**Morphology, Systematics, Evolution**

**Simulium (Gomphostilbia) merapiense sp. nov. (Diptera: Simuliidae) from Java, Indonesia**

Hiroyuki Takaoka,1,2 Mohd Sofian-Azirun,1 Zubaidah Ya’cob,1 Chee Dhang Chen,1 Van Lun Low,1 and Adnan Zaid3

1Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, 50603 Malaysia (takaoka@oita-u.ac.jp; msfianazirun@gmail.com; xuehy_perdana@yahoo.com; chen_cctbr@um.edu.my; lucaslow24@gmail.com), 2Corresponding author, e-mail: takaoka@oita-u.ac.jp, and 3University of Technology Yogyakarta, Jalan Ring Road Utara Jombor Sleman, Yogyakarta, 55285 Indonesia (adnan56zaid@yahoo.com)

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**Abstract**

*Simulium (Gomphostilbia) merapiense sp. nov.* is described based on females, males, pupae, and mature larvae from Yogyakarta, Java, Indonesia. This new species is placed in the *Simulium epitum* species-group, and is characterized by the pupal gill with eight short filaments all arising at the same level from a short stalk, somewhat enlarged basal fenestra, entirely bare pupal head and thoracic integument, and small and short larval postgenal cleft. These characters rarely are found in the subgenus. Taxonomic notes are given to separate this new species from related species of the *S. epitum* species-group.

**Key words**: black fly, *Simulium*, new species, Java

The black flies (Diptera: Simuliidae) of Java, Indonesia, were first studied in depth by Edwards (1934) and later revised by Takaoka and Davies (1996). *Simulium (Gomphostilbia) sundaicum* Edwards, one of the common black fly species in Java, was synonymized with *S. (G.) atratum* de Meijere (Takaoka 2012). So far, 21 species have been recorded from Java, all of which are classified in three subgenera in the genus *Simulium*: seven species in *Gomphostilbia*, four species in *Nevermannia*, and 10 species in *Simulium* (Adler and Crosskey 2015).

Although the number of subgenera in Java is low, the diversity of lineages in each subgenus is rich: five, three, and six species-groups are included in *Gomphostilbia*, *Nevermannia*, and *Simulium*, respectively (Adler and Crosskey 2015). Geographically located in the southernmost part of the Oriental Region, Java marks the southern boundary for the distributions of most of these groups, of which some (e.g., *S. (N.) vernum* species-group and *S. (S.) tuberosum* species-group) are widely distributed in the Oriental and Palaearctic regions (and even in the Nearctic Region); Java is also home to seven species endemic to Java (Takaoka and Davies 1996).

The biting habits and vectorial role of Javanese species of black flies are unknown yet, although three Oriental species of black flies, *S. (G.) asakoe* Takaoka & Davies, *S. (S.) nigrogilvum* Summers, and *S. (S.) nodosum* Puri, have been reported to be man-biters and transmit different kinds of animal filariae in Thailand (Fukuda et al. 2003, Takaoka et al. 2003).

We surveyed larval and pupal black flies in Yogyakarta in 2014 and collected a new species that is assigned to the subgenus *Gomphostilbia*. This new species is characterized by the pupal gill with eight short filaments all arising at the same level from a short stalk, somewhat enlarged basal fenestra, entirely bare pupal head and thoracic integument, and small larval postgenal cleft; all of these characters rarely occur in this subgenus. It is here described based on females, males, pupae, and mature larvae.

The methods of collection, description, and illustration, and terms for morphological features, follow those of Takaoka (2003). The holotype of the new species is deposited in the Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia.

