New species and new records of earthworms of the genus *Drawida* from Kerala part of the Western Ghats biodiversity hotspot, India (Oligochaeta, Moniligastridae)

S. Prasanth Narayanan¹, S. Sathrumithra¹, G. Christopher¹, J.M. Julka²

¹ Advanced Centre of Environmental Studies and Sustainable Development, Mahatma Gandhi University, Priyadarshini Hills, Kottayam – 686560, Kerala, India ² School of Biological and Environmental Sciences, Faculty of Basic Sciences, Shoolini University, Solan – 173212, Himachal Pradesh, India

Corresponding author: S. Prasanth Narayanan (narayanankc@gmail.com)

Academic editor: R. Blakemore | Received 10 April 2017 | Accepted 2 June 2017 | Published 17 August 2017

Citation: Narayanan SP, Sathrumithra S, Christopher G, Julka JM (2017) New species and new records of earthworms of the genus *Drawida* from Kerala part of the Western Ghats biodiversity hotspot, India (Oligochaeta, Moniligastridae). ZooKeys 691: 1–18. https://doi.org/10.3897/zookeys.691.13174

Abstract

Two new species of *Drawida* Michaelsen, 1900, namely *Drawida polydiverticulata* Narayanan & Julka, sp. n. and *Drawida thomasi* Narayanan & Julka, sp. n., are described from material collected from the Indian state of Kerala, which lies in the Western Ghats biodiversity hotspot. *Drawida elegans* Rao, 1921, *Drawida kanarensis* Stephenson, 1917, *Drawida modesta* Rao, 1921, *Drawida somavarpatana* Rao, 1921, and *Drawida thurstoni* Gates, 1945 are recorded for the first time from the state.

Keywords

Annelida, Clitellata, description, distribution, habitat, soil fauna, taxonomy

Introduction

Kerala is a narrow coastal equatorial tract of India (between 8°17′–12°47′N and 74°52′–77°24′E). The steep sloping land of Kerala along the southwest corner of the Indian Peninsula has its own unique identity (Nair 2011). The dominating surface
feature of the state is the Western Ghats, which is one of the eight ‘hottest hotspots’ of biodiversity in the world (Myers et al. 2000, Mittermeier et al. 2011). In a broad generalized approach, Kerala can be divided into three distinct physiographic regions, namely the coastal lowlands (< 75 m a.s.l.), midlands (75–500 m a.s.l.), and high ranges (500–2000 m a.s.l.) (Iype et al. 1991). The area experiences two rainy seasons, viz., the southwest monsoon (June to September) and northeast monsoon (October to November). Annual rainfall ranges from 1,520 to 4,075 mm, but it may be as high as 6,000 mm in certain pockets and as low as 600 mm in rain shadow areas (KSCSTE 2007). The general climate is mostly tropical but tends to be temperate in high mountainous areas (average temperature 19°C–37°C; minimum 0°C in high ranges). Major forest types are tropical evergreen and semi evergreen, tropical moist and dry deciduous, mountain ‘sholas’, grasslands and low land scrub jungles (Islam and Rahmani 2004).

A great variety of vegetation coupled with high rainfall and moderate temperature has created a cradle for earthworm diversity in Kerala, which harbours about 21% of country’s known earthworm species (Narayanan et al. 2016). It is noteworthy that Kerala also possesses about 40% of earthworm species found in the Western Ghats that constitute India’s mega earthworm diversity area with 200 species (Julka and Paliwal 2005, Julka et al. 2009, Narayanan et al. 2016) of the 505 species from the Indian region (Blakemore 2007).

Several species in Kerala are known only from the original description, and most of them were recorded more than 80–90 years ago (Narayanan et al. 2016). Hence, we conducted extensive survey of earthworms in diverse habitats in the coastal areas, midlands and various types of forests in the hilly regions of the state. This has revealed the presence of two new species and five new records of the genus *Drawida* Michaelsen, 1900. The details of the two new species *Drawida polydiverticulata* sp. n. and *Drawida thomasi* sp. n. and the newly recorded *Drawida elegans* Rao, 1921, *Drawida kanarensis* Stephenson, 1917, *Drawida modesta* Rao, 1921, *Drawida somavarpatana* Rao, 1921, and *Drawida thurstoni* Gates, 1945 are dealt with in this paper.

**Materials and methods**

Earthworms were obtained from soil by digging and hand sorting methods, and also searching organic microhabitats such as fallen tree trunks and leaf litter. Specimens were fixed in 5% formalin and subsequently transferred to ethanol. All anatomical observations were made by dissection under a stereomicroscope (Nikon SMZ800N), and illustrations were made by the attached drawing tube. Holotype and paratype specimens of the new species have been deposited at Zoological Survey of India, Western Ghats Regional Centre (ZSI-WGRC), Kozhikode (Calicut), Kerala, India. Other specimens are housed in Advanced Centre of Environmental Studies and Sustainable Development (ACCESSD), Mahatma Gandhi University, Kottayam, Kerala, India.
Systematic studies

Genus *Drawida* Michaelsen, 1900

**Type species.** *Drawida barwelli* Michaelsen, 1900

*Drawida polydiverticulata* Narayanan & Julka, sp. n.
http://zoobank.org/90E6A8F1-6BBD-4598-A93B-777BAF638391

**Type material.** *Holotype.* Clitellate (Reg. no. ZSI/WGRC/IR/INV-8835), Meenthottyola (10°10′21.4″N; 77°02′2.3″E) in Eravikulam National Park, Idukki District, Kerala State, India, 2010 m a.s.l., stream side in shola forest, 22 November 2016, S.P. Narayanan, S. Sathrumithra and G. Christopher coll.

*Paratype.* 6 clitellate (Reg. no. ZSI/WGRC/IR/INV-8836); same collection data as for holotype.

**Other material.** Two aclitellate (ACESSD/EW/721), Pullaradichola (10°11′33.4″N; 77°12′9.7″E) in Anamudi Shola National Park, Idukki District, Kerala State, India, 2113 m a.s.l., from the side of a water logged area within grassland, where recently the exotic wattle plantations has been clear felled, 25 May 2013, S.P. Narayanan, T. Augustine, A. Sasi and S. Sathrumithra coll.; 3 aclitellate (ACESSD/EW/722), Mattuchola (10°14′28.7″N; 77°14′12.9″E) in Chinnar Wildlife Sanctuary, Idukki District, Kerala State, India, 1954 m a.s.l., stream side in a grassland, 24 November 2013, T. Augustine, D. Kuriakose, S. Sathrumithra and S.P. Narayanan coll.; 4 aclitellate (ACESSD/EW/723), Pettymudy forest camp shed area (10°10′26.7″N; 77°01′25.6″E) in Eravikulam National Park, Idukki District, Kerala State, India, 1966 m a.s.l., stream side within shola forest, 21 November 2016, S.P. Narayanan, S. Sathrumithra and G. Christopher coll.

