



A new species of *Ceylonosticta* Fraser, 1931 (Odonata: Zygoptera: Platystictidae) from Sri Lanka

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A new species of *Ceylonosticta* from the wet zone of Sri Lanka is described and illustrated, namely *Ceylonosticta goodalei* sp. nov. (Kuruwita-Erathana foot path, Seethagangula, Adam's Peak, Samanala Nature Reserve, Ratnapura, 6.8196°N, 80.4615°E, 1109 m asl). The species is described from male specimens only and the genital ligula is described and illustrated. Females are as yet unknown. A brief review of *Ceylonosticta* “species-groups” is provided, provisionally incorporating three recently described species (*C. nancyae*, *C. rupasinghe*, *C. alwisi*) as well as *C. goodalei*. A determination key is updated by addition of these four newly described *Ceylonosticta* species and now covers 22 endemic species of the genus hereto known from the island.

<http://www.zoobank.org/urn:lsid:zoobank.org:pub:3A443B9F-CAD0-42AE-A4C1-8476C83DF8E9>

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Introduction

Despite the small land area (65,610 km²) of the island of Sri Lanka, it is home to a wide variety of odonates with a high number of endemics (Bedjanič, Conniff, van der Poorten, & Šalamun, 2014; Priyadarshana, Wijewardhane, & Herath, 2016). The 129 described species are placed into 12 families and 67 genera. There are 56 endemic species and nine endemic subspecies which comprise just over 50% of Odonata and more than 70% of Zygoptera in the island (Bedjanič et al., 2014; 2016; Priyadarshana et al., 2016; Priyadarshana, Wijewardana, van der Poorten, & Jayasooriya, 2015).

There are nine genera within the family Platystictidae: *Protosticta* Selys, 1885; *Palaemnema* Selys, 1860; *Platysticta* Selys, 1860; *Drepanosticta* Laidlaw, 1917; *Ceylonosticta* Fraser, 1931; *Sinosticta* Wilson, 1997; *Sulcosticta* van Tol, 2005; *Telosticta* Dow & Orr, 2012 and *Indosticta* Bedjanič, 2016 (Bedjanič et al., 2016; Dijkstra, Kalkman, Dow, Stokvis, & van Tol, 2014; van Tol, Reijnen, & Thomassen, 2009). About 10% of all currently described species of Platystictidae

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are found in Sri Lanka, restricted to an area of about 20,000 km² in the wet and intermediate climatic zones, making Sri Lanka a global Platystictidae hotspot (Bedjanič, 2010; Bedjanič et al., 2016). Two genera, *Ceylonosticta* (22 species, including the new species described in this paper) and *Platysticta* (four species), are endemic to Sri Lanka (Bedjanič et al., 2016; Dijkstra et al., 2014; Priyadarshana et al., 2016) and comprise the endemic subfamily Platystictinae (*sensu* Dijkstra et al., 2014).

The genus *Ceylonosticta* was originally differentiated from the genus *Drepanosticta* on the basis of the male having a dorsal ridge on the penial organ as both genera have very similar wing venation (Fraser, 1931a, 1931b). However, the genus *Ceylonosticta* was subsequently treated as a synonym of *Drepanosticta* by later authors (Bedjanič, 2010, 2012; Bedjanič et al., 2014; Lieftinck, 1940, 1955, 1971; van der Poorten & Conniff, 2012). Recent studies using phylogenetic and morphological information have shown that the Sri Lankan Platystictids are monophyletic, indicating that *Ceylonosticta* is a distinct genus and not congeneric with *Drepanosticta* (which has no representatives in Sri Lanka) (Bedjanič et al., 2016; Dijkstra et al., 2014). It was also shown that the genus *Platysticta* is endemic to Sri Lanka, as *Platysticta deccanensis* Laidlaw, 1915 from India belongs to another clade and has been accordingly transferred to a new genus, *Indosticta* (Bedjanič et al., 2016).

