THE LARVAL AND PUPAL STAGES OF THE BIBIONIDAE.

By HUBERT M. MORRIS, M.Sc., F.E.S.

Entomological Department, Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden.

Several species of BIBIONIDAE are very common in the adult state during the spring and early summer in Britain, but their larvae seem to have been very little studied. The latter frequently occur in large numbers together, and are from time to time reported to have caused damage to various crops.

Probably the commonest species of *Bibio* are *B. marci* and *B. johannis*, but several others are also very frequently met with. The life-history of *Bibio johannis*, L., has been fully dealt with previously (6), and in the present paper it is proposed to give some account of the life-histories of *Bibio marci*, L., *B. lacteipennis*, Ztt., and *B. venosus*, Mg.

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***Bibio marci*, L.**

Oviposition.

In the early part of May 1920, a number of adults of *Bibio marci*, of both sexes, were captured and placed in a glass jar, the top of which was covered with gauze.

Fig. 1. Eggs of *Bibio marci*, $\times 6$.

At the bottom of the jar a layer about 3 cm. in depth of fine damp soil was placed. The flies were fed on sweetened water, and by this means it was found possible to induce the females to oviposit. After a day or two, the time probably varying with their age when captured, females were seen making their way into the soil. This is accomplished almost entirely by means of the fore legs, which are moved up and down in front of the head, with their tarsi bent back, the actual pressing back of the soil being done by the distal ends of the tibiae. In this manner a burrow just large enough to contain the fly is made, the insect turning over from time to time so that the soil is pressed aside in all directions. The burrows have a very irregular course, but the flies gradually make their way downwards into the soil.

At a little distance below the surface, the depth varying in different cases, a small cell is constructed which is of greater diameter than the burrow, and in this cell a mass of eggs is deposited, the eggs being arranged in an orderly manner (fig. 1).

The depth of soil in the jar was not sufficient to show the maximum depth to which the flies would penetrate for the purpose of oviposition, as some of the egg-masses were in contact with the bottom of the jar, 3·5 cm. below the surface.

After oviposition the flies soon died, usually just outside the cell containing the eggs.

Eggs.

The jar containing the soil in which the eggs had been laid was placed in the laboratory, the soil being kept damp. The eggs were observed to hatch in from 33 to 35 days after being laid, all those in a mass hatching more or less at the same time.

The eggs are white when first laid, but soon afterwards darken at both ends. They are almost cylindrical, with rounded extremities, the diameter of one end being slightly greater than that of the other, and they are slightly curved. Their length is from 0·73 mm. to 0·76 mm. ; their diameter at the larger end 0·18 mm., and at the narrower end 0·15 mm.

The eggs appear rather opalescent owing to their being covered with small projections on the chorion.

Fig. 2. Newly hatched larva of *Bibio marci*, lateral view ; setae of right side omitted ; $\times 65$.

Newly hatched Larva.

The newly hatched larva (fig. 2) is about 1·6 mm. in total length, the length of the head being about 0·25 mm. The head is relatively large, of a pale yellowish-brown colour, and bears a number of relatively long setae.

The body is colourless and transparent, the contents of the alimentary canal showing through as a dark line. The body is divided into twelve segments, each bearing a number of long, slender setae. There is, in addition, a much greater number of shorter setae, all the setae arising from enlarged conical bases.

At this stage the larva bears a single pair of spiracles, which are situated on the twelfth segment, in a corresponding position to that occupied by the spiracles of that segment in the full-grown larva.

The head and mouth-parts are very similar to those of the full-grown larva. The mandibles are shorter, with relatively longer teeth ; the maxillae are similar to those of the older larva ; the projections at the anterior end of the submentum of the labium are sharper and relatively longer, and there is a median projection between them, which is not present in that of the full-grown larva.

Fully grown Larva.

Well grown larvae of *Bibio marci* were found in considerable numbers during the winter amongst the decaying remains of grass which had been cut the year before, or earlier, and allowed to rot on the ground. They were also found amongst the roots of grass.

Fig. 3. Fully grown larva of *Bibio marci*, $\times 5$; *sp. 1.*, spiracle of first segment; *sp. 12.*, spiracle of twelfth segment.

When fully grown the larva is from 20 to 24 mm. in length, and about 2.5 mm. in breadth. Its thickness is rather less than its breadth. The length of the head is about 1.5 mm. and its breadth a little less (fig. 3).

Fig. 4. Head of fully grown larva of *Bibio marci*, dorsal view, $\times 53$; *a*, antenna; *md*, mandible; *mp*, maxillary palp.