**Diagnosis.** Length 50–73 mm, diameter 4–5 mm, segments 120–136. Colour bluish. Male pores in 10/11, at centres of oval porophores, at about mid bc. Spermathecal pores in 7/8 at c lines. Genital markings absent. Gizzards number 3–5 in 12–17. Coiled vas deferens mass about one fourth to half of testis sac; vas passing directly into prostate dorsally at about its middle. Prostates glandular ovate and erect, prostatic capsule club-shaped. Spermathecal atria erect in segment 7, each with 4–6 ental lobes. Nephridiopores aligned with d.

**Description.** Colour bluish (bluish pigmentation in circular muscle layer); body circular in cross section. Dimension: *Holotype* – 73 mm by 4 mm at segment 9, 120 segments; paratypes – 50–72 mm by 4–5 mm at segment 9, 125–136 segments. Setae lumbricine, closely paired, present from segment 2; setal formula aa = 8–15.2 ab = 1.05–1.95 bc = 13.33–19 cd = 0.28–0.45 dd at segment 8, aa = 11.5–12.67 ab = 0.92–1.08 bc = 9.2–9.5 cd = 0.26–0.31 dd at segment 20. Clitellum annular, at segments 10–13 (4 segments), intersegmental furrows distinct, colour reddish. Spermathecal pores paired, small transverse slits, with tumescent lips, at intersegmental furrow 7/8, aligned with setae c; males pores paired, minute, at intersegmental furrow 10/11,
Figure 1. *Drawida polydiverticulata* sp. n. **A** Holotype – ventral view  **B** Paratype – ventral view  **C** Prostate – ventral view (gland uplifted)  **D** Prostatic capsule – dorsal view  **E** Spermathecal atria - dorsal view  **F** Spermathecal atria - ventral view. Abbreviations: Atr. – Atrium; Atr.D. – Atrial duct; Pr.C. – Prostatic capsule; Prs. – Prostate; Pr.D. – Prostatic duct; Sep. – Septum; Sp.D. – Spermathecal duct; Sp.P. – Spermathecal pore; Vd – Vas deferens.

each pore at centre of oval porophore at about mid bc (Fig. 1A, B). Genital markings absent. Nephridiopores present from segment 3, aligned with setae d.

Septa 5/6/7/8/9 slightly muscular. Gizzards 4 in segments 12–15 (holotype), smallest in segment 12 increasing in size progressively; number variable in other specimens, 3 in segments 12–14 or 13–15 (Meenthtothychola specimens), 3 in segments 13–15 or 4 in segments 12–15 (Pettymudy specimens), 4 in segments 13–16 (Pullaradichola specimens), 5 in segments 13–17 (Mattuchola specimens); intestine begins in segment 22±1. Last pair of hearts in segment 9; commissures of extra oesophageal vessels present on posterior face of septa 8/9 and 9/10. Testis sacs paired, mostly in segment
10, extending to segment 11; vas deferens long, coiled in a number of hairpin loops aggregated to form a mass about one fourth to half the size of testis sac, passing directly into prostate dorsally at about its middle. Prostates paired, glandular, ovate, erect (may be bent on itself anteriorly or posteriorly) (Fig. 1C); prostatic capsule smooth, club shaped (Fig. 1D); prostatic duct short, slender, narrowed before entering parietes. Spermathecae paired in segment 8; atrium erect in segment 7 and with 4–6 ental lobes arranged in two groups (Fig. 1E, F), spermathecal duct discharges at junction of common ducts of two groups. Ovarian chamber complete, ovisacs short, extending to segment 12–13. Nephridia holoic, avesiculate; functional at segment 10.

**Etymology.** The specific epithet ‘*polydiverticulata*’ is after multi-lobed condition of spermathecal atrium.

**Type locality.** Meenthottychola (10°10'21.4"N; 77°02'2.3"E) in Eravikulam National Park, Idukki District, Kerala State, India, 2010 m a.s.l., 23 km away from Munnar town, stream side in shola forest. Common vegetation of this region is dominated by *Syzygium arnottianum*, *Ilex denticulata*, *Michaelia nilagirica*, *Elaeocarpus recurvatus*, and *Microtropis ramiflora*.

**Ingesta.** Coagulum comprising of mineralized soil, rootlets, tiny pieces of bark and leaves.

**Distribution.** India: Kerala: District Idukki: Meenthottychola and Pettymudy in Eravikulam National Park, Pullaradichola in Anamudi Shola National Park and Mattuchola in Chinnar Wildlife Sanctuary (Fig. 2).

**Habitat.** Shola forest in vicinity of streams; near to stagnant pools or streams in grass lands.

**Remarks.** *Drawida polydiverticulata* sp. n. is distinguishable from all the known species of the genus in having spermathecal atrium with more than two lobes. In one specimen from Pettymudy, spermatheca on right side with one branch of atrium along with lobes extends to segment 8.

*Drawida thomasi* Narayanan & Julka, sp. n.
http://zoobank.org/319B601A-CEDE-4AD6-89AA-56056C42FC44

**Type material.** Holotype. Clitellate (Reg. no. ZSI/WGRC/IR/INV-8837), Kozhippara waterfalls (11°21’14.5"N; 76°6’29.2"E) near Kakkadampoyil, Malappuram District, Kerala State, India, 541 m a.s.l., by the side of tuber cultivated field earlier used for coffee plantation, 29 October 2014, S.P. Narayanan and S. Sathrumithra coll.

Paratype. One clitellate and one aclitellate (Reg. no. ZSI/WGRC/IR/INV-8838), same collection data as holotype.

**Diagnosis.** Length 55–66 mm, diameter 4.5 mm, segments 66–105. Colour bluish. Male pores in 10/11, large transverse slits, slightly lateral to b lines. Spermathecal pores in 7/8 at c lines. Genital markings absent. Gizzards number 3 in 15–17. Coiled vas deferens mass as large as testis sac; vas discharging directly into prostate dorsally at about its middle. Prostates glandular tubular, slightly bent, prostatic capsule tubular, bent entally. Spermath-
ecal atria bilobed, one lobe in segment 7 and the other in segment 8; atrial lobes tubular, very long, 9–10 mm in length, coiled into compact masses. Nephridiopores aligned with d.

