

Morphological description of four species belonging to the genus *Nigrobaetis* (Ephemeroptera: Baetidae) from Japan

Toshihito Fujitani¹ · Norio Kobayashi³ · Toshiya Hirowatari² · Kazumi Tanida⁴

Received: 18 May 2016 / Accepted: 13 December 2016
© The Japanese Society of Limnology 2017

Abstract We associated imagoes and nymphs of four *Nigrobaetis* species from Japan and described their morphological characters. We found that *N. sp. P* comprised two *Nigrobaetis* species in Kanto Plain and in Ishigaki Island, which we described as *N. apterus* Fujitani n. sp. and *N. ishigakiensis* Fujitani n. sp., respectively. We also described *N. sp. I* as *N. latus* Fujitani n. sp. We recorded *N. acinaciger* (Kluge), the nymph of which had been confused with *N. chocoatus* (Gose), from Japan for the first time. We provide identification keys for eight *Nigrobaetis* species of Japan.

Keywords *Nigrobaetis* · Morphology · Association · Imago · Nymph

Introduction

In Japan, Kobayashi (1987) distinguished the nymphs of 18 *Baetis* (sensu lato) species, among which he gave alphabetical provisional names to 13 species. Ishiwata et al. (2000) concluded *B. sp. L* is conspecific with *B. bicaudatus* Dodds, 1923. Fujitani et al. (2003a) transferred 14 *Baetis* (sensu lato) species to the genus *Alainites*, *Labiobaetis*, *Nigrobaetis* or *Tenuibaetis* according to the morphological characters. Fujitani et al. (2005) associated *L. sp. G* and *L. sp. Q* with *L. atrebatinus orientalis* (Kluge 1983) and *L. tricolor* (Tshernova 1928), respectively. Fujitani et al. (2011) associated *T. sp. H* with *T. flexifemora* (Gose 1980) and described *T. sp. E* as *T. parvipterus* Fujitani, 2011.

Imagoes of *Nigrobaetis* species are distinguishable from other baetid genera by the convex anterior margin of the frons in lateral view and elongate apical segment of forceps (Fujitani et al. 2003a). Nymphs of *Nigrobaetis* species are distinguishable from other baetid genera by the medial ridge of the frons, a row of spines on the inner margin of the mandible, a patch of setae near the apex of the glossa and absence of a projection near the distal end of the inner margin of the paraproct (Fujitani et al. 2003a, b).

Including species with alphabetical provisional names, a total of six *Nigrobaetis* species are distributed in Japan: *N. chocoatus* (Gose 1980), *N. sacishimensis* (Uéno 1969), *N. sp. D*, *N. sp. I*, *N. sp. N* and *N. sp. P* (Fujitani et al. 2003a, b). By rearing nymphs and collecting imagoes, we found two distinct undescribed species were included in the populations of *N. sp. P*. We also found that *N. acinaciger* (Kluge 1983), which was described from Maritime Territory of Russian Far East, was distributed in Japan and *N. sp. I* was a new species.

The generic status of *Nigrobaetis* is still in discussion. Novikova and Kluge (1987) and Bauernfueld and Soldán

Handling Editor: Junjiro N. Negishi.

✉ Toshihito Fujitani
ane3rokkaku@yahoo.co.jp

¹ Civil Engineering and Eco-technology Consultants Co., Ltd.,
1-1-606B Nishiki-cho, Okayama 700-0902, Japan

² Entomological Laboratory, Faculty of Agriculture, Kyushu
University, 6-10-1 Hakozaiki, Fukuoka 812-8581, Japan

³ Institute of River Biology, Yorii, Yorii-cho,
Saitama 369-1203, Japan

⁴ Osaka Museum of Natural History, 1-23 Nagai-Koen,
Osaka 546-0034, Japan

(2012) treated *Nigrobaetis* as a subgenus of the genus *Baetis*. We, however, treat *Nigrobaetis* as a distinct genus on the basis of the differences of morphological characters in both imago and nymph among the genera in *Baetis* (sensu lato) (Fujitani et al. 2003a).

Here, we provide morphological descriptions and diagnoses of four *Nigrobaetis* species. We also provide keys to *Nigrobaetis* species of Japan.

Materials and methods

In order to associate nymphs of *Nigrobaetis* species with their imagoes, we reared nymphs in the field using the methods of Müller-Liebenau (1969) and Edmunds et al. (1976). We put mature nymphs in plastic cups with minute vents, and covered the mouths of the cups with pieces of nylon stocking to prevent the imagoes and subimagoes from escaping. The cups were set in holes made in a urethane mat floating on slowly flowing water near the channel margin.

We also collected imagoes and subimagoes by indoor rearing, light trapping, and sweeping. Some subimagoes were reared to imagoes in vials.

In this paper, the following abbreviations are used: sw, collected by sweeping; lt, collected by light traps; mt, collected by Malaise traps, re: reared from nymph; m, male; f, female; OMNH, Osaka Museum of Natural History. Collectors were abbreviated as follows: TF, T. Fujitani; TI, Dr. T. Ito (Hokkaido Aquatic Biology).

We followed Kluge (1994) and Ubero-Pascal and Puig (2007) for terminology of sutures on the imaginal thorax and morphology of eggs, respectively.

For specifying latitude and longitude of the sampling sites, we referred to topographic maps provided on the online service of Geographical Information Authority of Japan (2013).

Type series and some other examined materials are deposited in Osaka Museum of Natural History (Osaka City, Japan).

Nigrobaetis acinaciger (Kluge 1983) (Figs. 1, 2)

[Japanese name: toge-era-tobihiro-kokagerou (new name)]

Baetis acinaciger Kluge 1983, 59–61, Figs. 47–62.

Baetis (*Nigrobaetis*) *acinaciger*: Tiunova 2009, 678, Table 1; Wang et al. 2009, 194, Table 1.

Nigrobaetis acinaciger: Bae and Park 1998, 10–11, Figs. 3, 27.

Baetis chcoratus: Kobayashi 1987, 53–60, Figs. 10–14; Ishiwata 2001, 180, Fig. 5H–5L; Ishiwata and Takemon 2005, 77–92, Figs. 23–26.

Male imago (Fig. 1a–c). Body 3.2–4.5 mm in length; fore wing 3.0–5.0 mm in length; hind wing 0.5–1.0 mm in length.

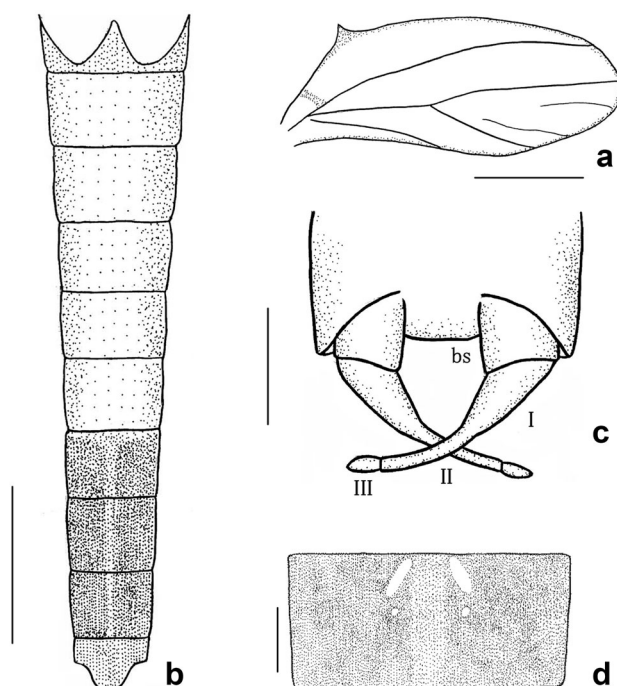


Fig. 1 *Nigrobaetis acinaciger* (Kluge) (imago): **a** hind wing; **b** abdomen of male imago (dorsal); **c** forceps; **d** abdomen of female imago (dorsal, segment V). Scale bars 1 mm in **b**; 0.1 mm in other figures. *I*, *II* and *III* indicate the first, second and third segments of forceps, respectively, and *bs* the basal segment of forceps

Head. Head dark brown with a medial light brown stripe; antennal pedicel and scape brown, flagellum light brown; turbinate eye orange; lower eye dark brown; ocellus transparent. Anterior margin of frons expanded in lateral view.

Thorax (Fig. 1a). Terga and sterna dark brown; fore wing and hind wing transparent; legs light brown. Hind wing with three distinct veins, vein II forked, two or three weak intercalaries between the forked veins; costal projection acute, hyaline (Fig. 1a).

Abdomen (Fig. 1b, c). Terga I dark brown, II–VI transparent, VII–X dark brown, VII–IX with an indistinct pale brown line medially; sterna transparent, VII–IX with brown lateral bands (Fig. 1b); cercus white. Basal segment of forceps without a projection on inner apical margin; base of segment I about 2–3 times as broad as apex; segment II cylindrical, nearly 1–1.5 times as long as segment I, segmentation from segment I weak; segment III oval, tapering at apex (Fig. 1c).

Female imago (Fig. 1d). Body 4.4–5.0 mm in length; fore wing 4.5–5.0 mm in length; hind wing 0.5 mm in length.

Head. Head brown; coloration of antenna and ocellus as in male imago. Compound eyes gray.

Thorax. Terga and sterna brown; coloration of wings and legs as in male imago. Shape and venation of hind wing as in male imago.

Abdomen (Fig. 1d). Terga brown, with a pair of light brown anterior streaks and posterior spots, a medial light brown stripe (Fig. 1d); sterna pale brown, with brown markings near lateral margins; coloration of cercus as in male imago.

Male subimago. Body 2.7–4.0 mm in length; fore wing 2.9–3.5 mm in length; hind wing 0.5 mm in length.

Head. Coloration of head, antenna, turbinate eyes and lower eyes as in male imago.

Thorax. Terga dark brown with light brown medial longitudinal suture and medioparapsidal suture; coloration of sterna and legs as in male imago. Fore wing and hind wing dark gray. Shape and venation of hind wing as in male imago.

Abdomen. Terga I brown, II–VI gray, VII–X brown; sterna I–VI gray, VII–IX white. Basal segment of forceps without a projection on inner apical margin; segment II twice as long as segment I at most; segment III oval. Cercus white.

