ON THE LARVAL STAGE OF *TIPULA PALUDOSA*, Meig.
AND *TIPULA LATERALIS*, Meig.

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(With 32 Figures).

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INTRODUCTORY.

Our present knowledge of the Tipulidae is still very incomplete, not only from the point of view of life-history and binomics, but also of their morphology and anatomy. Exact, detailed descriptions of individual genera and species are by no means abundant and in cases where such descriptions exist these are often unfortunately incomplete, and careful work is yet necessary in order to separate out from the numerous Tipulid species those that, as larvae, are destructive to agricultural crops.

During 1923, Dr R.S. MacDougall, of Edinburgh University, suggested to the writer that a detailed examination of species of the Tipulidae in their larval stage would form an interesting and useful piece of work and it has been the writer's purpose to describe the morphological characters which exist for those larvae studied. Careful attention has been given to the full-grown larvae in each case and descriptions of stages other than this have been largely omitted except where it was thought necessary to emphasize some particular point or where some record of observation confirmed or varied with an already existing one.

The larvae of three British species have been fully dealt with, namely: Tipula paludosa, Meig., Tipula lateralis, Meig., and Pedicia rivosa, L., the last named forming the subject of a separate paper. Detailed descriptions of the external morphology, with special reference to the hind spiracles, and the internal anatomy have been set down with a view to assisting the recognition of the three species above named in their larval stage.

At the same time a further degree of interest in the work is justified when one considers the mode of life and environment of the three species described. With the large number of Crane Flies which exists it is naturally a difficult problem in many cases for one to decide if a certain species must be considered aquatic or not as the transition between strictly aquatic and terrestrial forms is very gradual, and between the two extremes are many types living in the
neighbourhood of water, in saturated mosses and leaves, or inhabiting mud or similar semi-aquatic habitats. The larva of *T. paludosa*, however, represents a purely terrestrial Tipulid form, while that of *Pedicia rivosa* is strictly aquatic. *T. lateralis* larva serves the purpose of a connecting link between these two extremes and may be looked upon as a semi-aquatic form of Crane Fly. Not only, therefore, is the work on these species to be treated purely as descriptive, but also it forms a very useful comparative study.

The material forming the subject of this paper was collected during the spring and early summer of 1924. Larvae were taken from five different localities in an attempt to obtain several species, but, unfortunately, on breeding out the adults for determination it was found that only two species were represented. The larvae of *T. paludosa* were most abundant and were taken from the following situations:

1. Private garden, Newington district, Edinburgh; April.
2. Private garden, Cramond, near Edinburgh; April.
3. Oat-field, Rosebery, Gorebridge, Midlothian; June.
4. Fields at Drumadoon, Blackwaterfoot, Island of Arran; June.

While searching for specimens of *Pedicia rivosa*, the writer encountered a few larvae of *T. lateralis* in the moss at the bank of a small stream in open heather moorland.

A certain number of larvae from each locality were allowed to complete their development and on emergence of the adult the species was determined. Dr R. J. MacDougall and Mr Percy H. Grimshaw, of the Royal Scottish Museum, Edinburgh, kindly confirmed the identification in each case.
I. TIPULA PALUDO3A, Heig.

THE ADULT.

During the course of the work the writer has found difficulty existing in some quarters as to the definition of specific characters leading to a distinction between the adults of T. paludosa, Hs. and T. oleracea, L. It would appear as though some entomologists consider them as being identical or, at least, that the one is a variety of the other. De Jong and Elze (6) question whether they exist as separate species, while Bodenheimer (3) considers T. paludosa as synonymous with T. oleracea. Wingate (17:37) notes T. oleracea as being "a greyish species with grey-brown wings, the whitish streak (under the brown fore-margin of the wing) rather conspicuous. Female wings large, longer than abdomen." While the characters of T. paludosa are "reddish-brown species, the pale wing-streak indistinct. Female wings shorter than the abdomen." But a further difference seems to be made use of in scientific writings in relation to the habitat of the larvae, T. paludosa being noted as occurring in marshy places, moist earth of woods, and beneath leaf mould. T. oleracea larvae, on the other hand, are stated to live in garden earth, pastures and meadows, and beneath turf. Yet this distinction is not sufficient as T. paludosa larvae are often found in habitats similar to those of T. oleracea. Unfortunately the writer did not collect any material as larvae which yielded adults of T. oleracea characters, otherwise differences in the morphology of the larvae of the two species might have been encountered.

Mating and Oviposition.

Dr. Rennie (14) made a special study of the mating and oviposition of T. paludosa and has described in detail the sexual behaviour of this species. Additional observations are to be found in the various writings on this species. During the course of the work
the writer carried out investigations along much the same lines as
those described by Rennie, the results being confirmatory in nature.
To elaborate on this aspect is therefore unnecessary but the ex-
perimental records have been summarised and tabulated below.

1. **Mating**: Adults were bred out from pupae confined individually
on the introduction of the male beside the female coitus was effec-
ted almost immediately or within a few minutes. Recently hatched
adults paired most readily, and would easily resume coitus after
interruptions. The conduct of the two sexes during the pairing
was as described by Rennie. It was observed, however, that after
pairing had been completed and the female fertilised, she expelled
a droplet of clear liquid from the tip of the abdomen a short time
after the male had disengaged.

2. **Oviposition**: The process of oviposition was observed in fe-
males confined in glass vessels which contained a layer, about two
inches deep, of fine moistened sand. Their behaviour was similar
to that noted by Rennie. Soil or turf was not given to the insects
to oviposit in as it was the desire of the writer to find in how far
oviposition would proceed under the somewhat unnatural conditions.
Eggs were laid by the females, but only a limited number before
death occurred.

In the table given below it should be noted that after a male
and female had paired they were not allowed to come in contact with
any other female or male respectively, and that they were separated
from each other overnight or when not otherwise under observation.

<table>
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<th>$f_2 x f_2$</th>
<th>$f_3 x f_3$</th>
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</thead>
<tbody>
<tr>
<td>Total duration of coitus in minutes</td>
<td>144</td>
<td>153</td>
<td>122</td>
</tr>
<tr>
<td>Number of unions</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Number of eggs laid</td>
<td>109</td>
<td>61</td>
<td>49</td>
</tr>
<tr>
<td>Number of shelled eggs dissected from</td>
<td>360</td>
<td>374</td>
<td>431</td>
</tr>
<tr>
<td>dead female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of eggs</td>
<td>469</td>
<td>435</td>
<td>430</td>
</tr>
</tbody>
</table>
THE EGG.

