

A new species and seven new records of black flies (Diptera: Simuliidae) from Kalimantan, Indonesia

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A New Species of *Simulium* (*Gomphostilbia*) (Diptera: Simuliidae) From Kalimantan, Indonesia, With Keys to Identify 19 Bornean Species of the Subgenus *Gomphostilbia*

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Abstract

A new simuliid species, *Simulium kalimantanense* sp. nov., is described on the basis of females, males, pupae, and mature larvae from East Kalimantan, Indonesia, and is assigned to the *Simulium banauense* species-group of *Simulium* (*Gomphostilbia*). This new species has close similarities to *S. alienigenum* Takaoka from the Philippines, in many characters including the adult antennal color pattern and pupal gill with four long filaments arranged in two pairs each bearing a long stalk, but is distinguished from the latter in the female by the longer sensory vesicle and in the pupa by the gill with an elongate common basal stalk. *Simulium kalimantanense* sp. nov. is the first member of the *S. banauense* group in Borneo, and marks the most southerly distribution of the group. Keys to identify 19 Bornean species of the subgenus *Gomphostilbia* are provided.

Key words: Simuliidae, *Gomphostilbia*, new species, Kalimantan, Borneo

The Simuliidae (Diptera) of Borneo, the largest continental island in southeast Asia, are known only from its northern and north-western regions, i.e., Malaysian states of Sabah and Sarawak, where 38 taxa of the genus *Simulium* are recorded, of which 18 are placed in the subgenus *Gomphostilbia*, three in the subgenus *Nevermannia*, and 17 in the subgenus *Simulium* (Edwards 1933; Smart and Clifford 1969; Takaoka 1996, 2001a,b, 2007, 2008a,b, 2009; Adler and Crosskey 2015; Takaoka et al. 2015a,b,c; Ya'cob et al. 2015a,b). No records of black flies were present from its vast southern and eastern regions, that is, the Indonesian state of Kalimantan. The biting habits of these Bornean simuliid species remain unknown.

We carried out surveys of aquatic stages of black flies in Paser, East Kalimantan Province, Indonesia, in September 2015, and obtained nine species consisting of two new and seven known species. One new species, which is assigned to *Simulium* (*Gomphostilbia*), is here described based on females, males, pupae, and mature larvae. Keys to identify 19 Bornean *Gomphostilbia* species are provided.

The methods of collection, description and illustration, and terms for morphological features, follow those of Takaoka (2003).

Nomenclature

This paper and the nomenclatural act it contains have been registered in Zoobank (www.zoobank.com), the official register of the International Commission on Zoological Nomenclature. The LSID (Life Science Identifier) number of the publication is: urn:lsid:zoobank.org:pub:CB565BED-AC23-4D6C-A0A2-6248CE222708.

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

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Female

Body length 1.7–1.9 mm. *Head*. Nearly as wide as thorax. Eye vermilion. Frons black, densely covered with whitish to whitish-yellow scale-like recumbent short hairs and few to several dark hairs along each lateral margin and bare on upper two-thirds of medio-longitudinal area; frontal ratio 1.59:1.00:3.66; frons:head ratio 1.00:7.38. Clypeus black, moderately covered with whitish-yellow

