

Three species of a genus *Tenuibaetis* (Ephemeroptera: Baetidae) from Japan, with description of a new species

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Abstract We associated nymphs of three *Tenuibaetis* species with their imagoes by rearing. Herein we redescribe *T. flexifemora* and *T. pseudofrequentus*, and also provide description of a new species *T. parvipterus*. *Tenuibaetis pseudofrequentus* is morphologically similar to *T. flexifemora* in the imaginal stage, but we can distinguish these two species by the color patterns of their nymphs and their geographical distribution. *Tenuibaetis parvipterus* is distinguishable from the other two species by the fore femur, which is not bending distinctly, and abdominal sterna without distinct spots of male imago, reduced hind wing and abdominal sterna without distinct spots of female imago, and difference in color patterns of the abdomen of nymphs. Diagnostic characters of these species were tabulated.

Keywords *Tenuibaetis* · Baetidae · New species · Japan · Diagnostic characters

Introduction

Kang and Yang (in Kang et al. 1994) erected a subgenus *Tenuibaetis* from Taiwan. This subgenus included three species, and *Baetis (Tenuibaetis) pseudofrequentus* Müller-Liebenau 1985 was designated as type species (Kang et al. 1994). This subgenus is distinguishable from the other subgenera of *Baetis* (sensu lato) by the following characters of nymphs: mandible with smooth medial margin, pointed apex of labial palpus, villopore on femur and paraproct with a patch of notched scales (Kang et al. 1994).

Waltz and McCafferty (1997) assigned *Baetis (Tenuibaetis) pseudofrequentus* to the genus *Baetiella* Uéno 1931 based on the shape of the labial palpus. According to the original description of *Baetiella* by Uéno (1931), this genus is distinguishable from other baetid genera by the absence of hind wings in imago, labial palpus with a conical apical segment and glabrous lateral cercus in the nymph. In species of the subgenus *Tenuibaetis*, however, medial margins of the lateral cercus is fringed with fine setae (Kang et al. 1994).

Fujitani et al. (2003a) used a robust setae with median ridge on the dorsomedian surface of the nymphal femur to separate *Tenuibaetis* species from its relative genera and raised *Tenuibaetis* to the generic rank. Fujitani et al. (2003a) also assigned six Japanese *Baetis* species to genera *Alainites* Waltz and McCafferty, 1994, *Labiobaetis* Novikova and Kluge, 1987, *Nigrobaetis* Novikova and Kluge, 1987, and *Tenuibaetis*.

In Japan, Kobayashi (1987) distinguished the nymphs of 18 *Baetis* (sensu lato) species and gave alphabetical

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provisional names to 13 species that were not identified with known valid species. Kobayashi (1987) identified five remaining species with *Alainites yoshinensis* (Gose 1980), *Baetis sahoensis* Gose 1980, *B. thermicus* Uéno 1931, *Nigrobaetis chocoratus* (Gose 1980) and *Tenuibaetis pseudofrequentus* (Müller-Liebenau 1985). Comparing only characters of nymphs, Ishiwata et al. (2000) concluded *B. sp. L* is conspecific with *B. bicaudatus* Dodds, 1923, described from North America. Fujitani et al. (2005) reared nymphs of *Labiobaetis sp. G* and *L. sp. Q* to imagoes, and associated them with *L. atrebatinus orientalis* (Kluge 1983) and *L. tricolor* (Tshernova 1928), respectively.

In regard to the genus *Tenuibaetis*, the following three species were recorded from Japan in the nymphal stage: *T. pseudofrequentus*, *T. sp. E* and *T. sp. H* (Fujitani et al. 2003b). Here, we provide descriptions and diagnoses of the three species in the imaginal and nymphal stages.

Materials and methods

In order to associate nymphs of *Tenuibaetis* species to their imagoes, we slightly modified the rearing method adopted by Müller-Liebenau (1969) and Edmunds et al. (1976). We made pores in plastic cups for water and oxygen to pass through. Mature nymphs with black wing pads were put in plastic cups, and their mouths were covered with pieces of nylon stocking so as not to release the imagoes and subimagoes. The cups were set in holes bored in a urethane mat, which we floated on slowly flowing water near the channel margin. This method is favorable since the reared nymphs can take enough oxygen and avoid oxygen shortages triggered by the rise in water temperature.

The light trap method was used to collect imagoes and subimagoes near streams or rivers. We also swept riverine vegetation using a long-handled net.

Most subimagoes were reared to imagoes. The imagoes and subimagoes were preserved in 80% ethanol, and nymphs in 5% formalin or 80% ethanol.

The type series is deposited in Osaka Museum of Natural History (Osaka City, Japan). Other materials examined in this study are deposited in the Entomological Laboratory, Graduate School of Life and Environmental Sciences and the Ecological Laboratory, Graduate School of Science, Osaka Prefecture University, Japan. We also examined materials of nymphs of *T. pseudofrequentus* deposited in National Chung Hsien University, Taiwan. In the list of materials examined, the following abbreviations are used: sw, collected by sweeping; lt, collected by light traps; re, reared from nymph; m, male imago; f, female imago; ms, male subimago; fs, female subimago; OPU, Osaka Prefecture University. Collectors were abbreviated

as follows: TF, T. Fujitani; NK, N. Kobayashi; KT, K. Tanida; AO, A. Ohkawa; HCC, H.C. Chang; SCK, S.C. Kang.

We referred to topographic maps provided on the online service of the Geographical Survey Institute (2008) for latitude and longitude of the sampling sites where we can specify the location.

Tenuibaetis flexifemora (Gose 1980) comb.nov.

[Japanese name: Udemagari Kokagerou]

Baetis flexifemora Gose 1980, 122; Kobayashi 1992, 19.

Baetis sp. H: Kobayashi 1987, 55; Yamasaki 1987, 86; Kuranishi and Kuhara 1994, 1213.

Baetis flexifemora (laps.): Ishiwata 2001, 67.

Tenuibaetis sp. H: Fujitani 2002, 114; Fujitani et al. 2003b, 131; Fujitani 2008, 208.

Male imago (Fig. 1a–f). Length: body 3.1–5.5 mm; fore wing 4.1–6.9 mm; hind wing 0.5–0.9 mm.