**Description.** Colour bluish; body circular, slightly flattened dorsoventrally. Dimension: Holotype 66 mm by 4.5 mm at segment 9, 105 segments; paratypes 55–57.5 mm

**Figure 2.** Distribution of newly described and reported *Drawida* species from Kerala.
New species and new records of earthworms of the genus Drawida from Kerala part...

Table 1. Presence (√) or absence (x) of setae on some anterior segments of the type materials.

| Holotype | Setae on left side | Setae on right side |
|----------|--------------------|---------------------|
| Segment  | d | c | b | a | a | b | c | d |
| 2        | x | x | x | x | x | x | x | √ |
| 3        | x | x | x | x | x | x | x | √ |
| 4        | √ | x | x | x | √ | √ | x | √ |
| 5        | √ | x | x | x | x | x | x | √ |
| 6        | x | x | x | x | x | x | x | √ |
| 7        | √ | x | x | x | √ | √ | x | x |
| 8        | √ | x | x | x | √ | x | x | √ |
| 9        | √ | x | x | x | x | x | x | √ |
| 10       | √ | x | x | x | x | x | x | √ |

| Paratype 1 | Setae on left side | Setae on right side |
|------------|--------------------|---------------------|
| Segment    | d | c | b | a | a | b | c | d |
| 2          | √ | x | x | x | x | x | x | √ |
| 3          | √ | x | x | x | x | x | x | √ |
| 4          | x | x | x | x | x | x | x | √ |
| 5          | x | x | x | x | x | x | x | √ |
| 6          | x | x | x | x | x | x | x | √ |
| 7          | √ | x | x | x | x | x | x | √ |
| 8          | √ | x | x | x | x | x | x | √ |
| 9          | √ | x | x | x | x | x | x | √ |
| 10         | x | x | x | x | x | x | x | √ |

| Paratype 2 | setae on the left side | setae on the right side |
|------------|------------------------|-------------------------|
| Segment    | d | c | b | a | a | b | c | d |
| 2          | √ | x | x | x | x | x | x | x |
| 3          | √ | x | x | x | x | x | x | x |
| 4          | √ | x | x | x | x | x | x | x |
| 5          | x | x | x | x | x | x | x | x |
| 6          | x | x | x | x | x | x | x | x |
| 7          | x | x | x | x | x | x | x | x |
| 8          | x | x | x | x | x | x | x | x |
| 9          | x | x | x | x | x | x | x | x |
| 10         | x | x | x | x | x | x | x | x |

by 4.5 mm at segment 9, 66–96 segments. Setae lumbricine; some setae on anterior segments may be absent (Table 1); setae ab enlarged on segment 8 and posterioriad segments (Fig. 3A); setal formula aa = 5–7.5 ab = 1.11–3 bc = 5.71–7.5 cd = 0.17–0.31 dd at segment 8, aa = 6.25–14.5 ab = 0.71–1.11 bc = 8.33–14.5 cd = 0.24–0.29 dd at segment 20.

Clitellum annular, at segments 10–13 (= 4 segments), indicated by reddish colour and slight swelling, intersegmental furrows distinct. Spermathecal pores paired, small transverse slits at setae at intersegmental furrow 7/8, aligned with setae c; male pores paired, large transverse slits at intersegmental furrow 10/11, slightly lateral to setae
Figure 3. *Drawida thomasi* sp. n. A Holotype - ventral view B Prostate and testis sac C Prostatic capsule D Spermathecal atria - partially uncoiled. Abbreviations: Atr. – Atrium; Div. in seg. – diverticula in segment; Pr.C. – Prostatic capsule; Prs. – Prostate; Pr.D. – Prostatic duct; Sp.D. – Spermathecal duct; Sp.P. – Spermathecal pore; TS – Testis sac; Vd – Vas deferens.

b lines. Genital markings absent. Nephridiopores, present from segment 3, aligned with setae d.

Septa 5/6/7/8/9 slightly muscular. Gizzards 3 in segments 15–17 (holotype and paratypes); intestine begins in segment 24. Last pair of hearts in segment 9; commissures of extra oesophageal vessel present on posterior face of septum 8/9, not recognizable on posterior face of 9/10. Testis sacs paired, in segments 9 and 10, extending to segment 15 on left side and to segment 17 on right side; vas deferens long, coiled
in hairpin loops, aggregated into a mass as large as testis sac, discharging directly at about middle of dorsal face of prostate. Prostates paired, glandular, tubular, slightly bent at ental end (Fig. 3B); prostatic capsule shining, smooth, tubular, slightly bent entally (Fig. 3C); prostatic duct about half as long as gland, thick, slightly narrowed before entering parietes. Spermathecae paired, in segment 8; atrium bilobed, one lobe in segment 7 and the other in segment 8, each lobe tubular, very long and coiled into a compact mass occupying entire body cavity of respective segment, 9–10 mm long (when uncoiled); spermathecal duct short with a few coils entering at junction of two atrial lobes (Fig. 3D). Ovarian chamber incomplete; ovisacs paired extending back to segment 16. Nephridia holoic, avesiculate; functional at segment 10.

**Etymology.** Named after Prof. (Dr.) A.P. Thomas, who initiated taxonomic studies on the earthworms of Kerala state at Advanced Centre of Environmental Studies and Sustainable Development, Mahatma Gandhi University.

**Type locality.** Kozhippara waterfalls (11°21’14.5"N; 76°6’29.2"E) near Kakkadampoyil, 27 km away from Nilambur town, Malappuram District, Kerala State, India, 541 m a.s.l., by the side of tuber-ultivated field earlier used for coffee plantation.

**Distribution.** Known only from the type locality (Fig. 2).

**Ingesta.** Mostly silt, with tiny pieces of mica and organic material.

**Biology.** Autotomy is very common. Infested with nematodes in the region of reproductive system.

**Habitat.** Bushes with grassy under growth, loamy soil, rich in organic matter, by the side of tuber cultivated field earlier used for coffee plantation.

**Remarks.** *Drawida thomasi* sp. n. belongs to a group of species of *Drawida* with glandular prostates and bilobed spermathecal atria. It can be easily distinguished from other members of the group, *D. robusta robusta* (Bourne, 1887), *D. robusta ophidioides* (Bourne, 1894), *D. ghatensis* Michaelsen, 1910, and *D. somavarpatana* Rao, 1921 by the characteristics as given in Table 2.