The egg (Fig. 1) is spindle-shaped and black in colour with a distinct steel-blue or purplish metallic sheen which is lost before hatching. It measures on an average 1.1 mm. in length and 0.4 mm. in breadth at its widest part in the middle. The elongate oval shape of the egg is not uniform, one end being very slightly conical, the other rounded. The chorion is a strong and tough shell which exists around the egg before pairing occurs. It is unsculptured. Rennie (15:117) states he was unable to detect the presence of a microstyle, although adding it may exist. After allowing several eggs to lie in cold 5% KOH for a short period, the writer examined them microscopically, when a distinct small circular patch was observed, darker than the general colour of the chorion. This patch was situated a little way from the more pointed end of the egg and had in the middle a minute pore, detected by its light colour and probably representing the microstyle.

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THE LARVA.

1. The Early Larva.

The writer did not have the opportunity of examining any first stage larvae and the following remarks review to some extent the already existing knowledge of this stage. Rennie (15:117) finds that the emergence of the larva occurs in about 14 days from the laying of the egg. The larvae, pale reddish sandy colour, are about 2.7 mm. long and show through the skin the two longitudinal tracheal trunks and also the alimentary canal with its four anterior and single posterior diverticula. Gerbig (3:137-140) shows that this stage is quite different from the later developmental stages since the prominent 6-lobed spiracular disc of the more mature larva is represented by four heavily chitinised projections bearing only—a
few bristles on their outer margins. Further, eight branched bristles about equidistant from each other replace the two dorsal lobes, and the spiracles, which project a little beyond the level of the disc, are oval and not circular as in later instars. Rennie further states that "in about 12 to 13 days from the time of hatching the larvae are 4-5 mm. in length when fully extended, and already resemble the older and more familiar 'leather-jacket'. By about 3 weeks they have attained a size of 6 mm. They feed from the first day onward."

2. The Full-grown Larva.

(a) General Description.

The full-grown larva (Fig. 2) attains a length of 40 mm. when fully extended and has a diameter of 4 mm. It has no definite head but there is a well formed retractile mandibular capsule. In shape it is cylindrical, slightly narrowed anteriorly, and expanded posteriorly at the anal and stigmatic region. The larva, of a grey or brown-grey or earthy colour, has a soft but tough skin that has earned for it the well known common name of "leather-jacket". There are numerous inconspicuous transverse furrows in the body, but some, more definite than others, mark off 12 distinct segments which bear numerous minute bristles placed in definite positions. The truncated hind end is formed of two distinct regions, the upper peristigmatic papillae-bearing area, of a characteristic form, and the lower, anal area. The larva is metapneustic.

(b) Detailed Description.

The Head Capsule.

The head capsule (Figs. 3 and 4) is compact and massive, somewhat flattened and elongated, of a shining black-brown colour, paler in those regions which are less highly chitinised. It measures, on the average, 4 mm. in length and 2.6 mm. in breadth at its widest part. The larva is properly speaking in a "hemi-cephalous" con-
dition, the capsule being incomplete posteriorly due to the break-
ing up of the component parts. The capsule, which is permanen-
tly imbedded in the prothorax, is somewhat retractile and may at times
be completely withdrawn into the prothorax and anterior part of the
mesothorax.

Dorsally, the median sclerite or prefrons is continuous with
the lateral plates, but may be distinguished from the latter by
being less highly chitinised. It is fairly large, conspicuous and
narrowly triangular. The lateral plates, which constitute the
greater part of the capsule, are mussel-shaped with the posterior
longitudinal incisions extending through one-third the length of
the entire capsule. They are highly chitinised anteriorly, much
less so posteriorly, the lateral parts being in an intermediate con-
dition.

Ventrally, the two lateral plates are fused in the anterior
region for a short distance, but they soon separate and diverge to
form a deep V-shaped incision with sinuous sides, extending over
two-thirds of the length of the capsule. Again, the degree of
chitinisation diminishes from front to rear.

The greater part of the capsule is filled with muscles control-
ling its movements and those of the mouth-parts.

The labrum and clypeus (Fig. 5) are not distinct from each
other but have lost their individuality by fusion. Indeed, the
front also appears to have fused with the clypeus. The frontal
region, bearing minute scattered bristles laterally, 6 on each side,
extends forward from the anterior margins of the lateral plates and
joins the clypeus which is a transverse area bearing on each side a
distinct plate. A median, semi-transparent area widens anteriorly
to unite with the labrum which is fringed with hairs on the front
margin and bears two close-set median processes of small size on its
dorsal surface. A pair of broad protuberances occur as lateral
lobes and are each armed with two bristles, a short conical papilla,
and several hairs. The clypeo-labral region is clothed ventrally
with numerous stout hairs. The labrum proper bears several back-
wardly directed hairs arranged along the anterior edge in a somewhat
semicircular fashion, while the lateral regions bear a fan-shaped tuft of stout hairs.

The antennae (Fig. 11) are borne on the anterior lateral margins of the capsule on each side of the clypeo-labral region. The antenna is cylindrical, 4 times as long as broad, with a slight taper towards its distal end. Consisting of one joint, each antenna is situated on an almost transparent and slightly raised base which bears several fine hairs surrounding the joint. The distal end of the joint bears a small pear-shaped sensory papilla on the pale apex, while an auditory plate, circular in outline, is situated near the proximal end of the joint in an internal lateral position.

The Mouth Parts.

The mandible (Fig. 3) is stout with a rounded apex consisting of two teeth more or less equal in size. The inner part of the mandible bears an upper and lower row of 2 or 3 short blunt teeth, reduced to mere tubercles. The inner upper margin bears a sub-basal or median arm or tuft of hairs, while two setae are situated on the outside near the base of the mandible.

The maxillae (Fig. 7) are quadrate and of comparatively simple form. Each consists of a large and distinct transversely triangular cardo, a conspicuous stipes and distinct outer and inner apical lobes. The outer lobe bears a tuft of hairs and the palp which consists of a single short cylindrical joint, crowned by a number of minute sensory processes and with a small circular plate, similar to that of the antenna, on its outer face. The inner lobe is densely hairy at the tip and on the inner face, and carries two fairly prominent but widely separated thick bristles.

The hypopharynx (Fig. 6), which lies immediately dorsal of the labium, is heavily chitinised and takes the form of a flat plate, the anterior margin of which is dentate and bears 5 distinct teeth. From the rear of this plate two arms project, which, viewed ventrally, assume the form of an inverted U whose arms arch over the oesophageal opening. A cushion-shaped pad, covered with numerous
short blunt setae, is situated on the dorsal face of the plate, while the common duct from the salivary glands opens ventrally through the base of the plate and is masked by a small tuft of hairs.

The labium (Fig. 9). The labial region, heavily chitinised, appears to consist of two fused plates, a ventral plate, the mentum, and immediately dorsal and fused to it an inner plate. The outer plate furnishes the strong median apical tooth of the mentum while the inner plate adds three more teeth of approximately equal size, the tips of which form a straight transverse line, to each side, thus producing a 7-dentate mentum. The labial plate is incompletely divided being entire in its anterior half but diverging posteriorly into two arms which are continuous with the anterior portions of the lateral plates of the capsule.