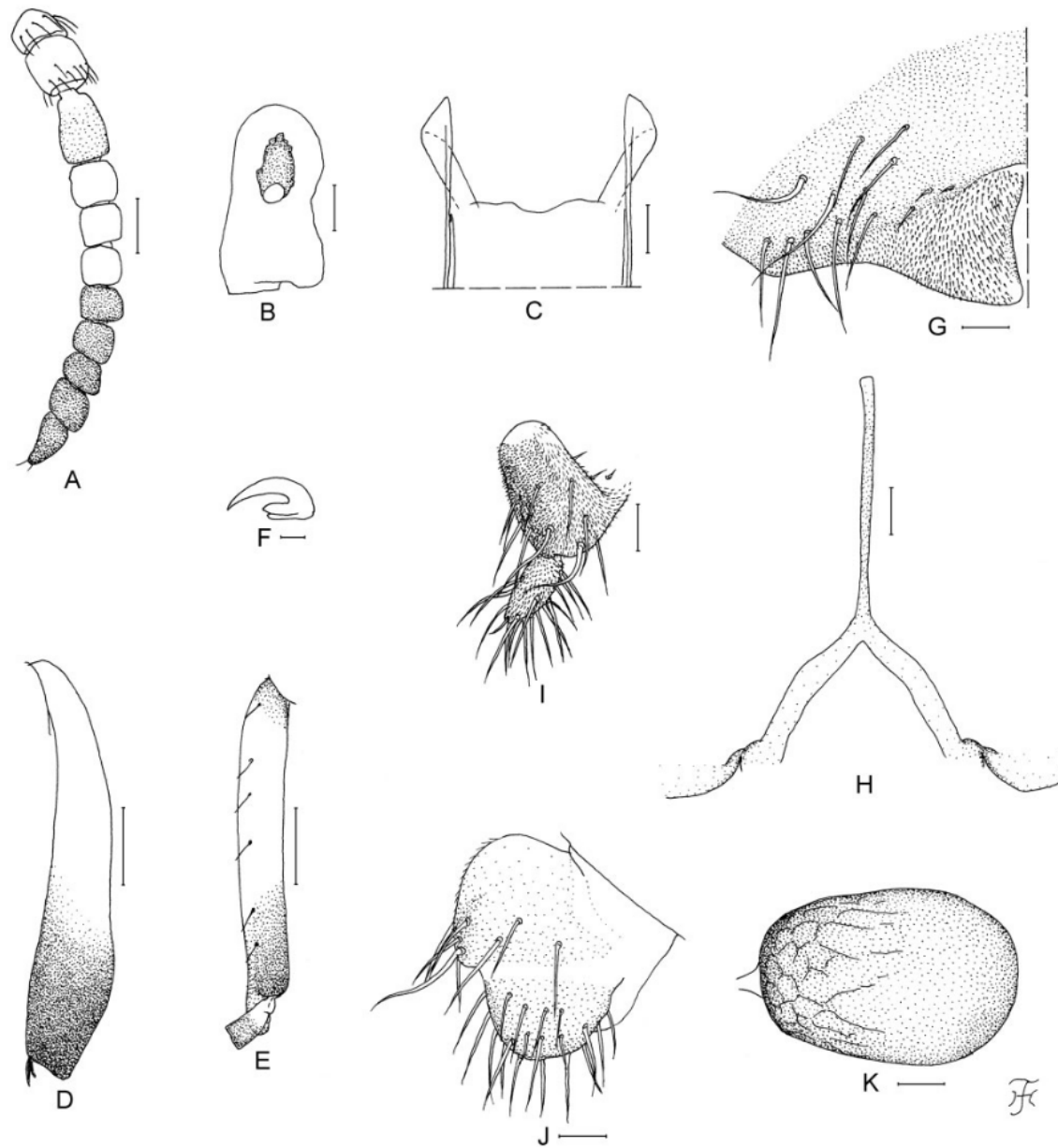


Fig. 1. Female of *S. (G.) kalimantanense* sp. nov. (A) Antenna (right side; dorsal view). (B) Third segment of maxillary palp showing sensory vesicle (right side; front view). (C) Cibarium (upper portion; front view). (D) Hind tibia (left side; outer view). (E) Hind basitarsus and second tarsomere (left side; outer view). (F) Claw. (G) Sternite 8 and ovipositor valve (right half; ventral view). (H) Genital fork (ventral view). (I) and (J) Paraprocts and cerci (I, right side and ventral view; J, left side and lateral view). (K) Spermatheca. Scale bars. 0.1 mm for D and E; 0.05 mm for A; 0.02 mm for B, C and G–K; and 0.01 mm for F.

scale-like recumbent hairs interspersed with dark longer hairs. Labrum 0.58 times as long as clypeus. Antenna (Fig. 1A) with scape, pedicel, and nine flagellomeres, brownish-black except scape, pedicel, and second to fourth flagellomeres yellow, and first flagellomere light to medium brown except base yellow. Maxillary palp with five segments; length ratio of third, fourth, and fifth segments 1.00:1.10:2.99; third segment (Fig. 1B) much enlarged, with elongate sensory vesicle (Fig. 1B) 0.38 times length of third segment and with medium-sized opening. Maxillary lacinia with seven or eight

inner teeth and 11 outer ones. Mandible with 16 inner teeth and lacking outer teeth (though right mandible of one female with one small tooth near apex). Cibarium (Fig. 1C): dorsal margin undulate. *Thorax*. Scutum brownish-black, shiny when illuminated, faintly with three narrow longitudinal vittae (one median, two submedian), densely covered with yellow scale-like recumbent hairs. Scutellum dark brown, with yellow short hairs and dark-brown long upright hairs. Postnotum dark brown, white pruinose when illuminated, and bare. Pleural membrane bare. Katapisternum longer than deep,

dark brown, thinly gray pruinose and shiny when illuminated, and haired. *Legs*. Foreleg: coxa whitish yellow; trochanter medium brown (though base yellowish), femur medium brown (though extreme apical tip yellow); tibia medium brown (though extreme basal tip yellow); tarsus dark brown to brownish black; basitarsus 6.67–7.50 times as long as its greatest width. Midleg: coxa medium brown though posterolateral surface brownish-black; trochanter medium brown; femur medium brown (though extreme apical tip yellow); tibia dark brown with basal one-third whitish yellow; tarsus medium brown except basal three-fifths of basitarsus and base of second tarsomere whitish yellow. Hind leg: coxa medium brown; trochanter whitish yellow; femur medium brown with basal tip whitish yellow and apical cap dark brown (though tip whitish yellow); tibia (Fig. 1D) whitish yellow to yellow on basal two-thirds and dark brown to brownish black on rest (though anterior surface little more widely darkened on apical half); tarsus (Fig. 1E) dark brown with basal three-fifths of basitarsus (though base light brown) and basal half of second tarsomere yellowish white; basitarsus (Fig. 1E) slender, parallel-sided, 6.67–6.96 times as long as wide, and 0.60 and 0.48 times as wide as greatest widths of tibia and femur, respectively; calcipala (Fig. 1E) 1.3 times as long as wide, and 0.46 times as wide as greatest width of basitarsus; pedisulcus well developed; claw tooth (Fig. 1F) 0.40 times length of claw. *Wing*. Length 1.6 mm. Costa with basal patch of whitish-yellow hairs. Subcosta haired except near apex bare. Basal portion of radial vein fully haired. Base of radial vein with whitish-yellow hair tuft. *Halter*. Creamy with base darkened. *Abdomen*. Basal scale light ochreous, with yellowish-white hairs. Dorsal surface of abdomen dark brown to brownish black except segment 2 yellow (though narrow portion along posterior margin medium brown), moderately covered with yellow hairs on segment 2, and with dark short to long hairs interspersed with yellow short hairs on other segments; tergites 2 and 6–9 shiny. Ventral surface of segment 2 creamy, those of other segments medium to dark brown; sternite 7 undeveloped. *Terminalia*. Sternite 8 (Fig. 1G) with 11 medium-long to long hairs together with few slender short hairs on each side. Ovipositor valves (Fig. 1G) triangular, thin, membranous, moderately covered with microsetae, and with one short hair or without hair; inner margins concave, moderately sclerotized, and somewhat separated from each other. Arms of genital fork (Fig. 1H) of moderate width, with lateral plate angled anterodorsally. Paraproct in ventral view (Fig. 1I) subquadrate, with weakly sclerotized anteromedial surface bearing three sensilla; paraproct in lateral view (Fig. 1J) 0.92 times as long as wide, with eight to ten medium-long to long hairs on ventral and lateral surfaces. Cercus in lateral view (Fig. 1J) short, rounded posteriorly, 0.6 times as long as wide. Spermatheca (Fig. 1K) ellipsoidal, 1.49 times as long as greatest width; internal setae absent; both accessory ducts slender, subequal in thickness to major one.

