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***ECHINOBAETIS PHAGAS* GEN. NOV., SPEC. NOV., A NEW MAYFLY FROM SULAWESI (EPHEMEROPTERA: BAETIDAE)**

by

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Mol, A. W. M.: *Echinobaetis phagas* gen. nov., spec. nov., a new mayfly from Sulawesi (Ephemeroptera: Baetidae).

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Key words: Ephemeroptera; Sulawesi; *Echinobaetis* gen. nov.; *E. phagas* spec. nov.

The new genus *Echinobaetis* is established for the new species *E. phagas* from Sulawesi. *Echinobaetis* is only known in the larval stage. Gut contents indicate predatory habits of the type species.

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During the Project Wallace Expedition to Sulawesi (formerly Celebes), (Indonesia), in 1985, Ephemeroptera were collected by Mr. J. van Tol (Leiden) in several localities situated in the northern, central and southern parts of the island. So far no Ephemeroptera have been recorded from Sulawesi.

The material consists of more than 1500 specimens, mainly larvae, belonging to at least 25 species. Among these, a species belonging to a remarkable new genus of Baetidae is present, which is described below.

Additional material of this taxon, collected on Sulawesi by Drs J. T. & D. A. Polhemus, was received from Dr. G. F. Edmunds Jr. (Utah).

***Echinobaetis* gen. nov.**

(figs. 1-31)

Larva. — Head flattened, prognate and almost circular in dorsal view (figs. 1, 2). Frontal area considerably enlarged, anterior margin convex and densely covered with bristle-like setae directed ventrally. Genae prolonged and direc-

ted forward below the antennae. Length of antennae about 1.5 times largest width of head.

Labrum attached to ventral side of head at some distance from anterior margin; lateral margins of labrum strongly convex, anterior margin with deep median triangular incision; surface of labrum densely covered with soft hairs (fig. 3). Mandibulae with subparallel margins; incisors with six large flat teeth and molar region strongly protruded, narrow, with acute apex (figs. 4-7). Hypopharynx with superlinguae laterally expanded; apex of lingua with three blunt lobes (figs. 9, 10). Maxillae with apical teeth large, the longest tooth nearly $\frac{3}{4}$ times the length of the lateral margin of the galeolacinea (figs. 13, 14); maxillary palps three-segmented with basal segment very short (figs. 11, 12). Labial palps three-segmented, segments 2 and 3 largely fused and together about as long as the basal segment; inner apical corner of segment 2 roundly protruded; ventral side with large fields of narrow setae on segments 1 and 2, and short stout setae on the apical segment; dorsal side of segment 2 with irregular submedian row of long stout setae (figs. 15, 17). Glossae and paraglossae about 2.3 times longer than wide, apex with groups of long slender setae; glossae with ventral field of narrow setae along the inner margin; submentum with two submedian ventral fields of short narrow setae (fig. 16).

Posterior margins of pro-, meso- and metanotum with 6-10 short conical spines in younger larvae; in older larvae these spines are reduced in number and size (figs. 18-21). Metanotum without hind wing pads.

Legs with femora flattened; posterior margins of femora and tibiae with a dense row of long soft hairs, finely fringed. Claws with a single row of 4-7 strong teeth and a single long seta near base of apical tooth (fig. 29).

Abdominal segments 2-8 each with three long slender dorsal spines directed caudally (figs. 22, 23); segment similar but spines much shorter and median spine sometimes absent; segments 9 and 10 without spines. Single gills on segments 1-7 (figs. 26-28). Cerci almost as long as body; terminal filament $\frac{1}{6}$ - $\frac{1}{4}$ times as long as cerci in full grown larvae and relatively shorter in younger larvae.

Imago and subimago. — Unknown.

Etymology. — Combination of *Echinus* (L.), meaning spine (because of the striking spines on thorax and abdomen) and *Baetis*.

Type species and only known species. — *Echinobaetis phagas* spec. nov.

