Species

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A new black fly (Diptera: Simuliidae) with a mild black to yellow thorax, belong the subgenus *Nevermannia* Enderlein (1921), from Eastern Ghats, South India

Suruliyandi Vijayan[1*], Sankarappan Anbalagan[2], Subramani Pandian[3]

ABSTRACT

Simulium (*Nevermannia*) *kiliyurense* sp. nov. is described based on female, pupa, and larva collecting from the Eastern continuous hills of Kollimalai, India. At present, the newly discovered species has been placed under *Simulium ruficorne* species group of the subgenus *Nevermannia* Enderlein. *S.* (*N.*) *kiliyurense* sp. nov. is characterized by a female antenna with nine flagellomeres, a pleural membrane bare, a Subcosta has medium brown hairs except for the apical 1/4 bare, male unknown, pupal cocoon sleeper-shaped and larval hypostoma with eight hypostomal bristles per side lying parallel to the lateral margin. It is similar to *S.* (*N.*) *aureohirtum* Brunetti, 1911 from India.

Keywords: Black flies, Diptera, *Nevermannia*, New species, Eastern Ghats

1. INTRODUCTION

Black flies (Diptera: Simuliidae) are medical and veterinary significant hematophagous insects. Many species are vectors of pathogen-causing agents in humans and other animals. For example, at least 26 species of black flies of the genus *Simulium* are vectors of *Onchocera volvulus* that cause human onchocerciasis Adler and McCreadie, (2019); Likewise, blood protozoa of the genus *Leucocytozoan*, which causes *luecocytozoonosis* in poultry, are spread by black flies.

Adler and McCreadie, (2019); Globally, 2407 black fly species were recorded Adler, (2024); and 87 species (74 named and 13 unnamed) were found in India Vijayan and Anbalagan, (2023); Among these 87 species belong to six subgenera in the genus *Simulium* Latreille Adler and Crosskey, (2019); *Eusimulium* (every one

species named and unnamed), *Gomphostilbia* (20 named and two unnamed species), *Montisimulium* (four named and one unnamed species), *Nevermannia* (eight named and two unnamed species), *Simulium* (40 named and seven unnamed species) and *Wilhelmia* (one species). Eight species in *Nevermannia* in India were recorded under three species groups: *Simulium* (*N.*) *feuerborni* (four species), *Simulium* (*N.*) *ruficorne*, and *Simulium* (*N.*) *vernum* (each two species). These species were assigned to the *Simulium ruficorne* species group of the subgenus *Nevermannia, S. (N.) killiyurense* sp. nov.

The Eastern Ghats are a scattered range of mountains that stretches from Tamil Nadu in the south to West Bengal in the north along India's eastern coast. It consists of a series of hills and mountains that run parallel to the Bay of Bengal. The Eastern Ghats are older and lower in elevation compared to the Western Ghats on the western coast of India. The seven central, prominent hills in the Tamil Nadu region of the Eastern Ghats include Alagarmalai, Javvadumalai, Karanthamalai, Kollimalai, Nallamalai, Servarayanmalai and Sirumalai. Both Javvadumalai and Nallamalai, despite the diversity of habitats, there have been limited studies on aquatic insects in this area Dinakaran and Anbalagan, (2007), Anbalagan et al., (2014), Balachandran et al., (2017), Ramar et al., (2018); including medical and veterinary significant insects such as black flies (Vijayan and Anbalagan, 2018; Anbalagan et al., 2020). This study explores black flies in the Servarayan hills of Eastern Ghats, South India. Among these specimens, we found a novel species of the genus *Nevermannia* Enderlein. These led to the provision of a description of this novel species.

2. MATERIALS AND METHODS

This study area, Kiliyur Falls, in Yercaud Hills (Figure 1). Kiliyur Falls is situated at 11°47'76.32''N & 78°12'06.29''E, elevation 1147 m, width 2.8–3 m, depth 15 cm, water temperature 20.5°C, more than partially shaded. Kiliyur falls and flows into Periyaaru in the Shervaroyan hill range in the Eastern Ghats, Tamil Nadu, India. Using fine forceps, pupae and larvae were picked up from submerged substrates (polythene sheets, boulders, pebbles, rocks, etc.) in the stream. The mature pupae was identified and reared in a plastic container with wet filter paper. The laboratory maintained this setup for one or two days until adult emergence. The larval and reared adult specimens were preserved in 90‑95% (v/v) ethanol. The descriptions and illustrations of morphological features follow by (Takaoka, 2003; Adler et al., 2004). Holotype and paratypes are deposit at the Department of Zoology, Government Arts College, Melur, Madurai, Tamil Nadu province, India.

***Simulium* (*Nevermannia*) *kiliyurense* sp. nov. (Figures 2 – 4)**

Diagnosis

Female adult: The only species of the *S. aureohirtum* group with ovipositor valves triangular, a pleural membrane bare, unknown male, gill composed of six slender thread-like filaments, labral fan with 44–47 main rays, eight hypostomal bristles per side lying parallel to lateral margin, median tooth longer than each corner tooth of the larval hypostomal.