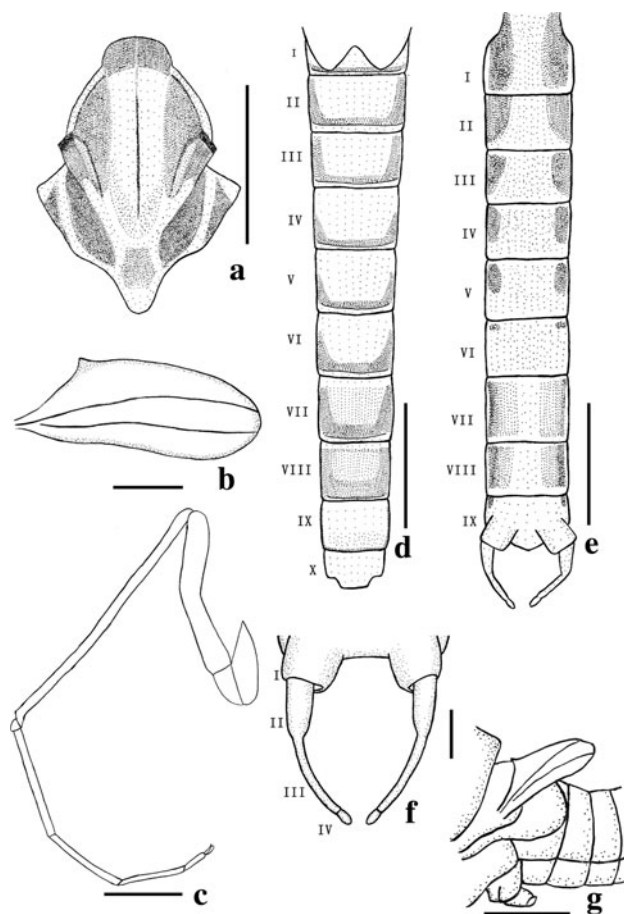


Fig. 1 *Tenuibaetis flexifemora* imago. **a** Thoracic terga of male; **b** hind wing of male; **c** fore leg of male; **d** abdominal terga of male; **e** abdominal sterna of male; **f** forceps, ventral view; **g** metathorax of female, lateral view. Scale bars 1 mm in **d, e, g**; 0.5 mm in **a, c**; 0.1 mm in **b, f**

Head. Head brown; antenna pale yellow, except for grey flagellum; turbinate eye orange; lower eye dark grey; ocellus white with grey base.

Thorax. Terga brown with lighter medial region (Fig. 1a) or wholly yellowish brown. Sterna brown or yellowish brown. Legs pale yellow in femur to tarsus, brown or yellowish brown in coxa. Wings hyaline. Hind wing with two simple longitudinal veins; costal projection prominent (Fig. 1b). Fore femur bending distinctly (Fig. 1c).

Abdomen. Terga I–VI white semihyaline, median region yellow, VII–VIII brown, IX–X whitish brown; II–VI with lateral and posterior brown bands, I–VIII with transverse brown stripes near posterior margins (Fig. 1d). Sterna II–VIII grey on anterior regions near lateral margins (Fig. 1e). Cercus pale grey. Segment I of forceps cylindrical, without a distomedial projection; segment II cylindrical and tapering at apex; segment III tubular and usually incurvate, about 1.5× as long as segment II; segment IV ellipse (Fig. 1f).

Female imago (Fig. 1g). Length: body 3.1–5.1 mm; fore wing 3.8–7.1 mm; hind wing 0.5–0.8 mm.

Head. Coloration of head and antenna yellow or brown, except for grey flagellum; compound eye dark grey.

Thorax. Terga brown or yellowish brown, with medial lighter region in some imago. Coloration of sterna, leg and wing as in male imago. Hind wing as in male imago (Fig. 1g).

Abdomen. Coloration of terga yellow or brown, II–VI with lateral and posterior grey bands, I–VIII with transverse brown stripes near posterior margins. Coloration of sterna yellowish brown, II–VIII grey on anterior regions near lateral margins in most imagoes. Cercus pale grey.

Male subimago. Length: body 3.0–5.4 mm; fore wing 3.8–5.5 mm; hind wing 0.5–0.6 mm.

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

Thorax. Coloration of terga dark grey with pale brown sutures. Coloration of sterna and leg as in male imago. Fore and hind wings grey, opaque.

Abdomen. Coloration of terga I–VI pale grey, VII–X brown; lateral and posterior grey bands and transverse brown stripes as in male imago. Coloration of sterna as in male imago.

Female subimago. Length: body 2.8–4.2 mm; fore wing 3.6–6.1 mm; hind wing 0.5–0.8 mm.

Head. As in female imago.

Thorax. As in female imago except for grey and opaque wings.

Abdomen. As in female imago.

Nymph (Fig. 2). Length: body 3.4–6.0 mm.

Head. Head brown; antenna white. Antennal scape without distal lobe; pedicel without robust setae. Labrum with a distinct notch medially on anterior margin; with 3–4 simple setae along each side of anterior margin. Left mandible with incisor possessing seven denticles on medial

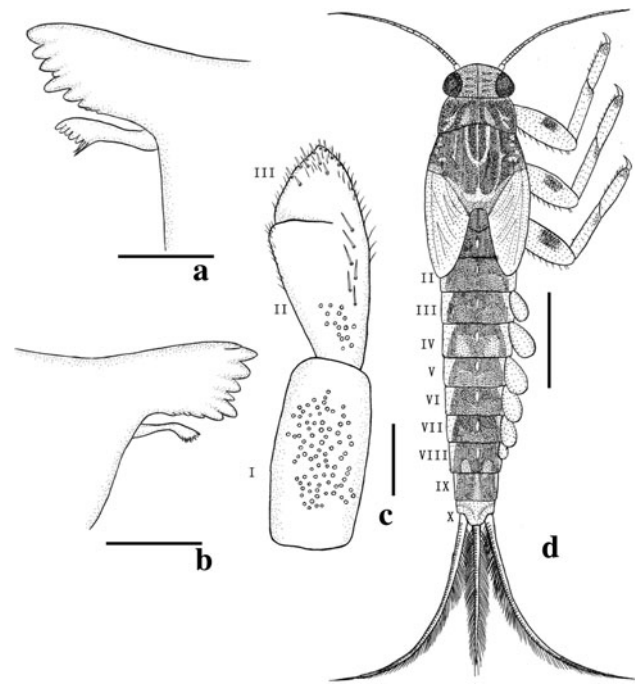


Fig. 2 *Tenuibaetis flexifemora* Nymph. **a** Left mandible; **b** right mandible; **c** labial palpus, dorsal view; **d** habitus, legs and gills on left side removed. Scale bars 1 mm in **d**; 0.1 mm in **a–c**

margin, fourth denticle reduced, fifth denticle the largest, seventh denticle with some notches at base; prostheca with blunt denticles on apical region and acute denticles on basal region (Figs. 2b). Right mandible with incisor possessing six denticles on medial margin, first denticle with a notch on anterior margin, sixth denticle with some notches on posterior margin; prostheca with acute denticles (Fig. 2c). Maxillary palpus without depression on distomedial margin. Paraglossa 1.3–1.8× as wide as glossa. Segment II of labial palpus with a row of 4–6 long setae, inner lobe weak; segment III triangular (Fig. 2d).

Thorax. Terga dark grey, with pale brown patterns (Fig. 2d). Sterna pale brown. Legs pale brown, femur grey in dorsomedial region, tibia and tarsus dark grey at distal region (Fig. 2d). Femur with robust setae possessing a medial ridge on dorsomedian surface; with clavate setae on outer margin. Tibia with robust setae on inner margin; without clavate setae on outer margin. Tarsus without clavate setae on inner margin; with fine setae on outer margin. Claws with a single row of fine denticles.

Abdomen. Terga dark grey, I–VIII usually with a anteromedial longitudinal streak, IV usually with a pair of pale brown oval spots, VIII usually with a pair of pale brown oval spots near posterior margin, IX usually with a pale brown medial stripe, X usually with a pair of dark grey slant streaks (Fig. 2d), size of pale brown patterns on terga IV, VIII and IX variable. Sterna pale brown. Cercus and paracercus pale brown (Fig. 2d). Seven pairs of oval gills

on posterolateral margins of segments I–VII; margins of gills fringed with spiny projections of uniform size and fine setae of various length. Paraproct with robust spiny projections on posterior 3/4 of medial margin, with notched scales on dorsal surface. Cercus with fine setae on medial margin (Fig. 2d). Paracercus 0.6–0.7× as long as cercus, with fine setae on lateral margins (Fig. 2d).