Echinobaetis phagas spec. nov.
(figs. 1-31)

Material. — All from Sulawesi (abbreviations: SU = Sulawesi Utara province; ST = Sulawesi Tengah province; SS = Sulawesi Selatan province). Holotype: Mature ♂ larva (SU), Dumoga-Bone National Park, River Tumpah near Edwards Camp (0°35'N-123°50'E), ca 600m, 29.IV.1985 (sample A), J. van Tol. Paratypes: 3 larvae, locality and date as holotype; 2 larvae, locality as holotype, 30.IV.1985 (sample A), J. van Tol; 1 larva (SU), Dumoga-Bone National Park, River Tumpah between Waterfall creek and confluence with river Toraut (0°34'N-123°54'E), 200-225m, 22.IV.1985 (sample A), J. van Tol; 13 larvae (SU), Dumoga-Bone National Park, River Tumpah (0°34'N-123°54'E), 222m, 4.IX.1985 (CL 2100), J.T. & D.A. Polhemus; 2 larvae (SU), Dumoga-Bone National Park, River Tumpah (0°35'N-123°53'E), 250m, 5.IX.1985 (CL 2102), J.T. & D.A. Polhemus; 1 larva (SU), Dumoga-Bone National Park, Waterfall creek (tributary of river Tumpah) (0°35'N-123°54'E), 225-250m, 23.IV.1985 (sample B), J. van Tol; 3 larvae (SU), Dumoga-Bone National Park, River Toraut (0°34'N-123°54'E), 211m, 3.IX.1985 (CL 2099), J.T. & D.A. Polhemus; 1 larva (SU), River Pononontuna (upper courses), 8 km N. of Malibagu (0°27'N-123°58'E), 254m, 7.V.1985 (sample B), J. van Tol; 1 larva, same locality, 18.V.1985 (sample B), J. van Tol; 4 larvae (SU), Metalanga river, 5 km S. of Doloduo, 7.IX.1985 (CL 2111), J.T. & D.A. Polhemus; 1 larva (ST), Lore Lindu National Park, Dongi shelter, River Sopa (1°13'S-120°11'E), 950m, 8.XII.1985 (sample A), J. van Tol; 11 larvae (ST), Lore Lindu National Park, Dongi shelter, tributary of River Sopa (1°13'S-120°11'E), 950m, 9.XII.1985 (sample A), J. van Tol; 1 larva (ST), Lore Lindu National Park, River Mbewe (1°32'S-120°01'E), 600-700m, 15.XII.1985 (sample C), J. van Tol; 2 larvae (ST), Lore Lindu National Park, Anaksungai Mbewe (tributary of River Mbewe), 600-700m, 17.XII.1985 (sample A), J. van Tol; 1 larva (ST), Lore Lindu National Park, Stream 10 km SE of Kamarora, 950m, 8.X.1985 (CL 2156), J.T. & D.A. Polhemus; 5 larvae (ST), Lore Lindu National Park, Stream at Lindu foot path, 830m, 5.X.1985 (CL 2155), J.T. & D.A. Polhemus; 13 larvae (SS), Rivulet near Malino, N. of Lompobattang (5°15'S-119°51'E), 800-1000m, 21.VI.1985 (sample A), J. van Tol; 3 larvae (SS), Pattunuang river, 7 km SW of Bantimurung, 0-100m, 13.X.1985 (CL 2165), J.T. & D.A. Polhemus.

Holotype and most paratypes in alcohol, 3 paratypes on slides. Deposition of material: Holotype and 20 paratypes in Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands; 11 paratypes in Museum Zoologicum Bogoriense, Bogor, Java, Indonesia; 23 paratypes in University of Utah, Salt Lake City, Utah, U.S.A.; 2 paratypes in Florida Agricultural and Mechanical University, Tallahassee, Florida, U.S.A.; 2 paratypes in Purdue University, West Lafayette, Indiana, U.S.A.; 2 paratypes in California Academy, San Francisco, California, U.S.A.; 2 paratypes in United States Museum of Natural History, Washington, D.C., U.S.A.; 6 paratypes in the author's collection.

Larva. — Length (full grown specimens): Body 12.2-15.7 mm; cerci 12.2-13.8 mm; filum terminale 2.0-3.2 mm.

Head (figs. 1, 2) dorsally brown with a large pale central spot and a pair of small submedian spot on the frontal area, lateral parts of genae and most sutures yellowish white; epicranium of female larvae and young larvae of both sexes with two submedian rows of 4-5 traverse yellowish brown spots each; epicranium of mature male larvae yellowish white. Specimens from central and south Sulawesi (ST, SS) have the pale spots on the frontal area considerably enlarged, often covering most of it, and both sexes have the epicranium yellowish white with only a vague indication of spots in some female larvae.