Male

Body length 2.0–2.1 mm. *Head*. Much wider than thorax. Upper eye medium brown, consisting of large facets in 10–12 vertical columns and in 12 horizontal rows. Clypeus brownish-black, whitish-gray pruinose when illuminated, and moderately covered with yellow scale-like short hairs interspersed with dark-brown longer hairs (except medial portion moderately bare). Antenna similar to that of female except first flagellomere light brown on apical half to apical two-thirds; first flagellomere elongate, 1.7 times as long as second one. Maxillary palp similar in color to that of female; length ratio of third, fourth, and fifth segments 1.00:1.08:3.00; third segment

(Fig. 2A) widened apically; sensory vesicle (Fig. 2A) ellipsoidal, 0.26–0.29 times length of third segment, with moderate opening. *Thorax*. Scutum brownish black, shiny when illuminated, densely covered with golden-yellow short hairs. Scutellum dark brown, with golden-yellow short hairs and dark-brown long upright hairs. Other features as in female. *Legs*. Color similar to that of female. Fore basitarsus slightly dilated, 6.63 times as long as greatest width. Hind tibia (Fig. 2B) whitish yellow to yellow on basal two-thirds and dark brown to brownish black on apical one-third (though anterior surface little more widely darkened on apical half or little more). Hind basitarsus (Fig. 2C) slender, nearly parallel-sided, 6.55 times as long as wide, and 0.55 and 0.46 times as wide as greatest width of hind tibia and femur, respectively. *Wing*. Length 1.5 mm. As in female except subcosta bare. *Halter*. Ochreous with base darkened. *Abdomen*. Almost similar in color to that of female except segment 2 entirely yellowish on dorsal surface; tergites 2, 5, 6, and 7 each with paired dorsolateral shiny spots. *Genitalia*. Coxites, styles, and ventral plate in ventral view as in Fig. 2D. Coxite in ventral view nearly rectangular, 1.63 times as long as its greatest width. Style in ventral view (Fig. 2D) curved inward, tapered toward apex, with subapical spine, 0.74 times length of coxite; style in ventrolateral view (Fig. 2E) wide basally, tapered toward apex, with round apex. Ventral plate in ventral view (Fig. 2D) transverse, 0.42 times as long as greatest width at base, angulate outward on each side, with posterior margin slightly concave, and densely covered with microsetae on ventral surface except wide area along anterior margin bare; basal arms of moderate length, slightly convergent apically; ventral plate in lateral view (Fig. 2F) with posterior portion of body much produced ventrally; ventral plate in caudal view (Fig. 2G) pointed ventromedially (width:height = 1.0:0.7), with dorsal margin concave medially, densely covered with microsetae on medial portion of posterior surface. Median sclerite (Fig. 2F, H) plate-like, arising from middle of dorsal part of ventral plate, and directed dorsally. Paramere (Fig. 2I) with one distinct hook and several smaller ones. Aedeagal membrane (Fig. 2J) moderately covered with microsetae, and with no sclerotized dorsal plate. Abdominal segment 10 (Fig. 2K,L) without distinct hair ventrally near posterolateral margin on each side. Cercus (Fig. 2K,L) rounded, slightly produced ventrally, with seven to nine hairs.

Pupa

Body length 2.0–2.2 mm. *Head*. Integument yellow, moderately covered with tubercles each bearing few minute secondary projections (Fig. 3A); three frontal trichomes unbranched and long, with straight apices (Fig. 3B) on each side; one facial trichome unbranched and long, with coiled apices (Fig. 3C) on each side; three frontal trichomes on each side arising close together, and slightly longer than facial ones. *Thorax*. Integument yellow, moderately covered with tubercles each bearing few minute secondary projections, similar to those on frons; thorax with three long trichomes with coiled apices mediadorsally (Fig. 3D), two long trichomes (anterior one somewhat more slender) anterolaterally (Fig. 3E), one medium-long trichome with straight apex mediolaterally (Fig. 3F), and three trichomes with straight apices (one short, two medium-long) ventrolaterally (Fig. 3G), on each side; all trichomes unbranched. Gill (Fig. 3H) with four slender long thread-like filaments in two pairs (outer and inner); each pair with long stalk and arising from long common basal stalk with normal basal fenestra; stalk of inner pair 1.00–1.58 times as long as and 1.07–1.08 times as thick as that of outer pair, and 1.92–2.63 times as long as and 0.71–0.75 times as thick as common basal stalk, which is 1.14 times length of