Remarks

Combination of fore femur bending in the middle, hind wing with brown costal projection and two longitudinal veins, and forceps without a distomedial projection was diagnostic for this species (Gose 1980). Although Dr. Gose examined specimens from Yoshino River, Gojo City, Nara Prefecture, Honshu, for the original description, type specimen and type locality were not designated in the original description (Fujitani 2006). Kobayashi (1992) recorded male imagoes of this species from Kanagawa Prefecture, Honshu. This is the only reliable record of this species.

Kobayashi (1987) distinguished the nymph of *Tenuibaetis* sp. H from other baetid nymphs. In this paper, he

also showed that this species was distributed in Honshu, Shikoku and Kyushu (Kobayashi 1987). Kuranishi and Kuhara (1994) recorded this species from Hokkaido.

We reared nymphs of *T. sp. H* to imagoes. With regard to the males, shape of fore femur and forceps was identical to those of *B. flexifemora* (Gose 1980). Costal projection of the hind wing was transparent, but it had a fine fold-like microstructure on the surface, and under the binocular microscope, it often looked brown. Thus, we concluded that *T. sp. H* is conspecific to *B. flexifemora* and transferred this species to the genus *Tenuibaetis*.

Diagnostic characters for *T. flexifemora* are given in Table 1.

Ecology. *Tenuibaetis flexifemora* mostly occur in flood plain rivers and streams (Fujitani 2002, 2006). Stream order of the regions where this species occur is usually 4 or 5. The nymphs inhabit the surface of stones, gravel and submerged parts of plants. They are often abundant on the surface of stones covered with filamentous green algae. Nymphs are collected in all seasons.

Distribution. Japan (Hokkaido, Honshu, Shikoku, Kyushu).

Table 1 Diagnostic characters for male imago, female imago and nymph of three *Tenuibaetis* species collected in Japan

	<i>T. flexifemora</i>	<i>T. pseudofrequentus</i>	<i>T. parvipterus</i>
Male imago			
Fore femur	Distinctly bending	Distinctly bending	Distinctly bending
Abdominal sterna II–VIII	Grey on anterior regions near lateral margins	Grey on anterior regions near lateral margins	Without distinct grey patterns
Female imago			
Hind wing	Not reduced	Not reduced	Reduced
Abdominal sterna II–VIII	Grey on anterior regions near lateral margins in most imagoes	Grey on anterior regions near lateral margins	Without distinct grey patterns
Nymph			
Abdominal tergum III	Distinct spots not present	Distinct spots not present	Usually with a pair of pale brown oval or triangular spots variable in size and often fused each other
Abdominal tergum IV	Usually with a pair of pale brown oval spots	With pale brown lateral regions or with a pair of oval spots	Usually with a pair of pale brown oval or triangular spots variable in size and often fused each other
Abdominal tergum V	Distinct spots not present	Often with a pair of triangular patterns	Usually with a pair of pale brown oval or triangular spots variable in size and often fused each other
Abdominal tergum VIII	Usually with a pair of pale brown oval spots near posterior margin	Distinct spots not present	Usually with a pair of pale brown circular spots
Abdominal tergum IX	Usually with a pale brown medial stripe	Pale brown in medial region	Pale brown in posterior region
Geographic distribution	Japan (Hokkaido, Honshu, Shikoku, Kyushu)	Japan (Amami Island, Okinawa Island, Ishigaki Island, Iriomote Island), Taiwan, Hong Kong	Japan (Hokkaido, Honshu, Shikoku, Kyushu)

Their geographic distribution is also tabulated

Materials examined

JAPAN. **IBARAKI:** Kasama, Shimo-Kagata, Hinuma Stream (36°20'15"N, 140°16'42"E), 4n, 9.v.2009, TF. Kasama, Hinuma Stream, Shishido Bridge (36°20'04"N, 140°17'28"E), 7n, 9.v.2009, TF. Joso, Ishige, Kinugawa Stream, Ishige Bridge (36°07'06"N, 139°58'04"E), 5 m, 2 f, 1 ms, 1 fs, 18 n [18 n, 19.iii.2001; 2 f (re), 23.v.2009; 5 m (re), 1 ms (re), 1 fs (re), 7.vi.2009], TF. **SAITAMA:** Okegawa, Arakawa Stream, Oketsume Bridge (35°58'18"N, 139°31'58"E), 2 m (re), 1 f (re), 23.ix.2009, TF. **NIIGATA:** Nagaoka, Ômiya, Shinanogawa River (37°25'60"N, 138°49'31"E), 9 n, 9.x.2001, TF. **NAGANO:** Ueda, Takeishi, Takeishigawa Stream (36°17'27"N, 138°15'11"E), 5 n, 20.v.2001, TF. **FUKUI:** Fukui, Hinogawa Stream, Asamiya Bridge (36°02'20"N, 136°10'28"E), 4 n, 22.iv.1993. **KYOTO:** Nantan, Tanano Stream, Tanamura Bridge (35°18'43"N, 135°33'08"E), 1 fs, 18 n [18 n, 25.iv.1999; 1 fs (re), 27.iv.1999], TF. Ayabe, Mutsuyori, Kanbayashigawa Stream (35°22'37"N, 135°26'43"E), 1 m (re), 1 f (re), 2.v.2000, TF. Ayabe, Yuragawa Stream, Tanba Bridge (35°17'57"N, 135°15'54"E), 6 m, 5 f, 2 ms, 45 n [5 m (re), 1 f (re), 30.iv.2000; 3 f (re), 1 ms (re), 45 n, 1.v.2000; 1 m (re), 1 f (re), 1 ms (re)], TF. Fukuchiyama, Ôecho-Kawahigashi, Yuragawa Stream (35°22'51"N, 135°08'30"E), 5 f, 11 n [1 f (re), 25.iv.1999; 3 f (re), 11 n, 26.iv.1999; 1 f (re), 27.iv.1999], TF. Fukuchiyama, Ôecho-Habi, Yuragawa Stream (35°23'02"N, 135°09'11"E), 9 m, 16 f, 1 ms, 16 n [2 f (re), 18.vi.1997; 1 m (re), 31.vii.1997; 2 m (re), 3 f (re), 24.v.1998; 2 m (re), 3 f (re), 5.viii.1998; 2 f (re), 12.x.1998; 2 f (re), 15.xi.1998; 1 m (re), 24.iv.1999; 1 f (re), 24.ix.1999; 2 m (re), 1 ms (re), 31.vii.2000; 16 n, 5.vi.2004; 1 m (re), 3 f (re), 6.vi.2004], TF. Kyoto, Sakyô-ku, Shimogamo, Kamogawa Stream (35°01'50"N, 135°46'15"E), 1 m, 42 n [1 m (li), 9.viii.1999; 42 n, 12.v.2001], TF. Kyoto, Higashiyama-ku, Gion, Shirakawa Stream (35°00'20"N, 135°46'25"E), 5 m (li), 1 f (li), 28.v.1998, TF. Kyoto, Higashiyama-ku, Kamogawa Stream, Donguri Bridge (35°00'08"N, 135°46'16"E), 4 m (li), 2 ms (li), 1 fs (li), 40n, 14.viii.2000, TF. Wazuka, Wazuka Stream, Iwaseto Bridge (34°48'05"N, 135°54'44"E), 1 f (re), 14.vi.1999, TF. **NARA:** Nara, Kawakami-cho, Sahogawa Stream (34°41'53"N, 135°50'27"E), 1 m, 1 f, 1 ms, 80 n [1 ms (re), 23.x.1999; 1 m (re), 1 f (re), 80 n, 24.x.1999], TF. **WAKAYAMA:** Hashimoto, Kinokawa River, Kinokawa Bridge (34°19'02"N, 135°37'09"E), 6 m, 2 f, 3 ms, 48 n [1 ms (re), 15.v.1999; 1 m (re), 1 ms (re), 4.viii.1999; 1 ms (re), 26.viii.1999; 2 m (re), 2 f (re), 17.x.1999; 48 n, 9.vi.2000; 3 m (re), 21.ix.2000], TF. **TOTTORI:** Yonago, Hinogawa Stream, Kimori Bridge (35°20'32"N, 133°26'04"E), 1 f (re), 22.xi.1999; TF. Yonago, Hinogawa Stream, Yawata Bridge (35°24'10"N, 133°23'25"E), 4 m, 4 f, 1 fs, 6 n [4 m (re), 4 f (re), 1 fs (re), 26.viii.2000; 6 n, 28.viii.2000], TF. Yonago,

