

Redescription of *Brachycercus japonicus* Gose, 1980 (Ephemeroptera, Caenidae)

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Abstract. A caenid mayflies, *Brachycercus japonicus* Gose, 1980, is redescribed and illustrated, and biological notes are given. The adult and egg of this species are described for the first time.

Key words: mayfly, Ephemeroptera, Caenidae, *Brachycercus japonicus*, redescription.

Introduction

Brachycercus japonicus is the only Japanese representative of the *Brachycercus* caenids, which are widely distributed in the Holarctic: in the Palaearctic from Algeria to Finland and in Sri Lanka and North-east Asia; all over the Nearctic including Alaska (cf. Tshernova, 1952; Gose, 1958, 1980, 1985; Edmunds *et al.*, 1976; Soldán 1986; Yoon & Bae, 1988; Kluge, 1991; Soldán & Landa, 1991; Bae *et al.*, 1994; Edmunds & Waltz, 1996; Bae, 1997; Bae & Yoon, 1997; Malzacher, 1997; Hwang & Bae, 1999).

Gose (1958) reported an unnamed mayfly, "*Brachycercus* sp. BA", based on a single nymphal specimen collected by the late Dr. M. Tsuda from the Nabarigawa (Satsuki-gawa) River, in Tsukigase-mura, Nara Prefecture (Gose, personal communication). Later, this was named as "*Brachycercus japonica*" by Gose (1980) (Gose, personal communication), but his description of this species is so brief and insufficient that its redescription has been desired, including information on the other developmental stages, *i.e.*, the adults and eggs. However, the type specimen of *Brachycercus japonicus* was unfortunately lost (Gose, personal communication). Moreover, there has been no record of collection of this species. Recently, I obtained some imaginal and nymphal specimens of a *Brachycercus* caenid, including eggs, from the type locality of *B. japonicus*. These specimens do not conflict with the characters of *B. japonicus* described by Gose (1958, 1980), and any other species of *Brachycercus* has not been found around the locality. Accordingly, I concluded that the specimens collected should be referred to *B. japonicus*. On the basis of these specimens, full descriptions of the adult, mature nymph and egg are here provided. Some biological notes on this species

are also given.

Brachycercus japonicus Gose, 1980

[Japanese name: Mitsutoge-hime-shiro-kagerou]

Brachycercus sp. (designated as BA): Gose, 1958: 33 [des. (nymph), fig. (nymph), key (nymph)].

Brachycercus japonica [sic], Gose, 1980: 454 [fig. (nymph), key (nymph)].

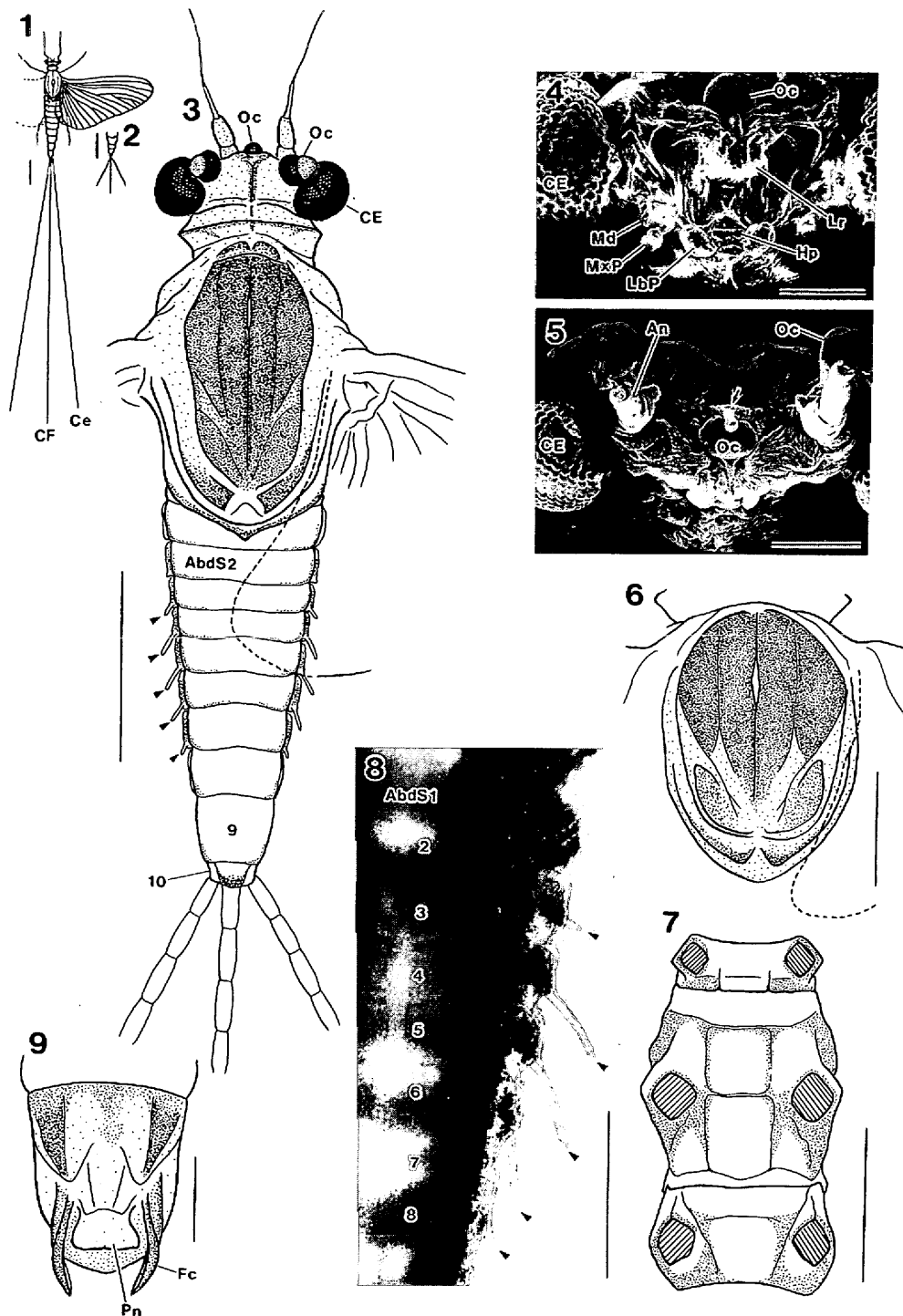
Brachycercus japonicus, Bae, 1997: 409 [catalog].

