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COMMUNICATION

TWO NEW SPECIES OF *EUPHAEA* SELYS, 1840 (ODONATA: ZYGOPTERA: EUPHAEIDAE) FROM NORTHERN WESTERN GHATS, INDIA

Shriram Dinkar Bhakare, Vinayan P Nair, Pratima Ashok Pawar, Sunil Hanmant Bhoite & Kalesh Sadasivan

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Two new species of *Euphaea* Selys, 1840 (Odonata: Zygoptera: Euphaeidae) from northern Western Ghats, India

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Abstract: Two new species of the damselfly genus *Euphaea* Selys, 1840 (Odonata: Euphaeidae) are described from the Western Ghats of Satara District, Maharashtra, distinguished by their distinct morphology and coloration. *E. thosegharensis* Sadasivan & Bhakare sp. nov. is similar to *E. cardinalis* (Fraser, 1924), but is distinguished by the extensor and flexor surface of all femora black while all femora bright red in *E. cardinalis*; apical fourth of Hw black while apical half of Hw black in *E. cardinalis*; genae reddish-orange, black in *E. cardinalis*; a tuft of sparse stub black hair on either side of tergite of S9 while both S8 and S9 with tufts of long ventral hairs in *E. cardinalis*. Male genital vesicle matt black, with distal border rounded angles, while vesicle black and hexagonal in shape with rounded angles in *E. cardinalis* and S9 twice the length of S10, while S9 and S10 of equal length in *E. cardinalis*. *E. pseudodispar* Sadasivan & Bhakare sp. nov., is very close to *E. dispar* (Rambur, 1842), but is differentiated easily by the absence of yellow patch on legs as in *E. dispar*; only apical fifth of Hw black; genae being yellowish-white, while black in *E. dispar*; male genital vesicle brownish-black & rhomboid-shaped and with no transverse rugosities while black with distal border rounded and with fine transverse rugosities in *E. dispar*; penis with single seta on each side while *E. dispar* has three pairs; sternite of S9 very prominently extending ventrally like a beak in comparison with *E. dispar*. We have identified additional morphological characters useful in taxonomy of *Euphaea* of the Western Ghats for example, tufts of ventral hairs on terminal abdominal segments genital vesicle, penile structure of males and sternite of S9 in the males, and vulvar scales of females. A taxonomic key to all known species of genus *Euphaea* of the Western Ghats is also provided.

Keywords: Additional morphological characters, Damselfly, Endemic, Maharashtra, taxonomic key.

Abbreviations: Ax—antennal crossveins | Fw—forewing | Hw—hindwing | Px—postnodal crossveins | Pt—pterostigma | S1–10—abdominal segments | TL—total length of the specimen including appendages | AL—abdominal length | FL—forewing length | HL—hindwing length | TNHS—Travancore Nature History Society | TORG—Travancore Odonate Research Group | KS—Kalesh Sadasivan | SDB—Sunil Hanmant Bhoite | SHB—Shriram Dinkar Bhakare | PAP—Pratima Ashok Pawar.

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INTRODUCTION

The genus *Euphaea* Selys, 1840 (Odonata: Euphaeidae) is represented by medium-sized damselflies distributed from the Western Ghats of peninsular India, northeastern India, Sri Lanka, Vietnam, and Malaya in Indochina & Borneo. India has five known species of *Euphaea* (Subramanian & Babu 2017); two species, *Euphaea masoni* Selys, 1879 and *Euphaea ochracea* Selys, 1859, are distributed in the northeastern region, while the Western Ghats has three species namely *Euphaea cardinalis* (Fraser, 1924), *E. dispar* (Rambur, 1842), and *E. fraseri* (Laidlaw, 1920) (Subramanian et al. 2018). They are characterized by males with hindwing apices more or less broadly opaque black having metallic iridescence in some light; forewings pointed, hindwing rounded and shorter than the forewing; discoidal cell traversed; thorax robust; abdomen long cylindrical in males and same length or shorter in females; abdominal segment 10 with a robust dorsal keel and its apex pointed, and the anal appendages with forcipate cerci and tiny paraprocts (Fraser 1934).

The species *E. cardinalis* is endemic to the Western Ghats and is distributed in Kerala and Tamil Nadu. It is a montane species seen above 900m south of the Palghat gap in the Anamalai, Palani, and Agasthyamalai hills. *E.*

dispar is confined to the Western Ghats north of the Palghat gap from South Kanara and Coorg to the Nilgiris (Malabar Wayanad) from 1,066 to 1,828 m (Fraser 1934). *E. fraseri* is a species seen in the forested foothills of the Western Ghats and is distributed from North and South Kanara, Malabar, Coorg, the Nilgiris Wayanad, and Anamalai Hills (Fraser, 1934), and its current distribution is from Kanyakumari to Maharashtra at 100–1,200 m (Subramanian et al. 2018). Here, we describe two new species of the genus from Satara District, Maharashtra the northern Western Ghats, north of the Amboli Ghat.

MATERIALS AND METHODS

SDB came across the specimens in May 2020 at Thoseghar, Satara District of Maharashtra (Image 1). The insects were collected and preserved in absolute alcohol and compared to specimens of known species of *Euphaea* from the Western Ghats. Nomenclature follow Subramanian & Babu (2017) and Paulson & Schorr (2020). The known distribution of the species follows Subramanian et al. (2018). Taxonomic keys to the species are modified based on Fraser (1934). The morphological description follows Garrison et al. (2006). The ventro-lateral wing like structure on segment 2 is

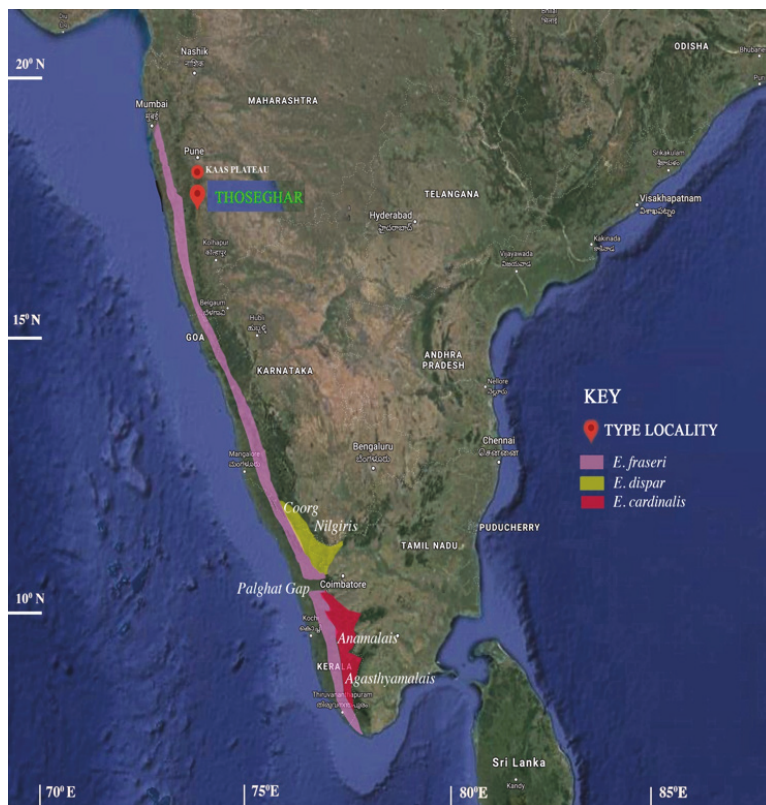


Image 1. Map showing distribution of the new damselfly species in Western Ghats, with type locality of *Euphaea thosegharensis* Sadasivan & Bhakare, sp. nov. and *E. pseudodispar* Sadasivan & Bhakare, sp. nov.

termed the pseudoauricle following Orr (2003). The scale like structure guarding the gonopore on ventrum of abdominal segment 9 (S9) is referred here to as the gonocoxae. The wing venation terminology follows Riek & Kukalová-Peck (1984). Measurements and morphological details of all species mentioned in text are based on specimens in voucher collections of TORG. Photographs of the specimens were taken with Canon (Canon Inc., Japan) EOS 70D DSLR fitted with 180mm macro lens.

Current distribution of known species of *Euphaea* is based on our personal records and Subramanian et al. (2018). The genitalia were studied by dissecting under a stereo-zoom microscope (HEADZ Model HD81) and later preserved in glycerol. Holotype and paratype are deposited in the insect collection facility of Zoological Survey of India (ZSI), Kozhikode. Additional material will be deposited in ZSI Pune and Bombay Natural History Society (BNHS), Mumbai. Illustrations were made by KS using the stereo-zoom microscope.

RESULTS

Euphaea thosegharensis Sadasivan & Bhakare, sp. nov.

(Image 2 A–G)

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Holotype: ZSI/WGRC/I.R-INV.15031, 30.v.2020, Male, wet specimen in alcohol, Thoseghar, Satara District, Maharashtra, India, 1,060m; specimen collected from a paddy field near a flowing stream, coll. SDB.

