

# Three new additions to the earthworm (Clitellata: Megadrili) fauna of Kerala state from the Western Ghats biodiversity hotspot, south-western India

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**Abstract.** In India, studies on above-ground biodiversity have received more attention than those on below-ground biodiversity. With this view, systematic surveys for earthworms were carried out in the Western Ghats mountain range of Kerala state in southwestern corner of Peninsular India. This research resulted in three new records for the state, viz. *Drawida nandiensis* Stephenson, 1924, *D. nepalensis* Michaelsen, 1907 and *Celeriella bursata* Jamieson, 1977. Among these, *D. nandiensis* and *D. nepalensis*, are recorded for the first time from the Western Ghats biodiversity hotspot. Previously *D. nandiensis* and *C. bursata* were known only from their respective type localities. With the addition of three species the total number of earthworm taxa reported from Kerala state has raised to 128 and now the Western Ghats mountain ranges has 271 species of earthworms.

**Keywords.** *Celeriella*, *Drawida*, endemic, Moniligastridae, Oligochaeta, Pampadum Shola National Park.

## INTRODUCTION

Western Ghats is a chain of mountain runs through the southwest Peninsular India and is considered as a refugium of the relict biota of the former Indian plate (Myers *et al.* 2000). The Western Ghats-Sri Lanka biodiversity hotspot exhibits exceptionally high diversity of earthworms with 328 taxa recorded, of these 264 are endemic (Narayanan *et al.* 2020a, 2021a, b, 2022, 2023a, b, Lone *et al.* 2022). In India, the Western Ghats and western coastal plains stand out as the area with highest level of earthworm spe-

cies richness (Julka *et al.* 2009, Narayanan *et al.* 2020a, 2023a), which holds about 58.4% of the hitherto known earthworm diversity of the country (Narayanan *et al.* 2020a). Due to varied geological history, physiography, climate and vegetation types, the earthworm fauna of the Western Ghats shows exceptionally high level of endemism both at genera (31%) and species (77%) level (Narayanan *et al.* 2020a). A number of earthworm species of the Western Ghats are recognized only from the original description or from their respective type localities (Narayanan *et al.* 2020a, 2023a).

Several workers have investigated the earthworm fauna of the Western Ghats and have published detailed taxonomical works and short communications. The list of earthworms from the Western Ghats and west coast region is continuously growing with the discovery of several new taxa and new reports (Julka *et al.* 1997, 2004, Nair *et al.* 2010, Narayanan *et al.* 2017, 2016a, 2019a, 2021a, 2022, 2023b, George *et al.* 2017, Lone *et al.* 2022). Kerala state, a narrow coastal equatorial tract situated in the southwestern corner of Peninsular India (between 8°17'–12°47'N and 74°52'–77°24'E) is an integral part of the Western Ghats. State-wise analysis of earthworm distribution showed that Kerala state harbours highest earthworm diversity in the Western Ghats biodiversity hotspot region with 125 species (Narayanan *et al.* 2020a, 2023a, b, c).

Taxonomical studies on the earthworms of Kerala were initiated during the last part of the 19<sup>th</sup> century (Bourne 1894) and quite a few species are known only from their original description, and majority of them were reported about a century back (Narayanan *et al.* 2016b). In the absence of revisionary works, the taxonomic status of many of the species published in the earlier centuries, their level of morphological variation, status, *etc.* cannot be considered as confirmed (Narayanan *et al.* 2016b, 2023d). New species are continuously being discovered and previously unreported species are being reported from the state indicating the fact that much remains to be learned about the earthworm diversity of the state (Julka *et al.* 1997, Nair *et al.* 2010, Narayanan *et al.* 2016a, c, 2017, 2019a, b, c, 2020b, 2021a, 2022, 2023b, c, George *et al.* 2017, Anuja *et al.* 2020, Lone *et al.* 2022). Hence, we made a thorough survey of the earthworms in different parts of the Western Ghats of Kerala state, which revealed the occurrence of three previously unreported earthworms from the state, namely, *Drawida nandiensis* Stephenson, 1924, *D. nepalensis* Michaelsen, 1907 and *Celeriella bursata* Jamieson, 1977. Here, we are providing details of the specimens collected along with its ecological notes.

