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SIMULIUM (*NEVERMANNIA*) *BONNINENSE* FROM THE OGASAWARA (BONIN) ISLANDS, JAPAN (DIPTERA: SIMULIIDAE): TAXONOMIC ASSIGNMENT TO THE *VERNUM*-GROUP AND DESCRIPTIONS OF MALE, PUPA AND MATURE LARVA

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Abstract: Descriptions and illustrations of male, pupa and mature larva of a black-fly species, *Simulium* (*Nevermannia*) *bonninense* (Shiraki, 1935), from the Ogasawara (Bonin) Islands in Japan are given for the first time; the female adult is also redescribed. Within the subgenus *Nevermannia*, this species is assigned to the *vernum*-group by the combination of the following characters: male genitalia with a lamellate ventral plate without median keel, an elongate style with a large, broad, inwardly-twisted apex, a single parameral hook per side, and an inverted Y-shaped median sclerite; pupal gill with four slender filaments per side; and larval mandible with supernumerary serrations. Interestingly, this species has the katepisternum haired in both sexes of adults, female genital fork with a prominent projection directed forwards on each arm, and pupal frons with two trichomes on each side, all of which are rare in this species-group. Brief notes on adult blood-feeding, and larval habitats of *S.* (*N.*) *bonninense* are given.

Key words: Simuliidae, *Simulium*, black fly, Ogasawara Islands, *bonninense*

Shiraki (1935) described *Simulium* (*Nevermannia*) *bonninense* (then, under the genus *Eusimulium*) from a single female adult specimen collected in the Ogasawara (Bonin) Islands, ca. 1,000 km south-southeast from Tokyo, in the Pacific Ocean. Stone (1964) gave excellent illustrations as well as a brief description of the female of this species based on 13 females collected in 1958 from Hahajima Is., while reporting three other species of Simuliidae from Micronesia. The immature stages of this species were found for the first time by Saito *et al.* (1974). However, no descriptions have ever been made.

The present paper gives the redescription of the female, and descriptions of the male, pupa and mature larva, of *S.* (*N.*) *bonninense*, based on reared or light-trapped adults, and immature stages recently collected by one of us (HS), as well as those examined by Saito *et al.* (1974), and one female loaned from the Natural History Museum, London, UK (BMNH). This species is assigned to the *vernum*-group within the subgenus *Nevermannia*, as provisionally treated by Takaoka and Davies (1995).

***Simulium* (*Nevermannia*) *bonninense* (Shiraki, 1935)**

Eusimulium bonninense Shiraki, 1935: 21-23.

Simulium (*Eusimulium*) *bonninense*: Tokunaga, 1943: 943; Stone, 1964: 634-635; Crosskey, 1989: 223.

Simulium (*Nevermannia*) *bonninense*: Takaoka and Okazawa, 1988: 98; Takaoka and Davies, 1995: 163; Crosskey and Howard, 1997: 49.

DESCRIPTION. **Female**. Body length 2.7-3.0 mm. ***Head.*** Narrower than thorax. Frons and clypeus brownish black, not shiny, white-pruinose, moderately covered with whitish yellow fine simple hairs, interspersed with brown longer and stouter hairs. Frontal ratio