Paratype: ZSI/WGRC/I.R-INV.15032, 30.v.2020, Female, same information as the Holotype.

Additional material examined: Males (n= 4) and females (n= 3) bear the same collection data as the holotype, wet specimens in alcohol, will be subsequently deposited in collections of ZSI Pune and BNHS Mumbai.

Additional field records (specimens not collected): Thoseghar (1,060m): 10 males and 4 females on 30.v.20; 14 males and 6 females on 07.vi.20; 7 males and 3 females on 14.vi.20; 8 males and 4 females on 21.vi.20; 8 males and 5 females on 28.vi.20; 8 males and 2 females on 02.vii.20; 2 males and 2 females on 04.viii.20. All observations by SHB & SDB. Chikhali (1,081m): 6 males and 2 females on 26.vii.20, observed by SB & SB. Kaas Lake (1,124m): 4 males on 02. viii. 20, observed by PAP.

Description of holotype male (Image 2A & 3)

Measurements (in mm): TL (including appendages) 51, AL 42, FL 4.0, HL 31.

Head: The coloration of the live insect is described below (in the dead insect the colours fade with respect to the hues). Labium dark amber brown to black. Labrum reddish-orange with a faint and obscure median streak and the mandible with same colour and a faint transverse upper streak. Anteclypeus shiny dark amber brown to black. Postclypeus pinkish-red with two thin black paradorsal vertical lines and two lateral black spots near the antero-lateral margin. Antefrons brownish-red and postfrons brownish-black. Genae are red inferiorly, middle part orange yellow and superior third red. Eyes dark amber black superiorly, middle part and laterally dark amber brown and the inferolateral aspect pale brown. Antennae shiny black and vertex matt black, with an ill-defined and obscure reddish patch, twice the size of the ocelli, with suffused margins running between the lateral ocellus and the base of the antenna on each side. This spot may be difficult to see once the specimen is preserved. The occiput, occipital bar and post-ocular region are greyish-matt black (Image 3B).

Prothorax: coloured in matt black with vermilion red spots. Anterior lobe is black with two small reddish spots at the medial part of the lateral third. Middle lobe black with the lateral triangular spots vermilion red, notopleural suture black and propleuron brownish-red. Posterior lobe black with the lateral angles pale brownish-red. No spines present (Image 3C).

Pterothorax: The ground colour of the pterothorax in the live insect is bright red with pinkish hue inferolaterally and orange dorsally. Dorsal carina black. The triangular mesothoracic acrotergite black. The paradorsal region on either side black. Nearly the whole humeral suture and the dorsal fifth of the interpleural suture marked in matt black. Mesostigmal plate black with its anterior edge pale pinkish-red. Mesepisternum red and encloses a thick black central mesepisternal stripe as thick as the paradorsal black band. This red ground colour of the mesepisternum not interrupted and is continuous all around the central black band, though very narrowly connected on the dorsal aspect near the antealar sinus. Thus, in other words the antehumeral stripe and the humeral stripes are connected around the central black band, and is coloured orange-red, the former being more orange and the later more red. Mesepimeron coloured red and encloses a central black band, with the red continuous all around the black band. Mesinfraepisternum is bordered with pale pinkish-red and has a large black spot occupying its antero-inferolateral aspect. The second lateral suture marked in black on its dorsal third. Metepisternum and Metepimeron are fully red. Metinfraepisternum pale

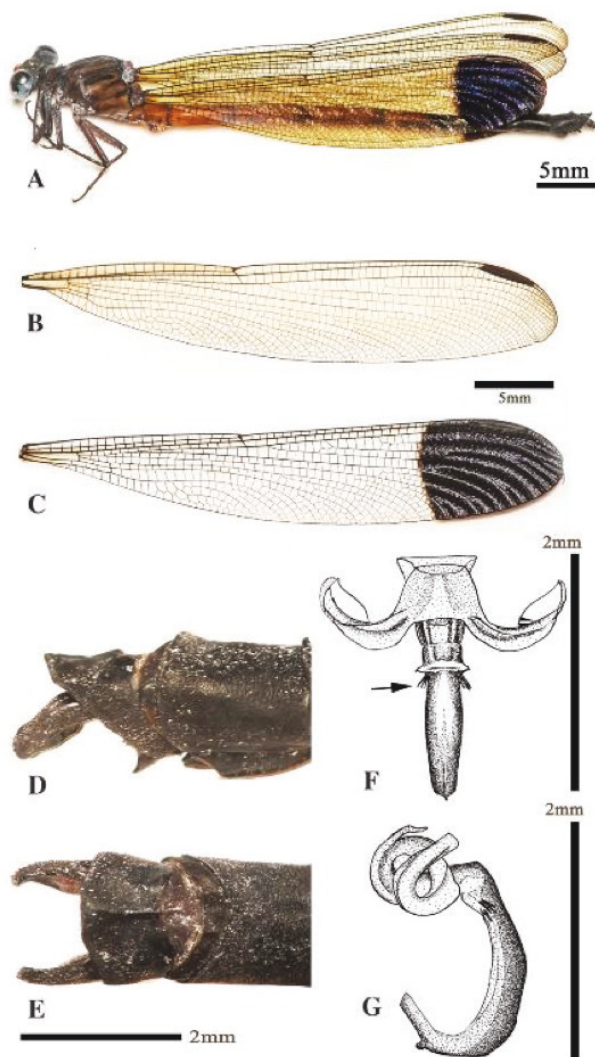


Image 2. *Euphaea thosegharensis* Sadasivan & Bhakare, sp. nov. Male: A—ZSI/WGRC/I.R-INV.15031 | B—Venation Fw | C—Venation Hw | D & E—Anal appendages | F & G—Genital lingula (arrow pointing to the setae). © Kalesh Sadasivan.

pinkish-red and its lower part is paler. Metathoracic spiracle amber brown (Image 3C).

Legs: Coxae are anteriorly greyish and pinkish on the postero-lateral aspect. The trochanter, femur, tibia, tarsus and the claws all are grey graphite black. The femur have an inconspicuous pale pinkish wash on the superior part of the flexor aspect (Image 3C).

Wings: Fw is hyaline and its tip up to 3–4 cell are faintly effumed. Veins are black. Left Fw Ax-24 & Px-35; right Fw Ax 25 & Px 36; left Hw Ax 18 & Px 32; right Hw Ax 18 & Px 31. Pt is black and is 10–11 cell wide in Fw and in Hw. Hw is hyaline and its distal fourth is coloured black with a metallic purplish to lilac violet reflex in some lights. The proximal margin of this black patch is convex and extends to 7 cells proximal to the Pt. Veins are black



Image 3. *Euphaea thosegharensis* Sadasivan & Bhakare, sp. nov. Male from field: A—lateral view | B—head and thorax dorsal view | C—lateral view of head and thorax. © Shriram Dinkar Bhakare.

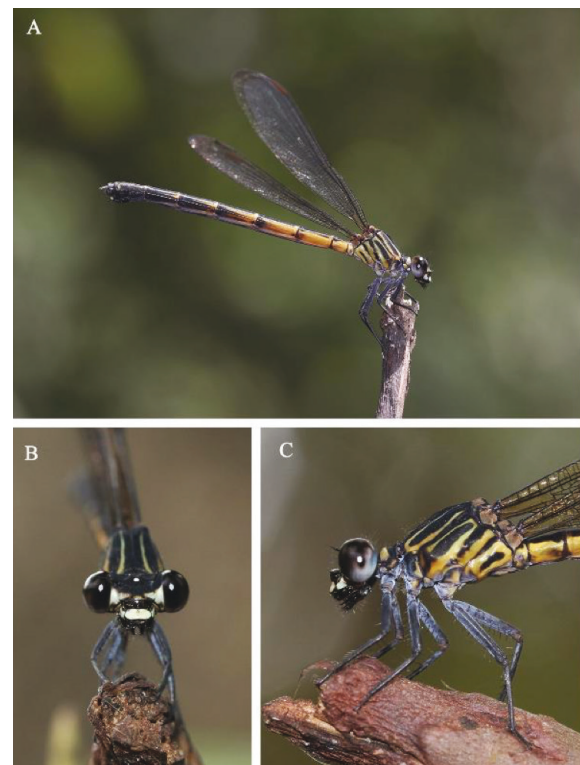


Image 4. *Euphaea thosegharensis* Sadasivan & Bhakare, sp. nov. Female from field: A—lateral view | B—head and thorax dorsal view | C—lateral view of head and thorax. © Shriram Dinkar Bhakare.

and has 18–19 Ax and 31 Px. Pt is black and is 10 cell wide. Cubital space with 3 cross veins in Fw and 3–4 cross veins in Hw (Image 2B & C).