Materials and methods

Field observations were made in two different locations within Ratnapura district, Sabaragamuwa province which are classified as belonging to the wet zone of Sri Lanka (Figure 1). Both primary literature (Bedjanič, 2010; Bedjanič et al., 2016; Fraser, 1931a, 1931b, 1933a, 1933b; Priyadarshana et al., 2016) and secondary literature (Bedjanič et al., 2014) were used to identify the specimens. Descriptive terminology and descriptions of wing venation follow Watson and O'Farrell (1991). Measurements are given in millimeters (mm). Except for the anal appendages, all coloration is given as detectable from live specimens. Supplemented photographs of the adult live specimens were taken with a Canon EOS 600D (Tokyo, Japan) camera body fitted with a Canon 18–55 mm lens. Photographs of the anal appendages and the preserved specimens (only males) were taken using Nikon Coolpix L120 (Tokyo, Japan) camera fitted onto a Leica DM2000 light microscope (Wetzlar, Germany). All illustrations were done by hand with the aid of a Leica DM2000 light microscope. The type specimens have been deposited in the research laboratory of the National Wildlife Research and Training Center (NWRTC), Giritale, Sri Lanka (voucher numbers: 019TIBSJ–021TIBSJ). Leg tissues and two of the adult male specimens were preserved in 100% ethanol for future molecular analyses. The key given by Bedjanič et al. (2016) for identifying *Ceylonosticta* species is modified by adding the three recently described new *Ceylonosticta* species (Priyadarshana et al., 2016) and the new species described here.

Ceylonosticta goodalei Priyadarshana & Wijewardhane sp. nov.
(Figure 2A–J)

Holotype

♂ (NWRTC 019TIBSJ), Sri Lanka, Sabaragamuwa province, Ratnapura district, Samanala Nature Reserve, Kuruwita–Erathana foot path, Seethangangula, Adam's Peak (6.8196°N, 80.4615°E, 1109 m asl), 2 May 2015, I.H. Wijewardhane leg. (Figure 2A).

Paratypes (2 males)

♂ (NWRTC 020TIBSJ), locality data same as for holotype on the same day, T.S. Priyadarshana leg; ♂ (NWRTC 021TIBSJ), Sri Lanka, Sabaragamuwa province, Ratnapura district, Samanala

