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Mayfly Nymphs

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Mayfly Nymphs¹⁾

Masuzo UÉNO

Through the kindness of Dr. Kinji Imanishi, the writer has been able to study a small collection of aquatic insect larvae gathered by him in Nepal, during the Japanese Himalayan Expedition in 1952. The specimens, in three vials, consisted of 24 nymphs (larvae) and fell into six genera belonging to three families of Ephemeroptera. However, they were not reared. Moreover, no reliable taxonomic references of mayfly nymphs of the Himalayas have appeared so far as is known to the writer. Concerning these nymphs, of which specific identification must remain in question, the writer has attempted to discuss and illustrate their details for the purpose of adding their peculiarities to our present knowledge of Himalayan mayflies.

The writer's grateful thanks are due to Dr. Imanishi who placed the collection at the writer's disposal for the present study and rendered much useful information regarding the localities.

List of Localities and Collected Nymphs

Loc. 1. A small stream narrower than 10 meters by the ascent road to Khoplang, northeast of Gurkha, which runs through paddy fields at the altitude of about 650 meters; September 22, 1952.

The collected nymphs are:

1. *Ecdyonurus* sp. 2.....2 individuals
2. *Ecdyonurus* sp. 3.....3 indivs.

Loc. 2. A small spring-fed brook flowing into a stream that runs down from the glacier of Annapurna, near the base camp set at Manangbhot, at about 3500 meters above the sea-level; October 28, 1952.

The collected nymphs are:

3. *Rhithrogena* sp.6 indivs.

Loc. 3. A stream running through paddy fields, larger than the stream of Loc. 1, near Nawakot located between Batar Bazar and a ford of Tadi Khola, at about 700 meters above the sea-level; December 13, 1952.

The collected nymphs are:

- | | |
|---|---|
| 4. <i>Ephemerella</i> sp. ...1 individual | 7. <i>Baetiella</i> sp.1 indiv. |
| 5. <i>Baëtis</i> sp. 14 indivs. | 8. <i>Ecdyonurus</i> sp. 1 ...5 indivs. |
| 6. <i>Baëtis</i> sp. 24 indivs. | 9. <i>Epeorus</i> sp.1 indiv. |

1) Contribution No. 150 from the Otsu Hydrobiological Station, Kyoto University.

Ephemerellidae*Ephemerella* sp.

One nymph; length of body 8.5 mm, caudal filaments 9.0 mm.

General colour olivaceous brown, legs and caudal filaments paler. This nymph is characterized in having tubercles on the head, thorax and abdominal segments; the body and legs were covered with silt.

Body somewhat arched dorsally, flattened ventrally, with rather flattened femora (Figs. 9-11).

Head quadrangular, frontal margin rounded, lateral margins somewhat expanded behind the eyes, armed with three pairs of blunt tubercles and one more median tubercle in front of them.

Labrum wider than long, slightly emarginate in the median part of anterior margin, beset thickly with short curved bristles; on the antero-lateral margin there are two rows of long bristles. Mandibles rather short and robust (Figs. 3, 4); canines rather short, being the inner canine of the left mandible longer than outer one (Fig. 3a), while that of the right mandible just as long as the outer one (Fig. 4a); prostheca well developed in both mandibles, each with a group of bristles on inner margin. Maxillae conical at apex, with two terminal teeth on the inner apical margin (Fig. 6a), two rows of bristles on the outer apical margin; maxillary palp much shorter than galea-lacinia, third joint elongated conical; bristles eight on the inner margin and ten or more on the outer margin (Fig. 6b); terminal joint rudimentary. Glossae and paraglossae of labium (Fig. 5) nearly equal in length, being the latter more than twice as wide as the former; labial palp relatively short and robust, bearing bristles on each side, terminal or the third joint rudimentary and conical; the arrangement of bristles on the terminal portion of palp is shown in Fig. 5a. Median lobe of hypopharynx round; lateral lobes rounded apically (Fig. 7).

Pronotum wider than head, quadrangular, a little widened posteriorly, anterior margin convex, lateral margins nearly straight, dorsum arched, bearing five knob-like tubercles, of which median one is near the anterior margin and the other four are arranged in two pairs behind it. Mesothorax arched dorsally, enlarged laterally, on the dorsum with five blunt tubercles, two in pair near the anterior margin and widely separated, the other two in the second pair present in the middle and much close from each other than the first pair, and the remaining median one near the posterior end (Fig. 1).

Lateral extensions are present on the abdominal segments 3 to 9 inclusive (Fig. 8), bearing postero-lateral processes, especially of greater development in flattened posterior segments. On the abdominal segments 3 to 9 inclusive, there are paired dorsal spines directed backwards and successively increased

in length posteriorly, being longest on the eighth tergite. Ninth sternite prolonged backwards into a tongue-shaped plate (Fig. 14), the tip of which extends beyond the hind end of the tenth segment.

Hind-leg is longest and fore-leg shortest (Figs. 9-11). Femora somewhat flattened, without tubercles or spines. The ratio, tarsus: tibia: femur, is: fore-leg, 1: 2: 2, mid-leg, 1: 2.8: 2.3, and hind-leg, 1: 3.8: 2.5; hind-tibia nearly twice as long as fore-tibia. Along the outer margin of femur of each leg there is a row of long hairs. Similar hairs occur also on tibiae and tarsi. Claws rather large, bearing three (four in hind-claw) small teeth on the inner margin (Figs. 9a, 11a).

Three caudal filaments of equal length, nearly as long as body; whorls of minute spines at joinings; hairs present on both sides of the inner filament and only on the inner side of the outer one.

Five pairs of gills present on the abdominal segments from 3 to 7, wholly dorsal in position, all bilamellate, the 7th smallest; each anterior lamella obtuse ovoid, tracheation not distinct; each posterior lamella cut into many small lobelets.

Locality: Loc. 3; December 13, 1952, collected by Imanishi.

Remarks: Two species of *Ephemerella* are recorded in the regions around the Himalayas, i. e., *E. sven-hedini* Ulmer of South Kansu and *E. submontana* Brodsky of "kleiner Issyksee" and the Issyk River. The latter author obtained large numbers of the nymphs of *E. submontana* from Kasakstan, Kirgisstan and Usbekistan, but he has given no description of them. A few specimens of nymphs belonging to Ephemerellinae were collected by Hora (1930, p. 192) from the Krelnu Giri Nallah at Dalhousie and the Rave River at Chamba in the western Himalayas.

Baëtidae

Baëtis sp. 1

Four nymphs, of which two are well grown (1♀, 1♂); length of body 7.0 mm, outer caudal filaments 4.0 mm, median caudal filament 3.0 mm.

Body slender, stream-lined form, dark brown (specimens in alcohol).

Head directed downwards, slightly narrower than posterior margin of pronotum; antennae rather robust.

Labrum (Fig. 29) rather large, quadrangular, a little wider than its length, with a shallow median notch on rounded apical margin; just inside the apical margin there is a row of numerous plumose bristles, inserted closely together, and another row of bristles on the apical margin; on the upper surface near the anterior margin there is a transverse row of stouter and longer bristles which reaches the lateral margin on each side, about 20 in total number. The

upper surface of the right half of the labrum is illustrated in Fig. 29a.

Mandibles (Figs. 30, 31) robust and pyramidal shape; each canine bears seven teeth; the outermost tooth of the left mandible rounded and projecting far beyond the other teeth, the fourth longer than the third; the outermost tooth of the right canine obliquely truncated and the fourth projecting beyond the third as in the left. Prosthema of the left mandible bears a series of teeth on its apical margin, being upper four short, lower five longer and spine-like; prosthema of the right mandible bears only four bristles on its outer end (Figs. 30a, 31a).

Maxillary palp shorter than galea-lacinia which bears two terminal teeth and two rows of long and short bristles on the apical margin.

Paraglossae of labium extend a little beyond glossae; outer apical margin beset with feathered bristles arranged in 1-4 rows; a well spaced row of 5-6 long bristles inside the inner margin; close to the outermost one of it there is a large clavate spine. Labial palp 3-jointed; second joint produced into a blunt process at its inner distal corner; terminal joint rounded conical, tip pointed, beset with numerous spines and fine bristles. Median and lateral lobes of hypopharynx nearly equal in width.

Legs pale, with a darker marking in the middle of femora; distal end of each femur, tibia, tarsus and claw dark; along the outer margin of femur there are moderately long straight spines which are replaced by short stout spines on its apex; moderately long spines present also on tibiae and tarsi. Claws bear 10-11 teeth on the inner margin. Hind-leg is shorter than mid- and fore-legs, especially in the tibia; the ratio, tarsus: tibia; femur, is: fore- and mid-legs, 1: 2: 2.4: hind-leg, 1: 1.5: 2.7; femora of all legs are longer than tibiae and tarsi (Figs. 26, 27, 28).

Abdominal segments 3 to 9 uniformly dark except at both sides, 2 and 9 entirely dark; on the segment 9 light areas developed and fused together in the posterior margin; within central darker area of the segments 4, 5 and 6 there is a pair of rod-shaped dark patterns. In one well developed nymph the patterns on the tergites somewhat differ from those described above. The light areas well developed on the segments from 2 to 6; light area occupies the posterior 1/3 on the segments from 2 and 3; two lighter oval areas developed laterally in the anterior half on the segment 5, such areas occur distally and fused together in the center leaving two dark peninsulas on the segment 6. On the segments 5 and 6 two lighter small areas appear again near the anterior margin. Segments 7 to 9 are dark, except at the lighter sides; the tenth segment entirely dark. Within the dark areas of the segments from 3 to 6 inclusive two or five lighter dots are seen, though they are hardly visible on the 4th segment.

Seven pairs of gills, all simple lamellae, the 7th much smaller than the

others, slightly asymmetrical from the 2nd to the 5th, others oblong oval; tracheation distinct, pinnately, branched and blackish brown (Figs. 20-24).

Three caudal filaments, pale throughout; the median one is $\frac{3}{4}$ as long as the outer ones, the former fringed with rather long hairs on both sides and the latter only on the inner side.

Locality: Loc. 3; December 13, 1952, collected by Imanishi.

Remarks: In the features of the canine teeth, the prostheca of both mandibles and the armature of bristles on the labrum, this nymph resembles closely that of the European *Baëtis rhodani* (Pictet), which has been discussed recently by Macan (1950) in detail. *B. rhodani* differs, however, from the present nymph in some characters especially in the markings on the abdominal tergites.

Baëtis sp. 2

Four nymphs; body length of the largest specimen 6.0 mm, caudal filaments ca. 6.0 mm.

Body stream-lined form, olivaceous brown dorsally and pale brown ventrally. Head nearly as wide as pronotum, directed downwards; antennae rather slender, composed of about 20 joints.

