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Short Communication

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A new species of *Simulium* (*Simulium*) (Diptera: Simuliidae), with keys to *S. striatum* species-group from India

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Abstract: *Simulium* (*Simulium*) *yanaense* sp. nov. is described based on the male, larva, and pupa. It is characterized by having a maxillary palp with a small sensory vesicle, and the subcosta and basal portion of the radius bare in the male; the gill with 10 short slender filaments and short common basal stalk in the pupa; and the thorax and abdomen without a pair of dorsolateral protuberances in the larva. Keys are provided to the species of the *S. striatum* species group of the subgenus *Simulium* known from India.

Keywords: Black fly, central Western Ghats, Karnataka, new species, *Simulium* (*Gomphostilbia*) *cauveryense*, *Simulium* (*Simulium*) *striatum*, taxonomic survey.

Black flies (Diptera: Simuliidae) are widely distributed on all continents except Antarctica. Approximately, 10–20 % of the species are of medical and veterinary importance due to their habit of biting humans and domestic animals (Adler & McCreadie 2009; Andrade-Souza et al. 2017). The immature stages of black flies inhabit lotic environments and play an important role in nutrient turnover in streams (Currie & Adler 2008). In India, 81 species of black flies were recorded, all of which are classified in six subgenera of the genus *Simulium* Latreille (Anbalagan et al. 2017). Around 24% of these species are recorded from southern India (Kerala, Karnataka, and Tamil Nadu states), whereas the remaining species are recorded from northeastern India.

To explore the black fly fauna in southern India, we surveyed larvae and pupae in the central Western Ghats in November 2016 and January 2017 and collected two described species, *Simulium* (*Simulium*) *striatum* Brunetti, 1912 and *S.* (*Gomphostilbia*) *cauveryense* (Anbalagan et al. 2015), along with a new species of the same genus herein described based on the male, pupa, and larva. We also provide keys to the *S. striatum* species-group known from India.

Materials and Methods

A taxonomic survey was conducted in the central Western Ghats between November 2016 and January 2017. We collected pupae and larvae from the streams at Yana and Balur, Kumta Taluk, Uttara Karnataka District, Karnataka State, India. The physical and chemical characteristics of the river at the type locality of the new species were as follows: dissolved oxygen 8.2mg/L, pH 6.4, conductivity 145µ/s, total dissolved solids 101.3ppm, width 2–3.5 m, depth 5–30 cm, water current 0.03–0.06 m/s. River substrates included bedrock, boulders, pebbles, gravel, and sand.

Larvae and pupae were collected manually from submerged leaf litter and woody debris in the water. Mature pupae were removed from substrates with a fine

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brush and forceps and reared to adults. We obtained males but no females. The descriptions and illustrations and terms for morphologic features follow those of Takaoka (2003) and partially those of Adler et al. (2004). The holotype and paratypes were deposited in the Department of Zoology, Government Arts College, Melur, Madurai, Tamil Nadu, India.

Results

Simulium (*Simulium*) *yanaense* Anbalagan sp. nov.

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(Figs. 1 & 2)