Female subimago. Body 3.5–4.0 mm in length; fore wing 3.5–4.0 mm in length; hind wing 0.5 mm in length.

Head. As in female imago.

Thorax. As in male subimago.

Abdomen. As in female imago.

Nymph (Fig. 2a–h). Body 2.5–6.0 mm in length; paracercus up to 1.0–2.5 mm in length (Fig. 2a).

Head (Fig. 2a–f). Head brown; antenna light brown. Anterior margin of frons with a median ridge. Antennal scape without distal lobe; flagellomere with spiny projections on distal margin of each segment. Labrum rounded, with fine setae thickly placed; a pair of longer setae medially and a pair of 2–3 longer setae near anterior margin (Fig. 2b). Left mandible without distinct spines on inner margin; incisor with 9 denticles, fifth one very small; prostheca with 4–5 short and blunt denticles distally, 2–3 long and acute denticles proximally (Fig. 2c). Right mandible without distinct spines on inner margin; incisor with 8 denticles; prostheca reduced into a pair of spines (Fig. 2d). Glossa with a tuft of about 10 fine setae on dorsal surface (Fig. 2e). Segment II of labial palpus with a row of 4–5 distinct setae; segment III subconical (Fig. 2f).

Thorax (Fig. 2a, g). Terga dark brown, with a medial light brown stripe; sterna light brown, with a pair of dark brown patches in each segment; legs light brown except for dark brown coxa, fore femur with a brown stripe on anterior and posterior margins (Fig. 2g), middle and hind femora with a brown patch in middle of dorsal surface; outer margin of femur with 10–12 robust setae in fore leg (Fig. 2g), 8–11 setae in middle leg, 8–12 setae in hind leg; outer margin of tibia with 1–4 robust setae in fore leg (Fig. 2g), 4–7 setae in middle leg, 3–6 setae in hind leg; outer margin of tarsus without robust setae (Fig. 2g).

Abdomen (Fig. 2a, h). Terga I–VIII dark brown with a medial light brown stripe, tergum VI with a pair of light

brown spots at posterolateral corner, tergum IX light brown in posterior half, tergum X light brown; sterna I–VIII dark brown with posterior margins light brown, sterna IX–X light brown; cercus and paracercus light brown with median dark brown bands. Abdominal terga with trapezoidal scale bases; posterior margins of terga II–X with triangular projections (Fig. 2h). Abdominal sterna with trapezoidal scale bases; posterior margins of sterna VII–IX with triangular projections on medial part. Six pairs of gills on posterolateral margins of segments II–VII; gills on segment II minute and ellipse, gills on segments III–V oval, gills on segments VI and VII distinctly pointed at apex. Margins of gills fringed with spiny projections of uniform size and setae of uniform length. Paraproct without a projection near distal end of inner margin.

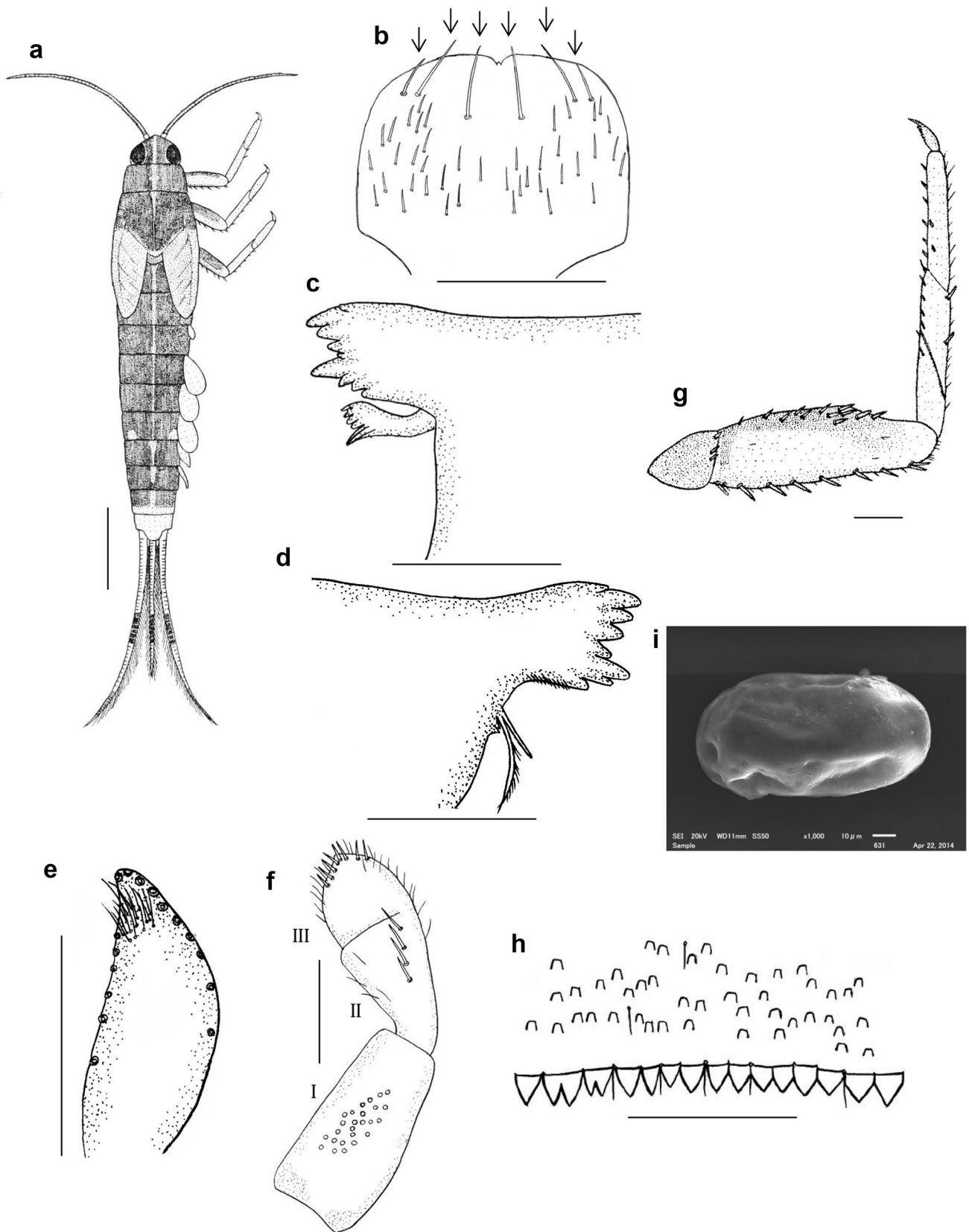
Egg (Fig. 2i). Ellipsoidal in shape. Chorionic surface smooth.

Materials examined.

Imago. Japan. Kyoto: 1♂, 30-VII-1997, re, Oe-cho, Habi, Yura Stream (35°23'02"N, 135°09'11"E), TF, OMNH; 1♀, 29-IV-1998, re, Miyama, Tauta, Yura Stream (35°19'15"N, 135°40'41"E), TF, OMNH; 2♂, 26-IV-1999, re, Miyama, Tanano Stream, Tanamura Bridge (35°18'44"N, 135°33'08"E), TF, OMNH. Nara: 2♂1♀ (1♂, 30-V-2001; 1♂, 5-V-2002; 1♀, 11-VI-2002), re, Kawakami, Unokawa, Nakai Stream (34°22'15"N, 135°57'09"E), TF, OMNH. Okayama: 2♂, 10-IX-2012, re, Mimasaka, Namazu, Yoshino Stream, Hattan Bridge (35°02'08"N, 134°13'34"E), TF, OMNH; 1♂, 10-IV-2013, re, Mimasaka, Yoshino Stream, Taihei Bridge (35°00'03"N, 134°08'43"E), TF, OMNH; 1♀, 3-V-2013, re, Mimasaka, Ute, Kajinami Stream (35°09'31"N, 134°14'23"E), TF, OMNH. 1♀, 9-IX-2012, re, Mimasaka, Sunami, Yamaga Stream (34°58'11"N, 134°44'45"E), TF, OMNH.

Subimago. Japan. Nara: 2♀, 5-V-2002, re, Kawakami, Unokawa, Nakai Stream (34°22'15"N, 135°57'09"E), TF, OMNH. Tottori: 2♂2♀, 28-VIII-2000, re, Yonago, Hino Stream, Yawata Bridge (35°24'10"N, 133°23'25"E), TF, OMNH. Okayama: 3♂, 10-IX-2012, re, Mimasaka, Sunami, Yamaga Stream (34°58'11"N, 134°44'45"E), TF, OMNH; 3♂3♀ (2♂, 4-IX-2012; 1♂1♀, 5-IX-2012; 2♀, 10-IX-2012), re, Mimasaka, Namazu, Yoshino Stream, Hattan Bridge (35°02'08"N, 134°13'34"E), TF, OMNH.

Nymph. Japan. Saitama: 21 exs, 7-VII-2007, Kumagaya, Kuge, Arakawa Stream (36°07'31"N, 139°23'49"E), TF, OPU; 2 exs, 6-III-2010, Moroyama, Oppe Stream, Miyashita Bridge (35°57'09"N, 139°20'08"E), TF, OMNH. Nagano: 1 ex, 22-V-2001, Azusagawa, Azusa, Azusagawa Stream (36°12'28"N, 137°51'21"E), TF, OMNH. Kyoto: 5 exs, 30-IV-1998, Miyama, Tauta, Yura Stream (35°19'15"N, 135°40'41"E), TF, OMNH; 2 exs, 25-IV-1999, re, Miyama, Tanano Stream, Tanamura Bridge



◀ **Fig. 2** *Nigrobaetis acinaciger* (Kluge) (nymph): **a** habitus of nymph (dorsal); **b** labrum (ventral, arrows indicate “longer setae” in description); **c** left mandible; **d** right mandible; **e** glossa (dorsal, robust setae omitted); **f** labial palpus (dorsal); **g** fore leg; **h** abdominal tergum V; **i** egg. Scale bars 1 mm in **a**; 0.01 mm in **i**; 0.1 mm in other figures. *I*, *II* and *III* indicate the first, second and third segments of labial palpus

(35°18'44"N, 135°33'08"E), TF, OMNH. NARA: 28 exs (25 exs, 12-V-2002; 1 ex, 2-V-2002; 2 exs, 5-V-2002), Kawakami, Unokawa, Nakai Stream (34°22'15"N, 135°57'09"E), TF, OMNH. Tottori: 4 exs, 28-VIII-2000, Yonago, Hino Stream, Yawata Bridge (35°24'10"N, 133°23'25"E), TF, OMNH.