Labrum (Fig. 36) rather large, quadrangular, nearly twice as wide as its length; a shallow median emargination on the rounded apical margin; on the surface just inside the apical margin there is a row of about 40 long bristles and 5-7 longer and stouter bristles near the lateral margin (Fig. 36a). Mandibles not slender in the basal half; canine bears seven teeth, of which the outermost one is larger and rounded at apical margin, not set back (Figs. 37a, 38a). Prostheca of the left mandible bears six teeth on its outer margin; that of the right mandible is more slender than that of the left one and bears four small teeth on the outer margin. Maxillary palp 3-jointed, not extending beyond the galea-lacinia (Fig. 39); the terminal joint nearly as long as the proximal two joints altogether; galea-lacinia terminates into four large and stout teeth (Fig. 39b). Glossae and paraglossae of labium nearly the same length (Fig. 40). Inner apical margin of glossa bears a row of 13-15 spines; the outer margin bears a few bristles; near the apex there are two large clavate spines (Fig. 40a). Apical margin of the paraglossa bears two rows of 5-6 long spines (Fig. 40b). Labial palp 3-jointed, the articulation of the terminal two joints not distinct, the last joint with numerous minute spines and bristles.

Legs relatively short (Figs. 46-48); fore femur longer than mid and hind ones; fore tibia shorter than mid and hind ones which are equal in length; the ratio, tarsus: tibia: femur, is: fore-leg, 1: 2: 3.2; mid-leg, 1: 2.7: 3.5; hind-leg, 1: 2.5: 3.5. Along the outer margin of each femur there is a row

of stout bristles; similar row of less stout bristles present on the outer margins of tibia and tarsus. On the upper surface of each femur there are numerous minute spines which are present also on its inner margin.

Abdomen cylindrical, somewhat depressed, dorsum pale brown; on each tergite there are two pairs of dark markings in the median line, the anterior one rod-like and divergent posteriorly, the posterior one much shorter than the anterior one; these markings become dots in the 8th and 9th segments, and indistinct in the tenth segment. The tenth tergite extends behind in a short plate; the tenth sternite forms a rounded quadrangular plate.

Gills present on the segments from 1 to 7, all simple and relatively larger in size (Figs. 42-45); each lamella oblong oval, somewhat asymmetrical, tracheation distinct and pinnately branched mostly on inner side, blackish brown; the first and the seventh are nearly equal in length.

Two caudal filaments, nearly as long as body, fringed with short hairs only on the inner side; median filament rudimentary, only 5-jointed, shorter than 1/2 of the width of the hind margin of the tenth tergite.

Locality: Loc. 3; December 13, 1952, collected by Imanishi.

Remarks: The markings on the abdominal segments of this nymph remind us of those on the segments from 2 to 6 of the imago of *Baëtis mycetopis* Brodsky from Taschkent.

Baëtiella

One nymph; length of body 5.0 mm, caudal filaments 5.0 mm. A slender, stream-line-formed baetine nymph with a median dorsal tooth on each abdominal segment. The median caudal filament is entirely absent.

Head directed downwards, chestnut brown (Fig. 56).

Labrum (Fig. 50) quadrangular, twice as wide as long, apical margin rounded, with a narrow but distinct median notch. The upper surface of the right half of the labrum is illustrated in Fig. 50a. Just inside the apical margin there is a row of numerous long bristles, inserted closely together, and on either side a transverse row of seven longer and stouter bristles which are present in continuing to the lateral margin. Two such long bristles are also present on either side of the median line. Mandibles (Figs. 51, 52) more slender than those of *Baëtis* sp. 2; canine of the left mandible bears seven blunt teeth, the outermost one of which is truncated and slightly set back; prostheca well developed, bearing on its outer margin eight teeth, shorter five distal and longer three proximal. Canine of the right mandible bears six teeth; prostheca with seven teeth on the outer margin.

Galea-lacinia of maxilla terminated into a triad of large teeth (Fig. 53a); inner apical lacinial margin beset with a row of shorter bristles and also with a few long feathered bristles. Paraglossae of labium a little longer than glossae (Fig. 54); glossa rather slender, inner margin beset with a row of 14 spines

which increase in length apically: outer apical margin with nine spines. Paraglossae twice as wide as glossae, apical margin obliquely rounded, bearing three rows of spines (Fig. 54b); near the inner margin there is a row of well spaced three spines. Labial palp extends beyond the tip of paraglossa; terminal joint rounded, with spines and bristles on the inner and outer margins, as illustrated in Fig. 54c.

Pronotum nearly as wide as head, brown. Second pair of wing pads absent. Abdomen slender, cylindrical; on the segments from 1 to 10 inclusive there is on the hind margin a median dorsal tooth directed backwards. These teeth successively decrease in length in the posterior segments. On the abdominal segments from 5 to 9 inclusive there is a pair of dark dots; the tenth segment much darker.

Seven pairs of gills, all simple and small lamellae, the last pair smallest; each lamella oval or broadly oval, fringed with minute bristles and hairs on the margin; tracheation indistinct (Figs. 63-65).

Legs rather slender (Figs. 57-59); fore-leg shorter than mid- and hind-legs which are equal in length. The ratio, tarsus: tibia: femur, is: 1: 2.3: 2.7 in the mid and hind-legs respectively, but femur a little shorter in fore-leg, the ratio being 1: 2.3: 2.3. On the hind portion of the upper surface of each femur there are dark markings. On the outer margin of each femur there is a row of bristles; similar but less stout bristles are present also on the outer margin of tibia and tarsus. Claws rather large but slender, bearing on the inner margin a row of 4 to 7 teeth and 1 (or 2 in hind-claw) bristles distal to them.

Only two caudal filaments, slightly longer than body, without fringes on both sides; no trace of median filament.

Locality: Loc. 3; December 13, 1952, collected by Imanishi.

Remarks: This nymph agrees closely with *Baëtiella japonica* Imanishi (1930, p. 263; Uéno 1931, p. 220), especially with a peculiar race, indicated by Imanishi (1940, p. 227) conveniently as *na*, from Korea and Saghalien. With respect to the presence of a median dorsal tooth on the abdominal segments from 1 to 10 inclusive, the Nepalian nymph differs evidently from *na* type of *B. japonica*. In the latter, a dorsal tooth is present only on the segments from 1 to 7, and is often lacking either in the first segment of the Saghalien race or in the seventh segment of the Korean race. The Nepalian species and *Baëtiella japonica* with dorsal teeth may probably belong to the same group. It is probable that the former is the original form from which the latter had been derived.

Imanishi (1940, p. 224) has classified two tailed baëtine nymphs as to belong to the genus *Baëtiella* Uéno (1931, p. 220), though he has doubted its validity as a genus. *Baëtiella* nymphs are very close to those of *Pseudocloëon* in the absence of the hind wing pads and in having only two caudal filaments and

seven pairs of simple gills. In separating the nymphs of *Pseudocloëon* from those of *Baëtis*, Ulmer (1939, p. 586) used the number of caudal filaments, two in the former and three in the latter. Needham, Traver and Hsu (1935, p. 656) also used this feature and the presence or absence of hind wing pads as well, for distinguishing the nymphs of the genera under consideration. There are, however, the North American nymphs which have only two caudal filaments, such as *Baëtis amplus* Traver and *B. bicaudatus* Dodds (Needham, Traver, Hsu, l. c., p. 681, 682). Taking the view stated above, Imanishi's *nx* type of *Baëtiella japonica* and *nX* of *Baëtiella* sp., both of which have the hind wing pads, seem probably to be referred to the genus *Baëtis*. The remaining two, *Baëtiella japonica* and the *na* type of the same species may belong to the genus *Baëtiella* which is now in question.

The imaginal characteristics of *Baëtiella* and *Pseudocloëon* agree with from each other in having the paired marginal intercalaries in the fore wings. The former differs, however, from the latter in the structure of the male genitalia, i. e., the elongated third joint of the forceps-limbs, the last joint of which is about 1/3 as long as the third, not slender as in *Pseudocloëon*, and clavate, with the rounded tip (Imanishi 1930). There is, however, an opinion (Spieth 1933, p. 339) that "even *Pseudocloëon* could be considered part of the genus *Baëtis*".

In the nymph of *Baëtiella*, the shape of the last joint of the labial palp which was adopted by Uéno (1931, p. 222) as one of its generic characters seems to be useless. The number and the relative length of the nymphal caudal filaments seem to be still useful for the distinction of the genus. In *Baëtiella* the caudal filaments which are bare on both sides are not shorter than the body and the median filament is entirely absent.

The nymphs of both genera, *Baëtiella* and *Pseudocloëon*, are so much alike in most structure of body parts that they can not easily separable the one for the other, as discussed above, but they are totally unlike in appearance. Bearing this in mind, the writer is of the opinion that *Baëtiella* represents an independent genus, to which the Nepalian nymph may be referred, though they were not reared. According to this view, this genus seems to be distributed rather widely in Asia, from the Himalayas to Korea, Saghalien and the Japanese Islands. Its nymph has a peculiar appearance and is a typical torrent inhabitant.

Ecdyonuridae

Ecdyonurus sp. 1

Five nymphs; length of body 10.0 mm, caudal filaments 12.0 mm. General colour brown (specimens in alcohol), ventral part of body and legs pale.

Head flattened, more than twice as wide as its length, widest at the level

of anterior portion of eyes, frontal margin rounded; general colour brown, frontal portion of the median ocellus, outer portions of the hind ocelli and coronal and epicranial sutures pale. A triad of pale spots present in the anterior part of head, one in the median line in front of the median ocellus and the other two close to the anterior margin (Fig. 75).

Labrum short and wide, nearly four times as wide as its length, fringed with long hairs on the apical margin (Fig. 67). Mandibles broad in the portion of galea-lacinia, but very slender in the basal half (Figs. 68, 69). Inner canine of the left mandible nearly as long as the outer one, with three blunt projections at the tip and three small teeth on the inner margin near the tip; inner margin of the outer canine crenated with about 14 blunt teeth; prostheca is represented by four long spines. Inner canine of the right mandible $5/6$ as long as the outer canine, with one rather long spine-like process at $2/3$ from the base; prostheca composed of three long spines. Molar surface of both mandibles well developed, irregularly serrated with stiff bristles; a row of 12-13 bristles present close to the lacinial end of the molar surface on the right mandible.

Maxillary palp rather slender, proximal joint with a series of long bristles on the outer and the inner margin respectively, second joint fringed on the outer margin with two series of long setae; terminal joint beset thickly with short bristles; on the apical margin of galea-lacinia there is a series of about twenty or more pectinate spines (Fig. 70a).

Glossae of labium small, separated widely at the base, slightly divergent apically from each other, apical margin rounded, thickly beset with long hairs on the intero-apical margin; labial palp large and robust, thickly beset with bristles on the outer border of the distal $2/3$ (Fig. 71). Lateral portion of hypopharynx strongly out-curved, narrowest at the tip, outer margin rather sinuate, fringed with long hairs on the margin from the inner to the sinuated portion (Fig. 72).

Pronotum short, slightly wider than head, with dilated and rounded lateral margins which are prolonged behind and fused to the sides of mesonotum, with darker markings on either side of the median line (Fig. 75).

