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Research Article

A new species of the genus *Diaphanes* (Coleoptera: Lampyridae: Lampyrinae), *D. uvaparanagama* Wijekoon, from Sri Lanka

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ABSTRACT

A new species, *Diaphanes uvaparanagama* Wijekoon sp. nov., from a freshwater-associated habitat in Uva province, Intermediate Zone, Sri Lanka, is described using males and reliably associated larvae. Males of this species are distinguished by a transparent pronotum and elytra with bright red thoracic terga and mesocutellum, pale yellow abdominal ventrites, and medial restricted photogenic organs. The conical-shaped photogenic organs challenge the traditional generic diagnosis of *Diaphanes* using light organ morphology.

Key words: *Diaphanes,* fireflies, new records, Sri Lanka

INTRODUCTION

Since the seventeenth century, several researchers have documented a huge variety of insect species in Sri Lanka. Fireflies are one such insect group that has not been concerned since it was discovered by Europeans. As a result, there is currently less biodiversity in Sri Lankan fireflies than in Southeast Asia.

The Lampyrinae is the largest subfamily in the Lampyridae, which includes over half of the genera. At both the species and generic levels, they are highly varied in the neotrophic realm. The five Lampyrinae genera, *Diaphanes* Motschulsky, *Pyrocoelia* Gorham, *Lamprigera* Motschulsky, *Vesta* Laporte de Castelnau, and *Lucidina* Gorham, are all found in the Oriental region. They are distributed throughout Asia, in every country in East and Southeast Asia. However, throughout the past few years, the systematic materials of Lampyrinae (Jeng *et al*. 1998, 1999, 2000, 2001, 2003; Li and Liang, 2007; Martin *et al*. 2009) have been limited.

The genus *Diaphanes* was established by Motschulsky (1853) based on *D. luniger* Motschulsky from Northern India. It is the fifth most diverse genus of Lampyridae after *Luciola, Photuris, Lucidota, and Photinus,* with over 90 species recorded from Afrotropical, Indo-malayan, and Palearctic biogeographic realms (Olivier, 1907, 1910; McDermott, 1964, 1966). *Diaphanes* species are distributed in all of the East and Southeast Asian countries and Russia (Pacific side) (Jeng, 2008). However, proper taxonomic accounts of Sri Lankan *Diaphanes* are still scarce (Wijekoon *et al*. 2016).

Repository records at the National Museums, Colombo, Sri Lanka, reveal five *Diaphanes* species from Sri Lanka (*D. lutescens* Walker, *D. oliveiri* Gorham, *D. taprobanus* Walker, *D. vitrifera*, and *D. bugnioni* Bourgeois) (Wijekoon *et al*. 2016). Whereas, after reviewing the literature and expert reviews, *D. taprobanus* was considered a synonym for *D. lutescens*. Through field specimens of *D. vitrifera* that have been tentatively identified by Wijekoon *et al*. (2021), based on the lodged repositories at the National Museums of Colombo, its taxonomic status is still doubtful because similar specimens had been originally recorded as *Lampyris vitrifera* but which were placed in the *Incertae sedis* by McDermott (1966). As a result, taxonomically confirmed *Diaphanes* in Sri Lanka are *D. lutescens*, *D. oliveiri*, and *D. bugnioni*. Among them, *D. lutescens* was re-described by Wijekoon and Wegiriya (2021), and *D. oliveiri* re-recorded with first record of its female by De Silva *et al*. (2024).

Here we report the new species *D. uvaparanagama* from Sri Lanka with a distinctly transparent dorsum, pale yellow ventral, and medially restricted photogenic organs. These morphological characteristics of *D. uvaparanagama* help place these enigmatic specimens in *Diaphanes* as a new species.