Kamifukubara, Hinogawa Stream (35°26'18"N, 133°22'04"E), 1 m, 1 f [1 m (re), 23.xi.1999; 1 f, 26.xi.1999], TF. **TOKUSHIMA:** Mima, Waki, Waki, Yoshinogawa River (34°03'57"N, 134°08'43"E), 2 m (re), 2 f (re), 70 n, 30.x.1999, TF. **FUKUOKA:** Tachiarai, Nishibaru, Chikugogawa River (33°21'27"N, 130°38'18"E), 10 m, 7 f, 4 ms, 1 fs, 39 n [1 m (li), 39 n, 21.ix.2000; 1 m (re), 23.ix.2000; 3 m (re), 7 f (re), 2 ms (re), 1 fs (re), 24.ix.2000; 5 m (re), 2 ms (re), 25.ix.2000], TF. Kama, Kodai Bridge, Onga Stream (33°33'46"N, 130°43'3"E), 2 f (li), 2 ms (re), 51 n, 20.ix.2000, TF.

Tenuibaetis pseudofrequentus (Müller-Liebenau 1985)

[Japanese name: Higetogari Kokagerou]

Baetis pseudofrequentus Müller-Liebenau 1985, 98; Kobayashi 1987, 55; Ishiwata and Kobayashi 2003, 304.

Baetis (Tenuibaetis) pseudofrequentus: Kang and Yang, in Kang et al. 1994, 26.

Baetiella pseudofrequentia: Waltz and McCafferty 1997, 136; Tong and Dudgeon 2000, 144.

Tenuibaetis pseudofrequentus: Fujitani et al. 2003b; Fujitani 2008, 208.

Male imago. Length: body 3.4–4.2 mm; fore wing 3.3–4.6 mm; hind wing 0.4–0.6 mm.

Head. Head brown; antenna pale yellow, except for grey flagellum; turbinate eye orange; lower eye dark grey; ocellus white with grey base.

Thorax. Terga brown with lighter medial region (Fig. 1a) or wholly yellowish brown. Sterna brown or yellowish brown. Legs pale yellow in femur to tarsus, brown or yellowish brown in coxa. Wings hyaline. Hind wing with two simple longitudinal veins; costal projection prominent. Fore femur bending distinctly.

Abdomen. Terga I–VI white semihyaline, median region yellow, VII–VIII brown, IX–X whitish brown; II–VI with lateral and posterior brown bands, I–VIII with transverse brown stripes near posterior margins; sterna II–VIII grey on anterior regions near lateral margins; cercus pale grey. Segment I of forceps cylindrical, without a distomedial projection, without a projection on distal end of medial margin; segment II cylindrical, tapering at apex; segment III tubular and usually incurvate, about 1.5× as long as segment II; segment IV ellipse.

Female imago. Length: body 2.9–4.0 mm; fore wing 3.4–3.9 mm; hind wing 0.4–0.5 mm.

Head. Coloration of head and antenna yellow or brown, except for grey flagellum; compound eye dark grey.

Thorax. Terga brown or yellowish brown, with medial lighter region in some imago. Coloration of sterna, leg and wing as in male imago. Hind wing as in male imago.

Abdomen. Coloration of terga yellowish brown, II–VI with lateral and posterior grey bands, I–VIII with transverse brown stripes near posterior margins. Coloration of

sterna yellowish brown, II–VIII grey on anterior regions near lateral margin. Cercus pale grey.

Male subimago. Length: body 3.2–3.9 mm; fore wing 3.5–3.7 mm; hind wing 0.4–0.5 mm.

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

Thorax. Coloration of terga dark grey with pale brown sutures. Coloration of sterna and leg as in male imago. Fore and hind wings grey, opaque.

Abdomen. Coloration of terga I–VI pale grey, VII–X brown; lateral and posterior grey bands and transverse brown stripes as in male imago. Coloration of sterna as in male imagoes.

Female subimago. Length: body 3.0–3.1 mm; fore wing 3.4–3.5 mm; hind wing 0.4–0.5 mm.

Head. As in female imago.

Thorax. As in female imago except for grey and opaque wings.

Abdomen. As in female imago.

Nymph (Fig. 3). Length: body 3.1–4.3 mm.

Head. Head brown; antenna white. Antennal scape without distal lobe; pedicel without robust setae. Labrum with a distinct notch medially on anterior margin; with 3–4 simple setae along each side of anterior margin. Left mandible with incisor possessing seven denticles on medial margin, fourth denticle reduced, fifth denticle the largest, seventh denticle with some notches at base; prosthema with blunt denticles on apical region and acute denticles on basal region (Fig. 3a). Right mandible with incisor

possessing six denticles on medial margin, first denticle with a notch on anterior margin, sixth denticle with some notches on posterior margin; prosthema with acute denticles (Fig. 3b). Maxillary palpus without depression on disto-medial margin. Paraglossa 1.3–1.8× as wide as glossa. Segment II of labial palpus with a row of 4–6 long setae, inner lobe weak; segment III triangular (Fig. 3c).

Thorax. Terga dark grey with pale brown patterns (Fig. 3d). Sterna pale brown. Legs pale brown, femur with a grey patch in dorsomedial region, tibia and tarsus dark grey at distal region (Fig. 3d). Femur with robust setae with a medial ridge on dorsomedian surface; with clavate setae on outer margin. Tibia with robust setae on inner margin; without clavate setae on outer margin. Tarsus with robust setae on inner margin; without clavate setae on outer margin. Claws with a single row of fine denticles.