The Body.

The body consists of three thoracic and nine abdominal segments. As already stated the shape is cylindrical, but not of consistent diameter as the larva is to some extent capable of contracting or expanding the body during locomotion or when irritated. The skin, generally tense in healthy larvae, is covered with a microscopic pubescence, more noticeable on the sides where it assumes the form of a comparatively broad hairy strip. Frequently this strip of cuticle may become more prominent by assuming the form of a longitudinal blunt keel-like ridge, due to the contraction of the larva. Apart from the numerous wrinkles in the cuticle, the abdominal segments often exhibit 3 furrows or creases which, inconspicuous as they may be, are, however, apparent under a lens and subdivide every abdominal segment except the last one into four rings. Even though all three furrows are not seen, the centre one, at least, slightly more prominent than the others, usually shows and serves to subdivide the segment into an anterior and a posterior ring. Locomotor appendages such as pseudopods or ventral raised creeping-pads do not exist.

The Chaetotaxy.

The cuticle bears numerous setae or pencils of hairs distri-
buted in a definite arrangement. In the literature consulted, the chaetotaxy of this species appears to have been incompletely described and figures are lacking. Accordingly the writer has made a very careful study of the chaetotaxy, as likely to be of specific value, and setal maps have been drawn out (Fig. 12). These maps are diagrammatic and are constructed in a similar manner to those employed in exhibiting the chaetotaxy of Lepidopterous larvae. Thus, in each map, the top boundary represents the mid-dorsal, and the bottom boundary the mid-ventral line. Hence each map shows the entire left half of a segment, while, in all cases, the head end is at the left.

In the course of the examination of the cuticle it was frequently noticed that some of the setae were lacking, having been broken off during larval life or in the preparation of the skin for microscopic examination. But in every case the origin of the seta was evident as a small pit. Moreover, the cuticle was often found to be interspersed with irregularly placed blackish dots, possibly skin abrasions, and care was necessary to distinguish these from pits. The maps which form Figure 12 show the arrangement and distribution of the setae and have been compiled from a careful microscopic examination of numerous larval skins.

The setae vary somewhat in length and stoutness, but are nowhere at all prominent. They are directed, as a rule, backwards and probably serve, as far as locomotion is concerned, to increase the contact between the larval body and the surrounding earth. Single setae are comparatively numerous, but pencils of fine setae also occur, while, at times, a single stout seta and a pencil of fine hairs are found together. None of the setae appear to be branched.

No system of numerals or letters, such as was drawn up by Müller, Dyar, Tracker and others for Lepidopterous caterpillars, has been applied to the setal arrangement of this and the following larva for two main reasons. In the first place, no such system appears to exist from which a nomenclature or enumeration could be adopted for the species at present studied. Secondly, lacking
such a pre-existing system, it is obviously of little use to attempt to evolve one from a consideration of but two forms from such a genus as Tipula which is relatively rich in species. Much work on many species is required in order to approximate at a generalised type so that this can be used as a basis and from it the various species differentiated.

The Spiracular Disc and Anal Region.

The posterior end of the body is truncated and divisible into two well defined regions, an upper half consisting of the spiracular area and surrounding lobes, and the lower half, the anal area (Fig. 13). The latter region often appears distinctly separated from the upper peristigmatic region by a thin, usually interrupted and sinuous dark brown or black line. Some specimens examined, however, did not possess this dividing line.

The anus, slightly subterminal, is surrounded by fleshy lobes of which 4 upper and 4 lower usually can be discerned. The anal region is usually somewhat lighter than the general body colour. At the dorso-lateral margins of this region a large retractile papilla, conical in shape, is situated on each side of the terminal segment. These papillae are considered as characteristic for this species by Beling (2), but Malloch (12:192) in discussing the family characters of the Tipulidae remarks that in "terrestrial forms .... the slender protrusive blood-gills usually absent, their function being performed by an irregular protrusive membranous organ".

The stigmatic area (Fig. 14) is expanded on its border into six conical fleshy lobes. Their arrangement is on a definite plan and they form three distinct pairs, viz: a dorsal pair arising from either side of the mid-line; a lateral pair arising from the dorso-lateral margin of the stigmatic area; and the third pair arising from the ventral border and more widely separated than the dorsal pair. All the processes are similar in shape but the ventral pair are somewhat thicker than the others. The whole of the stigmatic area appears as a shining surface including the posterior faces of the spiracular lobes, which are fringed by a row of moderately long
fine setae, of a light brown or yellowish colour. The setae are not situated on the outer edges of the processes but are set a little towards the interior of the posterior faces where they follow the boundary of a slightly raised elongated area. These hair-like setae are longest at the tips of the processes, diminishing in size as the bases are reached, and towards the point of the four dorsal lobes a bristle is brought into prominence through its insertion and strength. At the tip of the ventral lobes a conspicuously long dark-coloured bristle arises from a small pale raised knob which succeeds an oval area of brown-black chitin tailing off towards the spiracles as a narrow streak. At the base of each ventral lobe there is a pair of small pigmented spots sometimes coalesced into a short streak on each side. The hind face of each dorsal lobe bears two streaks of dark brown chitin within the setal fringes, while the lateral lobes bear a slightly broader streak towards their outside borders. These chitinised streaks or plates serve as points of attachment for the muscles controlling the movements of the lobes.

The two ventral lobes appear to have a sensory function as, in live specimens, they can be observed at times to be bent upwards and applied to the spiracles. This fact was observed by Rennie (18119) while Gerbig (3) considers the large bristles to be sensory.

The spiracles (Fig. 16) are large, of a brown colour, practically circular in outline and separated from one another by a distance almost equal to the diameter of one. Each consists of two distinct portions, an apparently uniform middle piece surrounded by a radially folded margin of almost constant width, the stigmal ring. This ring has a definite, but narrow, peripheral chitinous margin. The stigmal ring appears to consist of a large number of thin chitinous rods directed inwards and slightly downwards towards the atrium, so joined together and anastomosing as to present the appearance of a grating, an efficient barrier to the entrance of foreign particles. The middle piece has a narrow border of concentrically striated chitin surrounding an area which varies from place to place in its degree of chitinisation. This middle piece appears to be an imperforate plate, but Gerbig (3) shows that it
is split across, the cleft being closed by two overlapping membranes. On consulting the literature it would appear that some authors entertain the view that the middle piece is imperforate and that respiration takes place through the stigmal ring. Accordingly the writer made a careful examination of this part of the spiracle and was able to confirm Gerbig's observations. On microscopic examination the two membranes could be demonstrated, lying in their natural position, the one above the other, by careful adjustment of the focus, while in other cases, they could be seen separated when the spiracle was gently pulled apart (Fig. 10).