Abdomen: The general colour of abdomen is red on the proximal segments and black on the distal ones. The transition take place in S5-6, where the dorsal red merges with ventral black (Image 2A&3A). Segmental joints black. S1–S4 is fully red throughout. S2 with well-developed pseudoauricle on each side which bears two tiny black teeth at its summit; it is coloured pinkish-red on their lateral aspect. S5 is dorsally red, this red enclosing the base of the segment and distally it narrows to reach just short of the end of the segment. The distal end of the segment is black and this black color runs inferiorly and anteriorly but never reaches the base of the segment. S6 has its dorsal proximal third red and this extends along the lateral aspect of the segment to reach almost the half of the segment, and rest of the distal part black. S7 is wholly black except for a small baso-lateral red spot on each side. S8–10 are wholly black. A tuft of sparse stub black hair is seen on tergite of segment 9 near its base. No other hair tufts are seen on the ventrum of abdomen on S8 or S9. On ventral view, the gonopore margin trapezoid shaped, wider distally. Gonocoxae with their apices produced into small spines that are divergent at the tip. No tooth on the distal aspect sternite of S9 near the gonopore. Distal margin of S10 ‘{’ shaped, hence curved and wavy at its mid-ventrum. On lateral view, the mid part of distal margin of S9 does not extend much as tooth, over the gonopore (Image 11G). Abdominal segment 9 twice the length of S10. S10 bears a broad dorsal carina and a broad keel at its distal end (Image 2D&E).

Genitalia: S2 genital vesicle matt black, with distal border and angles rounded, transversely rugose about its anterior third; its proximal extension is square and shallowly excavated. Genital lingula illustrated. Penis with six setae one each side (Image 2F&G).

Anal appendages: The anal appendages are very similar to that of other species in the genus. They have forcipate cerci and tiny paraprocts. Paraprocts with tips medially directed and hence tips converge at rest. Paraprocts of same length as the gonocoxae. The size of paraprocts are much smaller than the S10 dorsal keel. Lamina of cerci as in *E. cardinalis*, but with the tip slightly more incurved (Image 11B&G). The cerci and paraprocts are fully black (Image 2D&E).

Description of paratype female (Image 4)

Measurements (in mm): TL (including appendages) 42, AL 33, FL 32 & HL 33 mm.

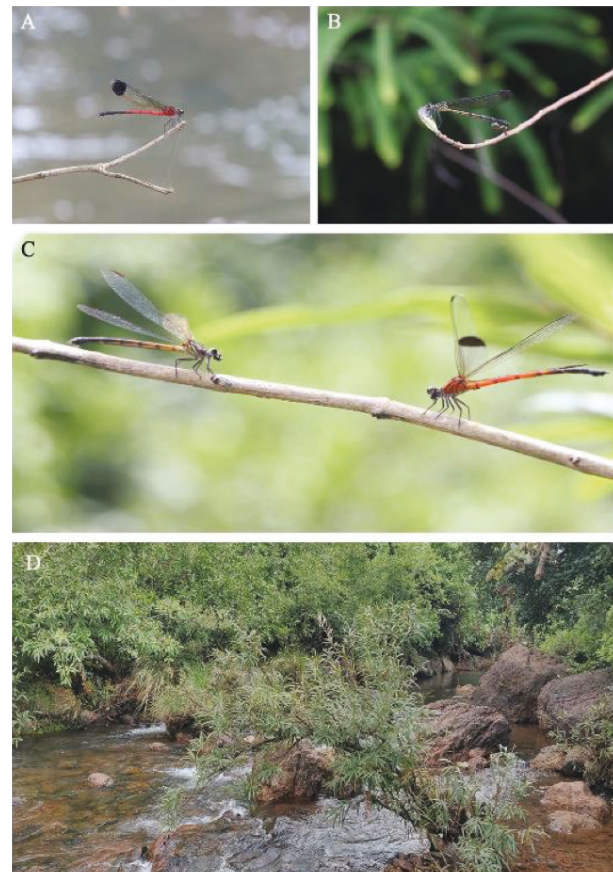


Image 5. Field images of *Euphaea thosegharensis* Sadasivan & Bhakare, sp. nov.: A—male | B—female | C—courtship | D—riparian habitat of the species. © Shriram Dinkar Bhakare.

Head: Labium black; labrum pale dirty white with a faint and obscure suggestion of the median black tongue; Anteclypeus blackish-amber brown; Postclypeus pale greenish-white with the vertical paradorsal black streaks extending laterally as suffused black patch obscuring the black streak on the lateral aspect its anterior border, thus appearing as grossly black with a central pale bluish-white patch; Antefrons centrally black and laterally pale greenish white; Post frons matt black; Genae pale greenish-white to almost white; antennae black, Vertex and occiput black; eyes as in the males black and paler inferiorly (Image 4B).

Prothorax: Structure and coloration of all the three lobes are closely similar to that in the male, but coloured pale yellowish instead of pinkish-red, otherwise matt black. No ornamentations or spines present (Image 4C).

Pterothorax: The reds of the males are replaced by pale greenish-white. The mesepisternum mesepimeron, metepisternum are as in the males, but with the orange and red colours replaced with pale greenish-yellow. The central black stripe in mesepisternum and the and



metepisternum are as in the males. In addition the metepimeron has a similar black streak, that the male lacks. Rest of the pterothorax is as in the males with the reds replaced by pale greenish-yellow (Image 4C).

Legs: Coxae are coloured posterolaterally in pale dirty greenish-white, and rest of the parts of the legs are matt black as in the male and is mildly pruinosed (Image 4C).

Wings: Both wings hyaline. Left Fw Ax-22 & Px-3; right Fw Ax 21 & Px 29; left Hw Ax 19 & Px 26; right Hw Ax 20 & Px 24. Pt is black and is 9–10 cell wide in Fw and 9–11 cell wide in Hw. Wings are hyaline with a faint smoky hue in life.

Abdomen: All segments are black dorsally with lateral pale greenish-yellow markings as follows: S2–3 with a large spot posterolaterally and the black of this anterolaterally merge with the yellow as brownish suffusion, S2–3 with a very narrow stripe, S4 similar to S3 but the black posterolateral spot and its proximal suffusion is much darker, S5 with a anterolateral 'T' shaped yellow mark whose central streak tapers and ends at the distal thirds, S6–7 with this anterolateral yellow streak progressively reduced to mere yellowish anterolateral triangles. S8–10 are fully black. Vulvar scale with a central shallow but wide sulcus and its postero-lateral angle is rounded. Anal appendages and ovipositor are black (Image 12F).

Variations

Males: There are some variation in the morphometrics (n= 4). Measurements (in mm) are TL (including appendages) 5.06 ± 0.21 , FL 3.73 ± 0.23 , HL 34.5 ± 0.7 & AL 39.5 ± 0.71 . There are only minor variations in hues and extent of coloration amongst males that we photographed from the region. In venation, in the Fw the number of Ax varies from 20–25, while Px varies from 35–36. Pt is black and is 9–11 cell wide. Hw had 17–19 Ax and 29–31 Px. Cubital space with 3–4 cross veins in all wings. The labrum, on its attached margin, in some specimens of both sexes may have a faint and obscure suggestion of a vertical median brownish-black band. Paratype females (n= 4) had variations in venation, with the Fw having 20–22 Ax and 21–24 Px, Hw with 19–21 Ax and 24–29 Px. Cubital space with 3–5 cross-veins in Fw and 3–4 in Hw. Wings have a faint smoky hue in life. The teneral are slightly different in color. Males are more orangish when young and as they mature become more reddish. In such mature individuals, red coloration of the face and thorax is brighter, and antehumeral stripe and spots on middle lobe of prothorax is pinkish orange. In well-marked individuals, antehumeral and the humeral

stripes are interrupted by the mesepisternal central black band dorsally near the antealar sinus. Abdominal segment 6 is colored red up to the half of the segment, but some individuals, observed in field, had the red restricted to the basal third to fourth.

Females: The pale greenish-yellow of females change to pale dirty brown on the thorax and to pale ochreous brown on the abdomen as the individuals age. The inferolateral aspect of thorax, coxae, trochanters, proximal femora and the ventral region of abdomen are pruinosed in older specimens. The females are sometimes heavily marked in black in which case the humeral and antehumeral stripes are very much reduced to thin irregular streaks. The pale greenish color of the genae may have a light blue wash in young individuals.

Etymology

The species name '*thosegharensis*' is a toponym derived from the type locality in Thoseghar, Satara District, Maharashtra, India.

Distribution As far as known, the species is restricted to the high-elevation streams and riparian patches of Satara District around Thoseghar, and Kaas Lake in Maharashtra, India.