Abdomen. Terga dark grey, I–VIII usually with a anteromedial longitudinal streak, IV with pale brown lateral regions or with a pair of oval spots, V often with a pair of triangular patterns, IX pale brown in medial region, X pale brown (Fig. 3d). Sterna pale brown. Cercus and paracercus brownish white (Fig. 3d). Seven pairs of oval gills on posterolateral margins of segments I–VII; margins of gills fringed with spiny projections in uniform size and fine setae in various length. Paraproct with robust spiny projections on posterior 3/4 of medial margin, with notched scales on dorsal surface. Cercus with fine setae on medial margin (Fig. 3d). Paracercus 0.6–0.7× as long as cercus, with fine setae on lateral margins (Fig. 3d).

Remarks

Müller-Liebenau (1985) described *Baetis pseudofrequentus* from Taiwan. Kobayashi (1987) recorded this species from the Ryukyu Islands (Amami Island, Okinawa Island, Ishigaki Island, Iriomote Island).

We reared nymphs of this species collected in Okinawa Island and Ishigaki Island to imagoes. Comparing morphological characters of the reared imagoes with the description by Tong and Dudgeon (2000), we could not find any significant differences.

Tenuibaetis pseudofrequentus and *T. flexifemora* are quite similar to each other in both imaginal and nymphal stages, but only color patterns on abdominal terga IV, VIII and IX are different and useful for distinguishing these species.

Diagnostic characters for *T. pseudofrequentus* are given in Table 1.

Ecology. Nymphs of *T. pseudofrequentus* mostly occur in mountain streams of the Ryukyu Islands. Stream order of the regions where this species occur is usually 2 or 3. They inhabit the surface of stones, gravel and submerged parts of plants.

Distribution. Japan (Amami Island, Okinawa Island, Ishigaki Island, Iriomote Island), Taiwan, Hong Kong.

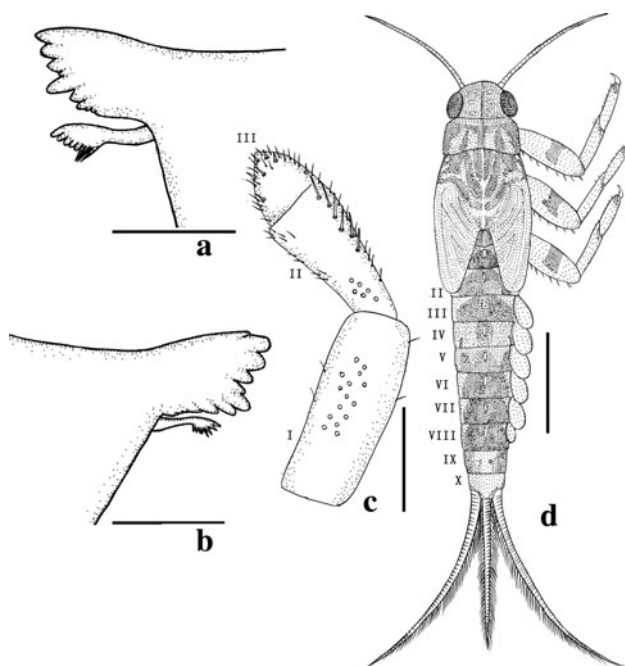


Fig. 3 *Tenuibaetis pseudofrequentus*. Nymph. **a** Left mandible; **b** right mandible; **c** labial palpus, dorsal view; **d** habitus, legs and gills on left side removed. Scale bars 1 mm in **d**; 0.1 mm in **a–c**

Materials examined

JAPAN. KAGOSHIMA: Amami, Chinaze, Chinazegawa Stream (28°22'07"N, 129°26'51"E), 4 n, 13.iv.2009, TF. Amami, Naze-Asato (28°20'02"N, 129°29'50"E), 1 m (li), 3 n, 11.iv.2009, TF. Amami, Sumiyo, Nishi-Nakama, Hiyakawa Stream (28°15'58"N, 129°24'33"E), 15 n, 12.iv.2009, TF. **OKINAWA:** Kunigami, Yona, Yonagawa Stream, Heigi Bridge (26°45'44"N, 128°12'55"E), 12 n, 16.iii.2004, TF. Kunigami, Yona, Yonagawa Stream (26°45'56"N, 128°12'40"E), 1 m, 8 n [8 n, 13.v.1998; 1 m (re), 17.iii.2004], TF. Ishigaki, Fukai (24°26'56"N, 124°12'36"E), 7 m, 4 f, 2 ms, 1 fs, 7 n [7 n, 11.v.1998; 6 m (re), 2 ms (re), 1 fs (re), 1.x.2002; 1 m (re), 4 f (re), 2.x.2002], TF. Ishigaki, Nagura, Nagura Stream, 6 n, 4.x.2002, TF. Ishigaki, Ohsato, Tohrogawa Stream (24°26'01"N, 124°14'30"E), 3 m, 4 n [4 n, 8.v.1998; 3 m (re), 9.v.1998], TF.

TAIWAN. TAICHUN HSIEN: Hsinshu, 2 n, 7.iii.1995, SCK. **TAIPEI:** Chingmei River, 1 n, 2.i.1989, KT.

Tenuibaetis parvipterus Fujitani sp. nov.

[Japanese name: Kobane Higetogari Kokagerou]

Baetis sp. E: Kobayashi 1987, 55; Yamasaki 1987, 86; Kuranishi and Kuhara 1994, 1212.

Tenuibaetis sp. E: Fujitani 2002, 114; Fujitani et al. 2003b, 131; Fujitani 2008, 208.

Male imago (Fig. 4). Length: body 3.2–5.4 mm; fore wing 3.5–5.6 mm; hind wing 0.3–0.7 mm.

Head. Head brown; antenna pale yellow, except for grey flagellum; turbinate eye orange; lower eye dark grey; ocellus white with grey base.

Thorax. Terga brown with lighter medial region (Fig. 1a), or wholly yellowish brown. Sterna brown or yellowish brown. Legs pale yellow in femur to tarsus, brown or yellowish brown in coxa. Wings hyaline. Hind wing with two simple longitudinal veins; costal projection prominent (Fig. 4b). Fore femur not bending distinctly (Fig. 4c).

Abdomen. Terga I–VI white semihyaline, median region yellow, VII–VIII brown, IX–X whitish brown; II–VI with lateral and posterior brown bands, I–VIII with transverse brown stripes near posterior margins (Fig. 4d). Sterna without distinct grey patterns (Fig. 4e). Cercus pale grey. Segment I of forceps cylindrical, without a distomedial projection; segment II cylindrical, tapering at apex; segment III tubular and incurvate, about 1.5× as long as segment II; segment IV ellipse (Fig. 4f).

Female imago (Fig. 5). Length: body 3.2–4.9 mm; fore wing 4.4–5.8 mm; hind wing less than 0.2 mm.

Head. Coloration of head and antenna yellow or brown, except for grey flagellum; compound eye dark grey.