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1.6:1.0:1.6. Frons-head ratio 1.0:4.9. Fronto-ocular area (Fig. 1) well developed. Antenna composed of 2+9 segments, dark brown to brownish black. Maxillary palp consisting of 5 segments, brownish black, proportional lengths of 3rd, 4th and 5th segments 1.0:1.0:1.7; 3rd segment (Fig. 2) somewhat enlarged, with sensory vesicle elongate, ca. 2.0× as long as wide, and ca. 0.3× as long as 3rd segment. Maxillary lacinia with 14 inner teeth and 15 or 16 outer ones. Mandible with 26-28 inner teeth and 11-15 outer ones. Cibarium smooth. ***Thorax.*** Scutum brownish black, white-pruinose, densely covered with whitish yellow recumbent fine hairs, and with several brown upright hairs on prescutellar area. Scutellum brownish black, with many brown upright hairs as well as whitish yellow recumbent fine hairs. Postscutellum brownish black, bare. Pleural membrane bare. Katepisternum longer than deep, with several fine hairs near upper margin on each side. ***Legs.*** Dark brown to brownish black, except hind trochanter dark yellow to light brown, base of hind tibia yellow, basal 3/5 of hind basitarsus and basal 1/2 of 2nd hind tarsal segment whitish yellow. Fore basitarsus slender, ca. 7.2× as long as wide. Hind basitarsus (Fig. 3) nearly parallel-sided, 5.6× as long as wide, and much narrower than hind tibia. Calcipala and pedisulcus (Fig. 3) well developed. Claws (Fig. 5) each with large basal tooth. ***Wing.*** Length 2.0-2.3 mm. Costa with 2 parallel rows of short spines as well as hairs. Subcosta haired except apical 1/4 bara (in 1 female, apical 1/2 bare). Hair tuft on stem vein brown. Basal portion of radius fully haired. Basal cell absent. ***Abdomen.*** Basal scale brownish black, with fringe of pale long hairs. Dorsal surface of abdominal segments dark brown to brownish black, not shiny, with short dark hairs; terga 3-6 medium, nearly quadrate, subequal in size to one another, tergum 7 nearly 2.0× as wide as terga 3-6, but still confined to dorsal surface, while terga 8 and 9 very wide, extending laterally. ***Genitalia*** (Figs. 6-8). Sternal plate of 7th abdominal segment well developed, nearly triangular. Sternum 8 wide, bare medially but furnished with ca. 12 stout hairs on each side. Anterior gonapophysis thin, membraneous, triangular, densely covered with microsetae and several short setae; inner margin narrowly sclerotized; posteromedian corner rounded. Genital fork with well sclerotized stem and wide arms; each arm with a wide round lobe directed medioposteriorly and a prominent projection directed forward. Paraproct somewhat protruding ventrally. Cercus rounded posteriorly in lateral view. Spermatheca ovoid or pear-shaped, strongly sclerotized except tube and small area of tubal base bare or weakly sclerotized; internal setae absent.