Distribution. Japan: Honshu, Shikoku and Kyushu (Kobayashi 1989; Fujitani et al. 2003a); Korea (Bae and Park 1998); Russian Far East: Maritime Territory (Kluge 1983), Ussuri Basin and Sakhalin Island (Tiunova 2009). Nymphs of this species are collected in riffles of the middle reaches of streams and rivers.

Diagnosis. *Nigrobaetis acinaciger* is distinguishable from other *Nigrobaetis* species by the following characters.

Male imago: segment III of forceps which is oval and slightly tapering at apex, and hind wings with 3 longitudinal veins with forked second vein.

Male subimago: hind wings with 3 longitudinal veins with forked second vein.

Female imago and subimago: light brown medial stripe on dorsal surface of abdomen, and hind wings with 3 longitudinal veins with forked second vein.

Nymph: medial light brown stripe on head and dorsal surface of thorax and abdomen, six pairs of gills, and pointed distal margins of gills VI and VII.

Remarks. *Nigrobaetis acinaciger* has been described from Russian Far East, Maritime Territory, Kievka River by Kluge (1983). This species is also distributed in Korea (Bae and Park 1998).

In its nymphal stage, this species is similar to *N. chocoratus* (Gose 1980), but easily distinguishable from *N. chocoratus* by the number of gills and shape of gills on abdominal segments VI and VII. In the original illustration by Gose (1980), the nymph of *N. chocoratus* has seven pairs of gills and the gills on abdominal segments VI and VII are oval.

Ishiwata (2001) recorded *N. chocoratus* with illustrations from Chiba Prefecture in eastern Japan, but judging from the shape of the gills, the illustrated nymphs are obviously *N. acinaciger*. As in this case, it is highly possible that most nymphs identified as *N. chocoratus* are *N. acinaciger*.

The specimens examined for the original description of *N. chocoratus* were collected at Kawakami Village, Nara Prefecture in western Japan, but the specimens have been lost (Gose personal communication). Even with our intensive sampling of *Nigrobaetis* species not only in the

village and the surrounding areas but also in other regions of Honshu, we have not collected nymphs with gills whose shapes match those described for *N. chocoratus* by Gose (1980).

At present, it is not possible to fix the taxonomical status of *N. chocoratus*.

Nigrobaetis apterus Fujitani n. sp. (Fig. 3)

[Japanese name: Hanenashi-tobihiro-kokagerou (new name)]

Baetis sp. P (partim): Kobayashi 1987, 53–60, Figs. 10–14; Ishiwata and Takemon 2005, 77, Figs. 23–26.

Nigrobaetis sp. P (partim): Fujitani et al. 2003b, 128–132.

Male imago (Fig. 3a, b). Body 3.5–4.0 mm in length; fore wing 3.5–4.0 mm in length.

Head. Head dark brown; antenna light brown; turbinate eye orange; lower eye dark gray; ocellus transparent. Anterior margin of frons expanded in lateral view.

Thorax. Terga and sterna dark brown; fore wing transparent; hind wing absent; legs light brown.

Abdomen (Fig. 3a, b). Terga I–VII transparent, VII with transverse dark brown marking along posterior margin, VIII–X dark brown; sterna transparent, VII–IX with brown lateral bands; cercus white. Basal segment of forceps without a projection on inner apical margin; base of segment I about 2–3 times as broad as apex; segment II cylindrical, twice as long as segment I at most, segmentation from segment I weak; segment III oval, tapering at apex (Fig. 3b).

Female imago. Body 3.5–3.6 mm in length; fore wing 3.5–3.8 mm in length.

Head. Head brown; coloration of antenna and ocellus as in male imago. Compound eyes dark grey.

Thorax. Terga and sterna brown; coloration of wings and legs as in male imago.

Abdomen. Terga I–III and V–VII brown, with a pair of light brown anterior streaks and posterior spots, IV and VIII–X light brown; sterna light brown, I–VII with brown patches near lateral margins; coloration of cercus as in male imago.

Male subimago. Body 3.0–3.5 mm in length; fore wing 3.5 mm in length.

Head. Coloration of head, antenna, turbinate eyes and lower eyes as in male imago.

Thorax. Terga dark brown with light brown medial longitudinal suture and medioparapsidal suture; coloration of sterna and leg as in male imago. Fore wing dark gray.

Abdomen. Terga I dark brown, II–VII gray, VIII–X brown; sterna I–VI gray, VII–IX white. Basal segment of forceps without a projection on inner apical margin; segment II twice as long as segment I at most; segment III oval. Cercus white.

Female subimago. Body 3.5 mm in length; fore wing 3.5 mm in length.

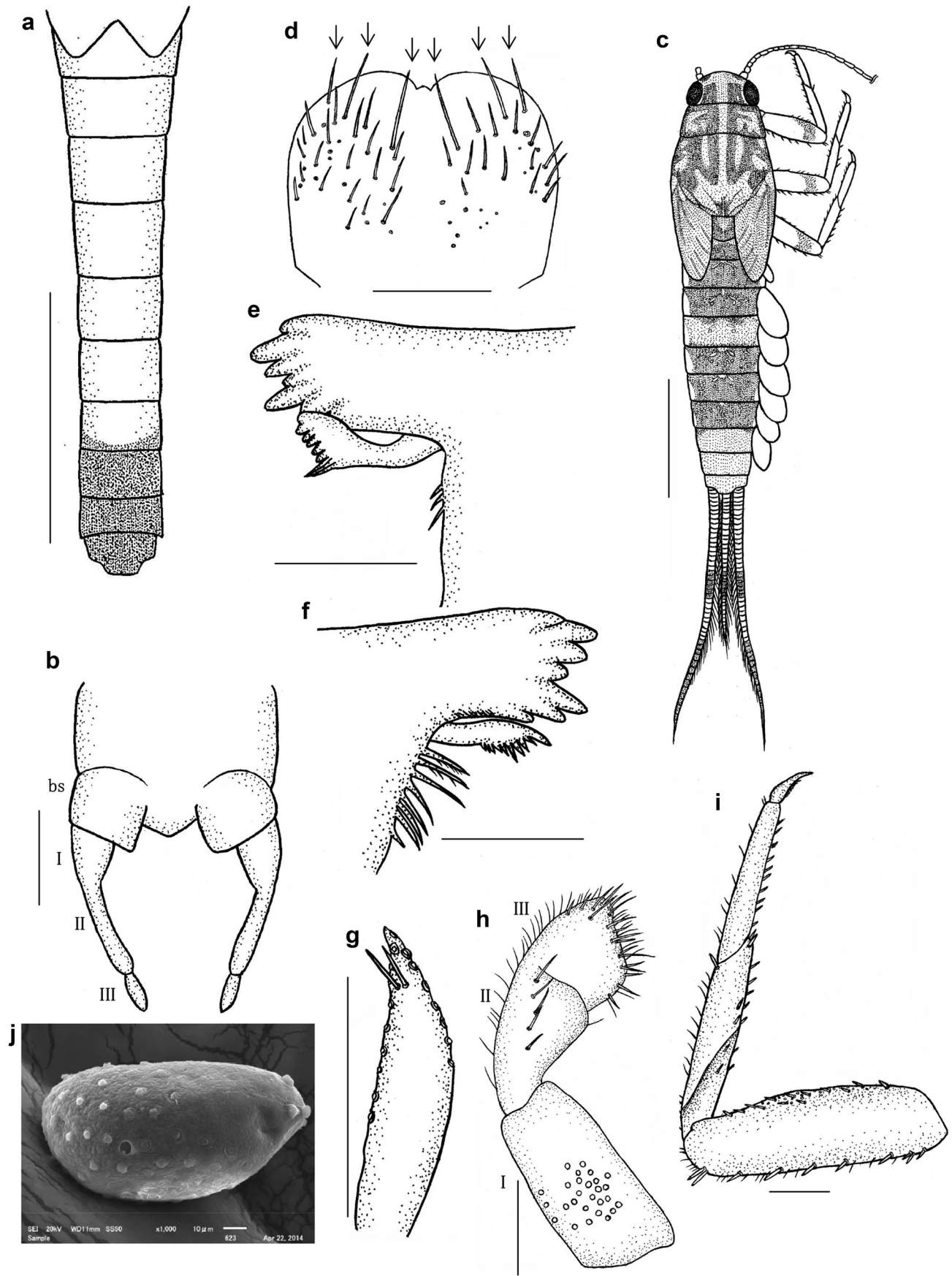


Fig. 3 *Nigrobaetis apterus* Fujitani n. sp.: **a** abdomen of male imago (dorsal); **b** forceps; **c** habitus of nymph (dorsal); **d** labrum (ventral, arrows indicate “longer setae” in description); **e** left mandible (sixth and seventh denticles covered with prosthema); **f** right mandible; **g** glossa (dorsal, robust setae omitted); **h** labial palpus (dorsal); **i** fore leg; **j** egg. Scale bars: 1 mm in **a**; 0.01 mm in **j**; 0.5 mm in **e**, **f**; 0.1 mm in other figures. *I*, *II* and *III* indicate the first, second and third segments of forceps and labial palpus, respectively, and *bs* the basal segment of forceps

Head. As in female imago.

Thorax. As in male subimago.

Abdomen. As in female imago.

Nymph (Fig. 3c–i). Body 3.5–4.0 mm in length; paracercus up to 1.5 mm in length (Fig. 3c).

Head (Fig. 3c–h). Head brown; antenna light brown. Anterior margin of frons with a median ridge. Antennal scape without distal lobe; flagellomere with spiny projections on distal margin of each segment. Labrum rounded, with fine setae thickly placed; a pair of longer setae medially and a pair of 2–3 longer setae near anterior margin (Fig. 3d). Left mandible with 3–5 distinct spines on inner margin; incisor with 7 denticles, fourth one very small; prosthema with 5–6 short and blunt denticles distally, 2–4 long and acute denticles proximally (Fig. 3e). Right mandible with 8–9 distinct spines on inner margin; incisor with 7 denticles; prosthema with 10–14 fine denticles (Fig. 3f). Glossa with 1–2 distinct setae, without a tuft of fine setae on dorsal surface near apex (Fig. 3g). Segment II of labial palpus with a row of 3–5 distinct setae on dorsal surface; segment III subconical, inner margin slightly expanded (Fig. 3h).