Description

Male: Body length 2.8mm. Head somewhat wider than thorax. Upper eye yellowish-brown, consisting of 12 vertical columns and 16 horizontal rows of large facets. Face brownish-black, greyish-white pruinose. Clypeus black, whitish pruinose, densely covered with golden-yellow scale-like medium-long hairs (directed upward and lateral) interspersed with several dark brown simple longer hairs. Antenna composed of scape, pedicel, and nine flagellomeres, yellow to brown; first flagellomere elongate, twice as long as second. Maxillary palp light to medium brown with five segments, proportional lengths of segments 3, 4, and 5 are 1.00:1.46:3.13; segment 3 (Fig. 1A) widened apically; sensory vesicle (Fig. 1A) globular, small (0.19 times as long as segment 3) and with small opening. Thorax: scutum slightly darker and short hairs on scutum golden yellow. Legs: foreleg coxa yellow; trochanter yellow with some portions light brown; femur light brown except apical cap brown; tibia brown with median 2/3 light brown and covered with dark brown hairs; tarsus brown to dark brown; basitarsus moderately dilated 6.75 times as long as its greatest width. Midleg: coxa yellowish-brown; trochanter yellow to brown; femur yellow except apical one-fourth brown; tibia medium brown to dark brown; tarsus dark brown to brownish-black except anterior surface of little less than basal half of basitarsus dark yellow to light brown. Hindleg: coxa dark yellow to brown; trochanter yellow; femur light brown except apical half dark brown; tibia (Fig. 1B) brown except base and apex dark brown; tarsus medium to dark brown except basal half (or little less) of basitarsus whitish-yellow and little less than basal one-third of second tarsomere white; basitarsus (Fig. 1C) enlarged, spindle-shaped, 4.1 times as long as wide, and 0.73 and 0.68 times as wide as greatest width of tibia and femur, respectively; calcipala (Fig. 1C) nearly as long as wide, and 0.36 times as wide as greatest width of basitarsus. Pedisulcus (Fig. 1C) well-defined. Wing: length 1.92mm. Costa with dark brown spinules as well as dark brown hairs except for basal portion with patch of yellowish hairs. Subcosta bare and basal portion of radius bare. Halter yellowish-brown except outer surface ochreous, basal stem darkened and apex white. Abdomen: basal scale dark brown with fringe of light to medium brown hairs. Dorsal surface of abdomen dark brown except segment 2 light brown (though posterior one-fourth of dorsal surface brown), covered with dark brown short to long hairs; segments 2–7 each with shiny dorsolateral or lateral patches; ventral surface of segment 2 yellow, those of segments 3 and 4 yellow except sternites medium brown, and those of other segments medium to dark brown. Genitalia: coxite in ventral view (Fig. 1D) nearly rectangle, 1.2 times as long as its greatest width. Style in ventral view (Fig. 1D) bent inward, slightly tapered from base toward middle, then nearly parallel-sided, rounded apically and with apical spine; style in medial view (Fig. 1E) longer than coxite (1.4 times as long as coxite), somewhat flattened dorso-ventrally, with short basal protuberance directed dorso-medially; style in ventrolateral view (Fig. 1F) with short basal protuberance having several spines near anterior margin. Ventral plate in ventral view (Fig. 1G) with body transverse, 0.66 times as long as wide, slightly narrowed posteriorly, without anterior margin produced anteromedially, and posterior margin convex medially, without microsetae on ventral surface; basal arms small, directed forward, convergent apically; ventral plate in lateral view (Fig. 1H) moderately produced ventrally; ventral plate in end view (Fig. 1I) concave ventrally, densely covered with microsetae on lateral surface. Median sclerite (Fig. 1H) thin, plate-like, wide. Paramere (Fig. 1J) of moderate size, with three distinct long and stout hooks and several smaller ones. Aedeagal membrane moderately setose, slightly sclerotized at base but dorsal plate not well-defined. Ventral surface of abdominal segment 10 without distinct hairs near posterior margin. Cercus in lateral view (Fig. 1K) small, rounded, with 9–11 hairs.

Pupa: Body length 3.1–3.3 mm. Head: integument dark yellow, moderately covered with small round tubercles; antennal sheath with protuberance; face with pair of simple long trichomes with uncoiled apices, and frons with three pairs of simple long trichomes with coiled or uncoiled apices; two frontal trichomes on each side arising close together, subequal in length to one another and slightly longer than facial one. Thorax: integument yellow, without covered round tubercles, with three simple long dorsomedial trichomes with uncoiled apices, one simple long anterolateral trichome with coiled apex, one simple long mediolateral trichome with uncoiled