## MATERIALS AND METHODS

Earthworms were collected by digging and hand sorting method (Julka 1990). Collected specimens were washed and then preserved in 5% formalin for further taxonomic identification. All relevant morphological and anatomical characterization of the earthworms was carried out under a Nikon stereomicroscope (Model: SMZ800N). Photos were taken with the help of a camera attached to the microscope. Collected specimens were identified with the help of standard literature (Stephenson 1923, 1924, Gates 1972, Jamieson 1977, Julka 1988, Blakemore 2012). The collected specimens are deposited in the museum of Advanced Centre of Environmental Studies and Sustainable Development (ACCESSD), Mahatma Gandhi University, Kerala, India. Family and genera level classification follows the recent publications of Brown *et al.* (2023) and Mısırlıoğlu *et al.* (2023).

*General abbreviations of the terms used are as follows.* C. – Clitellum; Fp. – Female pore, lhs – Left hand side, Mf. – Male field, Mp. – Male pore, P. – Prostate, Pc. – Prostatic capsule, Pd. – Prostatic duct, Pp. – Penes-like papillae, rhs – Right hand side, Sa. – Spermathecal ampulla, Sat. – Spermathecal atrium, Sd. – Spermathecal duct, Sdi. – Spermathecal diverticulum, Sg. – Seminal groove, Sp. – Spermathecal pore, Ts. – Testis sac, Vd. – Vas deferens.

*Acronyms of type hosting institutions are as follows:* BMNH = British Museum (Natural History), London (now NHM (Natural History Museum), United Kingdom; ZMUH = Zoologisches Museum Universität Hamburg, Hamburg (now ZMH- Zoological Museum Hamburg), Germany; ZSIC = Zoological Survey of India, Kolkata, India.

## TAXONOMY

**Order Moniligastrida Brinkhurst & Jamieson, 1971**

**Family Moniligastridae Claus, 1880**

***Drawida nandiensis* Stephenson, 1924**

(Figures 1A–D)

*Drawida nandiensis* Stephenson, 1924: 326.

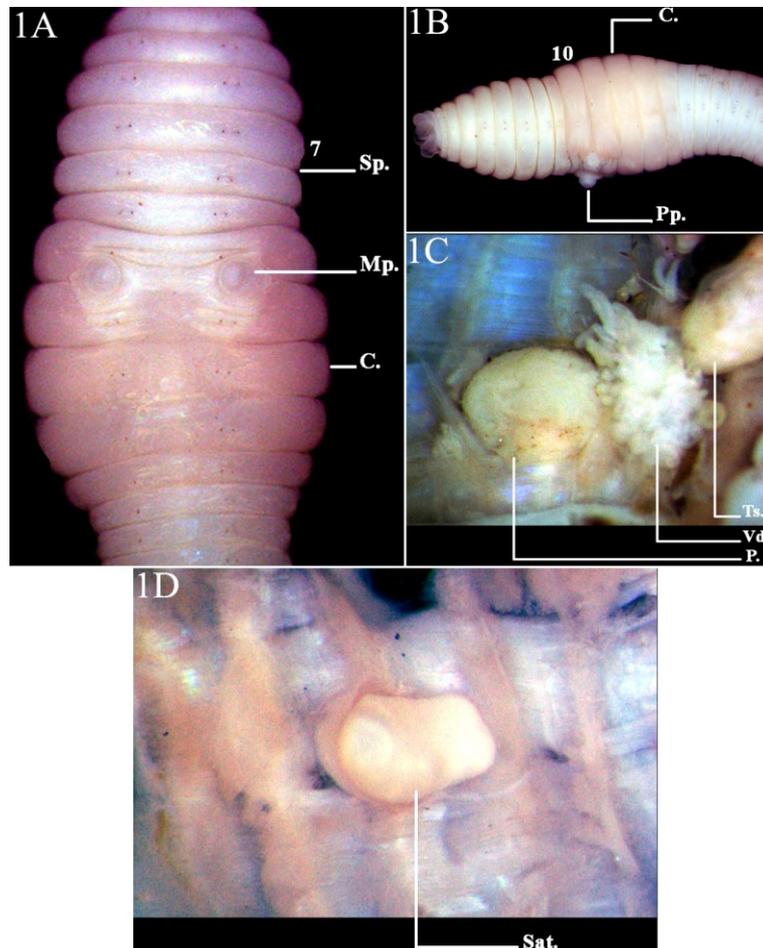
*Drawida nandiensis* Stephenson: Narayanan *et al.* 2023a: 30. Narayanan *et al.* 2024: 32.