It seems possible, therefore, that, while respiration probably does occur through the sieve-like stigmal ring, it also takes place through the cleft median plate.

The Internal Anatomy.

The Digestive System: The alimentary canal in this herbivorous larva is an almost straight tube of varying diameter (Fig. 17) extending the whole length of the body. It is enclosed in the coiled perforated sheets of the fat-body. The short pharynx, from whose walls muscles radiate to the walls of the head capsule, opens from the mouth. The pharynx quickly narrows to form the oesophagus, a slender tube of nearly uniform calibre, which in turn is succeeded in the rear part of the metathorax by the proventriculus, which has a large oesophageal invagination at its anterior end. The proventriculus merges into the stomach which is large and uncoiled.

Four comparatively short, sac-like diverticula of equal length arise at the oesophageal end of the stomach. The mid-gut quickly narrows in the rear part of the fourth abdominal segment where it joins the small intestine, a short uncoiled tube of narrow diameter. The commencement of the hind intestine is marked by the insertion of the four coiled Malpighian tubes. At the union of the small and the large intestine occurs a conspicuous diverticulum, remarkable for its large size. This coecum, almost as large in diameter as the stomach, extends forward from the posterior of the fifth to almost the middle of the third abdominal segments. It is divided from the
large intestine by a slight constriction. The large intestine also is a tube of wide calibre, narrowing towards the rear where it opens to the exterior at the anus.

The Malpighian tubes, four in number, are long slender coiled organs of uniform diameter arising separately at the beginning of the small intestine. They are light brown in colour and are to a large extent in contact with the fat tissue.

The salivary glands consist of two large, somewhat coiled tubes which, when extended, occupy the length of the first three abdominal segments. Their diameter is comparatively wide and uniform throughout. From the anterior end of each gland a narrow duct passes forward, which, by uniting, form a common collecting duct passing ventrally to the foregut and opening at the base of the hypopharynx. These ducts are short and in respect of their chitinous lining bear a close resemblance to tracheae.

The Nervous System (Fig. 13): The brain or supraoesophageal ganglion is composed of two lobes, united posteriorly, lying above the oesophagus in the anterior part of the mesothorax. Beneath the brain and on the underside of the oesophagus lies the suboesophageal ganglion, connected with the anterior ends of the brain lobes by two commissures, thus forming a complete ring around the alimentary canal. The nervous system leads backwards from the suboesophageal ganglion. In the posterior part of the mesothorax and anterior part of the metathorax are four closely approximated ganglia representing the three thoracic and first abdominal ganglia. Beyond these are the remaining six abdominal ganglia located in the anterior part of the first six abdominal segments, one ganglion in each segment. The longitudinal commissures between the seven abdominal ganglia are simple, and the terminal ganglion is larger than the others giving off, posteriorly, two main branches which are directed into the caudal segments. The brain, suboesophageal and three thoracic ganglia each send off two lateral nerve branches, and abdominal ganglia each giving rise to four lateral branches.

The head capsule is so completely filled with muscles controlling its actions that the brain is considerably displaced.
The Circulatory System (Fig. 19): The dorsal vessel consists of a series of eight chambers separated by seven pairs of lateral ostia, and runs forward from the rear of the eighth abdominal segment throughout the abdomen and is prolonged through the thorax as the aorta, terminating near the brain. Eight pairs of alary muscles are present in abdominal segments 1-8. The blood is colourless.

The Respiratory System (Fig. 20): There are two principal tracheal trunks, lying in a dorsal position, which run almost the whole length of the body, from the spiracles to the mesothorax where they divide and form several branches supplying the muscles controlling the head capsule, the oesophagus, brain and other closely connected ganglia. The trunks are connected across by simple tracheal commissures, delicate and unbranched. Secondary tracheal trunks arise from the main ones, a little distance from the spiracles, and run in a ventro-lateral position into the mesothorax. These communicate by short transverse connections, occurring in the second to the ninth segments, with the main trunks. From each of these short connecting tracheae a branch is given off which runs inwards and forwards supplying the fat tissue and the alimentary canal. In segments 2-10 inclusive a ventral branch arises from the secondary trunk and runs inwards to supply the nervous system. The dorsal regions are supplied by fine branches from the lateral trunks and also by tracheae from the supply to the alimentary canal.

Immediately below the spiracle, which has been already discussed, occurs the spiracular vestibule whose walls are provided with numerous branched chitinous fibres which are so intermixed that they form a dense network (Fig. 16). This trumpet-shaped part continues for a short distance and then becomes the main tracheal trunk proper with its spiral thickening of chitin. The wall of the vestibule is sponge-like in form and shows numerous irregularly placed channels. These consist of bundles of tracheoles which, arising from the special cavities in the 'network-chamber' radiate outwards and are prolonged for some little distance beyond the vestibular walls. Hence the terminal part of the trachea is surrounded by a
dense mass of tracheoles which make up the tracheal 'lungs'. Gerbig (8) while working on T. paludosa estimated that there were about 50 bundles, each of about 20 tracheoles, making a total of approximately 1000 of these air canals. The plexus of fine tracheal branches in the neighbourhood of the spiracles supplies the walls of the posterior region of the dorsal vessel and probably these branches function, en masse, as a kind of lung.

The anal region and spiracular lobes are supplied by small branches given off from near the origin of the main tracheal trunk.

**PUPATION.**

A certain proportion of the mature larvae collected were set aside for breeding work in order that the species might be determined from adult characters. It was found from records kept that the average length of the pupal period was 10 days, the maximum being 13, and the minimum 8 days. Of the 23 adults bred out for determination the proportion of the sexes was 7 males to 16 females. The breeding work was carried out in the laboratory during the summer months.
II. TIPULA LATERALIS, Meig.

The Full-grown Larva.

(a) General Description.

The full-grown larva (Fig. 21) measures on the average 24 mm. in length and 3 mm. in diameter, but it is capable of contracting to 18-20 mm. and expanding to 33 mm. in length. There is a definite head capsule. The body is cylindrical, slightly narrowed anteriorly and posteriorly, firm skinned and dirty yellow-grey or brownish-yellow. On the dorsal surface is a dark coloured narrow middle stripe and two less dark broad lateral stripes running longitudinally, in which are found lighter spots. These three longitudinal stripes are interrupted, moreover, by transverse lighter lines. The ventral surface is lighter in colour. The larva is 12-segmented, with a definite chaetotaxy, metapneustic, and with the hind end truncated forming a conspicuous spiracular disc bearing six prominent cuticular lobes fringed by glossy black-brown setae. The anus is sub-terminal and preceded ventrally by six skin processes consisting of four equally large and two smaller anal gills which are situated on the terminal segment.

(b) Detailed Description.

The Head Capsule.

