Two new species and a newly recorded species of black flies (Diptera: Simuliidae) from Hokkaido, Japan, with the description of the male of Simulium (Simulium) iwatense (Shiraki)

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Abstract: Two new species, Simulium (Simulium) iwasai and S. (S.) obihiroense, are described from females collected from Hokkaido, Japan. Both new species are placed in the S. (S.) venustum species-group. Simulium (Montisimulium) kobayashii Okamoto et al., is newly recorded from Hokkaido. In addition, the male of S. (S.) iwatense (Shiraki) in the S. (S.) ornatum species-group is fully described for the first time based on males reared from pupae collected from Hokkaido.

Key words: aquatic insects, taxonomy, biodiversity

INTRODUCTION

The fauna of black flies in Japan is represented by 79 species, of which 41 are recorded from Hokkaido, one of four main islands of Japan (Takaoka, 2014; Takaoka et al., 2018). They are placed in five genera: two species in Helodon Enderlein, five in Prosimulium Roubaud, three in Twinnia Stone & Jamnback, 30 in Simulium Latreille and one in Stegopterna Enderlein (Adler, 2020).

We collected three more species in the genus Simulium from Hokkaido, of which two species belonging to the S. venustum species-group in the subgenus Simulium Latreille s. str. are described as new species from females collected by sweeping around the udder of a cow, and the remaining one, S. (Montisimulium) kobayashii Okamoto et al., originally described from Tottori, Japan, is recorded for the first time from Hokkaido.

In addition, the male of S. (S.) iwatense (Shiraki) is fully described for the first time.

Methods of morphological observation, terms of features, descriptions, and illustrations, followed those of Takaoka (2003) and partially those of Adler et al. (2004).

The type specimens of two new species are deposited in Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan.

Simulium (Simulium) iwasai Takaoka, Otsuka & Fukuda sp. nov.

Female (n=5). Body length 3.0–3.6 mm. Head. Frons brownish black, shiny and whitish pruinose when illuminated, almost bare, though several hairs along each lateral margin and near lower margin; frontal ratio 1.36–1.40:1.00:1.04–1.14; frons: head ratio 1.00:3.24–3.59. Clypeus brownish black, shiny and white-pruinose when illuminated, and moderately covered with hairs. Labrum 0.71–0.76 times as long as clypeus. Antenna composed of scape, pedicel and nine flagellomeres, all dark brown. Maxillary palpus composed of five palpomeres; proportional lengths of third, fourth, and fifth palpomeres 1.00:1.08–1.17:2.06–2.24; sensory vesicle (Fig. 1A) ellipsoidal, 0.37–0.40 times length of third palpomere, with medium-sized round opening. Maxillary lacinia with 12–14 inner and 16–19 outer teeth. Mandible with 29 or 30 inner and 13–15 outer teeth. Cibarium (Fig. 1B) with 74–104 tiny processes medially; cornuae moderately developed. Thorax. Scutum black, shiny and white-pruinose on shoulders, lateral portion along each lateral margin, and prescutellar area when
illuminated at certain angles, moderately covered with yellow short hairs interspersed with several dark brown long upright hairs on prescutellar area. Scutellum black, with dark brown upright long hairs and yellow short hairs. Postnotum black, white-pruinose and shiny when illuminated at certain angles, and bare. Pleural membrane dark brown and bare. Katepisternum longer than deep, nearly black, shiny when illuminated, and bare. Legs. Foreleg: coxa yellow; trochanter medium brown; femur dark brown except base medium brown; tibia yellowish white except base dark yellow to light brown and apical cap brownish black, and with sheen on medial large portion of outer surface; tarsus black; basitarsus with thick dorsal hair crest, much inflated, 4.05–4.18 times as long as its greatest width. Midleg: coxa brownish black; trochanter dark brown; femur