Venter of head pale yellowish, Setae along anterior margin of head stiff, brownish yellow. Eyes placed at dorsal side of head, greyish black, turban eyes dark orange brown. Epicranium about three times width of one eye in female larvae, about two times width of one turban eye in male larvae. Ocelli black, inner part grey. Antennae (fig. 8), pale yellow, scapus slightly flattened and enlarged at medio-ventral side; pedicellus subcylindrical, about as long as scapus; both scapus and pedicellus with a small number of short hairs and short blunt setae at ventral side; flagellum with about 50 segments (in mature larvae), with joints perpendicular to the longitudinal axis in the basal half and slightly oblique towards the apex.

Labrum (fig. 3) about three times wider than long, dorsal side densely covered with fine soft hairs, ventral side with a small number of soft hairs along lateral margins, a dense row of short soft hairs at some distance from the anterior margin and a triangular central field of soft hairs. Mandibles (figs. 4-7) with incisors fused into two groups of three teeth each, inner margin of innermost tooth with short row of small denticles; molar regions with series of subapical stout setae; right prosthema palmate with about six teeth and a small ventral group of spines about twice as long as the teeth (fig. 7); left prosthema narrow with a small number of irregularly shaped teeth in apical half (fig. 6). Hypopharynx (figs. 9, 10) densely covered with short soft hairs. Maxillae (figs. 11-14) with apical teeth 2 and 3 considerably shorter than teeth 1 and 4; two stout subapical setae, slightly serrated, and 3-4 smaller setae at dorsal side (fig. 14); a series of ca 11 narrow setae, sigmoid curved, at ventral side (fig. 13). Maxillary palps with segment 2 slightly longer than half the total length of palp, flattened especially in the central part (fig. 11) and slightly curved inward with narrow apex; segment 3 about 0.6 times the length of segment 2, tapering from base towards apex and slightly curved in the opposite direction of segment 2 (fig. 12). Labial palps with basal segment about 1.4 times longer than wide; dorsal side with a small number of narrow setae, especially along lateral margins; ventral side with dense field of narrow setae, increasing in length and density towards apical and inner margins; second segment with inner apical protrusion covered with short setae, extending towards the centre of the segment at ventral side; dorsal side with irregular row of ca 10 long setae; apical segment conical with rounded apex, ventral side very densely covered with very short stout setae in apical half, gradually decreasing in number and size along outer margin towards base, inner margin with small number of hairs (figs. 15, 17). Glossa with inner margin straight, outer margin convex; ventral side with dense field of narrow setae near base and along inner margin, apex with group of setae about 2-3 times longer than other ventral setae; dorsal side with about 20 long setae mainly in outer half. Paraglossa with outer margin

convex and inner margin concave, apex with group of setae, slightly curved inward and about 1.2-1.5 times longer than apical setae of glossa; ventral side with about 20 stout setae, mainly near inner margin; dorsal side with a small row of setae along outer margin and 3-5 subapical setae along inner margin (fig. 16).

Pronotum with lateral parts brown, median part pale brown with two darker submedian oblique spots, sometimes only vaguely indicated; posterior margin with ca 14 short conical spines in early larval instars, gradually decreasing in size with increasing larval size and absent in ultimate larval instars. Mesonotum brown with irregularly shaped paler spots in anterior half and a broad transverse pale zone in posterior half; posterior margin between the wing pads dark brown with 8-10 short conical spines, well developed in early instars but decreasing in size with increasing larval size (figs. 18-21). Metanotum yellowish white with posterior and lateral margins bordered with brown; posterior margin with ca 8 long spines in young larvae (fig. 18), decreasing in size with increasing larval size, but still present even in the ultimate instars (figs. 19-21) except for the most lateral pair. No hind wing pads.