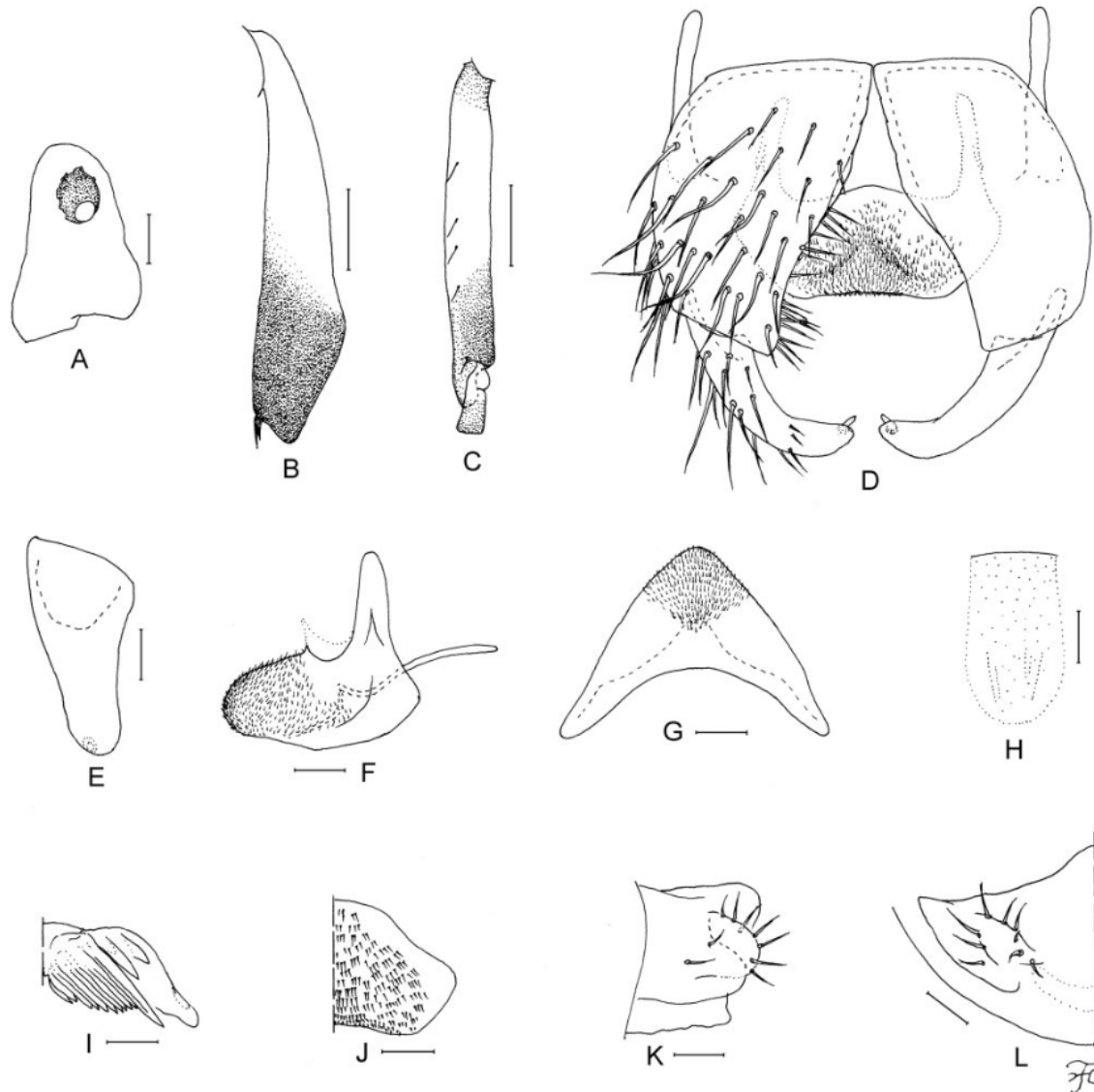


Fig. 2. Male of *S. (G.) kalimantanense* sp. nov. (A) Third segment of maxillary palp showing sensory vesicle (right side; front view). (B) Hind tibia (left side; outer view). (C) Hind basitarsus and second tarsomere (left side; outer view). (D) Coxites, styles, and ventral plate (ventral view). (E) 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 and parameral hooks (left side; caudal view). (J) Aedeagal membrane (left half; caudal view). (K) and (L) Tenth abdominal segments and cerci (right side; K, lateral view; L, caudal view). Scale bars: 0.1 mm for B and C; 0.02 mm for A and D–L.

interspiracular trunk; all filaments light brown, subequal in length (3.5–3.7 mm) and thickness to one another (though filaments of inner pair somewhat longer than those of outer pair); cuticle of all filaments with annular ridges and furrows (though becoming indistinct on apical half or more), and densely covered with minute tubercles. *Abdomen.* Dorsally, segments 1 and 2 gray, segment 9 light yellow, and other segments nearly unpigmented; segment 1 with one unbranched hair-like short seta (Fig. 3I) on each side; segment 2 with one unbranched hair-like medium-long seta and five short setae, of which one is slightly more slender than others (Fig. 3J), on

each side; segments 3 and 4 each with four hooked spines on each side; segment 5 with four unbranched short setae on each side; segments 6–8 each with two unbranched short setae on each side; segments 6–9 each with spine-combs and comb-like groups of minute spines on each side; terminal hooks (Fig. 3K) conical. Ventral surface of segment 4 with unbranched or bifid hook on each side; that of segment 5 with pair of bifid hooks on each side; those of segments 6 and 7 each with bifid inner and unbranched outer hooks on each side; lateral surface of segment 9 with grapnel-shaped hooklets. *Cocoon* (Fig. 3L). Light yellow to ochreous, wall-pocket-shaped,