The head capsule (Figs. 23 and 24) is similar to that of T. paludosa, but is more oval in outline. Shining black-brown in colour, with lateral and posterior lighter parts less highly chitinised, it is 3.2 mm. long and 1.9 mm. broad at the widest part. The capsule is very retractile and while it is permanently imbedded in the prothorax, it may be completely withdrawn into that segment and into the fore-part of the mesothorax. The prefrons, or median dorsal sclerite, is somewhat lighter than the lateral plates with which it is continuous and shows as a narrow triangular area, whose
posteriorly converging sides are slightly sinuous. The lateral plates are mussel-shaped and the posterior longitudinal incisions of the dorsal surface extend one-quarter the length of the entire capsule. The anterior parts of the lateral plates are most highly chitinised.

Ventrally, the lateral plates are fused for a short distance at their anterior region but they quickly separate and form a conspicuous incision which extends throughout five-sevenths the length of the capsule. The incision is not so pronounced a V-shape as in *T. paludosa* as the sides are somewhat concave and tend to approximate posteriorly, but it is slightly deeper.

The muscles controlling the movements of the capsule and its mouth-parts almost completely fill the cavity of the capsule.

The front, clypeus and labrum (Fig. 25) are not individually distinct but have fused together. The frontal region, which extends forward from the anterior margins of the lateral plates, bears scattered bristles laterally, five on each side. It meets and fuses with the clypeus which is a transverse area in front of the insertion of the antennae. The clypeal region resembles that met with in *T. paludosa* but is less rectangular in shape. It consists of two lateral plates, separated by a median semi-transparent area which gives rise anteriorly to the labrum. The labrum, fringed with hairs on its front margin, bears a pair of small close-set median processes, dorsally, and also a pair of protuberances which appear as lateral lobes armed with two bristles and a short conical papilla and a tuft of hairs. Ventrally, the clypeo-labral region bears numerous stout hairs. The fan-shaped tufts of hairs seen laterally on the labrum of *T. paludosa* are not present in this instance.

The antenna is very similar to that of *T. paludosa* and consists of a single cylindrical joint, four times as long as broad, set on a semi-transparent elevated base. The circular auditory plate is present at the proximal end and the pear-shaped papilla surmounts the distal end of the joint.
The Mouth Parts.

The mandible (Fig. 23) is stout but not so robust as that of *T. paludosa*. The apex consists of one tooth, while a single smaller dorsal tooth is sub-terminal in position. The ventral edge of the mandible is composed of three rather indistinct teeth, of which the median one is the least pronounced, and merely a tubercle. The inner upper margin bears a median tuft of hairs on a projecting arm.

The maxilla (Fig. 29). Consisting of the transverse triangular cards, wide stipes, and outer and inner apical lobes, great similarity is observable between the maxilla of *T. lateralis* and that of *T. paludosa*. The outer lobe bears a tuft of hairs and a short stout joint surmounted by several minute sensory processes. The inner lobe is densely hairy on the inner face and at the tip. Replacing the two fairly prominent bristles seen on the inner lobe of *T. paludosa* maxilla are tufts of fine bristles.

The hypopharynx (Fig. 26) assumes the form of a flat plate from the rear of which two projecting arms are directed dorsally arching round the oesophageal opening. The whole structure is chitinised, the arms more heavily than the remainder. The anterior edge of the plate is flatly rounded in outline, with shallow incisions which mark off five rather indistinct blunt teeth, the middle one being the most prominent. In this respect the hypopharynx of *T. lateralis* differs conspicuously from that of *T. paludosa*. The dorsal surface of the plate has a cushion-shaped pad, beset with short blunt setae, situated on it. The opening of the common duct from the salivary glands through the base of the plate is masked ventrally by a tuft of hairs in which two stand out more prominently near the anterior region.

The labium (Fig. 27) of this species differs markedly in shape from that of *T. paludosa*. It consists of the two fused plates, the ventral plate or mentum giving rise to the median tooth of the anterior edge, while the upper plate adds three more teeth to each side of this relatively long slender one. But, although the tips of these lateral teeth form a straight line, this line is not transverse but is directed posteriorly giving the front edge of the
labium a broad wedge shape. The teeth, moreover, are blunt and rounded, the two outside ones hardly justifying the term applied to them. The labial plate is entire anteriorly but is divided by a very narrow incision in its posterior region, the two arms thus formed being continuous with the ventral anterior portions of the lateral plates.

The Body.

The body, consisting of three thoracic and nine abdominal segments, is cylindrical but varies in diameter owing to the movements of the larva which is very contractile. Normally, there is a slight taper towards front and hind ends. The skin is tough and is covered with a pubescence which is very close-set on the thoracic segments, giving them a 'satiny' appearance and making them opaque in life. On the abdominal segments it is scantier, especially on the lateral parts, but becomes more pronounced towards the hind end, the terminal segments being distinctly hairy.

The abdominal segments, except the last one, have an inconspicuous constriction about the mid-length dividing each segment into an anterior and posterior portion.

The general colouring and occurrence of darker stripes has been discussed in the general description.

The Chaetotaxy.

The distribution and position of the setae on the larval cuticle of this species is definite and differs in certain respects from the chaetotaxy of the larva of T. paludosa. Setal maps, similarly constructed to those of the last named insect have been drawn up (Fig. 30) and the differences in the chaetotaxy of the two species may be observed by a careful comparison of the diagrams. In the case of the larva of T. lateralis, the setae are longer and stouter generally except on the thoracic segments, and branched setae make their appearance, while the fine pencils present on T. paludosa larva do not occur. The whole skin of the larva is pubescent, but this pubescence increases in coarseness towards the hind end so that the terminal segments are distinctly hairy. This condition, how-
ever, was not sufficiently pronounced as to obscure the setae.

**The Spiracular Disc.**

The stigmatic area ([Fig. 31](#)) is similarly constituted to that of the preceding larva but is quite distinct from it. The six fleshy lobes surrounding the area are long, slender, and finger-like and more salient than those of *T. paludosa* larva. They are all fringed with a border, set on the edge of the process, of conspicuously long setae, black at their origin but assuming a golden-brown colour throughout the greater part of their length. The fringe is longest at the ends of the processes, becoming shorter as the bases are reached. The whole of the stigmatic area, including the lobes, appears as a shining surface and is devoid of pubescence. The two dorsal lobes are furnished with a single terminal seta, arising from a distinct pit, and have at their base two glossy black-brown areas. The inner area of each lobe is linear and the outer somewhat semicircular in shape. The two lobes constituting the lateral pair are of the same length as, but somewhat more slender than, the dorsal pair. The single terminal seta appears again in this pair of lobes, but the black-brown areas are both linear, occurring on each side of the base close to the spiracle. A single brown streak on each lobe runs from near the tip down the mid-line tailing off after traversing a little more than half the length of the process. The two ventral lobes are stronger and blunter but equally as long as the others. They are each furnished at their tips with a conspicuous long dark coloured bristle arising from a small pale oval area. Surrounding this area, and running inwards from it along the mid-line of the lobe, is a brown streak which terminates near the base of the process. A diffuse darker patch is situated at the junction of the bases of these two lobes, but a very conspicuous blackish area occurs in the outer part of each base immediately ventral of each spiracle. These areas are irregular in shape but are more or less linear, terminating in a rounded patch at the end remote from the mid-line.