Legs pale yellowish with two dark broad bands irregular in shape on the upper surface of femora which are flattened and broad, 2.5 times as long as their width. The ratio, tarsus: tibia: femur, in the fore-leg, is 1: 4: 4.5, with a row of long bristles on the outer margin, short spines on the inner margin. Claws with four teeth on the inner margin.

On each abdominal segment from 2 to 5 there is a central darker arch-shaped area, and on either side of the median line there are pale areas towards the hind margin of tergite. In the sixth tergite these pale areas are separated near the hind margin into an oval pale area on each side. In the seventh

tergite they are fused together; in the eighth and ninth they encroach over almost the posterior half of the dark part. The tenth tergite is wholly dark. Near the middle of the segments from 6 to 10 inclusive there are two small pale spots on either side of the median line. In one well grown specimen the lateral margins of each segment are blackish brown.

Three caudal filaments nearly equal in length and a little longer than body, pale yellow; at joinings with whorls of minute spines.

Seven pairs of gills on the abdominal segments from 1 to 7 (Figs. 76-81), all lamellate, with filamentous gills, except the seventh pair which consists of lamellae only; the first pair a little longer than the seventh but lanceolate in outline; lamellae 2 to 6 broadly oval or obtuse oval, tracheation distinct, pinnately branched, blackish brown, 2 to 6 bearing a small lanceolate apical appendage (Fig. 79a); margins of each gill lamella fringed sparsely with minute bristles.

Locality: Loc. 3; December 13, 1952, collected by Imanishi.

Remarks: This nymph is characterized by the presence of a triad of pale spots on the frontal part of the head. The nymphs of *Ecdyonurus* are usually separated from those of both *Thalerosphyrus* and *Componeuriella* in having prominent postero-lateral extensions of the pronotum (Schoenemund 1930, Ulmer 1939, Kimmins 1942). In the nymph of *Ecdyonurus venosus* of Scotland, Ide (1936) has found that the outgrowths of the prothoracic extensions are homologous with wing pads and not special nymphal structures. He has also illustrated that the nymphal prothorax of *Heptagenia pulla* of America is "intimately fused to the mesothorax at the sides" (Ide, l. c., p. 238). The nymphs of *Ecdyonurus* of Nepal, the prothoracic extensions are, even in a well grown nymph, much less developed, slightly projecting backwards and fused to the sides of the mesothorax, as in the nymph of *Heptagenia pulla* (Ide, l. c., Fig. 8). Such a stage in the development of the prothoracic processes is always met with in the nymphs of the species of *Ecdyonurus* of Eastern Asia including Japan. *Ecdyonurus sumatranus* Ulmer (1939, p. 669) of western Sumatra, too, is not exceptional to this manner, its prothoracic prolongation being fused to the mesothorax at the sides. It is noteworthy that the Asiatic species of *Ecdyonurus* differ from the European ones of the same genus in this characteristic of nymphs.

Hora (1930, p. 185) found the nymphs of *Ecdyonurus* "in the hill-streams of India under stones in clear and moderately rapid-running waters", but he did not determine the species of them.

Ecdyonurus sp. 2

One nymph; body length 7.5 mm, outer caudal filaments 9.5 mm.

Head of this nymph is quadrangular but more rounded than in *Ecdyonurus*

sp. 1 (Fig. 83), more than 1.5 times wider than its length, anterior margin rounded, lateral margins slightly rounded, posterior margin slightly concave. General colour of head brown (specimen in alcohol); coronal and epicranial suture pale, the latter enlarged into a pale area close to the lateral margin. This nymph is characterized by four sets of pale spots on its head. Two series, which consist of four spots of nearly equal size, are seen in the fronto-clypeal area, one close to the anterior margin and the other in front of the antennae. In addition two more pairs of spots are found between the eyes on either side of the coronal suture.

Pronotum a little wider than head, lateral margins rounded, posterior processes fused to mesothorax at the sides; pale patterns on each side, namely outer longitudinal bands and two inner round areas.

Legs pale yellow; two irregular cross bands of dark brown on the femora of all legs (Fig. 84-86): the bands partly fused in the fore-femora; tibiae marked with two dark bands, one at about the middle and the other at the proximal part; tarsi dark brown. The ratio, tarsus: tibia: femur, is: fore-legs, 1: 3.3: 3.5; mid-leg, 1: 3.5: 4.2; hind-leg, 1: 3.3: 4.6; femur bulged and flattened, longest in the hind-leg; the ratio width: length is: fore-leg, 1: 2.25: mid-leg, 1: 2.5; hind-leg, 1: 2.9. Claws bear four teeth on inner margin.

Three caudal filaments, longer than body, pale yellow; at joinings with whorls of minute spines.

Locality: Loc. 1, Khoplang; September 22, 1952, collected by Imanishi.

Remarks: In the markings on the head, this nymph resembles closely that of *Ecdyonurus yoshidae* Takahashi (= *E. japonicus* Uéno), which has been known in the Japanese Islands, Formosa, Korea and Manchuria. In *E. yoshidae*, however, there are only a series of four spots on the anterior margin of the head and only one pair of spots between the eyes. The head markings of Nepalian nymph somewhat resembles that of *Componeuriella thienemanni* Ulmer (1939, Fig. 440) from Java and Sumatra, but its mouth-parts are typical to those of the genus *Ecdyonurus* and not of *Componeuriella*.

Ecdyonurus sp. 3

One nymph; body 6.5 mm in length, outer caudal filaments 10.0 mm.

The markings on the head of this nymph are an intermediate type between *Ecdyonurus* sp. 1 and *E.* sp. 2, as shown in Fig. 87 (compare Figs. 75, 83). In *Ecd.* sp. 3, however, there are five pale spots of nearly equal size in the fronto-clypeal area; three are arranged in a triad as in the nymph of *Ecd.* sp. 1 and two are situated on the position of the inner two of four spots seen in *Ecdyonurus* sp. 2. Two pairs of pale spots as seen in the nymph of *Ecd.* sp. 2 are present also in the present nymph.

Pronotum a little wider than head, lateral extensions slight and fused to

the mesothorax at the sides. The markings on the abdominal segments do not differ markedly from those of *Ecd.* sp. 1.

Locality: Loc. 1, September 22, 1952, collected by Imanishi.

Remarks: In regard to the markings of the anterior area of the head, this nymph resembles the nymph of Japanese *Ecdyonurus kibunensis* Imanishi (1936, p. 541), which is known also from Saghalien, Korea and Manchuria. In the nymphal head of *E. kibunensis*, however, the median one of five spots is entirely absent.

Rhithrogena sp.

Six nymphs; body of the largest specimen 11.0 mm in length, caudal filaments broken off in all the specimens.

Body chestnut to rusty brown, without distinct markings, ventral side and legs pale.

Head flattened (Fig. 88), slightly more than three times wider than its length, widest at the level of middle portion of eyes; anterior and lateral margins rounded, posterior margin straight, chestnut brown without markings. Pronotum short and narrower than head, widest posteriorly.

Labrum short but wide (Fig. 89), about five times as wide as its length, slightly emarginate in the median area of the anterior margin.

Mandibles slender especially in the basal half (Fig. 90); only one canine on each mandible (Figs. 91a, 92a), inner margin crenate; protheca short and thick with serrated apical margin; a row of spines present on the lacinial margin.

Proximal joint of maxillary palp broadly dilated near the base; distal joint about twice as long as the proximal, clavate, oblique at the distal half, inner margin nearly straight, provided with many series of pectinate spines (Fig. 93b); no fringes on the outer lateral margin upper the insertion of the palp; upper apical margin of galea-lacinia terminates into three prominent teeth; the inner margin of galea-lacinia bears two rows of bristles, one row of which is at a short distance back from margin and parallel to the outer row, which is composed of bristles much longer than the inner.

Glossae of labium longer than paraglossae, slightly divergent apically, bearing a series of spines on the inner margin and a fringe of bristles at the tip; proximal joint of labial palp elongated oval, distal joint rather short and broad, outer apical margin thickly beset with curved spines.

Legs rather slender (Figs. 95, 96); outer margin of femora armed with a row of stout bristles, inner margin with short spines and fine bristles; tibiae bearing fine bristles on the inner and outer margins. Tibiae shorter than femora; the ratio, tarsus: tibia: femur, is: fore-leg, 1: 3.3: 3.9; hind-leg, 1: 3.7: 4.7; tarsi nearly equal in length, but tibiae and femora successively increase in length in hind pairs. Claws bear a large tubercle near the base and one or two minute

teeth on the inner margin.

Gills on the abdominal segments from 1 to 7; each consists of lamellate and fibrillar portions; lamellae of the first pair are largest and kidney-shaped, and they meet beneath the body. The margin of each gill lamella incised into many lobes which are fringed on their margin with minute setae.

Three caudal filaments, partly broken off in all the specimens, their whole length impossible to measure.

Locality: Loc. 2; October 28, 1952, collected by Imanishi.

Remarks: Among the known nymphs of *Rhithrogena*, the most allied one to the Nepalian nymph described above will be that of *Rhithrogena tatriva* Zelinda (1953) known from the Slovakian High Tatra at the altitudes between 1450 and 1600 meters. The nymphs resemble from each other in the body length, in the colouration of body and legs, and in the structure of gill lamellae. A number of incisions occur in each gill lamella of the Nepalian nymph on its nearly whole margin, while in *R. tatriva* only on the outer side.

Epeorus sp.

One imperfectly preserved nymph; body 5.0 mm in length, all the legs and caudal filaments broken off. Yellowish brown (specimen in alcohol).

Body slightly convex dorsally, flattened ventrally. Head large and flattened, more than 1.3 times wider than its length, anterior and lateral margins rounded, posterior margin slightly convex; no distinct markings.

Labrum small (Fig. 101), about twice as wide as its length, antero-lateral margins rounded, a shallow excavation along the median line on the anterior margin.

Mandibles rather slender (Figs. 102, 103); inner canine slightly longer than 1/2 of the outer canine which bears eight or ten blunt teeth on the inner margin; prosthema is represented by only one bristle in the left and two in the right, no fringe of hairs or bristles on the lacinial margin; a row of 7-8 spines on the inner apical margin of galea-lacinia of each mandible.

Distal joint of maxillary palp is somewhat dilated distally, thickly beset with curved minute spines in the apical portion (Fig. 104); galea terminates into three large teeth at its apex, no hairs or bristles on the outer lateral border upper the insertion of the palp; on the inner margin of galea-lacinia there are two rows of bristles, one of which is at a short distance back from the margin and parallel to the outer row.

Labial palp short and broad, distal joint bearing 20-21 parallel series of pectinate spines on the outer margin; glossae conical, separated at base, bearing 7-8 long and short spines on the inner margin near apex (Fig. 105a).

Median lobe of hypopharynx round, lateral lobes much narrower than median lobe; each lobe somewhat dilated distally and its apical margin rounded.