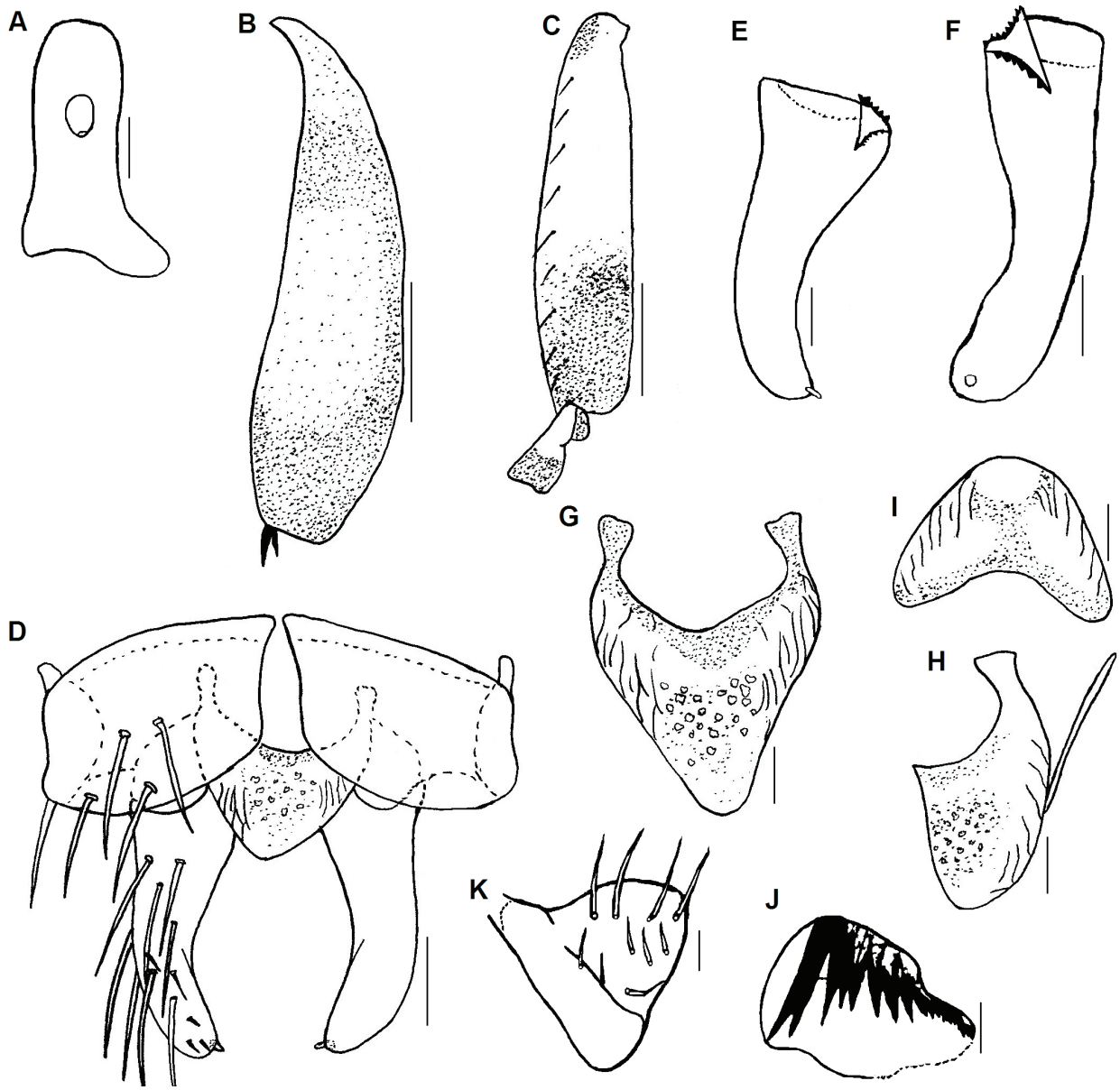

Figure 1. Male of *Simulium* (*Simulium*) *yanaense* sp. nov.: A - frontal view of third segment of left maxillary palp showing small sensory vesicle | B - outer view of left hind tibia | C - outer view of basitarsus and second tarsomere of left hind leg showing calcipala and pedisulcus | D - ventral view of coxites, styles, and ventral plate | E - medial view of right styles | F - ventrolateral view of right styles | G - ventral view of ventral plate | H - lateral view of ventral plate and median sclerite | I - end view of ventral plate | J - end view of left paramere and aedeagal membrane | K - right side and lateral view of tenth abdominal segment and cercus. Scale bars: 0.01mm for A; 0.1mm for B & C; 0.02mm for D–K.

