Pl. XI. fig. 4, Pl. XII. fig. 2.

The first muscle (*o*, Pl. XI. figs. 4, 5, and Pl. XII. figs. 2 & 5) rises partly from the upper lateral wall of the mesonotum immediately under the spiracle, partly from the medifurca, and passing downwards contracts into a tendon which is continued into the leg. It would tend to raise the leg.

The second rises from the anterior edge of the medipectus (Pl. XII. fig. 2, *p*), and passing straight back is attached to the anterior edge of the coxa.

In opposition to this the third muscle rises from the anterior portion of the central ridge of the medipectus (Pl. XII. fig. 2, *q*), and passing outwards and backwards is attached to the inner posterior edge of the coxa.

The fourth rises from the posterior portion of the central ridge of the medipectus, and passing outwards is attached (Pl. XII. fig. 2, *r*) to the inner edge of the coxa.

The fifth rises partly from the anterior wall of the medipectus (Pl. XII. fig. 2, *s*), partly from its median ridge, under *q*, and is attached to the outer anterior edge of the coxa.

The last (Pl. XII. figs. 2, 5, *t*) rises from the medifurca, and passing downwards and forwards is attached to the outer edge of the coxa.

Posterior Portion of Thorax.

The first elevator of the abdomen (*u*, Pl. XI. figs. 2 & 5) rises from the metanotum, on each side of and not far from the central line, and, running parallel to the same muscle on the other side, is attached to the upper anterior edge of the so-called knot.

The second elevator of the abdomen (u^1, Pl. XI. fig. 2, Pl. XII. fig. 2) rises from the postpectus, and passing upwards, outwards, and backwards is attached to the upper lateral anterior edge of the abdomen. It would draw the abdomen upwards and at the same time sideways.

The depressor of the abdomen rises partly from the metanotum behind the first elevator, and partly (*v*, Pl. XI. fig. 2, Pl. XII. fig. 2) from the upper part of the postfurca, and passing backwards and downwards is attached to the lower anterior edge of the abdomen.

The rotator of the abdomen rises from the metanotum just behind the first elevator (*w*, Pl. XI. figs. 2, 5, and Pl. XII. fig. 2), and passing backwards, downwards, and outwards is attached to the lateral edge of the first abdominal segment.

I now pass to the muscles of the posterior leg.

The first muscle of the leg rises partly from the lateral wall of the metanotum (*x*, Pl. XI. fig. 5, Pl. XII. fig. 2) and partly from the upper part of the postfurca, and passes downwards and backwards into the coxa.

The second muscle also rises from the postfurca below the preceding (Pl. XII. fig. 2, x^1), and passing downwards and backwards is attached to the upper posterior margin of the coxa. It terminates above in a strong chitinous tendon, which is connected with the postfurca by a number of tendinous filaments.

The third muscle rises from the lateral wall (Pl. XII. fig. 2, *y*) of the mesothorax, partly from that of the metathorax, and passing backwards is attached to the outer edge of the leg.

The fourth muscle is attached to the anterior edge of the postpectus (Pl. XII. fig 2, y^1), and passing backwards and outwards is attached to the external margin of the leg close to the preceding.

The fifth is also attached to the anterior edge of the postpectus, but, passing directly backwards (Pl. XII. fig. 2, *z*) above the preceding is attached to the exterior and anterior margin of the leg.

The sixth muscle is attached to the anterior edge of the metathorax, and passes

directly backwards (Pl. XII. fig. 2, z^1) and over the preceding to the internal and posterior edge of the posterior leg.

Although the workers of Ants do not possess wings, Dewitz has shown * that the larvæ possess "imaginal disks," like those from which the wings of the males and females are developed, but smaller. These embryonic wings reach no more advanced stage than that which they have already acquired in the full-grown larva, and in the imago no trace of the front wings appears to be discernible, while it is curious that the hinder wings, though they are smaller in the males and females, are in some cases still indicated by a minute protuberance.