Abbreviations for taxonomic characters and depositories:

DFC:	Department of Forest Conservation, Sri Lanka
DWLC:	Department of Wildlife Conservation, Sri Lanka
DZURSL:	Department of Zoology, University of Ruhuna, Sri Lanka
LO:	Light organ
LL:	Lateral lobes, aedeagus
ML:	Median lobe, aedeagus
NMCSL:	National Museums, Colombo, Sri Lanka
V:	Ventrite (abdominal)
UID:	Un Identified *Diaphanes*

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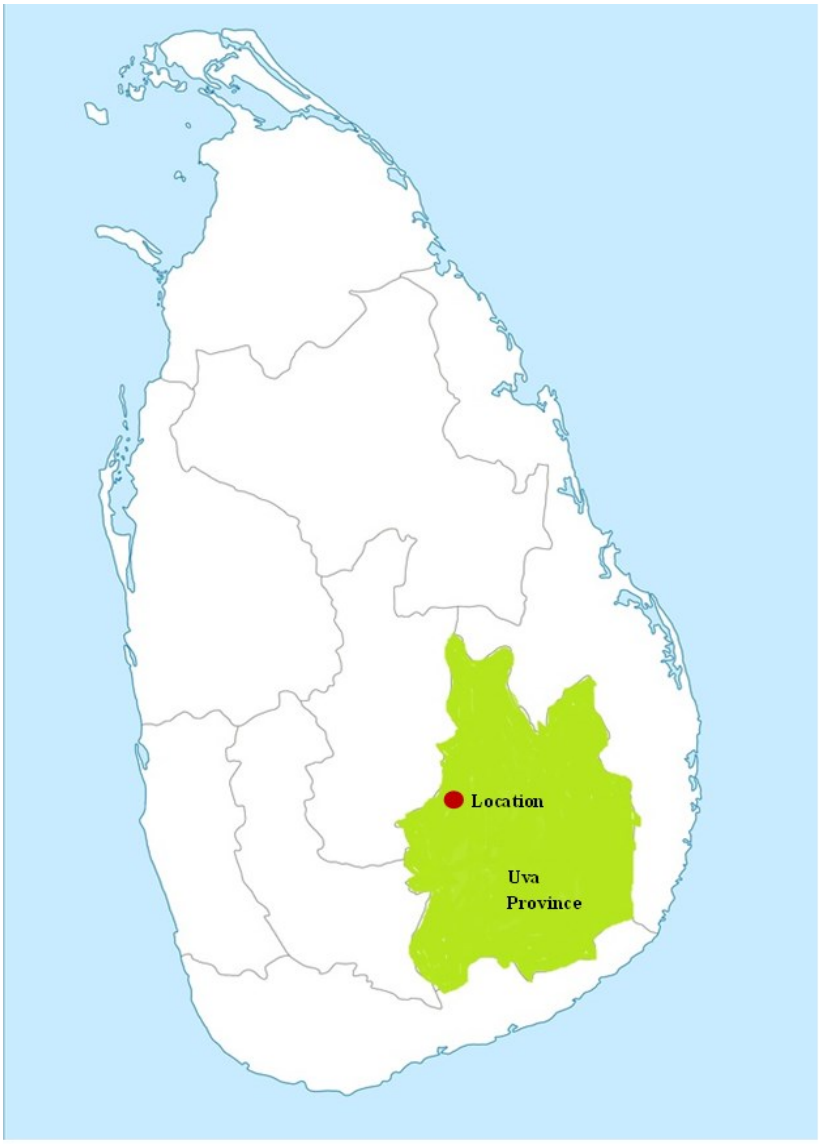

Figure 1. Location (Welimada, Uva Province, Intermediate Zone, 6° 54′ 04″ N, 80° 55′ 22″ E, Elevation-1133m) of *D. uvaparanagama* recorded in Sri Lanka

MATERIALS AND METHODS

Sampling location and specimen collection:

The sampling location was Uvaparanagama, Welimada, Uva Province, Intermediate Zone (6° 54′ 04″ N, 80° 55′ 22″ E, Elevation-1133m) (Figure 1). Field surveys were carried out from January to December 2010 once per month using twelve sampling days (02.I.2010, 20.II.2010, 15.III.2010, 12.IV.2010, 19.V.2010, 05.VI.2010, 21.VII.2010, 05.VIII.2010, 17.IX.2010, 16.X.2010, 05.XI.2010, 18.XII.2010). Field visits were conducted from 17.30 to 22.00 on each sampling day. Fireflies were observed along a selected line transect (50 m) in the habitat. Flying males were captured using an insect hand net (30.5 cm/12 inch). The observed larval stages were collected by fine forceps. A limited number of specimens collected following the guidelines of DWLC and DFC and they were preserved in plastic vials immersed in 70% ethanol medium and brought to the laboratory at the Department of Zoology, University of Ruhuna, for further identification and confirmation.

