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INVENTORY OF TELOGANODID MAYFLIES (EPHEMEROPTERA: TELOGANODIDAE) FROM SOUTHERN INDIA WITH RECORDS OF ENDEMIC TAXA

C. Selvakumar, K.G. Sivaramakrishnan, T. Kubendran & Kailash Chandra

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INVENTORY OF TELOGANODID MAYFLIES (EPHEMEROPTERA: TELOGANODIDAE) FROM SOUTHERN INDIA WITH RECORDS OF ENDEMIC TAXA

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Abstract: The present study deals with diagnostic characters, diversity, distribution and status of seven species belonging to four genera of Teloganodidae from southern India. Six of them are endemic to the Western Ghats as is the genus *Indoganodes* Selvakumar, Sivaramakrishnan & Jacobus, 2014 and one is endemic to the Eastern Ghats. Due to this high percentage of endemism, conservation of habitats and microhabitats harbouring this ancient gondwanan lineage gains priority. A larval key to the known genera and species of Teloganodidae of southern India is also provided. The present pattern of distribution of the family Teloganodidae is confined to southern Africa, Madagascar, southern India and Southeast Asia.

Keywords: Eastern Ghats, endemic taxa, identification, larval key, Western Ghats.

Mayfly fauna of India, a country endowed with two mega diversity hotspots, appears to be an assemblage of ancient Gondwanan derivatives, with a high percentage of endemism, a few Laurasian spillovers, along with some younger faunal elements that might have diversified in several spells at different periods in geological history by vicariant and dispersal events, through “out of India

and towards India” exchanges between the Indian subcontinent on the one hand and Afrotropics including Madagascar, Oriental Southeast Asia and Palearctic North on the other (Sivaramakrishnan 2016). Teloganodidae is an ancient group of mayflies of Gondwanan origin that currently are known from throughout the Oriental region and from the southern tip of Africa (McCafferty & Wang 2000; Jacobus & McCafferty 2006) as well as from Madagascar (Oliarinony et al. 2016).

Allen (1965) established the subfamily Teloganodinae within the Ephemerellidae. Teloganodinae was raised to family status by McCafferty & Wang (1997), and the composition of the family was refined by McCafferty & Wang (2000). Significant phylogenetic and biogeographic studies of teloganodid, and ephemerelloid mayflies in general, that have contributed to our current understanding of teloganodid systematics include works by McCafferty & Wang (1997, 2000), McCafferty & Benstead (2002), Jacobus & McCafferty (2006); these works have incorporated various cladistic analyses of

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both Afrotropical and Oriental Teloganodidae.

The recent landmark monograph on Oriental Teloganodidae by Sartori et al. (2008) distinguishes the Oriental lineages of Teloganodidae known at the time from the Afrotropical lineages and contributes to understanding patterns of distribution of the Oriental genera and species. The family currently includes the Afrotropical genera *Ephemerellina* Lestage, 1924, *Lestagella* Demoulin, 1970, *Lithoglea* Barnard, 1932, *Manohyphella* Allen, 1973 and *Nadinetella* McCafferty & Wang, 1998, and the Oriental genera *Derlethina* Sartori, 2008, *Dudgeodes* Sartori, 2008 and *Teloganodes* Eaton, 1882 (Sartori et al. 2008). Recently, two new genera, viz., *Indoganodes* Selvakumar, Sivaramakrishnan & Jacobus, 2014 and *Janohyphella* Selvakumar, Sivaramakrishnan & Jacobus, 2014, were established from southern India by Selvakumar et al. (2014), one of these genera, *Janohyphella* was later on synonymised with *Teloganella* Ulmer, 1939 by Kluge et al. (2015). Presently, seven species belonging to four genera are reported from southern India and none from northern India (Sivaramakrishnan 2016). The present study deals with documentation, diversity and status of Teloganodidae of southern India.

MATERIAL AND METHODS

All materials were collected from the streams and rivers of the Western and Eastern Ghats region of India. Collecting was conducted with an aquatic D-net. In streams, the substrate was kick-sampled, allowing the current to carry organic debris, including insects, into the net. Waterfalls were sampled by scouring the rock surfaces by hand, allowing the current to carry insects into the net. Along stream margins and in ponds, vegetation was swept with the D-net. Collected specimens were preserved in 85% ethyl alcohol. Temporary mounts of some specimens were made on slides to enable detailed microscopic observations. Photographs were taken using a Leica M205A microscope. Materials were identified using published taxonomic literature and type specimens in the Zoological Survey of India (ZSI), Southern Regional Centre, Chennai.