Male adult (Figs. 1, 3–4, 7–9, 10–13, 16–19).

Measurements ($N=20$): Body 3.7–4.0 mm (excluding antennae, cerci and caudal filament); antennae 0.9–1.1 mm; cerci 10.5–12.0 mm; caudal filament (median filament) 11.5–12.6 mm; fore wings 3.3–3.7 mm (Figs. 1, 3, 10).

Head: Generally milky white; compound eyes black, separated laterally; ocelli gray, bases of ocelli black (two lateral, one median) (Fig. 3). Antennae white, unicolorous; scapus and pedicellus short; scapus half as long as pedicellus; flagellum moderately tapered distally, about 3-fold as long as scapus+pedicellus (Fig. 3). Mouthparts reduced (Fig. 4). All of the three (two lateral and one median) protuberances or ocellar tubercles degenerated in contrast to the prominently developed nymphal ones.

Thorax: Pronotum and metanotum milky white, mesonotum brown (Fig. 3). Sterna milky white, with brown markings on leg bases (Fig. 7). Fore wings hyaline, without intercalary veins; main costal margin vein brownish; posterior margin of fore wing with dense marginal short hairs on the basal half (Figs. 10, 11). Hind wings absent. Fore legs light brown and elongate, as long as 1/2 to 3/4 of body length; coxae