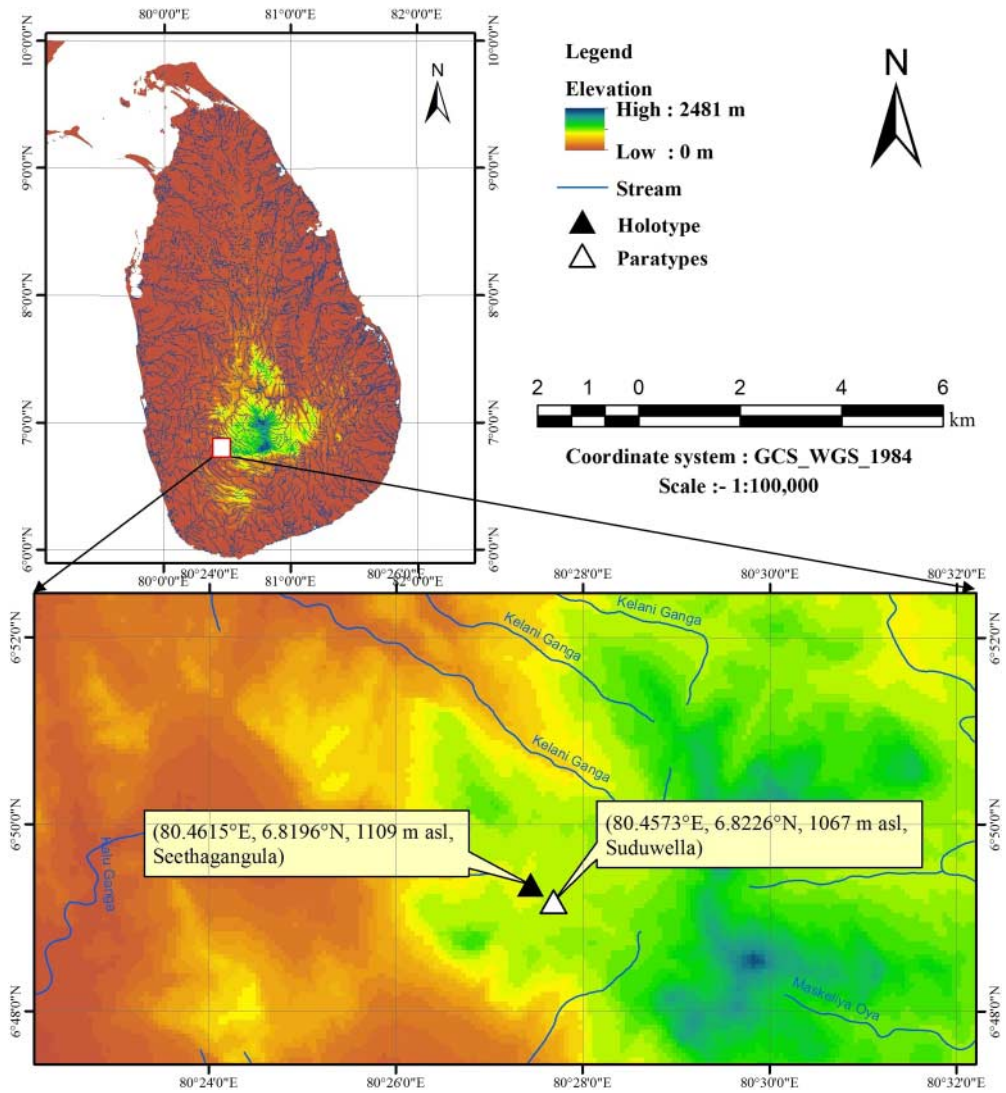


Figure 1. A map of the type localities: *Ceylonosticta goodalei* sp. nov., holotype ♂ (black triangle); paratypes of *C. goodalei* (white triangle).

Nature Reserve, Kuruwita-Erathana foot path, Suduwella, Adam’s Peak (6.8226°N, 80.4573°E, 1067 m asl), 11 August 2016, T.S. Priyadarshana leg.

Etymology

The species epithet is an eponym Latinized in the genitive singular, honoring Prof. Eben Goodale, ornithologist, from College of Forestry, Guangxi University, China. He has studied mixed-species bird flocks in Sinharaja World Heritage Site in Sri Lanka.

Description of holotype

Head. Labium brown; labrum, anteclypeus and genae pale blue; mandible glossy black. Frons slightly convex, metallic black below ocelli and antennae. Both dorsal and lateral ocellus