RESULTS

Systematic account

All genera and species are presented alphabetically for convenience. This order should in no way be regarded indicating phylogeny.

Order: Ephemeroptera

Superfamily: Ephemerelloidea

Family: Teloganodidae Allen, 1965

Genus: *Derlethina* Sartori, 2008

- *Derlethina tamiraparaniae* Selvakumar, Sivaramakrishnan & Jacobus, 2014

Genus: *Dudgeodes* Sartori, 2008

- *Dudgeodes bharathidasani* Anbalagan, 2015
- *Dudgeodes palnius* Selvakumar, Sivaramakrishnan & Jacobus, 2014

Genus: *Indoganodes* Selvakumar, Sivaramakrishnan & Jacobus, 2014

- *Indoganodes jobini* Selvakumar, Sivaramakrishnan & Jacobus, 2014

Genus: *Teloganodes* Eaton, 1882

- *Teloganodes dentatus* Navás, 1931
- *Teloganodes kodai* Sartori, 2008
- *Teloganodes sartorii* Selvakumar, Sivaramakrishnan & Jacobus, 2014

I. *Derlethina* Sartori, 2008

Type species: *Derlethina eloisae* Sartori, 2008

Diagnosis: *Derlethina* can be easily distinguished from *Teloganodes* and *Dudgeodes* by following combination of characters: in the imaginal stages (i) shape of the hindwing; (ii) absence of crossvein in the pterostigmatic area of the forewing; and (iii) shape of the hind femur; in the larval stage (i) absence of gill V.

Distribution: India (Western Ghats) and Borneo (eastern Malaysia - Sabah and Indonesia - eastern Kalimantan).

1. *Derlethina tamiraparaniae* Selvakumar, Sivaramakrishnan & Jacobus, 2014 (Image 1)

Materials examined: [ZSI-I/E 15], 15.v.2013, 3 larvae, Tamil Nadu, Tirunelveli, Tamiraparani River, Papanasam, 8.71030556°N & 77.36750000°E, 108m, coll. C. Selvakumar & K.G. Sivaramakrishnan; [UM-I/E 1] 02.v.2013, 1 larva, Karnataka, Agumbe, Jogi Gundi Falls, 13.49887500°N & 75.10277778°E, 514m, coll. C. Selvakumar, T. Kubendran & K. G. Sivaramakrishnan.

Diagnosis: *Derlethina tamiraparaniae* can be distinguished from *D. eloisae* by the following combination of characters: in the larval stage (i) gill 4 incised; (ii) outer margin of hind femora not concave; and (iii) prostheca of left mandible reduced, but with several well-developed seta-like projections.

Distribution: Known only from Tamil Nadu and Karnataka part of the Western Ghats.

Status: Endemic to the Western Ghats.

Remarks: Imaginal stage is unknown.

II. *Dudgeodes* Sartori, 2008

Type species: *Dudgeodes pescadori* Sartori, 2008

Diagnosis: The genus *Dudgeodes* can be easily distinguished from *Teloganodes* by the following combination of characters: in the imaginal stage (i) outer margin of forewing regularly convex; (ii) hindwing smaller with acute costal process; (iii) tarsi of male foreleg shorter than *Teloganodes*; (iv) styliger plate not strongly convex; in the larval stage (i) absence of gill VI and last gill always incised (entire in *Teloganodes*); (ii) shape of the incisor of the right mandible; and (iii) single seta on the ventral face of the galea-lacinia (except multiple in *D. ulmeri*).

Distribution: From southern China, India, throughout Southeast Asia up to Sulawesi (Australasian Realm).

2. *Dudgeodes bharathidasani* Anbalagan, 2015 (Image 2)

Diagnosis: *Dudgeodes bharathidasani* can be distinguished from other species of this genus by the following combination of characters: in the larval stage (i) transverse row of long and pointed setae across dorsal face; and (ii) labial palp segment 3 ca. 2.7 times as long as wide.

Distribution: Known only from Kallar stream, Kerala.

Status: Endemic to the Western Ghats.

Remarks: Imaginal stage is unknown.

