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Three new species of black flies (Diptera: Simuliidae) from the Lesser Sunda Archipelago, Indonesia

Takaoka, H.[1*], Sofian-Azirun, M.[2], Chen, C.D.[2], Lau, K.W.[2], Halim, M.R.A.[2], Low, V.L.[1] and Suana, I.W.[3]

[1]Tropical Infectious Diseases Research and Education Centre (TIDREC), University of Malaya, Kuala Lumpur, 50603 Malaysia

[2]Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia

[3]Faculty of Mathematics and Natural Science, University of Mataram (UNRAM), Mataram, 83125 Indonesia

[*]Corresponding author e-mail: takaoka@oita-u.ac.jp

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Abstract. *Simulium* (*Gomphostilbia*) *dhangi* sp. nov., *S.* (*G.*) *sumbaense* sp. nov. and *S.* (*Nevermannia*) *wayani* sp. nov. are described from the Lesser Sunda Archipelago, Indonesia. *Simulium* (*G.*) *sumbaense* sp. nov. is placed in the *S. varicorne* species-group and is characterized by the pupal gill with eight filaments arranged as (1+1+1+1+2)+2 from dorsal to ventral, while *S.* (*G.*) *dhangi* sp. nov., unplaced to group, is characterized by the pupal gill composed of two inflated trunks and four slender filaments all arising basally, and the short larval antenna as long as the stem of the labral fan. *Simulium* (*N.*) *wayani* sp. nov. belongs to the *S. ruficorne* species-group and is characterized by the female spermatheca with an unsclerotized neck, and pupal gill with four inflated filaments. The number of species of black flies from the archipelago increases from 19 to 22.

INTRODUCTION

The black fly fauna in the Lesser Sunda Archipelago, Indonesia, is essentially Oriental in character and rich in diversity. It is represented by 19 species belonging to 12 lineages across four subgenera of the genus *Simulium* Latreille (nine species in four species-groups in *Gomphostilbia* Enderlein, two species in two species-groups in *Nevermannia* Enderlein, seven species in five species-groups in *Simulium* and one species in *Wallacellum* Takaoka) (Takaoka *et al.*, 2006, 2017a, b, d).

Simulium (*Gomphostilbia*) *atratum* De Meijere was reported to feed on the blood of domestic fowls in Java (Friederichs, 1925) but the biting habits of other 18 species remain unknown.

We surveyed aquatic stages of black flies in Sumba and Timor in this archipelago in September 2017 and collected eight species including three new species, of which two are assigned to the subgenus *Gomphostilbia* and one to the subgenus *Nevermannia*. One of the two new species of the subgenus *Gomphostilbia* collected from Sumba is placed in the *S. varicorne* species-group, representing a first record of this species-group from the archipelago, whereas the other new species from Sumba and Timor is characterized by the pupal gill composed of two inflated trunks and four slender filaments all arising basally, and the larval antenna as long as the stem of the labral fan, a combination of characters not previously found in any species-groups. A new species of the subgenus *Nevermannia* collected from Timor is placed in the *S. ruficorne* species-group, representing the fourth member of this species-group in the Oriental Region.

This survey increases the number of species of black flies from the archipelago from 19 to 22.

MATERIAL AND METHODS

Larvae and pupae of black flies in this study were collected from nine sites in Sumba and 12 sites in Timor (Table 1). Collectors were M. Sofian-Azirun, C.D. Chen, K.W. Lau, M.R.A. Halim and I.W. Suana. This survey was carried out under the agreement of MOU between Mataram University and University of Malaya.

The methods of collection, description and illustration, and terms for morphological features used here, follow those of Takaoka (2003) and partially those of Adler *et al.* (2004).

The holotype and paratypes of the new species are deposited at Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia.

The adult black flies used in this study were reared from pupae. Immature larvae were examined under a dissecting microscope for infections with microsporidans, mermithid nematodes and fungi (*Coelomycidium* sp.). These infections were diagnosed by the visible signs and symptoms of the larval body characteristics of each of these pathogens (Crosskey, 1990).

RESULTS AND DISCUSSION

A total of the eight species collected are placed in the following four subgenera of the genus *Simulium*: four species in *Gomphostilbia*, two species in *Nevermannia*, one species in *Simulium* and one species in *Wallacelllum*.

Simulium (*Gomphostilbia*) *lemborense* Takaoka & Sofian-Azirun, 2017

Simulium (*Gomphostilbia*) *lemborense* Takaoka & Sofian-Azirun, in Takaoka *et al.*, 2017b: 150–156 (Female, male, pupa and larva).

Specimen examined. One female, with its associated pupal exuviae and cocoon (site 4).

Distribution. Flores and Sumba (**New record**).

Remarks. This species was described from females, males, pupae and mature larvae collected from Flores by Takaoka *et al.* (2017b). This is the only species of the *S. batoense* species-group in the Lesser Sunda Archipelago. It is characterized by a narrow female frons and pupal gill with eight filaments, of which two filaments of the ventral pair are three to four times as long as the six other filaments.

This is the first record of this species from Sumba.

Simulium (*Gomphostilbia*) *atratum* De Meijere, 1913

Simulium atratum De Meijere, 1913: 331–332 (Female and male).
Simulium (*Gomphostilbia*) *atratum*: Takaoka and Davies, 1996: 18.
Simulium (*Gomphostilbia*) *sundaicum* Edwards, 1934: Takaoka and Davies, 1996: 19–22 (Female, male, pupa and larva), synonymized by Takaoka (2012).

Specimens examined. Ten females, 7 males, 9 pupae, 6 mature larvae and 33 immature larvae (site 1); 1 mature larva and 14 immature larvae (site 2); 2 mature larvae and 26 immature larvae (site 4); 1 female, 4 males, 3 pupae, 13 mature larvae and 131 immature larvae (site 5); 4 males, 2 pupae, 1 mature larva and 4 immature larvae (site 7); 28 females, 29 males, 36 pupae, 48 mature larvae and 290 immature larvae (site 8); 6 females, 6 males, 5 pupae, 3 mature larvae and 30 immature larvae (site 9); 1 pupa and 3 immature larvae (site 13); 22 females, 16 males, 18 pupae, 31 mature larvae and 133 immature larvae (site 15); 1 mature larva (site 18); 5 females, 3 males, 6 pupae, 9 mature larvae and 116 immature larvae (site 19); 14 females, 33 males, 36 pupae, 9 mature larvae and 116 immature larvae (site 20); 1 pupa and 121 immature larvae (site 21).

Distribution. Bali, Flores, Java, Lombok, Sumatra, Sumba (**New record**), Sumbawa and Timor.

Remarks. This species is a member of the *S. epistum* species-group and is recorded from Sumba for the first time.

Table 1. Information for 21 stream sites, where pupae and larvae of black flies were collected from the Lesser Sunda Archipelago, Indonesia

No.	Locality name	Latitude, longitude	Elevation (m)	Water temperature (°C)	Stream width (m)	Stream depth (cm)	Stream bottom	Canopy	Sampling date
				Sumba					
1.	Wainokaka, Waikabubak	9°40'55.5"S, 119°27'49.1"E	33	26.2	0.5–1.0	10	Pebble	Partially shaded	6-X-2017
2.	Wainokaka, Waikabubak	9°40'28.2"S, 119°28'21.2"E	80	26.2	7–10	20–50	Rock, sand	Partially shaded	6-X-2017
3.	Wanokaka, Waibakul	9°40'45.9"S, 119°29'29.6"E	75	25.9	10–20	10–70	Rock	Open	6-X-2017
4.	Mbatakapidu, Waingapu	9°40'57.4"S, 120°13'50.7"E	67	25.8	0.1–0.2	5–10	Rock, pebble	Fully shaded	7-X-2017
5.	Metakapit, Waingapu	9°42'02.6"S, 120°13'21.8"E	101	25.0	3–5	20–30	Rock, pebble	Partially shaded	7-X-2017
6.	Watumbaka, Waingapu	9°39'57.3"S, 120°20'57.8"E	-3	30.0	0.5–0.6	20–30	Pebble, sand	Open	7-X-2017
7.	Lewa, East Sumba	9°42'22.0"S, 119°54'25.4"E	546	24.6	0.5	5	Concrete	Open / Partially shaded	8-X-2017
8.	Tana Dharu, Ngadu Bolu	9°38'33.5"S, 119°41'08.2"E	505	23.3	2–5	5–10	Rock, pebble	Partially shaded	8-X-2017
9.	Lole, West Sumba	9°37'16.4"S, 119°28'58.7"E	403	24.8	0.1–0.2	5	Rock, pebble	Open	8-X-2017
				Timor					
10.	Tuapukan, Kupang	10°06'30.2"S, 123°46'03.8"E	-2	26.0	0.5–2.0	5–10	Pebble, sand	Open	10-X-2017
11.	Air Kom, Kupang	10°05'27.4"S, 123°50'58.5"E	6	26.5	1.0–1.5	10–15	Pebble, sand	Open	10-X-2017
12.	Camplong, Kupang	10°02'47.7"S, 123°54'31.3E	39	28.5	3–4	5–10	Rock, pebble	Open	10-X-2017
13.	Oesusu, Kupang	9°58'16.7"S, 124°01'19.7"E	162	27.8	0.1–0.2	5	Concrete	Open	10-X-2017
14.	Boentuka, Tites	9°55'39.6"S, 124°10'38.7"E	186	36.0	2–3	5–10	Pebble, sand	Open	10-X-2017
15.	Nulle, Soe	9°51'56.0"S, 124°20'43.1"E	651	24.0	1–2	5–15	Pebble, sand	Partially shaded	11-X-2017
16.	Polen, Soe	9°41'32.1"S, 124°28'57.7"E	287	29.0	20–25	5–15	Pebble	Open	11-X-2017
17.	Polen, Soe	9°41'32.1"S, 124°28'57.7"E	287	28.1	2–3	5–10	Pebble	Open	11-X-2017
18.	Oeluan, Kefa	9°36'14.4"S, 124°29'30.4"E	512	30.0	0.2–0.5	2	Concrete	Partially shaded	11-X-2017
19.	Oeluan, Kefa	9°36'14.4"S, 124°29'30.4"E	512	30.0	0.2–0.5	2	Concrete	Fully shaded	11-X-2017
20.	Oehala, Soe	9°48'09.6"S, 124°18'28.9"E	679	23.5	1–3	2–5	Rock, pebble	Fully shaded	12-X-2017
21.	Oesusu, Kupang	9°59'08.6"S, 124°00'43.7"E	223	28.8	0.1–0.2	5	Rock, sand	Partially shaded	12-X-2017

According to a DNA gene-sequence based analysis (Low, unpublished data), *S.* (*G.*) *atratum* consists of two genoforms: one form from Java (type locality of this species) and Bali, a second form from Sumbawa, Sumba, Flores and Timor, and both genoforms from Lombok.

No pathogens were found in 913 immature larvae of this species.