Legs yellowish white with large brown spots on dorsal side of coxa, trochanter and femur; base of femur narrowly bordered with brown and apex of femur and base of tibia washed with brown (fig. 30). Trochanter with dense field of short narrow setae along anterior margin. Femur flattened, largest width near base and slightly tapering towards apex; length ratios of pro-, meso- and metathoracic femora are 1 : 1.12 : 1.16. Posterior margin of femur with dense, double row of long hairs, each finely feathered; anterior margin with dense field of short narrow setae and a small patch of short hair-like setae near the femur base; surface of femur smooth, only central part shagreened (especially in the brown pigmented area), without scales or setae. Tibia and tarsus not flattened, each with a single straight longitudinal row of hairs; hairs on tibia about as long as hairs on femur, hairs on tarsus 4-5 times shorter. Tibia with a dense field of short narrow setae in apical half; tarsus sparsely covered with short narrow setae and short hairs and 2-3 slightly larger setae near apex (fig. 29); both tibia and tarsus with a small number of more robust setae with enlarged basic socle, sparsely scattered among the other setae. Claws (fig. 29) with a strong apical tooth, a single row of 4-7 subequal teeth along outer ventral margin and a single long straight seta along inner ventral margin near base of apical tooth.

Abdomen without conspicuous colour pattern; terga pale brown, towards lateral margins pale yellow; a pair of sublateral pale spots with the anterior margin bordered with darker brown near anterior margin of terga 1-9; in some specimens a pair of faint oblique pale stripes near anterior margin of terga

2-10; attachment sites of gills on segments 1-7 narrowly bordered with dark brown. Sterna pale yellow. Terga 1-8 with a pair of long spines near the anterior margin and a single spine in the centre (figs. 22, 23); spines on segment 1 shorter than spines on other segments and central spine sometimes absent. Terga 9 and 10 without these spines. Posterior margins of terga 1-8 with short conical spines (fig. 24), towards lateral margins blunt spines (fig. 25), posterior margin between the two long spines smooth; posterior margins of terga 9 and 10 with sharp conical spines of various sizes, the longest about 2-3 times as long as the conical spines on terga 1-8. Surface of terga smooth, only slightly shagreened and sparsely covered with short hairs and some very short blunt setae. Single tracheal gills present on segment 1-7; gills 2-7 about 1.5-1.7 times longer than wide with tracheae dark brown and strongly ramified (figs. 27, 28); gills on segment 1 about as long as wide with tracheae pale brown and less ramified (fig. 26). Paraprocts (fig. 31) with dense row of slender denticles along inner margin; surface smooth, sparsely covered with short hair-like setae. Fila caudalia yellowish white, segments in basal half with short conical spines along posterior margins, segments in distal half smooth; hairs along inner margins of cerci and lateral margins of filum terminale short, about 1.5-2.5 times the width of corresponding segments.

Geographical variation. — Specimens from the northern part of the island (Sulawesi Utara province) are somewhat smaller than specimens of other localities; the brown pigmentation is extended over larger parts of frons and epicranium (fig. 1), while pronotum and mesonotum (and the abdomen to a lesser extent) show clear contrasts in colour between the paler and darker parts. Specimens from central and southern Sulawesi (Sulawesi Tengah province and Sulawesi Selatan province resp.) are larger; frons and epicranium are almost or entirely yellowish white, while thorax and abdomen display little colour contrast and may be even almost unicolorous pale brown in some cases. No morphological differences could be found, however, and all populations studied are regarded to be conspecific.

The distribution of both colour forms of *E. phagas* is very similar to the distribution of two subspecies of the dragonfly *Diplacina militaris* Ris (Van Tol, 1987).

Imago and subimago. — Unknown.

Etymology. — *phagas* (Greek for “glutton”), because of the predacious habits of the larvae.

Ecology. — *Echinobaetis phagas* feeds on larvae of other aquatic insects. Dissected guts of three nearly mature larvae contained remainings of at least 23 Ephemeroptera (21 Baetidae, mainly *Pseudocloeon*, and 2 *Prosopistoma*), 7 Diptera (mainly Simuliidae) and 1 trichopteron. Maximum prey size observed was approximately 3 mm.

Larvae of *Echinobaetis* were obtained from small rivers and larger brooks, partly in open country, partly covered by canopy. Width of the streams varied between 10 and 50 m, depth between 0.10 and 0.50 m (locally up to 1 m). Measured values of physical factors were: Velocity 0.3-1 m/sec (locally up to 2 m/sec); temperature 23.1-25.2 °C; conductivity 82-98 µS/cm and pH 7.1-7.4. The bottom substrate consisted of coarse sand, cobbles and larger boulders. *Echinobaetis* was found from about sea level up to 950 m.