Habitat and Ecology

The habits are as for the genus. The males are seen guarding parts of streams on vantage points, like rocks or on the tips of twigs. They stay on these perches for long time if not interfered by rivals or a potential mate worth investigating. Flight period is from April to August as inferred from past observations and photographs. The individuals are almost always found in the area of shallow, flowing stream with tree canopy at the edges. Males are often seen sitting on the rocks in the stream and show territorial behaviour (Image 5). Females are seen resting on the dry twigs along the edges of streams. Both retire on the dry bush twigs at the edges of streams to roost overnight.

Differential diagnosis (Table 1, 2)

The new species can be easily differentiated from all the known *Euphaea* species of Western Ghats based on morphology (Table 1) and coloration (Table 2). Based on the morphological features, it is differentiated from all others by its smaller size (Hw 34–35 mm, Abdomen 39–40 mm); the male genital vesicle being black with distal borders rounded and a tuft of sparse stub hairs on sternum of S9 only; the gonopore margin trapezoid shaped, wider distally; and the gonocoxae with their apices produced into small spines that are divergent at

the tip. From *E. fraseri*, it can be differentiated based on the presence of hair tufts on the former. Length of S9 twice the length of S10 in *E. thosegharensis*, and this distinguishes it from *E. dispar* and *E. pseudodispar*, both of them having S9 length 1.5 times the length of S10, whereas in *E. cardinalis* S9 and S10 are of equal length. Also, this species has no tooth on the distal aspect sternite of S9 near the gonopore unlike in *E. cardinalis*. The insect is of small size in comparison with *E. cardinalis* and *E. dispar*, and is almost the same size as *E. fraseri*. Based on coloration, it is distinguished from all its congeners by the orange labrum, orange-red genae, rose red spots on lateral aspect of middle lobe of prothorax, orange red antehumeral stripe, all legs being black and the apical fourth of Hw being black. The coloration of labrum is similar to *E. cardinalis* and the antehumeral stripes are closer to *E. dispar* and *E. cardinalis* (Image 11B).

***Euphaea pseudodispar* Sadasivan & Bhakare, sp. nov.**

(Image 6 A–G)

urn:lsid:zoobank.org:act:C46D7583-27B0-40A3-919C-6DC353E6FE9D

Holotype: ZSI/WGRC/I.R-INV.15033, 26.vii.20, Male, wet specimen in alcohol, Thoseghar, Satara District, Maharashtra, India, 1,060m, specimen collected from a paddy field near flowing stream, coll. SDB.

Paratype: ZSI/WGRC/I.R-INV.15034, 26.vii.20, female, same information as the Holotype.

Additional material examined: Males (n= 4) and females (n= 3) bears the same collection data as the holotype, wet specimens in alcohol, will be subsequently deposited in collections of ZSI Kozhikode & Pune and BNHS Mumbai.

Additional field records (specimens not collected): Thoseghar (1,060m): 3 males and 1 female on 02.vii.20; 4 males and 2 females on 15.vii.20; 2 males and 2 females on 26.vii.20; 5 males and 3 females on 04.viii.20; 5 males and 2 females on 06.viii.20; all observations by SHB & SDB. Kaas Lake (1,124 m): 3 males on 02.viii.20; observed by PAP.

Description of holotype male (Image 6)

Measurements (in mm): TL (including appendages) 47; AL 36; FL 33 & HL 31.

Head: Labium coloured dark amber brown to black; labrum pale bluish-white with a very distinct and prominent median black 'tongue' shaped mark at its attached end. Mandible pale bluish-white with an upper transverse black streak. Anteclypeus shiny dark amber brown to black and postclypeus is black,

antefrons & postfrons black and the genae pale bluish-white. Eyes black superiorly, middle part and laterally dark amber brownish-black and the inferolateral aspect brown; antennae shiny black; vertex matt black; occiput, occipital bar and post-ocular region are matt black (Image 7B).

Prothorax: coloured in matt black with yellowish spots. Anterior lobe fully black; middle lobe black with the lateral triangular spots yellowish, notopleural suture black and propleuron is mat black with a pair of indistinct reddish spots. Posterior lobe black with no ornamentations or spines present (Image 7C).

Pterothorax: The ground colour of the Pterothorax in the live insect is orange red with orange hue inferiorly and yellow dorsally. Dorsal carina is black. The triangular mesothoracic acrotergite black. The dorsal aspect of thorax- the Mesepisternum fully matt black. The humeral stripe yellowish orange, thin and irregular and is separated into a small spot on the dorsal end and the long stripe inferiorly. The antehumeral stripe pale yellow and tapers gradually towards the alar sinus. Thus, in other words the antehumeral stripe and the humeral stripes are not connected and significantly tapers dorsally. Mesostigmal plate mat black with its lateral lip pale pinkish-red. Mesinfraepisternum bordered with orange in the posterolateral aspect and antero-superiorly is black; these colours being separated sharply at the diagonal running from postero-superior to antero-inferior corners. Mesepimeron yellow superiorly and orange inferiorly, and encloses a central broad black band. The interpleural suture marked in reddish-black and this patch extends to about the middle of the mesepimeron. The second lateral suture marked in black on its dorsal third. Metepisternum and metepimeron are fully yellowish-orange. Metinfraepisternum brownish-orange. Venter of metathorax pale pinkish-orange. Metathoracic spiracle pale yellowish-white (Image 7C).

Legs: Coxae and trochanter of forelegs brown anteriorly and grey posteriorly. Coxae of mid and posterior legs brownish-orange. The femur, tibia, tarsus and the claws of legs are lustreless red with a cyan hue. The extensor surface of forelegs on the superior third are black. Knees are black. Claws are reddish-black to almost black (Image 7C).

Wings: Fw are hyaline, veins are black. Left Fw Ax-24 & Px-34; right Fw Ax 22 & Px 32; left Hw Ax 19 & Px 31; right Hw Ax 19 & Px 30. Pt is black and is 10 cell wide in Fw and 11 cell wide in Hw. Hindwing hyaline and its distal fifth coloured black with a metallic coppery to lilac reflex in some lights. The proximal margin of this black patch convex and extends to four cells proximal to

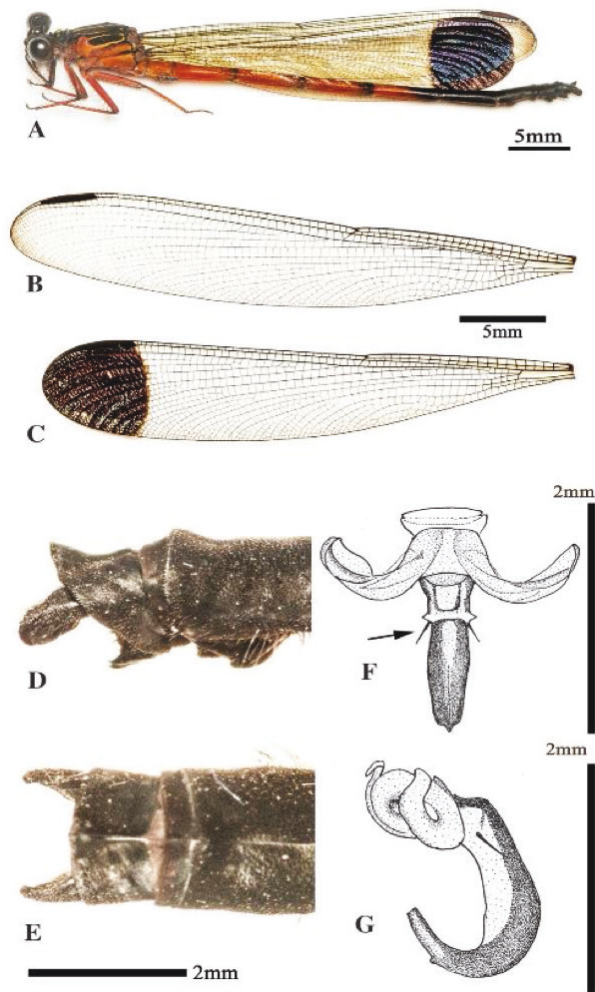


Image 6. *Euphaea pseudodispar* Sadasivan & Bhakare, sp. nov. A—holotype male ZSI/WGRC/I.R-INV.15033 | B—venation Fw | C—venation Hw | D & E—anal appendages | F & G—genital lingual (arrow pointing to the setae). © Kalesh Sadasivan.

the Pt. Cubital space with three cross veins in all wings (Image 6B&C).