Pronotum nearly as wide as head, lateral margins rounded. Long bristles present on the posterior margin of head, on the median line of pro- and mesonotum; such bristles occur also on the posterior margins of the abdominal tergites from 1 to 4. Hind margins of the abdominal tergites from 5 to 9 fringed with minute spines. A short median tooth directed backwards on the hind margin of the abdominal tergites from 2 to 9 (Fig. 100). No distinct markings are seen on the dorsum of thorax and abdomen.

Gills oval lamellae, white, tracheation hardly recognizable or indistinct, filamentous portion small; outer margin of each lamella thickened, fringed with numerous minute spines and long setae. The first pair of gills of the present specimen lost on both sides.

Two caudal filaments; their relative length to the body has not been determined.

Locality: Loc. 3; December 13, 1952, collected by Imanishi.

Remarks: This nymph is characterized in having a median tooth on the abdominal segment from 2 to 9, a row of bristles on the hind margins of the head, thorax and the abdominal segments from 1 to 4, and a median row of bristles throughout the pro- and mesonotum.

Hora (1930, p. 186) collected a large number of the nymphs of *Epeorus* in different parts of India, "notably in the Kangra Valley (Western Himalayas), at Pashok (Eastern Himalayas), at Dumpep (Khasi Hills), and in a rapid stream below Silver Cascades in the Palni Hills, South India", but he has given no specific names of those nymphs. Only a species of the genus, *Epeorus psi* Eaton is known from "Kooloo, Himalaya" (Eaton 1885, p. 242). This species was collected also in Formosa (Ulmer 1912).

General Notes

To the east of the Himalayas, there are known three species of Ephemeroptera from the northwestern parts of China (Szechwan and Kansu), namely *Ephemerella sven-hedini* Ulmer of Ephemerellidae, *Isonychia japonica* Ulmer of Siphonuridae and *Anepeorus hummeli* Ulmer of Ecdyonuridae (Ulmer 1935). No nymphs of these species are known. To the northwest of the Himalayas, Brodsky (1930) identified the nymphs of several species of Ephemeroptera in Tashkent and the neighbouring regions. Brodsky came to the conclusion that the nymphs of three ecdyonurids, *Iron montanus* Brod. and its varieties, *Iron rheophilus* Brod., and *Rhithrogena tianschana* Brod. were the components of the mountain torrent communities. The nymphs of *Ephemerella submontana* Brod., *Baëtis transiliensis* Brod., and *B. heptapotamicus* Brod. were found in the streams less rapid. On the contrary, *Ecdyonurus rubrofasciatus* Brod. inhabited the lower course of mountain streams. These Brodsky's findings agree rather well with the results obtained by Imanishi (1940) in the torrents of Japan

and the other Far Eastern districts.

As far as the present collection has been concerned, the occurrence of mayfly nymphs in the stream faunae of Nepal is somewhat different from the findings of Brodsky or Imanishi. *Rhithrogena* is the only representative in a cold water spring-fed brook (Loc. 2) at a much greater altitude (about 3500 meters) than the other two localities. The nymphs of *Rhithrogena* are believed to be more specialized for a torrential life than those of *Iron* or *Epeorus*, but Hora (1930, p. 190) has pointed out that *Rhithrogena* is an inhabitant of moderate currents less oxygenated than those in which *Iron* or *Epeorus* are found. Also in Japan, the nymphs of *Rhithrogena* are often found living in regions of moderate currents of the torrential streams. In localities 1 and 3, both lower courses of mountain streams at 650-700 meters above the sea-level, the mayfly fauna differs from Loc. 2, consisting of seven different forms, four ecdyonurids (*Ecdyonurus* and *Epeorus*), three baëtids and an ephemereid. The fauna composed of such kind of mayfly nymphs indicate that it is typical to torrent streams. The stream of Loc. 3 is richest in the variety of habitats that are suitable for various species of mayfly nymphs. According to Dr. Imanishi's observations during the Expedition, the stream fauna of Nepal seems to be richer in December than in the other months. This is probably due to the dry season in this region, during which time streams receive no floods of rain and not become heavily turbid. Therefore, the collection of December contained a few specimens of well developed nymphs.

The present material is not sufficient to discuss the geographical distribution of the Himalayan mayflies. It is, however, noted that there is a certain resemblance between the mayfly nymphs of Nepal and of Eastern Asia. In Nepal there occur the ecdyonurid nymphs which closely resemble both *Ecdyonurus yoshidae* and *Ecdyonurus kibunensis*, which are known from the insular (Japan) and the continental parts of Eastern Asia. *Isonychia japonica* from Japan and Korea was found in a collection from north-west Szechwan and southern Kansu, though not yet known in the Himalayas. *Baëtiella* sp. of loc. no. 3 resembles closely the nymph of Imanishi's *na* type of *Baëtiella japonica* (Imanishi) (Uéno 1931, p. 220, Imanishi 1940, p. 227). The brief accounts stated above suggest that the mayfly fauna of Nepal may comprise of certain forms closely related to the elements which have been known in the regions east of the Himalayas. It is notable that there occurs the nymph which closely resembles *Rhithrogena tatica* from the high mountain streams of Central Europe.

All the genera found in Nepal are those of the Holarctic distribution, with the exception of *Baëtis* which occurs also in the Neotropical and Indo-Australian regions. So far as the nymphs now known are concerned, there are no members of the genera of the Oriental region, but the record of *Epeorus psi* suggests the invasion of the Oriental elements into the Himalayas.