Thorax (Fig. 3c, i). Terga brown, with light brown medial stripe from head to mesonotum, a pair of light brown markings on pronotum, a pair of light brown stripes, lateral spots and an anchor-like marking on mesonotum (Fig. 3c); sterna light brown; legs light brown except for dark brown coxa, femur with dark gray marking near the distal end (Fig. 3c). Outer margin of femur with 8–10 robust setae in fore leg (Fig. 3i), 8–10 setae in middle leg, 6–9 setae in hind leg; outer margin of tibia with 1–3 robust setae in fore leg (Fig. 3i), 5–10 setae in middle leg, 5–8 setae in hind leg; outer margin of tarsus without robust setae (Fig. 3i).

Abdomen (Fig. 3c). Terga I–III and V–VII brown with small light brown spots on anterior margins; terga IV and VIII–X light brown (Fig. 3c); sterna light brown; cercus and paracercus light brown with median dark brown bands (Fig. 3c). Abdominal terga with trapezoidal scale bases; posterior margins of terga II–X with triangular projections. Abdominal sterna with trapezoidal scale bases; posterior margins of sterna VII–IX with triangular projections on lateral parts. Seven pairs of gills on segments I–VII; gills I minute and ellipse, gills II–VII oval (Fig. 3c). Margins of

gills fringed with spiny projections of uniform size and setae of uniform length. Paraproct without a projection near distal end of inner margin.

Egg (Fig. 3j). Ellipsoidal in shape; chorionic surface with many protuberances and a micropyle.

Holotype. Japan. Chiba: ♂, re, 4-VIII-2002, Nagareyama, Heiwadai, Edo River (35°51′06″N, 139°53′43″E), TF, OMNH (OMNH TI 519).

Paratype. Japan. Saitama: 1♂, re, 4-VIII-2002, Matsubushi, Edo River, Noda Bridge (35°56′22″N, 139°50′50″E), TF, OMNH; 1♀, re, 13-IX-2009, Okegawa, Arakawa River, Oketsume Bridge (35°58′18″N, 139°31′58″E), TF, OMNH. Chiba: 1♂, re, 4-VIII-2002, Nagareyama, Heiwadai, Edo River (35°51′06″N, 139°53′43″E), TF, OMNH.

Other materials examined.

Imago. Japan. Saitama: 2♂1♀, re, 4-VIII-2002, Matsubushi, Edo River, Noda Bridge (35°56′22″N, 139°50′50″E), TF, OMNH.

Subimago. Japan. Saitama: 4♂1♀(3♂1♀, re, 13-IX-2009; 1♂, re, 23-IX-2009), Okegawa, Arakawa River, Oketsume Bridge (35°58′18″N, 139°31′58″E), TF, OMNH.

Nymph. Japan. Saitama: 9 exs (5 exs, 13-IX-2009; 4 exs, 23-IX-2009), Okegawa, Arakawa River, Oketsume Bridge (35°58′18″N, 139°31′58″E), TF, OMNH; 5 exs, 29-VIII-2009, Kasukabe, Edo River, Houjubana Bridge (36°02′03″N, 139°48′58″E), TF, OMNH; 9 exs, 4-VIII-2002, Matsubushi, Edo River, Noda Bridge (35°56′22″N, 139°50′50″E), TF, OMNH. Chiba: 10 exs (9 exs, 14-VIII-2005; 1 ex, 6-IX-2009), Noda, Iwana, Edo River (35°58′37″N, 139°49′35″E), TF, OMNH.

Distribution. Japan: Honshu (Kanto Plain in central Japan: Tonegawa River system, Arakawa River system) (Kobayashi 1989; Fujitani 2010). Kobayashi (1989) recorded *N. apterus* in the Tonegawa River system, and Fujitani (2010) recorded this species in the Arakawa River system located near to the Tonegawa River system. We have no reliable records of this species from the other areas than Kanto Plain.

Diagnosis. *Nigrobaetis apterus* is distinguishable from other *Nigrobaetis* species by the following characters.

Male imago and male subimago: absence of hind wing.

Female imago and female subimago: absence of hind wing and abdominal tergum IV lighter than terga I–III and V–VIII.

Nymph: light brown patterns on pronotum, mesonotum and abdominal terga, and absence of hind wing pads.

Remarks. Kobayashi (1987, 1989) recorded *Baetis* sp. P from Kanto Plain (Honshu) and Ishigaki Island (Ryukyu Islands). In this paper, we described *Nigrobaetis* sp. P in Kanto Plain as *N. apterus* sp. n. by associating its nymph and imago.

The nymph of *N. apterus* is quite similar to *N. minutus* (Müller-Liebenau 1984), which was described from

nymphal materials collected in West Malaysia. In *N. minutus*, however, a tuft of setae is present near the apex of the glossa, and distinct dark brown markings are present in the median region of the femur and proximal region of the tibia (Müller-Liebenau 1984). In *N. apterus*, a tuft of setae is not present near the apex of the glossa, and distinct darker marking is not present in the proximal region of the tibia. Thus, we concluded that *N. apterus* is a different species from *N. minutus*.

The nymph of *N. apterus* is also quite similar to *N. paramakalyani* Kubendran and Balasubramanian, 2015, which was described from nymphal materials collected in India. In *N. paramakalyani*, however, thoracic terga are pale brown, and hind wing pads are present (Kubendran et al. 2015). In *N. apterus*, thoracic terga are brown and pale brown markings are also present, and hind wing pads are not present. Thus, we concluded that *N. apterus* is a different species from *N. paramakalyani*.

The tuft of setae near the apex of the glossa is one of the good diagnoses for distinguishing the genus *Nigrobaetis* from other genera (Novikova and Kluge 1987; Waltz et al. 1994; Fujitani et al. 2003a). Although a tuft of setae is not present near the apex of the glossa in *N. apterus*, this species has characters diagnostic for *Nigrobaetis*, such as convex anterior margin of the frons and elongate apical segment of forceps in the imago; and medial ridge of the frons, row of spines on inner margin of the mandible, and absence of a projection near the distal end of the inner margin of the paraproct in the nymph. Thus, we assigned this species to the genus *Nigrobaetis* (Fujitani et al. 2003a).

Etymology. The specific name “*apterus*” means “absence of wing” in Latin. This species was named after absence of hind wing in imagoes and subimagoes, which is the most distinct diagnosis among *Nigrobaetis* species in Japan.

Nigrobaetis ishigakiensis Fujitani n. sp. (Fig. 4)

[Japanese name: Ishigaki-tobihiro-kokagerou (new name)]

Baetis sp. P (partim): Kobayashi 1987, 53–60, Figs. 10–14; Ishiwata and Kobayashi 2003, 302–306, Figs. 10–11; Ishiwata and Takemon 2005, 77–92, Figs. 23–26.

Nigrobaetis sp. P (partim): Fujitani et al. 2003b, 128.

Male imago (Fig. 4a–c). Body 2.5–4.0 mm in length; fore wing 2.5–4.0 mm in length; hind wing 0.4–0.5 mm in length.

Head. Head dark brown; antenna light brown; turbinate eye reddish orange; lower eye dark gray; ocellus transparent. Anterior margin of frons expanded in lateral view.

Thorax. Terga dark brown; sterna dark brown; fore wing and hind wing transparent; legs light brown. Hind wing slender, transparent, with two veins and truncated costal projection (Fig. 4a).

Abdomen. Terga I–VI transparent, VII–X dark brown, VII with transparent marking along anterior margin; sterna transparent, VII–IX with brown bands on lateral margins; cercus white (Fig. 4b). Basal segment of forceps without a projection on inner apical margin; base of segment I 1–1.5 times as broad as apex; segment II cylindrical, 1–1.5 times as long as segment I; segmentation between segments I and II distinct; segment III elongate, about half as broad as segment II (Fig. 4c).

Female imago. Body 3.0–3.5 mm in length; fore wing 2.5–3.5 mm in length; hind wing 0.4–0.5 mm in length.

Head. Head brown; coloration of antenna and ocellus as in male imago. Compound eyes dark gray.

Thorax. Terga and sterna brown; coloration of wings and legs as in male imago. Shape and venation of hind wing as in male imago.

Abdomen. Terga II–III and V–VII brown, I, IV and VIII–X light brown; sterna light brown, segments I–VII with brown markings near lateral margins. Coloration of cercus as in male imago.

Male subimago. Body 2.5–4.0 mm in length; fore wing 2.5–3.0 mm in length; hind wing 0.3–0.5 mm in length.

Head. Coloration of head, antenna, turbinate eyes and lower eyes as in male imago.

Thorax. Terga dark brown with light brown medial longitudinal suture and lateroparapsidal sutures; coloration of sterna and legs as in male imago; fore and hind wings dark gray. Shape and venation of hind wing as in male imago.

Abdomen. Terga I–VI gray, VII–X brown; sterna I–VI gray, VII–IX white. Basal segment of forceps without a projection on inner apical margin; segment II twice as long as segment I at most; segment III oval. Cercus gray.

Female subimago. Body 3.5–4.0 mm in length; fore wing 3.5 mm in length; hind wing 0.5 mm in length.

Head. As in female imago.

Thorax. As in male subimago.

Abdomen. As in female imago.

Nymph (Fig. 4d–j). Body 3.0–4.5 mm in length; paracercus up to 2.0 mm in length (Fig. 4d).

