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Rediscovery of an endemic snail *Spiraculum beddomei* Blanford, 1866 (Mollusca: Cyclophoridae), with notes on its zoogeography and natural history

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Abstract

Spiraculum beddomei Blanford, 1866, a rare operculate land snail, was described in 1866 from Kimety (=Kimery) Hills, near Waltair (Vizagapatam), Madras Presidency in India has been reported nearly after 150 years from the adjoin Eastern Ghats landscape of Mahendragiri Hills in Gajapati district of Odisha in India. Here, we present new locality and detailed taxonomic characters of the species based on the direction of the sutural tube and flat spire along with a photomicrograph of the radula structure for the first time. A note on its zoogeography, habitat and natural history accounts are briefly discussed.

Keywords: Gastropoda, India, Natural History, Threat, Zoogeography

Introduction

The land snail genus *Spiraculum* Pearson, 1833 belongs to subfamily Cyclophorinae Gray, 1847 and tribe Pterocyclini Kobelt & Möllendorff, 1897 containing 26 nominal species and distributed across the Indo-Malayan realm (Kobelt, 1902; Gude, 1921; Yen, 1939; Wikramanayake *et al*., 2002; Ramakrishna *et al*., 2010; Marzuki & Clements, 2013; Raheem *et al*., 2014; Tumpeesuwan & Tumpeesuwan, 2015; Thach, 2017; Tripathy *et al*., 2018a; Inkhavilay *et al*., 2019). In India, five species are described from Himalaya, four from the Northeast region, one from the Deccan peninsula and two species from the Western Ghats, totaling 12 species, and all are endemic and known only from the type descriptions (Ramakrishna *et al*., 2010; Tripathy *et al*., 2018a).

Spiraculum beddomei Blanford, 1866 was described based on sutural tube direction and flat spire from "Kimery Hills, near Waltair (Vizagapatam), Madras Presidency [=Visakhapatnam District, Andhra Pradesh State, India] of Deccan peninsula (https://iiif.lib.harvard.edu/manifests/view/ids:13162821). Additionally, Dr Valentine Ball, F.R.S., Geological Survey of India, reported this species from Ganjam, within the Eastern Ghats range in Odisha during his visit to Mahendragiri while in search for establishing a sanatorium in 1870 and in the last *ca*. 150 years, there is no further reporting of the species from this region or elsewhere in the known range of its occurrence (Blanford, 1866; Nevill, 1877; Ball, 1880; Gude, 1921). During our recent field survey, we reinvestigate the nearby areas of Mahendragiri Hills in Odisha [= Orissa] state as suggested by Ball (1880) in his publication *"Jungle life in India"* to retrieve the species. Here, we confirm the presence of *Spiraculum beddomei* in proximity to the type locality, after a gap of *ca*. 150 years, and provides a first insight into the radula structure, notes on habitat and discuss the zoogeography and natural history of the species.

Material and Methods

Land snails were collected during the recent field visit in August 2019 in Mahendragiri Hills, South Odisha, India, as part of the ongoing faunal survey programme of the Zoological Survey of India. The macro and microhabitats were thoroughly investigated (following the methodology of Emberton *et al.* (1996). Collected specimens, including the one under rediscovery, were

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preserved in 70% ethanol for further anatomical study (including other molluscan taxa). All specimens were photographed using a Nikon D7000 DSLR camera with an AF-S Micro Nikkor 60 mm 1:2:8 G ED lens (made in Thailand) and in Leica stereomicroscope. For the preparation of microphotography of radula structure, the ethanol preserved specimen was dissected under microscope, the buccal mass was removed and soaked in 5% Potassium hydroxide solution for 6–8 hrs before extracting the radula and after removing the ribbon, were preserved in 70% ethanol with 3–4 drops of Glycerol added to it. Photomicrographs of the preserved radula were obtained after coating gold-palladium for 15 minutes before photographed on scanning electron microscope ZEISS EVO 18. Further, the complete morphometric measurements of the shell *viz*. shell diameter (D), shell width (W), aperture height (AH),and aperture width (AW) were measured using Mitutoyo dial vernier calliper (made in Japan, 0.05 mm) and the whorl count (N) were taken based on standard methodologies (Kerney and Cameron, 1979). The terminology used for the description of the radula was followed as suggested by Tumpeesuwan and Tumpeesuwan (2015) and the specimens identified based on the literature (Blanford, 1866; Kobelt, 1902; Gude, 1921; Sutcharit *et al*., 2019). For comparison of the type specimens, data on the syntype (NZSI M.33334/9 and NHMUK 1906.1.1.942) and the specimens housed in the National Zoological Collection of Zoological Survey of India, Kolkata were examined. The collected specimens were deposited in the NZSI.