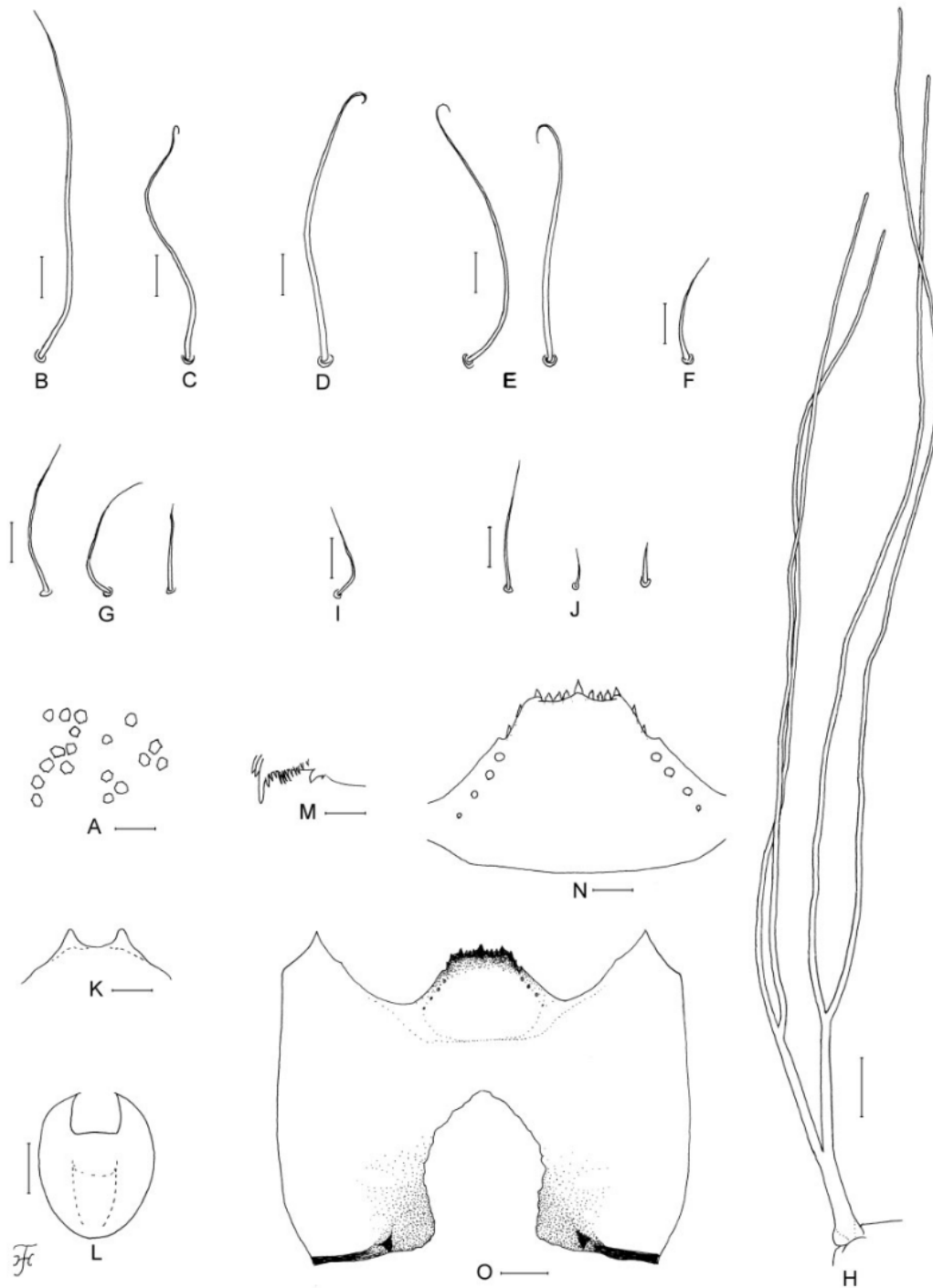


Fig. 3. Pupa and larva of *S. (G.) kalimantanense* sp. nov. Pupa (A)–(L) and larva (M)–(O). (A) Tubercles with minute secondary projections on frons. (B) Frontal trichome. (C) Facial trichome. (D)–(G) Thoracic trichomes (D, mediiodorsal; E, anterolateral; F, mediolateral; G, ventrolateral). (H) Gill filaments (left side; dorsal view). (I) Hair-like seta on dorsal surface of abdominal segment 1. (J) Hair-like seta, minute seta, and somewhat stout spinous seta on dorsal surface of abdominal segment 2. (K) Terminal hooks (caudal view). (L) Cocoon (dorsal view). (M) Mandible. (N) Hypostoma. (O) Head capsule showing postgenal cleft (ventral view). Scale bars. 1.0 mm for L; 0.2 mm for H; 0.05 mm for O; and 0.02 mm for A–G, I–K, and M and N.

moderately thickly woven, anterior margin thickly woven; individual threads visible; 2.8–3.0 mm long by 1.8–2.4 mm wide.