Identification of specimens & morphometric measurements:

Collected specimens were compared with the original descriptions, repository specimens at NMCSL, expert reviews and other related literature records of *Diaphanes* (Motschulsky, 1845, 1853; Olivier, 1907, 1910a; McDermott, 1964, 1966; Jeng *et al*. 1998, 1999, 2000, 2001, 2003; Li and Liang, 2007; Martin *et al*. 2009). Then the generic diagnosis of collected specimens was confirmed as *Diaphanes*.

10 males and 5 larvae were measured. The specimens were air-dried for 5–10 minutes. A light microscope (Nikon ECLIPSE-E100) (104) (with an ocular graticule micrometre) was used to take measurements. Male genitalia were dissected according to the methods described in Ballantyne and Lambkin (2009) and Ballantyne *et al*. (2019). Dissected genitalia of 5 males were kept in 70% ethanol in tiny glass vials (40 mm height, 10 mm diameter), labelled, and stored in DZURSL with the entire specimens.

The Dino-Lite camera (AM7515MT4A Digital Microscope, 2592 x 1944/5 MPixel, 415... 470x, USB 2.0) was used to take photographs of firefly specimens and select taxonomically important body features such as pronotum, mesocutellum, abdominal sternites, antennae, light organ shape, and aedeagus pattern.

Ecological and behavioral study

Habitat data such as vegetation cover, the presence of leaf litter on the soil layer, and human-induced threats in the habitat were recorded. The color of the light emitted by males and larvae was observed. The most active layer of the male in the vegetation was recorded.

RESULTS

Taxonomic hierarchy

Family: Lampyridae Rafinesque, 1815
Subfamily: Lampyrinae Rafinesque, 1815
Genus: *Diaphanes* Motschulsky, 1853

Diaphanes Motschulsky, 1853: 44 (original description) Gorham, 1880: 90 (general description). Olivier, 1885: 345 (definition); 1907: 40 (definition and catalogue); 1911a:81 (definition, female). Tennant, 1861 (checklist). McDermott, 1964:17 (morphology and taxonomy); 1966:10 (catalog). Jeng *et al*. 2001; 203-235 (revision). Li and Liang, 2007: 53 (new species). Martin *et al*. 2009 (check list). Wijekoon *et al*. 2016 (repository records: NMCSL). Wijekoon *et al*. 2021 (checklist). Wijekoon and Wegiriya, 2021:427 (description). De Silva *et al*. 2024 (description).

Generic diagnosis: Males have clear pronotal areolet areas, size of head to pronotum and eyes to head bigger than *Pyrocoelia* (Jeng *et al*. 2001); elytra pale to black, a semi-circular-shaped pronotum with lateral expansions. moniliform or filiform short antenna (Jeng *et al*. 2001) except *D. pectinealis* having pectinate antenna (Li and Liang, 2007).

Species of *Diaphanes* (taxonomically valid) in Sri Lanka

D. lutescens Walker, 1858
D. olivieri Gorham, 1895
D. bugnioni Bourgeois, 1909
D. uvaparanagama Wijekoon **sp. nov.**

***Diaphanes uvaparanagama* Wijekoon sp. nov.**

urn:lsid:zoobank.org:pub:0D2571E1-A5BF-4E3E-9277-85C2B82E3B08

Figs 2–6

Types:

Holotype. Male. Sri Lanka. Uva Province. Welimada, Uvaparanagama, 6° 54′ 04″ N, 80° 55′ 22″ E, Elevation-1133m, 02.I.2010, W. M. C. D. Wijekoon, deposited in the Lampyrid collection of DZURSL(specimen-UID1)

Paratypes. Same locality and collectors as holotype - 3 males (UID2, 3, 4) (20.II.2010); 2 males (UID5, 6), 2 larvae (UID7, 8) (15.III.2010); 2 males (UID9, 10), 1 larvae (UID11) (12.IV.2010); 2 males (UID12, 13) (19.V.2010); 1 male, 2 larvae (UID14, 15, 16) (21.VII.2010), Collector: W. M. C. D. Wijekoon, deposited in the Lampyrid collection of DZURSL.