*Type locality.* Nandi Hills (13.3702°N; 77.6835°E), Karnataka State, India.

*Type material.* ZSIC 1111; BMNH 1925:5:12: 29–30.

*Material examined.* 2 clitellates (Reg. No. ACESSD/EW/1010), Chethalayam, Wayanad District, Kerala State, India, *ca.* 950 m a.s.l., coffee plantation, 2 June 2018, leg. B. Thomas.

*Brief description.* Length 70–168 mm, diameter 4–5 mm, segments 147–205. Setae lumbricine, begin from segment 2. Prostomium prolobic. Dorsal pores absent. Clitellum on segments 9–14 (6), light orange in preservation, 10–13 particularly visible (Figs. 1 A, B). Spermathecal pores paired, in intersegmental furrow 7/8, at *c* setal line. Male pores paired in intersegmental furrow 10/11, between *bc* setal lines, nearer to *b*; pores situated on small papillae, which resembles small penes (Figs. 1 A, B). Gizzards 3, in the region of segments 13–17. Testis sacs paired; moderate-sized, irregularly shaped, chiefly in segment 10, but project into segment 9. Vas deferens coiled in mass of loops. Prostates paired, glandular, roughly spheroidal from dorsal view (Fig. 1 C),



**Figure 1.** *Drawida nandiensis* Stephenson, 1924: A = Male field, ventral view; B = Anterior lateral view; C = Prostate and mass of vas deferens, lhs, dorsal view; D = Spermathecal atrium, rhs, dorsal view.

duct thick, vas deferens enters the prostate at its anterior face. Prostatic capsule spheroidal. Spermathecae paired in segment 8, ampulla ovoidal, duct coiled, thin, pierces through the septum 7/8, joins at about near the ectal end of the atrium in segment 7, atrium irregular shaped, concave (Fig. 1 D). Ovarian chamber complete. Ovisacs short, cylindrical. Nephridiopores are on *cd* setal lines. Genital markings absent.

*Ingesta.* Colloids of soil, pebbles, and a few tiny bark like organic matter. Seems to be an endogeic species.

*Habitat.* Coffee plantation in Kerala.

*Distribution.* India: Kerala (present record), Karnataka (Stephenson 1924).

*Remarks.* Endemic. Dimensions of the present specimens - length 167–168 mm, diameter 4 mm, segments 147–162. It has 3 gizzards in segments 13–15. Hence the earlier diagnosis of the species has been updated based on the present new materials. It is reported for the first time from the Western Ghats. Previously it was known only from the type locality (Narayanan *et al.* 2023a, 2024).

#### ***Drawida nepalensis* Michaelsen, 1907**

(Figures 2A–C)

*Drawida nepalensis* Michaelsen, 1907: 146.

?*Drawida jalpaigurensis* Stephenson, 1916: 307. (synonymy with *D. nepalensis* is doubtful – see Narayanan *et al.* 2023a)

*Moniligaster ivaniosi* Manazhy *et al.*, 2011: 11. For further list of synonyms see Gates (1972) and Blakemore (2012).

*Type locality.* Gowchar near Kathmandu, Nepal.

*Type material.* ZMUH 7140 (Reynolds & Wetzel 2024).