3. *Dudgeodes palnius* Selvakumar, Sivaramakrishnan & Jacobus, 2014 (Image 3)

Materials examined: ZSI-I/E 13, 28.ix.2013, 3 larvae,

Tamil Nadu, Dindigul, Kodaikanal, Palni Hills, Perumal Malai stream, 10.27094167°N & 77.55416667°E, 1,484m; coll. C. Selvakumar & K.G. Sivaramakrishnan; ZSI-I/E 14, 06.ix.2010, 4 larvae, Tamil Nadu, Tirunelveli, Upper Kodaiyar, 8.53061111°N & 77.35916667°E, 1,299m; coll. C. Selvakumar & K. G. Sivaramakrishnan; [UM-I/E 2], 20.vii.2013, 1 larva, Tamil Nadu, Tirunelveli, Gadana River, Kallar, 8.80125000°N & 77.30138889°E, 144m; coll. C. Selvakumar & K. G. Sivaramakrishnan; [UM-I/E 3], 17.vii.2013, 3 larvae, Tamil Nadu, Tirunelveli, Puliyarai, Kannupulimedu, 8.93898611°N & 77.20694444°E, 164m; coll. C. Selvakumar & K. G. Sivaramakrishnan; [UM-I/E 4], 21.vii.2013, 1 larva, Tamil Nadu, Tirunelveli, Ramanathi River, 8.84816667°N & 77.31416667°E, 237m; coll. C. Selvakumar & K. G. Sivaramakrishnan.

Diagnosis: *Dudgeodes palnius* can be distinguished from other species of this genus by the following combination of characters: in the larval stage (i) transverse row of both long and stout pointed setae across dorsal face; and (ii) labial palp segment 3 ca. 2.5 times as long as wide.

Distribution: Known only from Tamil Nadu part of the Western Ghats.

Status: Endemic to the Western Ghats.

Remarks: Imaginal stage is unknown.

III. *Indoganodes* Selvakumar, Sivaramakrishnan & Jacobus, 2014

Type species: *Indoganodes jobini* Selvakumar,



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Image 1. *Derlethina tamiraparaniae* Selvakumar, Sivaramakrishnan & Jacobus, 2014; Image 2. *Dudgeodes bharathidasani* Anbalagan, 2015; Image 3. *Dudgeodes palnius* Selvakumar, Sivaramakrishnan & Jacobus, 2014

Sivaramakrishnan & Jacobus, 2014

Diagnosis: The larvae of *Indoganodes* can be distinguished from other genera of Teloganodidae, and from the apparently similar genus *Ephemerellina* (see McCafferty & Wang 1997), by the following combination of characters: (i) prosternum without bi-lobular, spinous process medially; (ii) abdominal posterolateral processes poorly developed on segments 1–5 and well developed on segments 6–9; (iii) tarsal claw hooked, bearing four small denticles medially; (iv) labrum subquadrate, approximately twice as broad as long, with short, scattered setae over entire dorsal surface; (v) superlinguae of hypopharynx moderately developed; and (vi) left mandible without medioapical setal patch.

Distribution: India (restricted to the Western Ghats).

4. *Indoganodes jobini* Selvakumar, Sivaramakrishnan & Jacobus, 2014 (Image 4)

Materials examined: ZSI-I/E 10, 18.iv.2013, 3 larvae, Kerala, Silent Valley, Poochipara, 11.11375000°N & 76.43111111°E, 935m, coll. Jobin C. Tharian.

Diagnosis: *Indoganodes jobini* can be distinguished from all other species of Teloganodidae by the following combination of characters: in the larval stage (i) abdominal gills present on segments II–VI; (ii) gill 1 absent; (iii) tarsal claw hooked, bearing 4 small denticles medially; and (iv) terminal filament subequal to cerci.

Distribution: Known only from Kerala part of the

Western Ghats.

Status: Endemic to the Western Ghats.

Remarks: Imaginal stage is unknown.

IV. *Teloganodes* Eaton, 1882

Type species: *Teloganodes tristis* (Hagen, 1858)

Diagnosis: The genus *Teloganodes* is easily distinguished from *Dudgeodes* by the following characters: in the imaginal stage, (i) forewing long and slender and pterostigmatic area with numerous crossveins reaching subcostal vein; (ii) hindwing broad with costal process rounded; (iii) tarsi of male foreleg longer than *Dudgeodes*; (iv) styliger plate distinctly convex; in the larval stage, (i) gills on abdominal segments II–V or II–VI; gill II with dorsal lamella entire and last gill always entire; (ii) shape of the incisor of the right mandible; and (iii) multiple seta on the ventral face of the galea-lacinia.