**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:BBE84D3D-79B2-42BF-8707-678ECD77F7BB

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

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**Female**

Body length 1.8–2.0 mm. *Head*. Nearly as wide as thorax. Frons brownish-black, densely covered with whitish to whitish-yellow.
scale-like recumbent short hairs and few to several dark hairs along each lateral margin; frontal ratio 1.83:1.00:2.33; fronshead ratio 1.00:4.36. Fronto-ocular area well developed, narrow, directed dorsolaterally. Clypeus brownish-black, slightly white pruinose, and densely covered with whitish-yellow recumbent hairs interspersed with several dark longer hairs on each side. Labrum 0.57 times length of clypeus. Antenna composed of scape, pedicel, and nine flagellomeres, light to medium brown except scape, pedicel and base of first flagellomere whitish yellow. Maxillary palp composed of five segments, light brown except third segment medium brown, proportional lengths of third, fourth, and fifth segments 1.00:0.79:1.81; third segment (Fig. 1A) much enlarged; sensory vesicle (Fig. 1A) elongate, 0.62–0.67 times length of third segment and with medium-sized opening. Maxillary lacinia with 9 inner and 12–14 outer teeth. Mandible with 18 inner and 11 outer teeth. Cibarium (Fig. 1B) with dorsal margin having short plate produced forward and downward, and with weakly sclerotized mediolongitudinal stripe bearing V-shaped apex. Thorax. Scutum dark brown, slightly white-pruinose, shiny when illuminated at certain angles, faintly with three narrow longitudinal viitae (one median, two submedian), densely covered with yellow scale-like recumbent hairs. Scutellum dark brown, covered with yellow short hairs and dark-brown long upright hairs. Postnotum dark brown, white pruinose and slightly shiny when illuminated at certain angles, and bare. Pleural membrane bare. Katepisternum longer than deep, dark brown, white pruinose and shiny when illuminated at certain