***Simulium* (*Gomphostilbia*) *dhangi* Takaoka & Sofian-Azirun, sp. nov.**

Pupa. Body length 3.0 mm. ***Head***. Integument moderately covered with small round tubercles; antennal sheath without any protuberances; frons with three pairs of unbranched long trichomes with coiled apices, arising close together, subequal in length to one another; face with pair of unbranched long trichomes with uncoiled apices. ***Thorax***. Integument yellow, moderately covered with round tubercles, with three long anterodorsal trichomes with coiled apices, two anterolateral trichomes (anterior one medium-long with straight apex, posterior one long with coiled apex), one medium-long mediolateral trichome with straight apex, and three ventrolateral trichomes with straight apices (one medium-long, two short) on each side; all trichomes unbranched. Gill (Fig. 1A) composed of two inflated trunks arising from short common basal stalk and two pairs of slender filaments closely arising basally from dorsal surface of dorsal inflated trunk; two inflated trunks subequal in length (ca. 1.3 mm) and thickness to each other, and four slender filaments subequal in length (ca. 0.6 mm) and thickness to one another; inflated trunks light brown, many ridges on their surface showing irregular patterns (Fig. 1B), covered with relatively larger tubercles on these ridges and smaller ones on inter-ridges; four filaments light brown, with annular ridges and furrows, covered with minute tubercles on their surface. ***Abdomen***. Dorsally, all segments transparent except segments 1, 2 and 9 light yellow; segments 1 and 2 each sparsely covered with minute tubercles; segment 1 with one unbranched slender short hair-like seta on each side; segment 2 with one unbranched slender short hair-like seta and five minute setae submedially on each side; segments 3 and 4 each with four hooked spines and one minute seta on each side; segment 5 with five minute setae on each side; segments 6–9 each with spine-combs in transverse row and comb-like groups of minute spines on each side; segments 6–8 each with one minute seta on each side; segment 9 with pair of broad plate-like terminal hooks each having outer margin crenulated (Fig. 1C). Ventrally, all segments transparent except segment 9 light yellow; segment 4 with one unbranched hook and few minute setae on each side; segment 5 with pair of bifid hooks submedially and few minute setae on each side; segments 6 and 7 each with pair of bifid inner and unbranched outer hooks somewhat spaced from each other and few minute setae on each side; segments 4–8 each with comb-like groups of minute spines. Each side of segment 9 with three grapnel-shaped hooklets. ***Cocoon*** (Fig. 1D). Wall-pocket-shaped, deep yellow, thickly woven, widely extended ventrolaterally; anterodorsal margin thickly woven; posterior half with floor roughly or moderately woven; individual threads invisible; 3.5 mm long by 2.9 mm wide.

Mature larva. Body length 5.5–5.8 mm. Body reddish brown. Head capsule: cephalic apotome moderately covered with colorless minute setae, yellow, with dark-brown head spots except anterior spots of posterolateral spots indistinct; lateral surface of head capsule yellow except eye-spot region yellowish white, with two large and two small spots near posterior margin medium or dark brown and one small round spot below eye-spot region light to medium brown; eye brow faintly or moderately defined; ventral surface of head capsule yellow except posteromedial area, elongate spot and round spot on each side of postgenal cleft medium to dark brown. Cervical sclerites composed of one small light-brown rod-like pieces, not fused to occiput, widely separated from each other. Antenna (Fig. 2A) composed of three articles and apical sensillum, subequal in length to stem of labral fan, darkened except third article pale yellow, apical sensillum and base

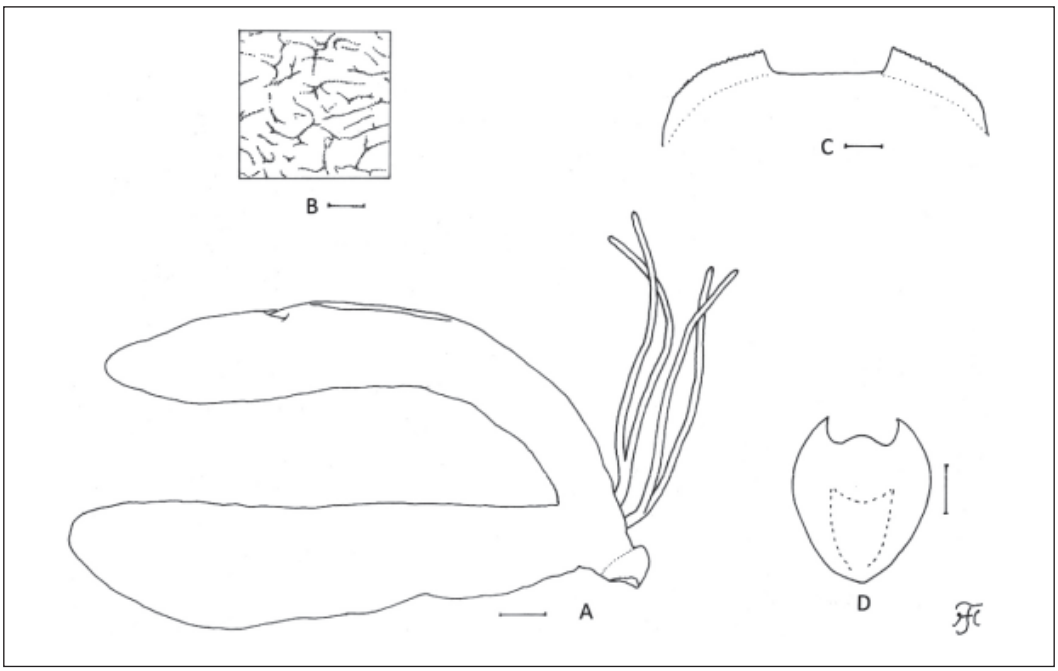

Figure 1. Pupa of *Simulium* (*Gomphostilbia*) *dhangi* sp. nov. (A) Gill (left side; outer view). (B) Surface of inflated trunk of gill. (C) Terminal hooks (anterodorsal view). (D) Cocoon (dorsal view). Scale bars. 1.0 mm for D; 0.1 mm for A; 0.02 mm for B and C.

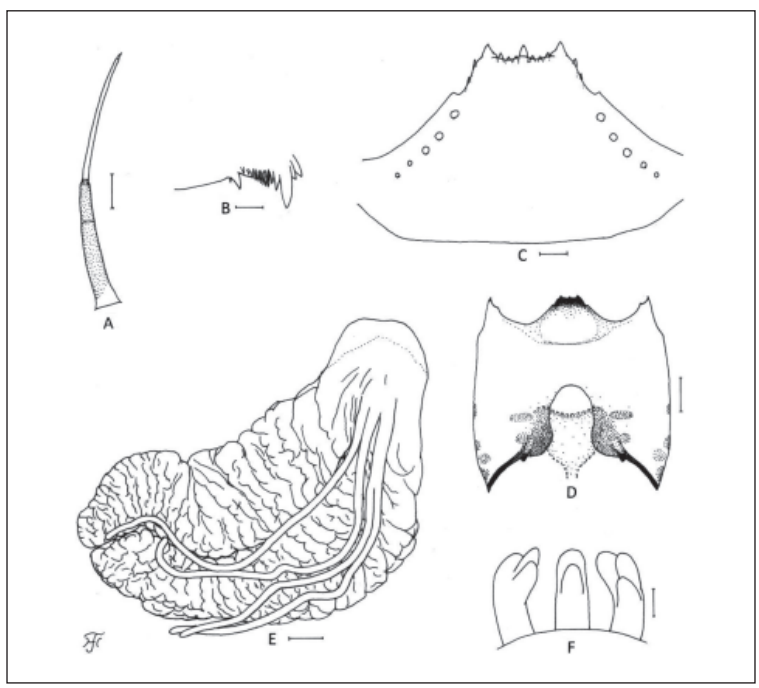

Figure 2. Larva of *Simulium* (*Gomphostilbia*) *dhangi* sp. nov. (A) Antenna (right side; dorsal view). (B) Mandible. (C) Hypostoma. (D) Head capsule showing postgenal cleft (ventral view). (E) Histoblast of pupal gill (right side; outer view). (F) Rectal organ (caudal view). Scale bars. 0.1 mm for D; 0.05 mm for A and E; 0.02 mm for B, C and F.

of first article unpigmented; proportional lengths of first, second, and third articles 1.0:0.5–0.7:1.4–1.5. Labral fan with 38 or 39 primary rays. Mandible (Fig. 2B) with three comb-teeth decreasing in length from first to third; mandibular serration composed of two teeth (one large and one small); large tooth at acute angle to mandible on apical side; sumernumerary serrations absent. Hypostoma (Fig. 2C) with row of nine apical teeth, of which median and corner teeth prominent, and intermediate teeth shortest; lateral margins smooth; five or six hypostomal bristles in row, nearly parallel to lateral margin on each side. Postgenal cleft (Fig. 2D) medium-sized, rounded apically, 1.4 times as long as postgenal bridge; sheath of subesophageal ganglion weakly pigmented. Pharate pupal gill (Fig. 2E) with two inflated trunks with four slender filaments arising from dorsal surface of basal portion of gill. Thoracic and abdominal cuticle moderately or densely covered with colorless minute setae dorsally and dorsolaterally, though each lateral surface (down to base of ventral papillae) of segment 9 also moderately covered with colorless minute setae. Rectal scales minute, colorless, sparsely distributed near apices of anterior arms of anal sclerite. Rectal organ (Fig. 2F) compound, each of three lobes with one or two thumb-like short secondary projections. Anal sclerite X-shaped, anterior arms 0.9 times as long as posterior ones; accessory sclerites absent; sensilla absent. Ventral papillae well developed, conical. Posterior circlet with 91–95 rows of up to15 hooks per row.

Female and **male**. Unknown.

Type material. HOLOTYPE: Pupa (together with its cocoon) (in 80% ethanol), collected from a small shallow stream flowing from the main channel of a stream (width 1–3 m, elevation 679 m, 9°48'09.6"S, 124°18'28.9"E), Oehala, Soe, Timor, Indonesia (site 20 in Table 1). PARATYPES: Two mature larvae (site 8 in Table 1) in Sumba.

Distribution. Indonesia (Sumba and Timor).

Etymology. The species name *dhangi* is in honor of Dr. Chee Dhang Chen, University of Malaya, who greatly contributed in faunal studies of black flies in the Lesser Sunda Archipelago.

Biological notes. The pupa of this new species was collected from a grass in the water. No associated species were found. Two mature larvae of this new species were collected together with those of *S.* (*G.*) *atratum*.

Remarks. The pupa and two mature larvae, which were collected in this survey, are so distinct morphologically, in particular, the pupal gill configuration (Fig. 1A) and larval antenna (Fig. 2A), that this species is here described as a new species, though adults are yet unknown.

According to the key to subgenera of the genus *Simulium* in the Oriental Region (Takaoka *et al.*, 2017c), this new species is assigned to the subgenus *Gomphostilbia* by having the following characters: in the pupa: frons with three pairs of trichomes, gill filaments without minute dark spots, abdominal segments 6–9 with spine-combs, and abdominal segment 9 with grapnel-like hooklets; and in the larva: mandible with main mandibular tooth at an acute angle against the ventral margin on the apical side (Fig. 2B), hypostoma with lateral margins smooth (Fig. 2C) and distinct conical ventral papillae.

It appears to be related to the *S. banauense* species-group from the Philippines and Sulawesi (15 species included) (Takaoka, 2003), the *S. rosemaryae* subgroup in the *S. ceylonicum* species-group from Sulawesi and Seram (three species included) (Takaoka, 2012; Takaoka *et al.*, 2017a) and the *S. sherwoodi* species-group from South Pacific (six species included) (Takaoka, 1995) by having a combination of six pupal gill filaments per side (Fig. 1A) and broadened terminal hooks with crenulated outer margins (Fig. 1C).