**Newly recorded species of Drawida from Kerala state**

*Drawida elegans* Rao, 1921

*Drawida elegans* Rao, 1921. Ann. Mag. Nat. Hist. (ser. 9), 8: 519.

*Drawida elegans*, Stephenson 1923. Fauna Br. India, Oligochaeta: 137.

**Material examined.** 7 aclitellate (ACESSD/EW/404), Paithalmala (12°10’1.7"N; 75°33’31.1"E), Kannur district, Kerala, India, 1076 m a.s.l., higher altitude evergreen forest, 30 November 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.

**Diagnosis.** Length 130 mm, diameter 5 mm, 206 segments. Setae aa = 20 ab = 1.2 bc = 20 cd on segment 7, aa = 27 ab = 1.7 bc = 27 cd on mid body segments. Male pores paired, small, at 10/11, slightly lateral to setae b lines, at centres of slightly raised oval papillae. Spermathecal pores paired, at 7/8, at setae c lines. Gizzards 5, in segments 12–16.
| Character          | *D. robusta robusta* (Bourne, 1887) | *D. robusta ophidioides* (Bourne, 1894) | *D. ghatensis* Michaelsen, 1910 | *D. somavarpatana* Rao, 1921 | *D. thomasi* sp. n. |
|-------------------|-----------------------------------|---------------------------------------|---------------------------------|-------------------------------|-------------------|
| Length (mm)       | 136–200                           | 310                                   | 80–160                          | 85 (81–133)                  | 55–66             |
| Diameter (mm)     | 6                                 | 7                                     | 2–6                             | 4 (5–6)                      | 4.5               |
| Segments          | 150–160                           | 200                                   | 145–150                         | 124 (104–154)                | 66–105            |
| Male pores        | Nearer to c setal lines           | Nearer to c setal lines               | About midway between b and c setal lines | Nearer to b setal lines      | Nearer to b setal lines |
| Spermathecal atrium | Distinctly bilobed; lobes erect, tubular; one lobe in segment 7 and the other in segment 8, anterior lobe larger | Distinctly bilobed; lobes test like, one lobe in segment 7 and the other in segment 8, anterior lobe smaller | Slightly bilobed; lobes slight protuberances, confined to segment 7 | Distinctly bilobed; lobes cylindrical, one lobe in segment 7 and the other in segment 8; both lobes of almost equal length | Distinctly bilobed; lobes tubular, one lobe in segment 7 and the other in segment 8; each lobe very long, coiled into a compact mass, occupying the entire body cavity of segment |
| Testis sacs       | Confined to segments 9 &10         | Confined to segments 9 &10             | Extend to segments 13–14         | Extend to segment 14          | Extend to segments 15–17 |
| Prostates         | Hemispherical, sessile            | Hemispherical, sessile                | Thickly pear-shaped             | Bifid; lobes erect, finger like | Tubular, erect, slightly bent entally |
| Opening of Vas into prostate | Ental end of prostate* | ?                                     | ?                               | Ectal end of prostate*       | About middle of prostate |
| Number of gizzards (segment location) | 4 (12,13–16) | 3 (14–16) | 4 (16–19) | 3 (16–18) | 3 (15–17) |

*Based on the present study; † As shown in the figure 5 of Moniligaster indicus Benham, 1893 in Bourne (1894), Moniligaster indicus is a synonym of Drawida robusta robusta (Michaelsen 1900); # As observed by one of the author (JMJ) during his studies on the types (syntypes) of Drawida somavarpatana (Reg. no. W416/1) in ‘National Zoological Collection’ at Zoological Survey of India, Kolkata.
Prostates glandular, sessile, elongated; vas deferens long, coiled into a mass of hairpin loops, discharging directly at ental end of prostate. Spermathecae paired, in segment 8; atrium large, shortly pear-shaped, narrower ectal end; spermathecal duct discharging at ental end of atrium.

**Distribution.** India: Kerala: District Kannur: Paithalmala (new record) (Fig. 2); Karnataka: District Kodagu (Coorg): Bhagamandla, Coorg Hills (Rao 1921).

**Remarks.** Range of the length, diameter, and number of segments in the Kerala specimens are 83–117 mm, 5–6 mm, and 161–171 respectively. Three gizzards in the present specimens in segments 12–14. Mass of vas deferens loops is shorter than testis sac.

**Drawida kanarensis** Stephenson, 1917

*Drawida kanarensis* Stephenson, 1917. Rec. Indian Mus., 13: 364.

*Drawida kanarensis*, Stephenson 1923. Fauna Br. India, Oligochaeta: 143.

**Material examined.** 2 clitellate, 2 aclitellate (ACESSD/EW/170), Ranipuram (12°25’18.2"N; 75°21’14.4"E), Kasaragod district, Kerala, India, 935 m a.s.l, evergreen forest, 19 October 2012, S.P. Narayanan, S. Sathrumithra and M. Ramesan coll.; 1 aclitellate (ACESSD/EW/174), Periyathaduka - Padre (12°37’26.6"N; 75°7’58.4"E), Kasaragod district, India, 89 m a.s.l., Arecanut plantation, 18 October 2012, S. Sathrumithra, S.P. Narayanan and M. Ramesan coll.; 1 clittellate (ACESSD/EW/175), Adakasthala - Perla (12°40’9.6"N; 75°6’54.3"E), Kasaragod district, Kerala, India, 77 m a.s.l., cultivated area near to river, 18 October 2012, S.P. Narayanan, S. Sathrumithra and M. Ramesan coll.; 3 clitellate, 2 aclitellate (ACESSD/EW/176), Pandigaya - Perla (12°40’27"N; 75°07’27.8"E), Kasaragod district, Kerala, India, 102 m a.s.l., rubber plantation, 18 October 2012, S.P. Narayanan, S. Sathrumithra and M. Ramesan coll.; 4 clitellate, 4 aclitellate (ACESSD/EW/177), Kottencheri (12°20’57.6"N; 75°24’45.9"E), Kasaragod district, India, 801 m a.s.l., evergreen forest, 20 October 2012, S.P. Narayanan, T. Augustine, S. Sathrumithra and M. Ramesan coll.; 3 clitellate, 3 aclitellate (ACESSD/EW/178), Plachikkara (12°20’6.2"N; 75°17’19.8"E), Kasaragod district, Kerala, India, 56 m a.s.l., degraded forest, 20 October 2012, T. Augustine, S.P. Narayanan and M. Ramesan coll.; 1 clittellate, 3 aclitellate (ACESSD/EW/179), Veeramalakunnu hillock (12°13’49.8"N; 75°9’15.8"E), Kasaragod district, Kerala, India, 13 m a.s.l., dense scrub land with exotic *Acacia auriculiformis* trees, 21 October 2012, S.P. Narayanan, M. Ramesan, T. Augustine and S. Sathrumithra coll.; 5 clitellate (ACESSD/EW/180), Melerippukavu Sree Veerabhadarakavu, Klayikkod (12°14’34.2"N; 75°9’55.2"E), Kasaragod district, Kerala, India, 19 m a.s.l., sacred grove, 21 October 2012, T. Augustine, M. Ramesan, S.P. Narayanan and S. Sathrumithra coll.; 11 clitellate, 12 aclitellate (ACESSD/EW/181), Sree Mannampurathukavu, Nileshwar (12°15’31"N; 75°7’58.1"E), Kasaragod district, Kerala, India, 13 m a.s.l., evergreen sacred grove, 20 October 2012, T. Augustine, S.P. Narayanan, S.
Sathrumithra and M. Ramesan coll.; 8 clitellate, 13 aclitellate (ACESSD/EW/182), Kulanagattumala Temple, Kadamgod (12°12’16.9”N; 75°8’3.9”E), Kasaragod district, Kerala, India, 7 m a.s.l., evergreen patch with litter, 21 October 2012, S.P. Narayanan, S. Sathrumithra, T. Augustine and M. Ramesan coll.