Abdomen: The general colour of abdomen reddish-orange on the proximal segments and black on the distal ones. The transition take place in S6, where the dorsal red merges with ventral black (Image 7A). Segmental joints black. S1 yellowish and posteriorly with orange wash. S2 anteriorly orange and distally reddish-orange. S2 with a non-flanged pseudoauricle on each side which bears few tiny teeth at its summit. S3 fully reddish-orange throughout. The distal aspect of S4 near the joint with S5 with a brownish hue. S5 also reddish orange with its distal fifth brownish-black. Proximal half of S6 orange red and its distal half is black, and this transition of red to black is gradual. S7–10 fully black. S10 bears a broad dorsal carina and an abrupt dorsal keel at its distal

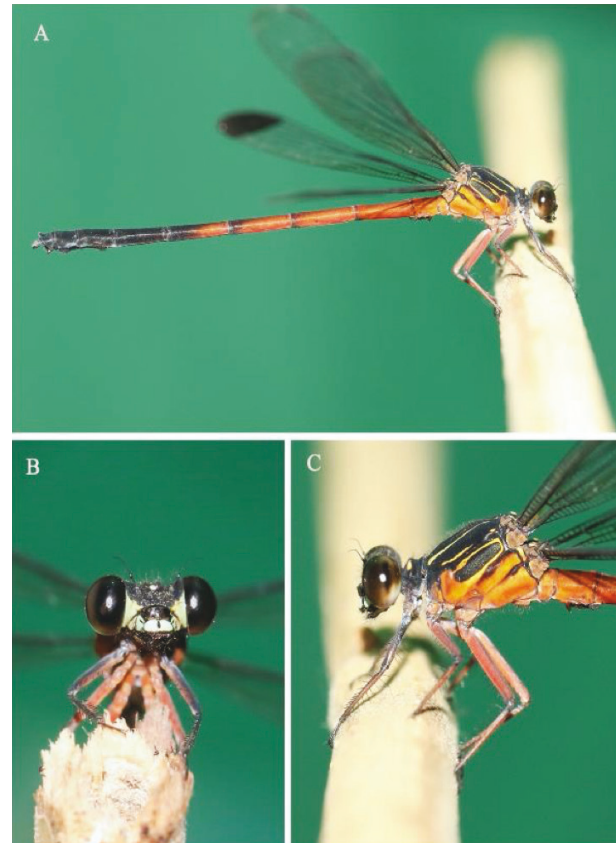


Image 7. *Euphaea pseudodispar* Sadasivan & Bhakare, sp. nov. Male from field: A—lateral view | B—head frontal view | C—lateral view of head and thorax. © Shriram Dinkar Bhakare.

end. A very small inconspicuous patch of moderately long brownish-orange hairs on lateral aspect of proximal part of S1, S2, and S3. A tuft of black hair seen on base of tergite of segment 8. On ventral view, S8 tergite with long hairs on its lateral border and the longest ones at its distal third. S9 tergite with long hairs on its proximal half. The sternite of S8 and S9 with a tuft of very sparse short hairs on its proximal aspect of its base. On ventral view, the gonopore margin oval. Gonocoxae with their apices blunt, no spine. No tooth on the distal aspect sternite of S9 near the gonopore. Distal margin of S10 'f' shaped, hence curved and wavy at its mid-ventrum. On lateral view, the mid part of distal margin of S9 prominently extending ventrally and its tip extends as a very short tooth, over the gonopore (Image 11I). S9 1.5 times the length of S10. On lateral view, the tips of paraprocts hooked, with tip directed dorsally (Image 6D).

Genitalia: S2 with a matt brownish black, rhomboidal genital vesicle, with distal end angulated, and no transverse surface rugosities (Image 12D). Genital lingula illustrated. Penis with a single setae on each side (Image 6F&G).

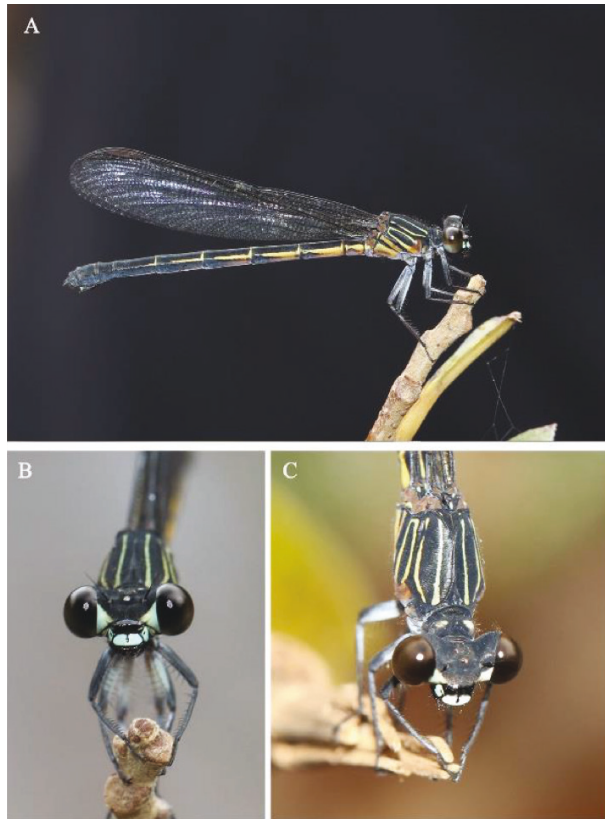


Image 8. *Euphaea pseudodispar* Sadasivan & Bhakare, sp. nov. Female from field: A—lateral view | B—head and thorax dorsal view | C—dorso-lateral view of head and thorax. © Shriram Dinkar Bhakare.

Anal appendages: The general structure is as in the genus with the cerci and paraprocts fully black. The cerci are forcipate. On ventral view, paraprocts with tips medially directed and hence tips converge at rest. Length of paraprocts longer than that of the gonocoxae. The size of paraprocts as large as the S10 dorsal prominence (Image 6D&E, 11I).

Description of paratype female (Image 8)

Measurements (in mm): TL (including appendages) 41, AL 30, FL 32 & HL 30.

Head: Labium black; labrum pale bluish-white with a prominent median black tongue; mandible pale bluish-white with the upper transverse black streak as in the male; Anteclypeus postclypeus, antefrons and postfrons are matt black; Genae pale bluish-white; antennae black, Vertex and occiput matt black; eyes as in the males black and brown inferiorly (Image 8B).

Prothorax: Structure and pattern of coloration all the three lobes are as in the males. The lateral spots on middle lobe is coloured pale yellowish-white, otherwise the whole structure is matt black. No spines present on posterior lobe (Image 8C).

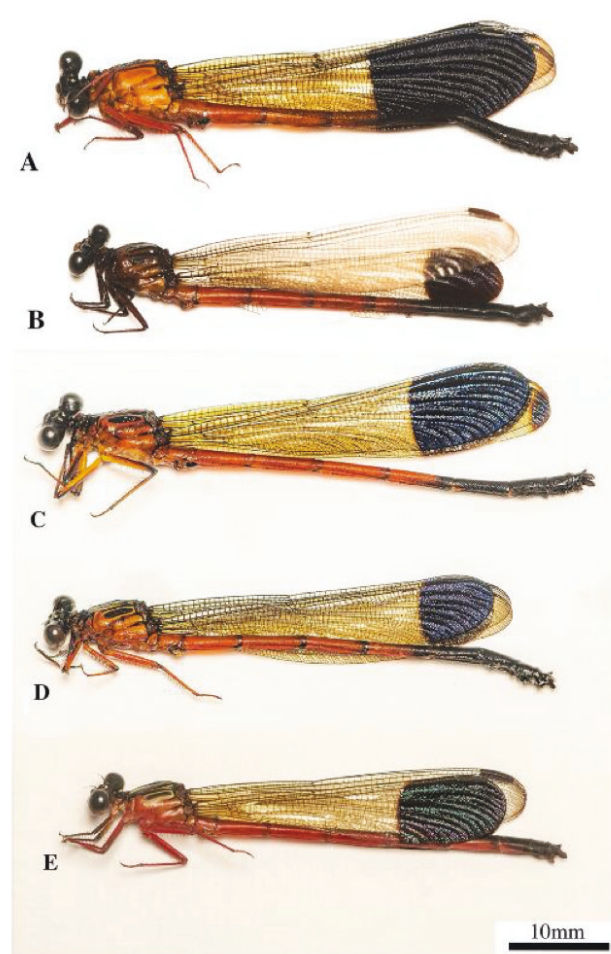


Image 9. Voucher specimen images of *Euphaea* males: A—*E. cardinalis* (Fraser, 1924) | B—*E. thosegharensis* Sadasivan & Bhakare, sp. nov. | C—*E. dispar* (Rambur, 1842) | D—*E. pseudodispar* Sadasivan & Bhakare, sp. nov. | E—*E. fraseri* (Laidlaw, 1920). © Kalesh Sadasivan.

Pterothorax: The reds of the males are replaced by pale greenish-white. The antehumeral and humeral stripes are pale yellowish-blue to pale blue. The mesepisternum, mesepimeron, and metepisternum are as in the male, with the orange and red replaced with pale bluish-yellow. The central black stripe in mesepisternum and the metepisternum are as in the males. Rest of the pterothorax is as in male, with the reds replaced by pale bluish to greenish-yellow (Image 8C).

Legs: Coxae are coloured posterolaterally by pale dirty greenish-white and are usually pruinose. The trochanters are grey. The femurs, tibia, tarsus and claws are black. The flexor aspect of the proximal fourth of forelegs, and whole length of the mid and hind tibia are coloured white (Image 8C).