apex, and three simple ventrolateral trichomes with coiled apices (one medium-long and two short) on each side. Gill (Fig. 2A) composed of 10 short slender filaments, arranged as [(2+3)+(1+2)]+2 or {[2+(2+1)]+(1+2)}+2 filaments from dorsal to ventral, with short common basal stalk having somewhat swollen transparent basal fenestra ventrally at base; common basal stalk 0.33 times length of interspiracular trunk; both dorsal and ventral stalks short, length of primary stalks of dorsal filaments combined slightly nearly subequal to stalk of ventral pair; stalk of ventral pair short, 0.6–0.7 times length of common basal stalk and 0.22–0.24 times length of interspiracular trunk; stalk of ventral pair 0.6–0.64 times as thick as primary stalk of dorsal pair, 0.38–0.4 times as thick as primary stalk of first dorsal triplet, and 0.6–0.7 times as thick as primary stalk of second dorsal triplet; primary stalk of dorsal pair lying against stalk of ventral pair at angle of 180° or little more when viewed laterally; all filaments yellowish-brown, decreasing their thickness toward apex; entire length of filaments (measured from base of gill to

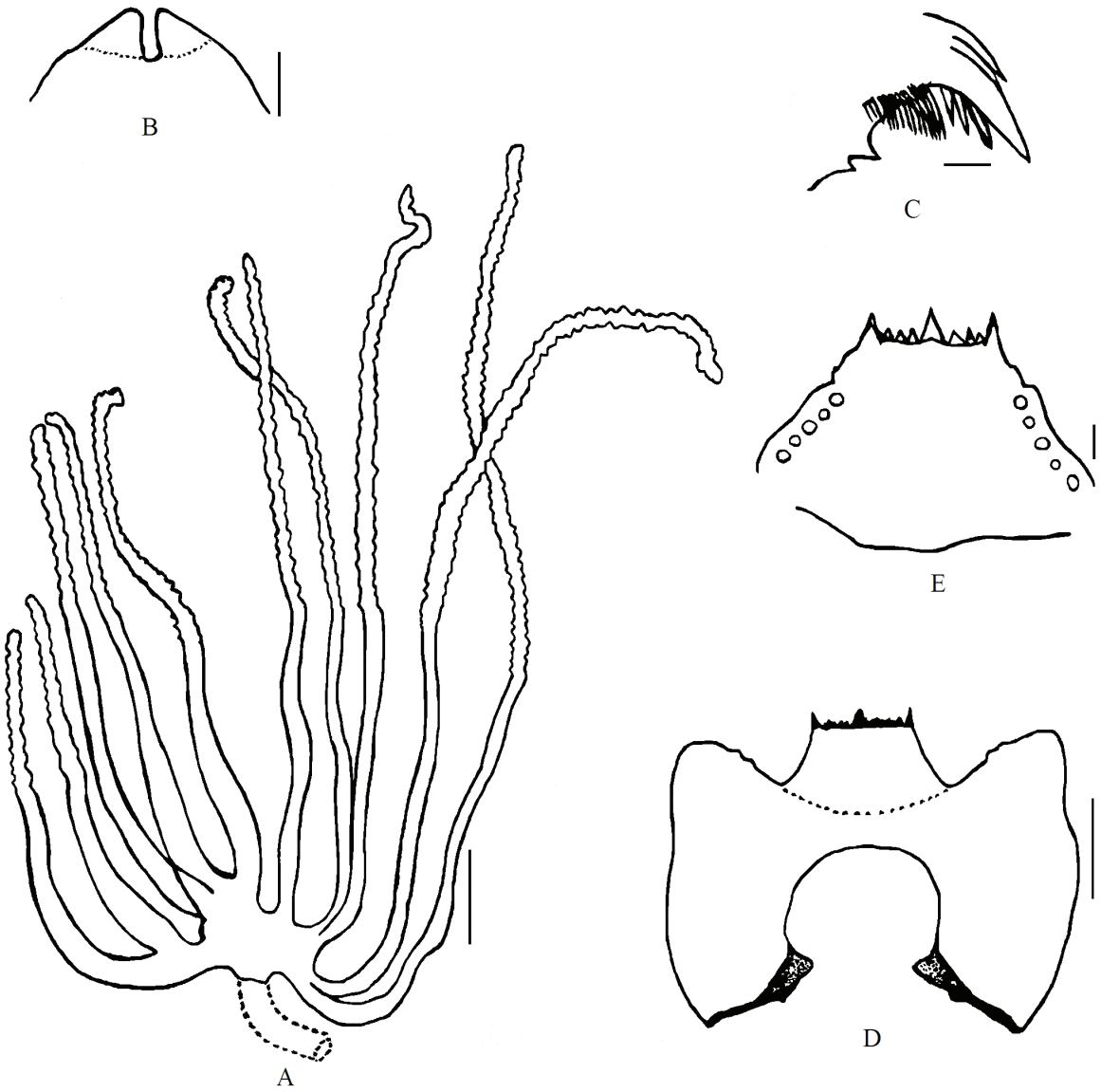

Figure 2. Pupa and larva of *Simulium* (*Simulium*) *yanaense* sp. nov.: A - outer view of left gill of pupa | B - dorsal view of terminal hooks of pupa | C - lateral view of right mandible of larva | D - ventral view of hypostoma of larva | E - ventral view of head capsule showing postgenal cleft and hypostoma of larva. Scale bars: 0.1mm for A & D; 0.01mm for B, C & E.

tips of filaments) based on one pupa as follows: 0.38–0.41 mm for dorsal pair, 0.63–0.72 mm for first dorsal triplet, 0.9–1.1 mm for second dorsal triplet, and 1.2–1.3 mm for ventral pair; cuticle of all filaments with indefinite annular ridges and furrows from base to apex, densely covered with minute tubercles. Abdomen: dorsally, segments 1 and 2 brownish-yellow and with tubercles; segment 