The larvae preferred sites with boulders and stones near the banks of the streams, whereas several other groups of Ephemeroptera, especially Heptageniidae and Prosopistomatidae, apparently preferred sites in the main current (Mr. J. van Tol, pers. comm.).

Discussion. — *Echinobaetis* is readily distinguished from other genera of Baetidae by the combination of an almost circular and flattened head with the frontal area considerably enlarged (figs. 1, 2), conspicuous triplets of dorsal spines on abdominal segments 1-8 (figs. 22, 23), claws with a very long single subapical seta (fig. 29) and the shape of mandibulae and maxillae (figs. 4-7, 12-14), clearly adopted for predacious habits.

The taxonomic position of *Echinobaetis* appears to be rather isolated. There is little evidence for a close relationship of the new genus with other genera of Baetidae. A comparison of *Echinobaetis* with other predacious genera (Müller-Liebenau, 1978; Mol, 1986) reveals that carnivorous habits must have developed independently in at least three different lineages within the Baetidae.

There is some resemblance in the shape of the head between *Echinobaetis* and *Jubabaetis* Müller-Liebenau, 1980, described from the Philippine island Luzon (Müller-Liebenau, 1980). Both genera share an enlarged, protruded frontal area, covering the mouthparts entirely, and bearing a dense row of setae along the anterior margin. This curious feature is not present in any of the other known genera of Baetidae. Table 1, however, shows that other features of the two genera are different to such an extent that a close relationship is not very likely. The more detailed structure of the head itself is different as well. Among other families of Ephemeroptera larvae with flattened heads and anterior borders of setae are found as well, being an adaptation to the currents in which the animals live. The similarities between *Echinobaetis* and

Jubabaetis should probably be considered as the result of convergent evolution. Although *Jubabaetis* is very distinctive, the more or less quadrangular shape of the head, the straight single row of long setae along the posterior margin of the femora and especially the long ventral setae near the apex of the tarsus, indicate a possible relationship between this genus and oriental species of *Pseudocloeon* Klapálek, 1905 and *Platybaetis* Müller-Liebenau, 1980.

Echinobaetis gen. nov.

Frontal area ca 2/3 times as wide as largest width of head.

Setae along anterior margin of head bristle-like and curved down.

Genae prolonged below antennae.

Antennae ca 1.5 times largest width of head; flagellum with ca 50 segments, joints in middle region more or less perpendicular to axis.

Labrum laterally protruded, surface and margins covered with soft hairs only.

Mandibulae with molars protruded, narrow and acute, bearing a small number of subapical setae.

Maxillae with long apical teeth; longest tooth nearly 3/4 times lateral margin of galeolacinea.

Glossa and paraglossa about 2.3 times longer than wide; apex of paraglossa rounded.

Metanotum without hind wing pads, but posterior margin with 6-8 conical tubercles.

Femur with a double row of long setae along posterior margin.

Jubabaetis Müller-Liebenau, 1980

Frontal area as wide as largest width of head.

Setae along anterior margin of head hair-like and curved upward.

Genae not prolonged below antennae.

Antennae about as long as largest width of head; flagellum with ca 30 segments; joints in middle region oblique (ca 30°) to axis.

Labrum with lateral margins convex but not considerably protruded, surface with traverse row of stout setae, lateral margins with compound setae.

Mandibulae of normal shape (molar region wide, more or less straight and covered with numerous small teeth).

Maxillae with longest apical tooth less than 1/3 times lateral margin of galeolacinea.

Glossa and paraglossa about 1.5 times longer than wide; apex of paraglossa subtruncate.

Metanotum with small hind wing pads, posterior margin smooth.

Femur with a single straight row of long setae along posterior margin

<p>Tarsus with dorsal hairs less than 1/5 times the length of hairs on tibia; ventral setae short and of about the same length.</p> <p>Claws with a single long seta near apex.</p> <p>Abdominal terga 1-8 with three long spines each; two submedian spines near the posterior margin and one spine in the centre of the tergites.</p> <p>Filum terminale with more than 50 segments and ca 1/6 - 1/4 times as long as cerci.</p>	<p>and a row of short stout setae parallel to it.</p> <p>Tarsus with dorsal hairs about 1/2 times the length of hairs on tibia; two ventral apical setae 8-10 times longer than other ventral setae.</p> <p>Claws without apical setae.</p> <p>Abdominal terga 1-9 each with a single median long spine at posterior margin.</p> <p>Filum terminale reduced to a single segment.</p>
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Table 1. Main differences between *Echinobaetis* gen. nov. and *Jubabaetis* Müller-Liebenau.