Mature Larva

Body length 3.6–3.8 mm. Body whitish yellow, encircled with reddish-brown transverse broad bands each on thoracic segment 1 and abdominal segments 1–8, though widely disconnected ventrally on abdominal segments 5, 7, and 8; and with concolorous transverse bands each on ventral surface of thoracic segments 2 and 3. Head capsule whitish yellow, with no distinct head spots, and sparsely covered with unpigmented minute setae, though moderately on anterior half of cephalic apotome (cephalic apotome somewhat darkened with faint negative head spots and ventral surface of head capsule light brown in two larvae, and head capsule almost entirely light brown with distinct negative head spots in three larvae). Antenna with three articles and apical sensillum, longer than stem of labral fan; length ratio of three articles (from base to tip) 1.00:0.65–0.68:1.02–1.09. Labral fan with 34–38 primary rays. Mandible (Fig. 3M) with serrations composed of two teeth (one medium-sized, one small); main tooth at acute angle to mandible on apical side; with three comb-teeth decreasing in length from first tooth to third; supernumerary serrations absent. Hypostoma (Fig. 3N) with nine anterior teeth, of which median tooth longer than each corner tooth; lateral margin smooth; three or four hypostomal bristles per side lying nearly parallel-sided or slightly divergent posteriorly from lateral margin. Postgenal cleft (Fig. 3O) arrow-head-shaped, long, 3.71–3.77 times as long as postgenal bridge. Cervical sclerites indistinct. Thoracic cuticle sparsely covered with colorless unbranched minute setae dorsally. Cuticle of abdominal segments 1–4 sparsely covered with colorless unbranched minute setae dorsally, and that of segments 5–9 moderately covered with colorless minute setae (unbranched, bifid, and trifid), dorsally and dorsolaterally (and even laterally down to base of ventral papillae of segment 9); each side of anal sclerite moderately covered with colorless unbranched short setae. Rectal scales minute and unpigmented. Rectal papilla compound, with five to seven finger-like secondary lobules per lobe. Anal sclerite X-shaped, with anterior arms 0.87 times as long as posterior ones, broadly sclerotized at base; three sensilla on broad base, and five sensilla posterior to posterior arms; accessory sclerite absent. Ventral papillae present. Posterior cirlet composed of 61–63 rows of hooklets with up to 11 or 12 hooklets per row.

Type Material

Holotype female, reared from a pupa collected from a stream (1–2 m wide, 5–10 cm deep, streambed rocky, water temperature 24.0°C, partially shaded, altitude 62 m, 01° 57'24.171" S, 116° 01'50.687" E), slow flowing in natural forest, Lempesu Waterfall, 4-IX-2015, by M. Sofian-Azirun, Z. Ya'cob. C. D. Chen, V. L. Low & Harmonis. Paratypes: One male, one pupal exuviae, three mature larvae, same data as those of holotype; one female, one male, two pupal exuviae, and one larva from a stream (width 1 m, depth 11 cm, streambed rocky, water temperature 25.0°C, partially shaded, altitude 230 m, 01° 32'56.079" S, 116° 03'19.814" E), slow flowing in natural forest, Longikis, 3-IX-2015, by the same collectors as above; one male, one pupal exuviae, and one mature larva from a small stream (width 1.5 m, depth 5–7 cm, streambed pebbles, water temperature 24.0°C, partially shaded, altitude 120 m, 01° 33'04.414" S, 116° 06'01.340" E), slow flowing in oil palm plantation, Longikis, 3-IX-2015, by the same collectors as above; four mature larvae from a stream (width 2 m, depth 7–10 cm, streambed pebbles, water temperature 25.0°C, partially shaded, altitude

118 m, 01° 33'28.150" S, 116° 05'44.395" E), slow flowing in natural forest, Longikis, 3-IX-2015, by the same collectors as above.

Depository of Types

The holotype and paratypes of *S. kalimantanense* sp. nov. are kept in the Institute of Biological Sciences, University of Malaya, Malaysia.

Bionomics

The biting habits and other biological aspects of adult females of *S. kalimantanense* sp. nov. are unknown. Substrates to which pupae and larvae were attached were leaves and sticks of trees and grasses. This species was collected together with *S. cheongi* Takaoka & Davies, *S. lebi* Takaoka, *S. sarawakense* Takaoka, *S. tabanense* Takaoka & Davies, and *S. keningauense* Takaoka.

Etymology

The species name *kalimantanense* is originated from the Indonesian state of Kalimantan.

Discussion

Simulium kalimantanense sp. nov. has close similarities to *S. alienigenum* from Palawan, the Philippines (Takaoka 1983), which is a member of the *Simulium banauense* species-group of the subgenus *Gomphostilbia* (Takaoka 2012), based on many characters including the color of the antenna and legs of adults (Figs. 1A, D, E and 2B, C), medium-sized female claw tooth (Fig. 1F), female and male genitalia (Figs. 1G–K and 2D–J), pupal gill with four long filaments (Fig. 3H), conical pupal terminal hooks (Fig. 3K), and medium-sized larval postgenal cleft (Fig. 3O). This new species is, however, distinguished from *S. alienigenum* by the characters as follows (those of *S. alienigenum* in parentheses): in both adults by lacking hairs on the pleural membrane or its vicinity (about 10 hairs present), in the female by the much narrower frons, i.e., frons: head ratio 1.0:7.4 (1.0:5.7) and longer sensory vesicle, i.e., its relative length to the third maxillary palpal segment 0.38 (0.25), in the pupa by the gill with an elongate common basal stalk (short common basal stalk), and in the larva by the shorter body length 3.6–3.8 mm (4.0–4.4 mm) and indistinct or negative head spots on the cephalic apotome (at least posterolateral spots and posterior spot of mediolongitudinal spots are somewhat darkened).