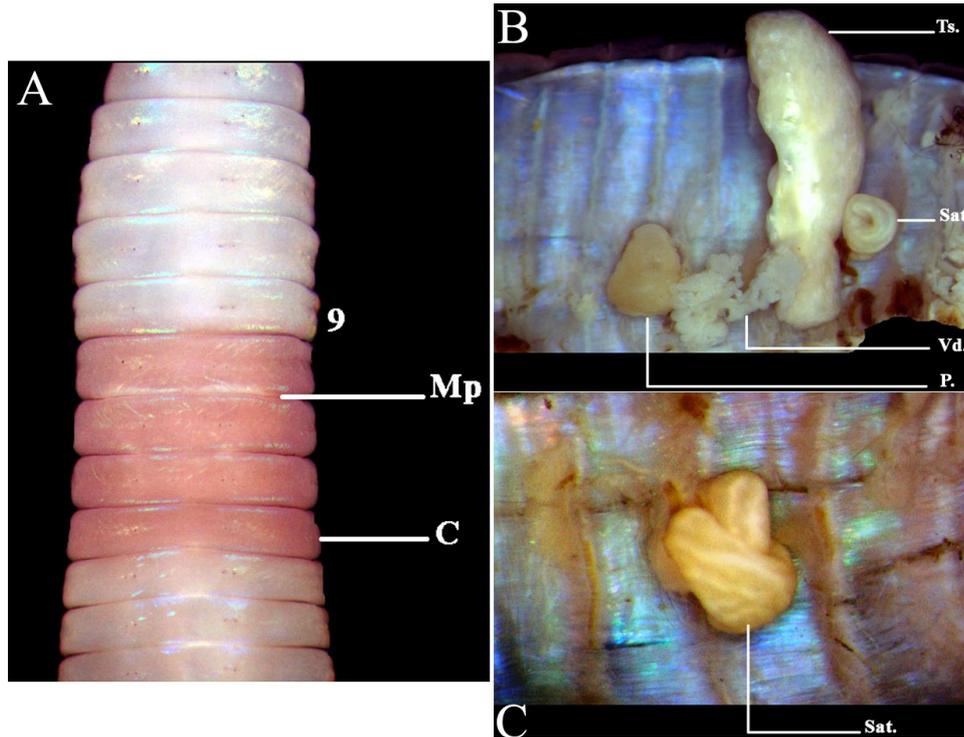
*Material examined.* 1 clitellate, 6 a clitellates, 4 juveniles (Reg. No. ACESSD/EW/1186), Urulanthanni in Thattekkad Bird Sanctuary (10°7'34.6"

N 76°45'35.9" E), Ernakulam District, Kerala State, ca. 60 m a.s.l., lowland evergreen forest, 1 September 2016, leg. S.P. Narayanan and S. Sathrumithra; 2 clitellates, 9 a clitellates (Reg. No. ACESSD/EW/1189), Njayapillimudi in Thattekkad Bird Sanctuary (10°8'1.9" N 76°42'55.6" E), Ernakulam District, Kerala State, ca 530 m a.s.l., hill top grassland with stunted deciduous trees, 2 September 2016, leg. S.P. Narayanan and S. Sathrumithra; 5 clitellates, 9 a clitellates (Reg. No. ACESSD/EW/1188), Bhoothathankettu (Thundathil Forest Range) (10°8'28.7" N 76°39'35.8" E), Ernakulam District, Kerala State, ca. 55 m a.s.l., degraded lowland evergreen forest, 31 August 2016, leg. S.P. Narayanan and S. Sathrumithra; 2 a clitellates (Reg. No. ACESSD/EW/1478), Perumbankuthu (10°8'27.6" N 76°54'7.1" E), Idukki District, Kerala State, 390 m a.s.l., evergreen forest with reeds, 30 August 2016, leg. S.P. Narayanan, T. Augustine and S. Sathrumithra.

*Brief description.* Length 50–128 mm, diameter 1.5 mm, segments 149–180. Setae lumbricine. Prostomium prolobic. Dorsal pores absent. Clitellum in segments 9¼–13 (4¼), reddish maroon in colour in preservation (Fig. 2A). Spermathecal pores paired, at intersegmental furrow 7/8, in *cd* setal lines. Male pores paired in intersegmental furrow 10/11, between *bc* setal lines. Gizzards 2–3 or more, in the region of segments 13,14,15–17,18, 19,20. Testis sac paired; inter septal 9/10. Vas deferens coiled in mass of loops, mass smaller than testis sacs (Fig. 2B). Prostates paired, glandular, U-shaped loop; vas deferens enters the prostate at its ental end. Prostatic capsule tubular. Spermathecae paired in segment 8, ampulla pear-shaped, duct undulating, thin, pierces through the septum 7/8 to enter the atrium in segment 7, atrium large, sac-like (Fig. 2C). Ovarian chamber complete. Ovisacs extend back through several segments. Nephridiopores are on *cd* setal lines. Genital markings present or absent.

*Ingesta.* Chiefly soil, with sparse mica, rootlets, plant fibers and bark portions.

*Habitat.* Forest (lowland evergreen, degraded lowland evergreen), hill top grassland with stunted deciduous trees.



**Figure 2.** *Drawida nepalensis* Michaelsen, 1907: **A** = Anterior ventral view; **B** = Prostate, mass of vas deferens, testes sac and spermathecal atrium, dorsal view; **C** = Spermathecal atrium, rhs, dorsal view.