**Diagnosis.** Length 60–70 mm, diameter 3.5 mm, 150–173 segments. Setae aa = 4.75–5.75 ab = 0.95–1.04 bc = 5.42–5.75 cd = 0.23–0.27 dd at segment 8; aa = 7.33–9 ab = 1–1.04 bc = 7.33–9 cd = 0.25–0.35 dd at segment 20. Male pores paired, at 10/11, slightly lateral to setae b lines. Spermathecal pores paired, at 7/8, at setae c lines. Genital markings paired, lateral to setae ab on segment 11, occasionally extending on to segment 12. Four gizzards in segments 13–16 or 14–17. Prostates glandular, hemi-ovoidal, sessile; vas deferens short, joining prostate at anterior and inner side. Spermathecae paired in segment 8; atrium cushion like ectal widening of spermathecal duct, partly embedded in body wall in segment 8, several times as wide as spermathecal duct.

**Distribution.** India: Kerala: District Kasaragod: Adakasthala, Kadamgod, Klayikkod, Kottencheri, Nileshwar, Pandigaya, Periyathaduka, Plachikkar, Ranipuram and Veeramalakunnu (all new records) (Fig.2); Karnataka: District Uttara Kannada (North Kanara): Talewadi, Castle Rock (Stephenson 1917); District Shivamogga (Shimoga): Batkal, Kogar, Nakkalu (Blanchart and Julka 1997).

**Remarks.** Range of the length, diameter, and number of segments of the Kerala specimens are 38–51 mm, 3 mm, and 166–177 respectively. Gizzards are in segments 14–17.

**Drawida modesta** Rao, 1921

*Drawida modesta* Rao, 1921. Ann. Mag. Nat. Hist. (ser. 9), 8: 525.  
*Drawida modesta*, Stephenson 1923. Fauna Br. India, Oligochaeta: 145.

**Material examined.** 14 clitellate, 4 aclitellate (ACESSD/EW/160), Chandanathodu - Kannavam range (11°51’3.2”N; 75°48’12”E), Kannur district, Kerala, India, 784 m a.s.l., evergreen forest, 01 December 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 3 clitellate (ACESSD/EW/166), Chandanathodu - Periya Range (11°50’44.6”N; 75°48’27.4”E), Wayanad district, Kerala, India, 778 m a.s.l., evergreen forest, 01 December 2012, T. Augustine, S. Sathrumithra and S.P. Narayanan coll.; 1 clitellate, 6 aclitellate (ACESSD/EW/399), Perumalkunnu (11°53’50.1”N; 75°54’16.3”E), Kannur district, Kerala, India, 1076 m a.s.l., grassland and evergreen forest, 02 December 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 14 clitellate (ACESSD/EW/401), Kunnathoorpadi (12°4’55”N; 75°37’39.1”E), Kannur district, Kerala, India, 579 m a.s.l., evergreen forest with reed breaks, 30 November 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 1 clitellate (ACESSD/EW/402), Chandanathodu - Kottiyoor range (11°51’4.2”N; 75°47’12”E), Kannur district, Kerala, India, 714 m a.s.l., evergreen forest, 1 December 2012, S.P. Narayanan and T. Augustine coll.; 4 clitellate (ACESSD/EW/403), Nedumpoil (11°50’30.5”N; 75°46’39.1”E), Kannur district, Kerala, India, 365 m a.s.l., semi-evergreen forest, 1 December 2012, S.P. Narayanan, S. Sathrumithra and T. Augustine coll.; 7 clitel-
late, 2 aclitellate (ACESSD/EW/406), Koovattumoola – Thirunelli (11°54’3.8”N; 76°0’48.4”E), Wayanad district, Kerala, India, 782 m a.s.l., abandoned paddy field, 21 December 2012, A. Sasi, S.P. Narayanan and S. Sathrumithra coll.; 1 clitellate (ACESSD/EW/407), Paithalmala (12°10’1.7”N; 75°33’31.1”E), Kannur district, Kerala, India, 1076 m a.s.l., higher altitude evergreen forest, 30 November 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 5 clitellate (ACESSD/EW/409), Ambayithodu (11°51’50.8”N; 75°53’37.2”E), Kannur district, Kerala, India, 216 m a.s.l., disturbed mixed forest area, 02 December 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 14 clitellate, 8 aclitellate (ACESSD/EW/472), below Kakkadampoyil (11°19’41.9”N; 76°9’54.8”E), Malappuram district, Kerala, India, 98 m a.s.l., semi-evergreen forest near to a stream, 29 October 2014, S.P. Narayanan and S. Sathrumithra coll.; 1 clitellate (ACESSD/EW/473), Naadukaani (11°25’58”N; 76°23’18.7”E), Malappuram district, Kerala, India, 530 m a.s.l., evergreen forest, 28 October 2014, S.P. Narayanan and S. Sathrumithra coll.