Among these three taxa, inflated pupal gill filaments are reported in the *S. banauense* and *S. sherwoodi* species-groups but not in the *S. rosemaryae* subgroup, and the configuration of the pupal gill (consisting of two inflated trunks and four slender filaments closely arising

basally) is essentially similar to that of *S.* (*G.*) *yuleae* Takaoka in the *S. sherwoodi* species-group (although the two inflated trunks of the gill are much thinner and have pointed apices, and the terminal hooks are united in the middle, in the latter species) (Takaoka, 1995), but differs from the configurations of the gills of species in the *S. banauense* species-group. The pupal gills of species in the *S. banauense* species-group have slender filaments apically when two of six filaments are inflated (Takaoka, 1983, 2000, 2005).

The broadened terminal hooks occur in species across several other species-groups in the subgenus *Gomphostilbia*, such as the *S. asakoae*, *S. ceylonicum*, *S. epistum* and *S. gombakense* species-groups (Takaoka, 2012).

The mature larva of this new species is characterized by the much shorter second antennal article, 0.5–0.7 times the length of the first one, a character often observed in species of the *S. banauense* species-group, and by the shorter antenna, which is as long as the stem of the labral fan, a character not reported in any species-groups in the subgenus *Gomphostilbia*, which always has the antenna somewhat longer than the stem of the labral fan.

Simulium (*G.*) *dhangi* sp. nov. is treated as a species of *Gomphostilbia* unplaced to species-group, because its adults are not available.

***Simulium* (*Gomphostilbia*) *sumbaense* Takaoka & Suana, sp. nov.**

Female. Body length 1.4–1.5 mm. ***Head***. Slightly narrower than width of thorax. Frons (Fig. 3A) black, not shiny, densely covered with white or yellowish-white scale-like recumbent short hairs; frontal ratio 1.5:1.0:1.4; frons:head ratio 1.0:3.9. Fronto-ocular area (Fig. 3A) well developed, tapered toward apex, directed dorso-laterally. Clypeus black, densely covered with whitish-yellow scale-like hairs interspersed with few yellow longer hairs near lower margin. Labrum 0.57 times as long as clypeus. Antenna (Fig. 3B) composed of scape, pedicel and eight flagellomeres, yellow except first flagellomere light brown (though base is yellowish white), third and fifth to eighth flagellomeres brownish black. Maxillary palp composed of five segments, light to medium brown except segments 1 and 2 yellowish; proportional lengths of third, fourth, and fifth segments 1.0:1.3:2.6; third segment (Fig. 3C) somewhat swollen; sensory vesicle (Fig. 3C) ellipsoidal, medium-sized (0.3 times as long as third segment), with medium-sized opening. Maxillary lacinia with eight or nine inner and 11 or 12 outer teeth. Mandible with 18–20 inner teeth and one to four weakly developed outer teeth at some distance from tip (although outer margin undulate, appearing to have several tiny round vestigial teeth between tip and outer teeth. Cibarium (Fig. 3D) with pair of well-sclerotized triangular projections at posterodorsal margin, which are in front covered by unpigmented transverse thin structure arising from both cornuae; several vestigial tiny processes near posterodorsal margin. ***Thorax***. Scutum black except anterolateral calli dark brown, shiny when illuminated at certain angles, and densely covered with white or yellowish-white scale-like recumbent hairs. Scutellum brownish black, covered with yellowish-whitish short hairs and brown long upright hairs along posterior margin. Postnotum brownish black, shiny white pruinose when illuminated at certain angles, and bare. Pleural membrane bare. Katepisternum brownish black, longer than deep, shiny when illuminated at certain angles, moderately covered with fine short hairs. ***Legs***. Foreleg: coxa whitish yellow; trochanter whitish yellow except lower portion somewhat darkened; femur light brown with apical cap medium brown (though extreme tip yellowish) except inner surface widely yellowish; tibia white or yellowish white except subbasal small portion light brown and apical cap medium brown (though extreme tip yellowish), though inner surface widely yellowish; tarsus brownish black, with moderate dorsal hair crest; basitarsus moderately dilated, 5.8 times as long as its greatest width. Midleg: coxa dark brown; trochanter yellow with darkened portion on outer surface; femur

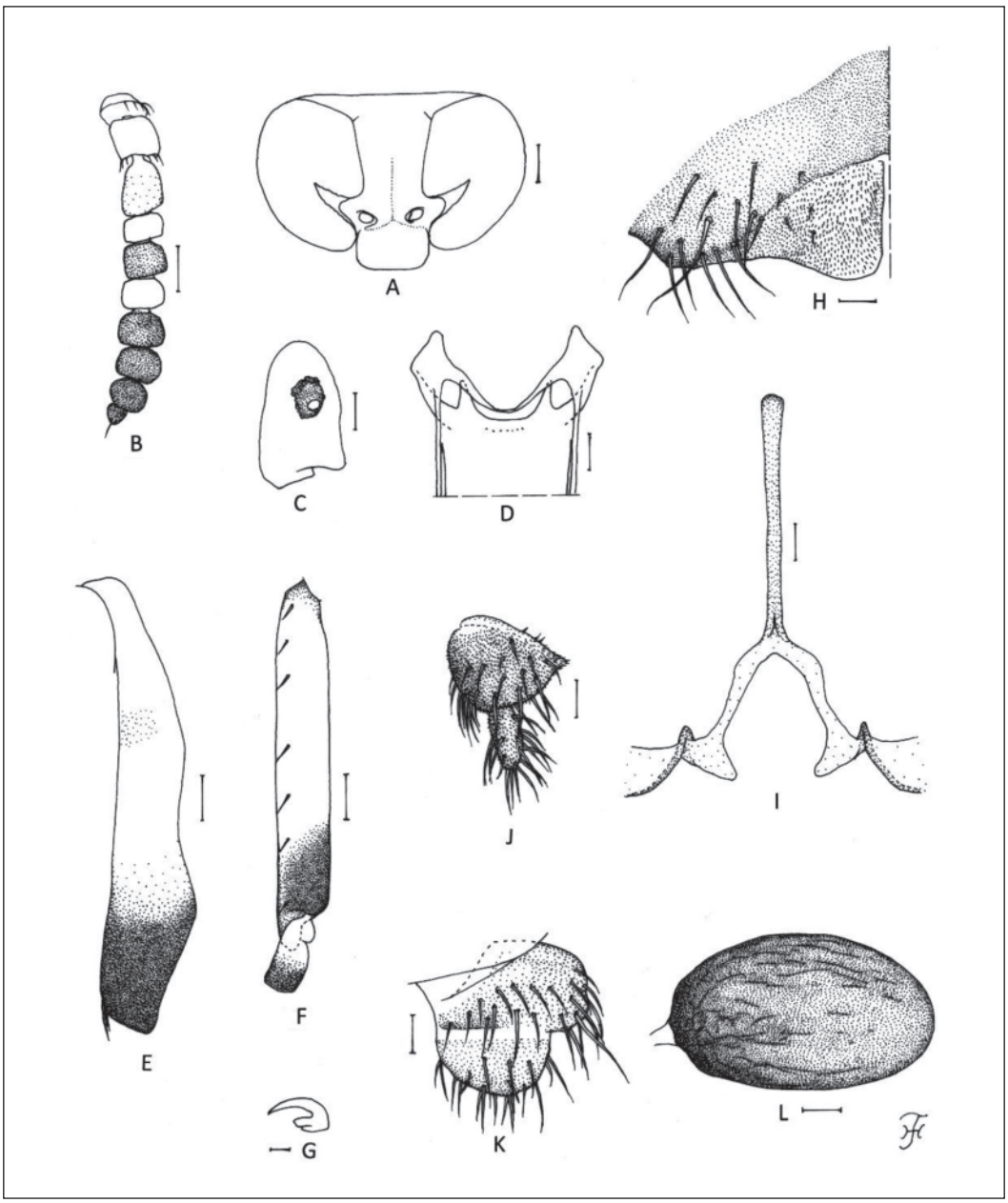

Figure 3. Female of *Simulium* (*Gomphostilbia*) *sumbaense* sp. nov. (A) Head (frontal view). (B) Antenna (right side; dorsal view). (C) Third segment of maxillary palp with sensory vesicle (right side; front view). (D) Cibarium. (E) Hind tibia (left side; outer view). (F) Basitarsus and tarsomere 2 of hind leg showing calcipala and pedisulcus (left side; outer view). (G) Claw. (H) Sternite 8 and ovipositor valve (only right half shown; ventral view). (I) Genital fork (ventral view). (J) & (K) Paraprocts and cerci (right side; J, ventral view; K, lateral view). (L) Spermatheca. Scale bars. 0.2 mm for A; 0.05 mm for B, E and F; 0.02 mm for C, D and H–L; 0.01 mm for G.

light brown with apical cap medium brown (though extreme tip yellowish); tibia yellowish white on basal two-fifths, with light brown subbasal spot, light to medium brown on rest, with apical cap medium brown (though extreme tip yellowish); tarsus medium brown except basal two-thirds of basitarsus and second tarsomere, and basal half of third tarsomere whitish. Hind leg: coxa medium brown; trochanter whitish yellow; femur medium brown, with base whitish yellow and apical cap dark brown (though extreme tip yellowish-white); tibia (Fig. 3E) white to whitish yellow on basal two-thirds, with light-brown subbasal spot, and brownish black on rest; tibia covered with whitish fine hairs on outer and posterior surfaces of basal two-thirds; tarsus light to medium brown except basal two-thirds or little more of basitarsus and basal half of tarsomeres 2 and 3 whitish; basitarsus (Fig. 3F) narrow, nearly parallel-sided, 6.2 times as long as wide, and 0.61 and 0.55 times as wide as greatest widths of tibia and femur, respectively; calcipala (Fig. 3F) slightly longer than width at base, and 0.46 times as wide as greatest width of basitarsus. Pedisulcus (Fig. 3F) well developed. Claw (Fig. 3G) with large basal tooth 0.43 times as long as claw. ***Wing***. Length 1.5 mm. Costa with dark spinules and pale hairs with basal patch of whitish hairs. Subcosta bare. Hair tuft on base of radial vein yellow. Basal portion of radius fully haired; R_1 with dark spinules and hairs. Basal cell absent. ***Halter***. White except basal stem darkened. ***Abdomen***. Basal scale medium brown, with fringe of whitish-yellow hairs. Dorsal surface of abdomen brownish black to black except most of segment 2 yellowish, moderately covered with whitish short hairs interspersed with dark long hairs; tergites of segments 2 and 6–9 shiny when illuminated at certain angles. Ventral surface of abdomen darkened except segment 2 mostly whitish yellow; sternal plate on segment 7 undeveloped. ***Terminalia***. Sternite 8 (Fig. 3H) bare medially, with 12 or 13 medium-long to long hairs together with two slender short hairs on each side. Ovipositor valve (Fig. 3H) triangular (though posteromedial corners rounded), thin, membranous, moderately covered with microsetae interspersed with three or four short hairs; inner margins nearly straight or sinuous, somewhat sclerotized, and moderately separated from each other. Genital fork (Fig. 3I) of usual inverted-Y form, with slender stem; arms gradually narrowed apically, moderately folded medially, and with triangular lobe directed posteromedially. Paraproct in ventral view (Fig. 3J) slightly concave anterolaterally, with three or four sensilla on anteromedial surface; paraproct in lateral view (Fig. 3K) somewhat produced ventrally, 0.6 times as long as wide, with 23 medium-long to long hairs on ventral and lateral surfaces. Cercus in lateral view (Fig. 3K) short, rounded posteriorly, 0.5 times as long as wide. Spermatheca (Fig. 3L) ellipsoidal, 1.7 times as long as its greatest width, well sclerotized even near juncture with duct, and with many longitudinal fissures on outer surface; internal setae absent; both accessory ducts slender, subequal in diameter to major one.