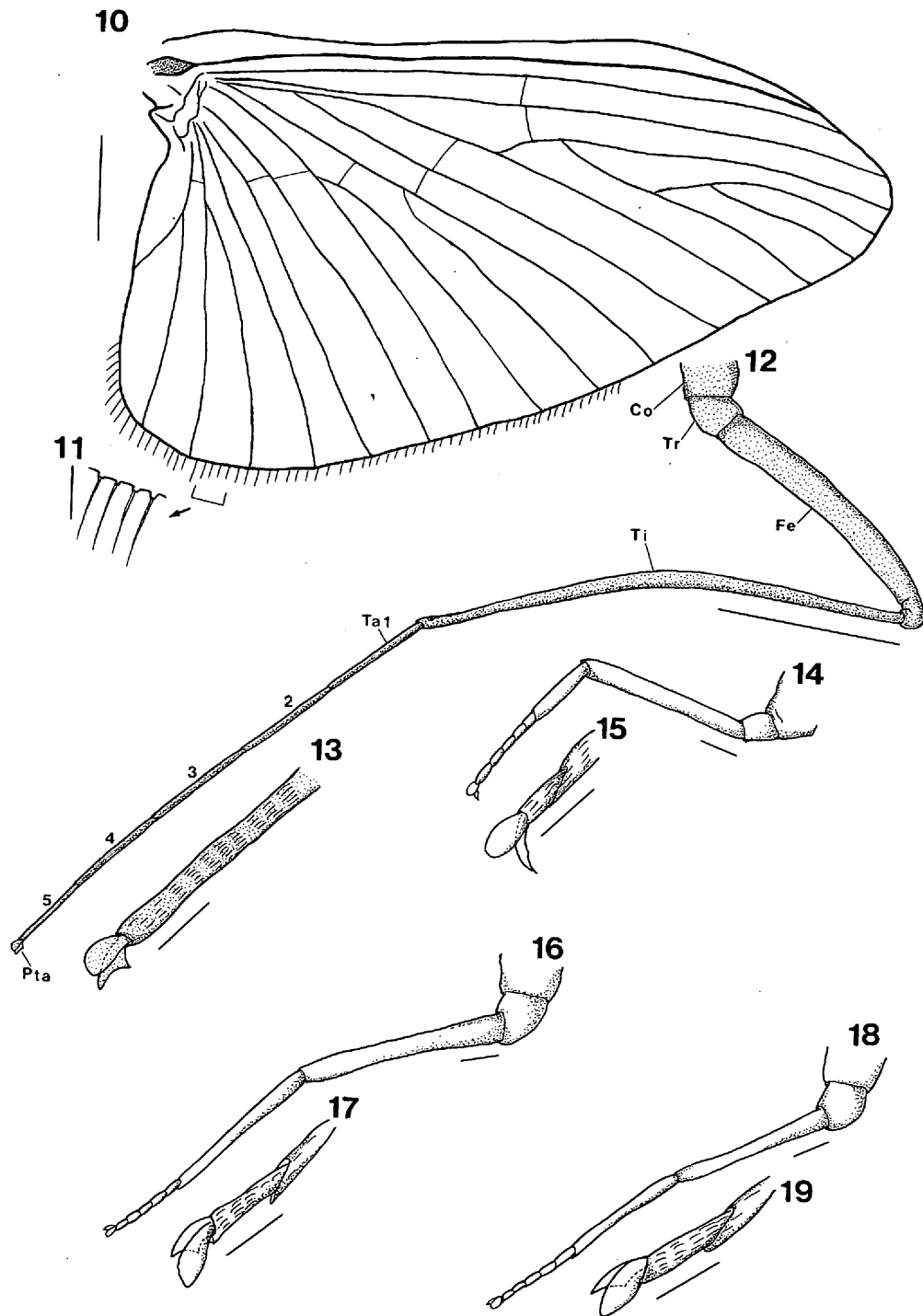


Figs. 1-9. *Brachycercus japonicus*.—1, dorsal view of habitus, male; 2, dorsal view of posterior abdomen with a caudal filament and cerci, female; 3, dorsal view of body, male; 4, ventral view of head, male (SEM); 5, frontal view of head, female (SEM), arrow shows traceable median protuberance; 6, mesonotum, male; 7, ventral view of thorax, male, appendages omitted; 8, right posterolateral projections (arrowheads) of abdominal segments, male, dorsal view; 9, ventral view of genitalia, male. AbdS 1-10, 1st to 10th abdominal segments; An, antenna; CE, compound eye; Ce, cercus; CF, caudal filament; Fc, forceps; Hp, hypopharynx; LbP, labial palp; Lr, labrum; Md, mandible; MxP, maxillary palp; Oc, ocellus; Pn, penis. Scale bars: 1-3, 6-8=0.5 mm; 4, 5, 9=0.1 mm.

widely separated from each other by a distance equal to compound eye width; tibia long, about twice as long as femur (Fig. 12); tarsus as long as tibia (Figs. 12,

13). Middle and hind legs white, poorly developed, about half of the fore leg length (Figs. 16-19).