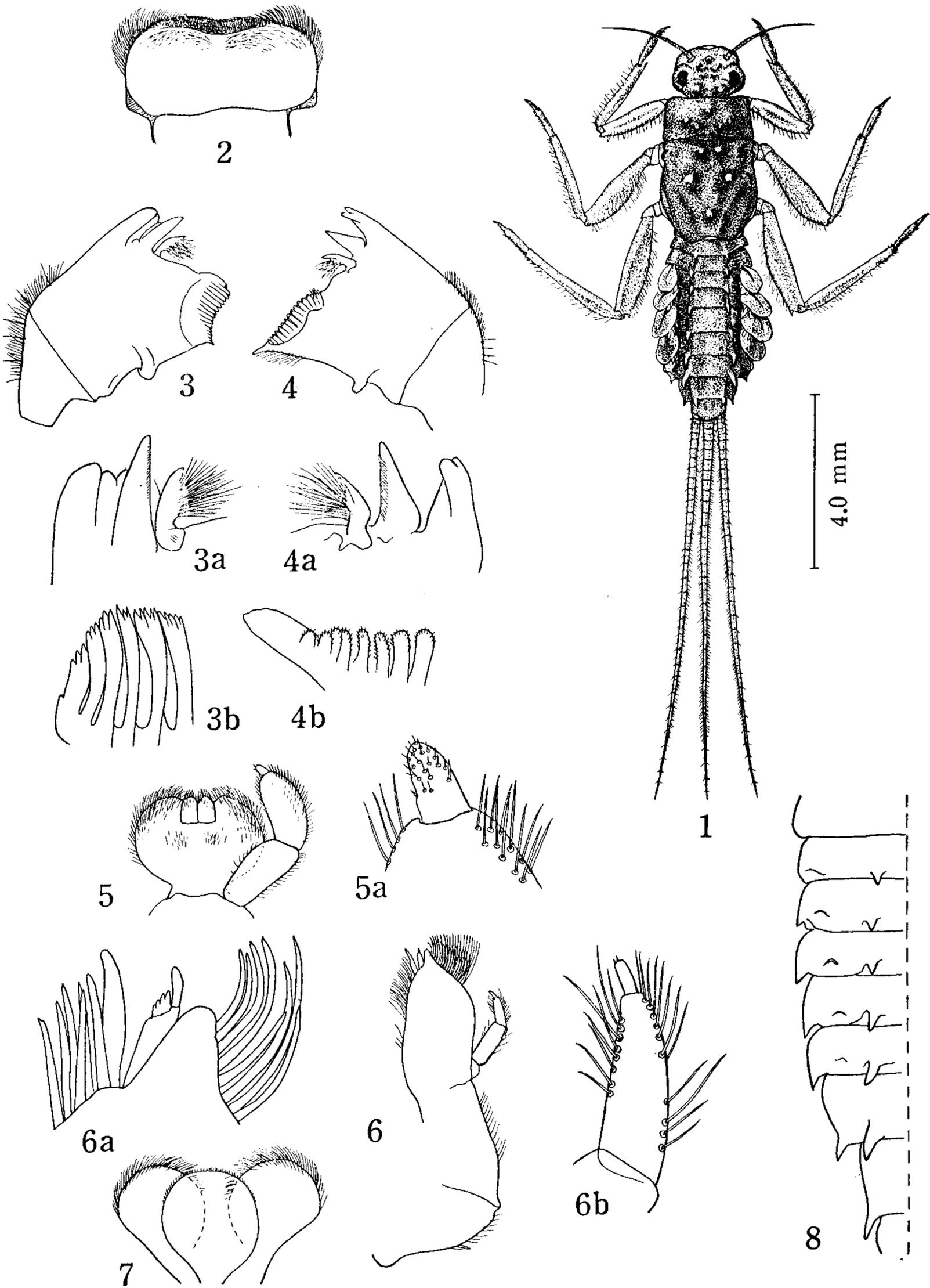
Literature

- Brodsky, Konstantin (1930). Zur Kenntnis der mittelasiatische Ephemeropteren. I. (Imagines). Zool. Jahrb. Abt. f. System, **59**, p. 681-720.
- Chopra, B. (1927). The Indian Ephemeroptera (Mayflies). Part I. Records Indian Museum, **29**, p. 91-138.
- Eaton, A. E. (1883-1888). A revisional monograph of recent Ephemeridae or mayflies. Trans. Linn. Soc. London, ser. 2, **3**, Zool., p. 1-352.
- Hora, Sunder Lal (1930). Ecology, bionomics and evolution of the torrential fauna, with special reference to the organs of attachment. Phil. Trans. Roy. Soc. London, ser. B, **218**, p. 171-282.
- Ide, E. P. (1936). The significance of the outgrowths on the prothorax of *Ecdyonurus venosus* Fabr. (Ephemeroptera). Canad. Entom., **68**, p. 234-238.
- (1937). Descriptions of eastern North American species of baetine mayflies with particular reference to the nymphal stages. Canad. Entom., **69**, p. 235-243.
- Imanishi, Kinji (1930). Mayflies from Japanese torrents I. New mayflies of the genera *Acentrella* and *Ameletus*. Trans. Nat. Hist. Soc. of Formosa, **20**, p. 263-267.
- (1936). Ibid. II. Notes on the genera *Ecdyonurus* and *Rhithrogena*. Annot. Zool. Japon., **15**, 4, p. 538-549.
- (1940). Ephemeroptera of Manchoukuo, Inner Mongolia and Chôsen. Rept. Limnol. Survey of Kwantung and Manchoukuo, Kwantung, 1940, p. 169-263 (in Japanese).
- Kimmins, D. E. (1942). Key to the British species of Ephemeroptera with keys to the genera of the nymphs. Freshwater Biol. Assoc. British Empire, Sci. Publ. no. 7, pp. 63.
- Macan, T. T. (1950). Descriptions of some nymphs of the British species of the genus *Baëtis* (Ephemeroptera). Trans. Soc. for British Entomol. **10**, p. 143-166.
- Needham, J. G., Traver, J. R. and Yin-Chi Hsu (1935). The Biology of Mayflies, with a systematic account of North American species. Ithaca, N. Y., Comstock Publ. Co., 1935, pp. 759.
- Schoenemund, E. (1930). Eintagsfliegen oder Ephemeroptera. Die Tierwelt Deutschlands und der angrenzende Meeresteile, Teil 19, p. 1-106.
- Spieth, Herman T. (1933). The phylogeny of some mayfly genera. Phylogenetic relations of genera. J. New York Entom. Soc., **41**, p. 327-391.
- Uéno, Masuzo (1928). Some Japanese mayfly nymphs. Mem. Coll. Sci., Kyoto Imp. Univ., **B**, **4**, p. 19-63, pls. 3-17.
- (1931). Contributions to the knowledge of Japanese Ephemeroptera. Annot. Zool. Japon., **13**, 2, p. 189-231.
- Ulmer, Georg (1912). H. Sauter's Formosa-Ausbeute. Ephemeriden. Entomol. Mitteilungen, **1**, 1912, 12, p. 369.
- (1920). Uebersicht über die Gattungen der Ephemeropteren nebst Bemerkungen über einzelne Arten. Stett. Entom. Ztg., **81**, p. 97-144.
- (1935-36). Neue chinesische Ephemeropteren, nebst Uebersicht über die bisher aus China bekannten Arten. Peking Nat. Hist. Bull., **10**, 3, p. 201-215.
- (1936). Schwedisch-chinesische wissenschaftliche Expedition nach den nord-westlichen Provinzen Chinas. Arkiv för Zoologi, **27A**, 36, p. 1-6.
- (1939). Eintagsfliegen (Ephemeropteren) von der Sunda Inseln. Archiv f. Hydrobiol., Suppl-Bd. **16**, p. 443-692.
- Zelinka, M. (1953). K proznání jepic (Ephemeroptera) Vysokých Tater. (Notes on the mayflies of the High Tatra with the description of *Rhithrogena tatica* n. sp.). Publ. de la Fac. der Sciences de l'Université Masaryk, **6**, 348, p. 157-167.

Explanation of Plate 1.

Figs. 1-8. *Ephemerella* sp.

1, dorsal view of the nymph; 2, labrum; 3, left mandible, 3a, canine area, 3b, part of molar; 4, right mandible, 4a, canine area, 4b, part of molar, 5, labium, 5a, terminal joint of labial palp; 6, maxilla, 6a, tip of galea-lacinia, 6b, distal two joints of maxillary palp; 7, hypopharynx; 8, dorsal view of left half of abdominal segments.



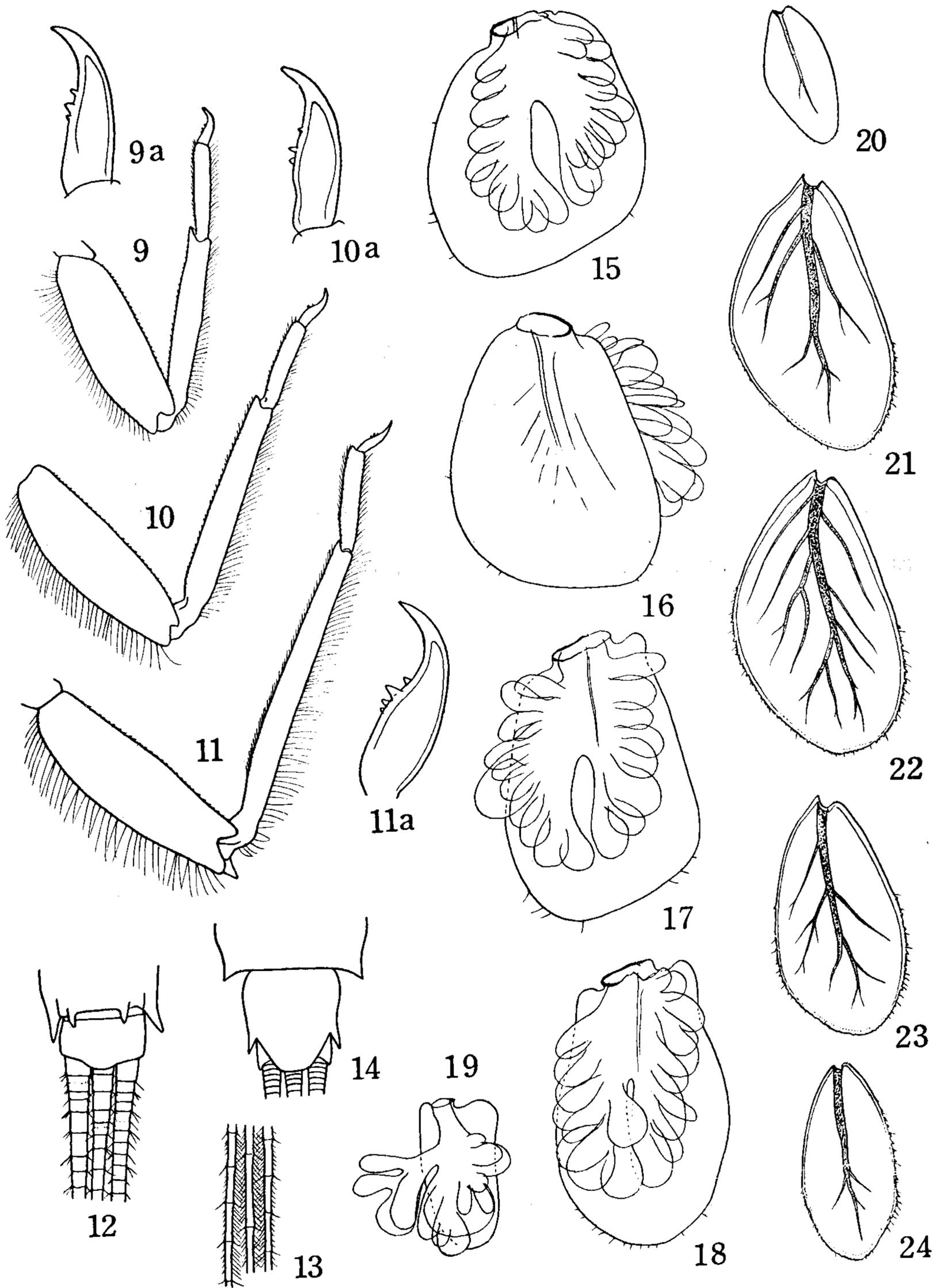
Explanation of Plate 2.

Figs. 9-19. *Ephemerella* sp.

9, right fore-leg, 9a, claw; 10, mid-leg, 10a, claw; 11, hind-leg, 11a, claw; 12, last two abdominal segments and basal parts of caudal filaments; 13, parts of caudal filaments near tips; 14, ventral aspect of 9 and 10 abdominal segments; 15-19, gills 1-5, numbered from the front.

Figs. 20-24. *Baëtis* sp. 1

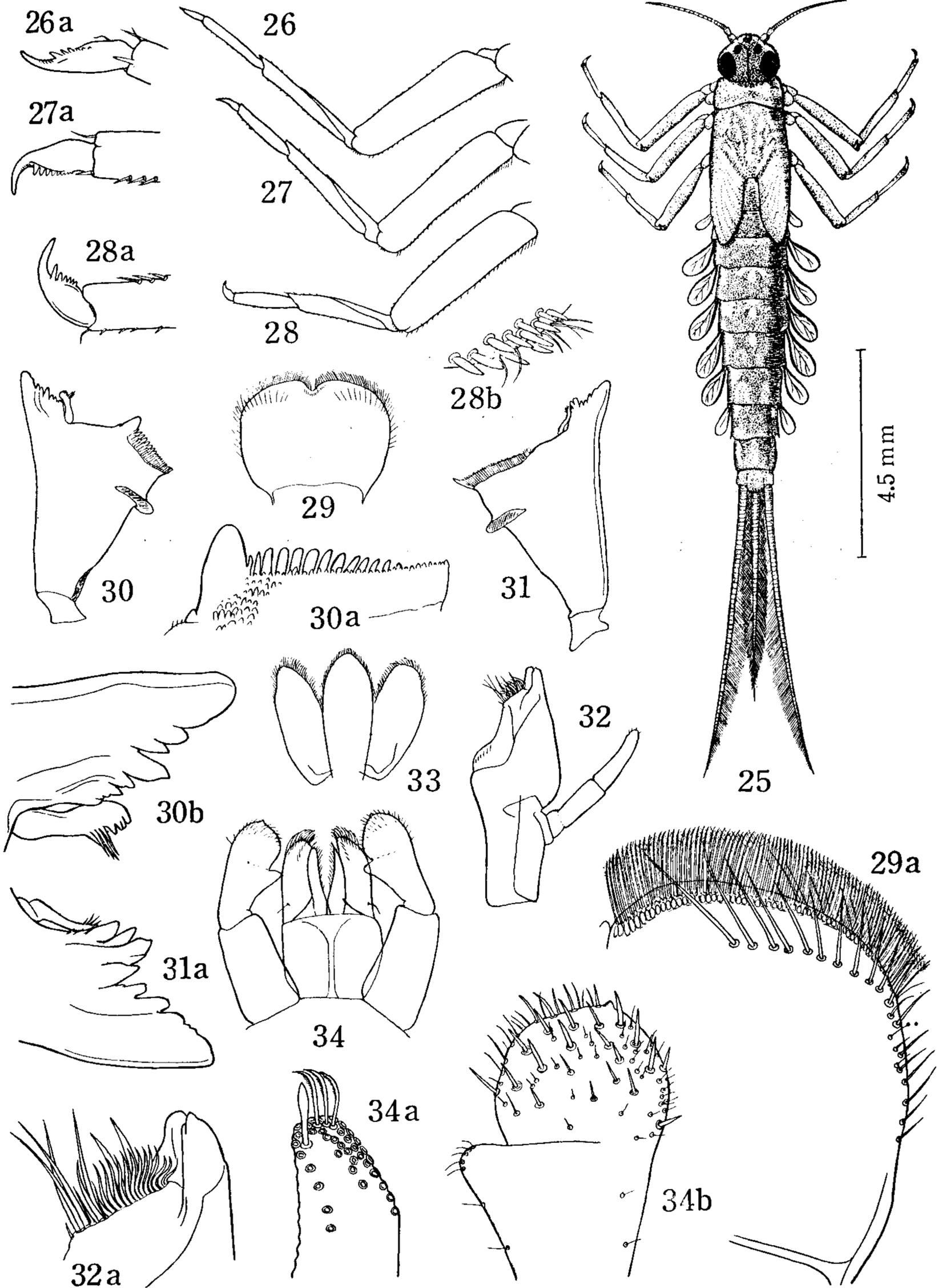
20-24, gills 1, 2, 5, 6 and 7, numbered from the front.