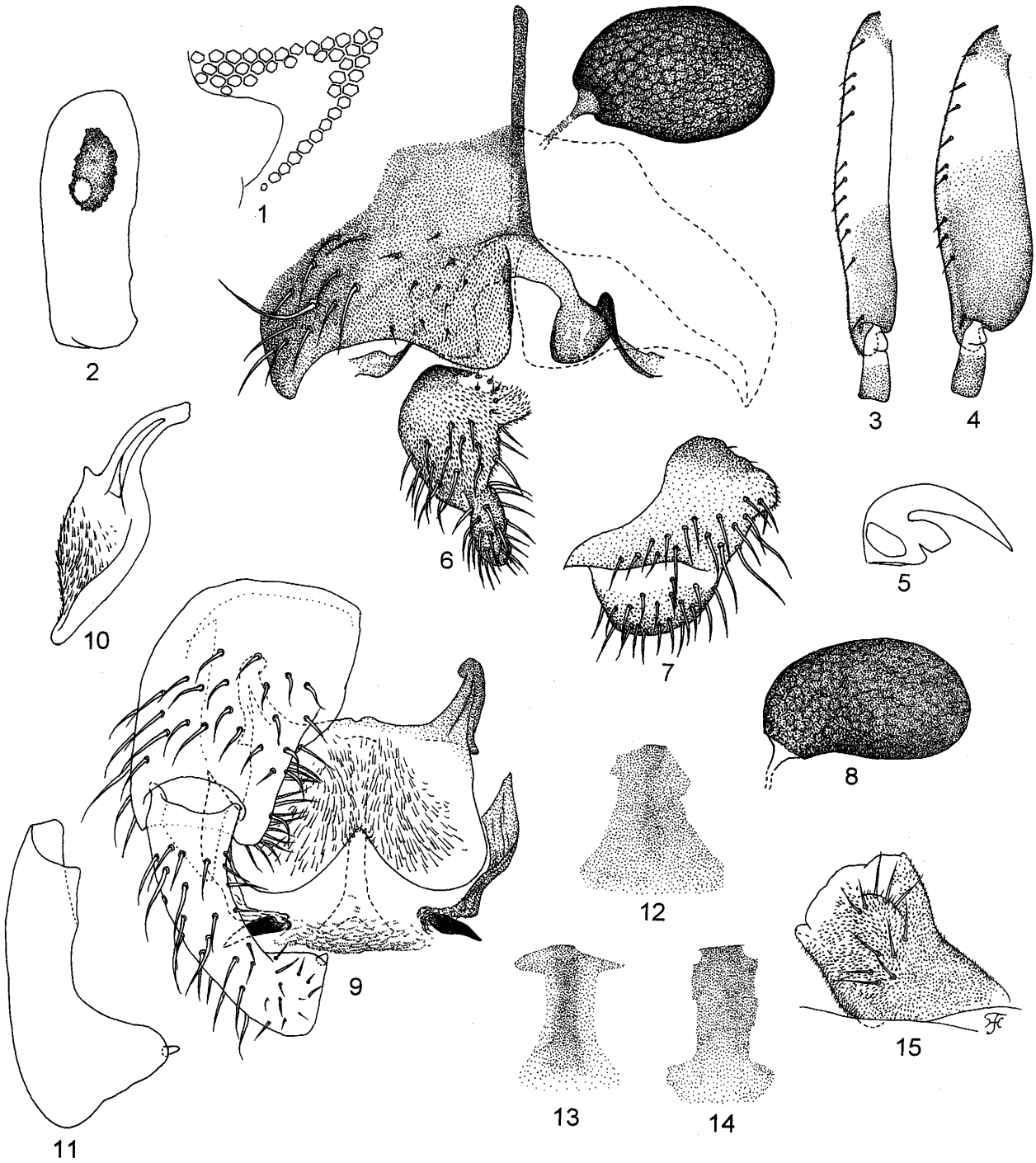
Male. Body length 2.5 mm. ***Head.*** As wide as, or slightly wider than, thorax. Holoptic; upper eye consisting of large facets in 19 vertical columns and 20 horizontal rows. Clypeus dark brown, gray-pruinose, moderately covered with dark simple hairs. Antenna composed of 2+9 segments, dark brown; 1st flagellar segment somewhat elongate, ca. 1.9× as long as 2nd flagellar segment. Maxillary palp brown, composed of 5 segments, proportional lengths of 3rd, 4th and 5th segments 1.0:1.0:2.3; sensory vesicle small, ellipsoidal. ***Thorax.*** Scutum brownish black, not shiny, densely covered with yellow recumbent fine hairs, and with several brown upright hairs on prescutellar area. Scutellum brownish black, with many brown upright hairs as well as pale fine hairs. Postscutellum brownish black, bare. Pleural membrane bare. Katepisternum longer than deep, with several fine hairs near upper margin on each side. ***Legs.*** Dark brown to brownish black except basal 2/5 of hind basitarsus and basal 1/2 of 2nd hind tarsal segment whitish yellow. Fore basitarsus slender, ca. 7.9× as long as wide. Hind basitarsus (Fig. 4) enlarged, 3.2× as long as its greatest width, slightly wider than hind tibia but slightly narrower than hind femur. Calcipala and pedisulcus (Fig. 4) well developed. ***Wing.*** As in female except subcosta bare or with a few hairs; length 2.0 mm. ***Abdomen.*** Basal scale brownish black, with fringe of pale long hairs. Dorsal surface of abdominal segments dark brown to brownish black, not shiny, with short dark hairs. ***Genitalia*** (Figs. 9-15). Coxite subquadrate much longer than wide. Style slightly shorter than coxite, broadly truncate apically, twisted, then apical part bent inwards, and with a subapical spine directed inward and forward. Ventral plate lamellate, shorter than wide, with a small medial notch on anterior border, and a deep medial concavity on posterior border, and moderately covered with fine short setae on ventral surface; arms short, stout, and bent inwardly and dorsally. Parameres of normal form, each with a distinct hook. Median sclerite slender, forked apically. Dorsal plate of various forms, much broader than median sclerite. Aedeagal membrane with spinous microsetae. Cercus small, spherical in lateral view, with several hairs.