Abdomen: Generally white. Posterolateral projec-



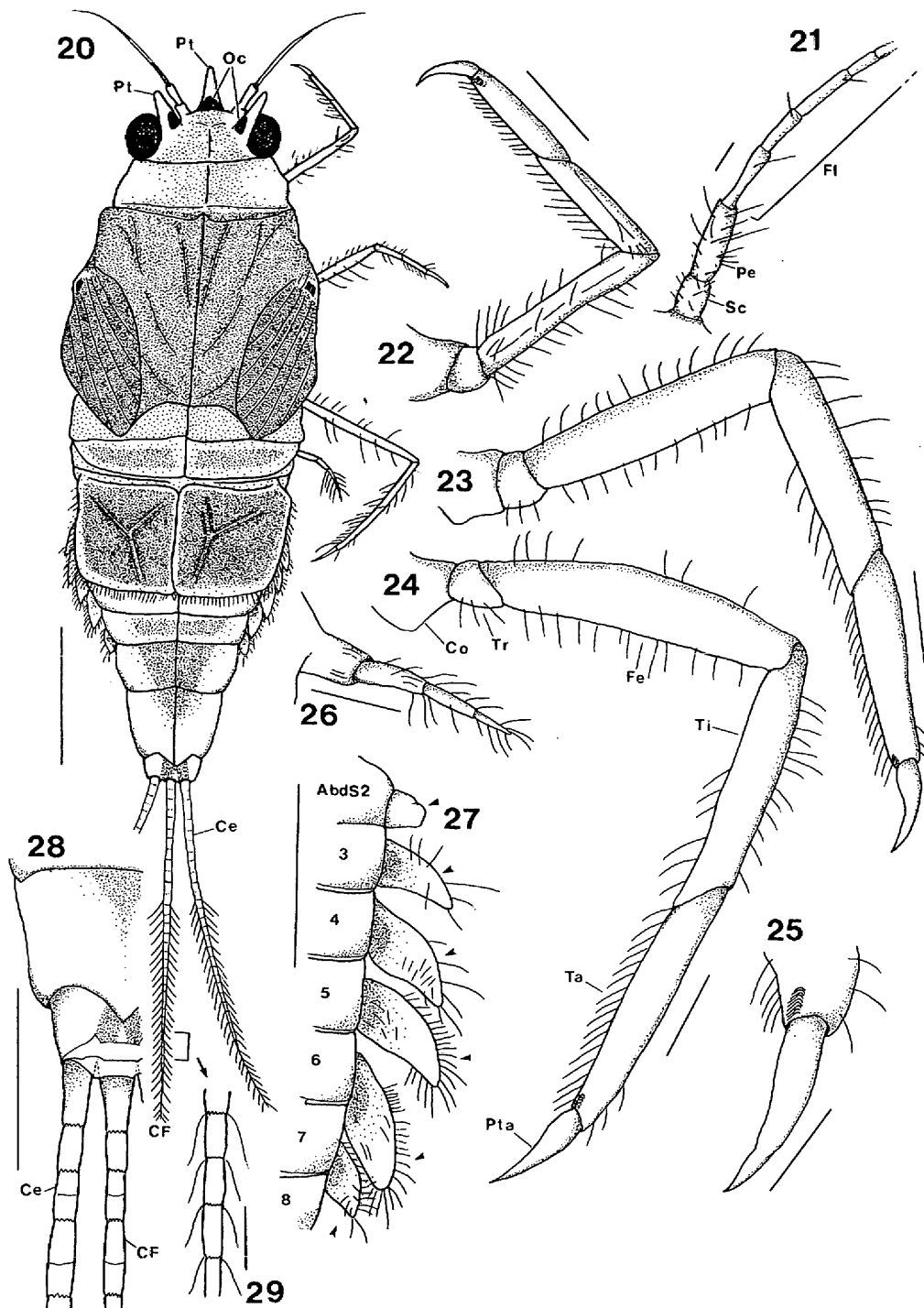
Figs. 10–19. Wing and legs of *Brachycercus japonicus*. —10, right wing, male; 11, enlargement of marginal hairs of wing; 12, right fore leg, male; 13, pretarsus (claw) and 5th tarsomere, male; 14, right fore leg, female; 15, pretarsus (claw) and 4–5th tarsomeres, female; 16, right middle leg, male; 17, pretarsus (claw) and 4–5th tarsomeres, male; 18, right hind leg, male; 19, pretarsus (claw) and 4–5th tarsomeres, male. Co, coxa; Fe, femur; Pta, pretarsus (claw); Ta 1–5, 1st–5th tarsomeres; Ti, tibia. Scale bars: 10=0.5 mm; 11, 12=50 μ m; 13, 15, 17, 19=5 μ m; 14, 16, 18=10 μ m.

tions directed backward, developed on both sides of the 3rd to 7th segments; projections of the 4th to 6th segments well developed, about 3-fold as long as those of the 3rd and 7th segments (Figs. 3, 8). Genital forceps non-segmented, slightly dark colored and twisted (Fig. 9). Cerci well developed, 3-fold as long as

body (Fig. 1). Caudal filament (median filament) also well developed, as long as cercus (Figs. 1, 3).

Female adult (Figs. 2, 5, 6, 14, 15).

Measurements ($N=20$): Body 4.6–5.6 mm (excluding antennae, cerci and caudal filament); antennae