Figure 2. *D. uvaparanagama* in natural colors (Male) (Scale bar = 1mm)

Etymology: This species is named for the area "Uvaparanagama," where the first specimen was found. This area is located in Welimada, Uva Province, Sri Lanka. We use the name *Uvaparanagama* as a noun in apposition to preserve the original language.

Diagnosis:

Male: 10–11 mm long, distinguished from other recorded *Diaphanes* by the transparent pronotum and elytra with vivid red thoracic terga and mesocutellum, distinctly pale yellow abdominal ventrites (I - VIII), black legs except the pale yellow femora, LO in both V6 and V7 are median restricted, conical-shaped and milky white (Figs. 2 - 5)

Larvae: 28.0–30.0 mm long, black dorsum with distinct white vertical spotted lines, pale yellow spots on posterior margin of each segment and outer margin of entire body, mid sagittal line clear, body elongated rather wide, first abdominal segment less longer than others (Figure 6).

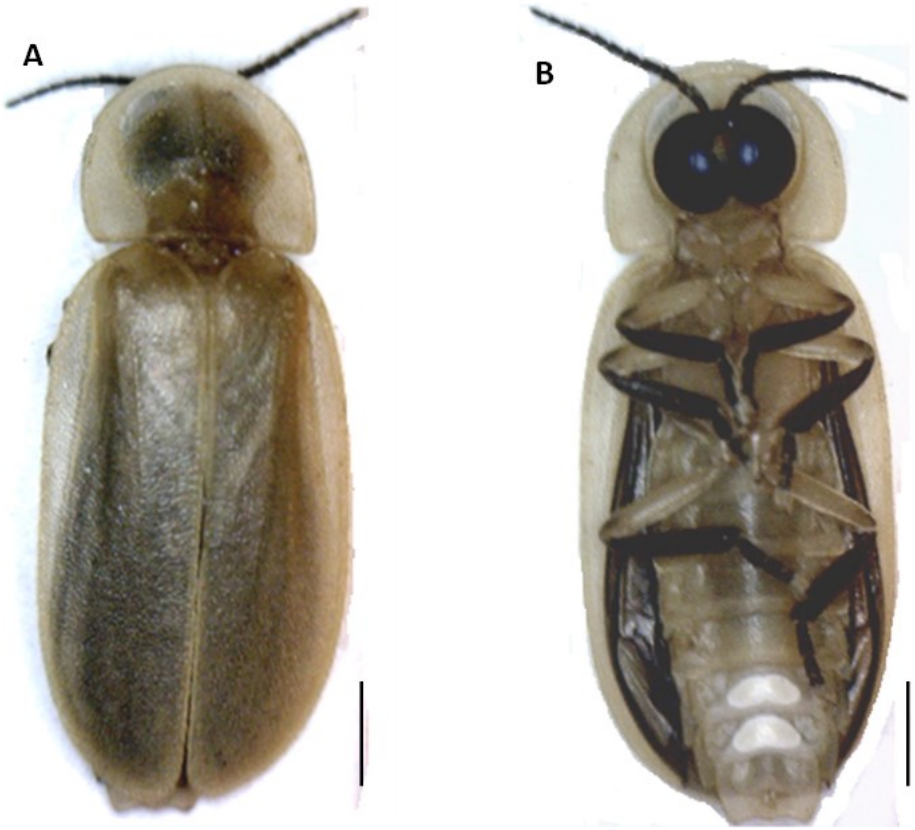

Figure 3. *D. uvaparanagama* (Male); A. Dorsal, B. Ventral. (Scale bar = 1mm)
(**Note:** natural colors are faded in alcohol specimens)

Description –Male: (Figs. 2 -5)