Male. Body length 1.5 mm. ***Head***. Somewhat wider than thorax. Upper eye dark brown, consisting of large facets in 13 vertical columns and 13 horizontal rows. Clypeus black, densely covered with golden yellow scale-like medium-long hairs (mostly directed upward) interspersed with several longer hairs near lower margin on each side. Antenna similar to that of female; first flagellomere elongate, 1.9 times as long as second. Maxillary palp light brown except segments 1 and 2 yellowish, proportional lengths of third, fourth, and fifth segments 1.00:1.25:2.63; third segment (Fig. 4A) widened apically; sensory vesicle (Fig. 4A) ellipsoidal, small (0.19 times as long as third segment), and with small opening. ***Thorax***. Nearly as in female except fine hairs on scutum and scutellum yellowish. ***Legs***. Color and shape nearly as in female except following characters: fore coxa whitish yellow, slightly darkened on anterior surface; trochanters of fore and mid legs light brown except base whitish yellow; mid basitarsus whitish on little more than basal two-thirds and medium brown on rest; hind tibia (Fig. 4B) whitish yellow on basal half

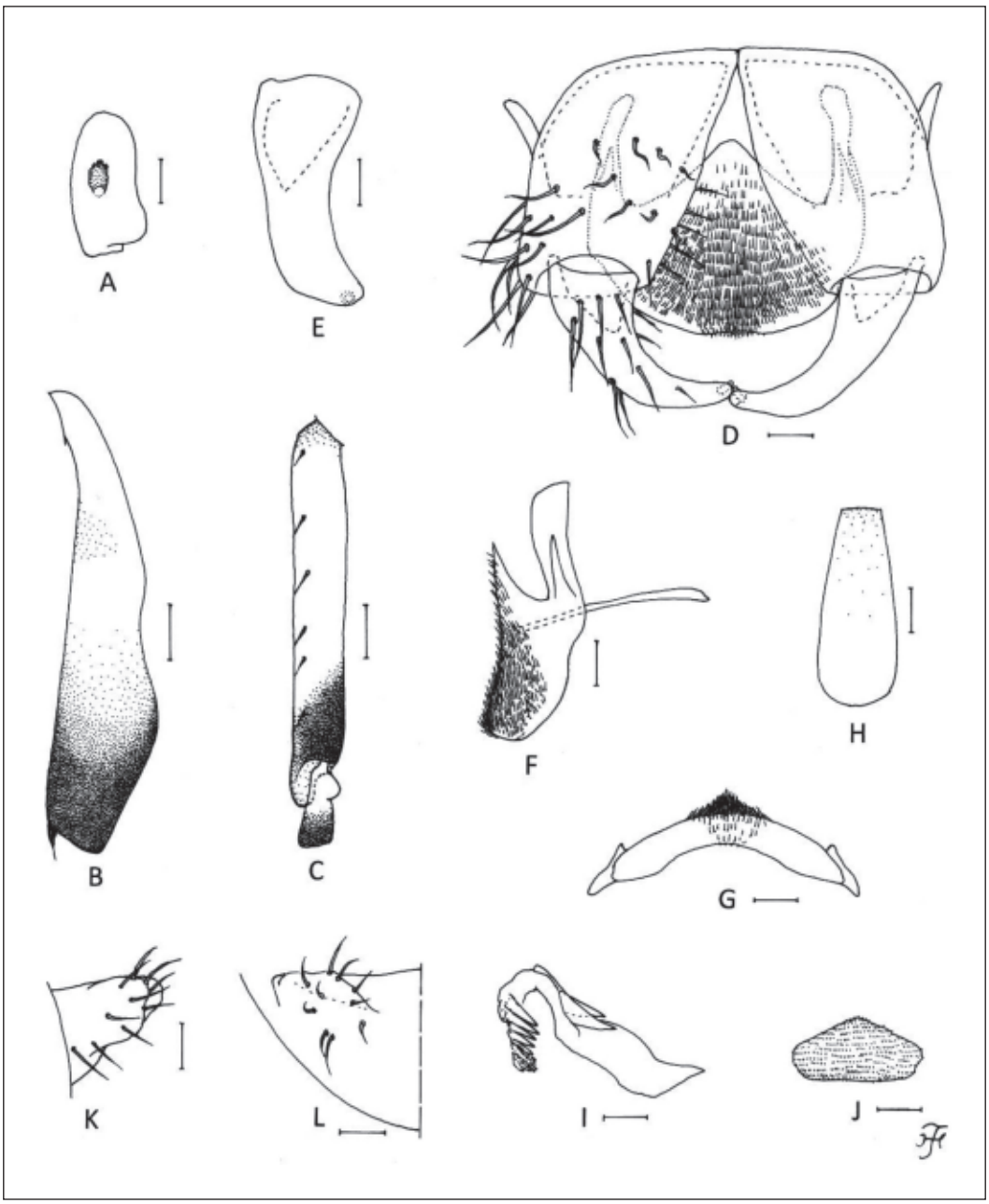

Figure 4. Male of *Simulium* (*Gomphostilbia*) *sumbaense* sp. nov. (A) Third segment of maxillary palp with sensory vesicle (right side; front view). (B) Hind tibia (left side; outer view). (C) Basitarsus and tarsomere 2 of hind leg showing calcipala and pedisulcus (left side; outer view). (D) Coxites, styles and ventral plate (ventral view). (E) Style (right side, ventrolateral view). (F) Ventral plate and median sclerite (lateral view). (G) Ventral plate (caudal view). (H) Median sclerite (caudal view). (I) Paramere (right side; dorsal view). (J) Aedeagal membrane (caudal view). (K) & (L) Abdominal segment 10 and cerci (K, lateral view; L, caudal view). Scale bars. 0.05 mm for B and C; 0.02 mm for A and D–L.

with light brown subbasal spot, light to dark brown on rest; third tarsomeres of mid and hind legs medium brown except base whitish; fore basitarsus moderately dilated, 6.1 times as long as its greatest width; hind basitarsus (Fig. 4C) 6.1 times as long as wide, and 0.6 and 0.5 times as wide as greatest width of tibia and femur, respectively; calcipala (Fig. 4C) slightly longer than wide, and 0.4 times as wide as greatest width of basitarsus. Pedisulcus (Fig. 4C) well developed. ***Wing***. Length 1.4 mm; other features as in female. ***Halter***. White except basal stem darkened. ***Abdomen***. Basal scale dark brown, with fringe of yellow hairs. Dorsal surface of abdomen brownish black to black except anterior two-thirds of segment 2 light brown, covered with yellow short hairs intermixed with dark long hairs; segments 2 and 5–8 each with pair of shiny dorsolateral or lateral patches. ***Genitalia***. Coxite in ventral view (Fig. 4D) nearly rectangular, 1.5 times as long as its greatest width, and 1.1 times length of style. Style in ventral view (Fig. 4D) bent inward, tapered from base toward apex, and with apical spine; style in ventrolateral view (Fig. 4E) gradually narrowed from base toward near middle, nearly parallel-sided to apical one-fifth, and then tapered toward apex. Ventral plate in ventral view (Fig. 4D) with body transverse, 0.8 times as long as wide, widest in middle, then narrowed posteriorly, with anterior margin produced anteromedially, and posterior margin nearly straight, densely covered with microsetae on ventral surface except anterolateral areas widely bare; basal arms of moderate length, directed forward, and somewhat convergent apically; ventral plate in lateral view (Fig. 4F) slightly produced ventrally; ventral plate in caudal view (Fig. 4G) gently rounded ventrally, moderately covered with microsetae medially on posterior surface. Median sclerite (Fig. 4F, H) thin, plate-like. Paramere (Fig. 4I) of moderate size, each with two distinct hooks directed outward and several hooks directed posterodorsally. Aedeagal membrane (Fig. 4J) moderately setose. Ventral surface of abdominal segment 10 without distinct hairs near posterior margin. Cercus (Fig. 4K, L) rounded, with 10–12 hairs.

Pupa. Body length 1.7–2.0 mm. ***Head***. Integument light yellow, moderately covered with small round tubercles (Fig. 5A); antennal sheath with outer margin undulate but without any protuberances; frons with three pairs of unbranched long trichomes with uncoiled apices, arising close together, subequal in length to one another (Fig. 5A, B); face with pair of unbranched long trichomes with uncoiled apices (Fig. 5A, C). ***Thorax***. Integument yellow, moderately covered with round tubercles, with three long anterodorsal trichomes with coiled or uncoiled apices (middle and posterior trichomes subequal in length to each other, and slightly shorter than anterior one) (Fig. 5D), two anterolateral trichomes (anterior one short with straight apex, posterior one long with coiled apex) (Fig. 5E), one short mediolateral trichome with straight apex (Fig. 5F), and three ventrolateral trichomes with straight apices (one medium-long, two short) (Fig. 5G) on each side; all trichomes unbranched. Gill (Fig. 5H) with eight filaments arranged in two groups (dorsal and ventral) arising from short common basal stalk; dorsal group composed of major filament, two paired filaments and three individual filaments, all arising from dorsal surface of major filament; ventral group composed of major filament and one filament arising at basal one-fourth of major filament; both major filaments subequal in length (0.8–2.0 mm) to each other, inflated through basal one-fourth, then tapered to middle, and nearly parallel-sided toward apices; major filament of ventral group somewhat thinner than that of dorsal group, when compared basally; six other filaments subequal in thickness and length (1.4–1.6 mm) to one another, when measured from base of gill to their apices; common basal stalk having transparent basal fenestra ventrally (partially broken); cuticle of all filaments with well-defined annular ridges and furrows though becoming less marked apically, densely covered with minute tubercles. ***Abdomen***. Dorsally, all segments transparent except segments 1, 2 and 9