Head (Fig. 4d–i). Head brown, antenna light brown. Anterior margin of frons with a median ridge. Antennal scape without distal lobe; flagellomere with spiny projections on distal margin of each segment. Labrum rounded, with fine setae sparsely placed; a pair of longer setae medially and a pair of 2–3 longer setae near anterior margin (Fig. 4e). Left mandible with 3–5 distinct spines on inner margin; incisor with 7 denticles, fourth one very small; prostheca with 5–6 short and blunt denticles distally, 2–3 long and acute denticles proximally (Fig. 4f). Right mandible with 6–9 distinct spines on inner margin; incisor with 7 denticles; prostheca with 13–15 fine denticles (Fig. 4g). Glossa with 1–2 distinct setae, without a tuft of

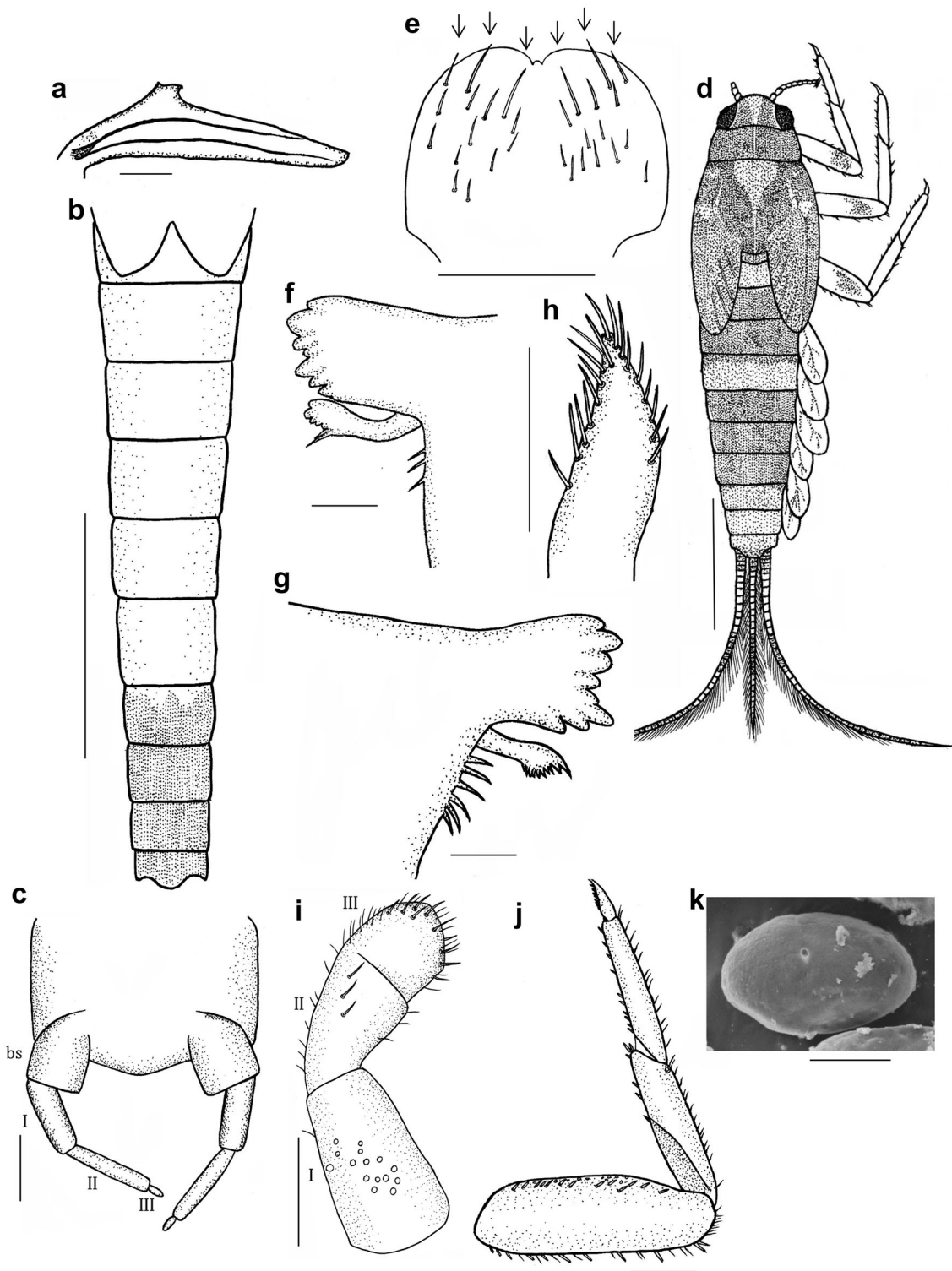


Fig. 4 *Nigrobaetis ishigakiensis* Fujitani n. sp.: **a** hind wing; **b** abdomen of male imago (dorsal); **c** forceps; **d** habitus of nymph (dorsal, gill on segment I is screened by forewing pad); **e** labrum (ventral, arrows indicate “longer setae” in description); **f** left mandible; **g** right mandible; **h** glossa (dorsal); **i** labial palpus (dorsal);

j fore leg (robust setae at distal end of tibia omitted); **k** egg. Scale bars: 1 mm in **b**, **d**; 0.01 mm in **k**; 0.5 mm in **f**, **g**; 0.1 mm in other figures. *I*, *II* and *III* indicate the first, second and third segments of forceps and labial palpus, respectively, and *bs* the basal segment of forceps

fine setae on dorsal surface near apex (Fig. 4h). Segment II of labial palpus with a row of three distinct setae on dorsal surface; segment III subconical, inner margin slightly expanded (Fig. 4i).

Thorax (Fig. 4d, j). Terga brown, with an anteromedial light brown patch on mesonotum (Fig. 4d); sterna light brown; leg light brown, femur dark gray in the anteromedial region (Fig. 4d). Outer margin of femur with 9–12 robust setae in fore leg (Fig. 4j), 8–10 setae in middle leg, 8–12 setae in hind leg; outer margin of tibia with a single robust seta at distal end in fore leg (Fig. 4j), with 3–8 setae in middle leg, 3–6 setae in hind leg; outer margin of tarsus without robust setae (Fig. 4j).

Abdomen (Fig. 4d). Terga II, III, V–VII uniformly dark brown; terga I, IV, VIII–X light brown (Fig. 4d); sterna light brown; cercus and paracercus light brown with median dark brown bands (Fig. 4d). Abdominal terga with trapezoidal scale bases; terga I–X or II–X with triangular projections on posterior margins. Abdominal sterna with trapezoidal scale bases; sterna VII–IX with spiny projections in medial parts. Seven pairs of gills on segments I–VII; gills I minute and ellipse (covered with forewing pad in Fig. 4d), gills II–VII oval. Margins of gills fringed with spiny projections of uniform size and setae of uniform length. Paraproct without a projection near distal end of inner margin.

Egg (Fig. 4k). Chorion surface smooth, with a micropyle.

Holotype. Japan. Okinawa: 1♂, re, 2-X-2002, Ishigaki, Osato, Omata Stream, Omata Bridge (24°26′01″N, 124°14′27″E), TF, OMNH (OMNH TI 520).

Paratype. Japan. Okinawa: 2♂, lt, 4-X-2002, Ishigaki, Nozoko, Nishihama Stream (24°29′03″N, 124°14′12″E), TF, OMNH. 2♀ (1♀, re, 4-X-2002; 1♀, re, 5-X-2002), Ishigaki, Osato, Omata Stream, Omata Bridge (24°26′01″N, 124°14′27″E), TF, OMNH.

Other materials examined.

Imagoes. Japan. Okinawa: 3♂4♀, 4-X-2002, re, Ishigaki, Nozoko, Nishihama Stream (24°29′03″N, 124°14′12″E), TF, OMNH; 1♂1♀(1♂, 4-X-2002; 1♀, 5-X-2002), re, Osato, Omata Stream, Omata Bridge (24°26′01″N, 124°14′27″E), TF, OMNH; 13♂, 25-X-2012, Ishigaki, mt, Nagura, Nagura Stream (24°26′01″N, 124°14′27″E), TI, OMNH.

Subimagoes. Japan. Okinawa: 1♂1♀, 4-X-2002, re, Ishigaki, Osato, Omata Stream (24°26′01″N, 124°14′27″E), TF, OMNH; 11♂15♀, 25-X-2012, mt, Ishigaki, Nagura, Nagura Stream (24°24′31″N, 124°09′41″E), TI, OMNH; 2♀, 25-31-X-2012, mt, Ishigaki, Nagura, Nagura Stream (24°25′01″N, 124°09′36″E), TI, OMNH.

Nymph. Japan. Okinawa: 87 exs (11 exs, 8-V-1998; 15 exs, 2-X-2002; 37 exs, 3-X-2002; 9 exs, 4-X-2002; 15 exs, 13-III-2004), Ishigaki, Osato, Omata Stream (24°26′01″N,

124°14′27″E), TF, OMNH; 17 exs (15 exs, 12-III-2004; 2 exs, 13-III-2004), Ishigaki, Nozoko, Nishihama Stream (24°29′03″N, 124°14′12″E), TF, OMNH; 8 exs, 1-X-2002, Ishigaki, Itona, TF, OMNH; 5 exs, 14-III-2004, Ishigaki, Aza Fukai (24°26′58″N, 124°12′35″E), TF, OMNH.

Distribution. Japan: Ryukyu Islands (Ishigaki Island) (Kobayashi 1989). The nymph of this species is collected from riffle and marginal areas with submerged plants, in the middle and lower reaches of streams.

Diagnosis. *Nigrobaetis ishigakiensis* is distinguishable from other *Nigrobaetis* species by the following characters.

Imago and subimago: truncated costal projection of hind wing.

Male imago: distinctly small segment III of forceps.

Nymph: light brown markings on head, pronotum, mesonotum, and abdominal terga.

Remarks. Kobayashi (1987, 1989) recorded *Baetis* sp. P in Kanto Plain (Honshu) and Ishigaki Island (Ryukyu Islands). In this paper, we describe *Nigrobaetis* sp. P from Ishigaki Island as *N. ishigakiensis* n. sp. by associating its nymph and imago.

Uéno (1969) described *N. sacishimensis* from imaginal materials collected from Ishigaki Island and Iriomote Island. This species is endemic to the Ryukyu Islands (Uéno 1969). In *N. sacishimensis*, the hind wing has an acute costal projection, unlike *N. ishigakiensis* (Uéno 1969). Thus, we concluded that *N. ishigakiensis* is a different species from *N. sacishimensis*.

The nymph of *N. ishigakiensis* is quite similar to *N. facetus* (Kang et al. 1994), which was described from nymphal materials collected in Taiwan. In *N. facetus*, however, hind wing pads are absent (Kang et al. 1994). In *N. ishigakiensis*, hind wings are present. Thus, we concluded that *N. ishigakiensis* is a different species from *N. facetus*.