The head (figs. 4, 5) is dark brown and shining, appearing almost black; the anterior half is somewhat darker in colour than the posterior and bears several long setae. The form of the mouth-parts and antennae is shown in figs. 6-9. The

antennae are exceedingly small and inconspicuous, being situated just above the bases of the mandibles. The structures which were previously considered to be the antennae (6) are lateral protuberances of the labrum.

Fig. 5. Head of fully grown larva of *Bibio marci*, ventral view, $\times 53$; *l.*, labium; *md.*, mandible; *mp.*, maxillary palp; *mx.*, maxilla.

The body is nearly cylindrical, but somewhat flattened dorso-ventrally, and normally is slightly curved, the ventral surface being concave. The body is divided into twelve segments, of which the first is the longest. It bears ten pairs of spiracles, which are situated a pair on each segment except the second and eleventh, and project slightly from the body. The spiracles on the first segment are about twice the size of those on segments 3 to 10, and those on segment 12 are about four times the size of those on segments 3 to 10, and each one has two openings.

Fig. 6. Antenna of larva of *Bibio marci*, $\times 580$.

Each segment bears a number of stout conical processes, which are arranged more or less in rows, on both the dorsal and ventral surfaces, the more lateral processes in the rows being usually at least twice as long as the median ones. The arrangement of these processes does not appear to vary in the different species of *Bibio* which have so far been examined.

The spiracles of the first segment are situated laterally near the posterior boundary of the segment. Dorsally the segment bears two rows of processes, each row containing eight processes, the lateral processes of the second row being slightly

Fig. 7. Right mandible of larva of *Bibio marci*, ventral view, $\times 100$.

Fig. 8. Right maxilla of larva of *Bibio marci*, ventral view, $\times 100$.

displaced forwards by the spiracle. Ventrally the segment bears three incomplete rows. The first row consists of two processes; the second of four, one pair near the median line and the other pair lateral; in the third row there are four processes.

The second segment, which has no spiracles, bears a row of eight processes dorsally and another row of eight processes ventrally; the median pair in the latter row is situated nearer to the anterior margin of the segment than the remainder.

Fig. 9. Labium of larva of *Bibio marci*, ventral view, $\times 100$.

The third segment bears a pair of spiracles laterally towards its anterior margin; dorsally it bears a row of eight processes, and ventrally a similar number, of which the middle pair is placed forwards as on the second segment.

The fourth segment bears a pair of spiracles in a similar position to those on the third segment. Dorsally this segment bears a row of eight processes, the lateral

pair being slightly nearer the anterior end than the remainder. On its ventral surface this segment bears two rows of processes, the first row containing six and the second four. The segments five to ten are similar to the fourth segment.

On the dorsal surface of the eleventh segment there is a row of six large processes near its posterior margin, of which the median pair is the largest. There is a single lateral process on each side near the anterior border of the segment and on the ventral side there are six processes.

The twelfth segment bears a pair of large spiracles anteriorly, which are placed in a more dorsal position than those on the other segments. Posteriorly it bears a row of four large dorsal processes, the median pair being the largest on the body. On the ventral surface of this segment there is a single pair of processes.

Fig. 10. Portion of cuticle of *Bibio marci* larva from dorsal surface of fourth segment; a, lateral view; b, surface view; the arrows directed anteriorly; $\times 330$.

The cuticle with which the body is covered bears many small scale-like structures, which are packed especially closely together on the processes. The largest of these scales bear stout backwardly-directed spines of a darker colour than the remainder of the cuticle (fig. 10). The scales on the first, second and third segments, and some on the ventral surface of the twelfth segment, bear from one to four spines, and those on the remaining segments usually carry a single stout spine, but a second more slender spine is present on certain of the scales. The scales on the base of the processes all carry several spines, but those on the upper part have only a single spine.

The alimentary canal (fig. 11) takes an almost straight course through the body, but has a loop near the posterior end, in the hind gut. The largest part of the alimentary canal is the mesenteron, which bears three large caeca at its anterior end, one lying on each side and the third, which is the largest, placed ventrally.

The four Malpighian tubes join the alimentary canal at the junction of the mesenteron and hind gut, entering the canal by a short common duct on the dorsal side. There is no posterior caecum such as is found in connection with the alimentary canal of *Bibio johannis*.

Fig. 11. Alimentary canal of larva of *Bibio marci*, lateral view, $\times 5$; c, caeca; M, Malpighian tubes; oe, oesophagus.

Pupa.