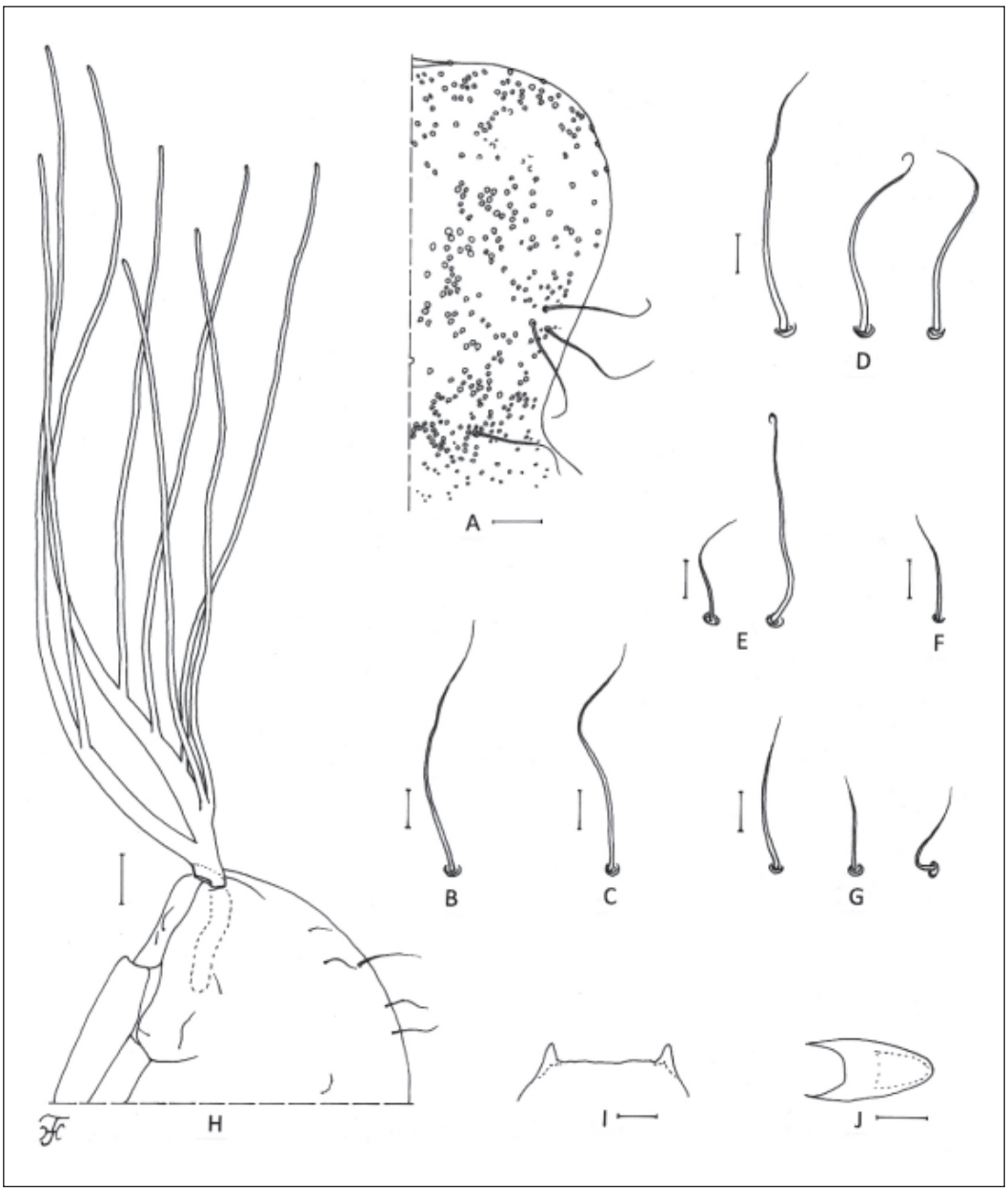

Figure 5. Pupa of *Simulium* (*Gomphostilbia*) *sumbaense* sp. nov. (A) Frons (left half). (B) Frontal trichome. (C) Facial trichome. (D)–(G) Thoracic trichomes (D, anterodorsal; E, anterolateral; F, mediolateral; G, ventrolateral). (H) Gill (left side; outer view). (I) Terminal hooks (caudal view). (J) Cocoon (dorsal view). Scale bars. 1.0 mm for J; 0.1 mm for H; 0.05 mm fro A; 0.02 mm for B–G and I.

light yellow; segment 1 with one unbranched slender short hair-like seta on each side; segment 2 with one unbranched slender short hair-like seta and five minute setae submedially on each side; segments 3 and 4 each with four hooked spines and one minute seta on each side; segment 5 with five minute setae on each side; segments 6–9 each with spine-combs in transverse row and comb-like groups of minute spines on each side; segments 6–8 each with one minute seta on each side; segment 9 with

pair of cone-like terminal hooks (Fig. 5I). Ventral surface of abdomen similar to that of *S.* (*G.*) *dhangi* sp. nov. ***Cocoon*** (Fig. 5J). Wall-pocket-shaped, light yellow, thinly and moderately woven, slightly extended ventrolaterally; anterodorsal margin not thickly woven; posterior half with floor roughly or moderately woven; individual threads invisible; 2.0–2.5 mm long by 1.1–1.3 mm wide.

Mature larva. Unknown.

Type material. HOLOTYPE: Female (with its associated pupal exuviae and cocoon) (in 80% ethanol) reared from a pupa, collected from a small stream (width 0.5–0.6 m, elevation 3 m below the sea level, 9°39'57.3"S, 120°20'57.8"E), Watumbaka, Waingapu, Sumba, Indonesia (site 6 in Table 1). PARATYPE: One male (with its associated pupal exuviae and cocoon) (in 80% ethanol) reared from a pupa, same data and date as the holotype.

Distribution. Indonesia (Sumba).

Etymology. The species name *sumbaense* refers to the island of Sumba, where this new species was collected.

Biological notes. The pupae of this new species were collected from grasses in the water. No associated species were found.

Remarks. *Simulium* (*G.*) *sumbaense* sp. nov. is assigned to the *S. varicorne* species-group in the subgenus *Gomphostilbia*, because it has eight flagellomeres in its adult antenna (Fig. 3B) and is further placed in the *S. chumpornense* subgroup by having the female and male pleural membrane bare, female subcosta bare, spermatheca ellipsoidal (Fig. 3L), male ventral plate nearly flat (Fig. 4D), and pupal gill divided into dorsal and ventral groups (Fig. 5H), as defined by Takaoka (2012). Among five species of this subgroup, *S.* (*G.*) *chumpornense* Takaoka & Kuvangkadilok from Thailand (Kuvangkadilok and Takaoka 2000) appears to be most similar to this new species by having a similar arrangement of the pupal gill filaments. However, *S.* (*G.*) *sumbaense* sp. nov. is distinguished from *S.* (*G.*) *chumpornense* by the following morphological characters (those of *S.* (*G.*) *chumpornense* in parentheses): in the female by the relative length of the height of the frons against the narrowest width 1.4 (1.7), and mandible with 18–20 inner and 1–4 outer teeth (22–24 inner teeth and lacking an outer tooth); in the male by the upper-eye large facets in 13 vertical columns and 13 horizontal rows (15 vertical columns and 15 horizontal rows); in the pupa by the two paired filaments near the base on the dorsal group (Fig. 4H) (two filaments are individual, not paired).

This new species is distinguished from four other related species in the same subgroup by the arrangement of filaments of the dorsal group, which is composed of two paired filaments and three individual filaments arising from the main filament (Fig. 5H) in this new species but is composed of three pairs of filaments in *S.* (*G.*) *tomae* Takaoka from Sulawesi (Takaoka 2003), two triplets in *S.* (*G.*) *varicorne* Edwards from Peninsular Malaysia (Takaoka and Davies, 1995) (though the pupa of *S.* (*G.*) *varicorne* from Sumatra and Java is unknown), eight individual filaments arising from the inflated tubular trunk in *S.* (*G.*) *kuvangkadilokae* Pramual & Tangkawanit from Thailand (Pramual and Tangkawanit, 2008; Takaoka and Srisuka, 2010), and four filaments in two pairs or two individual and two paired filaments in *S.* (*G.*) *piroonae* Takaoka & Srisuka from Thailand (Takaoka *et al.*, 2014).

The female of *S.* (*G.*) *sumbaense* sp. nov. is distinguished from that of *S.* (*G.*) *tomae* by the wider frons (Fig. 3A) (the frons:head ratio is 1.0:3.9 in this new species but 1.0:6.7 in *S.* (*G.*) *tomae*).

This is the first record of the *S. varicorne* species-group from the archipelago.

Simulium (*Nevermannia*) *aureohirtum* Brunetti, 1911

Simulium aureohirtum Brunetti 1911: 283–288 (Male).

Simulium (*Nevermannia*) *aureohirtum*: Ogata, 1956: 61–62; Ogata, 1966: 129; Takaoka and Roberts, 1988: 194–195; Takaoka, 2003: 37–45 (Female, male, pupa and larva).

Simulium (*Eusimulium*) *aureohirtum*: Puri, 1933: 1–7 (Female, male, pupa and larva); Takaoka, 1979: 382–384 (Female, male, pupa and larva).

Specimens examined. Thirteen females, 14 males, 18 pupae, 1 mature larva and 4 immature larvae (site 7); 1 female and 5 pupae (site 18).

Distribution. India, Bhutan, China, Guam, Indonesia (Java, Flores, Halmahera, Lombok, Sumatra, Sulawesi, Sumba (**New record**) and Timor), Japan, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Taiwan and Vietnam.

Remarks. This species is a member of the *S. ruficorne* species-group in the subgenus *Nevermannia*, and is widely distributed in the Oriental Region and sporadically in the Australasian and Palaearctic Regions (Takaoka 2003). Our collection of the pupae of this species in Timor (site 18) represents the first record of its coexistence with another species of the *S. ruficorne* species-group (*S.* (*N.*) *wayani* sp. nov.). The identity is confirmed by the female terminalia, in particular, the spermatheca with a sclerotized neck, and pupal gill with six filaments.

No pathogens were found in four immature larvae of this species.

***Simulium* (*Nevermannia*) *wayani* Takaoka & Chen sp. nov.**

Female. Body length 2.1–2.3 mm. ***Head***. Slightly narrower than thorax. Frons brownish black, not shiny, densely covered with yellowish-white recumbent short hairs and few to several longer upright hairs along each lateral margin; frontal ratio 1.5–1.7:1.0:1.8–2.0; frons:head ratio 1.0:4.1–4.7. Fronto-ocular area well developed, narrow, directed dorsolaterally. Clypeus brownish black, densely covered with yellowish white recumbent short hairs. Labrum 0.7–0.8 times as long as clypeus. Antenna composed of scape, pedicel and nine flagellomeres, yellow except first flagellomere light brown (though its base yellow), or dark yellow to light brown except scape, pedicel and base of first flagellomere yellow and most of first flagellomere medium brown. Maxillary palp composed of five segments, light brown except segments 1 and 2 dark yellow and segment 3 brownish black, proportional lengths of third, fourth, and fifth segments 1.0:0.9–1.0:2.0; third segment (Fig. 6A) somewhat produced inward; sensory vesicle (Fig. 6A) of medium size, 0.5–0.6 times as long as third segment, with medium-sized opening. Maxillary lacinia with 9–13 inner and 11–13 outer teeth. Mandible with 16–20 inner and 9–10 outer teeth. Cibarium (Fig. 6B) without processes. ***Thorax***. Scutum brownish black, slightly shiny when illuminated at certain angles, densely covered with yellowish-white recumbent hairs. Scutellum dark brown, covered with yellowish-white short hairs and with yellowish-white long upright hairs. Postnotum dark brown to brownish black, bare. Pleural membrane bare. Katepisternum dark brown, longer than deep, and bare. ***Legs***. Foreleg: coxa and trochanter whitish yellow; femur whitish yellow widely on anterior surface, and light brown except apical one-third whitish yellow (though having two light brown spots subapically) on posterior surface; tibia light brown except basal extreme and wide median portion yellowish white and apical cap medium brown; tarsus brownish black, with moderate dorsal hair crest; basitarsus moderately dilated, 6.1–6.4 times as long as its greatest width. Midleg: coxa medium brown except posterolateral surface dark brown; trochanter whitish yellow; femur whitish yellow with apical cap dark brown; tibia dark brown except basal extreme and wide median portion whitish yellow; tarsus dark brown though basal two-thirds of anterior surface of basitarsus somewhat lighter. Hind leg: coxa light to medium brown; trochanter whitish yellow; femur whitish yellow with apical cap dark brown; tibia (Fig. 6C) whitish yellow on basal half or little more, with medium to dark brown subbasal band, and medium to dark brown on rest, though apical cap brownish black; tarsus medium brown except basal two-thirds or little more of basitarsus (though base light brown) and basal half of second tarsomere whitish yellow; basitarsus (Fig. 6D) narrow, nearly parallel-sided, 6.1–6.8 times as long as wide, and 0.6–0.7 and 0.5