Pupa. Body length ca. 2.5 mm. ***Head.*** Integument yellowish brown, sparsely or moderately covered with cone-shaped tubercles of various sizes (Fig. 16); antennal sheath also sparsely covered with groups of many cone-shaped tubercles; face with 1 simple (or occasion-

ally bifid), stout trichome on each side (Fig. 17), while frons with 2 slenderer trichomes, of which 1 is much shorter, on each side (Fig. 18). ***Thorax.*** Integument yellowish brown, moderately covered with cone-shaped tubercles of various sizes, with 3 long, stout trichomes mediodorsally (Fig. 19), 2 (1 long, stout, and 1 medium, slender) trichomes mediolaterally (Fig. 20), 1 medium, stout trichome posterolaterally (Fig. 21), and 3 (2 medium, stout and 1 short, slender) trichomes ventrolaterally (Fig. 22), all simple (or occasionally bifid on tip). Gill (Fig. 23) with 4 slender filaments arranged in pairs, each pair with very short stalk, arising from very short basal common stalk; all filaments yellowish brown to dark brown, subequal in length to one another (1.7-2.0 mm) (or 2 filaments of dorsal pair slightly shorter than those of ventrolateral pair), and 2 filaments of dorsal pair slightly thicker than those of ventrolateral pair, at least near base; cuticular surface with distinct annular ridges and furrows, and densely covered with minute tubercles. ***Abdomen.*** Terga 1 and 2 yellowish brown, moderately tuberculate; tergum 1 with 1 medium, slender seta on each side; tergum 2 with 1 medium, slender seta and 5 short, spinous setae (1 or 2 occasionally much stouter than others). Terga 3-8 each with yellowish brown area of varying sizes anteriorly; terga 3 and 4 each with 4 hooks and a few spinous setae on each side; tergum 5 bare; terga 6-9 each with many groups of minute spines directed backward on each side; tergum 6 with 0-3 spine-combs, which are, if present, much smaller than those on tergum 8; tergum 7 with 0-8 spine-combs; tergum 8 with 7 or more spine-combs in transverse row on each side; tergum 9 yellowish brown, with a pair of distinct, cone-shaped terminal hooks (Fig. 24). Sternum 4 with 1 simple or bifid hook submedially, which is subequal in size to those on sterna 5-7, and a few slender setae (1 of which is often somewhat longer and stouter) on each side; sternum 5 with a pair of bifid hooks submedially and a few slender setae on each side; sterna 6 and 7 each with 1 bifid hook submedially and 1 simple hook laterally, and a few slender setae, on each side. ***Cocoon.*** Wall-pocket-shaped, usually with narrow anteroventral connection, compactly woven without open spaces in web, with anterior margin thickly woven, and only slightly extending ventrolaterally; 2.8-3.0 mm long ×1.2-1.4 mm wide.