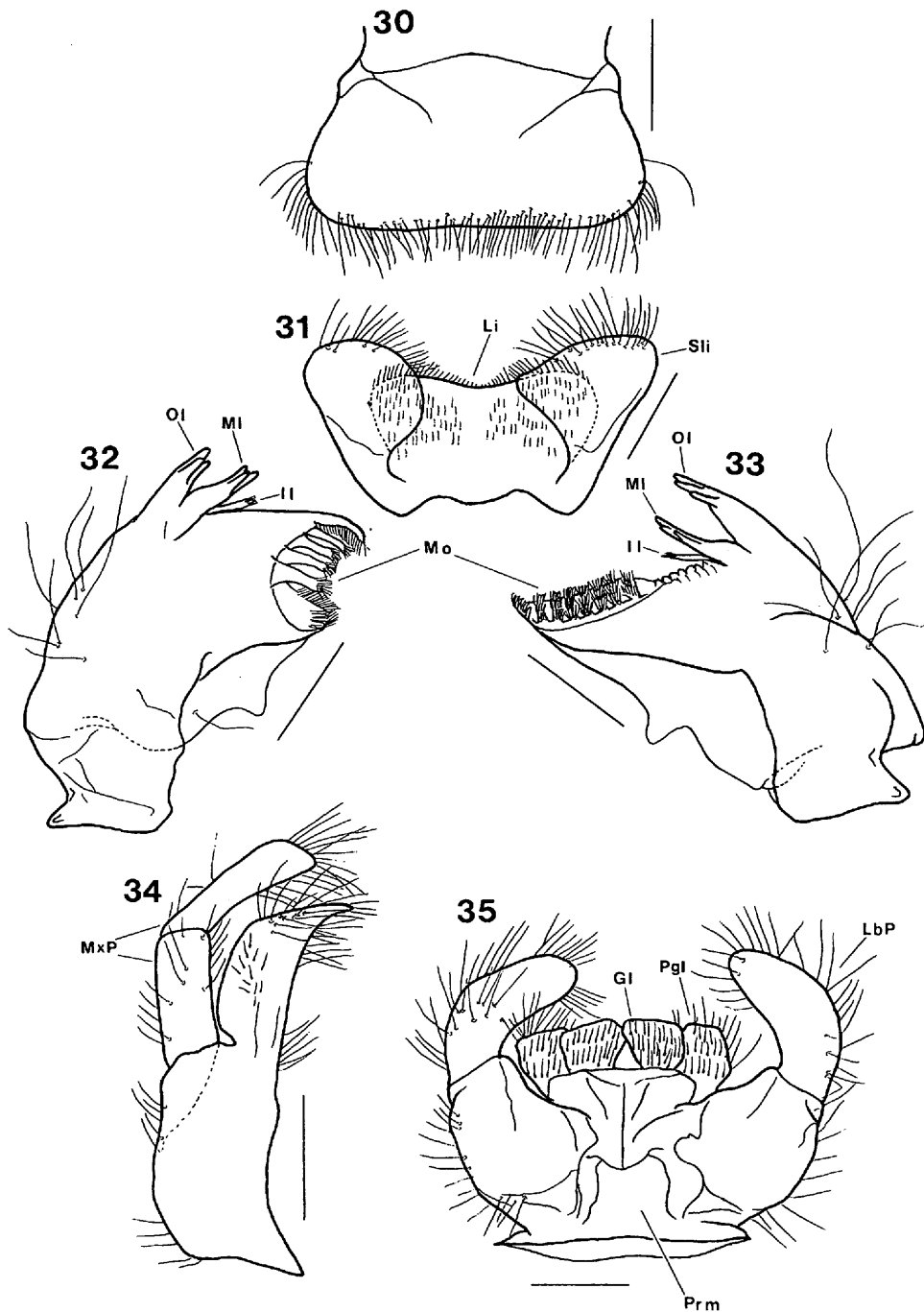


Figs. 20–29. Male mature nymph of *Brachycercus japonicus*. —20, dorsal view of habitus; 21, right antenna; 22, right fore leg; 23, right middle leg; 24, right hind leg; 25, right hind-pretarsus (claw); 26, right posterolateral projection of the 1st abdominal segment; 27, right lateral projections (arrowheads) of abdomen, dorsal view; 28, dorsal view of apex of abdomen with a caudal filament and left cercus; 29, distal region of caudal filament. Abds2–8, 2nd–8th abdominal segments; Ce, cercus; CF, caudal filament; Co, coxa; Fe, femur; Fl, flagellum; Oc, ocellus; Pe, pedicellus; Pt, protuberance (or prominent ocellar tubercles); Pta, pretarsus; Sc, scapus; Ta, tarsus; Ti, tibia; Tr, trochanter. Scale bars: 20=1 mm; 21, 25, 29=0.1 mm; 22–24, 26=0.2 mm.

0.75–0.85 mm; cerci 1.9–2.3 mm; caudal filament 1.9–2.4 mm. Fore wings 3.7–4.2 mm.

Head: Coloration similar to that of male. Scapus and pedicellus of antenna short; scapus half as long as

pedicellus; flagellum moderately tapered distally, about 3-fold as long as scapus+pedicellus. Compound eyes separated laterally. Mouthparts reduced minute. Lateral ocellar protuberances degenerate;