1 with one simple slender medium-long hair-like seta on each side; segment 2 with one simple medium-long and three short hair-like setae on each side; segments 3 and 4 each with four hooked spines and one short hair-like seta on each side; segment 5 lacking spine–combs and one short hair like seta on each side; segments 6–9 each with spine-combs in transverse row (though those on segment 9 slightly smaller than those on segment 8) and comb-like groups of minute spines on each side; segment 9 with pair of triangular flat terminal hooks, of which outer margin slightly longer than inner margin and not crenulated (Fig. 2B). Ventrally, segment 4 with one simple hook and few simple slender short setae on each side; segment 5 with pair of bifid hooks submedially and few short simple slender setae on each side; segments 4–8 each with comb-like groups of minute spines. Each side of segment 9 without grapnel-shaped hooklets. Cocoon: shoe-shaped, thinly and moderately woven, anterior margin somewhat thickly woven, with dorsal portion slightly produced anteriorly when viewed dorsally; posterior half with floor roughly or moderately woven; individual threads visible;

Keys to the species of *S. striatum* species group of the subgenus *Simulium* reported from India.

Adult females [1]

1. Frons dull black ..... *S.* (*S.*) *kapuri*
- Frons dull grey or greyish-black 2
2. Scape and two basal flagellar segments of antenna yellow or brownish-yellow ..... *S.* (*S.*) *pallidum*
- Scape and two basal flagellar segments of antenna brown or dark brown 3
3. Fore basitarsus slightly less than 5 times as long as its greatest width ..... *S.* (*S.*) *striatum*
- Fore basitarsus about 5 times as long as its greatest width 19
4. Basal section of radial vein fully haired ..... *S.* (*S.*) *grisescens*
- Basal section of radial bare ..... *S.* (*S.*) *consimile*

[1] Females of *S.* (*S.*) *palmatum* and *S.* (*S.*) *yanaense* sp. nov. are unknown.