**Distribution.** India: Kerala (present records), Andaman and Nicobar Islands, Arunachal Pradesh, Assam, Bihar, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Manipur, Meghalaya, Mizoram, Sikkim, Tamil Nadu, Tripura, Uttarakhand, West Bengal (Michaelsen 1909, Stephenson 1917, 1922, 1924, 1925, Gates 1962, Julka 1976, Soota & Halder 1981, Chaudhuri & Bhattacharjee 1999, Paliwal & Julka 2005, Mandal *et al.* 2011, 2013, Sharma & Bhardwaj 2014, Haokip & Singh 2017, Lalthanbara & Zodinpuui 2021). *Elsewhere.* Bangladesh, China, Indonesia, Myanmar, Nepal and Pakistan (Reynolds *et al.* 1995, Blakemore 2012, Narayanan *et al.* 2023a, 2024).

**Remarks.** Male pores are prominent, at *bc* setal lines or median to mid *bc* setal lines, each usually on or near end of protuberant papillae (Stephenson 1923, Gates 1972, Blakemore 2012). But such kind of protuberant papillae are absent in the present specimens. It is considered a cosmopolitan species among moniligastrids (Mısırlıoğlu *et al.* 2023, Narayanan *et al.* 2024). In India it is regarded as a

native peregrine species (Narayanan *et al.* 2023a). This is its first report from the Western Ghats. An Urulanthanni specimen has 2 gizzards, whereas, Bhoothathankettu specimens are with 3 gizzards. Genital markings are absent in the present specimens.

#### Order Crassicitellata Jamieson, 1988

#### Family Megascolecidae Rosa, 1891

#### *Celeriella bursata* Jamieson, 1977

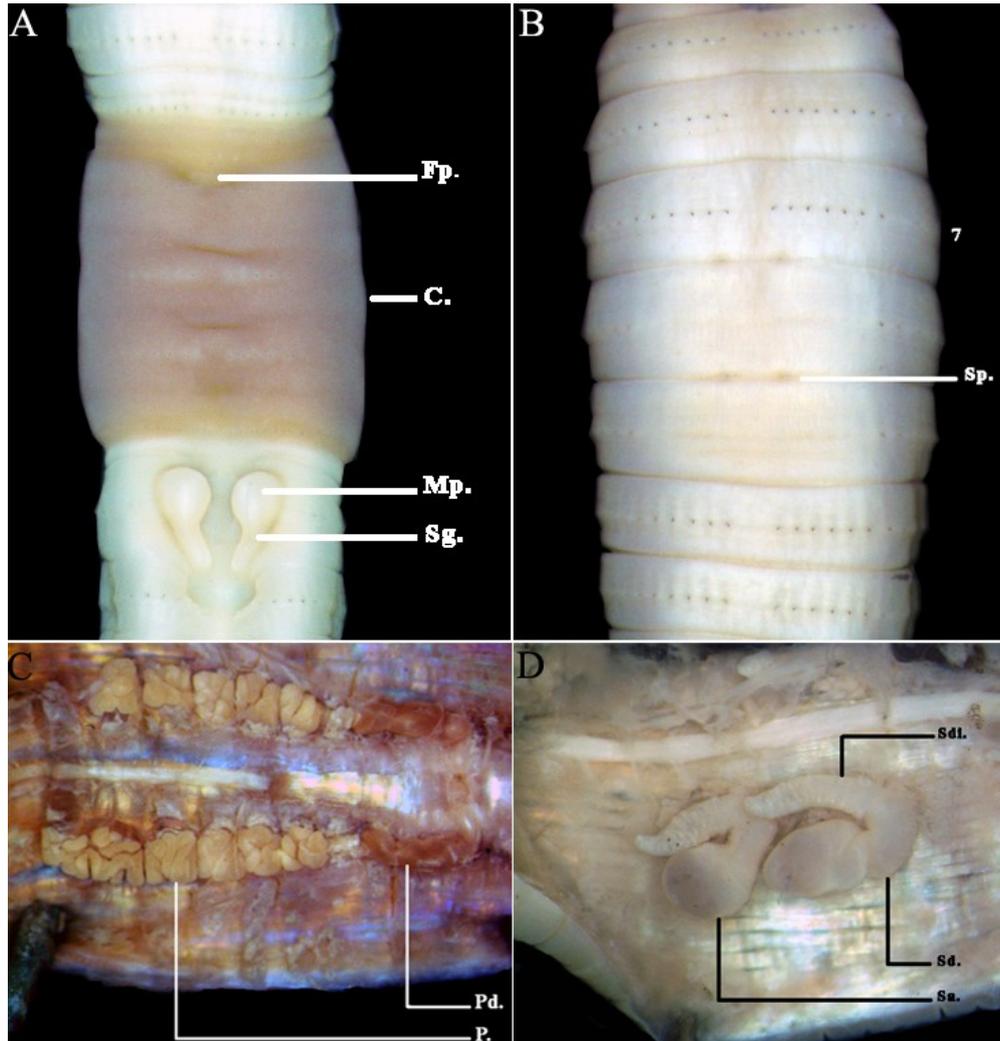
(Figures 3A–D)