Abbreviation: ASL — Above Sea Level, coll. — the Collector, NHMUK — Natural History Museum, London, UK (when citing specimens deposited in the NHM), NZSI — National Zoological Collection of Zoological Survey of India (when citing specimens deposited in the ZSI), Reg. No. — Registration Number, ZSI — Zoological Survey of India (Kolkata, India).

Results

Systematic Account

Superfamily CYCLOPHOROIDEA Gray, 1847

Family CYCLOPHORIDAE Gray, 1847

Subfamily CYCLOPHORINAE Gray, 1847

Tribe **Pterocyclini** Kobelt & Möllendorff, 1897

Genus ***Spiraculum*** Pearson, 1833

1833. *Spiraculum* (part.) Pearson, *J. Asiat. Soc. Bengal*., **2**: 590.
1902. *Pearsonia* Kobelt, *Das Tierreich Mollusca: Cyclophoridae*: 171.

Type species. Spiraculum hispidum Pearson, 1833.

Description: Shell depressed, subdiscoidal, covered with a thick periostracum, sometimes hairy or zigzag stripe; spire flats or somewhat elevated; aperture circular or diagonal, the edges of the peristome curved and projecting; last whorl with a short reverted sutural tube, open at both ends; shell widely umbilicated; Operculum with multi-spiral.

Remarks: Pearson (1833) nominated the generic name *Spiraculum* and designated *Spiraculum hispidum* as a type species. However, Kobelt (1902: 171) ambiguously proposed a new replacement name for it as *Pearsonia*. Much later, the detailed discrepancy has been described and resurrected *Spiraculum* as a valid genus by Inkhavilay *et al*. (2019).

Spiraculum beddomei Blanford, 1866
(Figure 1A–G)

1866. *Spiraculum beddomei* Blanford, *J. Asiat. Soc. Beng.*, **35**: 31–33.

1875. *Pterocyclos* (*Spiraculum*) *beddomei*: Hanley and Theobald, *Conch. Indica*, **1875**: 54, pl. 134, figs 5,6.

1902. *Pearsonia beddomei*: Kobelt, *Das Tierreich Mollusca: Cyclophoridae*: 172–173, fig. 36.

1921. *Pearsonia* (*Pearsonia*) *beddomei*: Gude, *Fauna Brit. India. Mollusca*, **3**: 115–116.

1989. *Pearsonia* (*Pearsonia*) *beddomei*: Subba Rao *et al.*, *Fauna of Orissa*, *State Fauna Series 1* (*Part-2*), *Invertebrates*: 253.

2002. *Pearsonia beddomei*: Ramakrishna and Mitra, *Rec. Zool. Surv. India*, *Occ. Paper No.*, **196**: 45.

2019. *Pearsonia beddomei*: Sutcharit *et al.*, *ZooKeys*, **842**: 10, fig. 2F.

2010. *Pearsonia* (*Pearsonia*) *beddomei*: Ramakrishna *et al.*, *Annotated Checklist of Indian Land Molluscs*: 79.

Type locality. "Kimery (=Kimrty) Hills near Waltair (Vizagapatam), northern division of the Madras Presidency" [=Visakhapatnam District, Andhra Pradesh State, India].

Type material: Syntype: NZSI M.33334/9 (single shell), from the type locality (Figure 1A); NHMUK 1906.1.1.942 (single shell) from the type locality (Figure 1B, D).

Other material: NZSI M.33335/9 (two shells), near Ganjam, Orissa [Odisha], India, coll. Dr Valentine Ball, September 1870 (Figure 1C, E); NZSI M.33336/9 (single specimen), Mahendragiri, Eastern Ghats, Odisha, coll. Dr P.G.S. Sethy and Party, 2 August 2019 (Figure 1D, F).