Description

Female

(n = 1). Body length 4.1 mm.

Head

Nearly as wide as the thorax. Frons grey, shiny, moderately covered with yellowish-white scale-like recumbent short hairs; frontal ratio 1.4:1.0:3.7; head ratio 1.0:6.2. Fronto-ocular area well developed, narrow, directed dorsolaterally. Clypeus yellowish-brown, densely cover with yellowish recumbent hairs, and interspersed with several dark longer hairs on either side. Labrum-epipharynx with 0.85 times as long as the clypeus wide. Antenna is cylindrical, and short with three portions scape, pedicel with nine flagellomeres, grey to white except scape, pedicle, and base of a first flagellomere dark yellow, proportional length of first and second flagellomeres 1.0:0.8.

Maxillary palp composed of five palpomeres, dark brown, proportional length; third, fourth, and fifth palpomeres 1.0:0.8:1.5; third palpomere of moderate size (Figure 2A); sensory vesicle ellipsoidal, long, 0.41 times length of third palpomere and with a medium-size opening. Maxillary lacinia with 11 inner and 15 outer teeth. Mandible with 32 inner and ten outer teeth. Cibarium (Figure 2B) medially forming sclerotized plate folded forward from posterior margin, with strongly sclerotized medial longitudinal ridge with well-sclerotized cup-like apex.

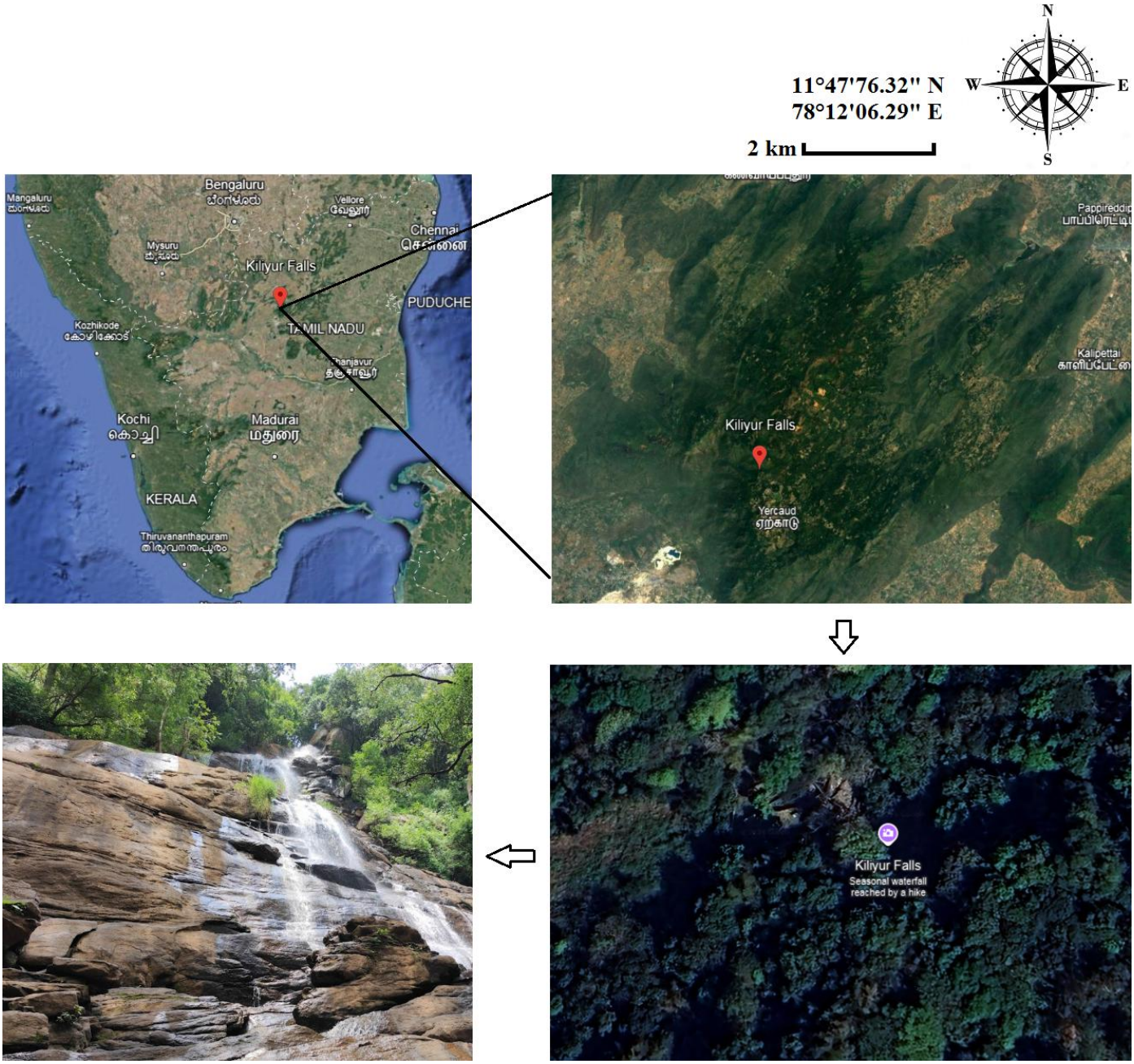

Figure 1 The study map indicates where this new species was collected.