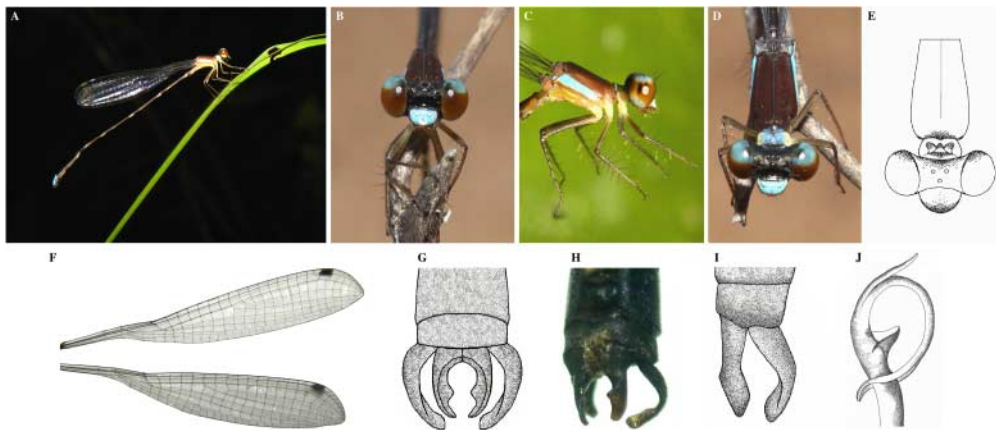


Figure 2. *Ceylonosticta goodalei* sp. nov., holotype (live specimen) ♂; (A) lateral view; (B) head, front view; (C) lateral view of head, prothorax and synthorax; (D) dorsal view of head, dorsum of prothorax and synthorax – sky blue markings visible on the middle lobe of prothorax; (E) a drawing of dorsum of head, prothorax and synthorax; (F) wings, right pair; (G) dorsal view of anal appendages; (H) ventral view of anal appendages; (I) lateral view of anal appendages; (J) genital ligula.

brown-black. Antennae black-brown. Eyes pale blue with a broad brown equatorial stripe, dorsum and lower one-fifth pale blue. Rest of the head metallic black (Figure 2B–D).

Thorax. Prothorax laterally pale yellow, dorsum of anterior lobe largely blue with blackish-brown anterior border, middle lobe is blue on dorsum which comprises a triangular-shaped central blue spot and a single round blue spot on either side, and lateral surface is yellowish, posterior lobe sky blue with narrow blackish-brown posterior border (Figure 2D, E). Mesepisternum chocolate-brown. Mesepimeron brown. Metepisternum with a sky-blue stripe, slightly broader posteriorly. Metepimeron pale brown (Figure 2C). The ventral side of thorax pale yellow.

Legs. Coxa and trochanter pale yellow. Femur brownish-black, joints black. Tibia, tarsus and claw black.

Wings. Hyaline. Pterostigma blackish-brown covering one cell. Fw two antenodals, $15\frac{1}{2}$ postnodals; Hw two antenodals, $14\frac{1}{2}$ postnodals. CuP reaching posterior margin of forewing approximately at level of Px5, in hind wing approximately at level of Px6. R_{4+5} distal to subnodus, then IR3 arising from distal R_{4+5} . Number of cells between Arc and place where CuP meets hind margin of hind wing 8.5. Sectors of arc arise from a common stalk. Ab incomplete (Figure 2F).

Abdomen. Slender. Dorsum blackish-brown, laterally pale brown, ventral surface pale yellow. S3–S8 and S10 with narrow sky blue dorsal basal markings which do not meet ventrally, markings on S4–S7 more prominent, a minute dorsal apical blue marking also on S8, sky blue on the dorsum of S9.

Anal appendages (dried specimen). Dark brown. Cerci hairy, in dorsal view broadly curving inwards and downwardly twisted near the distal one-fourth, in ventral view gradually curving downwards, distal end broadly rounded, slightly longer than paraprocts. Paraprocts with minute hairs, broad at base, in two planes with the outer plane depressed in dorsal view, then