Fig. 1. Female of S. (G.) merapiense sp. nov. (A) Third segment of maxillary palp showing sensory vesicle (right side; front view). (B) Cibarium (upper portion; front view). (C) Hind tibia (left side; outer view). (D) Basitarsus and second tarsomere of hind leg (left side; outer view). (E) Claw. Sternite 8 (F) and ovipositor valves (ventral view). (G) Genital fork (ventral view). (H) and (l) Paraprocts and cerci (right side; H, ventral view; I, lateral view). (J) Spermatheca. Scale bars. 0.1 mm for C and D; 0.02 mm for A, B, and E–J.
angles, moderately covered with pale and dark short hairs. **Legs.** Foreleg; coxa and trochanter whitish yellow; femur light brown with apical cap medium brown (though extreme tip whitish yellow); tibia light to medium brown except base and outer surface of basal half whitish yellow; tarsus dark brown to brownish black, with moderate dorsal hair crest; basitarsus somewhat dilated, 6.4 times as long as its greatest width. Midleg; coxa light brown except posterolateral surface dark brown; trochanter whitish yellow; femur light brown except base whitish yellow and apical cap medium brown (though extreme tip whitish yellow); tibia medium brown except basal two-fifths whitish yellow; tarsus dark brown except basal three-fifths or little less of basitarsus yellow. Hind leg: coxa light brown; trochanter whitish yellow; femur medium brown except base whitish yellow and apical cap dark brown (though tip whitish yellow); tibia (Fig. 1C) whitish yellow to yellow on basal three-fifths and dark brown on apical two-thirds; tarsus (Fig. 1D) dark brown except basal three-fifths of basitarsus (though base light brown) and little less than basal half of second tarsomere whitish yellow; basitarsus (Fig. 1D) narrow, parallel-sided toward middle, then slightly narrowed toward apex, 6.00 times as long as wide, and 0.67 and 0.57 times as wide as greatest widths of tibia and femur, respectively; calcipala (Fig. 1D) well developed, slightly longer than wide, and 0.53 times as wide as greatest width of basitarsus; pedisculus (Fig. 1D) well developed; claw (Fig. 1E) with large basal tooth 0.51 times length of claw. **Wing.** Length 1.8 mm. Costa with dark-brown spinules and light-brown hairs except basal patch of whitish-yellow. Subcosta haired except near apex bare. Base of radial vein with whitish-yellow hairs. Basal portion of radius fully whitish-yellow. Subcosta haired except near apex bare. Sensory vesicle (Fig. 2A) small, globular, 0.18 times length of third segment, with small opening. **Thorax.** Scutum brownish black, shiny entirely and white pruinose on shoulders, wide areas along lateral margins and prescutellar area when illuminated at certain angles, 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 almost similar to that of female except mid tibia whitish yellow on basal one-third, and mid basitarsus yellow on base or basal half, and hind tibia (Fig. 2B) whitish yellow on little more than basal half (though its border not well defined). Fore basitarsus slightly dilated, 6.5 times as long as greatest width. Hind basitarsus (Fig. 2C) not enlarged, much narrower than hind tibia and femur; calcipala (Fig. 2C) well developed, slightly longer than width at base. **Wing.** Length 2.2 mm. As in female except subcosta bare. **Halter.** Ochreous with basal portion darkened. **Abdomen.** Basal scale ochreous, with fringe of yellowish white hairs. Color of abdomen similar to that of female except segment 2 yellow on basal half and reddish brown on posterior half, and segment 3 reddish brown; ventral surface light brown except segment 2 yellow (though narrow area along posterior margin reddish brown), and segment 3 reddish brown; tergites 2 and 5–7 each with pair of dorsolateral iridescent spots when illuminated at certain angles. **Genitalia.** Coxites, styles, and ventral plate in ventral view as in Fig. 2D. Coxite in ventral view nearly rectangular, 1.53 times as long as its greatest width; coxite in ventrolateral view (Fig. 2E) 1.19 times as long as wide. Style in ventral view (Fig. 2D), curved inward, tapered toward apex, with subapical spine; style in ventrolateral view (Fig. 2F) wide, nearly parallel-sided from base to apical one-third, then much tapered toward apex, with round apex; style in medial view (Fig. 2G) narrow, slightly tapered from base toward apex, 0.8 times length of coxite. Ventral plate in ventral view (Fig. 2D) transverse, 0.36 times as long as greatest width at base, with anterior margin produced anteromedially, posterior margin nearly straight, and densely covered with microsetae on ventral surface except narrow area along anterior margin bare; basal arms of moderate length, slightly divergent, then convergent apically; ventral plate in lateral view (Fig. 2H) with posterior portion of body much produced ventrally; ventral plate in caudal view (Fig. 2J) pointed ventromedially (width:height = 1.00:0.48), with dorsal margin concave medially, and densely covered with microsetae on posterior surface. Median sclerite (Fig. 2H, J) plate-like, arising from level near anteromedial tip of ventral part of body of ventral plate, and directed posteriorly. Paramere (Fig. 2K) with six distinct hooks and few smaller ones. Aedeagal membrane (Fig. 2L) densely covered with microsetae, and with no sclerotized dorsal plate. Abdominal segment 10 (Fig. 2M, N) with one distinct hair ventrally near posterolateral margin and four or five distinct hairs laterally on each side. Cercus (Fig. 2M, N) rounded, slightly produced ventrally, with 10 or 11 hairs.