The nymph of *N. ishigakiensis* is also quite similar to *N. vuatazi* Gattolliat and Sartori, 2012, which was described from imaginal and nymphal materials collected in Jordan. In this species, the mesothoracic terga of the nymph are brown and lack clear patterns (Gattolliat et al. 2012). In *N. ishigakiensis*, however, a distinct pale brown marking is present on the mesonotum of the nymph. In the imago of *N. vuatazi*, the hind wing has an acute costal projection and segment III of the forceps is as broad as segment II, unlike *N. ishigakiensis* (Gattolliat et al. 2012). Thus, we concluded that *N. ishigakiensis* is different species from *N. vuatazi*.

The tuft of setae near the apex of the glossa is one of the good diagnoses for distinguishing the genus *Nigrobaetis* (Novikova and Kluge 1987; Waltz et al. 1994; Fujitani et al. 2003a). Although a tuft of setae is not present near the apex of the glossa in *N. ishigakiensis*, this species has other characters diagnostic for *Nigrobaetis*, such as convex anterior margin of the frons and elongate apical segment of

the forceps in the imago; and medial ridge of the frons, row of spines on inner margin of mandible, and absence of a projection near the distal end of the inner margin of the paraprot in the nymph. Thus, we assigned this species to the genus *Nigrobaetis* (Fujitani et al. 2003a).

Etymology. Species name “*ishigakiensis*” indicates its presence on Ishigaki Island.

Nigrobaetis latus Fujitani n. sp. (Figs. 5, 6)

[Japanese name: Hirobane-tobihiro-kokagerou (new name)]

Baetis sp. I: Kobayashi 1987, 53–60, Figs. 10–14; Ishiwata and Takemon 2005, 77–92, Figs. 23–26.

Nigrobaetis sp. I: Fujitani 2002, 111–121; Fujitani et al. 2003b, 128–132.

Male imago (Fig. 5a–c). Body 4.0–5.0 mm in length; fore wing 3.8–5.0 mm in length; hind wing 0.5–0.8 mm in length.

Head. Head brown; antenna light brown; turbinate eye orange; lower eye dark gray; ocellus transparent. Anterior margin of frons expanded in lateral view.

Thorax (Fig. 5a). Terga and sterna brown or dark brown; fore wing and hind wing transparent; legs light brown.

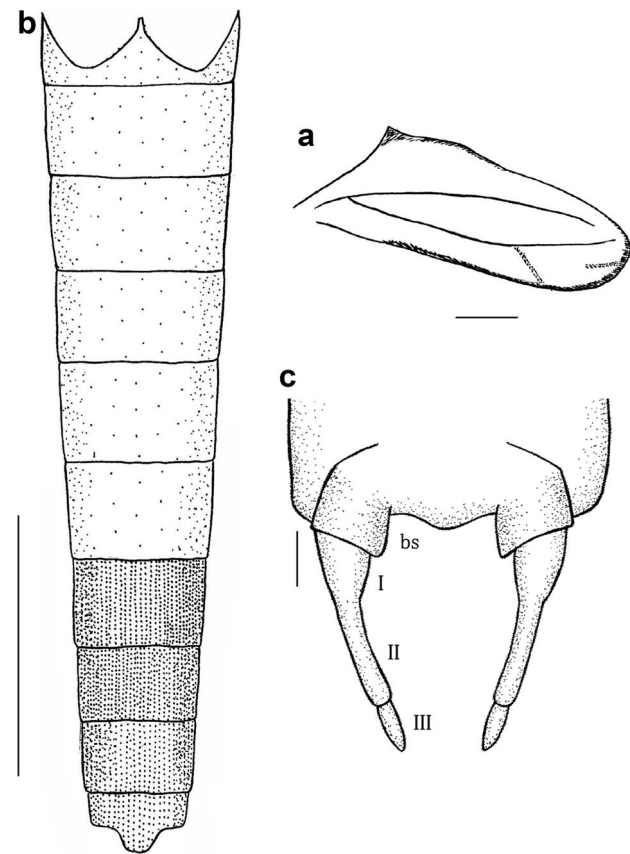


Fig. 5 *Nigrobaetis latus* Fujitani n. sp. (imago): **a** hind wing; **b** abdomen of male imago (dorsal); **c** forceps. Scale bars: 1 mm in **b**; 0.1 mm in other figures. *I*, *II* and *III* indicate the first, second and third segments of forceps, respectively, and *bs* the basal segment of forceps

Hind wing with two veins; generally vein II weak in the distal half; anterior margin expanding; costal projection acute (Fig. 5a).

Abdomen (Fig. 5b, c). Terga I–VI transparent, VII–X dark brown; sterna transparent, VII–IX with brown lateral bands; cercus white (Fig. 5b). Basal segment of forceps without a projection on inner apical margin; base of segment I about 2–3 times as broad as apex; segment II cylindrical, nearly 1–1.5 times as long as segment I, segmentation from segment I weak; segment III oval, slightly tapering at apex (Fig. 5c).

Female imago. Body 4.3–5.0 mm in length; fore wing 4.5–5.4 mm in length; hind wing 0.5–0.8 mm in length.

Head. Head brown; coloration of antenna and ocellus as in male imago. Compound eyes dark gray.

Thorax. Terga and sterna brown; coloration of wings and legs as in male imago. Shape and venation of hind wing as in male imago.

Abdomen. Terga brown, with a pair of light brown anterior streaks and posterior spots; sterna light brown, segments II–VII with brown patches near lateral margins; coloration of cercus as in male imago.

Male subimago. Body 4.5–5.0 mm in length; fore wing 4.5–5.0 mm in length; hind wing 0.7 mm in length.

Head. Coloration of head, antenna, turbinate eyes and lower eyes as in male imago.

Thorax. Terga dark brown with light brown medial longitudinal suture and medioparapsidal sutures; coloration of sterna and legs as in male imago. Fore and hind wings dark gray. Shape and venation of hind wing as in male imago.

Abdomen. Terga I–VI gray, VII–X brown; sterna I–VI gray, VII–IX light brown. Basal segment of forceps without a projection on inner apical margin; segment II twice as long as segment I at most; segment III oval. Cercus white.

Female subimago. Body 4.8 mm in length; fore wing 3.9 mm in length; hind wing 0.6 mm in length.

Head. As in female imago.

Thorax. As in male subimago.

Abdomen. As in female imago.

Nymph (Fig. 6a–h). Body 3.5–5.0 mm in length; paracercus up to 2.5 mm in length (Fig. 6a).

Head (Fig. 6a–f). Head brown; antenna light brown. Anterior margin of frons with a median ridge. Antennal scape without distal lobe; flagellomere with spiny projections on distal margin of each segment. Labrum rounded, with fine setae sparsely placed; a pair of longer setae medially and a pair of 2–3 longer setae near anterior margin (Fig. 6b). Left mandible with 6–10 distinct spines on inner margin; incisor with 7 denticles, fifth one very small; prostheca with 5–6 short and blunt denticles distally, 2–3 long and acute denticles proximally (Fig. 6c). Right mandible with 12–20 distinct spines on inner margin;

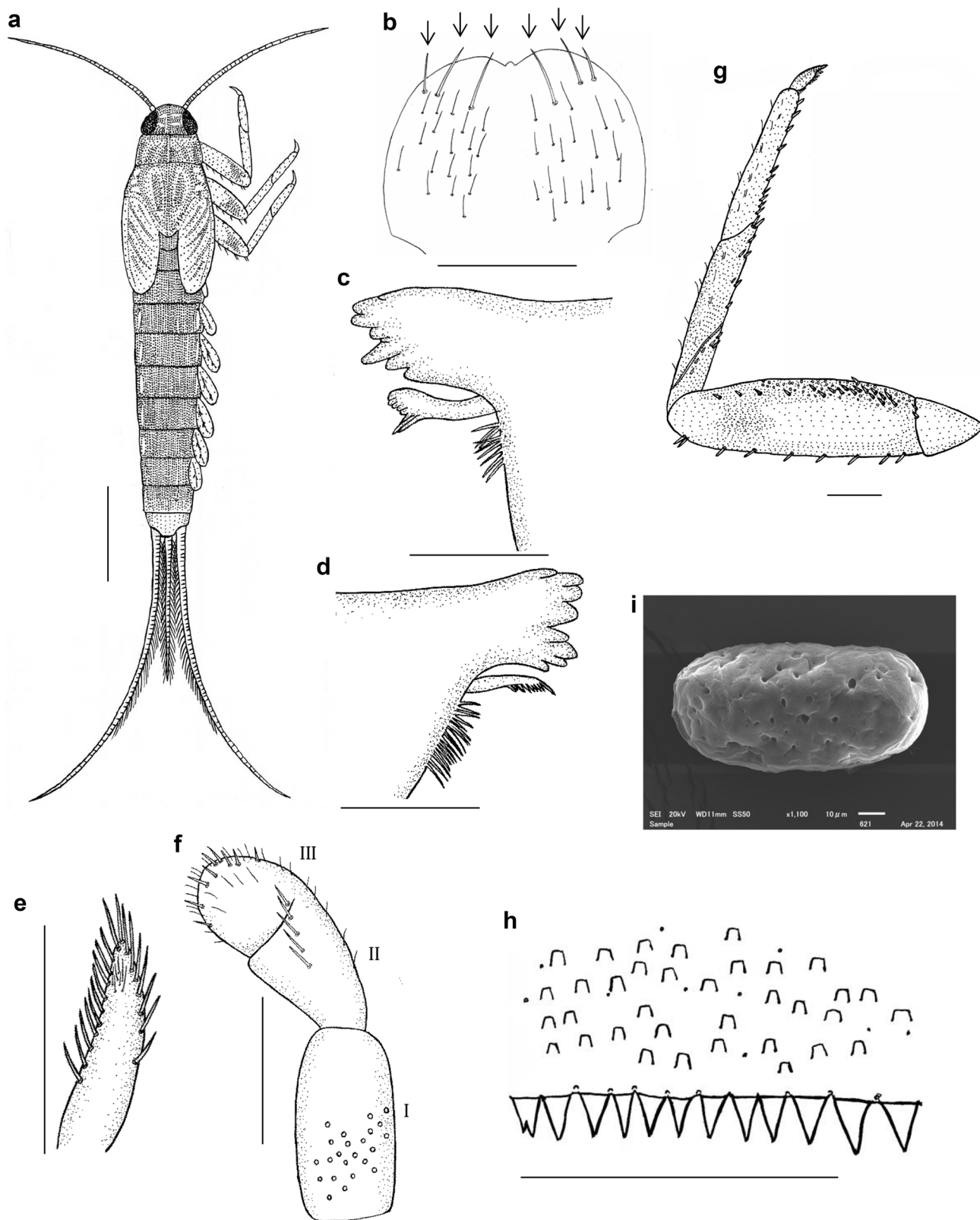


Fig. 6 *Nigrobaetis latus* Fujitani n. sp. (nymph): **a** habitus of nymph (dorsal); **b** labrum (ventral, arrows indicate “longer setae” in description); **c** left mandible; **d** right mandible; **e** glossa (dorsal); **f** labial palpus (dorsal); **g** fore leg; **h** abdominal tergum V; **i** egg.