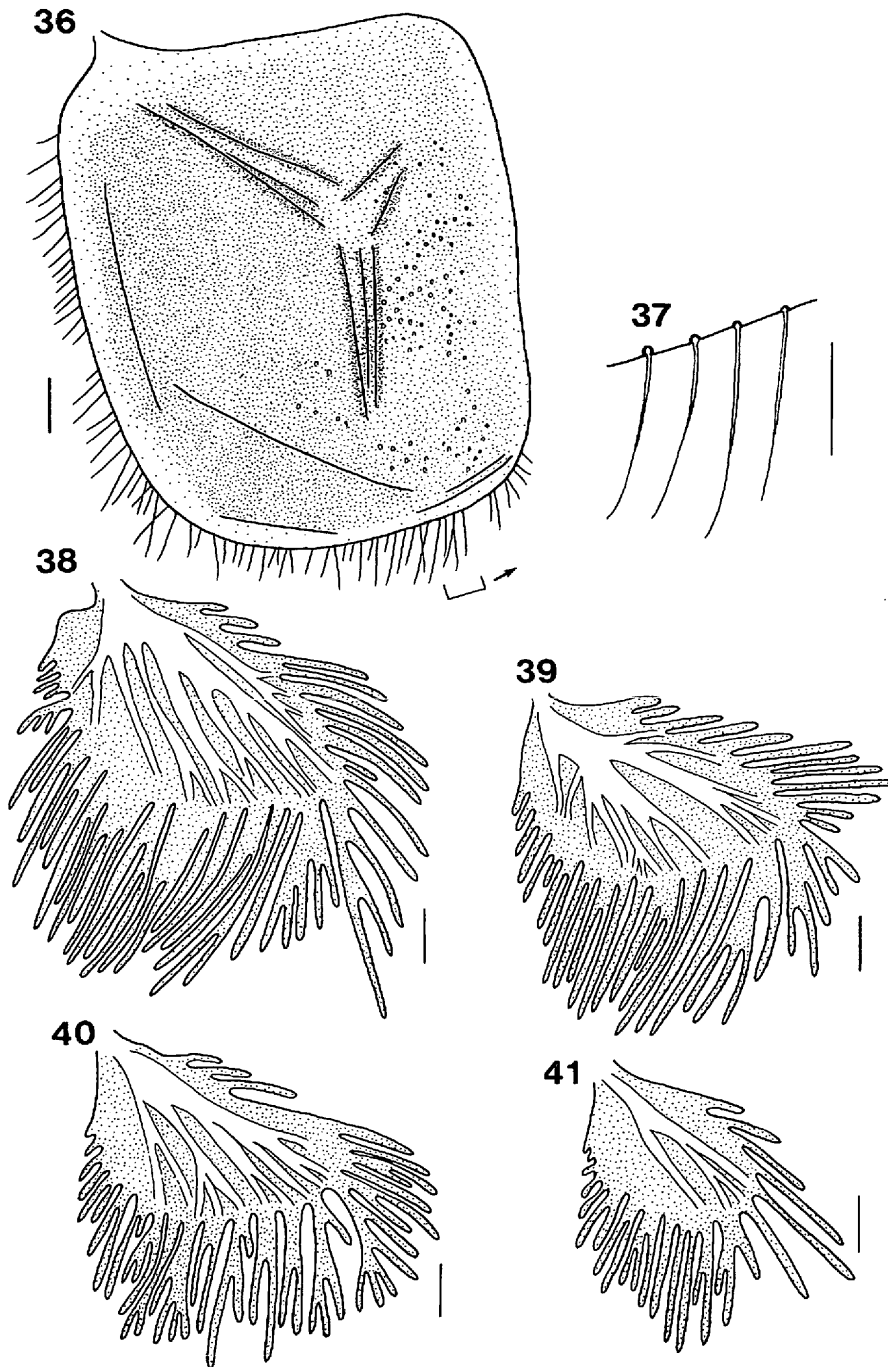
Figs. 30-35. Male mature nymph of *Brachycercus japonicus*. —30, labrum, dorsal view; 31, hypopharynx, ventral view; 32-33, right (32) and left (33) mandibles, ventral view; 34, right maxilla, ventral view; 35, labium, ventral view. Gl, glossa; II, inner incisor; LbP, labial palp; Li, lingua; MI, middle incisor; Mo, molar; MxP, maxillary palp; OI, outer incisor; Pgl, paraglossa; Prm, prementum; Sli, superlingua. Scale bars: 0.1 mm.

median one traceable (Fig. 5, arrow).

Thorax: Coloration similar to that of male. Fore wings slightly larger than those of male; posterior margin of fore wing with dense marginal short hairs on the basal half. Hind wings absent. Fore legs strikingly shorter than those of male; coxae widely separated as in male; femur about 2/3, tibia about 1/6 to 1/7, tarsus about 1/5 to 1/6 of those of male in

length (Figs. 14-15). Middle and hind legs as long as those of male (cf. Figs. 16-19).

Abdomen: Coloration similar to that of male. Posterolateral projections directed backward, developed on both sides of the 3rd to 7th segments; projections of the 4th to 6th segments well developed, about 3-fold as long as those of the 3rd and 7th segments (cf. Figs. 3, 8). Subgenital plate reduced; gonopore opening be-



Figs. 36-41. Gills of male mature nymph of *Brachycercus japonicus*. —36, left gill (or gill cover, operculate gill) of the 2nd abdominal segment (2nd gill); 37, enlargement of marginal hairs of left 2nd gill; 38, left 3rd gill; 39, left 4th gill; 40, left 5th gill; 41, left 6th gill. Scale bars: 0.1 mm.