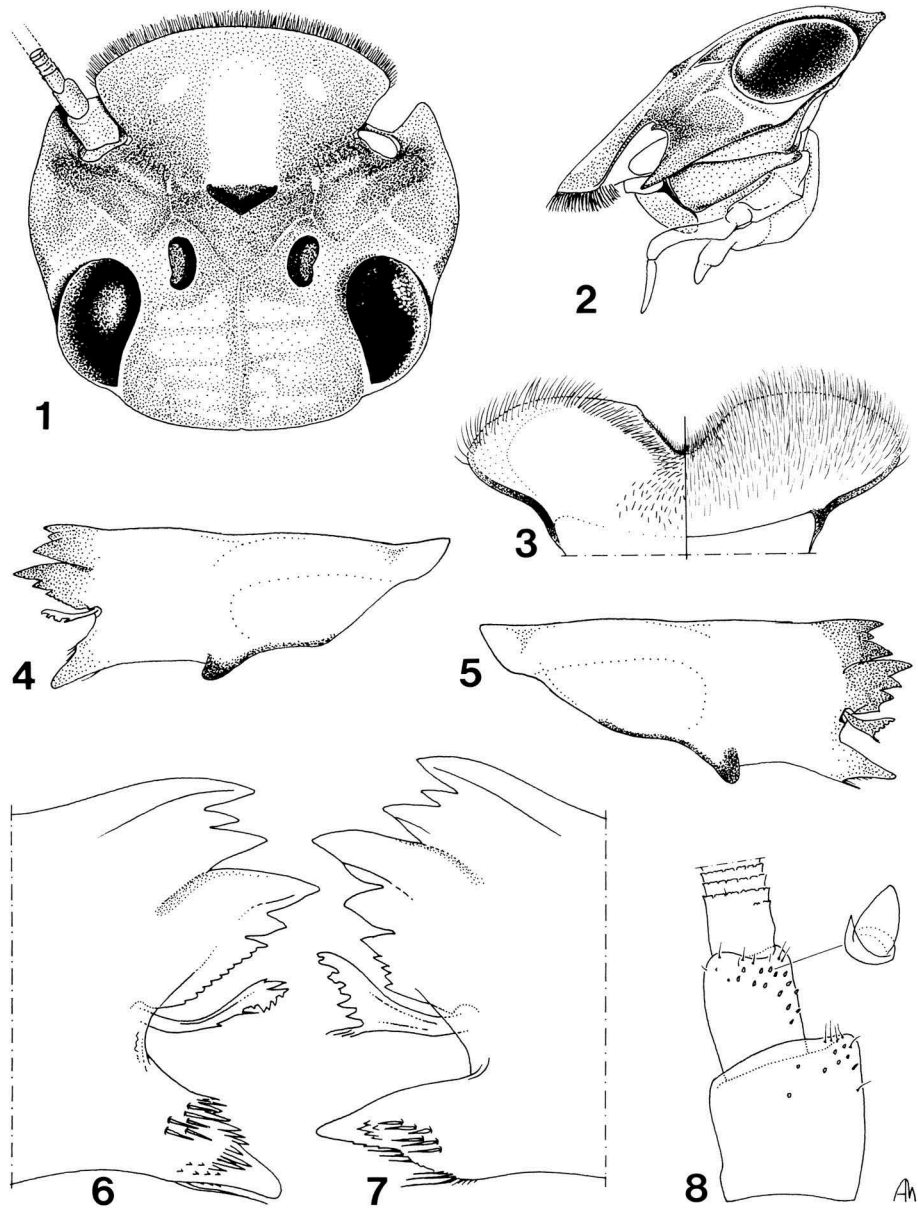
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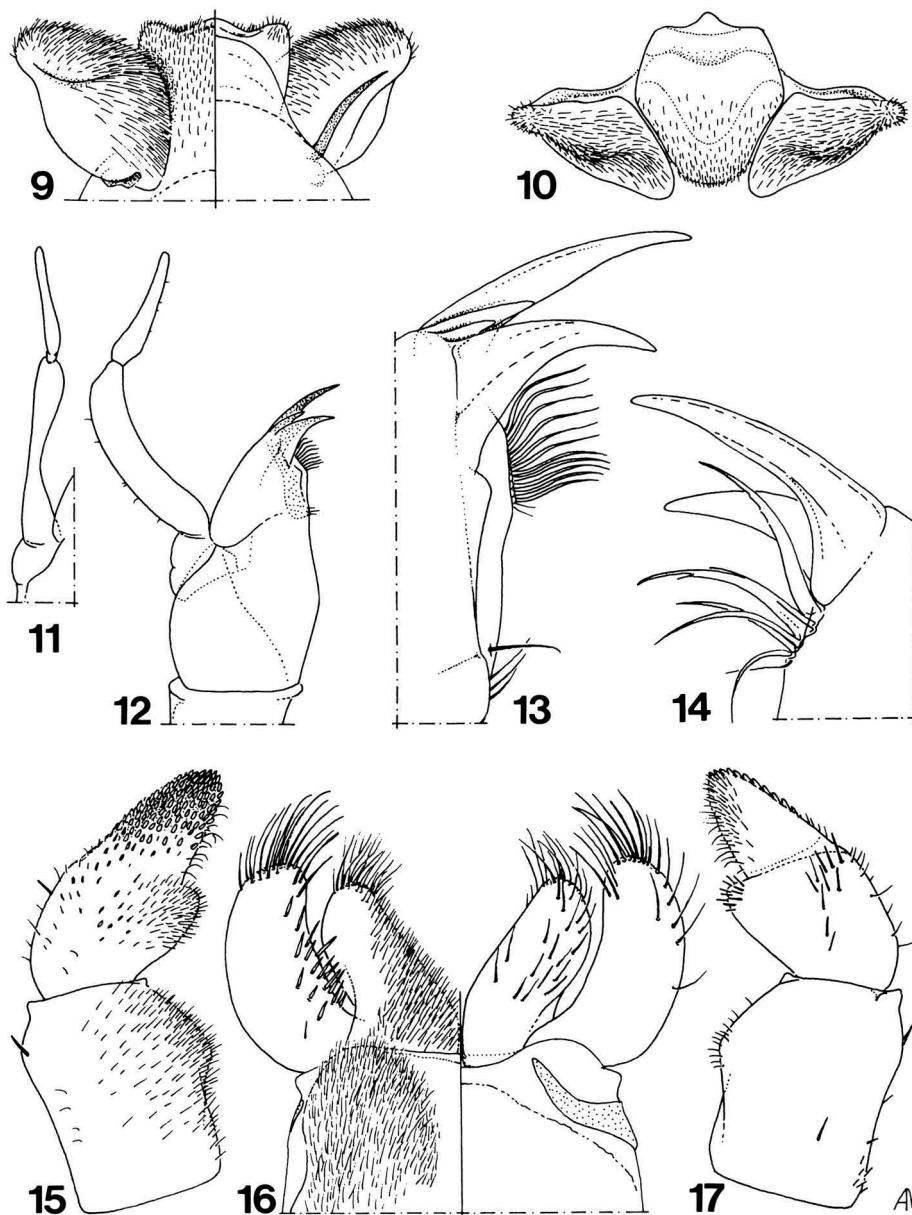
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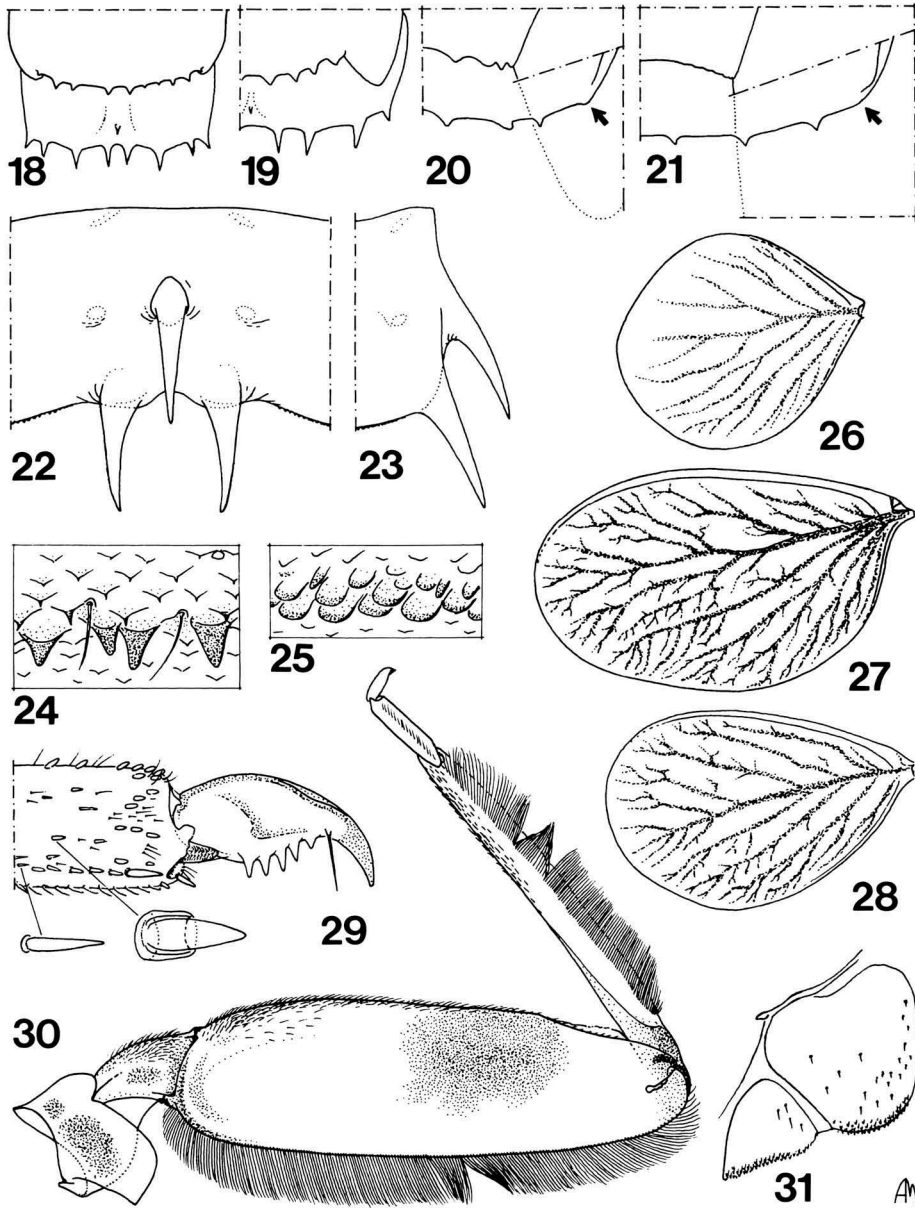
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Figs. 1-8. *Echinobaetis phagas* gen. nov., spec. nov., larva. 1. head, dorsal view; 2. head, lateral view; 3. labrum, right: dorsal side; left: ventral side; 4. left mandible; 5. right mandible; 6. left mandible, detail of incisors and molar region; 7. right mandible, detail of incisors and molar region; 8. antenna, basal part.



Figs. 9-17. *Echinobaetis phagas* gen. nov., spec. nov., larva. 9. hypopharynx, right: back side; left: frontal side; 10. hypopharynx, ventral view; 11. maxillary palp, lateral view; maxilla, ventral view; 12. maxilla, ventral view; 13. maxilla, detail of apex, ventral view; 14. maxilla, detail of apex, dorsal view; 15. labial palp, ventral view; 16. submentum, glossa and paraglossa, right: dorsal view, left: ventral view; 17. labial palp, dorsal view.



Figs. 18-31. *Echinobaetis phagas* gen. nov., spec. nov., larva. 18-21. posterior margin of meso- and metanotum; 18. young larva; 19. less than half-grown larva; 20. half-grown larva; 21. mature larva; 22. tergite 4, detail of dorsal spines; 23. idem, lateral view; 24. tergite 4, detail of posterior margin; 25. idem, lateral part; 26. gill 1; 27. gill 4; 28. gill 7; 29. apical part of tarsus and claw; 30. leg, dorsal view; 31. paraproct plate.