**Diagnosis.** Length 75 mm, diameter 4 mm, 207 segments. Intersegmental furrow 1/2 very faint. Setae aa = 13.3 ab = 0.7 bc = 13.3 cd on segment 7, aa = 15.3 ab = 0.7 bc = 15.3 cd on segment 35. Male pores paired, transverse slits with prominent lips, at 10/11, slightly lateral to setae b lines. Spermathecal pores paired, at 7/8, at or slightly lateral to setae b lines. Genital markings paired, oval shaped on segment 7, just anterior to spermathecal pores. Gizzards 2, in segments 13–14. Prostates paired, glandular, sessile, circular to oval in shape; vas deferens short, discharging at dorsal surface and centre of prostates. Spermathecae paired in segment 8; atrium absent.

**Distribution.** India: Kerala: District Kannur: Ambayithodu, Chandanathodu - Kannavam range, Chandanathodu - Kottiyoor range, Kunnathoorpadi, Nedumpoil, Paithalmala, Perumalkunnu; District Wayanad: Chandanathodu - Kannavam range, Koovattumoola – Thirunelli; District Malappuram: Kakkadampoyil, Naadukaani (all new records) (Fig. 2); Karnataka: District Kodagu (Coorg): Moornad, Coorg Hills (Rao 1921).

**Remarks.** Range of the length, diameter, and number of segments of the Kerala specimens are 60–72 mm, 3–4 mm, and 151–197 respectively. Genital markings are absent in some specimens from Kerala (Table 3).

---

**Table 3.** Number of *Drawida modesta* specimens with and without genital markings (GM).

| Site & Reg. no.                      | With GM | Without GM | Total |
|------------------------------------|---------|------------|-------|
| Chandanathodu (Periya range); ACESSD/EW/166 | 1       | 2          | 3     |
| Perumalkunnu; ACESSD/EW/399        | 3       | 4          | 7     |
| Kunnathoorpadi; ACESSD/EW/401      | 4       | 10         | 14    |
| Nedumpoil; ACESSD/EW/403           | 3       | 1          | 4     |
| Ambayithodu; ACESSD/EW/409         | 4       | 1          | 5     |
| Paithalmala; ACESSD/EW/407          | 1       | 0          | 1     |
| Koovathamuloo; ACESSD/EW/406        | 8       | 1          | 9     |
| Chandanathodu (Kottiyoor range); ACESSD/EW/402 | 0       | 1          | 1     |
| **Total**                          | 22      | 20         | 42    |
**Drawida somavarpatana** Rao, 1921

*Drawida somavarpatana* Rao, 1921. Ann. Mag. Nat. Hist. (ser. 9), 8: 497.  
*Drawida somavarpatana*, Stephenson 1923. Fauna Br. India, Oligochaeta: 158.

**Material examined.** 6 clitellate (ACESSD/EW/405), Ranipuram (12°25’5.7”N; 75°21’4.4”E), Kasaragod district, India, 935 m a.s.l., grassland and evergreen forest, 17 December 2013, S.P. Narayanan and S. Sathrumithra coll.; 2 clitellate (ACESSD/EW/408), Paithalmala (12°10’1.7”N; 75°33’31.1”E), Kannur Dist., India, 1076 m a.s.l., higher altitude evergreen forest, 30 November 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 1 clitellate, 3 aclitellate (ACESSD/EW/410), Koombanmala (12°20’43.2”N; 75°24’41.4”E), Kasaragod district, Kerala, India, 867 m a.s.l., grassland, 20 October 2012, S.P. Narayanan, S. Sathrumithra, M. Ramesan and T. Augustine coll.; 1 clitellate, 1 aclitellate (ACESSD/EW/411), Kottathalachimala (12°15’53.1”N; 75°25’45”E), Kannur district, Kerala, India, 664 m a.s.l., deciduous forest, 28 November 2012, S. Sathrumithra, T. Augustine and S.P. Narayanan coll.; 2 clitellate (ACESSD/EW/412), Kunnathoorpadi (12°4’55”N; 75°37’39.1”E), Kannur district, Kerala, India, 579 m a.s.l., evergreen forest with reed breaks, 30 November 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 2 clitellate (ACESSD/EW/413), Sree Deviyottukavu sacred grove - Aalapadamba (12°12’34.1”N; 75°15’9.7”E), Kannur district, Kerala, India, 8 m a.s.l., evergreen sacred grove, 29 November 2012, S.P. Narayanan, T. Augustine and S. Sathrumithra coll.; 9 clitellate, 12 aclitellate (ACESSD/EW/414), Kottencheri (12°20’57.6”N; 75°24’5.9”E), Kasaragod district, Kerala, India, 801 m a.s.l., evergreen forest, 20 October 2012, S.P. Narayanan, T. Augustine, S. Sathrumithra and M. Ramesan coll.; 4 aclitellate (ACESSD/EW/449), Panathoor (12°27’31.3”N; 75°20’42.9”E), Kasaragod district, Kerala, India, 98 m a.s.l., 24 October 2014, areca nut and coconut plantation, S. Sathrumithra coll.

**Diagnosis.** Length 82–133 mm, diameter 4–6 mm, 111–154 segments. Ventral setae enlarged on pre-clitellar segments; aa = 5 ab = bc = 5 cd on segment 7, aa = 11 ab = 0.7 bc = 11 cd on segment 35. Male pores paired puckered orifices with tumid lips, slightly lateral to setae b lines, at 10/11. Spermathecal pores paired, small, at 7/8, at setae c lines or in bc but closer to c. Gizzards 3–5, in segments 15–20. Prostates glandular, bilobed; vas deferens discharges at junction of prostatic lobes. Spermathecae paired in segment 8; atrium bilobed, elongate and erect; one lobe in segment 7 and the other in segment 8; spermathecal duct discharges at junction of atrial lobes.

**Distribution.** India: Kerala: District Kasaragod: Kooomanmala, Kottencheri, Panathoor, Ranipuram; District Kannur: Kottathalachimala, Kunnathoorpadi, Paithalmala, Aalpadamba (all new records from Kerala) (Fig.2); Karnataka: District Kodagu (Coorg): Somavarpata, spelt as ‘Somvarpet’ (Stephenson 1923), Coorg Hills (Rao 1921).

**Biology.** Spermathecae and male genitalia are absent in a number of worms from Kerala, indicating parthenogenetic mode of reproduction.