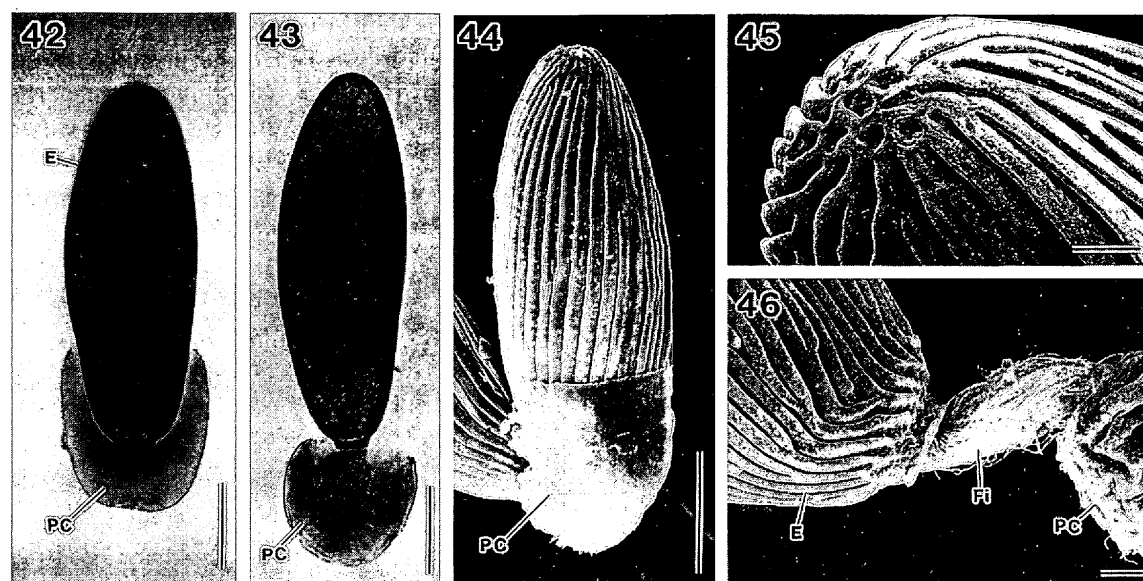
tween 7th and 8th sterna, which are similar to those of the other abdominal segments in shape. Cerci and caudal filament about 1/4 to 1/5 of those of male in length (Fig. 2).

Mature (ultimate instar) nymph (Figs. 20-41).

Measurements ($N=5$ for each sex): Body 4.5-5.0 mm (σ^7), 5.3-5.8 mm (♀) (excluding antennae, cerci

and caudal filament); antennae 1.3-1.4 mm (σ^7), 1.0-1.3 mm (♀); cerci 2.7-2.8 mm (σ^7), 2.2-2.6 mm (♀); caudal filament 2.7-2.9 mm (σ^7), 2.2-2.8 mm (♀).

Head: Generally brown; compound eyes and ocelli black. Three protuberances or ocellar tubercles prominent, milky white, distally rounded, approximately as long as antennal scapus + pedicellus (Fig. 20). Antennae white or milky white, unicolorous; scapus and



Figs. 42–46. Eggs of *Brachycercus japonicus*. —42–43, living eggs just after oviposition (42) and about 5-hours-old (43); 44, SEM of a newly laid egg; 45, SEM of egg's anterior region; 46, SEM of posterior region of a developing egg. E, egg; Fi, (coiled) filaments; PC, polar cap. Scale bars: 42–44 = 50 μm ; 45–46 = 10 μm .

pedicellus short; scapus half as long as pedicellus; flagellum moderately tapered distally, about 3-fold as long as scapus + pedicellus; scapus and pedicellus covered with hairs; flagellum glabrous or with sparse hairs (Figs. 20, 21). Labrum about twice as broad as long, slightly widened anterolaterally; its anterior and antero-lateral margins with dense marginal short hairs (Fig. 30). Hypopharyngeal lingua oblong with moderately convex lateral margins, on the ventral side with numerous tiny hairs; superlinguae rounded, with dense marginal hairs (Fig. 31). Outer and middle incisors of mandible equal in length, width and shape to the distal bluntly pointed teeth; inner incisor poorly developed; molar part of mandible with long and laterally denticulated chitinous projections (Figs. 32, 33). Maxillary palps two-segmented (Fig. 34). Labial palps strong, two-segmented; ventral side of glossa and paraglossa with numerous hairs; outer margin of labial palp with numerous bristles and hairs (Fig. 35).

Thorax: Pronotum about 3.5 to 4-fold as broad as long, generally brown (Fig. 20). Mesonotum yellowish brown with darker smudges, and dark brown diffuse spots near the wing pad (wing bud) base. Metanotum without wing pads, generally milky white, brown at the median region (Fig. 20). Thoracic sterna flat, generally milky white. Legs generally white, unicolorous, relatively long and slender, with sparse hairs; inner margins of femur, tibia and tarsus with rows of hairs; fore legs shorter than middle legs and hind legs; claw or pretarsus slender, half as long as tarsus, without denticles (Figs. 20, 22–25).

Abdomen: Generally milky white; 1st, 2nd, 7th and 8th terga with brownish bands; median region of the 9th and 10th terga brown. Posterior margins of the 1st to 7th terga straight; 9th tergum with conspicuous medial blunt projection (Figs. 20, 28). Sterna milky white, unicolorous, without markings. A pair of peculiar posterolateral projections in the 1st segment, similar to thoracic legs, 1/3 as long as the fore leg (Figs. 20, 26). Lateral projections of the 2nd and 7th segments triangular, bent upward; projections of the 3rd to 6th segments larger than those of 2nd and 7th segments (Fig. 27). Gill covers or operculate gills (modification of the gills of the 2nd segment) generally dark brown, lateral and posterior margins milky white, overlapping at midline, with conspicuous Y-shaped ridge on the dorsal surface and with marginal hairs (Figs. 20, 36–37). The 3rd to 6th gills with regular brownish stippings (Figs. 38–41). Cerci and caudal filament white, unicolorous, with rows of hairs on their distal halves (Figs. 20, 28–29).