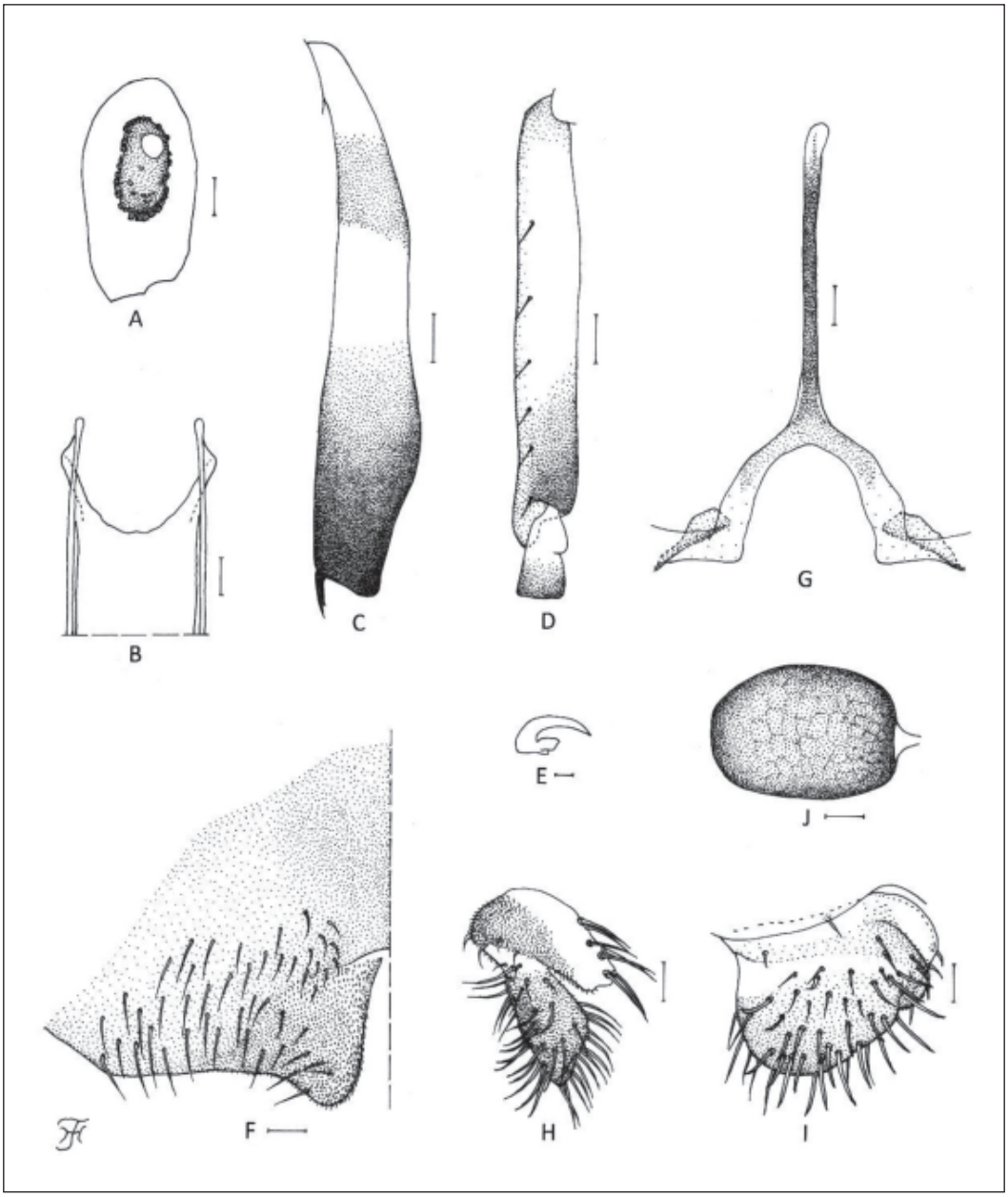

Figure 6. Female of *Simulium* (*Nevermannia*) *wayani* sp. nov. (A) Third segment of maxillary palp with sensory vesicle (right side; front view). (B) Cibarium. (C) Hind tibia (left side; outer view). (D) Basitarsus and tarsomere 2 of hind leg showing calcipala and pedisulcus (left side; outer view). (E) Claw. (F) Sternite 8 and ovipositor valve (only right half shown; ventral view). (G) Genital fork (ventral view). (H) & (I) Paraprocts and cerci (right side; H, ventral view; I, lateral view). (J) Spermatheca. Scale bars. 0.05 mm for C and D; 0.02 mm for A, B and F–J; 0.01 mm for E.

times as wide as greatest widths of tibia and femur, respectively; calcipala nearly as long as wide, and 0.4 times as wide as greatest width of basitarsus. Claw (Fig. 6E) with large basal tooth 0.4 times as long as claw.

Wing. Length 1.7–1.8 mm. Costa with dark brown spinules and light-brown hairs except basal portion with patch of yellowish-white hairs. Subcosta with medium-brown hairs except near apex bare. Hair tuft of base of

radius dark brown. Basal portion of radius fully haired; R_1 with dark-brown spinules and light-brown hairs. Basal cell absent. ***Halter***. White with somewhat dark base. ***Abdomen***. Basal scale dark brown except median portion light brown, with fringe of yellowish-white hairs. Dorsal surface of abdominal segments medium to dark brown, not shiny, densely covered with yellowish-white short hairs interspersed with somewhat longer hairs on posterior segments; sternal plate on segment 7 large and shiny when illuminated. ***Terminalia***. Sternite 8 (Fig. 6F) bare medially, with 32–38 short to long hairs on each side. Ovipositor valve (Fig. 6F) tongue-like, with round posteromedial corner, thin, membranous, moderately covered with microsetae interspersed with 6–10 short hairs; inner margins nearly straight, slightly sclerotized and moderately separated from each other. Genital fork (Fig. 6G) of usual inverted-Y form, with well sclerotized stem, of which basal portion is widened to various extent in some females; arms of moderate width, widened from middle toward apices, and with rounded plate-like projection directed anterodorsally. Paraproct in ventral view (Fig. 6H) widely depressed, bare and transparent along medial margin, and with 7–11 somewhat sinuous colorless setae on depressed portion and on median margin, and densely covered with microsetae on outer half of ventral surface; paraproct in lateral view (Fig. 6I) slightly produced ventrally, much narrowed dorsally, with five to seven short hairs on ventral and lateral surfaces. Cercus in lateral view (Fig. 6I) short, rounded posteriorly, 0.6 times as long as wide, and with numerous short to medium-long stout setae intermixed with short fine setae. Spermatheca (Fig. 6J) ellipsoidal, 1.3–1.5 times as long as wide, well sclerotized except duct and small area at juncture with duct unsclerotized, and with faint reticulate pattern on surface; internal setae absent; both accessory ducts slender, unpigmented, subequal in diameter to each other and to major duct.

Male. Body length 2.0–2.2 mm. ***Head***. Much wider than thorax. Holoptic, upper eye consisting of large facets in 16–19 vertical columns and in 19–21 horizontal rows. Clypeus dark brown, white pruinose, moderately covered with yellow short hairs interspersed with longer hairs. Antenna: color as in female; first flagellomere somewhat elongate, 1.9 times as long as second flagellomere. Maxillary palp composed of five segments, proportional lengths of third, fourth and fifth segments 1.0:1.1:2.3; third segment (Fig. 7A) not enlarged; sensory vesicle (Fig. 7A) globular, 0.2 times as long as third segment, with small opening apically. ***Thorax***. Scutum brownish black, densely covered with yellowish-white scale-like recumbent hairs on shoulders, along lateral margins and prescutellar area, and moderately covered with similar colored hairs in form of narrow submedian longitudinal lines connected anteriorly to shoulders and posteriorly to prescutellar area with yellowish hairs, and densely covered with dark recumbent setae on rest. Scutellum dark brown, with yellowish-white short hairs and upright long hairs. Postnotum dark brown and bare. Pleural membrane bare. Katepisternum longer than deep, and bare. ***Legs***. Color nearly as in female except hind basitarsus yellowish on basal half or little more. Fore basitarsus 7.8–8.6 times as long as its greatest width. Hind basitarsus (Fig. 7B) nearly parallel-sided, 5.9–6.3 times as long as its greatest width, and 0.6 and 0.5–0.6 times as wide as hind tibia and femur, respectively; calcipala moderately developed, nearly as long as wide, and 0.4 times as wide as greatest width of basitarsus; pedisulcus moderately developed. ***Wing***. Length 1.5 mm; other characters as in female except subcosta bare and basal patch of hairs on costa darkened with pale apices. ***Halter***. White with darkened base. ***Abdomen***. Basal scale dark brown with fringe of yellowish-white long hairs laterally. Dorsal surface of abdomen dark brown to brownish black, moderately to densely covered with yellowish-white short hairs. ***Genitalia***. Coxites, styles and ventral plate in ventral view as in Fig. 7C. Coxite in ventral view (Fig. 7C) subquadrate, 1.6 times as long as wide. Style in ventral view (Fig. 7C) short, 0.7–0.8 times as long as