Thorax. Terga brown or yellowish brown, with medial lighter region in some imago. Coloration of sterna and leg

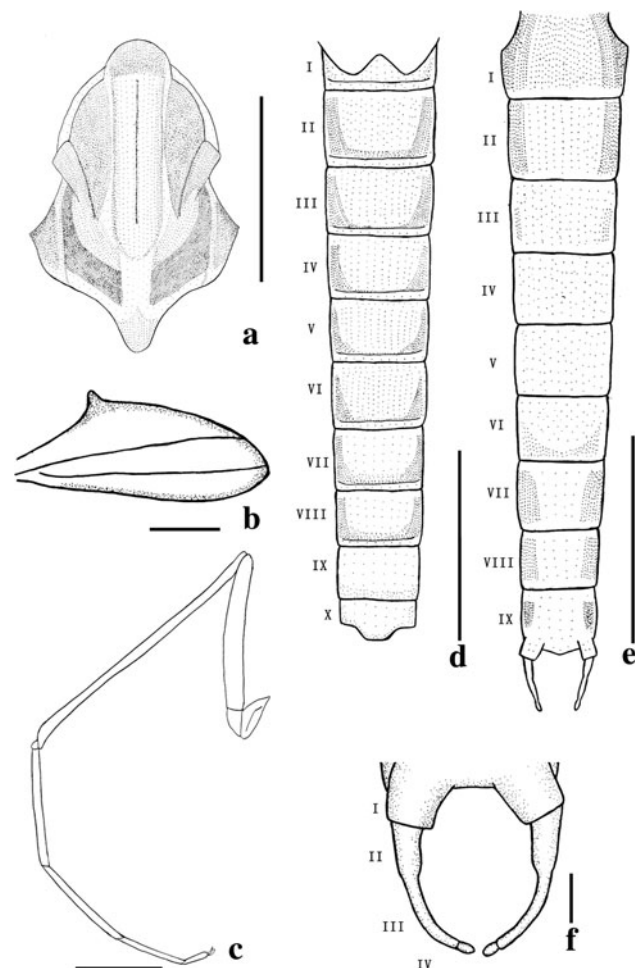


Fig. 4 *Tenuibaetis parvipterus* sp. n. Male imago. **a** Thoracic terga; **b** hind wing; **c** fore leg; **d** abdominal terga; **e**, abdominal sterna; **f**, forceps, ventral view. Scale bars 1 mm in **d**, **e**; 0.5 mm in **a**, **c**; 0.1 mm in **b**, **f**

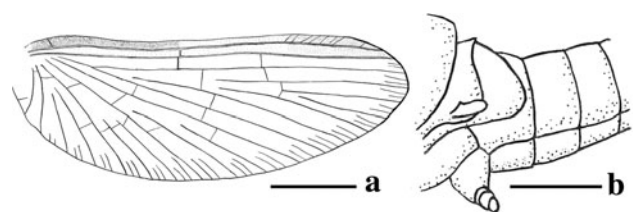


Fig. 5 *Tenuibaetis parvipterus* sp. n. Female imago. **a** Fore wing; **b** thorax, lateral view. Scale bars 1 mm

as in male imago. Fore wing generally hyaline, medial region near anterior margin dark brown in some imagos (Fig. 5a). Hind wing reduced; veins indistinct (Fig. 5b).

Abdomen. Coloration of terga yellowish brown, II–VI with lateral and posterior grey bands, I–VIII with transverse brown stripes on posterior margins. Coloration of sterna yellowish brown. Cercus pale grey.

Male subimago. Length: body 3.0–4.7 mm; fore wing 3.3–5.6 mm; hind wing 0.6–0.8 mm.

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

Thorax. Coloration of terga dark grey with pale brown sutures. Coloration of sterna and leg as in male imago. Fore and hind wings grey, opaque.

Abdomen. Coloration of terga I–VI pale grey, VII–X brown; lateral and posterior grey bands and transverse brown stripes as in male imago; coloration of abdominal sterna as in male imago.

Female subimago. Length: body 3.0–4.0 mm; fore wing 3.3–5.8 mm; hind wing less than 0.2 mm.

Head. As in female imago.

Thorax. As in female imago except for grey and opaque wings.

Abdomen. As in female imago.

Nymph (Fig. 6). Length: body 2.7–5.1 mm.

Head. Head brown; antenna white. Antennal scape without distal lobe; pedicel without robust setae. Labrum with a distinct notch medially on anterior margin; with 3–4 simple setae along each side of anterior margin. Left mandible with incisor possessing seven denticles on medial margin, fourth denticle reduced, fifth denticle the largest, seventh denticle with some notches at base; prostheca with blunt denticles on apical region and acute denticles on basal region (Fig. 6a). Right mandible with incisor possessing six denticles on medial margin, first denticle with a notch on anterior margin, sixth denticle with some notches on posterior margin; prostheca with acute denticles (Fig. 6b).

Maxillary palpus without depression on distomedial margin. Paraglossa 1.3–1.5× as wide as glossa. Segment II of labial palpus with a row of 4–5 long setae, inner lobe weak; segment III triangular (Fig. 6c).

Thorax. Terga brown with pale brown patterns (Fig. 6d). Sterna pale brown. Leg pale brown, femur with a grey patch in dorsomedian region, tibia and tarsus dark grey at distal region (Fig. 6d). Femur with robust setae with a medial ridge on dorsomedian surface; with clavate setae on distal margin. Tibia with robust setae on inner margin; without clavate setae on outer margin. Tarsus with robust setae on inner margin; without clavate setae on outer margin. Claws with a single row of fine denticles.

Abdomen. Terga brown, I–III and V–IX with a anteromedial longitudinal streak, II and VI–VIII usually with a pair of pale brown circular spots, III–V usually with a pair of pale brown oval or triangular spots variable in size and often fused each other, IX pale brown in posterior region, X pale brown (Fig. 6d). Sterna pale brown. Cercus and paracercus pale brown (Fig. 6d). Seven pairs of oval gills on posterolateral margins of segments I–VII; margins of gills fringed with spiny projections in uniform size and fine setae in various length. Paraproct with robust spiny projections on posterior 3/4 of medial margin, with notched scales on the dorsal surface. Cercus with fine setae on medial margin (Fig. 6d). Paracercus 0.6–0.7× as long as cercus, with fine setae on lateral margins (Fig. 6d).

Remarks

Kobayashi (1987) distinguished the nymph of *Tenuibaetis* sp. E from other baetid nymphs. In this paper, he also showed that this species was distributed in Hokkaido, Honshu, Shikoku and Kyushu (Kobayashi 1987).

Male imagoes of *T.* sp. E resemble those of *B. ursinus* Kazlauskas, 1963 in regard to coloration of body and shape of forceps. But, comparing the morphological characters with the description by Kluge (1983), *T.* sp. E is distinguishable by venation of hind wing.

Hind wing of female imago of *T.* sp. E is smaller than those of the male imagoes (Fig. 5b). This character is useful for distinguishing female imagoes of *T.* sp. E from closely related species. According to the difference in hind wing, we concluded that *T.* sp. E and *B. ursinus* were not conspecific, and *T.* sp. E was an undescribed species. Thus, we describe this species as a new species herein.

Brown pigmentation of the fore wing was observed in some female imagoes from mountain streams of central Japan, Yuragawa Stream (Kyoto Pref.), Takamigawa Stream (Nara Pref.), Totsugawa Stream (Nara Pref.) and Hinogawa Stream (Tottori Pref.). Concerning this variation, we did not find a distinct tendency in season and geographical distribution.