Thorax

Scutum brownish-black except anterolateral calli ochreous, somewhat lustrous when illuminated from a certain angle, densely encompassed by yellow scale-like recumbent hairs, interspersed with several yellow medium to long hairs, as well as dark-brown long upright hairs on prescutellar area. Scutellum is shiny, with dark brown short hairs. Postnotum brownish-yellow and bare. Pleural membrane bare. Katepisternum bare, dark brown to yellowish-brown, longer than deep, to a slight sheeny when illuminated from specific angles.

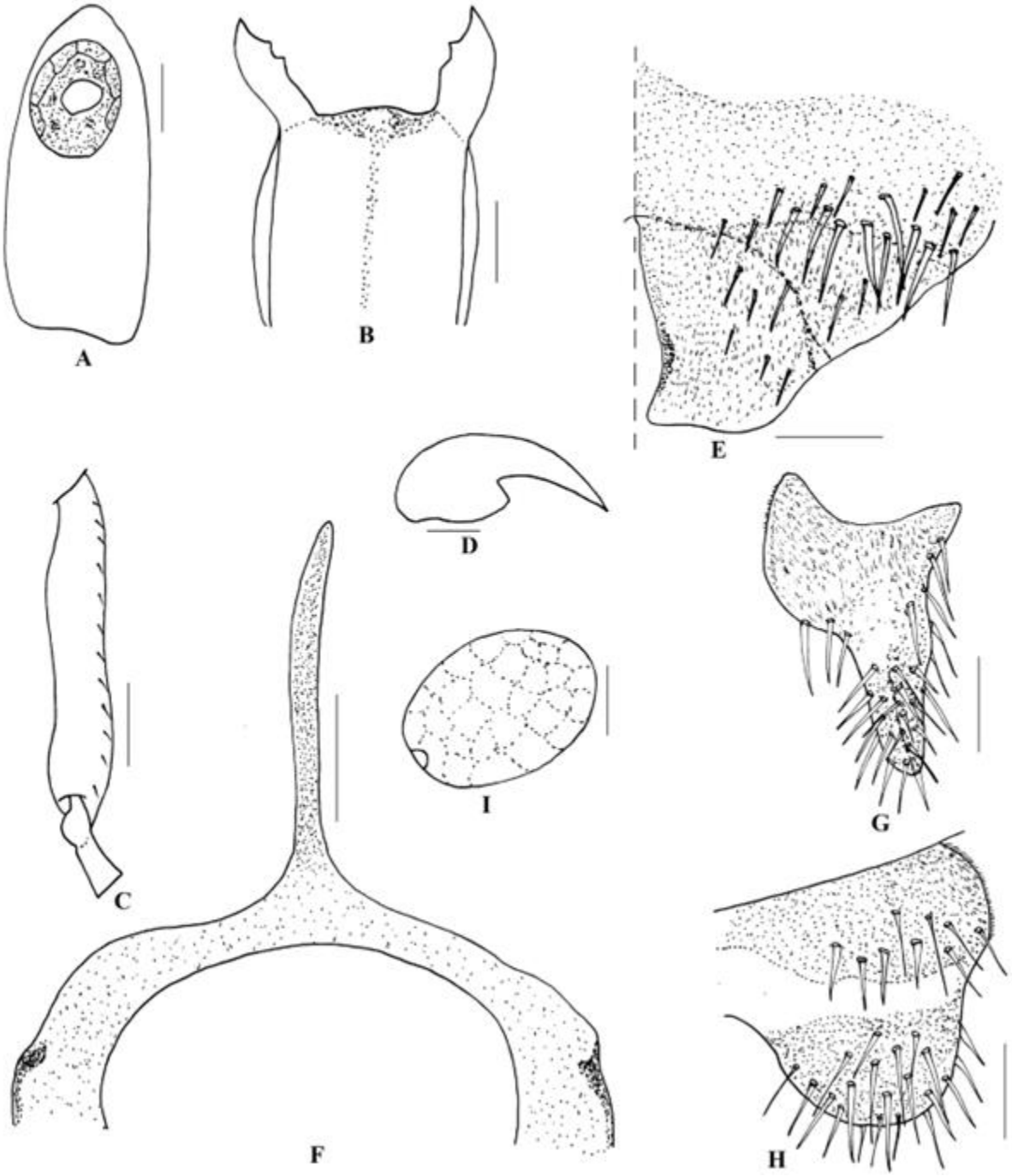

Figure 2 Female of Simulium (Nevermannia) kiliyurense sp. n. A, 3rdsegment of right maxillary palp showing sensory vesicle (front view); B, cibarium (front view); C, basitarsus and 2ndtarsomere of left hind leg showing calcipala and pedisulcus (outer view); D, tarsal claw; E, 8thsternite, ovipositor valves (ventral view); F, genital fork (ventral view); G & H, right paraprocts and cerci (G, ventral view; H, lateral view); I, spermatheca (lateral view). Scale bars. 0.01 mm for D and I; 0.05 mm B, E, F, G and H; 0.1 mm for A and C.