Adult males [2]

1. Fore basitarsus 6 to 7 times as long as its greatest width 2
- Fore basitarsus 5 to 5.5 times as long as its greatest width 3
2. Hind basitarsus parallel-sided ..... *S.* (*S.*) *pallidum*
- Hind basitarsus spindle-shaped ..... *S.* (*S.*) *yanaense* sp. nov.
3. Hind coxae brownish-black ..... *S.* (*S.*) *consimile*
- Hind coxae black 4
4. Middle femur black ..... *S.* (*S.*) *grisescens*
- Middle femur grayish-yellow ..... *S.* (*S.*) *striatum*

[2] Males of *S.* (*S.*) *kapuri* and *S.* (*S.*) *palmatum* are unknown.

Pupae

1. Gill with eight filaments ..... *S.* (*S.*) *kapuri*
- Gill with 10 filaments 2
2. Thoracic integument yellow ..... *S.* (*S.*) *yanaense* sp. nov.
- Thoracic integument brown 3
3. Anterior of cocoon without spaces ..... *S.* (*S.*) *palmatum*
- Anterior of cocoon with large spaces 4
4. Cocoon loosely woven ..... *S.* (*S.*) *striatum*
- Cocoon closely woven ..... *S.* (*S.*) *consimile*, *S.* (*S.*) *grisescens* & *S.* (*S.*) *pallidum*

Larvae[3]

1. Pharate pupal gill with 8 filaments ..... *S.* (*S.*) *kapuri*
- Pharate pupal gill with 10 filaments 2
2. Labral fan with 33 main rays ..... *S.* (*S.*) *yanaense* sp. nov.
- Labral fan with 50 main rays ..... *S.* (*S.*) *grisescens*

[3] Larvae of *S.* (*S.*) *consimile*, *S.* (*S.*) *pallidum*, *S.* (*S.*) *palmatum*, and *S.* (*S.*) *striatum* are unknown.

3.2mm long by 1.35mm wide.

Mature larva: Body length 4.3–4.5 mm. Body creamy with markings as follows: thoracic segment one greyish dorsally, laterally encircled with a transverse band (though disconnected ventrally), proleg greyish-black, thoracic segments 2 and 3 grayish dorsally and each with distinct ochreous wide areas ventrally, abdominal segments 1–4 each encircled with yellowish-brown broad band, abdominal segments 5–8 almost entirely covered by yellowish-brown transverse broad band on dorsal and dorsolateral surfaces; abdominal segments 5 and 6 each with W-shaped broad transverse band on dorsolateral surfaces of posterior half of each segment; abdominal segment 7 and 8 with transverse yellowish-brown band on ventral surface; cephalic apotome yellowish-brown and sparsely covered with simple minute setae; head spots indistinct. Lateral surface of head capsule yellowish-brown except eye-spot region yellow and sparsely covered with simple minute setae; spots indistinct. Ventral surface of head capsule yellowish-brown except somewhat darkened area near posterior margin on each side of postgenal cleft and sparsely covered with simple minute setae. Antenna composed of three articles and apical sensillum, 1.23 times longer than stem of labral fan; proportional lengths of segments 1, 2, and 3 are 1.00:1.20:0.76. Labral fan with 33 main rays. Mandible (Fig. 2C) with three comb-teeth decreasing in length from first to third; mandibular serrations composed of two teeth (one medium-sized and one small); major tooth at acute angle against mandible on apical side. Hypostoma (Fig. 2D) with row of nine apical teeth; median and each corner tooth prominent (though median tooth slightly longer than corner teeth) and much longer than three intermediate teeth on each side; lateral margin weakly serrate apically; five hypostomal bristles per side lying parallel to lateral margin. Postgenal cleft (Fig. 2E) arrow-head-shaped, 3.1 times as long as postgenal bridge; sub-esophageal ganglion moderately pigmented. Thoracic cuticle finely covered with minute dark spinules. Thorax and abdomen without pair of dorsolateral protuberances.