The spiracles ([Fig. 32](#)) are large, conspicuous and dark brown
in colour. Their shape is irregular but each has a more or less circular outline except for that portion of the spiracle which abuts on the mid-line of the stigmatic area. Here the boundary is practically a straight line. They are separated from one another by a distance approximately equal to two-thirds the breadth of the spiracle. As in the case of *T. paludosa* each consists of the grating-like stigmal ring with a narrow peripheral margin and the middle piece which, owing to the variation in the degree of chitinisation, does not exhibit a uniform colour. Gerbig (8:154) in his short notice of this larva, writing of the spiracle, says "the middle part does not shine as a uniform black plate, but as a light area with a not very spacious middle dark spot of an oval form." This appearance was observed and from careful examination the 'middle dark spot' of Gerbig was seen to be composed of the two over-lapping membranes closing the cleft of the middle piece which, as in *T. paludosa*, is also split across. Thus the construction of the posterior spiracles in the two species studied is very similar, both having the perforated stigmal ring enclosing the central cleft area, and the shape alone leads to distinctions.

**The Anal Region.**

The lower part of the truncated hind end of the larva consists of the anal area. The anus is slightly sub-terminal and is surrounded by very blunt fleshy lobes, forming a ring (Fig. 22). As a rule, six upper and six lower lobes can usually be discerned and these are paler than the general body colour. At the lateral margins of the anal region, situated on the terminal segment are the proportionately large gills which consist of four equally large and two smaller skin processes. The anterior pair of gills are the shortest and measure only 0.75 mm, but the two succeeding pairs of gills attain a length of 2 mm. The smaller gills are bluntly conical, unconstricted and capable of retraction within the body. In life they are often directed backwards when fully protruded. The larger gills also are conical, but more slender and are constricted slightly about their mid-length. They, too, are capable of retrac-
tion within the body and are usually conspicuous and spread laterally in life.

Alexander makes some interesting remarks on the anal gills of Crane Flies (1:743) and says: "In the species of Tipula the number of gills varies from four to eight. In the latter case each of the four principal gills is deeply bifid and the gills are arranged transversely, as in *T. ignobilis*; in species with six gills the posterior branches of the posterior gills are atrophied as a rule; in other species, which have but four gills, the four anterior branches are preserved, the posterior pair being usually atrophied."

Bearing in mind these remarks and considering the exact location of the six gills of *T. lateralis* larva it seems probable that the short pair of gills consist of a basal branch of the large anterior pair, and therefore the gill apparatus really consists of two pairs of gills; there is an anterior pair, which is bifid producing a large branch and a small basal one, and there is a posterior pair, large and unbranched.

The Internal Anatomy.

What has been written of the internal anatomy of *T. paludosa* applies equally well to *T. lateralis*, with one or two exceptions where slight differences are encountered. In both species the nervous and circulatory systems are alike. In the main the digestive systems resemble one another, the four anterior and single posterior diverticula being encountered in each. But in *T. lateralis* the posterior diverticulum, which occurs at the union of the small and the large intestine is conspicuously smaller than that observed in the other species studied and hardly extends through the length of one abdominal segment.

As far as was observed the respiratory systems were generally similar in both species, the chief differences lying in the distribution of the tracheae at the hind end. Owing to the lack of sufficient material the writer was unable to examine the respiratory apparatus of the larva in detail, especially with reference to the distribution of the tracheae and tracheoles to the anal gills. The
spiracular vestibule and first part of the main tracheal trunk was, however, thoroughly examined and was found to resemble the condition met with in the larva of *T. paludosa*, where the vestibule with its numerous bundles of tracheoles gives rise to the plexus of air-tubes which forms the so-called "tracheal lung".

The Habits of the Larva.

The larvae of *T. lateralis* were collected during July, 1924 in the region of Loch Awe, Argyllshire, from the saturated moss and leaves which had collected at the sides of a small, moderately quick flowing stream in open heather moorland. Gerbig (8:163) observes that the animals appear at the margins of channels (or ditches) with flowing water, and that they are found especially at the boundary between water and land where they remain suspended with their hind ends at the surface of the water, burrowing with the front end of their bodies in the mud. He adds, moreover, that the larvae were observed in abundance amongst plants at the surface of waters. Grünberg (9:73), basing his accounts on Beling's descriptions mentions that the larvae occur "in moist, humid or muddy earth. Found at the end of June in the moist earth of the bank of streams."

Under observation in artificial conditions the larvae lived without discomfort in a large glass beaker half filled with saturated sphagnum moss. The larva was frequently seen to lie quite motionless in the moss just below the water surface with the anal extremity projecting slightly into the air. Frequently only the fringed lobes of the spiracular disc, spread widely apart, made distinct projections above the surface film. When disturbed (by touching with a fine brush) the hind end was quickly withdrawn below the water surface, the spiracular lobes folding together and contracting to obscure the spiracles. When this happened, on almost every occasion a fairly large air-bubble was enclosed within the lobes, and this was carried down with the larva into the water. At the same time the body of the animal contracted very markedly. It then lay for a short time in a semi-contracted condition, quite motionless, until a further supply of air was required when the
larva again came to the water surface to resume its former position. The intervals during which the animal remained below the water, after being disturbed, were recorded and these periods varied from 2 mins., 50 secs. up to 4 mins., 2 secs.

Kept in water only, without moss, as long as the depth was shallow enough to allow of the hind end to be thrust above the surface, the animal behaved normally. In deeper water, the larva, unable to attain the surface, persisted in wriggling about and waving the hind end in an attempt to reach and break the surface film.

During life the larva is yellowish-grey in colour with a semi-transparent skin, except for the three thoracic segments which are opaque. The main and larger secondary tracheae and the alimentary canal can be seen through the skin. The head capsule is seldom fully protruded and locomotion appears to be accomplished by the animal gripping hold of objects (pieces of moss, etc.) within reach by the mandibles and pulling the rest of the body forward, bit by bit. As soon as the larva finds itself in the water it spreads out the anal gills conspicuously widely.

The larvae lived in the moss for several weeks until pupation without the addition of any material as food. This would point to a vegetarian diet and on dissection the alimentary canal was found to contain the remains of partly digested plant matter.