Wings: Both wings hyaline. Left Fw Ax-21 & Px-29; right Fw Ax 21 & Px 30; left Hw Ax 17 & Px 28; right Hw



Ax 17 & Px 27. Pt is black and is 10–11 cell wide in Fw and Hw.

Abdomen: All segments from S1 are black dorsally with a thin dorsal carinal yellow streak. Laterally, the inferior half of all segments have yellow transverse streaks that thin out distally. The dorsal carinal streaks disappear at S6, while the lateral yellow streaks disappear after S7. The rest of the abdomen on its ventrum and the segments 8–10 are fully black. Vulvar scale without any central sulcus and its postero-lateral angle is produced as an postero-medially directed wide and blunt tooth (Image 12G). Appendages and ovipositor are black.

Variations

Males: In the paratype males (n= 4), with regards to the morphometrics there are some variations. The measurements (in mm) are TL (including appendages) 4.7 ± 0.7 , FL 3.3 ± 0.1 , HL 32.5 ± 0.7 & AL 36.5 ± 2.12 . With respect to the coloration, the variation is usually restricted to the humeral stripes which may be thinned out to become a streak inferiorly and spot superiorly, or sometimes becomes a thin and irregular one along its entire length in some specimens as observed in field. Venation showed some variation with Fw having Ax range of 22–26 and Px of 32–34 and the Hw have 19–24 Ax, and 30–31 Px. Pt was 10–11 cells wide and the wings had usually three cubital cross veins.

Female: The paratype females (n= 2), had a variation in abdominal length from 30–33 mm and Hw length from 30–33 mm. Not much variation in colour was noted. The variations in venation was with the Fw having Ax 21–22 & Px 29–32, and the Hw with Ax 17–19 & Px 27–28. Pt are 8–11 cells wide and there were 2–3 cubital cross veins.

Etymology

The species name *pseudodispar* is coined as reminder to the close resemblance to the species *E. dispar* (Rambur, 1842) in coloration.

Distribution

As far as known, the species is restricted to the high-elevation streams and riparian patches of Thoseghar, Satara district, in Maharashtra, India.

Habitat and Ecology

The habits are as for the genus and this species shares the habitat with *E. thosegharensis* Sadasivan & Bhakare, sp. nov. Flight period is from June to September as per our field observations and past field records.

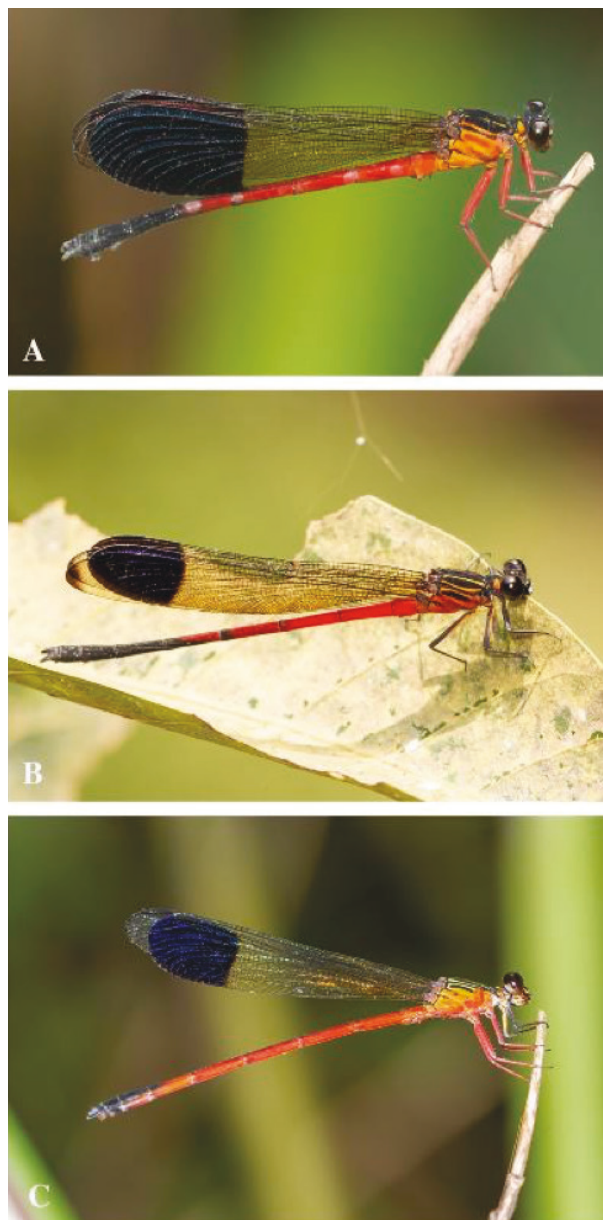


Image 10. Field images of *Euphaea* male: A—*E. cardinalis* (Fraser, 1924) | B—*E. dispar* (Rambur, 1842) | C—*E. fraseri* (Laidlaw, 1920). © Kalesh Sadasivan.

Differential diagnosis

This species can be easily differentiated from all the known *Euphaea* species of the Western Ghats based on morphology and coloration (Table 1, 2). The new species can be distinguished from *E. dispar* by the extensor surface of foreleg femora being black and those of hind and middle legs red as in *E. fraseri*, but with no yellow patch on legs as in *E. dispar*. Only the apical fifth of Hw are black in this species while the apical fourth of Hw are black in *E. dispar*, the genae of face are yellowish-white in the new species while it is black in *E. dispar* (Image

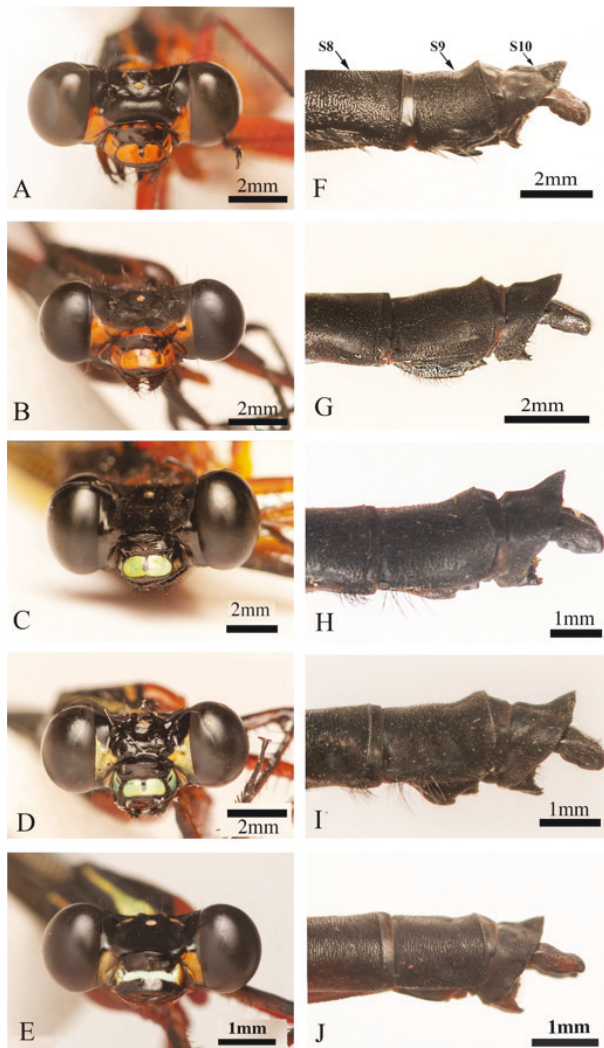


Image 11. Comparison of head and terminal abdominal segments (S8–S10) of *Euphaea* showing the hair tufts of males: A & F—*E. cardinalis* (Fraser, 1924) | B & G—*E. thosegharensis* Sadasivan & Bhakare, sp. nov. | C & H—*E. dispar* (Rambur, 1842) | D & I —*E. pseudodispar* Sadasivan & Bhakare, sp. nov. | E & J—*E. fraseri* (Laidlaw, 1920). © Kalesh Sadasivan

11C&D). The color of legs are as in *E. fraseri*. Segment 9 is 1.5 times the length of S10 in this species, as is in *E. dispar*; while they are of equal length in *E. cardinalis* and S9 twice the length of S10 in *E. thosegharensis* (See key below). The new species can be distinguished from *E. fraseri* by the absence of hair tufts in the males of the latter. The colour of labrum is as seen in *E. dispar* with labrum being pale blue with its distal free border very thinly bordered with black, and with a prominent median black tongue. The pale turquoise blue labrum distinguishes it from *E. cardinalis* and *E. thosegharensis* both of which have orange to red labrum (Image A&B). The species appears similar to *E. fraseri* and *E. dispar*, because of the bluish labrum. The labrum of *E. fraseri*