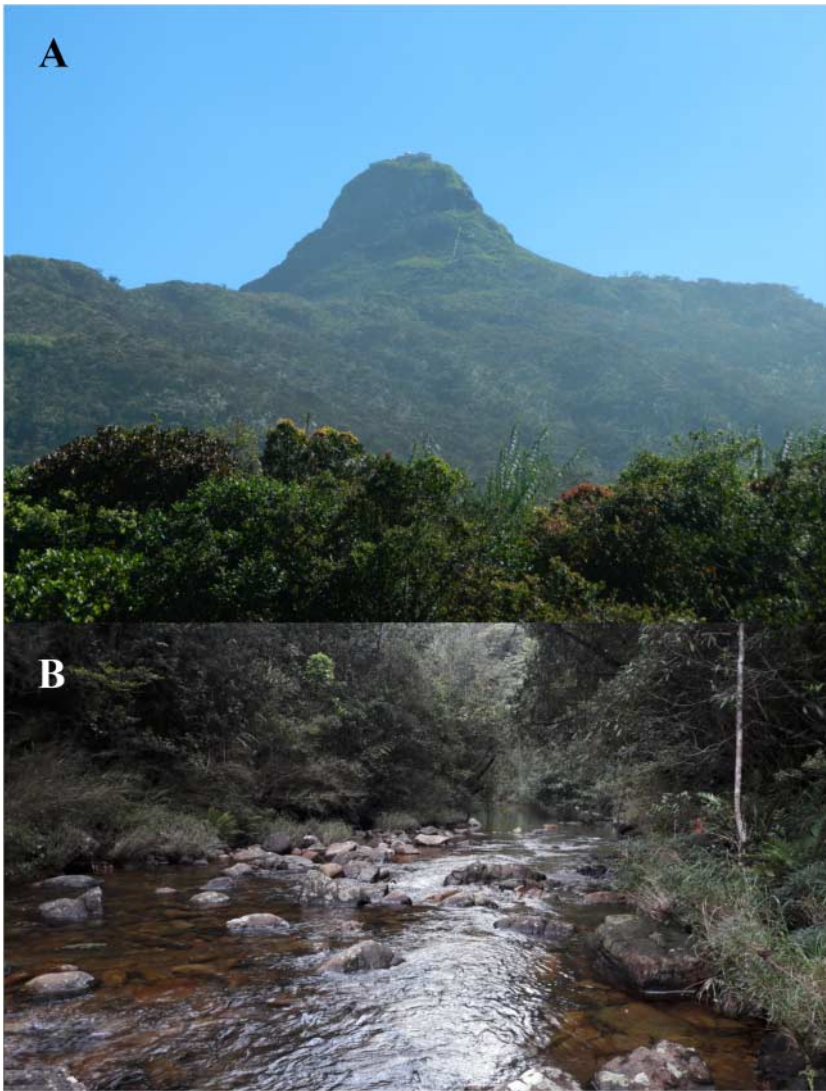


Figure 3. Habitats of *Ceylonosticta goodalei* sp. nov.; (A) Adam's Peak (Samanala Nature Reserve), Ratnapura district, Sabaragamuwa province, Sri Lanka; (B) *C. goodalei* sp. nov., Kuru Ganga (Kuru River), Seethagangula, Kuruwita-Erathana foot path, Adam's Peak (Samanala Nature Reserve), adjacent to the type locality (~ 10 m).

tapering to a broad point, a blunt inwardly pointing spine two-thirds of the way to the tip (Figure 2G–I).

Genital ligula. Curled over and embracing the stem of the organ which is ellipsoidal in shape, another branch spreads outwards from the stem. Possesses a ridge on its dorsum; the ridge is broad at base, cone-shaped and blunt at apex (Figure 3J).

Measurements (mm). Head width = 4, synthorax length = 5, abdomen length with anal appendages = 32, hind wing length = 23.

Variations in males. Paratype males did not show significant variation from the holotype.

Differential diagnosis

Medium-sized. Prothorax with anterior lobe mostly blue, dorsum of the median lobe blue and yellowish on the sides, and posterior lobe sky blue with narrow blackish-brown posterior border. Synthorax chocolate-brown on dorsum. Abdomen chocolate-brown with narrow blue dorsal basal markings on S2–S8 and S10, also a minute dorsal apical blue marking on S8, sky blue on the dorsum of S9. Cerci slightly longer than paraprocts and downwardly twisted near the distal one-fourth and broadly rounded at the end. Paraprocts in two different planes with the outer plane depressed (in dorsal view), narrow with a blunt inwardly pointing spine two-thirds to the tip.