Distribution: Borneo, India, Philippines and Sri Lanka.

5. *Teloganodes dentatus* Navás, 1931

Diagnosis: *Teloganodes dentatus* can be distinguished from closely related species *T. tristis* by the following combination of characters: in the imaginal stage (i) darker colour of the abdomen and shape of the costal process of the hind wing; (ii) penis lobes fused for entire length except the apex “U” shaped; (iii) ventrally a groove visible that ends at the middle of the penes; and



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Image 4. *Indoganodes jobini* Selvakumar, Sivaramakrishnan & Jacobus, 2014; Image 5. *Teloganodes kodai* Sartori 2008; Image 6. *Teloganodes sartorii* Selvakumar, Sivaramakrishnan & Jacobus, 2014

(iv) styliger plate markedly convex.

Distribution: Known only from Khandala, Maharashtra (India).

Status: Endemic to the Western Ghats.

Remarks: Larval stage is unknown.

6. *Teloganodes kodai* Sartori, 2008 (Image 5)

Materials examined: [UM-I/E 5], 28.ix.2013, 4 larvae, Tamil Nadu, Dindigul, Kodaikanal, Palni Hills, Perumal Malai stream, 10.27094167°N & 77.55416667°E, 1,484m; coll. C. Selvakumar & K. G. Sivaramakrishnan; [UM-I/E 6], 06.ix.20103 larvae, Tamil Nadu, Tirunelveli, Upper Kodaiyar, 8.53061111°N & 77.35916667°E, 1,299m; coll. C. Selvakumar & K. G. Sivaramakrishnan; [UM-I/E 7], 20.vii.2013, 4 larvae, Tamil Nadu, Tirunelveli, Gadana River, Kallar, 8.66791667°N & 77.30138889°E, 144m; coll. C. Selvakumar & K. G. Sivaramakrishnan; [UM-I/E 8], 23.ii.2012, 2 larvae, Tamil Nadu, Tirunelveli, Nambiyar River, Nambikovil, 8.43367222°N & 77.49861111°E, 412m, coll. C. Selvakumar & K. G. Sivaramakrishnan.

Diagnosis: *Teloganodes kodai* can be easily distinguished from other species of this genus by following combination of characters: in the larval stage (i) shape of the labrum; (ii) proportions of the femora, as well as the relative sizes of the median tubercle on abdominal terga 3 and 10; (iii) length of the antennae; (iv) ornamentation of the femora; and (v) posterolateral projections of the abdomen.

Distribution: Tamil Nadu part of the Western Ghats.

Status: Endemic to the Western Ghats.

Remarks: Imaginal stage is unknown.

7. *Teloganodes sartorii* Selvakumar, Sivaramakrishnan & Jacobus, 2014 (Image 6)

Materials examined: ZSI-I/E 11, 20.viii.2010, 6 larvae,

Tamil Nadu, Salem, Yercaud, Killiyur Falls,

11.794458330N & 78.199722220E, 1,226m; coll. C. Selvakumar & K.G. Sivaramakrishnan.

Diagnosis: *Teloganodes sartorii* can be distinguished from the apparently similar species *T. kodai* by the following combination of characters: in the larval stage (i) legs not similar in shape and without ornamentation; (ii) outer margin of the forefemora having a row of thick setae and two clusters of thin setae on apex; (iii) antennae long, 1.2 times head width, flagellum with 19–20 segments; and (iv) cerci with whorl of spines on every segment, spines shorter than length of corresponding segment.

Distribution: Tamil Nadu part of the Eastern Ghats.

Status: Endemic to the Eastern Ghats.

Remarks: Imaginal stage is unknown.