General morphology – Body (Figs. 2, 3) is elongate, 10 –11 mm long and 4.0–5.0 mm wide. Body dorsal is transparent. ***Elytra:*** (Figs. 2, 3, 4B) 8.0–9.0 mm long, 4.0–5.0 mm wide; the entire elytra are transparent, and lack intestinal lines; smooth dorsal surface. ***Pronotum:*** (Figs. 2, 3, 4A) 3.0-4.0 mm long, 3.0-4.0 mm wide, with lateral expansions and a medial circular transparent disc, semielliptical pronotum, slightly broader than long. ***Mesocutellum:*** (Figs. 2, 3, 4A) vivid red, thoracic terga light red on disc, prosternum and mesosternum, hypomera vivid red (Figure 2) but fading in alcohol specimens (Figs. 3, 4A). ***Head:*** (Figure 4C) black. eyes large, weakly reniform laterally; interspace between eyes almost uniformly wide from frons to ventral angle, about 0.21–0.25 times as wide as head width. Mouthparts well developed, about 0.30–0.41 times as wide as protnotum width. ***Antenna:*** (Figure 4C) 3.0–4.0 mm long, relatively short, moniliform, 11-segmented, 11th antennomere smaller than others. ***Thorax:*** (Figure 4D) pale yellow ventrally and dorsally. ***Legs:*** (Figure 4D) femur pale yellow; the entire tibia, tarsus, and claws of the legs are black. ***Abdomen:*** (Figs. 4E, F) 8 visible abdominal ventrites, abdominal spiracles present on the ventral side of abdomen, abdominal ventrites 1I-V pale yellow, both VI and VII ventrites bear median restricted, conical shaped and milky white LOs (Figure 4F), ventrite VIII is pale yellow and narrowed posterior, and tergite 8 curls around the apex of ventrite VIII, creating a wide lobe. Los are same in size in both V6 and V7.
Aedeagus: (Figure 5A) trilobed structure, single ML and two LL present; ML narrowed and LL have a wider part and narrowed tip at the end, apical thumb like structure; LL fused dorsally and enfolds to ventral side; 0.5 mm long, 0.2mm wide. ***Aedeagal sheath:*** (Figure 5B) the shape of the aedeagal sheath is of taxonomic significance; it enfolds the aedeagus, asymmetrical, sheath sternite expanding along length beginning before tergite articulation 0.6 mm long, 0.2 mm wide.

Female: Not recorded during the study

Larvae: (Figure 5)

General morphology – 28.0–30.0 mm long, 4.0–5.0 mm wide, 12 dorsal segments distinct as 3 thoracic and 9 abdominal, body dorsally black colour with distinct white vertical spotted lines, pale yellow colour spots presence on posterior margin of each segment and outer margin of entire body, mid sagittal line clear in black colour, body elongated rather wide, first abdominal segment less longer than others. ***Head:*** (Figure 6B) retracted head beneath, retractable mouth parts distinct. ***Thorax:*** (Figure 6C) prothorax longer than wide; anterior margin bluntly rounded, narrowed at anterior, pro, meso, and meta thorax covering plates are larger and distinct of rests; base and tip of legs are milky white and rest black. ***Abdomen:*** (Figure 6D, E) usually abdominal segments slightly narrowed posterior and subequal, dorsal surface of body roughened but projections absent, abdominal segments ventrally milky white in mid region with black vertical strips in sides, I-VIII of abdominal segments have single laterotergites at each side, black colour, two spots like LOs present in outer margin of abdominal segment VIII, final plate clearly divided, making fin structure, and abdomen terminated by a series of filaments or holdfast organs that function in locomotion and cleaning.