C. goodalei sp. nov. belongs to the *C. austeni*-species group *sensu* Bedjanič et al. (2016). Males of *C. digna* Hagen, 1860, *C. nietneri* Fraser, 1931, and *C. austeni* Lieftinck, 1940 can be readily distinguished from the new species because they all have a sky-blue stripe on the dorsum of the synthorax. *C. brincki* Lieftinck, 1971 and *C. venusta* Bedjanič & Conniff, 2016 are uniform rusty-brown on the dorsum of the synthorax, as is *C. goodalei*, and are distinguished by the shape of the paraprocts in the male. The paraprocts of *C. brincki* are without a conspicuous subapical inwardly directed spine and are apically widened, and hollowed out interiorly, with crescent shaped emargination. Those of *C. venusta* have a conspicuous, sharp, subapical, inward- and slightly backward-directed spine.

Female. Unknown

Habitat.

The species was observed inside a well-shaded typical wet-zone forest, near to the Kuru Ganga (Kuru River). Both sides of the river are densely vegetated with species of *Elaeocarpus*, *Dipterocarpus* and *Michelia*, and various typical wet-zone shrubs (Figure 3A, B).

Discussion

A brief review of *Ceylonosticta* species-groups

The grouping of members of the *Ceylonosticta* has been attempted twice. Fraser (1933b) provisionally grouped the 10 species known at the time into two groups based on venation: Group I included the species in which vein R_{4+5} arises proximal to the vein descending from the node, and Group II included those in which vein R_{4+5} arises at or a little distal to the vein descending from the node. Bedjanič et al. (2016) assigned the 18 known species into seven “species-groups”, viz., *anamia*, *adami*, *austeni*, *bine*, *hilaris*, *mojca*, and *montana*, based on morphological and molecular analyses.

Three recently described species were not included in these assignments: *Ceylonosticta nancyae* Priyadarshana & Wijewardhane, 2016, *Ceylonosticta alwisi* Priyadarshana & Wijewardhane, 2016 and *Ceylonosticta rupasinghe* Priyadarshana & Wijewardhane, 2016. *C. nancyae* does not belong to any of these species-groups based on morphological characters, and molecular analyses are needed to clarify the proper placement of this species within the species-groups. *Ceylonosticta alwisi* can be placed within the *mojca* group based on the conspicuous stalked dorsal processes on the anterior lobe of the prothorax. *Ceylonosticta rupasinghe* does not fit clearly into any of the defined species-groups, but it could belong to the *anamia* group based on the following characters: its general appearance, the vein $R_4 + 5$ arising well proximal of the crossvein descending from the node in both wings, the orange-yellowish

middle lobe of the prothorax in mature individuals, the number of the forewing Px (more than 16) and the shape of the paraprocts. Molecular analyses are needed to confirm this placement.

The *austeni*-group, to which *C. goodalei* has been assigned, now consists of six species and is the most speciose group among endemic Sri Lankan Platystictids. *C. goodalei* appears to be closely related to *C. brincki* and *C. venusta*, but molecular work is needed to further elucidate the relationships within this interesting group of species.

Addendum to the key to *Ceylonosticta* species

Note: This key is modified from Bedjanič et al. (2016) by adding species described since then (Priyadarshana et al., 2016; and the present article). As the comprehensive determination key of Bedjanič et al. (2016) covers 18 *Ceylonosticta* species and is accompanied by over 150 figures and distribution maps for all species, the goal of the present addendum is to incorporate four new species descriptions, those of *C. alwisi*, *C. rupasinghe*, *C. nancyae* and *C. goodalei*, so that the original structure and numbering in the key are retained. In doing so, the dichotomous structure of the key has been expanded where appropriate to trichotomous. For these four species, the appropriate reference, citing figures from the original article, is given.

