

Plate VIII.—*Grylloblatta campodeiformis*, terminal abdominal segments and genitalia of male. 1, adult, dorsal view; 2, same, ventral view; 3, same, caudal view; 4, same, ventro-caudal view; 5, nymph, stage A, ventral view; 6, nymph, stage B, ventral view; 7, same, caudal view.

Plate IX.—*Grylloblatta campodeiformis*. 8, adult male, right lateral view of terminal abdominal segments; 9, left lateral view of same; 10, female nymph, ventral view of terminal segments; 11, same with ventral valves bent forward to show inner valves; 12, diagram of probable method of coupling; 13, adult male dorsal view; 14, male nymph, stage A; 15, male nymph, stage B.

THE MAY-FLY OVIPOSITOR, WITH NOTES ON *LEPTOPHLEBIA* AND *HAGENULUS*.*

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The biological and morphological information contained in this paper was obtained from field trips made at Cornell University in the early summer of 1917, and from a laboratory study of the material thus collected and of related forms in the University collection. The work was undertaken at the suggestion of Dr. J. G. Needham who called the writer's attention to this may-fly and to the unusual structure present on the seventh and eighth abdominal segments of the adult female, and suggested that it might prove an interesting subject for a summer's study, an examination of other related species perhaps revealing similar modifications heretofore unnoted. For this original suggestion and for subsequent additions and corrections to the work, the writer is greatly indebted to him.

This species was first described by Dr. Needham (3) as *Choroterpes betteni* from specimens which had been collected by Dr. Cornelius Betten near Hamburg, N. Y., in 1906. Only adults were available for study at that time, and the species was doubtfully referred to the genus *Choroterpes*. Ten years later Dr. Needham found a swarm of little red may-flies near McLean, New York, which upon examination proved to be the same species; and in the nearby stream were the reddish-brown nymphs which he suspected to be its immature form. An examination of the nymphs showed that they belonged to the genus *Leptophlebia*. The observations and breeding work of the writer confirmed Dr. Needham's opinion that both nymphs and adults were the same species, *Leptophlebia betteni*.

Habitat.

The local habitat of this species is rather unique. It lies in the midst of a series of peat and grass bogs which are located near McLean, New York. Both the fauna and flora of this region are extremely localized, owing to the peculiar manner of the formation of peat bogs. The water in the streams which run through the peat bogs is of a deep coffee colour. It is in such a coffee-coloured stream which runs from a pond in the midst of the bogs that the nymphs of *Leptophlebia betteni* live, on logs which have dropped into the stream and have become water soaked and partially rotted. The brown nymphs were found in the longitudinal fissures of these logs, and so closely do they resemble the wet wood in colour that it is impossible to distinguish them when they remain motionless. On the logs with them may be found numerous Parnid beetles,

*Contribution from the Entomological Laboratory of Cornell University.
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Bryozoans and fresh water sponges, together with the comb-horned fish fly, *Chauliodes*; the green may-fly, *Baetis*; Chironomid larvæ; the stone fly *Perla*; such caddis worms as *Hydropsyche*; and the Hydrophilid beetle, *Hydrobius globosus*. This may-fly is also extremely localized in habitat for the imagoes were found for a distance of only about twenty feet and were abundant for only about six feet. The immature forms were found in the stream opposite this place of greatest abundance. At this point the stream bed breaks into gentle riffles in which lives the mollusk, *Anodonta footiana*, in some numbers. Just above the riffles the stream bed changes abruptly to soft, black ooze which is filled with another mollusk, *Sphaerium*.

The writer visited the stream on the 25th and 30th of June, hoping to find the may-flies swarming, and if possible to observe mating and oviposition. However, the season had been late and cold and there were no swarms, although the nymphs were transforming; both subimagos and adults were clinging to the herbage and shrubs along the stream. Although no egg masses could be found, there were many of the small brown nymphs on the water-soaked wood, and from some of these which were carried into the laboratory it was possible to rear both sub-imagos and adults.