Explanation of Plate 3.

Figs. 25-34. *Baëtis* sp. 1

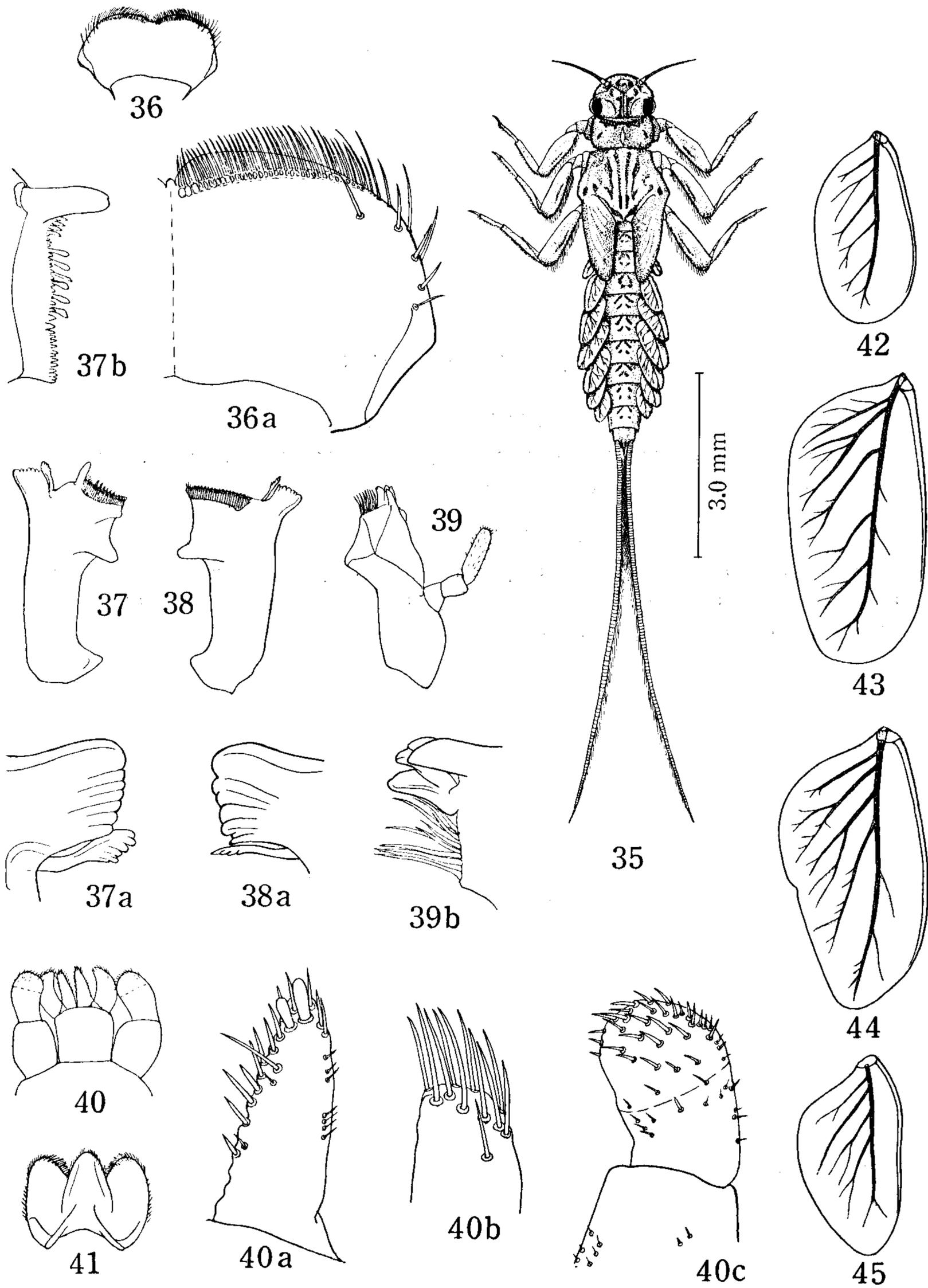
25, Dorsal view of the nymph; 26-28, fore-, mid- and hind-legs; 26a, 27a, 28a, fore-, mid- and hind-claws; 28b, armature of distal margin of hind femur; 29, labrum, 29a, upper surface of the right half of labrum; 30, left mandible, 30a, molar surface, 30b, canine area; 31, right mandible, 31a, canine area; 32, maxilla, 32a, apical part of galea-lacinia; 33, hypopharynx; 34, labium, 34a, tip of paraglossa, 34b, tip of labial palp.



Explanation of Plate 4.

Figs. 35-45. *Baëtis* sp. 2

35, dorsal view of the nymph; 36, labrum, 36a, upper surface of the right half of labrum; 37, left mandible. 37a, canine area, 37b, molar; 38, right mandible, 38a, canine area; 39, maxilla, 39b, tip of galea-lacinia; 40, labium, 40a, glossa, 40b, tip of paraglossa, 40c, distal part of labial palp; 41, hypopharynx; 42-45, gills 1, 2, 5, 7, numbered from the front.



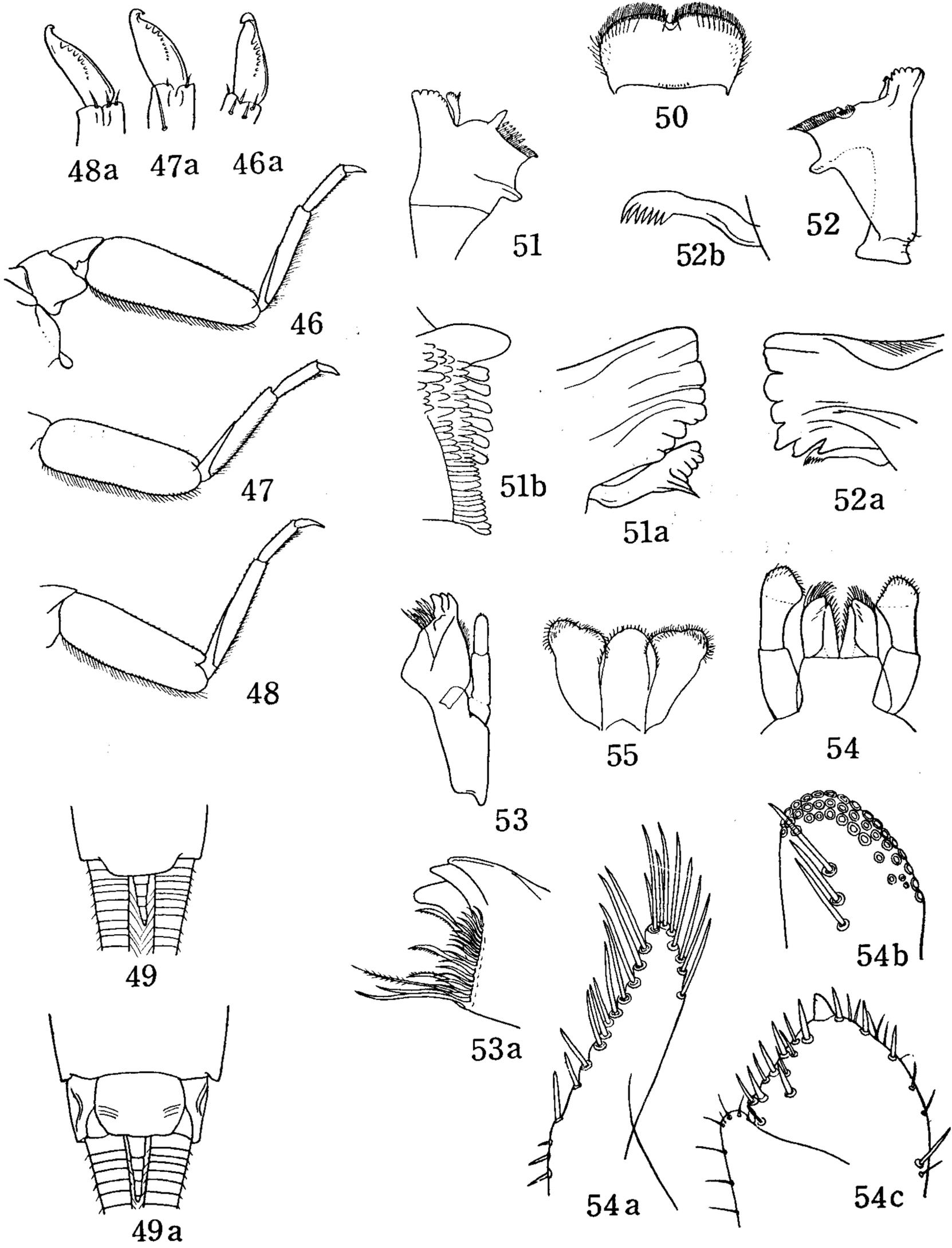
Explanation of Plate 5.

Figs. 46-49. *Baëtis* sp. 2

46-48, fore-, mid- and hind-legs; 46-48a, fore-, mid- and hind-claws; 49, last abdominal tergite and basal parts of caudal filaments; 49a, last abdominal sternite.

Figs. 50-55. *Baëtiella* sp.