Fig. 1. Female of S. (S.) inwasai sp. nov. A, maxillary palpus (right side; anterior view); B, upper part of cibarium (anterior view); C, tibia of hind leg (left side; outer view); D, basitarsus and second tarsomere of hind leg (left side; outer view); E, sternite 8 and ovipositor valves (ventral view); F and G, genital forks (F, ventral view; G, lateral view); H and I, paraprocts and cerci (H, ventral view; I, lateral view); J, spermatheca. Scale bars. 0.1 mm for C and D; 0.04 mm for A; 0.02 mm for B and E–J.
brownish black; tibia brownish black to black except basal two-fifths whitish yellow (though posterior surface whitish yellow on basal half); tibia with sheen on posterior surface; tarsus brownish black except basal one-third of basitarsus dark yellow. Hind leg: coxa brownish black; trochanter dark yellow; femur brownish black except base dark yellow to light brown; tibia (Fig. 1C) brownish black except little more than basal half whitish yellow (though posterior surface yellowish white on basal two-thirds), and with sheen on posterior surface; tarsus dark brown to brownish black except basal half (or little more) of basitarsus whitish yellow (though base light brown) and basal half of second tarsomere yellow to light brown; basitarsi (Fig. 1D) nearly parallel-sided, 0.42–0.44 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 1D) slightly shorter than width at base, 0.42–0.44 times as wide as basitarsi; pedisculus (Fig. 1D) well developed; claw simple, without tooth. 

**Wing**. Length 2.5–2.6 mm. Costa with dark spinules and yellow hairs. Subcosta haired except apical one-fourth bare. Basal section of vein R bare; R 1 with dark and yellow hairs. Subcosta haired except apical one-third of basitarsus dark yellow. Hind leg: coxa brownish black; trochanter dark yellow; femur brownish black except base dark yellow to light brown; tibia (Fig. 1C) brownish black except little more than basal half whitish yellow (though posterior surface yellowish white on basal two-thirds), and with sheen on posterior surface; tarsus dark brown to brownish black except basal half (or little more) of basitarsus whitish yellow (though base light brown) and basal half of second tarsomere yellow to light brown; basitarsi (Fig. 1D) nearly parallel-sided, 5.81–6.19 times as long as its greatest width, 0.66–0.70 and 0.59 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 1D) slightly shorter than width at base, 0.42–0.44 times as wide as basitarsi; pedisculus (Fig. 1D) well developed; claw simple, without tooth.

**Type specimens.** Holotype. Female, collected by sweeping around the udder of a cow, in Obihiro, Hokkaido, Japan, 24-VI-2014, by M. Iwasa. Paratypes. Four females, same data as for the holotype.

**Etymology.** The species, *iwasai*, is in honor of Dr. M. Iwasa, Professor Emeritus, Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan, who collected this new species.

**Remarks.** *Simulium* (S.) *iwasai* sp. nov. is assigned to the *S. (S.) venustum* species-group in having the scutum unpatterned, simple claws, and triangular ovipositor valves (Adler et al. 2004). This new species is distinguished from *S. (S.) arakawai* Matsumura, *S. (S.) nipponense* Shiraki and *S. (S.) tobetsuense* Ono, the three Japanese species of the *S. venustum* species-group, by the darker leg color (*e.g.*, the forefemur dark brown in this new species but yellowish brown with the base yellow in *S. (S.) nipponense*, and the mid tibia brownish black to black except the basal two-fifths whitish yellow in this new species but yellow except the apical one-third or one-fourth darkened in *S. (S.) arakawai* and *S. (S.) tobetsuense*) and the greater number of stout hairs on the ovipositor valve (18–20 hairs in this new species but 10–13 hairs in *S. (S.) arakawai* and *S. (S.) tobetsuense*; no information on the number of hairs on the ovipositor valve in *S. (S.) nipponense* (Shiraki, 1935; Ono, 1977; Takaoka, 1977; Rubtsov, 1989).

*Simulium* (S.) *rubtzi* Smart from Russia and Alaska is similar to this new species by having similar terminalia including the sternite 8 and ovipositor valves covered with numerous distinct hairs (Adler et al., 2004) but is distinguished from this new species by the relative length of the sensory vesicle against the third palpomere, which is 0.3 times in *S. (S.) rubtzi* (according to Rubtsov, 1989) versus 0.37–0.40 times in this new species, and four of five sensilla on the anteromedial surface of the paraproct present on the sclerotized portion, according to Adler et al. (2004) (eight sensilla all on the unsclerotized portion in this new species).

*Simulium* (S.) *curvitarse* Rubtsov described from Kamchatka, Russia (Rubtsov, 1989) is also similar to this new species by having similar dark leg color and an ovipositor valve with its inner margin concave and covered with 16–20 hairs, but distinguished by the smaller number of hairs on each lateral side of sternite 8 (22–24 hairs versus 53–56 hairs in this new species).

*Simulium* (Simulium) *obihiroense* Takaoka & Iwasa sp. nov.