**Remarks.** The diagnosis is based on the present material from Kerala, description as given by Stephenson (1923) and re-examination of type material in Zoological Survey
of India, Kolkata (Reg. no. W416/1). Worms from Kerala are longer and stouter, and have a greater number of gizzards than worms from Karnataka (Rao 1921). Body dimensions and number of gizzards in Kerala worms are: average length 94.61 mm (range = 82–133 mm; n = 13); average width 5.38 mm (range 5–6 mm; n = 17); average number of segments 128.23 (range 111–154; n = 13), gizzards 3–5, mainly located between segments 15–20 (Table 4).

**Table 4.** Length, width, number of segments, and number of gizzards in selected specimens of *Drawida somavarpatana* from various localities.

| Site name & registration number | Length (mm) | Width (mm) | Number of segments | Number of gizzards (segments) |
|---------------------------------|-------------|------------|--------------------|-------------------------------|
| Koombanmala; ACESSD/EW/410      | 87          | 5          | 125                | 5 (16–20)                     |
|                                 | 83          | 5          | 119                | 5 (16–20)                     |
|                                 | 83          | 6          | 130                | NC                            |
| Kottathalachimala; ACESSD/EW/411| 82          | 5          | 104                | 5 (16–20)                     |
|                                 | NM          | 6          | 113                | NC                            |
| Kunnathoorpadi; ACESSD/EW/412   | 107         | 6          | 135                | NC                            |
|                                 | 86          | 5          | 134                | 3 (17–19)                     |
| Sree Deviyottukavu – Alapadamba; ACESSD/EW/413 | NM          | 5          | NC                 | 3 (18–20)                     |
|                                 | NM          | 5          | NC                 | 3 (17–19)                     |
| Kottencheri; ACESSD/EW/414      | 133         | 6          | 154                | 4 (16–19)                     |
|                                 | 101         | 5          | 142                | 5 (15–19)                     |
|                                 | 97          | 5.5        | 144                | 4 (16–19)                     |
| Ranipuram; ACESSD/EW/405        | NM          | 5          | NC                 | 4 (16–19)                     |
|                                 | 89          | 6          | 111                | 4 (16–19)                     |
|                                 | 96          | 5          | NC                 | 4 (15–19)                     |
|                                 | NM          | NM         | NC                 | 5 (15–19)                     |

NM – not measured, NC – not counted.

**Drawida thurstoni** Gates, 1945

*Drawida thurstoni* Gates, 1945. *Jl. R. Asiat. Soc. Bengal*, 11: 71.

**Material examined.** 2 clitellate, 4 aclitellate (ACESSD/EW/183), Kanjipara (11°26’16.4"N; 76°7’41.7"E), Kozhikode district, Kerala, India, 2000 m a.s.l., Shola forest, 23 December 2012, T. Augustine, S.P. Narayanan, A. Sasi and S. Sathrumithra coll.

**Diagnosis.** Length 185–220 mm, diameter 7–8 mm, 166–187 segments. Setae aa = 12–13.33 ab = 1.06–1.11 bc = 12–16 cd = 0.21–0.23 dd at segment 8; aa = 13.66–14 ab = 1.13–1.23 bc = 20.5–21 cd = 0.24–0.28 dd at segment 20. Male pores paired, transverse slits at 10/11, about mid bc. Spermathecal pores paired, minute at
7/8, close to setae c lines. Nephridiopores on or close to setae d lines, occasionally displaced into setae a, b on some segments behind clitellum. Genital markings absent. Gizzards 5, in segments 14–22. Prostates glandular, mushroom-shaped, stalked and erect, laterally compressed, glandular lining restricted to ental end; prostatic capsule vertical, ovoid; vas deferens coiled into a cluster of hairpin loops; vas discharging into anterior face of prostate at ectal end. Spermathecae paired in segment 8; atrium irregularly ovoid, covered over by a thin layer of muscle, in segment 7 only or slightly extending to segment 8.

**Distribution.** India: Kerala: District Kozhikode: Kanjipara (new record) (Fig. 2); Tamil Nadu: District Nilgiris: Nilgiri Hills (Gates 1945).

**Remarks.** Range of the length, diameter, and number of segments of the Kerala specimens are 171–176 mm, 7.5–8 mm, and 183–185 respectively.

**Discussion**

Earthworms of the primitive family Moniligastridae are believed to have originated somewhere in the region of Malaya Archipelago (Gates 1972, Blakemore et al. 2014); Jamieson (1977) suggests their origin near Myanmar. Its natural range encompass, south, southeast and east Asia, from peninsular India to Japan through Myanmar, China, extreme southern portion of Far East Russia, Korea, the Philippines, Borneo, and Sumatra (Gates 1972). The large range is primarily due to the spread of Drawida, the most speciose moniligastrid genus that presumably colonized peninsular India after the collision of Indian plate with Asia during Caenozoic period (Gates 1972, Blakemore et al. 2014). Recent attempts to resolve conflicts within the taxonomy of the genus have used molecular mtDNA barcoding, where possible of primary types (Blakemore et al. 2010, 2014; Blakemore and Kupriyanova 2010).

*Drawida* has undergone extensive radiation in India with 72 species listed by Blakemore (2007) but its greatest concentration (43 species) is found in the Western Ghats (Stephenson 1923, Gates 1945). Within the Western Ghats, the genus has an important centre of speciation in the southernmost state of Kerala, most species being endemic; there are 16 species, ten of which are endemic (Narayanan et al. 2016). The present discovery of two new species and five new records of *Drawida* further contribute to the vast species richness of the genus in the state.

**Acknowledgements**

We thank Dr. M. Ramesan, Mr. Toms Augustine, Mr. S. Arun Sasi, and Mr. Dinu Kuria-kose for their help with the fieldwork. Thanks are also due to Mr. Karunakaran Akhildev for preparing the distribution map. We are grateful to the Department of Forest and Wildlife, Govt. of Kerala state, for providing the permissions and necessary facilities.
References

Blakemore RJ (2007) Checklist of Indian earthworms. A Series of Searchable Texts on Earthworm Biodiversity, Ecology and Systematics from Various Regions of the World – 3rd Edition. http://www.annelida.net/earthworm/Indian.pdf

Blakemore RJ, Lee S, Seo H-Y (2014) Reports of Drawida (Oligochaeta: Moniligastridae) from East Asia. Journal of Species Research 3(2): 127–166. https://doi.org/10.12651/JSR.2014.3.2.127