Ceylonosticta goodalei Priyadarshana & Wijewardhane

Key of Bedjanič et al. (2016): [1a] → [2a] → [3b] → [6]

- 6a. Superior anal appendages of males longer than inferiors, the latter apically widened, hollowed out interiorly, with crescent-shaped emargination and without conspicuous subapical inwardly directed spine. In males, apical sky-blue markings on S8–S10. In females, posterior margin of posterior prothoracic lobe evenly rounded, last two abdominal segments sky-blue on dorsum. Synthorax in mature individuals of both sexes brown above and below lateral blue stripe; ♂ [mm]: Hw 19–21.6, Abd 27.4–33.8, ♀ [mm]: Hw 19.7–22.2, Abd 27.4–29.3 (Bedjanič et al., 2016, figures 45–50, 146–147, map 4) *Ceylonosticta brincki*
- 6b. Superior and inferior anal appendages of males equal in length, the latter apically prolonged, with conspicuous subapical inward- and slightly backward-directed spine. In males, apical sky-blue markings only on S9–S10, including narrow intersegmental membrane between S9 and S8. In females, posterior margin of posterior prothoracic lobe with marked rounded dorsolateral expansions, the last abdominal segment sky-blue on dorsum, while on S9 the blue coloration is obscured proximally. Synthorax in mature individuals of both sexes brown above the lateral blue stripe and golden yellow below; ♂ [mm]: Hw 24.1–24.4, Abd 36.2–36.7, ♀ [mm]: Hw 22.8, Abd 31.3 (Bedjanič et al., 2016, figures 63–69, 151–153; map 5) *Ceylonosticta venusta*
- 6c. [NEW] Superior anal appendages of males slightly longer than inferiors. Inferior anal appendages with a blunt inwardly pointing spine two-thirds of the way to the tip. In males, blue dorsal basal markings on S2–S8 and S10, also a minute dorsal apical blue marking on S8, sky blue on the dorsum of S9. Female unknown. ♂ [mm]: Hw 23, Abd 32, (Figure 2A–J; present paper) *Ceylonosticta goodalei* sp. nov.

Ceylonosticta nancyae Priyadarshana & Wijewardhane

Key of Bedjanič et al. (2016): [1a] → [2b] → [7b] → [8b] → [12b] → [14]

- 14a. Dorsum of middle lobe of prothorax whitish blue in young individuals and sky blue in older individuals of both sexes. Whole synthorax, also ventrally, brown, dark brown or almost black in old individuals of both sexes, with contrasting pale blue to sky-blue stripes on metepisternum. In males, superior anal appendages without dorsal obtuse tooth distally above point of their angulation. In females, posterior lobe of prothorax markedly prolonged medially; ♂ [mm]: Hw 20.5–24, Abd 33.3–38.3, ♀ [mm]: Hw 19.7–22, Abd 28.4–32 (Bedjanič et al., 2016, figures 81–86, 158–159, map 6).....*Ceylonosticta walli*
- 14b. Dorsum of middle lobe of prothorax whitish or yellowish. Stripes on metepisternum only slightly bluish and of similar pale color, as are posterolateral and ventral parts of synthorax, which are white in young individuals and light golden yellow in older individuals of both sexes. In males, superior anal appendages with dorsal obtuse tooth distally above point of their angulation. In females, posterior lobe of prothorax not prolonged medially; ♂ [mm]: Hw 22.2–27, Abd 37–43, ♀ [mm]: Hw 23.7–26.4, Abd 32–38.5 (Bedjanič et al., 2016, figures 70–74, 154–155, map 6).....*Ceylonosticta hilaris*
- 14c. [NEW] Dorsum of the middle lobe pale yellow with whitish-blue markings. Ventral surface of synthorax yellowish. In males, superior anal appendages more than twice as long than inferiors, broad at the base, gradually curving inwards, spatulate for first 1/3 and near to apex, and that spatulate portion bears a small indentation at the distal end, without dorsal obtuse tooth distally. Inferior anal appendages bifurcated, the shorter interior branch spreads towards the superior appendages and sharply bends downwards at the distal end, the longer exterior branch curves slightly upwards at the distal end. Female undescribed. ♂ [mm]: Hw No data, Abd 48, (Priyadarshana et al., 2016, figures 2A–I, 6A–C, 7A).....*Ceylonosticta nancyae*