**Male**

Body length 2.2–2.5 mm. **Head.** Slightly wider than thorax. Upper eye medium brown, consisting of 12 or 13 vertical columns and 13 horizontal rows of large facets. Face brownish black, whitish-gray pruinose when illuminated at certain angles. Clypeus brownish black, whitish-gray pruinose when illuminated at certain angles, and densely covered with yellow short scale-like hairs (except mediolongitudinal narrow portion of lower half bare) interspersed with three dark-brown longer hairs on each side of lower portion. Antenna composed of scape, pedicel, and nine flagellomeres (though right antenna of one male with eight flagellomeres), yellowish (except apical four or five flagellomeres somewhat darkened); first flagellomere elongate, 2.05 times length of second one. Maxillary palp with five segments, light brown, proportional lengths of third, fourth, and fifth segments 1.00:0.94:2.32; third segment (Fig. 2A) not enlarged; sensory vesicle (Fig. 2A) small, globular, 0.18 times length of third segment, with small opening. **Thorax.** Scutum brownish black, shiny entirely and white pruinose on shoulders, wide areas along lateral margins and prescutellar area when illuminated at certain angles, 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 almost similar to that of female except mid tibia whitish yellow on basal one-third, and mid basitarsus yellow on base or basal half, and hind tibia (Fig. 2B) whitish yellow on little more than basal half (though its border not well defined). Fore basitarsus slightly dilated, 6.5 times as long as greatest width. Hind basitarsus (Fig. 2C) not enlarged, much narrower than hind tibia and femur; calcipala (Fig. 2C) well developed, slightly longer than width at base. **Wing.** Length 2.2 mm. As in female except subcosta bare. **Halter.** Ochreous with basal portion darkened. **Abdomen.** Basal scale ochreous, with fringe of yellowish white hairs. Color of abdomen similar to that of female except segment 2 yellow on basal half and reddish brown on posterior half, and segment 3 reddish brown; ventral surface light brown except segment 2 yellow (though narrow area along posterior margin reddish brown), and segment 3 reddish brown; tergites 2 and 5–7 each with pair of dorsolateral iridescent spots when illuminated at certain angles. **Genitalia.** Coxites, styles, and ventral plate in ventral view as in Fig. 2D. Coxite in ventral view nearly rectangular, 1.53 times as long as its greatest width; coxite in ventrolateral view (Fig. 2E) 1.19 times as long as wide. Style in ventral view (Fig. 2D), curved inward, tapered toward apex, with subapical spine; style in ventrolateral view (Fig. 2F) wide, nearly parallel-sided from base to apical one-third, then much tapered toward apex, with round apex; style in medial view (Fig. 2G) narrow, slightly tapered from base toward apex, 0.8 times length of coxite. Ventral plate in ventral view (Fig. 2D) transverse, 0.36 times as long as greatest width at base, with anterior margin produced anteromedially, posterior margin nearly straight, and densely covered with microsetae on ventral surface except narrow area along anterior margin bare; basal arms of moderate length, slightly divergent, then convergent apically; ventral plate in lateral view (Fig. 2H) with posterior portion of body much produced ventrally; ventral plate in caudal view (Fig. 2J) pointed ventromedially (width:height = 1.00:0.48), with dorsal margin concave medially, and densely covered with microsetae on posterior surface. Median sclerite (Fig. 2H, J) plate-like, arising from level near anteromedial tip of ventral part of body of ventral plate, and directed posteriorly. Paramere (Fig. 2K) with six distinct hooks and few smaller ones. Aedeagal membrane (Fig. 2L) densely covered with microsetae, and with no sclerotized dorsal plate. Abdominal segment 10 (Fig. 2M, N) with one distinct hair ventrally near posterolateral margin and four or five distinct hairs laterally on each side. Cercus (Fig. 2M, N) rounded, slightly produced ventrally, with 10 or 11 hairs.
Pupa

Body length 2.1–2.4 mm. **Head.** Integument yellow, entirely bare; antennal sheath without tubercles; frons with two pairs of unbranched long trichomes with uncoiled apices (Fig. 3A); face with pair of unbranched long trichomes with coiled apices (Fig. 3B); two frontal trichomes on each side arising close together, subequal in length to each other and somewhat longer than facial ones. **Thorax.** Integument yellow and entirely bare; thorax on each side with three long anterodorsal trichomes with coiled apices (Fig. 3C), two long anterolateral trichomes (anterior one with straight apex, posterior one with coiled apex; Fig. 3D), one long mediolateral trichome with straight apex (Fig. 3E), and three ventrolateral trichomes with straight apices (two short, one medium-long; Fig. 3F); all trichomes unbranched. Gill (Fig. 3G) composed of eight slender short thread-like filaments, arising at same level from short common