**Female** (*n* = 1). Body length 2.9 mm. **Head.** Frons brownish black, shiny and white-pruinose when illuminated, almost bare, though several hairs along each lateral margin and near lower margin; frontal ratio 1.36:1.00:1.34; frons:head ratio 1.00:3.85. Clypeus brownish black, shiny and white-pruinose
when illuminated, and moderately covered with hairs. Labrum 0.71 times as long as clypeus. Flagellomeres of antenna lost on both sides. Maxillary palpus composed of five palpomeres (segmentation appears to be incomplete between palpomeres 3 and 4 on right side (Fig. 2A) and between palpomeres 4 and 5 on left side (Fig. 2B); sensory vesicle (Fig. 2A, B) ellipsoidal, 0.30 times length of third palpomere, with medium-sized round opening. Maxillary lacinia with 11 or 12 inner and 17 outer teeth. Mandible with 28–30 inner and 12 outer teeth. Cibarium (Fig. 2C) with 60 tiny processes medially; cornuae moderately developed. Thorax. Nearly as in female of S. (S.) iwasai sp. nov. Legs. Foreleg: coxa dark yellow; trochanter medium brown; femur dark brown; tibia (Fig. 2D) yellowish white except base dark brown and apical cap brownish black, and with medial large portion on outer surface white and shiny; tarsus black; basitarsus with thick dorsal hair crest, much inflated, 4.06 times as long as its greatest width. Midleg: coxa brownish black;
trochanter and femur dark brown; tibia (Fig. 2E) medium brown to brownish black on apical three-fifths, medium brown on base and yellow on rest; tarsus dark brown except basal one-third of basitarsus light to medium brown. Hind leg: coxa brownish black; trochanter dark brown with apex brownish black; tibia (Fig. 2F) whitish yellow on basal half (though base dark yellow), and medium brown to brownish black on rest; tarsus (Fig. 2G) dark brown except basal two-fifths of basitarsus whitish yellow (though base and narrow area along anterior margin medium brown) and basal half of second tarsomere medium brown; basitarsus (Fig. 2G) nearly parallel-sided, 6.08 times as long as its greatest width, 0.68 and 0.57 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 2G) slightly shorter than width at base, 0.39 times as wide as basitarsus; pedisulcus (Fig. 2G) well developed; claw simple, without tooth. 

**Wing.** Length 2.1 mm. Other characteristics as in female of *S. (iwasai)* sp. nov. *Halter and Abdomen.* Nearly as in female of *S. (iwasai)* sp. nov. except abdominal segment 7 without sternal plate(s) medially. **Terminalia** Sternite 8 (Fig. 2H) with anterior margin convex medially and posterior margin moderately concave, and covered with 33–39 short to long hairs on each side. Ovipositor valve (Fig. 2H), genital fork (Fig. 2L), paraproct and cercus (Figs. 2K, L) nearly as in female of *S. (iwasai)* sp. nov. except paraproct in ventral view with five sensilla on anteromedial surface, paraproct in lateral view (Fig. 2L) 0.65 times as long as wide, with 32–34 short to long stout hairs on lateral surface, and cercus in lateral view (Fig. 2L) 0.59 times as long as its greatest width. Spermatheca (Fig. 2M) ellipsoidal, 1.6 times as long as wide, well sclerotized except duct and area of junction with duct unsclerotized, without reticulate surface patterns; minute internal setae present.

**Type specimen.** Holotype. Female, collected by sweeping around the udder of a cow, in Obihiro, Hokkaido, Japan, 24–VI-2014, by M. Iwasa.

**Etymology.** The species name, *obihiroense,* refers to the city, Obihiro, where this new species was collected.

**Remarks.** *Simulium (S.) obihiroense* sp. nov. is assigned to the *S. (S.) venustum* species-group in having the scutum unpatterned, simple claws, and triangular ovipositor valves (Adler et al., 2004).

This new species is distinguished from *S. (S.) arakawae,* *S. (S.) nipponense* and *S. (S.) tobetsuense* by the darker leg color (e.g., the hind femur dark brown to brownish black in this new species but yellowish brown to blackish brown except the base or the basal half yellow in the latter three species) and the greater number of stout hairs on the ovipositor valve (18–20 hairs in this new species but 10–13 hairs in *S. (S.) arakawae* and *S. (S.) tobetsuense*).

This new species is distinguished from *S. (S.) iwasai* sp. nov. by the darkened base of the mid tibia (Fig. 2E) (the base of the mid tibia whitish yellow in *S. (S.) iwasai* sp. nov.) and hind basitarsus (Fig. 2G) much darker than that of *S. (S.) iwasai* sp. nov. (Fig. 1D).