Legs

Foreleg: Coxa dark yellow; trochanter light to medium brown for except basal 1/2 of outer surface dark yellow; femur yellow to dark yellow except apical cap light to medium brown; tibia medium brown, with median large portion on outer surface grayish light brown; tarsus dark brown, with moderate dorsal hair crest; basitarsus slightly dilated, 6.4 times as long as its greatest width. Midleg: coxa

yellowish brown except posterior surface darkbrown; trochanter yellow to light brown; femur and tibia brown; tarsus brownish-black except basal 1/2 of basitarsus deep yellow.

Hind leg: Coxa yellowish-brown; trochanter yellow to dark yellow except anterior surface medium brown; femur deep yellow with apical cap slight medium brown and basal tip medium brown on anterior surface; tibia deep brown except extreme base yellow, and medial large portion on outer surface grayish light brown; tarsus dark brown except basitarsus light to medium brown (though base dark brown) and basal 1/2 of second tarsomere grayish; basitarsus (Figure 2C) narrow, nearly parallel-sided, 5.2 times as long as wide, and 0.7 and 0.8 times as wide as greatest width of tibia and femur, respectively; calcipala (Figure 2C) slightly shorter than width at base, and 0.61 times as wide as greatest width of basitarsus. Pedisulcus (Figure 2C) well defined. Claw (Figure 2D) with large basal tooth 0.52 times as long as claw.

Wing

Length 3.8 mm. Costa with deep brown spinules and hairs, excepting basal part, which has cover with patch of yellow hairs. Subcosta has medium brown hairs except for the apical 1/4 bare. Hair tufts on trunk vein medium to darker brown. A basal portion of the radius completely haired; R1 with dark spinules and hairs; R2 with hairs only. Basal cell absent. Halter. Clear white, with the exception of the darken colour basal stalk and margin.

Abdomen

Basal scale ochreous to light brown, with a fringe of whitish-yellow hairs. Surface of the dorsal abdomen is darker brown to brownish-black except segments 2 and 7–9, light brown (even so for segment two a base is ochreous), somewhat surrounded by darker yellow medium to long hairs; tergites of segments 3–6 are relatively narrow, those of segments 2 and 7–9 wide and all dull. Its abdomen of ventral surface is primarily pale ochreous, and a medially developed sternal plate on segment seven.

Genitalia

Sternite 8 (Figure 2E) bare medially, covered with 6–8 long hairs on each side. Ovipositor valves thin and triangular, membrane-bound, and fairly coated in microsetae, inner margins are convex, somewhat sclerotized, and slightly separated from each other. Genital fork (Figure 2F) usually inverted-Y form, with slender stalk; arms of modest medially width; either arm of the lateral plate is strongly sclerotized along the dorso-lateral fringes, and with thin lobe directed medioposteriorly. Paraproct in ventral view (Figure 2G) is nearly pentagonal, 4 or 5 sensilla on unpigmented anteromedial surface; paraproct in lateral view (Figure 2H) somewhat produced ventrally, 0.73 times as long as wide, with 7–9 medium-long too long hairs on ventral and lateral surfaces. Cercus in lateral view (Figure 2H) is short, rounded posteriorly, 0.42 times as long as wide. Spermatheca (Figure 2I) ovoidal, 1.5 times as long as its greatest width, not well sclerotized, and with hexagonal patterns (though not well defined) on a surface; internal setae absent; both accessory ducts slender, subequal in diameter to major one.

Male

Unknown

Pupa

(n = 6). Body length 4.3–4.5 mm.

Head

Integument light to dark yellow, moderately covered with round tubercles, though frons with few to several tubercles; antennal sheath without any protuberances; face with pair of simple long trichomes with coiled apices, and frons with two simples long trichomes with uncoiled apices on each side (Figure 3A), face with one simple very long trichome with coiled apex (Figure 3B) on each side.

Thorax

Integument light yellowish-brown, densely covered with small tubercles except anterodorsal surface sparsely covered with small tubercles; thorax with two simples very long trichomes with coiled apices mediodorsally (Figure 3C), one simple very long trichome

with coiled apex (Figure 3D), 1 bifid medium-long trichome with coiled apex mediolaterally (Figure 3E), and three simple trichomes (one long with coiled apex, one medium-long with coiled apex, one medium-long with uncoiled apex) ventrolaterally (Figure 3F).