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**Fig. 2.** Male of *G. (G.) merapiense* sp. nov. (A) Third segment of maxillary palp showing sensory vesicle (left side; front view). (B) Hind tibia (left side; outer view). (C) Basitarsus and second tarsomere of hind leg (left side; outer view). (D) Coxites, styles, and ventral plate (ventral view). (E) Coxite (ventrolateral view). (F) and (G) Styles (right side; F, ventrolateral view; G, medial view). (H) Ventral plate and median sclerite (lateral view). (I) Ventral plate (caudal view). (J) Median sclerite (ventral view). (K) Paramere (left side; caudal view). (L) Aedeagal membrane (left half; caudal view). (M) and (N) Tenth abdominal segments and cerci (right side; M, lateral view; N, caudal view). Scale bars. 0.1 mm for B and C; 0.02 mm for A, B, and D–N.
basal stalk, which has somewhat swollen basal fenestra (Fig. 3G, H); all filaments light brown, subequal in length (1.0–1.2 mm) and thickness to one another (though lower filaments appearing to be somewhat longer than dorsal ones); cuticle of all filaments without annular ridges (though shallow furrows present at irregular intervals), and densely covered with minute tubercles. **Abdomen.** Dorsally, all segments nearly unpigmented and without tubercles; segment 1 with one unbranched slender short hair-like seta (Fig. 3I) on each side; segment 2 with one unbranched...
slender short hair-like seta and five short setae, of which two to five are stout and others are fine (Fig. 3J) submedially near posterior margin on each side; segments 3 and 4 each with four hooked spines and one short somewhat spinous seta near posterior margin on each side; segments 5–8 each with two or three unbranched (occasionally bifid) short setae near posterior margin on each side; segments 6–8 each with spine-combs in transverse row and comb-like groups of minute spines near anterior margin; segment 9 with pair of wide terminal hooks (Fig. 3K) and comb-like groups of minute spines near anterior margin. Ventrally, segment 5 with pair of bifid or trifid hooks submedially and few unbranched short slender setae on each side; segments 6 and 7 each with pair of bifid or trifid inner and unbranched or bifid outer hooks somewhat spaced from each other and few unbranched short slender setae on each side; segments 4–8 with comb-like groups of minute spines. Each side of segment 9 with two or three grappling-shaped hooklets.

Cocoon (Fig. 3L, M). Yellowish white, wall-pocket-shaped (though one cocoon with both anteroventral tips approaching each other and connected anteromesially), moderately woven, somewhat extended ventrolaterally; anterior margin thickly woven, without anterodorsal bulge or projection; posterior half with floor roughly or moderately woven; individual threads invisible; 2.5–3.0 mm long by 1.2–1.5 mm wide.

Mature larva

Body length 4.5–4.8 mm. Body ochreous to light brown with marked blackish transverse broad band on each of thoracic segments 1 and 3, abdominal segments 4, 5, 7 and 8 (and indefinite dark markings on abdominal segment 6 in some larvae). Head capsule covered with minute unpigmented setae moderately on cephalic apotome, sparsely on lateral and ventral surfaces. Cephalic apotome yellow to ochreous, with distinct positive head spots. Lateral surface of head capsule yellow except eye-spot region white, areas above eye-spot region and posterior one-third medium brown, and with distinct dark round spot below eye-spot region; eyebrow well defined; two relatively large spots and one or two small spots near posterior margin merged with dark background. Ventral surface of head capsule ochreous with wide median portion medium brown; elongate spot on each side of postgenal cleft merged with dark background. Antenna composed of three segments and apical sensillum, longer than stem of labral fan; proportional lengths of first, second, and third segments 1.0:0.61:0.87. Labral fan with 37 main rays. Mandible (Fig. 4A) with three comb-teeth decreasing in length from first tooth to third; mandibular serration composed of two teeth (one medium-sized, one small); major tooth at acute angle against mandible on apical side; supernumerary serrations absent. Hypostoma (Fig. 4B) with row of nine apical teeth, of which median tooth subequal in length to each corner tooth; lateral margin smooth; five or six hypostomal bristles per side lying parallel to lateral margin. Postgenal cleft (Fig. 4C, D) small, 0.27 times length of postgenal bridge, and variable in shape. Cervical sclerites composed of pair of small yellow rod-like pieces, not fused to occiput, widely separated mediad from each other. Thoracic proleg without hairs; thoracic cuticle sparsely covered with minute colorless setae dorsally; abdominal cuticle of segments 1–6 sparsely covered with minute colorless setae dorsally and that of segments 7–9 moderately to densely covered with similar setae dorsally and dorsolaterally (and even laterally down to tip of ventral papillae of segment 9); last abdominal segment densely covered also with little longer colorless setae on each side of anal sclerite; when viewed dorsally, abdomen moderately constricted between abdominal segments 4 and 5; thorax and abdomen without dorsal protuberances. Rectal scales present. Rectal papilla (Fig. 4E) compound, each of three lobes with one or two nipple-like secondary projections. Anal sclerite of usual X-form, with anterior nearly as long as, or slightly longer than posterior ones, broadly sclerotized at base; accessory sclerite absent. Last abdominal segment with pair of large conical ventral papillae. Posterior circllet with 96–102 rows of hooklets with up to 12 hooklets per row.