Scale bars: 1 mm in **a**; 0.01 mm in **i**; 0.5 mm in **c**, **d**; 0.1 mm in other figures. *I*, *II* and *III* indicate the first, second and third segments of labial palpus, respectively, and *bs* the basal segment of forceps

incisor with 7 denticles; prostheca with 6–12 fine denticles (Fig. 6d). Glossa with a tuft of about 5 fine setae on dorsal surface (Fig. 6e). Segment II of labial palpus with a row of 4–5 distinct setae, without inner lobe; segment III subconical (Fig. 6f).

Thorax (Fig. 6a, g). Terga brown; sterna light brown; leg light brown except for dark brown coxa, femur dark gray in the anteromedial region (Fig. 6a). Outer margin of femur with 10–14 robust setae in fore leg (Fig. 6g), 9–13 setae in middle leg, 9–13 setae in hind leg (Fig. 6g); outer margin of tibia with 2–10 robust setae in middle leg, 4–10 setae in hind leg, but without robust setae in fore leg (Fig. 6g); outer margin of tarsus without robust setae (Fig. 6g).

Abdomen (Fig. 6a, h). Abdominal terga I–IX brown, tergum X light brown; sterna light brown; cercus and paracercus light brown, without dark bands (Fig. 6a). Abdominal terga with trapezoidal scale bases; posterior margins of abdominal terga I–X with triangular projections (Fig. 6h). Abdominal sterna with trapezoidal scale bases; posterior margins of sterna VII–VIII with spiny projections. Seven pairs of gills on segments I–VII; gill I minute and ellipse, gills II–VII oval. Margins of gills fringed with spiny projections of uniform size and setae of uniform length. Paraproct without a projection near distal end of inner margin.

Egg (Fig. 6i). Chorionic surface with depressions.

Holotype. Japan. Kyoto: 1♂, re, 29-IV-1998, Miyama, Tauta, Yura Stream (35°19'15"N, 135°40'41"E), TF, OMNH (OMNH TI 521).

Paratypes. Japan. Kyoto: 2♂, same as holotype, OMNH. Okayama: 1♂1♀, re, 3-V-2014, Mimasaka, Ohara, Ohara Stream, TF (34°59'10"N, 134°11'43"E), OMNH.

Other materials examined.

Imago. Japan. Aomori: 1♀, sw, 6-IX-2010, Nishimeya, Anmon Stream, Anmon-Ohashi, (40°31'21"N, 140°10'36"E), TF, OMNH. Saitama: 2♀, lt, 12-V-2007, Hannou, Haraichiba, TF, OMNH. Nagano: 1♂2♀ (1♀, sw, 21-V-2001; 1♀, sw, 22-V-2001; 1♂, sw, 23-V-2001), Azumi, Shimashimadani Stream (36°11'14"N, 137°46'53"E), TF, OMNH. Osaka: 2♂1♀ (1♂1♀, re, 13-IV-2000; 1♂, re, 3-V-2000), Kaizuka, Sobura, Kogi Stream (34°21'36"N, 135°25'12"E), TF, OMNH. Nara: 1♂1♀ (1♀, lt, 29-X-2000; 1♂, re, 31-X-2001), Totsukawa, Uenoji, Totsukawa Stream (34°06'41"N, 135°46'20"E), TF, OMNH. 2♀ (1♀, lt, 29-X-2000; 1♀, lt, 31-X-2001), Kawakami, Unokawa, Nakai Stream (34°22'15"N, 135°57'09"E), TF, OMNH. Okayama: 4♂1♀ (1♂, re, 27-IV-2014; 1♂1♀, re, 29-IV-2014; 2♂, re, 3-V-2014), Mimasaka, Ohara, Ohara Stream, TF (34°59'10"N, 134°11'43"E), OMNH. Kagawa: 1♂, lt, 13-X-2006,

Takamatsu, Shioe, Koto Stream, TF (34°10'06"N, 134°05'12"E), OMNH.

Subimago. Japan. Kyoto: 1♂, re, 2-V-2000, Ayabe, Yura Stream, Tamba Bridge (35°17'57"N, 135°15'54"E), TF, OMNH. Osaka: 1♀, re, 13-IV-2000, Kaizuka, Sobura, Kogi Stream (34°21'36"N, 135°25'12"E), TF, OMNH. Okayama: 2♂ (1♂, re, 29-IV-2014; 1♂, re, 3-V-2014), Mimasaka, Ohara, Ohara Stream (34°59'10"N, 134°11'43"E), TF, OMNH.

Nymph. Japan. Kyoto: 1 ex, 2-V-2000, Ayabe, Mut-suyori, Kambayashi Stream (35°22'37"N, 135°26'43"E), TF, OMNH. Osaka: 1 ex, Kaizuka, Sobura, Kogi Stream (34°21'36"N, 135°25'12"E), TF, OMNH. Nara: 4 exs, 31-X-2000, Totsukawa, Uenoji, Totsukawa Stream (34°06'41"N, 135°46'20"E), TF, OMNH. 10 exs, 12-V-2001, Kawakami, Unokawa, Nakai Stream (34°22'15"N, 135°57'09"E), TF, OMNH. 1 ex, 5-V-2001, Higashi-yoshino, Omata, Kuramae Bridge (34°22'43"N, 136°03'46"E), TF, OMNH. Okayama: 10 exs, 10-IV-2013, Mimasaka, Ohara, Ohara Stream (34°59'10"N, 134°11'43"E), TF, OMNH; 2 exs, 8-IX-2012, Mimasaka, Sunami, Yamaga Stream (34°58'11"N, 134°44'45"E), TF, OMNH; 6 exs, 30-III-2013, Bizen, Tama, Hattoji Stream (34°51'25"N, 134°14'43"E), TF, OMNH. Nagasaki: 16 exs, 7-VI-2001, Sotome, Maruo, Gounoura Stream (32°52'46"N, 129°41'23"E), TF, OMNH; 1 ex, 7-VI-2001, Sotome, Kounoura-Ougiyamagou, TF, OMNH; 3 exs, 7-VI-2001, Ohseto, Gotsu Stream, Iwaseto Bridge (32°54'45"N, 129°42'27"E), TF, OMNH; 8 exs, 18-IX-2000, Isahaya, Takaki, Todoroki Stream (latitude and longitude unknown), TF, OMNH.

Egg. Japan. Nara: 1 ex, 11-VI-2002, Kawakami, Unokawa, Nakai Stream (34°22'15"N, 135°57'09"E), TF, OMNH.

Distribution. Japan: Hokkaido, Honshu, Shikoku and Kyushu (Kobayashi 1989; Fujitani et al. 2003a). Nymphs of this species are collected in run, marginal area with submerged plants, channel margins and pools of the upper and middle reaches of streams and rivers.

Diagnosis. *Nigrobaetis latus* is distinguishable from other *Nigrobaetis* species by the following characters.

Imago and subimago: expansion on anterior margin of hind wings.

Nymph: more than 10 distinct spines on inner margin of right mandible and light colored abdominal tergum X.

Remarks. Kobayashi (1989) recorded *Baetis* sp. I from Hokkaido, Honshu, Shikoku and Kyushu. In this paper, we describe *Nigrobaetis* sp. I as *N. latus* n. sp. by associating its nymph and imago.

The nymph of *N. latus* is similar to *Nigrobaetis terminus* (Kang et al. 1994), which was described from materials

collected in Taiwan. In *N. terminus*, however, spiny projections on the posterior margins of abdominal terga are present on terga III–VII. In *N. latus*, posterior spines on abdominal terga are present on terga I–VII. Thus, we concluded that *N. latus* is a different species from *N. terminus*.

Etymology. *Latus* means broad in Latin. This species was named after the hind wings which look broader than those of the other *Nigrobaetis* species due to expansion on the anterior margin.

Keys for *Nigrobaetis* species in Japan.

We provide keys for *Nigrobaetis* species in Japan as follows.

- Nigrobaetis chocoratus*, *N. sp. D*, and *N. sp. N* are known only in the nymphal stage (Kobayashi 1987; Ishiwata and Takemon 2005; Fujitani 2006).
- Nigrobaetis sacishimensis* is only known in the imaginal stage (Uéno 1969; Fujitani 2006).
- Reliable records and description are not known for *N. chocoratus* except for the original description.
- Nigrobaetis sp. D* is distributed in Honshu, Kyushu, and Ryukyu Islands (Fujitani 2006). We have already associated the imagoes of *N. sp. D* with its nymphs. We found that the imagoes correspond to *N. acuminatus* (Gose 1980), but the eggs show clear morphological variation between Honshu and Ryukyu Islands. Taxonomical description of *N. sp. D* will be launched later.
- Male imago:
1. Hind wing absent.-----*apterus* Fujitani: n.sp.
 - Hind wing present.-----2
 2. Segment III of forceps about half as broad as segment II (fig. 4c). Costal projection of hind wing truncated (fig. 4a).----- *ishigakiensis* Fujitani: n.sp.
 - Segment III of forceps as broad as segment II. Costal projection of hind wing acute.-----3
 3. Hind wing with distinct three veins (fig. 1a).-----*acinaciger* (Kluge)
 - Hind wing with distinct two veins.-----4
 4. Anterior margin of hind wing expanded (fig. 5a).-----*latus* Fujitani: n.sp.
 - Anterior margin of hind wing not expanded.-----5
 5. Distributed in Ryukyu Islands.----- *sacishimensis* (Uéno)
 - Distributed in Honshu, Shikoku and Kyushu.----- sp.D
- (Male imago of *N. sp. N* is not associated with its nymph.)