Mature larva. Body length 5.0-5.3 mm. Body grayish dorsally, mottled to varying extents with dark violet brown color on each thoracic and abdominal segment. Cephalic apotome (Photo. 1) pale on anterior 2/5, dark yellow to yellowish brown on posterior 3/5, with posterior margin somewhat darkened, and with distinct positive head spots. Cervical sclerite composed of 2 small rod-like pieces, not fused to occiput, widely separated medially from each other. Antenna consisting of 3 segments and apical sensillum, longer than stem of labral fan; proportional lengths of 1st, 2nd and 3rd segments 1.0:1.1:0.7-0.8. Labral fan with 34-36 main rays. Mandible (Fig. 25) with a few supernumerary serrations, as well as 2 usual mandibular serrations; comb-teeth composed of 3 teeth, of which 1st tooth is largest, 2nd is smallest and 3rd is intermediate. Hypostomium (Fig. 26) with a row of 9 apical teeth, of which median and corner teeth are moderately developed, and 3 intermediate teeth on each side are small and subequal in size to one another; lateral serrations moderately developed; 5 or 6 hypostomal bristles lying slightly divergent posteriorly from lateral margin on each side. Postgenal cleft (Fig. 27) medium, miter-shaped, with apex pointed or occasionally rounded, variable in length, 1.0-1.8× as long as postgenal bridge. Thoracic cuticle bare. Abdominal cuticle bare except last segment covered with colorless short setae on each side of anal sclerite. Rectal papilla of 3 simple lobes, without secondary lobules. Anal sclerite of usual X-form, with posterior arms ca. 1.4× as long as anterior ones; basal portion of arms and anterior arms widely sclerotized. Accessory sclerite absent. Ventral papillae small, laterally placed, then, often indiscernible when the larva is viewed laterally. Posterior circlet with ca. 90 rows of up to 15 hooklets per row.

SPECIMENS EXAMINED. HAHAJIMA IS. (E142°07′-E142°11′, N26°36′-N26°43′), OGASAWARA (BONIN) ISLANDS, JAPAN: 1 female (genitalia dissected and mounted on glass slide), pinned, probably light-trapped, 26.IV-9.VI.1958, F.M. Snyder (BMNH); 3 females, 3 males, all reared from pupae (all dissected and mounted on glass slides), 14 pupae, 10 pupal exuviae, 5 mature larvae, 3.VII.1973, K. Saito; 2 pupal exuviae, Kitamura, 20.IV.1996, H. Suzuki; 2 females, light-trapped, 10.V.1996, M. Yoshihara; 5 females, 27.V.1996, M. Yoshihara; 6 females (1 blood-engorged), light-trapped, 17.VI.1996, M. Yoshihara; 3 females, 17.VII.1996, M. Yoshihara; 3 females, 12.VIII.1996, M. Yoshihara; 1 female, netted, 10.VII.1997, K. Takehara. CHICHIJIMA IS. (E142°11′-E142°14′, N27°02′-N27°06′), OGASAWARA (BONIN) ISLANDS: 2 females, light-trapped, Sakaiura, 15.IV.1996, H. Suzuki; 3 pupae, 2 pupal exuviae, 9 mature larvae, Sakaiura, 17.IV.1996, H. Suzuki; 5 females (all blood-engorged), 2 males, light-trapped, 16.IV.1996, H.