Description of the Stages.

Egg.

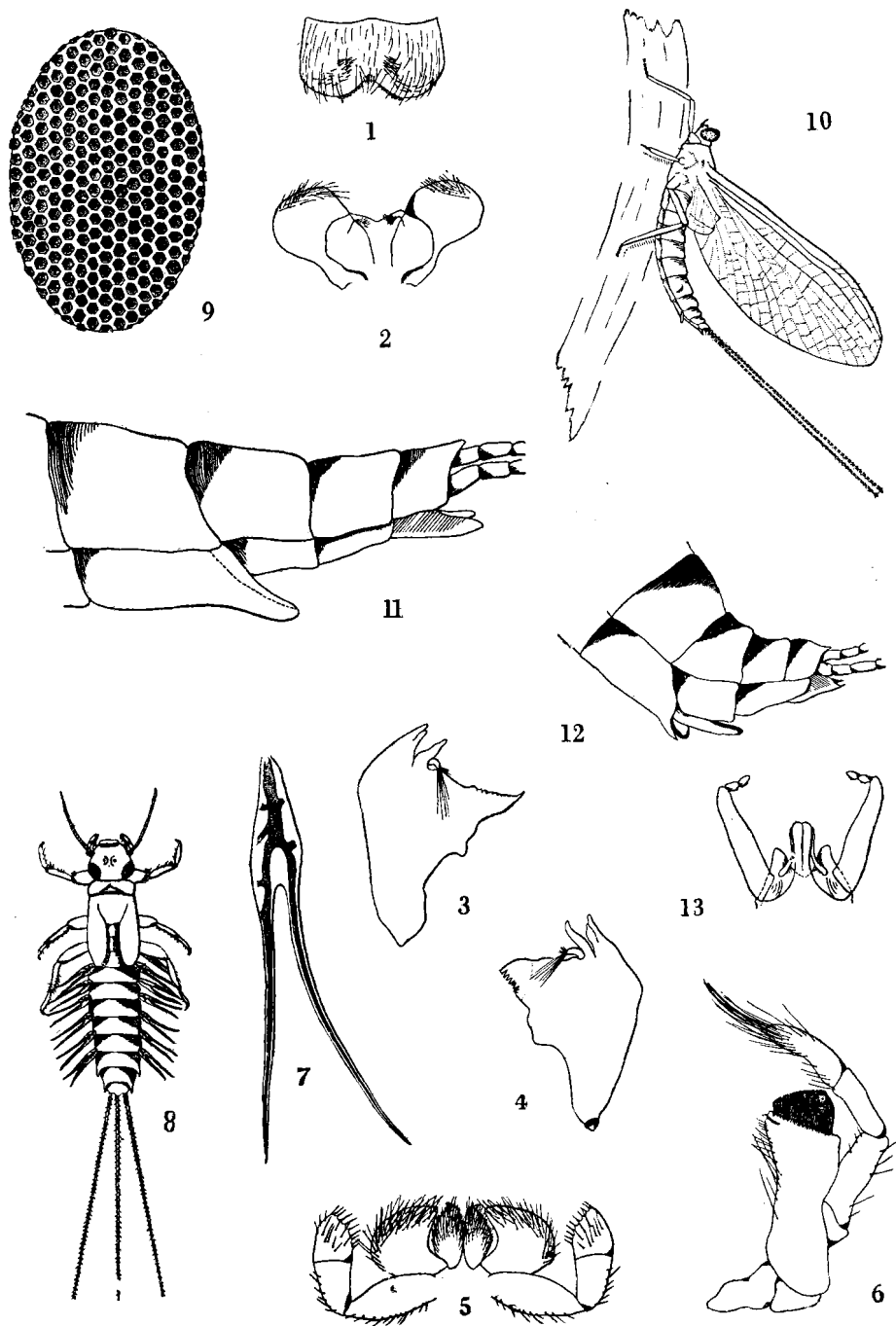
A dissection of the ovaries of a female of this species showed the presence of about six hundred eggs. The following description was made from material thus obtained. The egg (Pl. X, Fig. 9) is broadly ovate, .195 mm. long, by .11 mm. wide. The surface of the egg shell is laid off in numerous minute hexagonal areas with depressed centres. The dissected material was translucent whitish, and it was necessary to stain the shell to bring out the reticulation clearly.