This new species is also similar to *S. (S.) rubtzovi* and *S. (S.) curvitarse* but is distinguished from these two species by the hind basitarsus darkened on the apical three-fifths (Fig. 2G) (hind basitarsi darkened on the apical half or less in the latter two species according to Rubtsov (1989)).

**Simulium (Montisimulium) kobayashii** Okamoto, 1958

*S. (Eusimulium) kobayashii* Okamoto, Yoshida, Sato & Shogaki, 1958

**Simulium (Eustigmatolimnium) kobayashii** Okamoto, Yoshida, Sato & Shogaki, 1958: 183–186 (Female, male and pupa).

**Specimen examined.** One male and its associated pupal exuviae and cocoon, collected from a Fundo Waterfall, Hiroo-cho, Hiroo-gun, Hokkaido, Japan, 29–VI-2009, by H. Takaoka.

**Remarks.** This species was described from Tottori, western Honshu, Japan by Okamoto et al. (1958). The pupa of this species is characterized by the gill with 12 thread-like filaments arising from a short common basal stalk and arranged as seven filaments in a dorsal group and five ones in a ventral group (the dorsal group consisting of 2+3+2 filaments and the ventral group consisting of 3+2 filaments arranged from inside to outside), and a simple cocoon without an anterodorsal projection. The present pupa collected from Hokkaido, Japan, has almost the same characteristics as in the original description.

The characteristics of the present male including the dark leg color and shape of the genitalia are also the same as those originally described. The number of upper-eye (large) facets in 21 vertical columns and 22 horizontal rows, one of key male characteristics not mentioned in the original description, is added.

**Simulium (Simulium) iwatense** (Shiraki, 1935)

*Odagmia iwatensis* Shiraki, 1935: 40–42 (Female). *Simulium ornatum* (not sensu Meigen): Bentinck, 1955: 11 (Female, male and pupa).

**Male** (*n*=5). Body length 3.0–3.3 mm. **Head.** Nearly as wide as thorax. Upper eye medium brown, with large facets in 24 vertical columns and 24 or 25 horizontal rows. Clypeus brownish black, thickly white-pruinose, covered with dark brown hairs along lateral margins and near ventral margin and medial portion bare. Antenna composed of scape, pedicel and nine flagellomeres, dark brown; first flagellomere elongate, 1.59 times as long as second one. Maxillary palpus light brown except third and fourth palpomeres dark brown, composed of five palpomeres, with proportional lengths of third, fourth, and fifth palpomeres 1.00:1.29:3.07; third palpomere (Fig. 3A) with apex produced inwardly; sensory vesicle (Fig. 3A) having the scutum unpatterned, simple claws, and *clypeus* having the scutum unpatterned, simple claws, and *clypeus*
Fig. 3. Male of S. (S.) iwatense. A, third palpomere of maxillary palpus showing sensory vesicle (right side; anterior view); B and C, basitarsi and second tarsomeres of hind leg (left side; outer view); D, coxites and styles (ventral view); E and F, styles (right side; E, ventrolateral view; F, medial view); G and I, ventral plates (G, anteroventral view; I, caudal view); H, ventral plate and median sclerite (lateral view); J, median sclerite (caudal view); K, paramere (left side; caudal view); L, aedeagal membrane (caudal view); M and N, tenth abdominal segments and ceci (right half; M, lateral view; N, caudal view). Scale bars. 0.1 mm for B and C; 0.02 mm for A and D–N.
3A) small, ellipsoidal, 0.21–0.26 times as long as third palpomere, and with small opening. **Thorax.** Scutum brownish black, with white-pruinose pattern, *i.e.*, anterior pair of triangular spots on shoulders extended posteriorly along lateral margins and connected near base of wings to large transverse posterior spot entirely covering prescutellar area; these pruinose areas silvery or bluish iridescent when illuminated at certain angles; scutum uniformly and moderately covered with yellow recumbent short hairs interspersed with several dark brown long upright hairs on prescutellar area. Scutellum brownish black, with several dark brown long upright hairs and yellow short hairs. Postnotum brownish black, white-pruinose when illuminated at certain angles and bare. Pleural membrane with many fine yellow hairs on upper portion and even on small area anterior to pleural membrane. Katepisternum longer than deep, brownish black, white-pruinose when illuminated at certain angles, and bare. **Legs.** Foreleg: coxa yellow; trochanter medium brown; femur medium brown except apical cap dark brown; tibia medium brown except median large portion white on outer surface and apical cap dark brown; tarsus brownish black, with moderate dorsal hair crest; basitarsus greatly dilated, 5.76–5.88 times as long as its greatest width. Midleg: coxa brownish black; trochanter medium brown; femur medium brown except apical cap dark brown; tibia light to dark brown except basal two-fifths whitish on posterior surface (border obliquely delimited when viewed laterally); tarsus medium brown except basal one-third or less of basitarsus dark yellow to light brown. Hind leg: coxa dark brown; trochanter dark yellow to light brown; femur medium brown except base yellow and apical cap dark brown; tibia medium brown except dark brown except base yellowish white; tarsus (Fig. 3B, C) medium brown except basal half of basitarsus (though extreme base light brown) yellowish and basal half or little less of second tarsomere light brown; basitarsus moderately enlarged, slightly widened from base to apical one-third, then slightly narrowed, as in Fig. 3B, or slightly widened from base to apical one-fourth, then nearly parallel-sided, as in Fig. 3C, 4.65–5.45 times as long as its greatest width, 0.77–0.82 and 0.71–0.82 times as wide as greatest widths of hind tibia and femur, respectively; calcipala (Fig. 3B, C) small, much shorter than wide, 0.29–0.35 times as wide as greatest width of basitarsus; pedisculus (Fig. 3B, C) well developed.