DISCUSSION

Teloganodidae is Old World Gondwanan in origin. Tectonic events leading to the post-split Gondwana and subsequent northward migration of the Deccan plateau of peninsular India some 150 million years ago apparently led to this region being a cradle of evolution for the Oriental lineage of Teloganodidae, with further and subsequent diversification in Southeast Asia (Selvakumar et al. 2014). The present pattern of distribution of the family Teloganodidae, being confined to southern Africa, Madagascar, southern India and Southeast Asia, suggests that the family might have been present in Gondwana prior to any breakup of Madagascar, the Indian subcontinent and Africa (McCafferty & Benstead 2002). Totally, of the seven species reported from southern India, six of them are endemic to the Western Ghats as is the genus *Indoganodes* Selvakumar, Sivaramakrishnan & Jacobus, 2014 and one is endemic to the Eastern Ghats.

Larval key to the known genera and species of Teloganodidae (except *T. dentatus* Navás, 1931, larva unknown)

1. Terminal filament length subequal to length of cerci..... *Indoganodes jobini*
- Terminal filament reduced to a short stub or apparently absent.....2
2. Abdominal gills present on segments II–IV; prostheca of left mandible reduced, but with several well-developed seta-like projections.....*Derlethina tamiraparaniae*
- Abdominal gills present on segments II–V or II–VI; prostheca of left mandible not reduced, without seta-like projections3
3. Abdominal gills present on segments II–VI; forefemur without a row of transverse setae on dorsal face; teeth of inner incisor of left mandible similar in size.....4
- Abdominal gills present on segments II–V; forefemur with a row of transverse setae on dorsal face; teeth of inner incisor of left mandible dissimilar.....5
4. Outer margin of the forefemora with a row of thick setae; two clusters of thin setae on apex.....*Teloganodes sartorii*
- Outer margin of the forefemora without a row of thick setae; without two cluster of thin setae on apex *Teloganodes kodai*
5. Transverse row of both long and stout pointed setae across dorsal face; labial palp segments 3 ca. 2.5 times as long as wide *Dudgeodes palnius*
- Transverse row of long and pointed setae across dorsal face; labial palp segment 3 ca. 2.7 times as long as wide*Dudgeodes bharathidasani*

Due to this high percentage of endemism, conservation of habitats and microhabitats harbouring this ancient Gondwanan lineage gains priority.

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Communications

Home range and spatial organization by the Hoary Fox *Lycalopex vetulus* (Mammalia: Carnivora: Canidae): response to social disruption of two neighboring pairs

-- Julio C. Dalponte, Herson S. Lima, Stuart Klorfine & Nelton C. da Luz, Pp. 11703–11709

People's attitude towards wild elephants, forest conservation and Human-Elephant conflict in Nilambur, southern Western Ghats of Kerala, India

-- C.K. Rohini, T. Aravindan, K.S. Anoop Das & P.A. Vinayan, Pp. 11710–11716

Analysis of regurgitated pellets of Spotted Owlet *Athene brama* (Temminck, 1821) (Aves: Strigiformes: Strigidae) from Punjab, India

-- Renuka Malhotra & Neena Singla, Pp. 11717–11724

Species diversity and abundance of birds on Bharathiar University Campus, Tamil Nadu, India

-- L. Arul Pragasam & M. Madesh, Pp. 11725–11731

On the taxonomy of the first record of rare deep-water rough shark species of Oxynotidae (Chondrichthyes: Squaliformes) in the western Indian Ocean

-- Sarah Viana & Mark W. Lisher, Pp. 11732–11742

Forest evergreenness and tree endemism in the central Western Ghats, southern India

-- Divakar K. Mesta & Ganesh R. Hegde, Pp. 11743–11752

Distribution of *Rhododendron falconeri* Hook. F. (Ericales: Ericaceae) in Yuxsam-Dzongri trekking corridor of Khangchendzonga National Park, Sikkim, India

-- Aseesh Pandey & Hemant K. Badola, Pp. 11753–11759

Peer Commentary

The characteristics, representativeness, function and conservation importance of tropical dry evergreen forest on India's Coromandel Coast

-- Mark Everard, Pp. 11760–11769

Short Communications

Mugger Crocodile *Crocodylus palustris* Lesson, 1831 (Reptilia: Crocodylia: Crocodylidae) in river Saberi of Godavari system in southern Odisha, India: conservation implications

-- Subrat Debata, Swetashree Purohit, Anirban Mahata, Sudheer Kumar Jena & Sharat Kumar Palita, Pp. 11770–11774

A new record of the lesser-known butterfly Small Woodbrown *Lethe nicetella* de Nicéville, 1887 (Lepidoptera: Nymphalidae: Satyrinae) from Khangchendzonga National Park, Sikkim, India

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