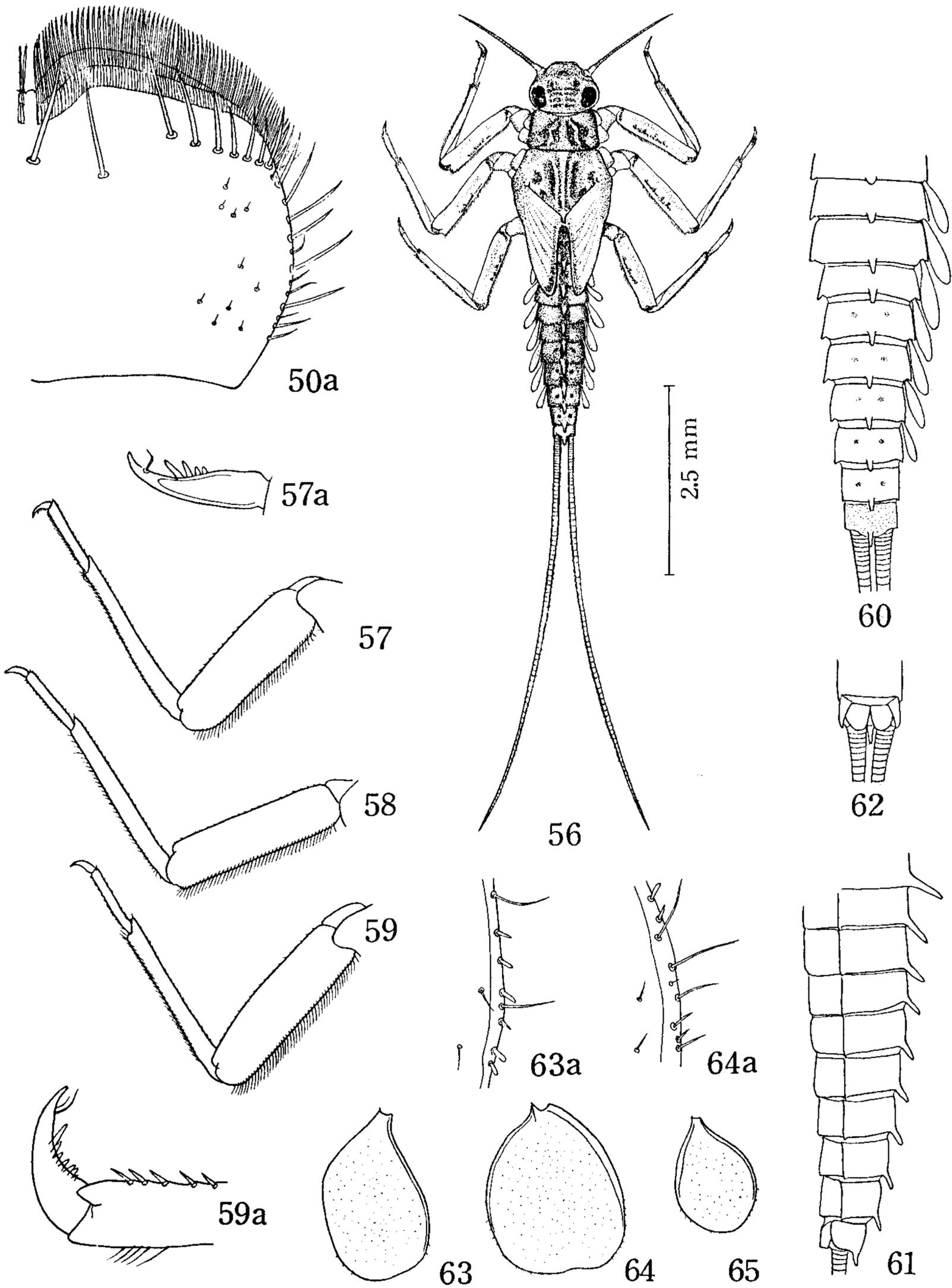
50, labrum; 51, left mandible, 51a, canine area, 51b, molar; 52, right mandible, 52a, canine area, 52b, prosthaca; 53, maxilla, 53a, tip of galea-lacinia; 54, labium, 54a, glossa, 54b, tip of paraglossa, 54c, tip of labial palp; 55, hypopharynx.



Explanation of Plate 6.

Figs. 56-65. *Baëtiella* sp.

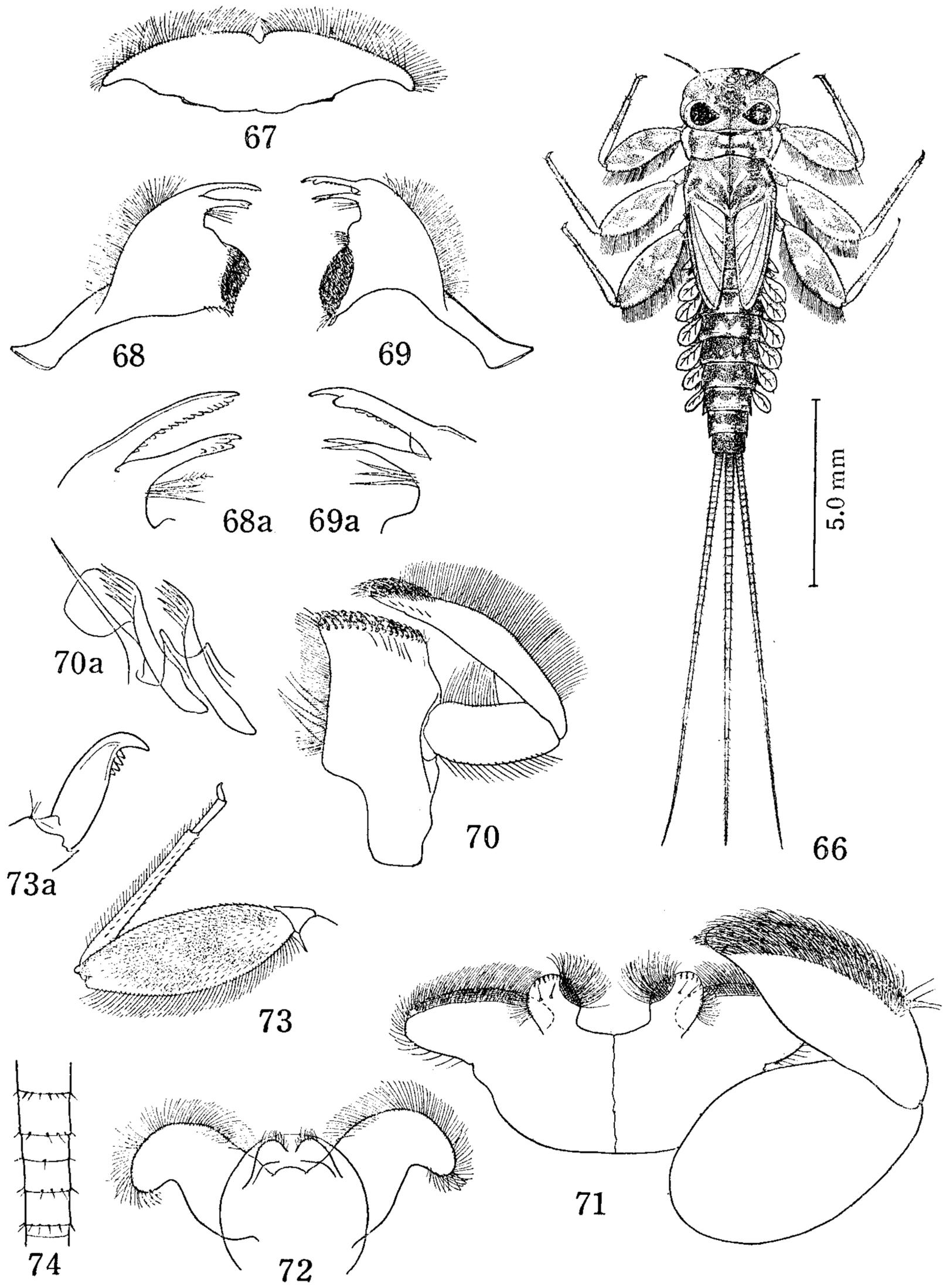
56, dorsal view of the nymph; 50a, upper surface of the right half of labrum; 57-59, fore-, mid- and hind-legs; 57a, fore-claw; 59a, hind-claw; 60, dorsal view of abdominal segments 1 to 10; 61, lateral view of the same; 62, ventral view of last abdominal segment; 63-65, gills 1, 4, 7, numbered from the front; 63a, 64a, marginal portions of gills 4 (63a) and 7 (64a).



Explanation of Plate 7.

Figs. 66-74. *Ecdyonurus* sp. 1

66, dorsal view of the nymph; 67, labrum; 68, left mandible, 68a, canine area; 69, right mandible, 69a, canine area; 70, maxilla, 70a, pectinate spines of apical margin of galea-lacinia; 71, labium; 72, hypopharynx; 73, fore leg, 73a, claw; 74, part of caudal filament.



Explanation of Plate 8.