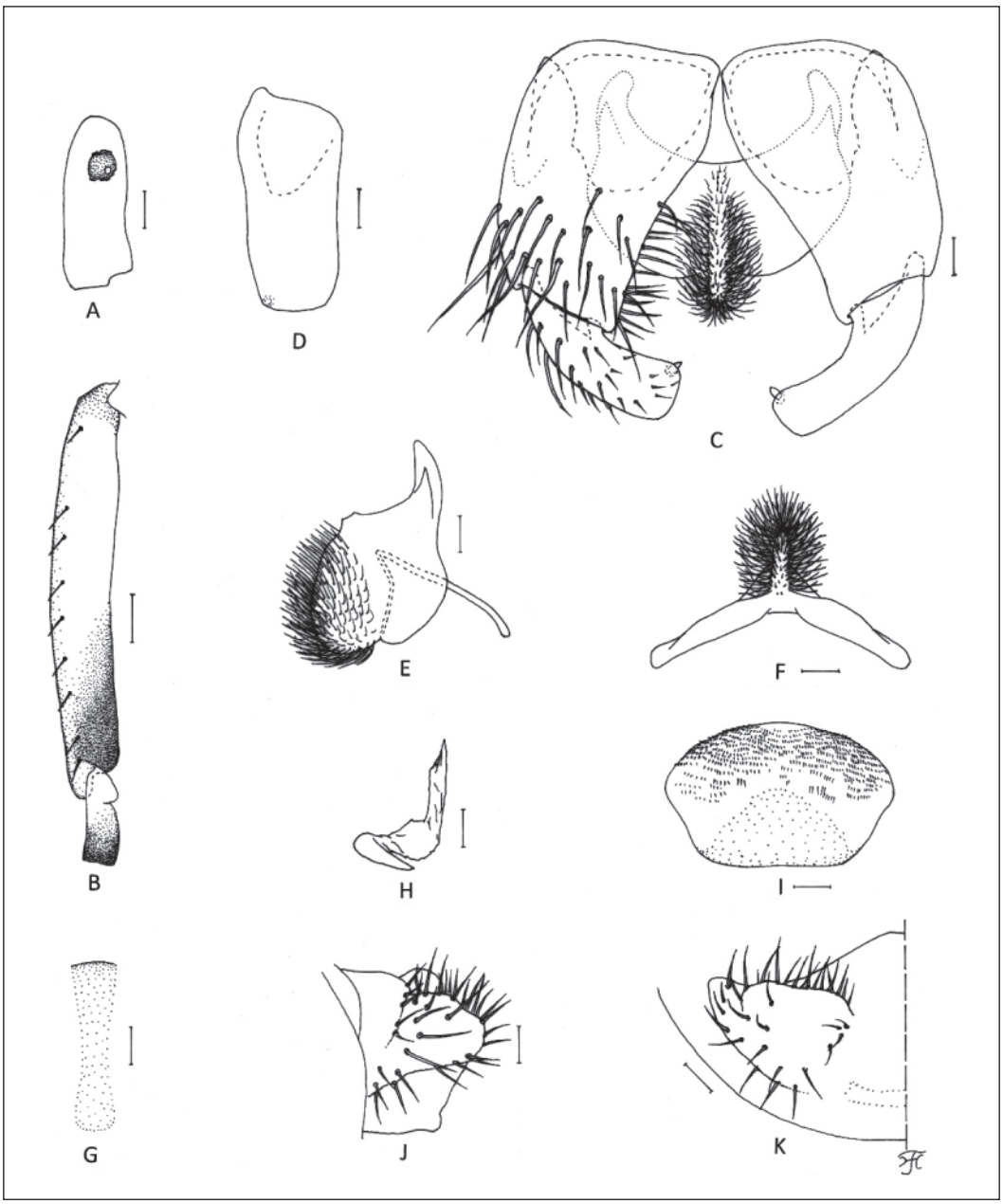

Figure 7. Male of *Simulium* (*Nevermannia*) *wayani* sp. nov. (A) Third segment of maxillary palp with sensory vesicle (right side; front view). (B) Basitarsus and tarsomere 2 of hind leg showing calcipala and pedisulcus (left side; outer view). (C) Coxites, styles and ventral plate (ventral view). (D) Style (right side; ventrolateral view). (E) Ventral plate and median sclerite (lateral view). (F) Ventral plate (caudal view). (G) Median sclerite (caudal view). (H) Paramere (left side; ventral view). (I) Aedeagal membrane and dorsal plate (caudal view). (J) & (K) Abdominal segment 10 and cerci (J, lateral view; K, caudal view). Scale bars. 0.05 mm for B; 0.02 mm for A and C–K.

coxite, gently curved inward, and with one apical spine; style in ventrolateral view (Fig. 7D) nearly parallel-sided from base toward apex, 2.1–2.3 times as long as wide. Ventral plate in ventral view (Fig. 7C) transverse, much wider than long, with anterior margin concave, with posterior margin slightly concave in middle, and with

median keel densely covered with colorless setae on its surface; basal arms short, somewhat convergent apically; ventral plate in lateral view (Fig. 7E) with median keel having round apex, densely covered with colorless setae; ventral plate in caudal view (Fig. 7F) inverted-Y-shaped, with median keel much shorter than half of width of ventral plate. Median sclerite (Fig. 7G) narrow and flat. Paramere (Fig. 7H) of moderate size, with one hook. Aedeagal membrane (Fig. 7I) sparsely to moderately covered with microsetae; dorsal plate wide, tapered ventrally, lightly pigmented. Ventral surface of abdominal segment 10 (Fig. 7J, K) with seven to nine short hairs. Cercus (Fig. 7J, K) well developed, with 23–26 short hairs.

Pupa. Body length 2.4–2.6 mm. ***Head***. Integument ochreous, moderately covered with round tubercles except antennal sheath bare. Frons with two unbranched short somewhat stout trichomes with straight apices (Fig. 8A) on each side. Face with one unbranched short and somewhat stout trichome with straight apex (Fig. 8B) on each side. ***Thorax***. Integument ochreous, moderately covered with round tubercles except dorsal surface of posterior portion covered with conical tubercles, with two medium-long anterodorsal trichomes (Fig. 8C), two anterolateral trichomes (one medium-long and stout, one short and slender) (Fig. 8D), one short stout mediolateral trichome (Fig. 8E), and three short stout ventrolateral trichomes (Fig. 8F), on each side; all unbranched and with straight apices except anterodorsal and mediolateral trichomes rarely bifid. Gill (Fig. 8G–J) with four somewhat inflated filaments arising from extremely short common basal stalk, and arranged as 1+2+1 from dorsal to ventral; middle paired filaments with short stalk: all filaments light to medium brown, variable in length from 1.0 mm to 3.6 mm and in configuration of apical half from nearly parallel-sided to tapered or widened toward apices, by individual pupae, though four filaments of each gill subequal in length and thickness to one another, as shown in Fig. 8G–J; cuticular surface with annular ridges forming reticulate pattern and densely covered with minute tubercles. ***Abdomen***. Dorsally, segments 1 and 2 (often segments 3 and 4, too) each sparsely or moderately covered with microtubercles, segment 1 entirely light brown, anterior half or little more of segment 2 light brown, anterior one-third of segments 3 and 4, portions of spine-combs on segments 7 and 8 pale yellow to dark yellow, and segment 9 entirely dark yellow; segment 1 with one slender short seta (Fig. 8K) on each side; segment 2 with one slender short seta and five short spinous setae (Fig. 8L) on each side; segments 3 and 4 each with four hooked spines and one short spinous seta on each side; segments 7 and 8 (often segment 6, too) each with spine-combs on each side; segments 6–9 (rarely segment 5, too) each with comb-like groups of minute spines in transverse row on each side; segment 5 with four minute setae on each side; segment 6 with three minute setae on each side; segments 7 and 8 each with two minute setae on each side; segment 9 with pair of small conical terminal hooks (Fig. 8M). Ventrally, segment 2 with two short stout setae on each side; segment 4 with four short stout setae, one of which is much stouter unbranched or bifid hook, on each side; segment 5 with pair of bifid or trifid hooks submedially and few short setae on each side; segments 6 and 7 each with pair of bifid inner and unbranched (rarely bifid) outer hooks somewhat spaced from each other, and few short setae on each side; grapnel-shaped hooklets absent on each side of segment 9. ***Cocoon*** (Fig. 8N). Wall-pocket-shaped, pale yellow to ochreous, thinly woven with no open spaces in weave, with anterodorsal projection, though variable in length from extremely short to medium-long; floor weakly woven on posterior half; individual threads not visible; 2.5–3.9 mm long by 1.5–2.0 mm wide.

Mature larva. Body length 4.5–5.8 mm. Body grayish or light brown or light purplish. Head capsule: cephalic apotome moderately covered with colorless minute setae, yellow, with positive head spots, anterior and posterior mediolongitudinal spots dark brown and often connected to each other, and mediolateral spots and anterior spots

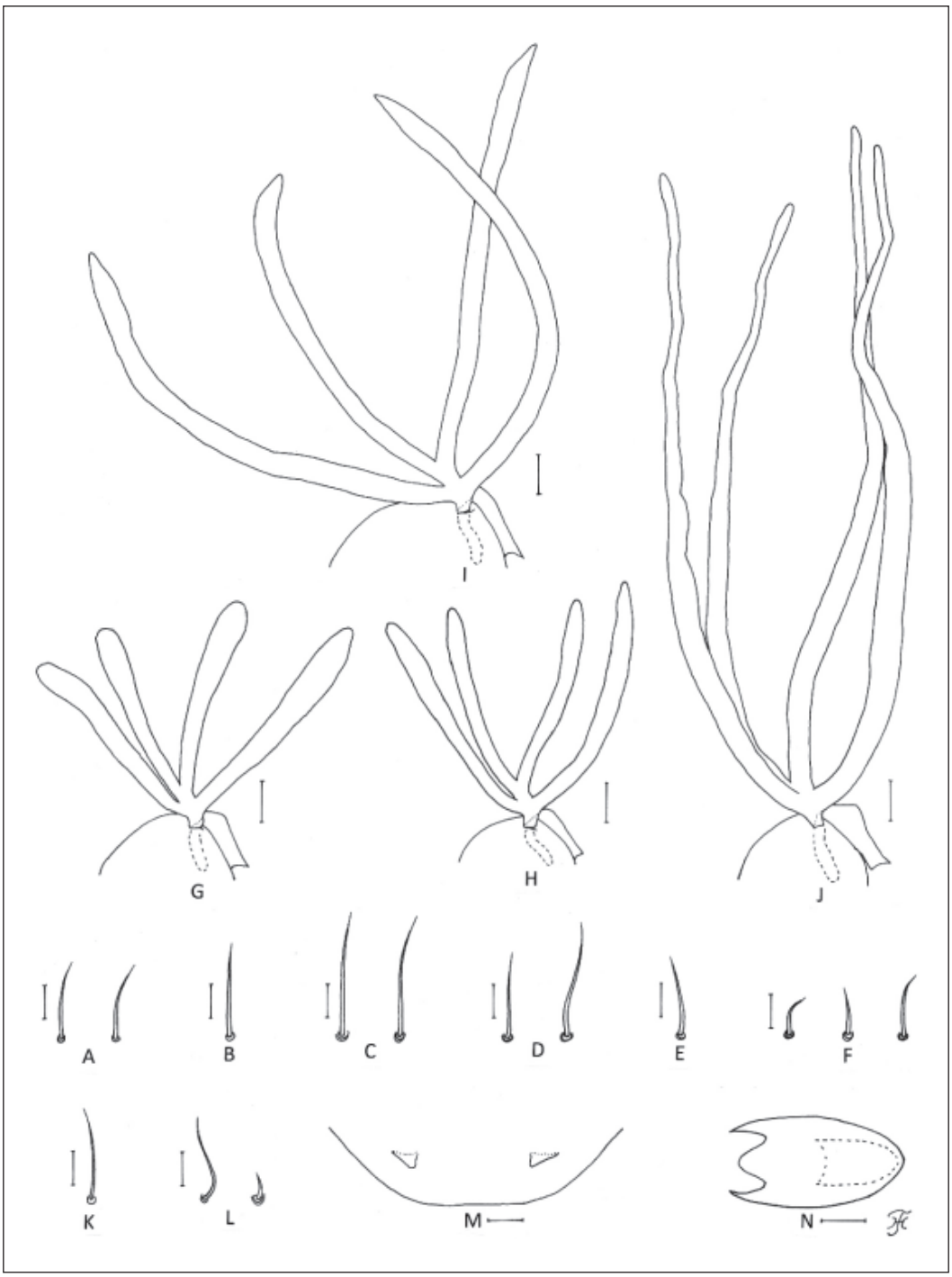

Figure 8. Pupa of *Simulium* (*Nevermannia*) *wayani* sp. nov. (A) Frontal trichomes. (B) Facial trichome. (C)–(F) Thoracic trichomes (C, anterodorsal; E, anterolateral; E, mediolateral; F, ventrolateral). (G–J) Gill filaments of various length and thickness (right side; outer view). (K) One slender short seta on dorsum of abdominal segment 1. (L) One slender short seta and one stout short seta on dorsum of abdominal segment 2. (M) Terminal hooks (dorsal view). (N) Cocoon (dorsal view). Scale bars. 1.0 mm for N; 0.2 mm for G–J; 0.02 mm for A–F and K–M.

of posterolateral spots usually light brown; rarely, cephalic apotome widely darkened along posterior margin including posterolateral spots, which is connected in middle to fused median longitudinal spots, thus appearing dark-brown, inverted-T (though mediolateral spots light brown); lateral surface of head capsule yellow except eye-spot region yellowish white and surrounding areas of eye-spot region darkened, and two large and one small spots near posterior margin darkened, though lateral surface except eye-spot region entirely darkened in few larvae; ventral surface of head spots yellow except elongate spot and round spot on each side of postgenal cleft darkened, though ventral surface entirely or partially darkened in some larvae. Cervical sclerites composed of two small light brown rod-like pieces, not fused to occiput, widely separated from each other. Antenna composed of three articles and apical sensillum, much longer than stem of labral fan; proportional lengths of first, second, and third articles 1.0:1.1:0. 9. Labral fan with 39–48 primary rays. Mandible (Fig. 9A) with first tooth of three comb-teeth longest, and second and third ones subequal in length to each other; mandibular serration composed of two teeth (one large and one medium-sized); large tooth at acute angle to mandible on apical side; sumernumerary serrations absent. Hypostoma (Fig. 9B) with row of nine apical teeth, of which corner teeth slightly longer than median tooth, and intermediate teeth shortest; lateral margins serrated apically; five to seven hypostomal bristles in row, nearly parallel to lateral margin on each side. Postgenal cleft (Fig. 9C) medium-sized, quadrate, subequal in length to postgenal bridge; sheath of subesophageal ganglion partially pigmented. Pharate pupal gill with four inflated filaments. Thoracic cuticle bare. Abdominal cuticle almost bare except dorsal and dorsolateral surfaces of segments 5–8 and dorsolateral and lateral surfaces (down to base of ventral papillae) of segment 9 moderately covered with colorless simple setae. Rectal scales unpigmented. Rectal organ simple, though one or two of three lobes with one or two nipple-like secondary projections. Anal sclerite X-shaped, anterior arms 0.7–0.8 times as long as posterior ones; accessory sclerites absent; sensilla absent. Ventral papillae well developed, conical. Posterior circlet with 64–71 rows of up to 13–15 hooks per row.