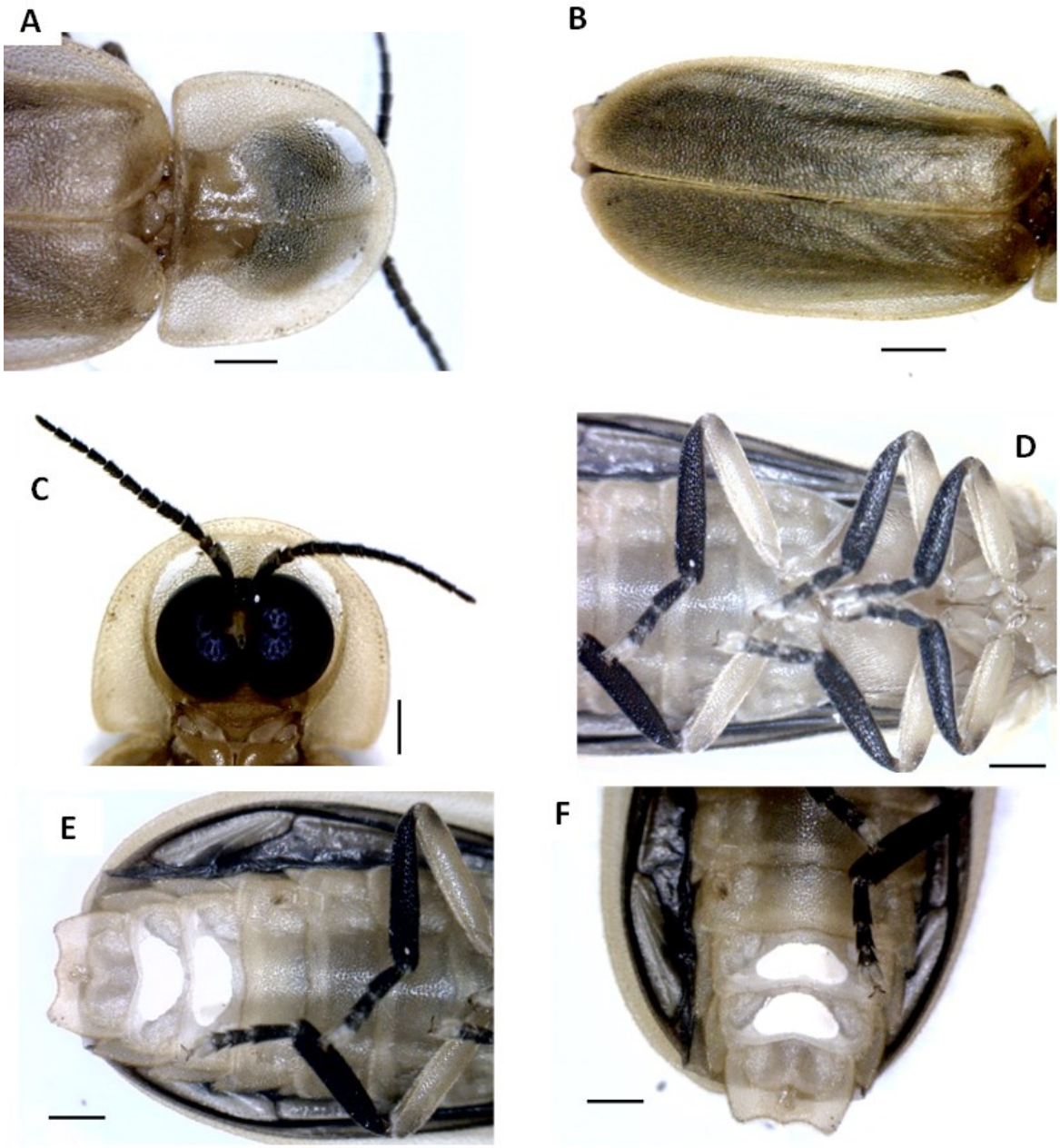

Figure 4. *D. uvaparanagama* (Male); **A** Pronotum (dorsal). **B.** Elytra (dorsal). **C.** Head & Antennae. **D** Thorax & Legs; **E**. Abdomen (ventrites I-VIII). **G**. Light organ in ventrite VII & VII. (Scale bar = 1mm) (**Note:** natural colors are faded in alcohol specimens)