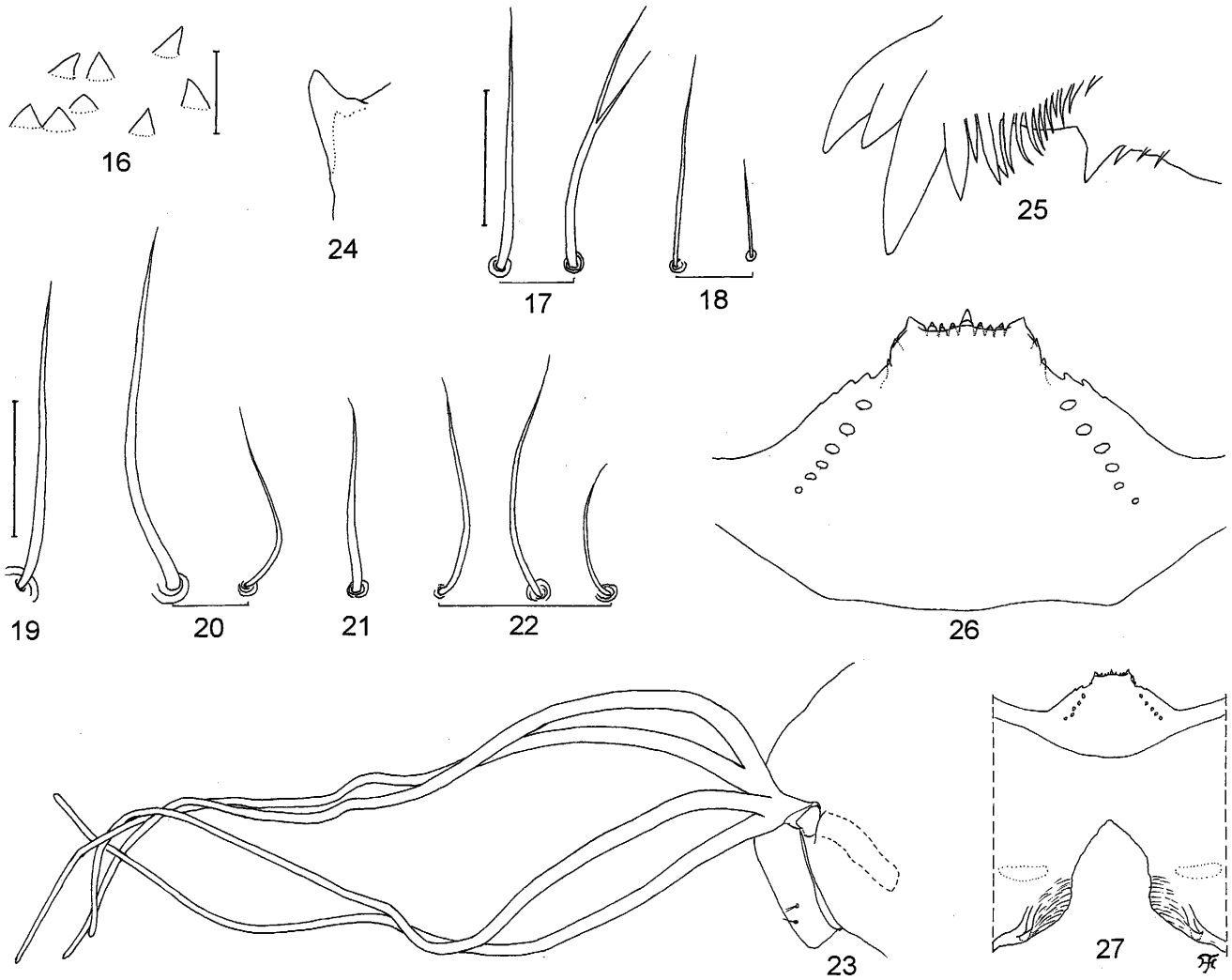
Figures 1-15. Female and male adult characters of *Simulium* (*Nevermannia*) *bonninense*. 1, fronto-ocular area of female; 2, 3rd segment with sensory vesicle of female maxillary palp; 3 and 4, basitarsus and 2nd tarsal segment of hind leg, showing calcipala and pedisulcus (3, female; 4, male); 5, tarsal claw of female foreleg; 6, female genitalia (ventral view, female loaned from BMNH), showing 8th sternite, anterior gonapophyses, genital fork, spermatheca with weakly sclerotized tubal base and right paraproct and cercus; 7, right paraproct and cercus (lateral view); 8, spermatheca with pale tubal base (female reared from pupa); 9, male genitalia (ventral view), showing coxite, style of right side, ventral plate, parameres, aedeagal membrane and median sclerite; 10, ventral plate (lateral view); 11, style (ventromedial view); 12-14, dorsal plates in different shapes; 15, male 10th abdominal segment (lateral view) showing small hairy round cercus.

Suzuki; 3 females, 1 male, all reared from pupae, 9 pupae, 2 pupal exuviae, 17 mature larvae, Shigure-dam, 16.IV.1996, H. Suzuki; 4 mature larvae, Ohgiura, 18.IV. 1996, H. Suzuki.

BIOLOGICAL NOTES. Female and male adults of *S.* (*N.*) *bonninense* were captured by light trap from April to August, and some of the females were fully blood-fed, indicating that its life cycle is multivoltine, and its ovarian development is anautogenous. Host animals are unknown. One female adult was netted while flying around the knee of man during day-time. It remains uncertain as to whether this species feeds on man, although villagers often claimed so.