Blakemore RJ, Kupriyanova E, Grygier MJ (2010) Neotypification of Drawida hattamimizu Hatai, 1930 (Annelida, Oligochaeta, Megadrili, Moniligastridae) as a model linking mtDNA (COI) sequences to an earthworm type, with a response to the ‘Can of Worms’ theory of cryptic species. ZooKeys 41: 1–29. https://doi.org/10.3897/zookeys.41.374

Blakemore RJ, Kupriyanova EK (2010) Unravelling some Kinki worms (Annelida: Oligochaeta: Megadrili: Moniligastridae) Part I. Opuscula Zoologica Budapest 40: 3–18. http://opuscula.elte.hu/PDF/T omus41_1/1_Op%20-%20Blakemore_Drawida.pdf

Blanchart E, Julka JM (1997) Influence of forest disturbance on earthworm (Oligochaeta) communities in the Western Ghats (south India). Soil Biology and Biochemistry 29(3–4): 303–306. https://doi.org/10.1016/S0038-0717(96)00094-6

Bourne AG (1894) On Moniligaster grandis, A.G.B., from the Nilghiris, S. India; together with descriptions of other species of the genus Moniligaster. Quarterly Journal of Microscopical Science 36: 307–384.

Blakemore RJ (2007) Checklist of Indian earthworms. A Series of Searchable Texts on Earthworm Biodiversity, Ecology and Systematics from Various Regions of the World – 3rd Edition. http://www.annelida.net/earthworm/Indian.pdf

Blakemore RJ, Lee S, Seo H-Y (2014) Reports of Drawida (Oligochaeta: Moniligastridae) from East Asia. Journal of Species Research 3(2): 127–166. https://doi.org/10.12651/JSR.2014.3.2.127

Blakemore RJ, Kupriyanova E, Grygier MJ (2010) Neotypification of Drawida hattamimizu Hatai, 1930 (Annelida, Oligochaeta, Megadrili, Moniligastridae) as a model linking mtDNA (COI) sequences to an earthworm type, with a response to the ‘Can of Worms’ theory of cryptic species. ZooKeys 41: 1–29. https://doi.org/10.3897/zookeys.41.374

Blakemore RJ, Kupriyanova EK (2010) Unravelling some Kinki worms (Annelida: Oligochaeta: Megadrili: Moniligastridae) Part I. Opuscula Zoologica Budapest 40: 3–18. http://opuscula.elte.hu/PDF/T omus41_1/1_Op%20-%20Blakemore_Drawida.pdf

Blanchart E, Julka JM (1997) Influence of forest disturbance on earthworm (Oligochaeta) communities in the Western Ghats (south India). Soil Biology and Biochemistry 29(3–4): 303–306. https://doi.org/10.1016/S0038-0717(96)00094-6

Bourne AG (1894) On Moniligaster grandis, A.G.B., from the Nilghiris, S. India; together with descriptions of other species of the genus Moniligaster. Quarterly Journal of Microscopical Science 36: 307–384.

Gates GE (1945) On some Indian earthworms II. Journal of the Royal Asiatic Society Bengal 11: 54–91.

Gates GE (1972) Burmese earthworms, an introduction to the systematic and biology of the Megadrile Oligochaetes with special reference to southeast Asia. Transactions of the American Philosophical Society 62(7): 1–326. https://doi.org/10.2307/1006214

Islam MZ, Rahmani AR (2004) Important Bird Areas in India: Priority Sites for Conservation. Indian Bird Conservation Network: Bombay Natural History Society and Birdlife International (UK), 1152 pp.

Iype VC, Nybe EV, Pillai PV (1991) Status report of high range zone. National agricultural research project, Kerala Agriculture University, Thrissur, Kerala.

Jamieson BGM (1977) On the phylogeny of the Moniligastridae, with description of a new species of Moniligaster (Oligochaeta, Annelida). Evolutionary Theory 2: 95–114.

Julka JM, Paliwal R (2005) Distribution of earthworms in different agro-climatic region of India. In: Ramakrishnan PS, Saxena KG, Swift MJ, Rao KS, Maikhuri RK (Eds) Soil Biodiversity, Ecological Processes and Landscape. Oxford and ABH Publications Co. Pvt. New Delhi, 3–13.

Julka JM, Paliwal R, Kathireswari P (2009) Biodiversity of Indian earthworms – an overview. In: Edwards CA, Jayaraaj R, Jayraaj IA (Eds) Proceedings of Indo-US Workshop on Vermitechnology in Human Welfare, Rohini Achagam, Coimbatore, India, 36–56.

KSCSTE (2007) State of the Environment Report of Kerala 2007 Volume – I. Kerala State Council for Science, Technology and Environment, Thiruvananthapuram, 45 pp.
Michaelsen W (1910) Die Oligochäten fauna der vorderindisch-ceylonischen region. Abdruck Verhandelungen der Naturwissenschaftlichen Vereins zu Hamburg 19(5): 1–108.

Michaelsen W (1900) Das Tierreich 10: Vermes, Oligochaeta. Friedländer & Sohn, Berlin, 575 pp.

Mittermeier RA, Turner WR, Larsen FW, Brooks TM, Gascon C (2011) Global biodiversity conservation: the critical role of hotspots. In: Zachos FE, Habel JC (Eds) Biodiversity Hotspots: Distribution and Protection of Priority Conservation Areas. Springer-Verlag, Berlin, 33–22. https://doi.org/10.1007/978-3-642-20992-5_1

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403: 853–858. https://doi.org/10.1038/35002501

Nair SSC (2011) The changing landscape of Kerala. In: Sashikumar C, Praveen J, Palot MJ, Nameer PO (Eds) Birds of Kerala status and distribution. DC Books, Kottayam, 30–53.

Narayanan SP, Sathrumithra S, Christopher G, Thomas AP, Julka JM (2016) Checklist of the earthworms (Oligochaeta) of Kerala, a constituent of Western Ghats biodiversity hotspot, India. Zootaxa 4193(1): 117–137. http://doi.org/10.11646/zootaxa.4193.1.5

Rao CRN (1921) On the anatomy of some new species of Drawida. Annals and Magazine of Natural History 8(9): 496–536. https://doi.org/10.1080/00222932108632613

Stephenson J (1917) On a collection of Oligochaeta from various parts of India and further India. Records of the Indian Museum 13: 353–416. https://doi.org/10.5962/bhl.part.5865

Stephenson J (1923) The Fauna of British India, including Ceylon and Burma – Oligochaeta. Taylor and Francis, London, 518 pp.