Figs. 75-82. *Ecdyonurus* sp. 1

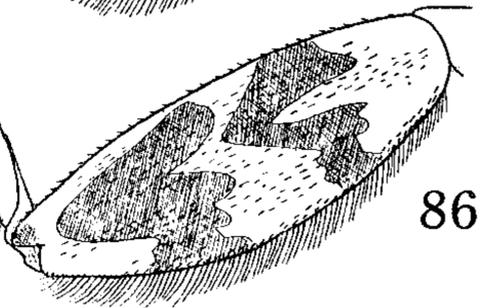
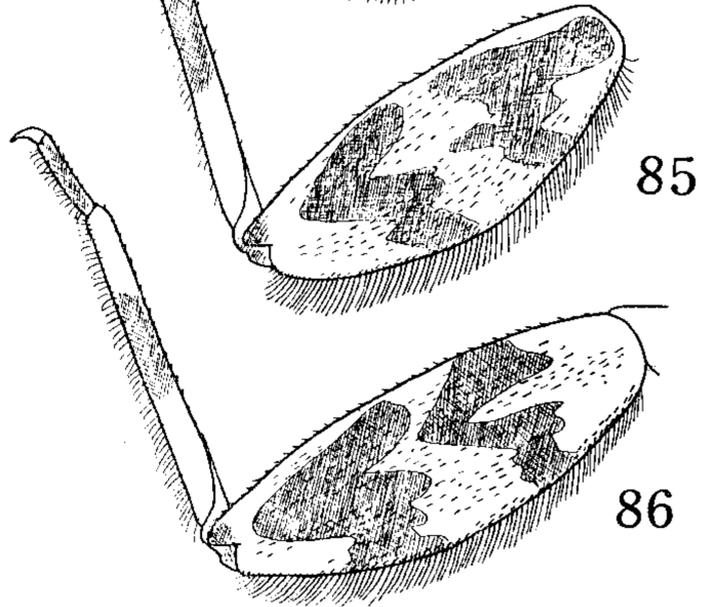
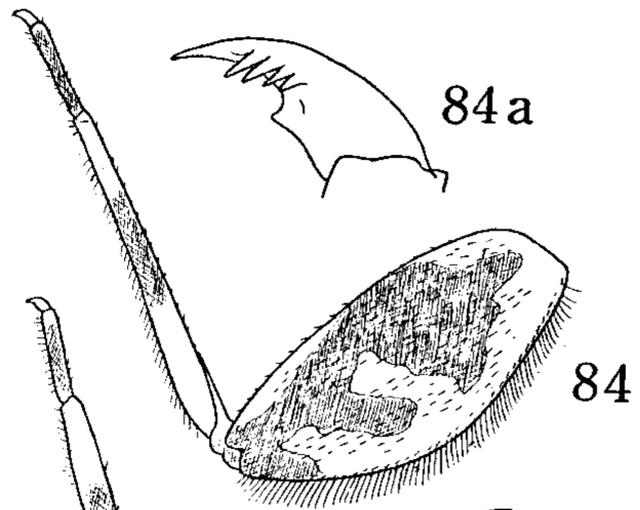
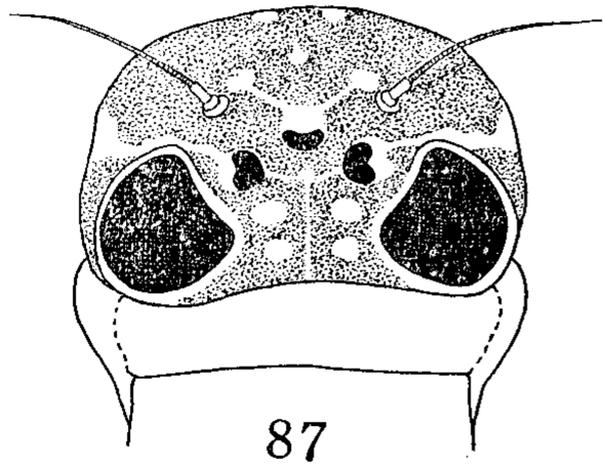
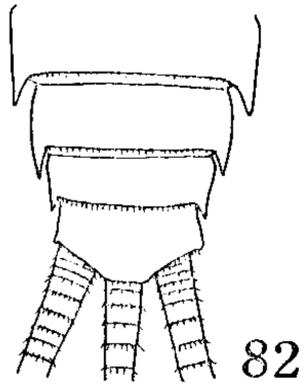
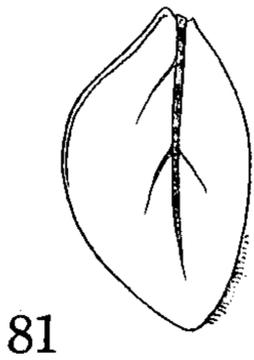
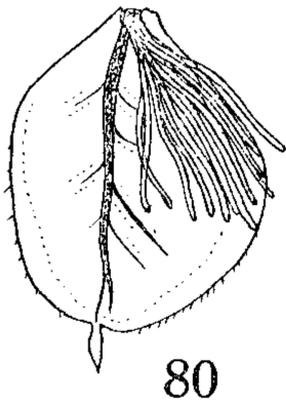
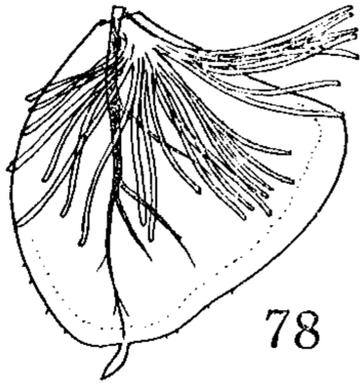
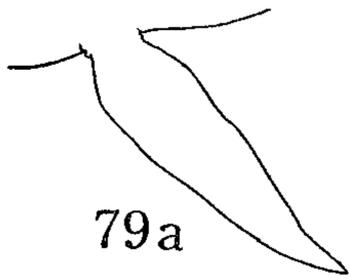
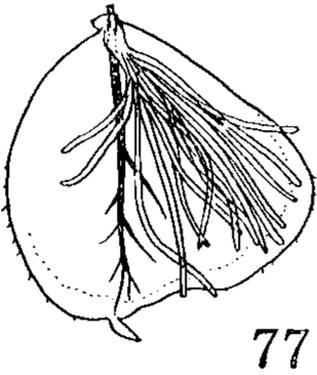
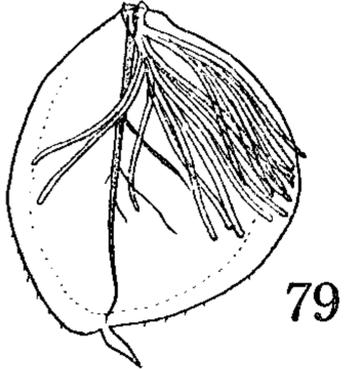
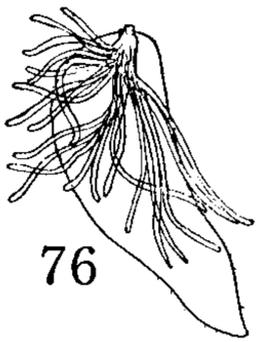
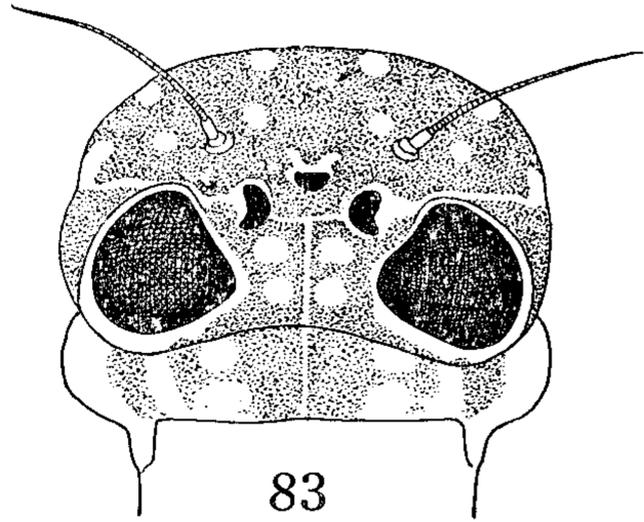
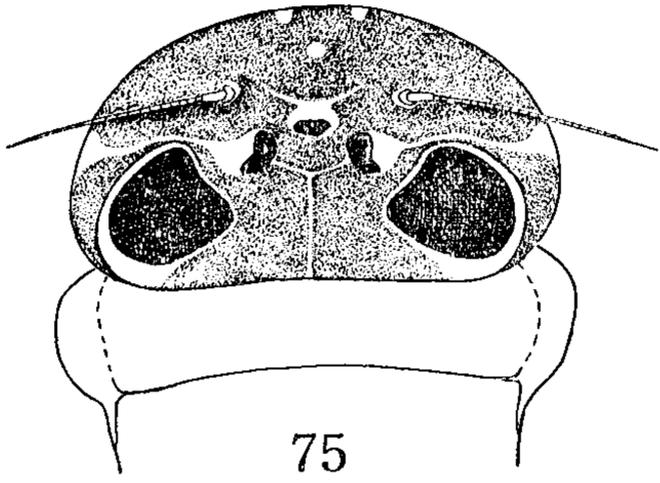
75, head and pronotum; 76-81, gills 1, 2, 3, 5, 6 and 7, numbered from the front; 79a, apical appendage of the 5th gill; 82, abdominal segments 7-10, dorsal aspect.

Figs. 83-86. *Ecdyonurus* sp. 2

83, head and pronotum; 84-86, fore-, mid- and hind-legs; 84a, fore-claw.

Fig. 87. *Ecdyonurus* sp. 3

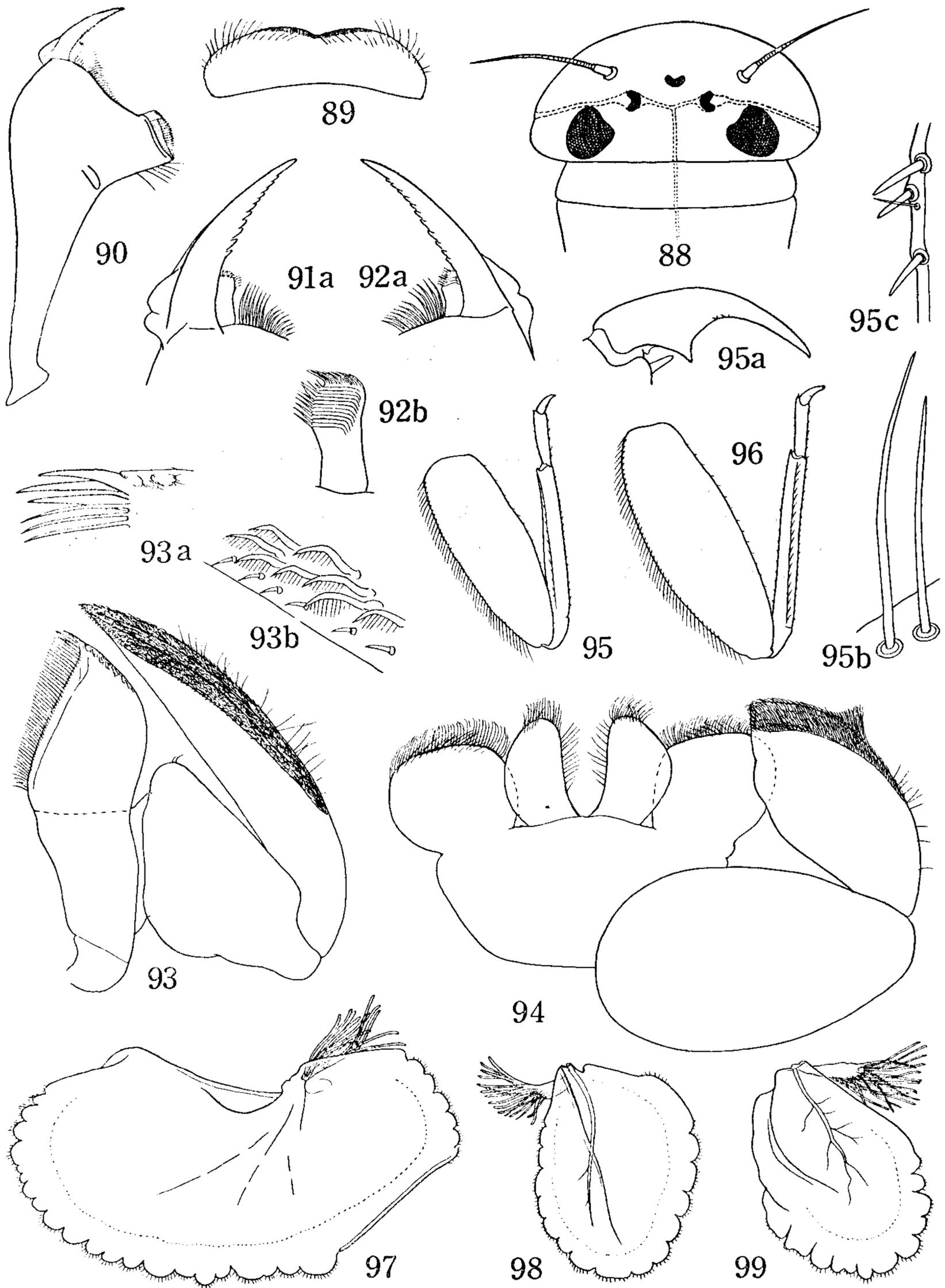
87, head and pronotum.



Explanation of Plate 9.

Figs. 88-99. *Rhithrogena* sp.

88, head and pronotum; 89, labrum; 90, left mandible, 91a, canine area of right mandible, 92b, protheca; 93, maxilla, 93a, triad of teeth of galea-lacinia, 93b, pectinate spines on apical portion of maxillary palp; 94, labium; 95, fore-leg; 96, hind-leg; 95a, hind-claw, 95b, bristles on inner margin of fore femur, 95c, spines on inner margin of the same; 97-99, gills 1, 4, 7, numbered from the front.



Explanation of Plate 10.

Figs. 100-110. *Epeorus* sp.

100, dorsal view of the head, thorax and abdomen; 101, labrum; 102, left mandible, 102a, molar, 102b, canine area; 103, right mandible, 103a, molar, 103b, canine area; 104, maxilla, 104a, tip of galea-lacinia; 105, labium, 105a, tip of glossa, 105b, armature of labial palp; 106, hypopharynx; 107, last sternite; 108-110, gills 2, 4, 7; 110a, armature on the margin of the 7th gill.