Elongate, cylindrical, tapering gently to posterior end, abruptly at anterior end. Completely free from larval skin. Colour at first white, head and thorax of imago showing dark through cuticle later. Length from head to tip of abdomen, ♂, 12.5 mm.; ♀, 15 mm. (fig. 12). Head with very slight, blunt, anterior, median process; a slight median dorsal ridge extending from the anterior median process to posterior margin of thorax, dehiscence for emergence of imago occurring along this ridge. Antennae extremely short, arising between bases of eyes, extending laterally over eyes. In the males, eyes large and protruding; in female, smaller and less conspicuous. Labium elongate, semicircular; labial palpi elongate, conical, extending laterally. Dorsally, most of head covered by prothorax, only eyes of male visible.

Thorax strongly arched dorsally. Pair of thoracic spiracles slightly projecting laterally. Tibiae and tarsi of fore legs extending from side of eyes level with antennae to anterior margin of second abdominal segment, with tarsi in apposition along median line. Second and third pairs of legs parallel to first, all except tibiae and first and last tarsal segments of second and last tarsal segment of third, covered by wings; last tarsal segments appearing posterior to those of first leg, and those of each pair in contact along median line.

Fig. 12. Pupa of *Bibio marci*, ♂, $\times 5$.

Abdomen nine-segmented; length of segments in proportion 7, 10, 11, 12, 12, 11, 10, 9, 9; width of segments decreasing gradually towards posterior end. Cuticle with many fine wrinkles, mainly transverse; on abdominal segments, dorsally and ventrally, bearing numerous spines similar to, but less stout than, those of larva, occurring singly or in groups of two to four, on slight swellings of cuticle. Terminal segment (fig. 13) bluntly conical, bearing a pair of stout, dark brown, sharply pointed processes at the posterior end, directed posteriorly and outwardly, and a pair of rounded papillae. All segments except eighth bearing a pair of slightly projecting spiracles laterally, towards the anterior margin of the segment.

Fig. 13. Posterior extremity of pupa of *Bibio marci*, ♂ dorsal view, $\times 18$.

***Bibio lacteipennis*, Ztt.**

A number of larvae which proved to be those of *Bibio lacteipennis*, Ztt., were found in a plant pot at Withington, Manchester, during February 1918. The larvae were kept in some of the same soil, which was a rich leaf-mould in which bulbs had been grown, in the laboratory, and the first pupa was seen on 23rd March, and the first adult appeared on 13th April.

Larva.

It is proposed to point out the differences between the larva of this species and that of *Bibio marci*, L., which has been described above.

The most obvious differences between these two species are the smaller size of the larva of *B. lacteipennis* and the fact that the processes on its body are relatively more slender. The number and arrangement of the processes on all the segments is the same in both species.

The most striking difference is exhibited in the cuticle. In both species the cuticle of the full-grown larva bears a great number of small, irregularly-shaped, scale-like structures. In *B. marci* the largest of these scales bear one stout spine, while in *B. lacteipennis* (fig. 14) the scales are much less well developed, and only those on the processes, and on the anterior part of the ventral side of the first segment of the body, bear these spines. The latter are, moreover, less stout than those of *B. marci*, and there do not seem to be more than two on any scale. On the ventral surface of the twelfth segment a few of the scales bear single, long, stout spines.

Fig. 14. Portion of cuticle of larva of *Bibio lacteipennis* from dorsal surface of fourth segment :
a, lateral view ; b, vertical view ; $\times 330$.

The only apparent difference in the mouth-parts is the presence of a slight median projection between the two processes at the anterior end of the submentum.

The larva bears a pair of protrusible pseudopod-like structures at the end of the twelfth segment, which are relatively larger and better developed than is the case in *B. marci*.

The alimentary canal, Malpighian tubes and caeca appear to be similar to those of *B. marci*, and there is no posterior caecum.

The length of the full-grown larva is about 15 mm.

Pupa.

The pupa of *Bibio lacteipennis* bears a considerable resemblance to that of *B. marci*. It is distinguished from the latter by its smaller size and the somewhat greater development of the median process at the anterior end. The male pupa bears a pair of small, blunt processes, slightly ventral to the median process and situated on the anterior portion of the eyes. Length of pupa 7 to 7.5 mm.

***Bibio venosus*, Mg.**

Larva.

A few larvae of this species were found in leaf-mould at Brockenhurst on 22nd March 1920, but unfortunately before they could be thoroughly examined they had all pupated.

The mouth-parts do not show any noticeable difference from those of *Bibio marci*, and the number and arrangement of the spiracles and processes is similar. With this larva again, as in the case of *B. lacteipennis*, the chief difference from *B. marci* is in the scales on the cuticle. As in *B. lacteipennis*, these scales are very slightly developed and do not bear spines, except those on the twelfth segment

and occasional ones on other segments, which bear a single, short, blunt spine. The scales in this larva are much more regular and are placed more closely together than in any other species so far examined (fig. 15).