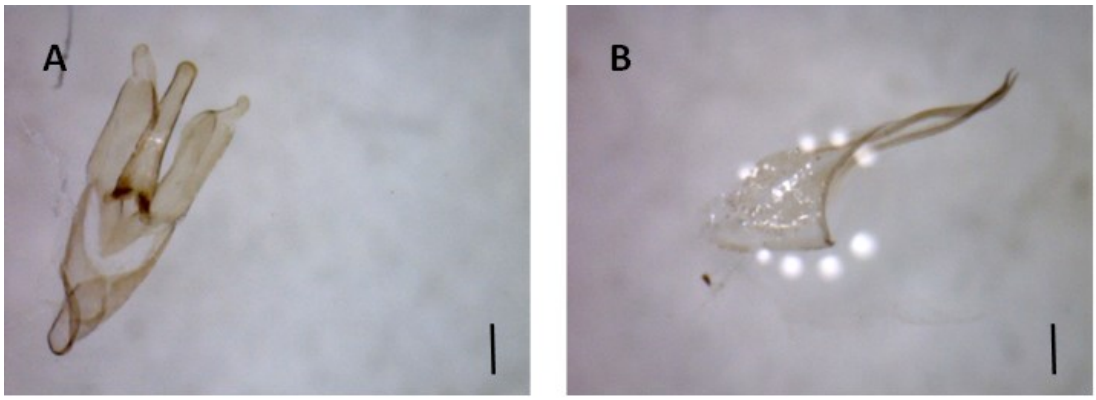

Figure 5. *D. uvaparanagama* (Male); **A** aedeagus (ventral). **B** aedeagal sheath (lateral) (Scale bar = 0.1mm)