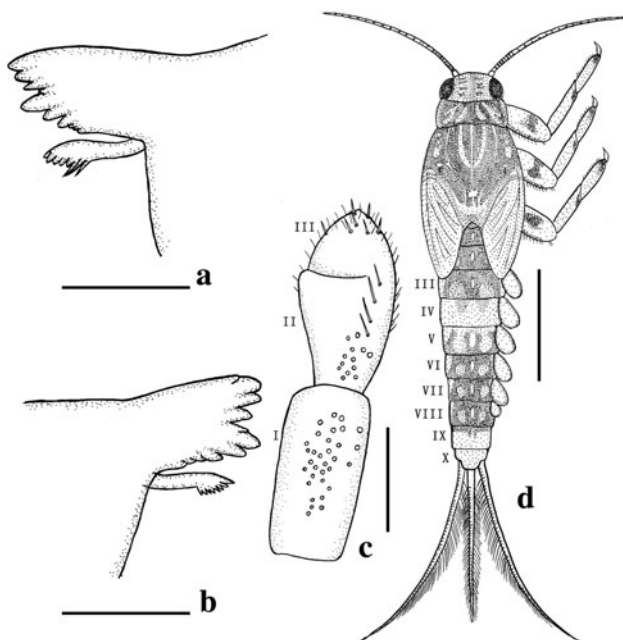


Fig. 6 *Tenuibaetis parvipterus* sp. n. Nymph. **a** Left mandible; **b** right mandible; **c** labial palpus, dorsal view; **d** habitus, legs and gills on left side removed. Scale bars 1 mm in **d**; 0.1 mm in **a–c**

Diagnostic characters for *T. parvipterus* are tabulated in Table 1.

Etymology. In the species name, “parvi” and “pterus” mean small and wing in Latin, respectively. This species was named after the reduced hind wing of females.

Ecology. Nymphs of *T. parvipterus* are present in mountain streams and plain rivers, and the center of downstream distribution is in the former (Fujitani 2002, 2006). Stream order of the regions where this species occur is usually 3 or 4. They inhabit the surface of stones, gravel and submerged parts of plants. They are often abundant on the surface of stones covered with filamentous green algae. Nymphs are collected in all seasons.

Distribution. Japan (Hokkaido, Honshu, Shikoku, Kyushu).

Materials examined

Holotype. ONNH TI 490. JAPAN. KYOTO: Ayabe, Mutsuyori, Kanbayashigawa Stream (35°22′37″N, 135°26′43″E), 1 m (re), 2-V-2000, TF.

Paratypes. KYOTO: Ayabe, Yuragawa Stream, Tanba Bridge (35°17′57″N, 135°15′54″E), 1 m (re), 1 f (re), 30-IV-2000, TF; Ayabe, Mutsuyori, Kanbayashigawa Stream (35°22′37″N, 135°26′43″E), 1 m (re), 1 f (re), 2-V-2000, TF. NARA: Higashi-Yoshino, Kozugawa, Takamigawa Stream (34°23′52″N, 135°59′34″E), 1 f (re), 4-XI-1999, TF; 2 m (re), 8-XI-1999, TF.

Other materials examined

JAPAN. NIIGATA: Murakami, Komata, Komatagawa Stream (38°30′37″N, 139°35′39″E), 18n, 21.x.2004, TF. NAGANO: Ueda, Takeishi, Takeishigawa Stream (36°17′27″N, 138°15′11″E), 6 n, 20.v.2001, TF. MATSUMOTO: Azusagawa-Azusa, Azusagawa (36°12′28″N, 137°51′16″E), 26 n, 22.v.2001, TF. MATSUMOTO: Azumi, Shimashima, Shimashimadani-gawa Stream (36°11′16″N, 137°46′45″E), 1 m, 1 f, 6 n [1 m (re), 6 n, 21.v.2001; 1 f (re), 22.v.2001], TF. MATSUMOTO: Nagawa, Kawaura, Nagawa Stream (36°02′28″N, 137°38′21″E), 1 n, 21.v.2001, TF. HASE: Sugishima, Mibu Stream (35°43′45″N, 138°05′13″E), 1 m (re), 2 f (re), 24.v.2001, TF. SHIZUOKA: Shinuzu, Kakita Stream, Kakita Bridge (35°06′01″N, 138°54′04″E), 4 m, 1 f, 7 n [1 f (re), 4 n, 23.iv.2001; 4 m (sw), 3 n, 24.iv.2001], TF. FUKUI: Kuzuryûgawa Stream, Asamiya Bridge (36°02′20″N, 136°10′28″E), 1 n, 22.iv.1993. SHIGA: Takashima, Kutsuki, Tateto, Kitagawa Stream, 2 m (re), 6 n, 7.x.1999, TF. KYOTO: Kyotango, Inotani, Ukawa Stream, 12 n, 31.vii.2000, TF. Ayabe, Mutsuyori, Kanbayashigawa