Fig. 15. Portion of cuticle of larva of *Bibio venosus* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; $\times 330$.

Pupa.

This pupa again bears a considerable resemblance to that of *B. marci*, from which it also differs in its smaller size; in the greater development of the process at the anterior end, which is slightly larger than that of *B. lacteipennis*; and in the presence in the male of a pair of similar blunt processes on the anterior portion of the eyes. The eyes in the male of this species are rather smaller than in the two species previously described. Length of pupa 10 to 11.5 mm. In the laboratory the pupal state lasted 19 days.

Differences between Larvae of various Species.

In the foregoing descriptions of *Bibio* larvae it will be noticed that attention is drawn to the differences in the cuticular structures in the different species dealt with. These differences seem so far to be sufficiently distinct and regular to give

Fig. 16. Portion of cuticle of larva of *Bibio johannis* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; $\times 330$.

a ready means of distinguishing between the species in the larval state. There are many other species of *Bibio*, the larvae of which have not yet been examined, but it is possible that some such distinction may hold good throughout.

In addition to the three species described above, larvae of *Bibio johannis*, L. (fig. 16), have been examined, and also larvae believed to be those of *B. pomonae*, F. (fig. 17), but the latter were not definitely identified in the adult state. As will be seen from the illustrations, these two species are quite distinct from the other species figured.

Fig. 17. Portion of cuticle of larva of *Bibio pomonae* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; the arrows directed anteriorly; $\times 330$.

The alimentary canal also varies in some of the species examined, that of *B. marci* and *B. lacteipennis* being without the posterior caecum which is present in the canal of *B. johannis*. This posterior caecum is also absent, according to Keilin (4), from the alimentary canal of *B. hortulanus*, L. The labium also shows slight variations in different species.

Parasites of Bibionid Larvae.

Very few parasites of the BIBIONIDAE are known. In addition to the mite and nematode recorded by Lyonet, Keilin (4) mentions the Gregarine *Schneideria mucronata*, Leger, occurring in the mid-gut and anterior caeca of Bibionid larvae, and also a bacterial disease. He further mentions a Microsporidian, probably a *Glugea*, which invades the epithelial cells of the mid-gut and caeca of Scatopsid larvae.

Sorauer (7) gives *Agyrtes bicolor* as a parasite of the larvae of *Scatopse*.

A Gregarine, probably the *Schneideria* mentioned by Keilin, was found in the posterior caecum of a *Dilophus febrilis* larva, and in the same larva two cysts full of spores were found free in the body. Another parasite, probably the *Glugea* mentioned above, was found infesting the epithelium of the alimentary canal in a *Bibio johannis* larva.

In addition to these a Dipterous parasite was met with in connection with *Bibio marci* larvae. This was the Phorid *Hypocera incrassata*, Mg. The fully grown larvae emerged from the *B. marci* larvae when the latter were about to pupate, and almost immediately entered the pupal state. Only a single parasite was observed in each larva attacked.

Additions to Literature since 1917.

In 1917 an account of the larva and pupa of *Bibio johannis* was published, in which the literature up to that date was referred to. The following publications have appeared since that date.

A brief account, with figures of the larva, pupa and adult, of *Plecia fulvicollis*, F., an Indian Bibionid, has been published (3). Keilin (4) has given a short account of the alimentary canal in *Scatopse notata*, *Bibio hortulanus* and *Dilophus febrilis*. That of *B. hortulanus* resembles the alimentary canal of *B. marci* in the absence of the posterior caecum, which however is present in a well developed state in *Dilophus febrilis*.

A few additional records of damage to crops by Bibionid larvae have been published also. Carpenter (1) records *Bibio* larvae as having caused much damage in wheat fields in Co. Cavan, Ireland, in March 1918, by eating the roots of the plants; and *Bibio marci* larvae are reported to have damaged potatoes in a "pit" in Co. Louth, in October 1916.

Molz (5) records *Bibio hortulanus* larvae as damaging potatoes near Halle in September 1918 by eating beneath the skin. It was noticed that only parts of the field which had been treated with stable manure were infested. Afterwards winter wheat was sown and larvae were found to be feeding on the seed. In experiments it was found that the larvae attacked the seed at the point of germination, and also that only potatoes which had previously been injured were attacked. Potato skins steeped in a 1 per cent. solution of arsenious acid were found to form an attractive and effective poison bait.

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