Nymph.

The fully grown nymph (Pl. X, Fig. 8) is 7 mm. long with the three anal setæ 4 mm. long and subequal, and the antennæ 1.7 mm. long. The body is elongate, slender, flat below and slightly convex above. It is widest at the mesothorax, while the prothorax is slightly narrower than the head. The wing pads project posteriorly over the margins of the first two segments of the abdomen. The abdomen is long and narrow, twice as long as the head and thorax combined, widest at the sixth segment and with segments eight and nine produced posteriorly at each lateral margin into a triangular spine, while the caudal margins of segments nine and ten bear a fringe of spines dorsally. The deeply bifurcate abdominal gills are present on the lateral margins of segments one to seven and are all approximately equal in length, with broad basal portion about half as long as each of the slender terminal filaments. The body above is reddish brown in colour and slightly lighter beneath.

Mouth Parts of the Nymph.

The labrum (Pl. X, Fig. 1) is larger than wide and rather deeply incised medially, while on the under surface are a number of fine hairs which aid in straining food particles from the water. The mandibles are very roughly and irregularly triangular in shape, with the articulation and muscle attachment occupying about half of the base and with a group of large, erect fangs



LEPTOPHLEBIA BETTENI (NEEDHAM) AND L. PRÆPEDITA ETN.(?)

projecting at right angles to the axis of each mandible near its apex, while just within this group of fangs is the much smaller movable endopodite, terminating in a tiny brush of differentiated long and short hairs. The molar surface of the right mandible (Pl. X, Fig. 4) is situated on the lateral margin, while that of the left mandible (Pl. X, Fig. 3) is on the outer anterior margin. Each maxilla (Pl. X, Fig. 6) is made up of a basal portion, the cardo, which is roughly broad-triangular in shape and apparently divided into two sclerites. A united galea, lacinia and stipes, oblong in shape, more or less constricted in the middle, with apex diagonally truncate and the base rounded off on the inner side, is apparently attached to both sclerites of the cardo. A short suture at the inner apical corner of this combined sclerite marks the only differentiation between the galea and lacinia, while these structures cannot be separated from the stipes. A thick brush of long, fine hairs borders the truncate distal margin of the galea. The four-segmented palpi are attached about midway on the outer margin of this combined sclerite, with the basal segment minute triangular and the remaining segments elongate cylindrical. The second and fourth palpal segments are subequal in length, the third is a little shorter. The apical segment terminates in a cluster of hairs nearly as long as the segment. The labium (Pl. X, Fig. 5) consists of a ligula divided into oval glossæ and much wider paraglossæ, a pair of large, three-segmented labial palps, and a very much reduced and undifferentiated mentum, submentum and palpifer. The glossæ are clothed, except at the base with short, fine hairs, have a row of short, stout spines on the lateral margin, and terminate at the apex in a hook-like spine. The hairs on the distal portion of the paraglossæ are much longer than those on the glossæ. The apical segment of each labial palpus possesses a row of rather stout hairs on its inner margin, while there are finer hairs on the outer margins of the basal segments. The hypopharynx (Pl. X, Fig. 2) which normally lies closely applied to the labium, is divided into a central piece and two large lateral lobes which have long, fine hairs on their distal portions, while there are two short tufts close to the median margin of the central piece.

Adult.

(Pl. X, Fig. 10).

Dr. Needham (3) has described the adult as follows:—

"*?Choroterpes betteni*

"Length 5–6 mm.; expanse 10–11 mm.; setæ of the male 5–6 mm., and of the female $4\frac{1}{2}$ –5 mm.; colour nearly uniform, dark reddish brown, slightly paler on the middle abdominal segments in the female; wings hyaline, veins pale brown; legs yellowish brown, hind femur with two darker bands, fore femur of the female wholly dark; setæ pale yellowish with brown rings, three in number, equal; forceps of the male pale brownish, darker beneath with one very long basal and two very short apical joints."