Simulium disneyi Takaoka & Roberts described from a female from northern Sulawesi, a member of the *S. banauense* species-group recorded in Indonesia (Takaoka and Roberts 1988), is differentiated from this new species by having hairs on the pleural membrane and dark hind tibia. All the nine known species of the *S. banauense* species-group in the Philippines bear a haired pleural membrane, dark legs, pupal gill with six filaments and wide, plate-like pupal terminal hooks, differing from those of this new species (Takaoka 1983, 2000, 2005).

Due to its close similarity to *S. alienigenum*, *S. kalimantanense* sp. nov. is here placed in the *S. banauense* species-group, although it lacks hairs on the pleural membrane or its vicinity, departing from the redefinition of this species-group (Takaoka 2012). This new species is the first as a member of the *S. banauense* species-group found in Borneo and marks the most southerly distribution of the group.

This new species is distinct from eight Javanese *Gomphostilbia* species (belonging to the *S. asakoeae*, *S. batoense*, *S. ceylonicum*, *S. epistum*, and *S. varicorne* species-groups) including *S. merapiense* Takaoka & Sofian-Azirun, recently described from Yogyakarta

(Takaoka and Davies 1996, Takaoka et al. 2015d), by the adult antennal color pattern (Fig. 1A), and gill with four filaments (Fig. 3H).

Keys to identify 19 species (including this new species) of the subgenus *Gomphostilbia* recorded from Sabah, Sarawak, and Kalimantan are presented as follows.

Keys to Identify 19 Species of *Simulium* (*Gomphostilbia*) Recorded From Borneo

Females*

1. Antenna composed of seven flagellomeres..... *S. charlesi*
Antenna composed of nine flagellomeres..... 2
2. Base of radius with yellow hair tuft 3
Base of radius with dark hair tuft..... 9
3. Hind tibia whitish yellow on basal two-thirds or three-fourths and dark on rest 4
Hind tibia whitish yellow on little more than basal two-fifths to basal two-thirds with dark subbasal spot 5
4. Antenna brownish-black except scape, pedicel, second to fourth flagellomeres yellow, and first flagellomere light to medium brown except base yellow *S. kalimantanense* sp. nov.
Antenna medium brown except scape, pedicel, and base of first flagellomere pale yellow *S. lebi*
5. Mid basitarsus brown *S. rayohense*
Mid basitarsus dark brown except basal half or little more whitish yellow or dark yellow 6
6. Mandible without outer teeth..... *S. barioense*
Mandible with outer teeth 7
7. Sensory vesicle 0.30–0.34 times as long as third maxillary palpal segment *S. fulgidum*
Sensory vesicle 0.23–0.26 times as long as third maxillary palpal segment 8
8. Wing 2.5 mm long..... *S. kelabitense*
Wing 1.7 mm long *S. sarawakense*
9. Fore coxa darkened..... 10
Fore coxa not darkened 11
10. Seventh sternite developed *S. guniki*
Seventh sternite undeveloped *S. hiroyukii*
11. Sensory vesicle 0.5 times or more as long as third maxillary palpal segment 12
Sensory vesicle 0.2–0.35 times as long as third maxillary palpal segment 13
12. Hind tibia darkened except base pale *S. parahiyangum*
Hind tibia whitish yellow on basal half and darkened on rest *S. sheilae*
13. Frons with narrowest width in middle and moderately covered with short hairs *S. terengganuense*
Frons with narrowest width near lower margin and largely bare except several hairs along each lateral margin and above lower margin..... 14
14. Basal tooth of claw 0.4 length of claw *S. tabanense*
Basal tooth of claw 0.52 length of claw *S. paukatense*

Males

1. Antenna composed of seven flagellomeres..... *S. charlesi*
Antenna composed of nine flagellomeres..... 2
2. Hind basitarsus enlarged 3
Hind basitarsus slender, nearly parallel-sided 6
3. Fore coxa darkened..... 4
Fore coxa not darkened 5
4. Ventral plate with lateral margins concave *S. hiroyukii*

- Ventral plate with lateral margins nearly straight *S. guniki*
5. Upper-eye facets in 13 horizontal rows..... *S. sheilae*
Upper-eye facets in 16 or 17 horizontal rows..... *S. capillatum*
6. Base of radius with yellow hair tuft 7
Base of radius with dark hair tuft 14
7. Antenna brownish-black except scape, pedicel, second to fourth flagellomeres yellow, and first flagellomere light to medium brown except base yellow *S. kalimantanense* sp. nov.
Antenna otherwise 8
8. Hind tibia yellowish white on basal three-fourths and medium brown on rest, without dark subbasal spot..... *S. lebi*
Hind tibia whitish yellow to yellow on little more than basal half and medium to dark brown on rest, with light brown subbasal spot 9
9. Upper-eye facets in 15 or 16 vertical columns and in 15 horizontal rows *S. auratum*
Upper-eye facets in 9–12 vertical columns and in 10–13 horizontal rows 10
10. Antenna yellow, though apical tip somewhat darkened *S. kelabitense*
Antenna yellow, though apical two to five flagellomeres somewhat darkened..... 11
11. Abdomen dark brown dorsally except tergite 2 yellow *S. rayohense*
Abdomen dark brown to brownish black dorsally except segments 2 and 3 yellow or dark yellow though medial area light to dark brown..... 12
12. Antenna yellow, though apical two flagellomeres somewhat darkened *S. fulgidum*
Antenna yellow, though apical three to five flagellomeres somewhat darkened..... 13
13. Cercus with 9–12 hairs *S. sarawakense*
Cercus with 15 hairs *S. barioense*
14. Abdominal segments 2, 6, and 7 each with pair of dorsolateral shiny spots..... *S. parahiyangum*
Abdominal segments 2, 5, 6, and 7 each with pair of dorsolateral shiny spots..... 15
15. Antenna grayish yellow except scape, pedicel, and first flagellomere somewhat darkened and ninth flagellomere grayish *S. terengganuense*
Antenna otherwise 16
16. Upper-eye facets in 11 vertical columns 17
Upper-eye facets in 15–18 vertical columns 18
17. Upper-eye facets in 11 horizontal rows..... *S. tabanense*
Upper-eye facets in 13 horizontal rows..... *S. bakalalanense*
18. Upper-eye facets in 15 or 16 vertical columns and in 15 horizontal rows *S. pegalanense*
Upper-eye facets in 17 or 18 vertical columns and in 16 or 17 horizontal rows *S. paukatense*