Gill

(Figure 3G) composed of 6 slender thread-like filaments, arranged as 2+2+2 from dorsal to ventral; all pairs short-stalked, stalks of ventral pair subequal in length to each other; common basal stalk short; all filaments yellowish-brown, extending close together anteriorly, subequal in length of all filaments (1.2–1.8 mm) except one ventral pair filament (1.56 times longer than another ventral filament) and thickness to one another (though filaments of ventral pair very slightly thicker than others when compared basally); cuticular surface with distinct annular ridges and furrows, and densely cover with minute tubercles of different sizes (larger ones on ridges and smaller ones on interridges).

Abdomen

Dorsally, segments 1–9 are brownish and without distinct tubercles; segment one has one medium-long simple slender hair-like seta on each side; segment two has one short simple, slender, hair-like seta and four short somewhat spinous setae submedially on each side; segments three and four each has four hooked spines and one short, somewhat spinous seta on each side; segment five bare; segments 6–8 each with spine-combs in a transverse row on each side, and each segment of 6–9 has comb likes clusters of tiny spines on either side; segment nine yellow, with pair of conical terminal hooks (Figure 3H).

Ventrally, segment four has one simple hook and few simple, slender, short setae on either side; segment five such as pair submedially positioned bifid hooks and a few shorter, simple, slender setae on either side; segments 6 and 7, each having a pair of inner bifid and simple outer hooks somewhat spaced from each other and few short, simple, slender setae on each side; segments 4–8 with comb-like groups of minute spines. Segment 9 without grapnel-shaped hooklets.

Cocoon

(Figure 3I) Slipper-shaped, thickly woven, slightly extended ventrolaterally, anterior margin thickly woven, with a short mediodorsal projection; posterior 2/3 with floor roughly or moderately woven; individual threads not visible; 5.1–5.3 mm long by 2.1– 2.3 mm wide.

Mature larva

(n = 4). Body length 6.2–6.4 mm. Body creamy. Cephalic apotome is brownish-yellow with a narrow, though narrow area along posterior margin somewhat darkened yellow, head spots moderately positive except anterior spot of posterolateral spots usually obscure. Lateral surface of head capsule whitish-yellow except eye-spot region whitish; eyebrow moderately positive brownish-yellow, among the spots above eye-spot in front of posterior margin has two relatively large spots moderately positive, and two small spots faintly positive; one or two small round spots below eye-spot region indistinct or faintly positive. Ventral surface of head capsule whitish-yellow to yellow, except darkened area near posterior margin, on each side of postgenal cleft; horizontal long spot and round spot on each side of postgenal cleft faintly or moderately positive.

Antenna composed of three segments with apical sensillum, somewhat longer than stem of labral fan; proportional lengths of 1st, 2nd, and 3rd segments 1.00:1.20:0.73. Labral fan with 44–47 main rays. Mandible (Figure 3J) with three comb-teeth, of which 1st tooth longest and 2nd tooth as long as or slightly longer than 3rd one; mandibular serration composed of two teeth (one very small and one medium-sized); large tooth at nearly right angle against mandible on apical side; supernumerary serration absent. Hypostoma (Figure 3K) with row of nine apical teeth; median tooth longer than either corner tooth; lateral margin serrated; eight hypostomal bristles per side lying parallel to lateral margin.

Postgenal cleft (Figure 3L) medium-size, triangular apically, 0.65–0.69 times as long as the postgenal bridge. Cervical sclerites comprise of two lights to medium brown oblong pieces, not fused to occiput, widely separated medially from each other. Thoracic cuticle bare. The cuticle of the abdomen is almost bare. Rectal scales are present. Rectal papillae are compound, either have three finger-like secondary lobules of segments 6–8. Anal sclerite of usual X-form, with anterior arms 0.75–0.78 times as long as posterior ones, broadly sclerotized at base; accessory sclerites absent. Last abdominal segment with pair of large conical ventral papillae. Posterior circlet with 74–77 rows of up to 18–20 hooklets per row.