**Wing.** Length 2.3–2.5 mm. Costa with dark spinules and hairs except basal patch of hairs light brown; subcosta bare; basal section of radius bare; R 1 with dark brown spinules and hairs; R 2 with dark brown hairs; hair tuft on base of radius dark brown; basal cell absent. **Abdomen.** Basal scale brownish black, with fringe of dark long hairs. Dorsal surface of abdomen brownish black, with dark short hairs; segments 2, 6, 7 and 8 each with pair of white large spots dorsolaterally or laterally (though segment 5 appearing to have pair of white small spots dorsolaterally anterior margin), those on segment 2 broadly connected in middle to each other. Sternites 4–8 each subquadrate, simple plate-like. Sternite of segment 9 in form of well sclerotized and dark pigmented horizontal bar. **Genitalia.** Coxite in ventral view (Fig. 3D) nearly quadrate. Style in ventral view (Fig. 3D) elongate, much longer than coxite, with subterminal spine; style in ventrolateral view (Fig. 3E) widest at basal one-fourth, slightly widened from base to basal one-fourth, somewhat tapered toward apical one-third, and nearly parallel-sided to apex, and with round apex; style in medial view (Fig. 3F) somewhat produced dorsally at basal one-fourth, then narrowed toward apical one-third. Ventral plate in anteroventral view (Fig. 3G) Y-shaped, well sclerotized and dark pigmented, with body subquadrate having median process moderately covered with setae; arms divergent at right angle or little less from each other; ventral plate in lateral view (Fig. 3H) with body having serrated posterior margin and distinct median process directed ventrally; ventral plate in caudal view (Fig. 3I) with body short and slightly narrowed ventrally, having about ten teeth in each of two vertical and parallel rows, and round median process moderately covered with minute setae on posterior surface. Median sclerite in lateral view (Fig. 3H) arising near anterior tip of body of ventral plate, directed posteriorly and dorsally; median sclerite in caudal view (Fig. 3J) plate-like, gradually widened from base to middle, then nearly parallel-sided. Paramere in caudal view (Fig. 3K) broad basally, with several distinct hooks. Aedeagal membrane (Fig. 3L) densely covered with microsetae, with dorsal plate indistinct. Abdominal segment 10 with two distinct hairs on ventral surface on each side (Fig. 3M, N). Cercus rounded posteriorly, nearly as long as basal width (when viewed laterally), with 10–13 hairs (Fig. 3M).

**Specimens examined.** Five males with their associated pupal exuviae and cocoons, collected from Shihoro-cho, Hokkaido, Japan, 5-VIII-2011, by Y. Otsuka.

**Distribution.** Japan (Hokkaido and Honshu), China, Korea and Siberia.

**Remarks.** The male of *S. (iwatense)* is fully described and illustrated based on five males reared from pupae collected from Hokkaido, Japan. The genitalia of this species are almost the same as those illustrated by Bentinck (1955) based on specimens collected from Honshu, Japan. The morphological characteristics of the male of *S. (iwatense)* including upper-eye (large) facets in 24 vertical columns and 24 or 25 horizontal rows, as shown here, will be useful for comparison with the 23 other members in the *S. (ornatum)* species-group, all of which are recorded from Palaearctic and Nearctic.
Regions (Adler, 2020).

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