The presence of wings necessarily entails may other differences, and consequently

The thorax of the male and female Ants is very unlike that of the workers—not, indeed, in the arrangement of the muscles already described, but by the changes and additions contingent upon the presence of wings. The females, as is well known in most cases, strip off their wings soon after the marriage-flight. In *Anergates atratulus* the males are wingless, and, according to Schenck†, the queens in some cases do not acquire wings. The great muscles of flight are, as might be expected, very large in the winged Ants; on the other hand, they are few in number, more simple, as it would appear, than those of most other insects. There are, indeed, several small muscles attached to the wings; but the main muscles are only four in number—two elevators and two depressors, which therefore are the same for both the wings. Among most other insects there are said to be an elevator and a depressor for each wing; in the Lepidoptera, Hemiptera, and certain Hymenoptera (Sawflies) the depressors on each side have coalesced, while in Ants and their allies the same is also the case with the elevators.

The depressors (Pl. XII. fig. 8 & 9, β) are powerful muscles which occupy a considerable part of the upper portion of the thorax. They rise from the mesonotum and pass horizontally backwards, lying close to one another along the median line. At their posterior end they are attached to the two processes of the metaphragma (Pl. XII. fig. 8) (costal of Chabrier), an arched process concave in front and convex behind, which, starting from the true hinder edge of the metathorax, passes downwards, terminating in two processes.

The elevators (Pl. XII. fig. 8 & 9, θ) of the wings lie almost at right angles to the preceding. They rise from the meso- and metasternum, and passing upwards and forwards outside the preceding are attached to the wall of the back.

Immediately under the metanotum in this part of the body lies the so-called "metathoracic gland." It consists of a number of large nucleated cells opening into a vestibule (Pl. XII. fig. 7) by short minute ducts. The inner wall of the vestibule, at least in the workers of *Lasius flavus*, is thrown into several curved ridges, from which proceed a number of strong hairs. The vestibule in this species is elliptic in form and opens to the outside by a wide mouth. In other species the shape is different; in *Myrmica ruginodis* it is somewhat S-shaped and the hairs are smaller; in *Lasius fuliginosus* it falls into two divisions, the outer one funnel-shaped, the inner thrown into a number of spherical chambers. This organ seems to be less highly developed in the males and females than in the workers.

* Zeitschr. f. wiss. Zool. 1878. † Jahrb. des Ver. für Naturkunde im Herz. Nassau, p. 6.

The abdomen is moved by two muscles (Pl. XI. fig. 2, Pl. XII. fig. 8) situated in the so-called first segment or knot.

The first of these muscles occupies the greater portion of the upper part of the knot, and, passing downwards and backwards, is attached to the lower wall of the abdomen.

The second muscle is attached to the anterior wall of the knot, immediately below the preceding, and, passing straight backwards, is attached to the upper wall of the abdomen.

DESCRIPTION OF THE PLATES.

The lettering used for the different figures is as follows :—

H. Head. *Pr.* Prothorax. *Mes.* Mesothorax. *Met.* Metathorax.
Sp^1. 1st pair of spiracles. Sp^2. 2nd pair. Sp^3. 3rd pair.
Z. Membrane connecting the thorax with head.
Z^1. „ „ the propectus with medipectus.
Z^2. „ „ the pronotum with the propectus.
An. Antefurca.
Med. Medifurca.
Po. Postfurca.
gl. Site of thoracic salivary gland.
P. Propectus. *Pr*, and in some figures *B*, Pronotum. *W.* Processes of the head.
X. Processes of the propectus. G^1. 1st ganglion. G^2. 2nd ganglion.
G^3. 3rd ganglion. G^4. 4th ganglion. L^1. Base of 1st pair of legs.
L^2. Base of 2nd pair of legs. L^3. Base of 3rd pair of legs.
C. Anterior plate of propectus. *T.* Posterior plate of propectus.
Ab. Abdomen. *fm.* Femur. *tr.* Trochanter. *Cx.* Coxa.