Male Genitalia.

The male genitalia follow the general plan of structure which is constant in all of the species of *Leptophlebia* which were examined. They (Pl. X, Fig. 13) consist of paired penes placed between the forceps, each limb of which is made up of one long stout, slightly tapering basal segment and two small oval terminal segments, equal in size. The penes form an unjointed lobe-like pro-

tubercle, about half the length of the basal forceps arm, the paired arrangement, which shows distinctly in other species, being indicated only by a deep median cleft. The sperm ducts terminate in a pair of openings at the end of the paired lobes, while from below the middle of each margin there projects upwards and outwards as far as the base of the lobe, an elongate slender structure, slightly clavate near the apex.

So very distinct are these variations in structure that they may be used to separate the species. Thus in *Leptophlebia mollis* (Pl. XI, Fig. 11, 12) the basal portion of the basal forceps segment is decidedly enlarged and there extends from each of the divided penes a distinctly sword-shaped protrusion. And in a form closely resembling *Leptophlebia prapedita** (Pl. XI, Fig. 13, 14) there is a small, additional segment at the base of each forcep limb, and the penes are long with a proportionately smaller lateral extension.

The Ovipositor in May-flies.

That a modification of the abdominal segments about the egg-valve, (that is ventrally between segments seven and eight) exists in certain may-flies, has previously to the description of *L. betteni*, been noted apparently by but two other workers. Dr. Hagen (2) seems to have been the first to note the presence of any such modification, for he states (p. 2) "Some of the females have a rounded egg-valve at the antepenultimate abdominal plate;" and again in characterizing the genus *Potamanthus* which included the *Leptophlebia* of modern writers, he states (p. 17) that the egg-valve is long. Dr. Eaton (1) in his Monograph of the Ephemeridæ, (p. 2) makes the following statement:—

"In the female the oviducts terminate separately in the joining of the seventh and eighth segments; there is no real ovipositor, but in some genera (e. g., *Heptagenia*) the apex of the seventh segment is produced into a short, rounded flap, and in one *Hagenulus* this projection takes the form of a spout."

In order to determine if this modification existed in any other forms, the writer made an examination of several species of the genus *Leptophlebia*, of the related genus *Choroterpes*, and the genus *Heptagenia*, all of which had been collected near Ithaca, New York. In *Choroterpes* and *Heptagenia* no trace of such a condition could be found, but in two species of *Leptophlebia* other than *betteni* there was a marked differentiation in the ventral structure of segments seven and eight between which the egg-valve opens. *Leptophlebia mollis* shows the simplest condition in this respect. The ventral portion of segment seven extends backward very slightly, as compared with the other abdominal segments, to form a broad truncated lobe, under which lie the two openings of the oviducts. Plate XI, Fig. 10 shows the ventral aspect of the abdomen at this point. In the centre of segment seven are two prominent conjoined ganglia (*n*) on either side of which lies an oviduct (*o*) filled with eggs, opening beneath the lobe. The modification of segment eight consists of two rounded chitinous ridges, converging posteriorly, covered with small

*"This is the *Leptophlebia prapedita* (?) Etn. of Needham's 'May-flies and Midges of New York' (N. Y. State Mus. Bull. 86, pp. 49-51, 1904, Pl. 11, Fig. 1, 2) and the nymph is there described. The gills lack the basal tracheal stubs that are shown in both the forms figured in this paper."—J. G. N.