Stream (35°22′37″N, 135°26′43″E), 2 m, 2 f, 2 ms, 1 fs, 3n [1 f (re), 1 ms (re), 1 fs (re), 1.v.2000; 2 m (re), 1 f (re), 1 ms (re), 3 n, 2.v.2000], TF. Nantan, Tanano Stream, Tanamura Bridge (35°18′43″N, 135°33′08″E), 2 f (re), 27.iv.1999, TF. Nantan, Miyamacho-Minami, Yuragawa Stream (35°18′37″N, 135°38′11″E), 1 f (li), 8.v.2000, TF. Nantan, Miyamacho-Ashiu, Yuragawa Stream (35°18′28″N, 135°43′05″E), 1 ms, 11 n [1 ms (re), 9.v.2000; 11 n, 10.v.2000], TF. KYOTO: Sakyo-ku, Kurama (35°06′48″N, 135°46′24″E), 2 m, 1 f [2 m (li), 11.viii.1999; 1 f (li), 12.viii.1999], TF. KYOTO: Sakyo-ku, Ohara, 1 f (re), 12.viii.1999, TF. Wazuka, Wazuka Stream, Iwai Bridge (34°48′05″N, 135°54′44″E), 1 f, 2 ms, 1 fs, 5 n [5 n, 13.vi.1999; 1 f, 2 ms, 1 fs, 14.vi.1999], TF. OSAKA: Kaizuka, Sobura, Kogi Stream (34°21′33″N, 135°25′16″E), 2 m, 1 f [1 m (re), 3.v.2000; 1 f (re), 25.iv.2000; 1 m (re), 4.xi.2001], TF. Kaizuka, Sobura, Akiyamagawa Stream (34°22′19″N, 135°24′22″E), 1 f (re), 21.iv.1999, TF. NARA: Higashiyosino, Kozukawa, Takamigawa Stream (34°23′52″N, 135°59′34″E), 8 m, 9 f, 5 ms, 3 fs, 27 n [1 m (re), 1 f (re), 1.xi.1999; 3 f (re), 3.xi.1999; 2 m (re), 4.xi.1999; 1 f (re), 1 ms (re), 27 n, 5.xi.1999; 1 m (re), 1 f (re), 6.xi.1999; 1 f (re), 1 ms (re), 7.xi.1999; 2 m (re), 8.xi.1999; 2 m (li), 2 f (li), 3 ms (li), 3 fs (li), 25.vii.2000], TF. Higashi-Yoshino, Ômata, Shigogawa Stream, Kuramae Bridge (34°22′42″N, 136°03′45″E), 1 f, 29 n [6 n, 5.v.2001; 23 n, 6.v.2001; 1 f, 12.v.2001], TF. Yoshino, Kamiichi, Yoshino River (34°23′39″N, 135°52′06″E), 1 m (li), 1 f (li), 8.vi.2002, TF. Kawakami, Unokawa, Yoshinogawa River (34°22′17″N, 135°56′37″E), 2 f (re), 1 ms (re), 1 fs (re), 18.v.2001, TF. Kawakami, Unokawa, Nakaigawa Stream (34°22′15″N, 135°57′09″E), 1 fs, 46 n [16 n, 12.v.2001; 5 n, 17.xi.2001; 21 n, 16.ii.2002; 1 n, 11.iv.2002; 1 fs (re), 2.v.2001; 3 n, 5.v.2001], TF. Totsukawa, Uenoji, Totsukawa Stream (34°06′41″N, 135°46′20″E), 8 m, 3 f, 1 ms, 1 fs, 10 n [1 m (re), 4 m (li), 1 ms (li), 1 f (li), 29.x.2000; 2 m (re), 2 f (re), 1 fs (re), 30.x.2000; 1 m (re), 10 n, 31.x.2000], TF. WAKAYAMA: Hashimoto, Kinokawa River, Kinokawa Bridge (34°19′02″N, 135°37′09″E), 1 ms, 2 n [1 ms (re), 15.x.1999; 2 n, 17.x.1999], TF. TOTTORI: Houki, Mizokuchi, Hinogawa Stream, Kimori Bridge (35°20′33″N, 133°26′05″E), 1 f (re), 3 n, 23.xi.1999, TF. Yonago, Hinogawa Stream, Yawata Bridge (35°24′10″N, 133°23′25″E), 1 m (re), 27.viii.2000, TF. TOKUSHIMA: Waki, Kanekawa, Higashimatatanigawa Stream (34°08′05″N, 134°11′36″E), 1 m, 5 f, 91 n [71 n, 30.x.1999; 1 m (re), 3 f (re), 20 n, 31.x.1999; 1 f (re), 1.xi.1999; 1 f (re), 2.xi.1999], TF. FUKUOKA: Kama, Kodai Bridge, Onga Stream (33°33′46″N, 130°43′3″E), 1 f (re), 20.ix.2000, TF. Hisayama, Todoroki Bridge (33°40′31″N, 130°31′20″E), 1 n, 21.ix.2000, AO. NAGASAKI: Oseto, Gotsu Stream, Iwaseto Bridge (32°57′37″N, 129°42′36″E), 1 m (re), 3 m (li), 1 f (li), 7 n, 7.vi.2001, TF.

Discussion

The genus *Tenuibaetis* consists of five species: *T. pseudofrequentus*, *T. arduus* Kang and Yang, *T. inornatus* Kang and Yang, *T. flexifemora*, and *T. parvipterus* (Kang et al. 1994). *Tenuibaetis pseudofrequentus* is distributed in Ryukyu Island, Taiwan and Hong Kong. *Tenuibaetis flexifemora* and *T. parvipterus* are only recorded in Japan. *Tenuibaetis arduus* and *T. inornatus* are considered to be endemic to Taiwan (Kang et al. 1994). Imago and nymph were only associated in three species that occur in Japan. Thus, it is important to associate imagoes and nymphs of two endemic species of Taiwan and examine their generic situation.

Tenuibaetis species have been recorded from the eastern part of the Palearctic realm and northern part of the Oriental realm. In regard to the eastern part of the Palearctic realm, recently baetid species have not been described or revised in China (Gattolliat and Nieto 2009). In regard to the Oriental realm, it is highly possible that we only know a small part of the baetid fauna (Gattolliat and Nieto 2009). Thus, it is important to examine baetid species from these realms and evaluate if they can be assigned to *Tenuibaetis* or other genera. As our taxonomic study on Baetidae advances in the Palearctic realm and Oriental realm, distribution of this genus may be revealed to be wider.

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References

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 (in Japanese). *Jpn J Limnol* 67:185–207
- Fujitani T (2008) The family Baetidae from Japan. In: Hauer FR, Stanford JA, Newell RL (eds) International advances in the ecology zoogeography and systematics of mayflies and stoneflies. University of California Publications, Berkeley, pp 205–218
- 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 & 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
- Gattolliat JL, Nieto C (2009) The family Baetidae (Insecta: Ephemeroptera): synthesis and future challenges. *Aquat Insects* 31(Suppl 1):41–62
- Geographical Survey Institute (2008) Watchizu. Online service for searching and reading 1:25,000 topographic maps of Japan. <http://watchizu.gsi.go.jp/>. Last accessed 23/1/2010
- Gose K (1980) The mayflies of Japanese 7 (in Japanese). *Aquabiology* 2:122–123
- Ishiwata S (2001) A checklist of Japanese Ephemeroptera. In: Bae YJ (ed) The 21st century and aquatic entomology in East Asia. Proc. 1st Symp. AESEA. Proceedings of the first symposium of aquatic entomologists in East Asia. The Korean Society of Aquatic Entomology, Seoul, pp 55–84
- Ishiwata S, Kobayashi N (2003) Ephemeroptera (in Japanese). 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
- 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
- Kobayashi N (1987) *Baetis* species as biological indices of water quality (in Japanese). 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
- Kobayashi N (1992) Ephemeroptera (in Japanese). In: Moriya H (ed) Benthic fauna in Sagami-hara City. The Sagami-hara Board of Education, Kanagawa, pp 18–24
- Kuranishi RB, Kuhara N (1994) Benthic fauna in Akan (in Japanese). The Nature of Akan National Park, 1993. Maeda Ippoen Foundation, Akan, Hokkaido, pp 835–1240
- Müller-Liebenau I (1969) Revision der europäischen Arten der Gattung *Baetis* Leach, 1815 (Insecta, Ephemeroptera) (in German). *Gewässer Abwässer* 48(49):1–214
- Müller-Liebenau I (1985) Baetidae from Taiwan with remarks on *Baetiella* Uéno, 1931 (Insecta, Ephemeroptera). *Arch Hydrobiol* 104:93–104

- Tong X, Dudgeon D (2000) *Baetiella* (Ephemeroptera: Baetidae) in Hong Kong, with description of a new species. *Entomol News* 111:143–148
- Uéno M (1931) Einige neue Ephemeropteren und Plecopteren aus Mittel-Japan (in German). *Annot Zool Jpn* 13:91–104
- Waltz RD, McCafferty WP (1997) New generic synonymies in Baetidae (Ephemeroptera). *Entomol News* 108:134–140
- Yamasaki T (1987) Mayflies of the Tamagawa River system and their distribution (in Japanese). In: Ishikawa R, Yamasaki T, Kojima J, Uchida S (eds) *Analytic studies on the distribution of some insect groups in the Tamagawa River system and its upper reaches*. Tokyu Foundation for Better Environment, Tokyo, pp 81–120