Type Materials

HOLOTYPE. Female, reared from a pupa collected from a small stream (width 2 cm, depth 1 cm, water temperature 20.0°C, shaded, altitude 920 m, 07° 35'31" S/110° 25'5.79" E), slow flowing for a

Fig. 4. Mature larva of S. (G.) merapiense sp. nov. (A) Mandible. (B) Hypostoma. (C) Head capsule showing postgenal cleft (ventral view). (D) Postgenal cleft of different shape. (E) Rectal papilla (anterodorsal view). Scale bars. 0.1 mm for E; 0.05 mm for C and D; 0.02 mm for A and B.
short distance in shrubs, then going underground, Merapi National Park, Kalibaruang Province, Java, Indonesia, 28-V-2014, by M. Sofian-Azirun and Z. Ya’cob. PARATYPES: Two females, two pharate females, two pharate males, two pupae, and three larvae, same data as those of holotype.

Biological Notes
The biting habits of adult females of this new species are unknown. The pupae and larvae of this new species were collected from plastic sheets in the water. No other species were collected.

Etymology
The species name merapiense refers to the volcano Merapi, because this new species was collected in the vicinity of this mountain.

Remarks
This new species is assigned to the S. epistum species-group of the subgenus Gomphostilbia, defined by Takaoka (2012), based on adults with the antenna composed of scape, pedicel, and nine flagellomeres, pleural membrane bare, base of the radial vein with yellow hairs, hind tibiae yellowish on more than basal half (Figs. 1C and 2B); female claw with a large tooth (Fig. 1E); male hind basitarsus slender and parallel-sided (Fig. 2C); and pupal terminal hooks wide and crenulated on the outer margin (Fig. 3K).

This new species is easily distinguished from all 29 members of the S. epistum species-group including S. (G.) atratum de Meijere, the only member in Java (Takaoka and Davies 1996), by the arrangement of the eight pupal gill filaments (Fig. 3G), entirely bare pupal head and thoracic integument, and small larval postgenal cleft (Fig. 4C,D).

Simulium (G.) fulgidum Takaoka (S. epistum species-group) from Sarawak, Malaysia (Takaoka 2009), has a similar arrangement of the pupal gill filaments but differs in many characters including the pupal head and thoracic integument covered with tubercles, terminal hooks not crenulated, and short cocoon.

Simulium (G.) batoense Takaoka & Shrestha (S. batoense species-group) from Nepal (Takaoka and Shrestha 2010) has a somewhat enlarged basal fenestra, like this new species, but its pupal gill filaments and terminal hooks differ from those of S. (G.) merapiense sp. nov.

Two other characters of this new species, the pupal head and thoracic integument entirely bare and the small larval postgenal cleft, have never been reported in other Gomphostilbia species, though S. (G.) palauense Stone (S. palauense species-group) from Palau Island, Micronesia, lacks a larval postgenal cleft (Takaoka and Craig 1999).

This new species is distinguished in the female from that of S. (G.) atratum by an elongate sensory vesicle (Fig. 1A), although a similar elongated sensory vesicle is known for S. (G.) atratoides Takaoka & Davies (S. ceylonicum species-group) and S. (G.) para-bhiyangum Takaoka & Sigit (S. batoense species-group), both described from Java (Takaoka and Davies 1996; Takaoka and Sigit 1992).

The male of S. (G.) merapiense sp. nov. is similar to that of S. (G.) atratum, which was described based on a specimen from Mt. Gede, West Java (De Meijere 1913), but differs from the latter by the light brown mid femur (c.f., yellowish mid femur in S. (G.) atratum).

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