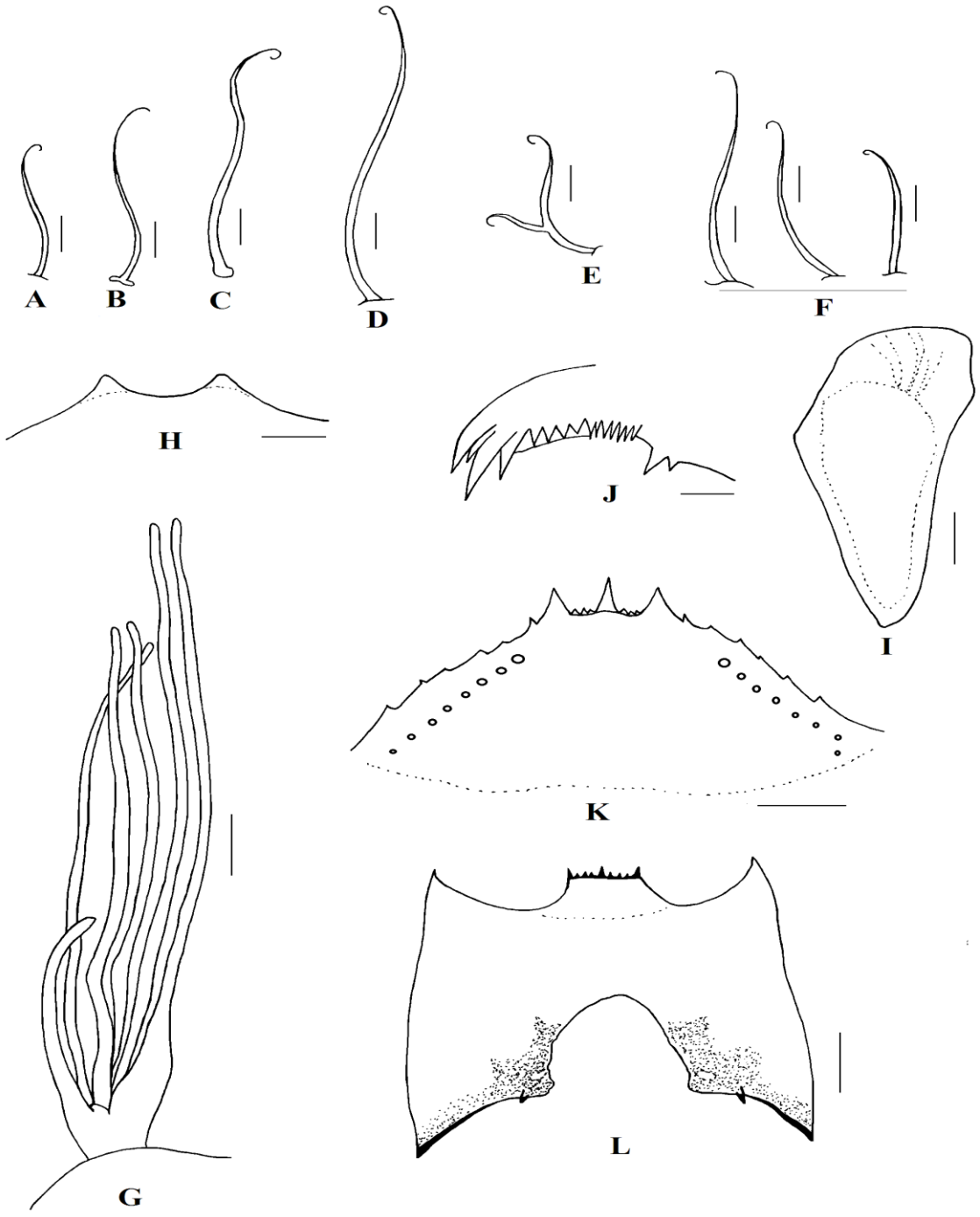

Figure 3 Pupa and larva of Simulium (Nevermannia) kiliyurense sp. n. (A–I) pupa and (J–L) larva; A, frontal trichome; B, facial trichome, C–F, thoracic trichomes (C, mediodorsal; D, anterolateral; E, mediolateral; F, ventrolateral), G, left gill filaments (outer view); H, terminal hooks (end view); I, cocoon with pupa (lateral view); J, right mandible (lateral view); K, hypostoma (ventral view); L, head capsule showing postgenal cleft and hypostoma (ventral view). Scale bars. 0.01 mm for J; 0.02 mm for A–G; 0.05 mm for K; 0.1 mm for L; 0.2 mm for H; 1.0 mm for I.

Type series

Holotype (in alcohol): Female (with associated pupal exuviae, and cocoon, in absolute ethanol), were collected from a stream (width 2.8–3 m, depth 15 cm, water temperature 20.5°C, more than partially shaded, elevation 1147 m, 11°47'76.32" N, 78°12'06.29" E), moderately running in a natural forest, Kiliyur falls, Yercaud, Salem district, Tamil Nadu, India, 22. XI.2021, by S Vijayan & S Anblagan.