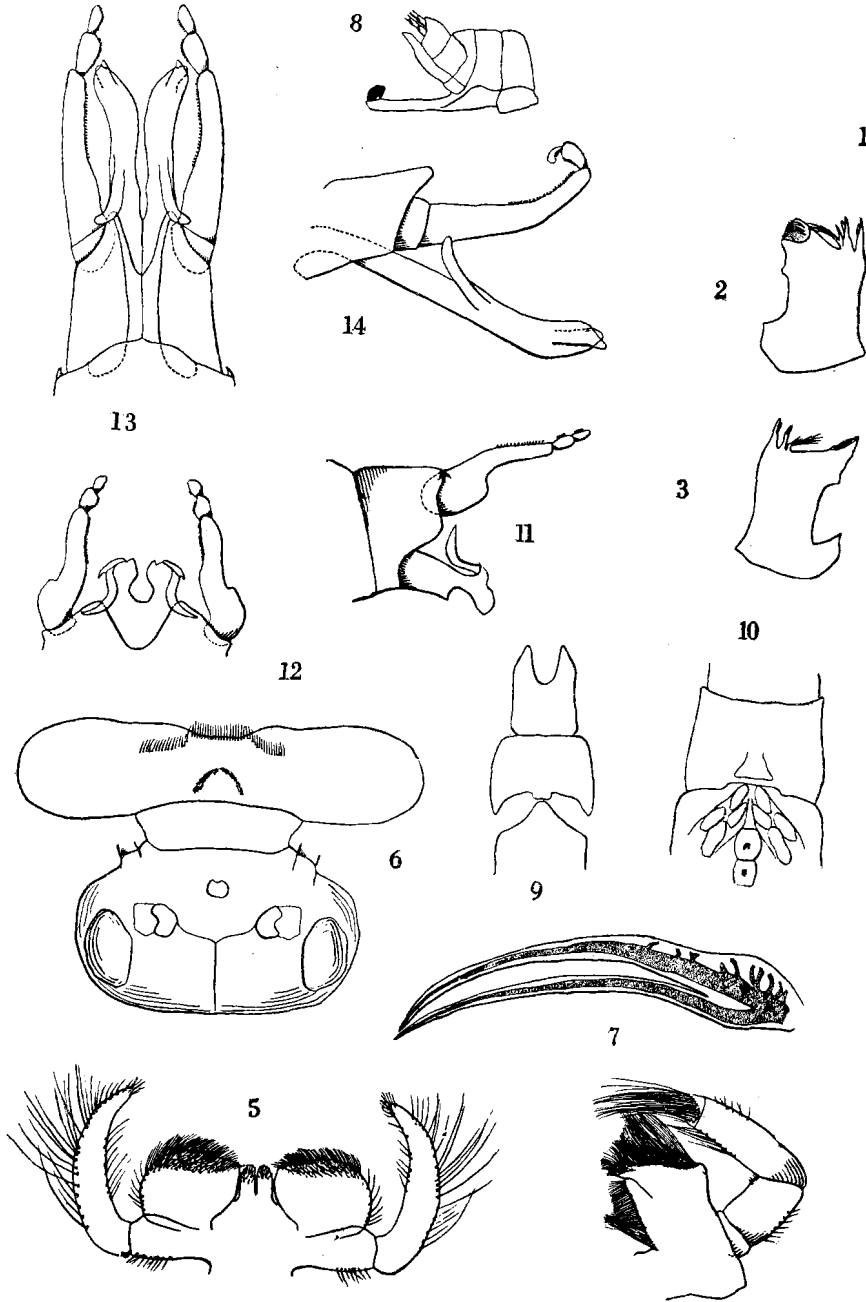
spinules, with a concave area between the ridges, placed on the anterior third of the segment and extending nearly to the truncate lobe of the seventh segment. In *Leptophlebia submarginata* these last mentioned ridges are closer together and shorter and completely covered by a mid-ventral triangular prolongation of the apex of segment seven.