Immature stages of *S.* (*N.*) *bonninense* were found in small, swift-flowing streams partially shaded by shrubbery. Stream beds were mostly rocky and widths were about 50 cm or less. The pupae and larvae attached to grasses trailing in the water from the banks. The larvae collected comprised a final instar and many other earlier instars including a first instar. No other simuliid species was found in all the streams sampled.

DISTRIBUTION. Chichijima Is. and Hahajima Is. in



Figures 16-27. Pupal and larval characters of *Simulium* (*Nevermannia*) *bonninense*. 16-24, pupa; 25-27, larva. 16, tubercles on frons (oblique view); 17, facial trichomes (left, of usual simple form; right, of occasional bifid form); 18, frontal trichomes; 19, mediodorsal thoracic trichome; 20, mediolateral thoracic trichomes; 21, posterolateral thoracic trichome; 22, ventrolateral thoracic trichomes; 23, gill filaments (lateral view); 24, terminal hook (lateral view); 25, apical part of mandible; 26, hypostomium (ventral view); 27, head capsule (ventral view) showing postgenal cleft. Scale bars: 0.02 mm for Fig. 16; 0.04 mm for Figs. 17 and 18, and Figs. 19-22.

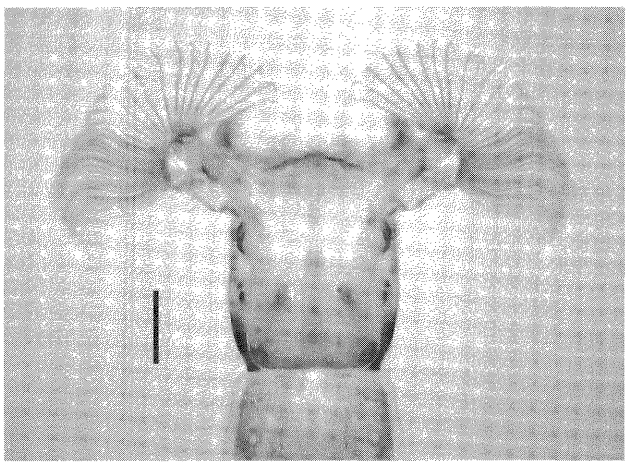


Photo. 1 Larval head (dorsal view) of *Simulium* (*Nevermannia*) *bonninense*. Scale bar: 0.2 mm.

the Ogasawara (Bonin) Islands, Japan.

PRMARKS. Within the subgenus *Simulium* (*Nevermannia*), *S.* (*N.*) *bonninense* is assigned to the *vernum*-group (formerly *latipes*-group, as defined by Crosskey in 1969), by the combination of the following characters: male genitalia with a simple, lamellate ventral plate, an elongate style with a large, inwardly-twisted apex, a single parameral hook per side, and an inverted Y-shaped median sclerite; pupal gill with four slender filaments per side; and larval mandible with supernumerary serrations.

It is worthwhile to note that *S.* (*N.*) *bonninense* has the katepisternum haired in both sexes of adults, female genital fork with a prominent projection directed forwards on each arm, and pupal frons with two trichomes on each side, all of which are rare in the *vernum*-group.

There are five other known species belonging to the *vernum*-group in Japan: *S.* (*N.*) *acmeria* (Ono), *S.* (*N.*) *boldstemta* (Ono) (Ono, 1978), *S.* (*N.*) *larvipilosum* Okazawa (Okazawa, 1984), *S.* (*N.*) *subcostatum* (Takahasi) and *S.* (*N.*) *uchidai* (Takahasi) (Takaoka, 1976). The first two species resemble *S.* (*N.*) *bonninense* by having the forwardly-directed projection on each arm of the female genital fork and two pairs of trichomes on the pupal frons, although there are great differences in many other characters including the shape of the ventral plate and the coloration of the hind legs.

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