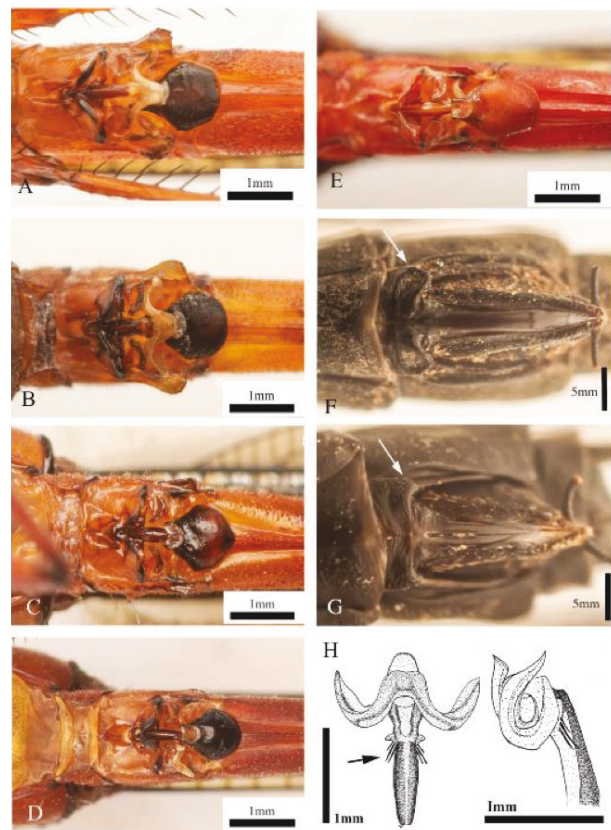


Image 12. Secondary genitalia & vesicles of males and female vulvar scales: A—*E. cardinalis* (Fraser, 1924) | B—*E. thosegharensis* Sadasivan & Bhakare, sp. nov. | C—*E. dispar* (Rambur, 1842) | D—*E. pseudodispar* Sadasivan & Bhakare, sp. nov. | E—*E. fraseri* (Laidlaw, 1920) | F—vulvar scales of *E. thosegharensis* | G—*E. pseudodispar* | H—penile structure of *E. dispar* (Rambur, 1842) (arrow pointing to the setae). © Kalesh Sadasivan.

is coloured black in the inferior half and pale blue in the superior half and has no median black tongue (Image 11E), while the pattern in the new species is as in *E. dispar*. With respect to secondary genitalia, the penis bears a single seta on each side for the *E. pseudodispar*, while three pairs of setae are seen in *E. dispar* (Image 12H). For additional morphological differences in characters see Table 1.

The females of the *E. pseudodispar* can be easily differentiated from *E. thosegharensis* based on the bluish-white labrum with prominent black ‘tongue’ of the former (dirty white with indistinct central tongue in *E. thosegharensis*), the black postclypeus (pale patch on postclypeus in *E. thosegharensis*) the wider posterior lobe of prothorax (shorter posterior lobe in the latter), the structure of the vulvar scale without any central sulcus and its postero-lateral angle being produced as a wide and blunt tooth (rounded with no tooth *E. thosegharensis*) and black legs with white flexor patches

Table 1. Morphological comparison between males of *Euphaea* species of Western Ghats.

Species	Total length, Abdomen length (both including appendages), Fw and Hw length (in mm)	Venation	Male genital vesicle and pseudoauricle, and abdominal hair tufts of males	Appendages and gonocoxae
<i>E. cardinalis</i> (Image 11F, 12A)	Large species TL 52.5 ± 0.70 AL 43.0 ± 2.83 FL 40.0 ± 1.00 HL 38.0 ± 2.80	<i>Fw</i> Ax 23-25 Px 40 Pt 11 cell wide <i>Hw</i> Ax 17-18 Px 36-40 Pt 11 cell wide	Male genital vesicle black, hexagonal with rounded angles and distal margin round. Surface transversely rugose. On ventral view, S8 tergite with long hairs on its middle third and S9 tergite with long hairs on its proximal half. The sternites of S8 and S9 with no hair tufts.	On ventral view, the distal margin of S9 forming the border of the gonopore is 'C' shaped. Gonocoxae with their apices blunt, no spine. A pair of anteriorly directed blunt tooth on the distal aspect sternite of S9 near the gonopore. Distal margin of S10 'l' shaped, hence rectangular and stepped, at its mid-ventrum. On lateral view the mid-ventral part of distal margin of S9 extends over the gonopore as a long blunt tooth. S9 and S10 of equal length. Paraprocts with tips medially directed and hence tips converge to a point at rest. Paraprocts of same length as the gonocoxae. Lamina of cerci not well developed as in <i>E. dispar</i> .
<i>E. thosegharensis</i> sp. nov. (Image 11G, 12B)	Large species TL 50.6 ± 2.10 AL 39.5 ± 0.71 FL 37.3 ± 2.30 HL 34.5 ± 0.70	<i>Fw</i> Ax 20-25 Px 35-36 Pt 9-11 cell wide <i>Hw</i> Ax 17-19 Px 29-31 Pt 9-11 cell wide	Male genital vesicle black matt black, with distal border rounded angles and distal margin round. Surface transversely rugose. On ventral view, tergites of S8 and S9 with no hair tufts. A tuft of sparse stub black hair is seen on sternite of S9.	On ventral view, the gonopore margin trapezoid shaped, wider distally. Gonocoxae with their apices produced into small spines that are divergent at the tip. No tooth on the distal aspect sternite of S9 near the gonopore. Distal margin of S10 'l' shaped, hence curved and wavy at its mid-ventrum. On lateral view, the mid-ventral part of distal margin of S9 does not extend as tooth, over the gonopore. S9 twice the length of S10. Paraprocts with tips medially directed and hence tips converge at rest. Paraprocts of same length as the gonocoxae. Lamina of cerci as in <i>E. cardinalis</i> , but with the tip slightly more incurved.
<i>E. dispar</i> (Image 11H, 12C)	Large species TL 53.25 ± 1.06 AL 41.50 ± 2.12 FL 38.25 ± 0.35 HL 36.0 ± 1.41	<i>Fw</i> Ax 20-22 Px 31-32 Pt 10 cell wide <i>Hw</i> Ax 18 Px 31-33 Pt 10 cell wide	Male genital vesicle black matt black, rhomboid shaped with distal margin round, and surface with very fine transverse rugosities. On ventral view, the pseudoauricle rounded, less prominent than in <i>E. cardinalis</i> . S8 tergite with long hairs on distal half of its lateral border. S9 tergite with long hairs on its proximal half. The sternite of S8 with a tuft of very sparse short hairs on its proximal aspect of its base. Sternite of S9 without very sparse hairs at its base. A very small inconspicuous patch of moderately long brownish-orange hairs on lateral aspect of proximal S1 and S2. Penis with 3 setae on each side (Image 12. H).	On ventral view, the distal margin of S9 forming the border of the gonopore is 'C' shaped. Gonocoxae with their apices blunt, no spines. No tooth on the distal aspect sternite of S9 near the gonopore. Distal margin of S10 'l' shaped, hence curved and wavy at its mid-ventrum. S9 1.5 times the length of S10. Paraprocts longer than the gonocoxae. On lateral view, sternite of S9 not prominently extending mid-ventrally as in <i>E. pseudodispar</i> . The mid part of distal margin of S9 does not conspicuously extend over the gonopore. The dorsal prominence on S10 is robust and its superior border slightly curved on lateral view.
<i>E. pseudodispar</i> sp. nov. (Image 11I, 12D)	Small species TL 47.0 ± 0.70 AL 36.5 ± 2.12 FL 33.0 ± 1.00 HL 32.5 ± 0.70	<i>Fw</i> Ax 22-24 Px 32-34 Pt 10 cell wide <i>Hw</i> Ax 19 Px 30-31 Pt 11 cell wide	Male genital vesicle brownish-black, rhomboidal, with distal end angulated and surface with no transverse rugosities. On ventral view, the pseudoauricle angular, and more prominent than in <i>E. dispar</i> . Penis with a single seta on each side. Hair tufts as in <i>E. dispar</i> . In addition a very small inconspicuous patch of moderately long brownish-orange hairs on lateral aspect of proximal S3.	Terminal segments and appendages and Gonocoxae are similar to <i>E. dispar</i> . On lateral view, sternite of S9 very prominently extending mid-ventrally like a beak. The mid part of distal margin of this S9 beak extends as a very short tooth, over the gonopore. The dorsal prominence on S10 is short, angular and its superior border is straight on lateral view.