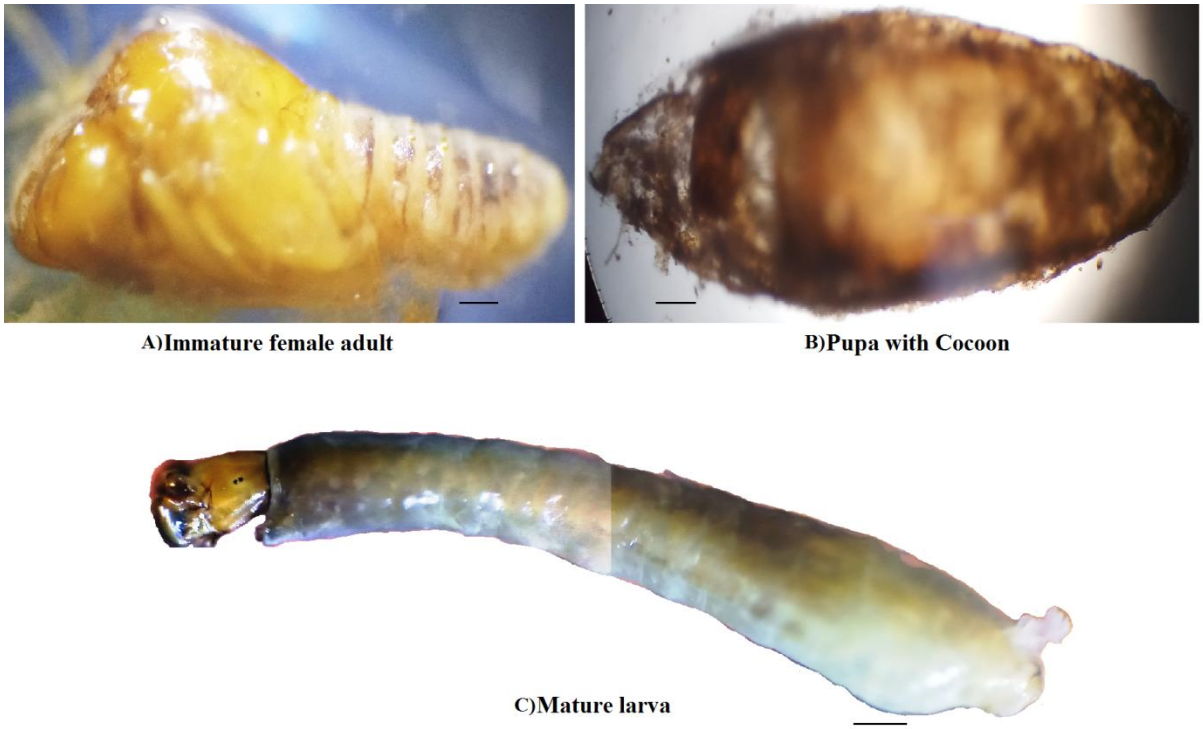

Figure 4 Digital image of S. (N.) kiliyurense sp. nov. Scale bars. 0.2 mm for A and B; 0.5 mm for C.

Paratypes (in alcohol): One female, 15 pupae, 22 mature larvae and 11 immature larvae, same data as the holotype; two pupae, and five mature larvae, were collected from a small stream (width 2.8–3 m, depth 8 cm, water temperature 22.5°C, partially shaded, elevation 396 m, 11°71'92.97" N, 78°16'24.43" E), moderately running in a natural forest, Kuruvampatty falls, Kuruvampatty, Salem district, Tamil Nadu, India, 22. XI.2021, by S. Vijayan & S. Anblagan; one pupa, two pupal exuviae, three mature larvae, and seven immature larvae, were collected from a small stream (width 1.9–2 m, depth 10 cm, water temperature 21°C, partially shaded, elevation 901 m, 11°49'05.47" N, 78°16'35.19" E), moderately running in a natural forest, Aathuppalam stream, Athuppalam, Salem district, Tamil Nadu, India, 22. XI.2021, by S Vijayan & S Anblagan.

Distribution

Aathuppalam stream, Kiliyur falls, and Kuruvampatty falls.

Biological notes

The pupae and larvae samples of this newly discovered species were collected from human discharge waste material submerged in a polythene sheet in water. No other black fly species were found.

Etymology

The species named *kiliyurense* refers to the locality name, Kiliyur Falls, where this new species was collected.

Remarks

This new species is assigned to the *ruficorne* species group of the subgenus *Nevermannia* by having the unique shape of the genitalia of a female and a median tooth longer than each corner tooth of the larval hypostomium. The morphology of this newly discover species has characteristics similar to *S.* (*N.*) *aureohirtum* Brunetti, 1911 by having six respiratory filaments in the pupa. Still, this new species has distinguished from *S.* (*N.*) *aureohirtum* by cuticle of all respiratory filaments with well-defined annular ridges and densely cover with minute tubercles of pupae and six hypostomal bristles lying parallel to lateral margin.

Further, this new species is distinguished from *S.* (*N.*) *aureohirtum* by the following characters (those of *S.* (*N.*) *aureohirtum* in parenthesis): spermatheca 1.5 times as long as its greatest width and with hexagonal patterns on the surface (1.7 times as long as its greatest width and without hexagonal patterns on the surface) in the female, cocoon with slipper-shaped (wall-pocket shaped), and eight hypostomal bristles per side lying parallel to lateral margin (six hypostomal bristles per side lying parallel to lateral margin) in the larva.