- Female imago: 1. Hind wing absent.-----*apterus* Fujitani: n.sp.
- Hind wing present. ----- 2
2. Costal projection of hind wing truncated (fig. 4a). Abdominal segment IV light brown.-----*ishigakiensis* Fujitani: n.sp.
- Costal projection of hind wing acute. Abdominal segment IV brown.----- 3
3. Hind wing with distinct three veins (fig. 1a). Abdominal terga with a medial light brown stripe (fig. 1d).-----*acinaciger* (Kluge)
- Hind wing with distinct two veins. Abdominal terga without a medial light brown stripe.-----4
4. Anterior margin of hind wing expanded (fig. 5a).-----*latus* Fujitani: n.sp.
- Anterior margin of hind wing not expanded.-----5
5. Distributed in Ryukyu Islands.----- *sacishimensis* (Uéno)
- Distributed in Honshu, Shikoku and Kyushu.----- sp.D
- (Female imago of *N. sp. N* is not associated with its nymph.)

- Nymph: 1. Gills six pairs.-----2
- Gills seven pairs.-----3
2. Gills on abdominal segments VI and VII tapering at distal ends (fig. 2a).----- *acinaciger* (Kluge)
- Gills on abdominal segments VI and VII rounded at distal ends. ----- sp. N
3. Terga of abdominal segment IV lighter than the adjacent terga (figs. 3c, 4d). -----4
- Terga of abdominal segment IV not lighter than the adjacent terga (fig. 6a). -----5
4. Hind wing pads present.----- *ishigakiensis* Fujitani: n.sp.
- Hind wing pads absent.----- *apterus* Fujitani: n.sp.
5. Medial pale brown stripe present on dorsal surface of head, thorax and abdomen.
-----*chocoratus* (Gose)
- Medial pale brown stripe absent on dorsal surface of body. -----6
6. More than 10 distinct spines present on inner margin of right mandible.
-----*latus* Fujitani: n.sp.
- Less than 10 distinct spines present on inner margin of right mandible. -----sp. D

Acknowledgements We sincerely thank Professor M. Ishii and Dr. N. Hirai, Entomological Laboratory, Graduate School of Life and Environmental Sciences, Osaka Prefecture University for their useful comments on this study. We are very indebted to Dr. Y. Takemon, Disaster Prevention Research Institute, Kyoto University, for helping us to communicate with the late Dr. K. Gose, Gojo City, Japan. We are also grateful to the late Dr. K. Gose for giving us information on the locality of baetid species which he described. We express our gratitude to Dr. J. T. Yang and Dr. M. M. Yang, National Chung Hsien University, Taiwan, for the loan of the paratypes of Taiwanese baetid species. We extend our thanks to Dr. Shin-ichi Ishiwata, Kanagawa Institute of Technology, and Mr. N. Shimura for taking SEM images of eggs of baetid species. This study was partly supported by funds to T. Fujitani from the Ecology and Civil Engineering Society, Japan (No. 2); to K. Tanida from the Ministry of Education,

Culture, Sports, Science and Technology, Japan (No. 08874106) and from the River Foundation, Japan (Taxonomic Studies on Freshwater Animals. Integration of Systematic and Ecological Data on Trichoptera and Other Aquatic Insects, 1994).

References

- Bae YJ, Park SY (1998) *Alainites*, *Baetis*, *Labiobaetis* and *Nigrobaetis* (Ephemeroptera) in Korea. Korean J Syst Zool 14:1–12
- Bauernfueld E, Soldán T (2012) The mayflies of Europe (Ephemeroptera). Apollo Books, Denmark
- Edmunds GF Jr, Jensen SL, Berner L (1976) The mayflies of North and Central America. University of Minnesota Press, Minneapolis

- Fujitani T (2002) Species composition and distribution patterns of baetid nymphs (Baetidae: Ephemeroptera) in a Japanese stream. *Hydrobiologia* 485:111–121
- Fujitani T (2006) Japanese Baetidae (Ephemeroptera): keys to seven genera with information on taxonomy, distribution and habitat. *Jpn J Limnol* 67:185–207 (in Japanese)
- Fujitani T (2010) The first record of *Nigrobaetis* sp. P (Ephemeroptera: Baetidae) from the Arakawa River, Kanto District, Japan. *Hyogo Freshw Biol* 61–62:41–44 (in Japanese)
- Fujitani T, Hirowatari T, Tanida K (2003a) Genera and species of Baetidae in Japan: *Nigrobaetis*, *Aainites*, *Labiobaetis*, and *Tenuibaetis* n. stat. (Ephemeroptera). *Limnology* 4:121–129
- Fujitani T, Hirowatari T, Tanida K (2003b) Nymphs of *Nigrobaetis*, *Alainites*, *Labiobaetis*, *Tenuibaetis* and *Baetis* from Japan (Ephemeroptera: Baetidae): diagnosis and keys for genera and species. In: Gaino E (ed) Research update on Ephemeroptera and Plecoptera. University of Perugia, Perugia, pp 127–133
- Fujitani T, Hirowatari T, Tanida K (2005) *Labiobaetis* species of Japan, Taiwan, and Korea, with a new synonym of *L. atrebatinus* (Eaton 1870) and reerection of the subspecies *L. atrebatinus orientalis* (Kluge 1983) (Ephemeroptera, Baetidae). *Limnology* 6:141–147
- Fujitani T, Hirowatari T, Tanida K (2011) Three species of a genus *Tenuibaetis* (Ephemeroptera: Baetidae) from Japan, with description of a new species. *Limnology* 12:213–223
- Gattolliat JL, Vuataz L, Sartori M (2012) First contribution to the mayflies of Jordan. *Zool Middle East* 56:91–110
- Geographical Information Authority of Japan (2013) GSI maps. <http://maps.gsi.go.jp/>. Accessed 3 Oct 2015 (in Japanese)
- Gose K (1980) The mayflies of Japanese 6. *Aquabiology* 2:76–79
- Ishiwata S (2001) Mayflies of Chiba Prefecture, Japan—checklist, diagnoses, and keys—. *J Nat Hist Mus Inst Chiba* 6:163–200 (in Japanese)
- Ishiwata S, Kobayashi N (2003) Ephemeroptera. In: Nishida M, Shikatani N, Shokita S (eds) The flora and fauna of inland waters in the Ryukyu Islands. Tokai University Press, Tokyo, pp 296–321 (in Japanese)
- Ishiwata S, Takemon Y (2005) Ephemeroptera. In: Kawai T, Tanida K (eds) Aquatic insects of Japan: manual with keys and illustration. Tokai University Press, Tokyo, pp 31–128 (in Japanese)
- Ishiwata S, Tiunova TM, Kuranishi RB (2000) The mayflies (Insecta: Ephemeroptera) collected from the Kamchatka Peninsula and the North Kuril Islands in 1996–1997. *Nat Hist Res (Special Issue)* 7:67–75
- Kang SC, Chang HC, Yang CT (1994) A revision of the genus *Baetis* in Taiwan. *J Taiwan Mus* 47:9–44
- Kluge NJ (1983) New and little known mayflies of the fam. Baetidae (Ephemeroptera) from the Primor'ye. *Entomol Rev* 61:53–68
- Kluge NJ (1994) Pterothorax structure of mayflies (Ephemeroptera) and its use in systematics. *Bull Soc Entomol Fr* 99:41–61
- Kobayashi N (1987) *Baetis* species as biological indices of water quality. In: Yasuno M, Iwakuma T (eds) Proceedings of the symposium “Problems and perspectives of the aquatic biological index”. National Institute of Environmental Studies, Tokyo, pp 41–52 (in Japanese)
- Kobayashi N (1989) *Baetis* species from Japan and their systematics. In: Shibatani A, Tanida K (eds) Recent progress in aquatic entomology in Japan, with special reference to speciation and Sumiwake. Tokai Univ Press, Tokyo, pp 53–67 (in Japanese)
- Kubendran T, Balasubramanian C, Selvakumar C, Gattolliat JL, Sivaramakrishnan KG (2015) Contribution to the knowledge of *Tenuibaetis* Kang & Yang 1994, *Nigrobaetis* Novikova & Kluge 1987 and *Labiobaetis* Novikova & Kluge 1987 (Ephemeroptera: Baetidae) from the Western Ghats (India). *Zootaxa* 3957:188–200
- Müller-Liebenau I (1969) Revision der europäischen Arten der Gattung *Baetis* Leach, 1815 (Insecta, Ephemeroptera) (in German). *Gewässer und Abwässer* 48(49):1–214 (in German)
- Müller-Liebenau I (1984) New genera and species of the family Baetidae from West-Malaysia (River Gombak) (Insecta: Ephemeroptera). *Spixiana* 7:253–284 (in German)
- Novikova EA, Kluge NJ (1987) Systematics of the genus *Baetis* (Ephemeroptera: Baetidae) with description of a new species from Middle Asia. *Vestnik Zool* 1987:8–19 (in Russian)
- Tiunova TM (2009) Biodiversity and distribution of mayflies (Ephemeroptera) in the Russian Far East. *Aquat Insects* 31(supplement 1):671–691
- Ubero-Pascal N, Puig MA (2007) Microscopy and egg morphology of mayflies. In: Méndez-Vilas A, Diaz J (eds) Modern research and educational topics in microscopy. Formatex, Badajoz, Spain, pp 326–335
- Uéno M (1969) Mayflies (Ephemeroptera) from various regions of Southeast Asia. *Orient Insects* 3:221–238
- Waltz RD, McCafferty WP, Thomas A (1994) Systematics of *Alainites* n. gen., *Dipheter*, *Indobaetis*, *Nigrobaetis* n. stat., and *Takobia* n. stat. (Ephemeroptera, Baetidae). *Bull Soc Hist Nat Toulouse* 130:33–36
- Wang SL, Xie H, Chen P, Jia YY, Zhou CF (2009) Diversity and biogeography of mayflies in Northeast Asia. *Acta Zootaxonomica Sin* 34:193–198