***Ceylonosticta rupasinghe* Priyadarshana & Wijewardhane**

Key of Bedjanič et al. (2016): [1a] → [2b] → [7b] → [8b] → [12a] → [13]

- 13a. Px in forewing > 16, moderately large species. Middle lobe of prothorax white or light greyish blue in young individuals and yellowish orange in adults of both sexes, with pair of distinctive small nipples on dorsum. Whole synthorax dark brown, with contrasting light blue to sky blue stripes on metepisternum, ventral surface of synthorax light brown. In males, inferior anal appendages distally narrowed and turned slightly up, ending in peculiar structure, similar to narrow inverted boot, with totally flat surface of sole turned slightly upwards and tips pointing inwards; ♂ [mm]: Hw 24.7–27.9, Abd 35.8–44.1, ♀ [mm]: Hw 27.6–28.7, Abd 38.9–39 (Bedjanič et al., 2016, figures 1–4, 132–133, map 2).....*Ceylonosticta anamia*
- 13b. Px in forewing ≤ 16, medium-sized species. Middle lobe of prothorax white or light blue, not yellowish, with flat rounded bulge on each side, which are slightly tipped with black on the top in mature individuals. Synthorax bronzed black on dorsum, its sides bronzed black to metapleural suture, with contrasting white or light blue stripes on metepisternum. Metepimeron and ventral parts of synthorax white or light ochreous. In males, inferior anal appendages with spoon-shaped dilatation of apices; ♂ [mm]: Hw 24–26.1, Abd 37–43.7, ♀ [mm]: Hw 24, Abd 34 (Bedjanič et al., 2016, figures 34–38, 142–143, map 2).....*Ceylonosticta adami*
- 13c. [NEW] Px in forewing > 16, large species. Anterior lobe of prothorax with pronounced blackish-brown posterior collar, middle lobe orange-yellow, posterior lobe blackish-brown with conspicuous flattened projections on each side that are twisted at the base. Genae yellow. Superior anal appendages broad and curve inwards, blunt at the distal end. Inferior anal appendages broad at base and bifurcated, with an axe-head

appearance. ♂ [mm]: Hw no data, Abd 52 (Priyadarshana et al., 2016, figures 3A–I, 6D–F, 7B)..... *Ceylonosticta rupasinghe*

Ceylonosticta alwisi Priyadarshana & Wijewardhane

Key of Bedjanič et al. (2016): [1a] → [2b] → [7a] → [15b] → [17]

- 17a. Middle lobe of prothorax of both sexes brown, dorsal processes on anterior lobe narrow, slightly upcurved, nearly as long as length of prothorax. Inferior anal appendages of males strongly reduced, basal portions expanded, each with robust medially directed spine, which reach bases of superiors. Distal prolongation of last tergite in males bluntly triangular from above; ♂ [mm]: Hw 19.5–22.2, Abd 34.2–37.8 (Bedjanič et al., 2016, figures 5–8, 134–135, map 3) *Ceylonosticta mojca*
- 17b. Middle lobe of prothorax of both sexes white or bluish white, dorsal processes on anterior lobe longer than length of prothorax. Inferior anal appendages of males extremely reduced, basal portions expanded, each with rudimentary spine, which do not reach bases of superiors. Distal prolongation of last tergite in males trapezoidal from above [18]
- 17c. [NEW] Middle lobe of prothorax blue-white, posterior lobe brown-black. In males, stalked processes on anterior lobe of prothorax nearly as long as the prothorax, cylindrical, broad at the base, curved towards the tip that inclines towards the head. Inferior anal appendages not reduced, approximately half the length of the superior appendage, sharply bent near the distal end, apex is pointed. No distal prolongation of last tergite in males. Female undescribed. ♂ [mm]: Hw no data, Abd 41 (Priyadarshana et al., 2016, figures 4A–J, 6G–I, 7C) *Ceylonosticta alwisi*

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