Thoracic cuticle almost bare. Abdominal cuticle almost bare except few posterior segments sparsely to moderately covered with simple minute setae dorsally and dorsolaterally and last segment densely covered with colourless simple setae on each side of anal sclerite, and with dorsal pairs of conical protuberances. Rectal scales present. Rectal papillae compound, each of three lobes with five finger-like secondary lobules. Anal sclerite of usual X-form, with anterior arms slightly shorter (0.91 times as long as posterior arms) than posterior ones, broadly sclerotized at base; accessory sclerite absent. Last abdominal segment expanded ventrolaterally but lacking ventral papillae. Posterior circlet with 78 rows of hooklets with up to 22–24 hooklets per row.

Type series: Holotype: BYH19, male, 19.xi.2016, Yana downstream, Kumta Taluk, Uttara Kannada District, Karnataka State, India, 14.522^{0}N & 74.320^{0}E , 55m, coll. S. Vijayan & S. Anbalagan.

Paratype: 2 males, 8 pupae, 41 mature larvae, same data as the holotype (catalogue number BY003).

Etymology: The species is named after the place of collection, Yana.

Habitat: The larvae and pupae of *Simulium* (*Simulium*) *yanaense* sp. nov. are mainly found in leaf litter and on woody debris submerged in water.

Diagnosis: This new species is characterized by having a maxillary palp with a small sensory vesicle (0.19 times as long as segment 3), hind basitarsus 4.1 times as long as its greatest width, and coxite 1.2 times as long as its greatest width in the male; gill with 10 short slender filaments and a short common basal stalk in the pupa; and five hypostomal bristles per side lying parallel to the lateral margin, thorax, and abdomen without a pair of dorsolateral protuberances, and the posterior circlet with 78 rows of hooklets in the larvae.

Discussion

This new species is assigned to the subgenus *Simulium*, defined by Takaoka & Choochote (2004), by having the katepisternum bare and coxite shorter than the style in the male, absence of grapnel-like hooklets on the last abdominal segment in the pupa, and lack of ventral papillae on the last abdominal segment in the larva. This new species is placed in the *Simulium striatum* species-group, redefined by Takaoka (2017), on the basis of the saddle-shaped ventral plate of the male.

The morphologic features of the male genitalia and arrangement of the pupal gill filaments of this new species are similar to those of *S*. (*S*.) *grisescens*, *S*. (*S*.) *kapuri*, and *S*. (*S*.) *striatum* from India, and *S*. (*S*.) *baliense* from Indonesia (Takaoka et al. 2017). The new species, however, is distinguished from *S*. (*S*.) *striatum* by the following characters (those of *S*. (*S*.) *striatum* in parentheses): in the male by the hind basitarsus 0.73 and 0.68 times as wide as greatest width of tibia and femur, respectively (0.75 and 0.26 times as wide as greatest width). The new species is indistinguishable in the male from *S*. (*S*.) *kapuri* but is distinguished in the pupa by the gill with 10 filaments (eight filaments). The new species is distinguished in the pupa from *S*. (*S*.) *grisescens* by having the stalk of the ventral pair of filaments 0.6 times as thick as the primary stalk of the dorsal pair (1.6 times as thick as the primary stalk of the dorsal pair).

This new species is distinguished from *S*. (*S*.) *baliense* by the following characters: in the male by the large upper eye facets in 12 vertical columns and 16 horizontal rows (15 vertical columns and 15 horizontal rows), hind basitarsus 4.1 times as long as wide (5.64 times as long as its greatest width), and coxite in ventral view 1.2 times as long as wide (0.75 times as long as wide), and in the larva by the posterior circlet with 78 rows of hooklets (104 rows of hooklets).

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