**PUPATION.**

Under artificial conditions the larva was induced to complete its development in the laboratory and, after a pupation period of eight days, the adult emerged at the beginning of August. The larvae were kept in sphagnum moss highly saturated with water and a pupa was discovered projecting about two-thirds of its length from some entangled moss. Grünberg (9:72) notes that pupation occurs in August in the slime of a dry bank, but says according to Gercke's observations that it may occur in the water should the larva be prevented from reaching the land.
ECONOMIC IMPORTANCE.

Much has been written in the published references to the activities of those larvae destructive to agricultural crops and it is not the writer's present intention to enlarge to any great extent on this subject in relation to the two Tipulid species studied.

Amongst the harmful species, such as *Tipula oleracea*, *T. paludosa*, *Pachyrhina histrio*, *P. maculosa*, *P. histrio*, *P. maculosa*, and others, it is interesting to note that *T. paludosa* attacks, according to the literature, quite a number of crops such as corn, barley, oats, wheat and rye, peas and beans and other vegetables, and also meadows and pastures. In instances, serious or excessive damage may be effected, but in other cases the larvae may be present in considerable numbers without their presence becoming apparent. A great deal of the *T. paludosa* material used by the writer was collected from Rosebery, Midlothian, and here the damage was very evident and the larvae were encountered in large numbers. In a letter, Mr. A. Mitchell, Overseer of the estate, estimated the damage thus:

"The 'Wellhill' field was cropped as follows: 1920, oats; 1921, hay; 1922, grass; 1923, grass; 1924, oats. In 1924 there would probably be two acres, out of a 22¹/₂ acre total, completely destroyed by the grubs and all over the crop was more or less thinned. ... The field in question is about 300 ft. above sea-level, the soil is good loam about 12 inches deep, and the field is well drained."

Not only are the larvae of *Tipulidae* to be considered as pests to the agriculturalist, but also they are destructive at the roots of trees in the seedling and nursery stages and therefore of some economic importance to the forester. One of the batches of larvae of *T. paludosa* collected by the writer was found in an experimental forest-tree nursery bed where the grubs were damaging the roots of 2 year, 2 year transplants of Norway Spruce (*Picea excelsa*) and Douglas Fir (*Pseudotsuga Douglasii*).

The larvae of *T. lateralis* do not appear to occur so extensively as pests, although Cameron (5) found the immature stages of this Cran-*fly* infesting a potato field where they commonly occurred. Walton (1
states that in 1916 *T. lateralis* was fairly common in the Aberystwyth area.


Of the three species studied, two belong to the family Tipulidae and *Fedicia rivosa* belongs to the family Limnobiidae. While possessing certain similar characteristics the last named insect is, however, sufficiently well defined by its family characters to be easily recognisable from the two Tipulid species. The retractile head capsule with its appendages furnishes the best distinctions and although similar to that of *Tipula*, in *Fedicia* the antennae are more slender and shorter than the maxillary palp and the labial plate is divided longitudinally in the centre, each part being provided with distinct teeth. In *Tipula* the antennae are elongated and larger than the maxillary palp and the labial plate is entire and subtriangular with a single apical tooth and several lateral teeth. Further, the mandibles of *Fedicia* are slender but powerful and sickle-shaped but in *Tipula* they are robust with rounded apex and with two teeth more or less equal in size, the inner upper margin being provided with a fringe of hairs near the middle. There is a marked contrast in the shape of the hypopharynx in the representatives of the two families.

The body form is moderately elongated and hirsute in all three animals but the chaetotaxy for each is definite and specific and this character is of importance. The pseudopods of *Fedicia* are distinctive and are absent from the Tipulidae.

The apical segment in the Limnobiidae is very differently constituted in the different genera but as far as can be learned there are never six processes of the spiracular disc which in the Tipulidae is the almost invariable number. In *Fedicia* there are only two lobes. The spiracles are constituted in all three species of the stigmal ring and the middle piece but they vary in shape and
size and, while it has been demonstrated that the middle piece is cleft in *T. paludosa* and *T. lateralis*, it remains for further detailed investigations to show if this character holds good for all species of *Tipula*. In *Pedicia*, at least, the middle piece is apparently imperforate.

Anal gills are found in representatives of almost all the major groups of Crane Flies and their loss is apparently the result of habitat and non-usage. In *T. lateralis* and *P. rivosa* their number and shape provide distinctions.

In the internal anatomy the most outstanding difference between *Pedicia* and the two *Tipulids* is in the digestive system. *Pedicia* is carnivorous and the alimentary canal has the minimum of caeca and diverticula. In the *Tipulid* species, both of which are herbivorous, there are the four small diverticula of the stomach and the more or less prominent diverticulum at the union of the large and small intestine. Otherwise the internal anatomy does not exhibit such marked differences as to be distinctly helpful for comparison.

In the case of the two species of *Tipula*, it has been attempted to describe the larvae with sufficient detail as to render distinctions possible, but on considering the number of species in such a genus as *Tipula* it seems of little use to compare the two species studied at this point. The writer rather prefers to indicate the characters that will prove of greatest value in the separation of the larvae of the species of *Tipula*—not only of the two already studied but of others which may be examined in detail in the future.

(a). Head Capsule: While the head capsule seems to be remarkably uniform in the genus, the best distinctions are to be found in the clypeo-labral region, hypopharynx and mentum, especially in the two last named parts which show variations in shape and in the number, size and shape of the teeth of their anterior margins. Other details of the capsule in addition will prove helpful.

(b). Chaetotaxy: The arrangement and distribution of the setae of the body appears, from the species examined, to be specific and therefore ought to be of great assistance in the separation of the various species.
(c) Spiracular Disc: This also is characteristic in the various species and the number of lobes surrounding the disc and the nature and character of the fringe of hairs of the lobes ought to be noted along with the markings on the face of the spiracular area. The size, shape, distance apart and detailed structure of the spiracles are points of importance.

(d) Anal Gills: These may or may not be present. When they occur their form, function, number and arrangement of the branches are of primary importance.

The mode of life and environmental conditions of *T. paludosa*, *T. lateralis*, and *Pedicia rivosa* are of interest and these species furnish examples of three closely related Crane Flies which show remarkable adaptations to habitat. Indeed Miall (13:11) uses the family Tipulidae as his example in discussing the degrees of adaptation to aquatic conditions and says: "How did Insects ever come to seek the water, seeing that their mode of respiration is primarily adapted to another element? We can see almost all the steps of the adaptation on the shores of our rivers, lakes and seas. We can see Dipterous larvae which, like the "leather jacket" (the larva of the Daddy-long-legs), burrow in the ground for their vegetable food, and devour the roots of grasses. Other larvae of the same family (Tipulidae) prefer moist earth in the neighbourhood of streams. Others again live immersed in water, or mud saturated with water, though they come to the surface at times and push their tails, which carry the spiracles, into the air. Some few have become so completely aquatic that they seldom, if ever, come to the surface, and all their supply of oxygen is obtained from the water." It seems certain that the larvae of the different species of the genus Tipula have a distinct mode of life, and *T. paludosa* may be accepted as a purely terrestrial species. *Pedicia rivosa*, on the other hand, is an allied Crane Fly of purely aquatic habits, living its larval existence in the water of streams or in wet places in mud or saturated leaves. *T. lateralis* provides an intermediate type which, in relation to a moist environment, prefers to live in the banks of streams.
or in wet moss. It is therefore evident that it is exceedingly difficult to decide whether a form is to be reckoned amongst the aquatic fauna because it depends in the most cases on individual discretion. But, nevertheless, the Crane Flies of the genus Tipula and closely related genera are of extreme interest and a great amount of work still remains to be done on the immature stages.