*Celeriella bursata* Jamieson, 1977: 487.

*Celeriella bursata* Jamieson: Julka 1988: 78.

**Type locality.** Vandaravu range, Tamil Nadu State (near Kerala border) (10.13°N; 77.27°E), India.

**Type material.** Paris Museum AH328 (Holotype) (Jamieson 1977).



**Figure 3.** *Celeriella bursata* Jamieson, 1977: **A** = Male genital region, ventral view; **B** = Spermathecal pores, dorsal view; **C** = Prostates, dorsal view; **D** = Spermatheca, rhs, dorsal view.

*Material examined.* India: 10 clitellates, 11 a clitellates (Reg. No. ACESSD/EW/582), Mottakunnu in Bandar (Vandaravu) in Pampadam Shola National Park (10°7'38"N 77°16'5.8"E), Idukki District, Kerala State, ca. 2450 m a.s.l., higher altitude grassland, 27 May 2013, leg. T. Augustine, S.P. Narayanan, A. Sasi and S. Sathrumithra.

*Brief description.* Length 77–144 mm, diameter 2.6–5 mm, segments 110–135. Perichaetate. Prostomium epilobic, tongue open. First dorsal pore at intersegmental furrow 5/6. Clitellum annular in segments  $\frac{1}{4}12$ – $\frac{3}{4}17$  (= 5), setae

visible, intersegmental furrows indistinct. Male field is longitudinal depression, occupying whole segment 18 and extending to setal arc of segment 19, broad at segment 18 and pond like at segment 19; male porophores at the anterior end of a broad, comma-like raised area, seminal groove comma-shaped, which extends posteriomedianly to the posterior margin of segment 18 (Fig. 3A). Spermathecal pores minute, at intersegmental furrows 7/8/9, in line with *ab* setal lines (Fig. 3B). Genital markings absent. Septa 4/5–9/10 slightly muscular, 10/11/12 muscular. Oesophagus with paired pouches with calciferous lamellae, in seg-

ment 13–14. Intestine begins in segment 17. Holandric, seminal vesicles racemose, in segment 11 and 12. Prostates extend posteriorly to segment 27–33 (Fig. 3C). Spermathecae paired in segment 8 and 9, each with a digitiform ectal diverticulum, about as long as combined length of the duct and ampulla, duct short (Fig. 3D).

*Ingesta.* Chiefly colloids of organic matters, also tiny portions of woody materials, barks, moss leaves etc. Seems to be an epigeic species.

*Habitat.* Higher altitude grassland of shola-grassland complex.

*Distribution.* India: Kerala (present record) (Fig. 4), Tamil Nadu (Jamieson 1977).

*Remarks.* Endemic to Bandar (Vandaravu) in Kerala and Tamil Nadu part of the Western Ghats (Palani Hills). Dimensions of the present specimens - length 106–144 mm, diameter 4–5 mm, segments 128–131. Hence the diagnosis of the species has been updated based on the present new material. In the current specimens the prostate extends posteriorly to segments 27–28 (Fig. 3C). The spermathecal diverticulum is slightly longer than the combined length of duct plus ampulla.