In *Leptophlebia præpedita* (?) (Pl. X, Fig. 11) the posterior portion of the seventh abdominal sternite is still more elongated, extending outward and backward so as to be distinctly visible from the side. Segment eight is but slightly modified. *Leptophlebia betteni* shows a further specialization in which both segments seven and eight are conspicuously involved (Pl. X, Fig. 12). The greatest development occurs in segment eight, the expanded portion of which is extended ventrally into a long and narrow, distinctly ovipositor-like organ the tip of which is quite heavily chitinized and basally into a short egg guide. A backward prolongation of segment seven forms with segment eight a channel for the passage of the eggs. An internal dissection showed that the oviducts, extend to the egg-valve and open separately at its base. One species of *Hagenulus*, which is found in Cuba has a much longer ovipositor-like extension (Pl. XI, Fig. 8) than has *Leptophlebia betteni*. A female specimen of this form, which is in the Museum of Comparative Zoology at Cambridge, Mass., was kindly loaned by Dr. Nathan Banks, and upon examination it was found that segment seven extends beyond the apex of the abdomen, folding together toward the tip in a tubular form with an opening on the upper surface. Three chitinous ridges extend along the under surface, converging to the tip. The oviducts extend and open separately, the eggs passing into the ovipositor in two strings whose identity is lost as they pass out of the aperture in a cylinder.

No nymphs of the genus *Hagenulus* have hitherto been made known; but a specimen collected by Professor C. F. Baker in Cuba and sent to Dr. Needham, in whose slide collection it now appears, dissected and mounted, has enabled the writer to present herewith Figures 1 to 7 of Plate XI. Noteworthy are the inequilateral gills, the form of both labial and maxillary palpi, and most remarkable of all, the extraordinary lateral extension of the labium, its breadth greatly exceeding that of the head.

Bibliography.

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- (2) 1863. Hagen, Hermann August. Synopsis of the British Ephemerida. In the Entomologist's Annual for MDCCCLXIII, (1863) p. 1-35.
- (3) 1908. Needham, James G. New Data Concerning May-flies and Dragon Flies of New York. In Museum Bulletin 124, 33rd Report of the State Entomologist on Injurious and Other Insects of the State of New York, 1907 (1908), p. 188-198, pl. 10.



HAGENULUS AND LEPTOPHLEBIA; STRUCTURAL DETAILS.

EXPLANATION OF PLATES.

Plate X.

Leptophlebia betteni.

- Figure 1. Labrum of nymph.
 " 2. Hypopharynx of nymph.
 " 3. Left mandible of nymph.
 " 4. Right mandible of nymph.
 " 5. Labium of nymph.
 " 6. Maxilla of nymph.
 " 7. Abdominal gill of nymph.
 " 8. Fully grown nymph.
 " 9. Egg.
 " 10. Adult female.

Leptophlebia præpedita (?).

- " 11. Lateral view of end of abdomen of female.

Leptophlebia betteni.

- " 12. Lateral view of end of abdomen of female, showing an egg partly extruded between the prolongations of segments 7 and 8.

Plate XI.

Hagenulus sp.

- Figure 1. Hypopharynx of nymph.
 " 2. Right mandible of nymph.
 " 3. Left mandible of nymph.
 " 4. Maxilla of nymph.
 " 5. Labium of nymph.
 " 6. Head and labium of nymph.
 " 7. Inequilateral abdominal gill of nymph.

Hagenulus caligiatus.

- " 8. Lateral view of end of abdomen of adult female, showing ovipositor bearing extruded egg-mass at its tip.

Leptophlebia submarginata (European).

- " 9. Ventral view of segments 7, 8 and 9 of female, 7 and 8 being slightly separated to show prolongations that form the egg-guide.

Leptophlebia mollis.

- " 10. Ventral view of segments 7 and 8 of adult female.
 " 11. Lateral view of male abdominal appendages.
 " 12. Dorsal view of male abdominal appendages.

Leptophlebia præpedita (?).

- " 13. Dorsal view of male abdominal appendages.
 " 14. Lateral view of male abdominal appendages.

DELPHACIDÆ OF THE BRITISH MUSEUM—ERRATUM.

On p. 7, line 16, for "3, Pundaluoya simplex Dist." read "3, Pundaluoya simplicia Dist."

F. MUIR.