Keys to the black fly species of subgenus *Nevermannia* from India

Adult females1

1. Hind tibia subbasal spot dark.....*S.* (*N.*) *aureohirtum*
- Hind tibia medium to dark brown.....2
2. Hind ttibia dark brown.....*S.* (*N.*) *kiliyurense* sp. nov.
- Hind tibia medium brown.....3
3. Scutum yellow.....*S.* (*N.*) *subratai*
- Scutum reddish-brown.....4
4. Halteres brown.....*S.* (*N.*) *rufithorax*
- Halteres yellowish brown.....5
5. Tergites II gray..... *S.* (*N.*) *pruii*
- Tergites II light brown.....*S.* (*N.*) *karavalliense*
6. Genital fork with anterodorsal projection on each arm.....*S.* (*N.*) *praelargum*
- Genital fork without any projection on each arm.....*S.* (*N.*) *gracile*

1Female of *S.* (*N.*) *senile* is unknown.

Adult males2

1. Abdominal basal scale dark brown.....*S.* (*N.*) *karavalliense*
- Abdominal basal scale black or gray.....2
2. Abdominal basal scale black.....3
- Abdominal basal scale gray.....6
3. Scutum black.....*S.* (*N.*) *senile*
- Scutum reddish-brown.....4
4. Halteres brown.....*S.* (*N.*) *aureohirtum*
- Halteres pale yellow.....5
5. Pleuron reddish-brown.....*S.* (*N.*) *praelargum*
- Pleuron blackish-gray.....*S.* (*N.*) *rufithorax*
6. Upper facets with 16 horizontal rows.....*S.* (*N.*) *gracile*
- Upper facets with 15 horizontal rows.....*S.* (*N.*) *purii*

2Male of *S.* (*N.*) *subratai* and *S.* (*N.*) *kiliyurense* sp. nov. are unknown.

Pupae3

1. Gill with 6 filaments.....*S.* (*N.*) *kiliyurense* sp. nov.
- Gill with 6 or 8 filaments.....2
2. Gill with 8 filaments.....S. (*N.*) *karavalliense*
- Gill with 6 filaments.....4

3. Gill with medium-long common basal stalk..... *S.* (*N.*) *purii*
- Gill with short common basal stalk.....*S.* (*N.*) *gracile*
4. Cocoon is closely woven.....*S.* (*N.*) *subratai*
- Cocoon has loosely woven.....5
5. Stalk of ventral pair slightly longer dorsal pairs.....*S.* (*N.*) *aureohirtum*
- Stalk of ventral pair much longer dorsal pairs.....*S.* (*N.*) *praelargum*

3Pupae of *S.* (*N.*) *rufithorax* and *S.* (*N.*) *senile* are unknown.

Larvae4

1. Pharate pupal gill with 8 filaments.....*S.* (*N.*) *karavalliense*
- Pharate pupal gill 4 or 6 filaments.....2
2. Pharate pupal gill 6 filaments.....*S.* (*N.*) *kiliyurense* sp. nov.
- Pharate pupal gill 4 filaments.....3
3. Common basal stalk of pharate pupal gill medium-long..... *S.* (*N.*) *purii*
- Common basal stalk of pharate pupal gill very short.....*S.* (*N.*) *gracile*
4. 3 or 5 hypostomal bristles per side lying parallel to lateral margin.....*S.* (*N.*) *subratai*
- more than 5 hypostomal bristles per side lying parallel to lateral margin.....5
5. Postgenal cleft smaller than postgenal bridge.....*S.* (*N.*) *praelargum*
- Postgenal cleft slightly longer than postgenal bridge.....*S.* (*N.*) *aureohirtum*

4Larvae of *S.* (*N.*) *rufithorax* and *S.* (*N.*) *senile* are unknown.

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Author Contributions

SV – Experimental design, conduct of experiments, writing of manuscript, interpretation of data, microscopic study, illustrate with figures, and proof reads; SA – Experimental design, conduct of experiments, writing of manuscript, interpretation of data, microscopic study, and illustrate with figures; SP – Re-writing of manuscript, interpretation of data, and proof reads.

Ethical approval

In this article, as per the animal regulations followed in Department of Zoology, Government Arts College (Affiliated to Madurai Kamaraj University), Melur–625106, Madurai, Tamil Nadu, India, the authors observed a new black fly (Diptera: Simuliidae) with a mild black to yellow thorax, belong the subgenus *Nevermannia* Enderlein (1921), from Eastern Ghats, South India. The Animal ethical guidelines are followed in the study for species observation, identification & experimentation. Holotype and paratypes are deposit at the Department of Zoology, Government Arts College, Melur, Madurai, Tamil Nadu province, India. The new species (Diptera: Simuliidae) details deposited in Zoobank; id:- 2EA297AD-622E-4E25-944C-9E440A67EBEF.
Url: https://zoobank.org/References/2EA297AD-622E-4E25-944C-9E440A67EBEF

Informed consent

Not applicable.

Conflicts of interests:

The authors declare that there are no conflicts of interests.

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Data and materials availability
All data associated with this study are present in the paper.

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