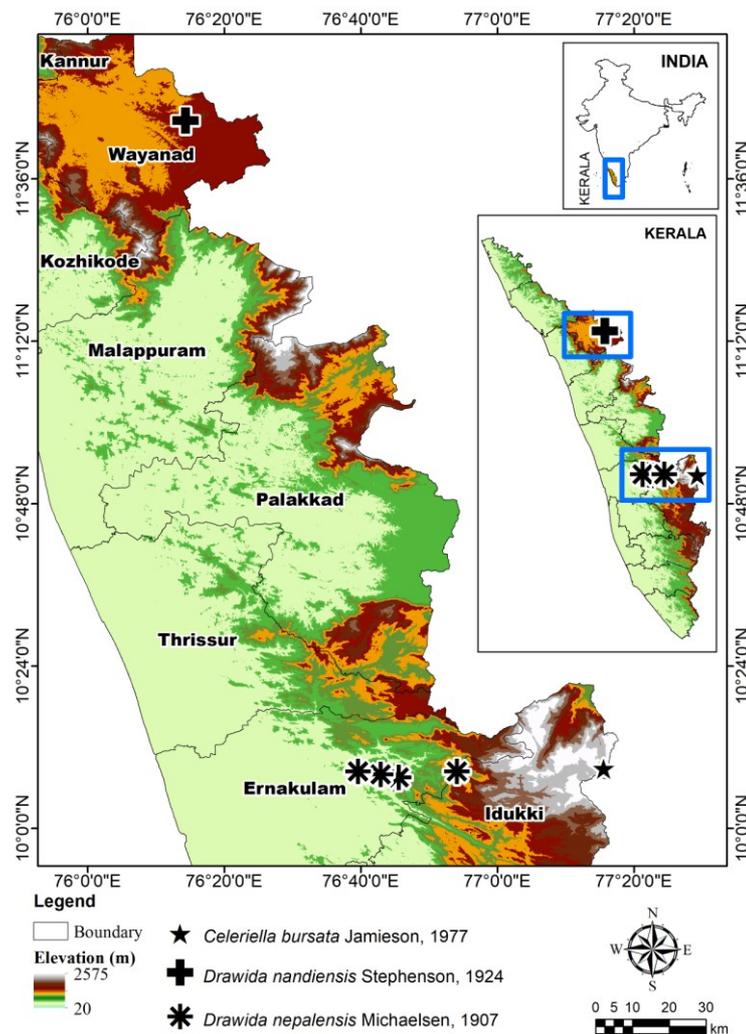


Figure 4. Distribution of *Drawida nandiensis* Stephenson, 1924, *D. nepalensis* Michaelsen, 1907 and *Celeriella bursata* Jamieson, 1977 in Kerala state, India

## DISCUSSION

*Drawida nandiensis*, *D. nepalensis* and *Celeriella bursata* are recorded for the first time from the state. *D. nandiensis* is rediscovered after its original description in 1924 by Stephenson from the isolated Nandi Hills of Karnataka state (Narayanan et al. 2023a, 2024). Meanwhile *D. nepalensis* is a widespread native peregrine species within the country (Narayanan et al. 2023a, 2024), it seems that they have expanded its range to the Kerala state for the first time. Remarkably both these species are reported for the first time from the Western Ghats. *Celeriella bursata* was described from the Vandaravu range, border between Kerala and Tamil Nadu states, but within Tamil Nadu (Jamieson 1977, Kathireswari et al. 2005). Hence its present report from the Mottakunnu in Bandar (Vandaravu) Kerala side of the border is not that unexpected. However, its description was based on an acelitellate specimen (Jamieson 1977). Present study has expanded its characterizations by adding more details about the male-genital region, clitellum and associated features. Exotic invasive earthworm *Amyntas corticis* (Kinberg, 1867) has recently colonized various parts of the Idukki district including Bander in Pampadum Shola National Park (Narayanan et al. 2016c). But it was not recorded in the extensive survey of earthworms of Vandaravu range (= Bander) of Tamil Nadu – Kerala border by Jamieson (1977). Hence it is presumed that the presence of the invasive *A. corticis* may prevent persistence of many native earthworms in this region.

With the addition of three new species the total number of earthworm species occurring in Kerala state are increased to 128 (Jaya et al. 2011, Narayanan et al. 2016a, b, c, 2017, 2019a, b, c, 2021a, 2022, 2023a, b, c, George et al. 2017, Anuja et al. 2020, Lone et al. 2022). And now the species recorded from the Western Ghats mountain ranges has increased to 271 species (Narayanan et al. 2023a, b). Addition of three species to the earthworm fauna of Kerala indicates its importance for earthworms in the Western Ghats biodiversity hotspot. Surveys of underexplored

and unexplored areas of Kerala may unearth many more earthworm species.

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