Muscles.

a. 1st elevator of the head. a^1. 2nd elevator of the head. *b*. 1st depressor of the head.
b^1. 2nd depressor of the head. *c*. 1st rotator of the head. c^1. 2nd rotator of the head.
c^2. 3rd rotator of the head. *d* & d^1. 4th and 5th rotators of the head.
e. Protractor of the head. *f*. Elevator of antepectus. f^1. Elevator of antepectus.
g. Depressor of antepectus. *h*. 1st muscle of anterior leg. *i*. 2nd muscle of anterior leg.
i^2. 3rd muscle of anterior leg. *k*. 4th muscle of anterior leg. *l*. 5th muscle of anterior leg.
m. Depressor of prothorax. *n*. Elevator of prothorax. *o*. 1st muscle of middle leg.
p. 2nd muscle of middle leg. *q*. 3rd muscle of middle leg. *r*. 4th muscle of middle leg.
s. 5th muscle of middle leg. *t*. 6th muscle of middle leg. *u*. 1st elevator of abdomen.
u^1. 2nd elevator of abdomen. *v*. 1st depressor of abdomen. v^1. 2nd depressor of abdomen.
w. 1st rotator of abdomen. *x*. 1st muscle of posterior leg. x^1. 2nd muscle of posterior leg.
y. 3rd muscle of posterior leg. y^1. 4th muscle of posterior leg. *z*. 5th muscle of posterior leg.
z^1. 6th muscle of posterior leg.
β. Depressor of wings. θ. Elevator of wings.
π. Elevator of abdomen. ϕ. Depressor of abdomen.

Plate XI.

Fig. 1. Vertical and longitudinal section through the prothorax of *Lasius flavus*. × 125.

H, posterior wall of head; *B*, pronotum; *P*, propectus; *Z*, membrane connecting the head and the pronotum; Z^1, membrane connecting the head and the propectus; *L*, base of leg cut short; *An*, antefurca. Muscles:—*a*, first, and a^1, second elevator of the head; *b*, first, and b^1, second depressor of the head; *c*, first rotator of the head; *d*, fourth, and d^1, fifth rotator of the head; *e*, protractor of the head; *f*, elevator of antepectus; *i*, second muscle of anterior leg; *l*, fifth ditto.

Fig. 2. Longitudinal and vertical section through the thorax of *Lasius flavus*. × 125.

H, posterior part of head; *Pr*, prothorax; *Mes*, mesothorax; *Met*, metathorax; *C*, anterior plate of propectus; *T*, posterior plate of propectus; G^1, first, G^2, second, G^3, third, and G^4, fourth thoracic ganglion; *gl*, thoracic salvary gland; Sp^2, second, and Sp^3, third spiracle; *Z*, membrane connecting the head and the pronotum. Muscles:—*a*, first, a^1, second elevator of the head; *b*, first depressor of the head; *c*, first, *d*, fourth, and d^1, fifth rotator of the head; *f*, elevator of antepectus; *i*, second muscle of anterior leg; *l*, fifth muscle of anterior leg; *m*, depressor, and *n*, elevator of prothorax; *q*, third, and *r*, fourth muscle of middle leg; *u*, first, and u^1, second elevator of abdomen; *v*, first depressor of abdomen; *w*, first rotator of abdomen; *x*, first muscle of posterior leg.

Fig. 3. Glandular organ at base of prothorax in *Myrmica ruginodis*. *L*, upper portion of coxa of anterior leg. × 200.

Fig. 4. Vertical and longitudinal section through the thorax of *Lasius flavus*. × 125.

Pr, pronotum; *P*, propectus; Sp^1, first, Sp^2, second, and Sp^3, third spiracle; L^1, base of anterior leg; L^2, base of middle leg; L^3, base of posterior leg; *Cx*, coxa. Muscles:—*c*, first, c^1, second, and c^2, third rotator of the head; *f*, elevator of antepectus; *h*, first, *i*, second, *k*, fourth, and *l*, fifth muscle of anterior leg; *m*, depressor of prothorax; *o*, 1st muscle of middle leg.

Fig. 5. Thorax of *Lasius flavus*, seen from above and somewhat flattened out. The external hairs are omitted. × 125.

Pr, prothorax; *Mes*, mesothorax; *Met*, metathorax; Sp^1, first, and Sp^3, third pair of spiracles; *Z*, membrane connecting the thorax with the head; *An*, antefurca; *Sgl*, site of the posthoracic glands. Muscles:—*a*, first, and a^1, second elevator of the head; *c*, first rotator of head; *e*, protractor of head; *f* and f^1, the two elevators of the antepectus; *g*, depressor of antepectus; *l*, fifth muscle of anterior leg; *m*, depressor, and *n*, elevator of prothorax; *o*, first muscle of the middle leg; *u*, first elevator of abdomen; *w*, first rotator of abdomen; *x*, first, *y*, third muscle of posterior leg.