Type material. HOLOTYPE. Female (with associated pupal exuviae and cocoon) (in 80% ethanol) reared from a pupa collected from a river (width 20–25 m, elevation 287 m, 9°41'32.1"S, 124°28'57.7"E), Polen, Soe, Timor, Indonesia (site 16 in Table 1). PARATYPES. Five females and 5 males (with their associated pupal exuviae and cocoons) and 6 mature larvae (in 80% ethanol), same data and date as the holotype.

Other specimens examined. Four females, 7 males, 6 pupae, 7 mature larvae and 38 immature larvae (site 10); 2 females, 1 male, 1 pupa, 1 mature larva and 6 immature larvae (site 11); 1 male, 2 pupae and 3 immature larvae (site 12); 1 female, 2 males and 2 pupae (site 13); 23 females, 24 males, 44 pupae, 14 mature larvae and 63 immature larvae (site 14); 1 mature larva and 1 immature larva (site 15); 12 females, 5 males, 4 pupae, and 47 immature larvae (site 16); 11 females, 22 males, 16 pupae, 4 mature larvae and 17 immature larvae (site 17); 39 females, 14 males, 7 pupae, 59 mature larvae and 184 immature larvae (site 18); 5 females, 2 males, 5 pupae, 5 mature larvae and 18 immature larvae (site 19); 1 immature larva (site 20); 8 males, 3 pupae, 11 mature larvae and 95 immature larvae (site 21).

Distribution. Indonesia (Timor).

Etymology. The species name *wayani* is in honor of Dr. I. Wayan Suana, University of Mataram, who greatly contributed to faunal studies of black flies in the Lesser Sunda Archipelago.

Biological notes. The pupae and larvae of this new species were collected from grasses and plastic sheets in the water. Associated species were *S.* (*G.*) *atratum* and *S.* (*N.*) *aureohirtum*, *S.* (*S.*) *timorense* and *S.* (*W.*) sp.

Remarks. This new species is assigned to the *S. ruficorne* species-group in having the characteristic female and male genitalia (Figs. 6F–I & 7C). It is similar to *S.* (*N.*)

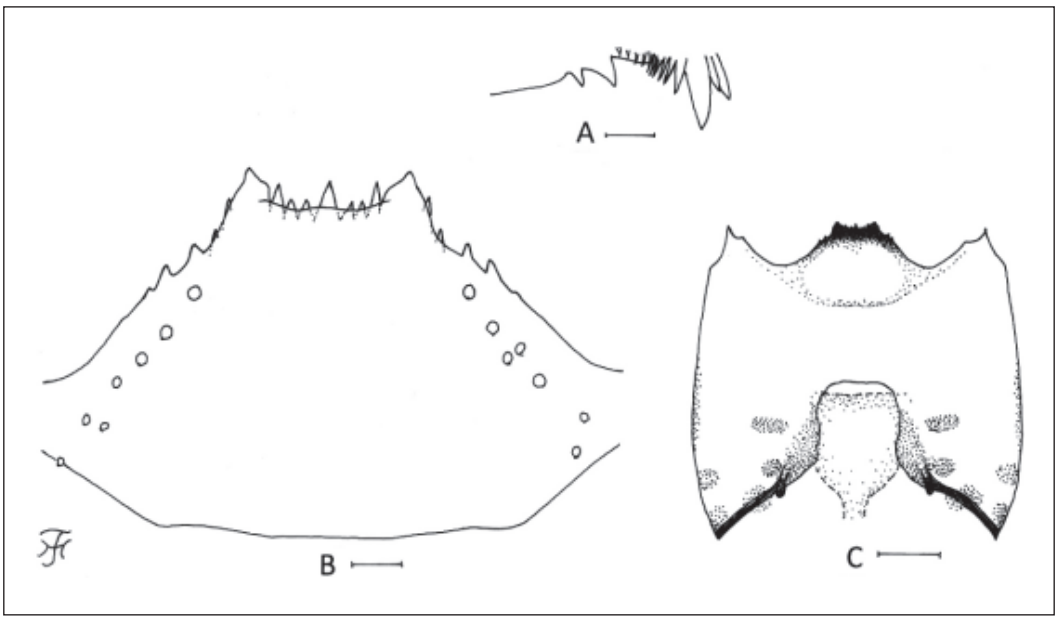

Figure 9. Larva of *Simulium* (*Nevermannia*) *wayani* sp. nov. (A) Mandible (lateral view). (B) Hypostoma. (C) Head capsule showing postgenal cleft (ventral view). Scale bars. 0.1 mm for C; 0.02 mm for A and B.

ornatipes Skuse, a common species of the *S. ruficorne* species-group in the Australasian Region (Takaoka, 2003), in many characters including the pupal gill with four filaments, which vary in their arrangement, as shown in Fig. 8G–J. However, *S.* (*N.*) *wayani* sp. nov. is distinguished from the latter in the female by the fore basitarsus 6.1–6.4 times as long as its greatest width (7.1 times in *S.* (*N.*) *ornatipes*), spermatheca (Fig. 6J) with an unsclerotized neck (with a sclerotized neck in *S.* (*N.*) *ornatipes*) and relatively shorter spermatheca against its greatest width 1.2–1.4 (1.7 in *S.* (*N.*) *ornatipes*), and in the male by the number of upper-eye large facets in 16–19 vertical columns and 19–21 horizontal rows (22 or 23 vertical columns and 24 or 25 horizontal rows in *S.* (*N.*) *ornatipes*), ventral plate with a lower median keel (Fig. 7F), and relative length of the style against its width (2.1–2.3 in this new species vs. 1.9 in *S.* (*N.*) *ornatipes*).

This new species was predominant in 8 of the 12 streams surveyed in Timor, whereas *S.* (*N.*) *aureohirtum*, its close ally, was collected in a small number, together with this new species in only one stream (site 18) in Timor. It is likely that *S.* (*N.*) *wayani* sp. nov. is more adaptable than *S.* (*N.*) *aureohirtum* to breed in streams in Timor.

The discovery of a new species in the *S. ruficorne* species-group appears to represent another example of speciation in the Lesser Sunda Archipelago by species in Java and Sumatra while undergoing eastward dispersal. Other examples noted in Takaoka *et al.* (2017d) include *S.* (*S.*) *baliense* Takaoka & Sofian-Azirun in the *S. striatum* species-group from Bali and Lombok (probably evolved from an ancestor similar to *S.* (*S.*) *argyrocinctum* from Java and Sumatra), and *S.* (*S.*) *timorense* Takaoka, Hadi & Sigit in the *S. nobile* species-group from Lombok, Sumbawa, Sumba, Flores and Timor (probably evolved from an ancestor similar to *S.* (*S.*) *nobile* from Java and Sumatra).

Takaoka (2017) inferred that species of the *S. ruficorne* species-group have dispersed from Sumatra eastward to the Australasian Region while reducing the number of the pupal gill filaments from

eight (*S.* (*N.*) *glattharri* Takaoka & Davies) to four (*S.* (*N.*) *ornatipes*) through six (*S.* (*N.*) *aureohirtum*). However, whether *S.* (*N.*) *wayani* sp. nov. has evolved from an ancestor like *S.* (*N.*) *aureohirtum* should be investigated by future chromosomal and genetic analyses.

All the females reared from pupae of this new species contained a high quantity of fat body in their abdomens, suggesting that *S.* (*N.*) *wayani* sp. nov. is autogenous at least for the first batch of eggs, like *S.* (*N.*) *ornatipes* and *S.* (*N.*) *aureohirtum* (Hunter, 1977; Takaoka and Noda, 1979).

No pathogens were found in 473 immature larvae of this species.

***Simulium* (*Simulium*) *timorense* Takaoka, Hadi & Sigit, 2006**

Simulium (*Simulium*) *timorense* Takaoka, Hadi & Sigit, 2006: 18–24 (Female, male, pupa and larva).

Specimens examined. One male (site 1); 7 females, 3 males, 4 pupae, 1 mature larva and 6 immature larvae (site 2); 5 females, 3 males, 1 pupa, 4 mature larvae and 40 immature larvae (site 3); 45 females, 56 males, 39 pupae, 7 mature larvae and 131 immature larvae (site 5); 1 female and 1 male (site 8); 1 male (site 13); 1 female (site 19).

Distribution. Indonesia (Flores, Lombok, Sumba (**New record**), Sumbawa and Timor).

Remarks. This species is placed in the *S. nobile* species-group (Takaoka *et al.*, 2006) and is widely distributed from Lombok eastward to Timor (Takaoka *et al.*, 2017d). It is recorded for the first time from Sumba.

Pathogens were not found in 177 immature larvae examined.

***Simulium* (*Wallacellum*) sp.**

Simulium (*Wallacellum*) sp. Takaoka, Hadi & Sigit, 2006: 25 (Larva).

Specimens examined. One immature larva (site 3); 4 immature larvae (site 5); 1 immature larva (site 19); 1 immature larva (site 21).

Distribution. Flores, Sumba (**New record**) and Timor.

Remarks. This species was recorded from Flores based on a single mature larva, and was assigned to the subgenus *Wallacellum* by Takaoka *et al.* (2006). Its female, male and pupa remain unknown. It was also recorded from Timor by Almet *et al.* (2016). This species is recorded for the first time from Sumba.

No pathogens were found in seven immature larvae examined.

CONCLUSION

The survey of black flies in Sumba and Timor in the Lesser Sunda Archipelago, Indonesia added three more new species increasing the number of species of black flies in this archipelago from 19 to 22. Among four subgenera of the genus *Simulium*, *Gomphostilbia* is the richest in the number and lineage diversity, represented by 11 species in six species-groups, followed by *Simulium* (seven species in five species-groups) and *Nevermannia* (three species in two species-groups). Most species endemic to this archipelago are inferred to have originated from ancestral populations in Java and Sumatra.

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