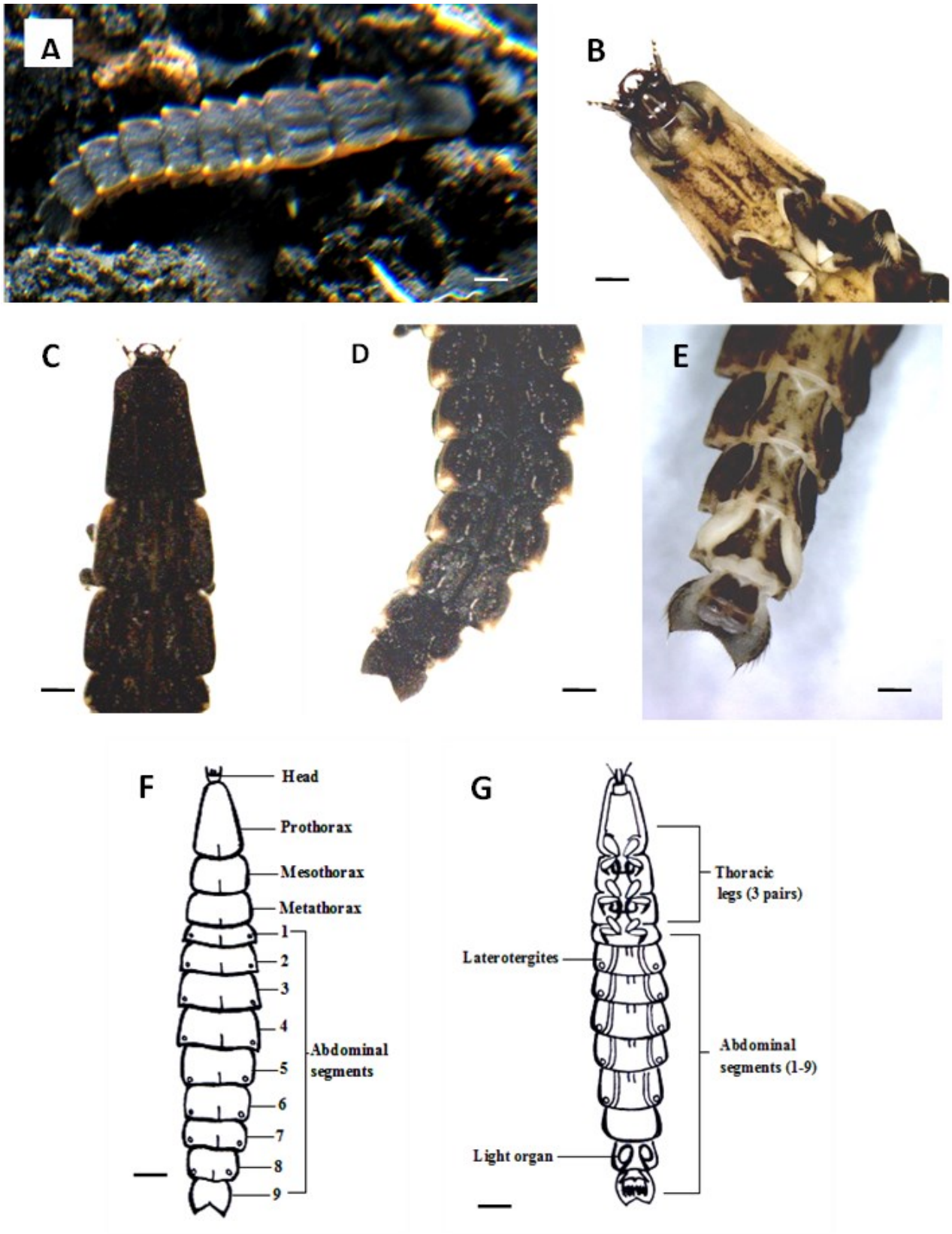

Figure 6. *D. uvaparanagama* (Larva); **A** Larva in natural habitat. **B** Head and Mouthparts. **C** pro, meso and metathorax region. **D** abdominal segments I-VII. **E** light organ and ventral abdominal morphology. **F, G** line diagram, **F** dorsal, **G** ventral (Scale bar = 1mm)

Ecological Remarks: *Behavior*: This species is nocturnal. Males are active in the lowermost layers of vegetation and are very slow fliers. They emit green light when they fly. Larvae emit a weak green light. ***Habitat:*** fresh water-associated habitat; contains natural vegetation with water-associated plants; dense leaf litter cover on the soil layer; site is daily disturbed by human-induced activities like cattle grazing and walking, but no light pollution.

DISCUSSION

The taxonomic knowledge of *Diaphanes* is limited globally. After establishing the genus *Diaphanes* by Motschulsky (1853), a genus revision was presented by Jeng *et al*. 2001. Further, he presented that *Diaphanes* is currently a heterogeneous assemblage. Li and Liang (2007) also emphasized the need for the generic revision of *Diaphanes* because, with recent new records, the traditional generic morphological features of the genus are challenged. Li and Liang (2007) recorded a new species, *D. pectinealis*, having a pectinate antenna, which is a deviation of *Diaphanes* generic features, such as moniliform or filiform antennas, described by Jeng *et al*. (2001).

Diaphanes uvaparanagama has distinct median-restricted, conical-shaped light organs, which vary from the *Diaphanes* character described by Jeng *et al*. (2001), as they have well-developed photic organs. Despite that, other generic features of *D. uvaparanagama* agree with Motschulsky (1853), Gorham (1880), and Jeng *et al*. (2001). Moreover, Jeng *et al*. (2001) pointed out that *Lampyris* and *Nyctophila* species have rudimentary photic organs, whereas their pronotal areolet areas are obscure, and both groups are distributed in the Western-Palaeoarctic region and Europe. But *D. uvaparanagama* has clear pronotal areolet areas, confirming their generic placement. As such, there is a crucial need for a genus revision of *Diaphanes* in a broader sense.

Diaphanes uvaparanagama is different from morphologically close *D. lampyroides* Olivier in Hong Kong (YIU, 2012) and *D. niveus* Jeng in Taiwan (Zachary, 2003) by having a transparent dorsum, pale yellow ventrites, and conical-shaped light organs.

The larvae were identified by pink markings on the posterior margin of their abdominal segments, which is a characteristic feature of the genus *Diaphanes* larvae (Jeng *et al*. 2001). The larvae of *D. uvaparanagama* were observed when they occurred in the same habitat as their males.

Diaphanes uvaparanagama was found in a fresh-water-associated habitat that is in proximity to a natural stream. The site is densely covered with riparian plants and grasses, and there is a dense layer of leaf litter on the soil. The larva was found when it occurred among leaf litter in the surrounding riparian area of the stream, indicating the larva might be semiaquatic rather than terrestrial. Besides, in 2001, Jeng *et al*. mentioned that the majority of the larvae of the genus *Diaphanes* are terrestrial. This habitat is always disturbed by cattle grazing and other human activities, apart from light pollution.

The discovery of *D. uvaparanagama* is vital to fill the void of firefly biodiversity in Sri Lanka. Further detail revision is required for assessing the generic characters of the genus *Diaphanes*.

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Conflicts of interest

Authors would like to declare that there are no conflicts of interest.

Funding statement

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Author`s contributions

W. M. C. D. Wijekoon conducted field surveys, data collection, data entry, data analysis, and writing the manuscript; H. C. E. Wegiriya did the supervision, and reviewing the manuscript.

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