Fig. 6. Longitudinal and horizontal section through the prothorax of *Lasius flavus*. × 125. Seen from below.

P, wall of the propectus; *B*, wall of the pronotum; Z^1, membrane connecting the pro- and medipectus; *X*, processes of the propectus; *W*, processes of the head; G^1, first ganglion; *An*, antefurca. Muscles:—*b*, first depressor of the head; c^1, c^2, cut ends of the rotators of the head; *d*, d^1, rotators of head; *g*, cut ends of depressor of antepectus.

Fig. 7. Section through the prothorax at a rather lower level than the preceding. × 125.

P, wall of the propectus; *B*, wall of the pronotum; Z^1, membrane connecting the pro- and medipectus; *X*, processes of the propectus; *W*, processes of the head; G^1, first ganglion; G^2, second ganglion; *L*, base of the leg; *An*, antefurca. Muscles:—c^1, second, and c^2, third rotator of the head; *g*, depressor of antepectus; *h*, first, *k*, fourth, and *l*, fifth muscle of anterior leg (part of these being cut across).

Plate XII.

Fig. 1. Propectus of *Lasius flavus*, seen from below. × 100.

H, head; *B*, pronotum; *P*, propectus; *X*, processes of the propectus; *W*, processes of the head; *Z*, membrane connecting thorax with head; *Cx*, coxa; *tr*, trochanter; *fm*, femur. Muscles:—*b*, first, and b^1, second depressor of head; c^1, c^2, second and third rotators of head; *g*, depressor of antepectus; *h*, first, and *i*, third muscles of anterior leg.

Fig. 2. Longitudinal and horizontal section through the posterior portion of the thorax of *Lasius flavus*. × 125.

Pr, posterior margin of prothorax; *Mes*, mesothorax; L^2, base of second, and L^3, base of third pair of legs; G^2, second, and G^3, third thoracic ganglion; *Ab*, commencement of abdomen. Muscles:—*o*, first, *p*, second, *q*, third, *r*, fourth, *s*, fifth, and *t*, sixth muscle of middle leg; *u*, first, and u^1, second elevator of abdomen; *v*, first depressor of abdomen; *x*, first, x^1, second, *y*, third, y^1, fourth, *z*, fifth, z^1, sixth, and z^2, seventh muscle of posterior leg.

Fig. 3. Longitudinal and horizontal section through the thorax of *Lasius flavus*. × 125.

Fig. 4. Transverse and vertical section through the prothorax of *Lasius flavus*. × 125.

B, pronotum; *P*, propectus; *L L*, bases of legs; *Cx*, coxa; *G*, ganglion; *An*, antefurca; Z^2, membrane connecting the pronotum and propectus. Muscles:—*c*, first rotator of head; *f*, elevator of antepectus; *h*, first, *i*, second, i^1, third, *k*, fourth muscle of anterior leg.

Fig. 5. Transverse and vertical section of thorax of *Lasius flavus* passing through the second pair of spiracles and the base of the middle legs. × 125.

Sp^2 Sp^2, spiracles of second pair; *Med*, medifurca; *L L*, bases of legs; *n*, elevator of thorax; *o*, first, and *t*, sixth muscle of middle leg.

Fig. 6. Transverse and vertical section through the thorax of *Lasius flavus*, showing the postfurca. × 125.

Fig. 7. Metathoracic organ of *Lasius flavus*. × 125.

Fig. 8. Longitudinal and vertical section through the thorax of a queen of *Lasius flavus*. × 50.

H, head; a^1, elevator of head; *b*, first depressor of head; *G G G G*, ganglia in depressor of prothorax; β, depressor of wings; θ, elevator of wings; π, elevator of abdomen; ϕ, depressor of abdomen.

Fig. 9. Longitudinal and vertical section through the thorax of a male of *Lasius flavus*. × 50.

An, antefurca; β, depressor of wings; θ, elevator of wings.