**SUMMARY.**

The full-grown larvae of Tipula paludosa, Meig. and T. lateralis, Meig. (Tipulidae, Diptera) have been studied in detail with a view to the distinction of species. The external morphology and internal anatomy are described, special attention being given to the hind spiracles and to the chaetotaxy.

A short note on the economic importance is included and mating and oviposition experiments with T. paludosa adults are summarised. The egg is also described and the knowledge of the early larva is reviewed to some extent. The habits of the full-grown larva of T. lateralis are noted.

The paper concludes with a brief comparison of T. paludosa, T. lateralis and the closely allied Pedicia rivosa.

The writer desires to express his indebtedness to Dr R. S. MacDougall for the helpful advice and suggestions given during the course of this work. For help in determining the species of the adults bred out, thanks are due to Mr Percy H. Grimshaw. Through the kindness of Mr A. Mitchell it was possible to collect sufficient material for detailed work and the writer acknowledges this courtesy.


12. MALLOCH, J.R. - A Preliminary Classification of Diptera, exclu-
ive of Pupipara, based on Larval and Pupal Characters, with keys to Imagines in Certain Families. Part I.

13. MIALL, L.C. - The Natural History of Aquatic Insects.


EXPLANATION OF FIGURES.

(All figures except No. 1 relate to the full-grown larval stage).

NOTE: As the original figures have been used for reproduction work and are not available, reduced copies from the blocks have been inserted. The arrangement differs from the original but references in the text have been retained and the necessary alterations made in the following explanations.

*Tipula paludosa*, Meig.:

For Fig. 1 in text read Fig. 3. The egg. $\times 27$

For Fig. 2 in text read Fig. 1. The larva, lateral aspect, normally extended. $\times 3$.

For Fig. 3 in text read Fig. 6. Head capsule, dorsal aspect. $\times 15$. The line shows the position of the anterior edge of the prothorax. $lr =$ labrum; $a =$ antenna; $pf =$ prefrons; $fp =$ lateral plate.

For Fig. 4 in text read Fig. 7. Head capsule, ventral aspect. $\times 15$. The line shows the position of the anterior edge of the prothoracic segment. $lr =$ labrum; $a =$ antenna; $li =$ labial region; $lp =$ lateral plate.

For Fig. 5 in text read Fig. 11. Clypeo-labral region of the head capsule, dorsal aspect. $\times 60$. $lr =$ labrum; $cl =$ clypeus; $a =$ antenna; $f =$ frons; $lp =$ lateral plate.

For Fig. 6 in text read Fig. 19. Hypopharynx, ventral aspect. $\times 60$.

For Fig. 7 in text read Fig. 17. Left maxilla, ventral aspect. $\times 60$. $c =$ cardo; $st =$ stipes; $il =$ inner lobe; $p =$ palp.

For Fig. 8 in text read Fig. 13. Left mandible, dorsal aspect. $\times 60$.

For Fig. 9 in text read Fig. 15. Mentum or labial plate, ventral aspect. $\times 70$.

For Fig. 10 in text read Fig. 24. Posterior spiracle split to show overlapping membranes of the middle piece. $\times 60$. 
For Fig. 11 in text read Fig. 5. Left antenna, dorsal view. x 210.
For Fig. 12 in text read Fig. 28. Setal maps. Map 1, prothorax; 2, meso- and metathorax; 3, abdominal segments, 1-7; 4, abdominal segment, 8; 5, abdominal segment, 9.
For Fig. 13 in text read Fig. 22. Posterior aspect of segment 12 showing the spiracular disc and the anal area. x 14.
For Fig. 14 in text read Fig. 23. Spiracular disc. x 22.
For Fig. 15 in text read Fig. 25. Right posterior spiracle. x 75.
For Fig. 16 in text read Fig. 21. Spiracular vestibule and beginning of main tracheal trunk in the larva. (tracheoles of "lung" omitted). x 60.
For Fig. 17 in text read Fig. 4. The digestive system. x 4.
oe = oesophagus; st = stomach with diverticula; sg = salivary glands; m = Malpighian tubes; d = large diverticulum; si = small intestine; li = large intestine.
For Fig. 18 in text read Fig. 30. The nervous system (partly diagrammatic). x 4.
For Fig. 19 in text read Fig. 31. The circulatory system (partly diagrammatic). x 4.
For Fig. 20 in text read Fig. 32. The respiratory system (partly diagrammatic). x 4. sp = spiracle; mt = main tracheal trunk; c = connectives of main trunk; st = secondary tracheal trunk; as = branch supplying alimentary canal, fat tissue, etc.; ns = branch supplying nervous system.

Tipula lateralis, Meig.:
For Fig. 21 in text read Fig. 2. The larva, lateral aspect, fully extended. x 3.
For Fig. 22 in text read Fig. 10. Hind end of larva, ventral aspect, showing anal gills. x 15.
For Fig. 23 in text read Fig. 8. Head capsule, dorsal aspect. x 15. The line shows the position of the anterior edge of the prothoracic segment.
For Fig. 24 in text read Fig. 9. Head capsule, ventral aspect. x 15. The line shows the position of the anterior edge of the prothoracic segment.

For Fig. 25 in text read Fig. 12. Clypeo-labral region of the head capsule, dorsal aspect. x 60.

For Fig. 26 in text read Fig. 20. Hypopharynx, ventral aspect. x 75.

For Fig. 27 in text read Fig. 16. Mentum or labial plate, ventral aspect. x 75.

For Fig. 28 in text read Fig. 14. Left mandible, dorsal aspect. x 75.

For Fig. 29 in text read Fig. 18. Left maxilla, ventral aspect. x 75.

For Fig. 30 in text read Fig. 29. Setal Maps. Map 1, prothorax; 2, meso- and meta-thorax; 3, abdominal segments, 1-7; 4, abdominal segment, 8; 5, abdominal segment, 9.

For Fig. 31 in text read Fig. 27. Spiracular disc of terminal segment. x 26.

For Fig. 32 in text read Fig. 26. Left posterior spiracle. x 60.