Pupae

1. Gill with four filaments *S. kalimantanense* sp. nov.
Gill with six to 16 filaments 2
2. Gill with six filaments *S. paukatense*
Gill with eight to 16 filaments 3
3. Gill with 13 or 16 filaments..... *S. barioense*
Gill with eight filaments 4
4. Gill with swollen basal fenestra *S. bakalalanense*
Gill without such swollen basal fenestra..... 5
5. Gill filaments short, <1.0 mm 6
Gill filaments 1.6 mm or longer 7

6. Gill filaments arising at same level from common basal stalk *S. fulgidum*
Gill filaments arranged as 3 + 3 + 2 filaments from dorsal to ventral *S. parahiyangum*
7. Gill filaments 1.6 mm long, closely arising at same level from short common stalk *S. guniki*
Gill filaments over 2.0 mm long, arranged differently 8
8. Inner filament of ventral pair longer and thicker than outer filament *S. pegalanense*
Inner filament of ventral pair as thick as or thinner than outer filament 9
9. Inner filament of ventral pair nearly as thick as outer filament 10
Inner filament of ventral pair thinner and shorter than outer filament 16
10. Stalks of dorsal and middle triplets and ventral pair arising at same level from common basal stalk 11
Stalks of dorsal and middle triplets sharing short stalk 12
11. Grapnel-shaped hooklets absent *S. lehi*
Grapnel-shaped hooklets present *S. charlesi*
12. Filaments of ventral pair much longer than six other filaments. . . *S. tabanense*
All filaments subequal in length 13
13. Terminal hooks mushroom-shaped *S. terenggauense*
Terminal hooks triangular or widened, and plate-like 14
14. Both dorsal triplet primary stalk and middle triplet secondary stalk extraordinarily long, being half to two-thirds of entire length of filaments *S. hiroyukii*
Both dorsal triplet primary stalk and middle triplet secondary stalk short 15
15. Frons and thorax almost bare, without tubercles *S. capillatum*
Frons and thorax moderately covered with tubercles *S. sheilae*
16. All filaments except outer filament of ventral pair 2.0–2.3 mm long *S. kelabitense* and *S. rayobense*
All filaments except outer filament of ventral pair 1.2–1.6 mm long 17
17. Outer filament of ventral pair 2.1–2.3 mm long, 1.5 times as thick as inner filament *S. auratum*
Outer filament of ventral pair 3.0 mm long, twice as thick as inner filament *S. sarawakense*
8. Postgenal cleft reaching or approaching posterior border of hypostoma 9
Postgenal cleft not reaching posterior border of hypostoma 10
9. Labral fan with 31–34 primary rays *S. sheilae*
Labral fan with 38 primary rays *S. pegalanense*
10. Postgenal cleft short, 0.4 times as long as postgenal bridge *S. gumiki*
Postgenal cleft, medium-long to long, longer than postgenal bridge 11
11. Body entirely grayish green or dark gray 12
Body color otherwise 13
12. Body grayish green *S. lehi*
Body dark gray *S. bakalalanense*
13. Abdominal cuticle almost bare *S. hiroyukii*
Abdominal cuticle with branched dark spinous setae 14
14. Histoblast of gill with eight filaments arising together from short common basal stalk *S. fulgidum*
Histoblast of gill arranged otherwise 15
15. Body length 5.0–6.0 mm 16
Body length 4.5 mm or shorter 17
16. Labral fan with 40–47 primary rays *S. terenggauense*
Labral fan with 30–32 primary rays *S. kelabitense*
17. Abdominal segments 1–4 almost bare *S. sarawakense*
Abdominal segments 1–4 covered with branched *S. rayobense*
*The females of *S. auratum*, *S. bakalalanense*, *S. capillatum*, and *S. pegalanense* are unknown. **The larva of *S. auratum* is unknown.

Mature larvae**

1. Histoblast of gill with 13 or 16 filaments *S. barioense*
Histoblast of gill with four, six, or eight filaments 2
2. Histoblast of gill with four filaments . *S. kalimantanense* sp. nov.
Histoblast of gill with six or eight filaments 3
3. Histoblast of gill with six filaments *S. paukatense*
Histoblast of gill with eight filaments 4
4. Thoracic proleg covered with unbranched and branched setae *S. capillatum*
Thoracic proleg without such setae 5
5. Abdominal segments 1–5 each with paired dorsolateral protuberances 6
Abdominal segments 1–5 without such dorsolateral protuberances 7
6. Thoracic segments 2 and 3, and abdominal segments 1–5 each with pair of dorsolateral protuberances *S. charlesi*
Abdominal segments 1–5 each with two pairs of such protuberances *S. parahiyangum*
7. Two grayish-black transverse bands each on thoracic segment 1 and abdominal segment 1 *S. tabanense*
Such grayish-black transverse bands absent 8

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