Species	Total length, Abdomen length (both including appendages), Fw and Hw length (in mm)	Venation	Male genital vesicle and pseudoauricle, and abdominal hair tufts of males	Appendages and gonocoxae
<i>E. fraseri</i> (Image 11J, 12E)	Small species TL 45.7 ± 2.10 AL 38.5 ± 3.54 FL 36.0 ± 2.80 HL 32.0 ± 4.20	Fw Ax 17-19 Px 26-29 Pt 9-11 cell wide Hw Ax 15-16 Px 26-27 Pt 9-10 cell wide	Male genital vesicle red, longitudinally elongated, apple shaped and distal margin round. Surface transversely rugose. Pseudoauricles not expanded laterally on ventral view. No hair tufts	The gonopore margin “W” shaped with the apices rounded and its arms divergent. Gonocoxae flat and without any spines. Distal margin of S10 ‘l’ shaped, hence curved and wavy at its mid-ventrum. S9 is a little less than 1.5 times the length of S10. Paraprocts longer than gonocoxae. On lateral view, Sternite of S9 not extending mid-ventrally.

Table 2. Coloration comparison between males of *Euphaea* species of Western Ghats.

Species	Labrum	Genae	Lateral spots on middle lobe of prothorax	Antehumeral stripe	Femur	Black apices of wing
<i>E. cardinalis</i> (Image 9A,10A,11A)	Labrum bright ochreous-orange, narrowly bordered with reddish-brown, and an obscure mediobasal ‘tongue’ of dark brown	Orange	Yellow orange	Yellow orange	All legs red	Almost apical half (or slightly less) of Hw black
<i>E. thosegharensis</i> sp. nov. (Image 9B, 3A 11B)	Reddish-orange with a faint and obscure median streak	Orange red	Rose red	Orange red	All legs black	Apical fourth of Hw black
<i>E. dispar</i> (Image 9C, 10B,11C)	Labrum turquoise-blue, finely bordered with black and with a black mediobasal ‘tongue’	Black	Orange yellow	Yellow	Fully red, with yellow patches	Apical fourth of Hw black. The tips of Fw tipped with blackish-brown
<i>E. pseudodispar</i> sp. nov. (Image 9D, 7A, 11D)	Labrum turquoise-blue, finely bordered with black and with a black mediobasal ‘tongue’	Pale yellowish-white	Pale yellowish-white	Yellow	Font legs black, mid and hindlegs red	Apical fifth of Hw black Fw hyaline at the tips
<i>E. fraseri</i> (Image 9E, 10C, 11E)	Labrum pale azure-blue, with its anterior border broadly black, no medio-basal black ‘tongue’	Pale yellowish	Blue	bright azure blue	Font legs black, Mid and hindlegs red	Apical fourth of Hw black

(*E. thosegharensis* has them fully black).

DISCUSSION

This paper describes two new species of *Euphaea* from the Western Ghats of Peninsular India. Though the insects are superficially similar to other *Euphaea* of Western Ghats, these two new species can be differentiated from all the others with distinct features in morphology and coloration.

Morphologically, the five species of *Euphaea* are easily told apart. Regarding the size of the species, *E. cardinalis* and *E. dispar* (TL 53.25 ± 1.06 mm) are large species and so is *E. thosegharensis* (TL 50.6 ± 2.1 mm). All these three species have total lengths more than 5cm. While *E. fraseri* (TL 45.7 ± 2.1 mm) and *E. pseudodispar* (TL 47.0 ± 0.7 mm) are much smaller, with total lengths always less than 5cm. Since the structure of anal appendages are similar, the best characters to

depend are the structure of the male vesicle and the male abdominal hair tufts best seen on ventral view. With respect to the smaller species, *E. fraseri* has no hair tufts on the ventral side of abdomen on S8 or S9 (Image 11J), while *E. pseudodispar* has tufts on central part of sternite and lateral aspects of tergite on S8 and lateral tufts on proximal aspect of tergite of S9 (Image 11 I). Among the three larger species, *E. cardinalis* has hairs on S8 and S9 with tufts of long ventral hairs on the sternites; while, *E. dispar* has tuft at apex of S8 sternite and a tuft of short black hairs on its ventral surface, and about eight long stiff black hairs beneath the base of S9 sternite (Image 11H); and *E. thosegharensis* has a tuft of sparse stub black hair on either side of tergite of S9 and no hair tufts on S8 (Image 11G). The male genital vesicles are also a dependable character to differentiate them. The smaller species, *E. fraseri* has red colored, longitudinally elongated, apple shaped, while in *E. pseudodispar* they are brownish-black and pear shaped. Among the



Revised key to males of the genus *Euphaea* Selys, 1840 of Western Ghats, peninsular India

(for additional characters see Table 1&2)

1. Tufts of ventral hairs on terminal abdominal segments of males present; Antehumeral stripes on thorax not azure blue; Lateral aspect of middle lobe of prothorax with orange spots 2
 - Tufts of ventral hairs on terminal abdominal segments of males absent; Antehumeral stripes bright azure blue and lateral aspect of middle lobe of prothorax with an azure blue or pale blue spot; Male genital vesicle red, longitudinally elongated, apple shaped. TL 45.7 ± 2.10 mm *E. fraseri* (Laidlaw, 1920)

2. Labrum pale turquoise blue; antehumeral stripe yellowish 3
 - Labrum orange-ochre to vermilion red; antehumeral stripe reddish-orange 4

3. Extensor surface of all femora black, flexor surface of proximal 2/3rd all femora with bright yellow patch; Fw tipped with blackish-brown, apical fourth of Hw black; Genae black. Male genital vesicle black with distal border rounded and with fine transverse rugosities. Penis with three pairs of setae. Sternite of S9 not prominently extending ventrally. TL 53.25 ± 1.06 mm *E. dispar* (Rambur, 1842)
 - Extensor surface of all femora black, no yellow patch on legs; Only apical fifth of Hw black; Genae yellowish white. Male genital vesicle brownish black & rhomboid-shaped and with no transverse rugosities. Penis with single seta on each side. Sternite of S9 very prominently extending ventrally like a beak. TL 47.0 ± 0.70 mm *E. pseudodispar* Sadasivan & Bhakare, sp. nov.

4. Extensor and flexor surface of all femora bright red; Apical half of Hw black; S8 and S9 with tufts of long ventral hairs. Male genital vesicle black and hexagonal in shape with rounded angles. S9 and S10 of equal length. TL 52.5 ± 0.70 mm *E. cardinalis* (Fraser, 1924)
 - Extensor and flexor surface of all femora black; Apical fourth of Hw black; A tuft of sparse stub black hair on either side of tergite of S9. Male genital vesicle matt black, with distal border rounded angles. S9 twice the length of S10. TL 50.6 ± 2.10mm *E. thosegharensis* Sadasivan & Bhakare, sp. nov.

larger species, *E. cardinalis* has black hexagonal vesicle with rounded angles; while *E. thosegharensis* has them rounded and matt black; and in *E. dispar* they are matt black and scrotal shaped (Image 12 A & B).

With regards to coloration, we observed that the colors of the labrum and that of the legs of the insects were dependable field characters, the later was already used by Fraser (1934) for his keys to *Euphaea*. The bright yellow patches on femurs of *E. dispar* identifies it easily from all the other species. Blue labrum can be seen in three species, *E. fraseri*, *E. dispar* and *E. pseudodispar*. Amongst them, *E. fraseri* can be told apart by the labrum with inferior half black, superior half bluish-white, no median black 'tongue'; while the other two species have labrum pale turquoise blue with its distal free border very thinly bordered with black, and with a prominent median black 'tongue'. *E. dispar* (TL 53.25 ± 1.06 mm) can be distinguished from *E. pseudodispar* (TL 47.0 ± 0.70 mm) by its large size, having yellow patches on femur, black genae and in addition the differences in male vesicle and hair tufts under S8 & S9. Species with orange-ochre to vermilion red are *E. cardinalis* and *E. thosegharensis*. These are large insects of almost same size, but can be differentiated by the absence of hair tufts under S8 in *E. thosegharensis* (S8 and S9 with tufts of long ventral hairs in *E. cardinalis*) and the less extensive black apical patch in Hw in *E. thosegharensis* (restricted to apical fourth), while almost the apical half of Hw is black in *E. cardinalis*.

With respect to geographical distribution, *E. pseudodispar* and *E. thosegharensis*, both are restricted to the northern Western Ghats region north of the Amboli Ghats, and hence endemic to the region. The new species is seen in the higher reaches above 1,000m. *Euphaea cardinalis* is restricted to mountains south of the Palghat Gap, and *E. dispar* is distributed on mountains between the Palghat gap and Coorg. These two montane species are restricted below the Goa gap. With respect to geographical distribution *E. fraseri* is the only species seen in the same geographical region north of the Amboli Ghats. But, *E. fraseri* is probably distributed only in the lower elevations around the foothills below 900m all along the Western Ghats. The new taxa are currently known only from Kaas and Thoseghar regions of Satara District of Maharashtra. The species were probably overlooked for their superficial similarity to other species of *Euphaea* known from the Western Ghats. This discovery highlights the need for more systematic surveys of invertebrates in the northern Western Ghats.

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