Egg (Figs. 42–46).

Egg ellipsoidal, about 210 μm in length (without polar cap), about 75 μm in width (immediately after oviposition) (Figs. 42–44). Chorion brownish translucent, with longitudinal costates (Figs. 42–46). Polar cap light-brownish and translucent (Figs. 42, 43); initially tightly covering egg's posterior region (Figs. 42, 44), but soon expanded into a form of attachment apparatus (Figs. 43, 46); expanded polar cap and egg proper jointed by densely coiled filaments (Figs. 43,

46).

Specimens examined

Twenty male adults, 20 female adults with eggs: Hirose (34°40'N, 136°05'E, 150 m alt.), Nabari-gawa (Satsuki-gawa) River at Tsukigase-mura, Nara Prefecture, Honshu, Japan, 4-IX-1999, K. Tojo (KT). Five male and 5 female mature (ultimate instar) nymphs: Komoo (34°38'N, 136°05'E, 175 m alt.), Nabari-gawa (Satsuki-gawa) River, Nabari-shi, Mie Prefecture, Honshu, Japan, 4-IX-1999, K.T. Of these specimens, 5 male adults, 5 female adults, 3 male mature nymphs and 3 female mature nymphs are deposited in the collections of the Natural History Museum and Institute, Chiba (CBM-ZI 88383-88398), and the others in the collections of the Biological Sciences of University of Tsukuba (TKB-anim. 1005-1007) and my private collections.

Other specimens

In addition to the localities mentioned above, I have hitherto found the species inhabiting the following areas: Ishige, Kinu-gawa River, Ishige-machi, Ibaraki Prefecture, Honshu, Japan (36°07'N, 139°58'E, 15 m alt.); Mushikake, Sakura-gawa River, Tsukuba-shi, Ibaraki Prefecture, Honshu, Japan (36°05'N, 140°10'E, 4 m alt.); Osose, Nabari-gawa River, Nabari-shi, Mie Prefecture, Honshu, Japan (34°02'N, 136°03'E, 120 m alt.).

Remarks

This species is assigned to the genus *Brachycercus*, possessing the following features diagnostic to the genus: *i.e.*, the widely separated coxae (Fig. 7) and well developed abdominal posterolateral projections (Figs. 3, 8) (adults); the prominent three protuberances or ocellar tubercles (Fig. 20) and lateral projections of the 2nd to 7th abdominal segments (Fig. 27) (nymphs).

From the East Asia, four *Brachycercus* species other than *B. japonicus* have been described: *B. corniger* Kluge, *B. magnus* Tshernova and *B. minutus* Tshernova from the Far East Russia; *B. tubulatus* Tshernova from the Far East Russia and Korea (Tshernova, 1952; Kluge, 1991; Hwang & Bae, 1999), but adults of two species, *B. magnus* and *B. tubulatus* have not been found. From these *Brachycercus* species, this species can be distinguished as follows: in adults, this species is distinguishable from *B. corniger* by the degeneration of all of the three protuberances or ocellar tubercles (Fig. 3); in nymphs, from *B. corniger* by the relatively short maxillary palp (Fig. 34), relatively

long and articulated 1st abdominal posterolateral projections (Figs. 20, 26) and the shape of the 2nd gills (Figs. 20, 36), from *B. minutus* by the prominent protuberances (Fig. 20) and relatively wide thorax and abdomen (Fig. 20), and from *B. tubulatus* by the shape of the lateral projections of 2nd to 7th abdominal segments (Fig. 27); in eggs, from *B. corniger* and *B. minutus* by the shape and number of longitudinal costae (Figs. 44-46).

Our knowledge on the morphology of the East Asian *Brachycercus* species still remains fragmented. It is expected that the present study facilitate future taxonomic investigations on the group for precise comparison among the species.

Biology

Nymphs of *Brachycercus japonicus* are predominantly collected from slow-flowing muddy banks of main rivers and backwaters (dammed pools) connected to the main river (e.g., side arm), and are hardly found in riffles of main rivers or continuously flowing side arms [cf. see Roux (1982) and Shimatani (2000) habitat definition]. This mayfly probably has a univoltine life cycle judging from the restricted emergence from July to September. Male and female subimagos emerged at daybreak or 30-40 minutes before sunrise. Immediately after emergence, the subimagos shed the exoskeleton on the shoreline ground or rocks, and soon flew up for mating. The subimaginal stage of *B. japonicus* lasted no more than a few minutes, and the imaginal stage for some minutes. Mating flights took place over the river only at daybreak, as in a polymitarcyid mayfly, *Ephoron eophilum* Ishiwata (cf. Ishiwata, 1996). Thus, they suddenly appeared over the river at daybreak and made a sudden disappearance by sunrise. The peculiar nymphal habitat and the short duration of the subimago and imago stages may have made it difficult for us to meet this mayfly in the field.

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