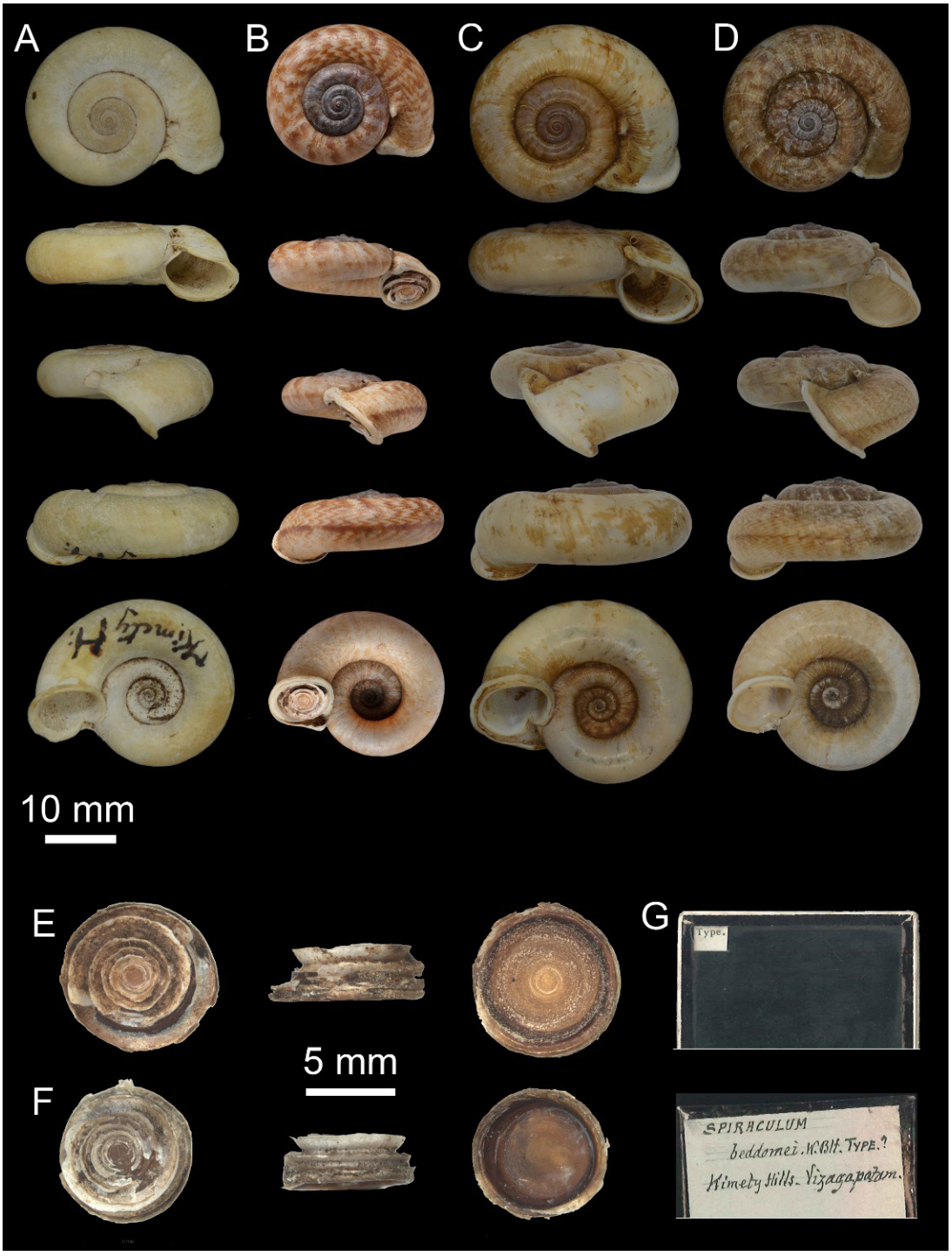

Figure 1. Shell of *Spiraculum beddomei* Blanford, 1866, **A**. Syntype NZSI M.33334/9 from type locality, **B**. Syntype NHMUK 1906.1.1.942 from type locality, **C. E**. *S. beddomei* from Ganjam NZSI M.33335/9 (Ball, 1870), and **D, F.** *S. beddomei* Mahendragiri Hills, NZSI M.33336/9. **G**. type label of *S. beddomei* from NHMUK.

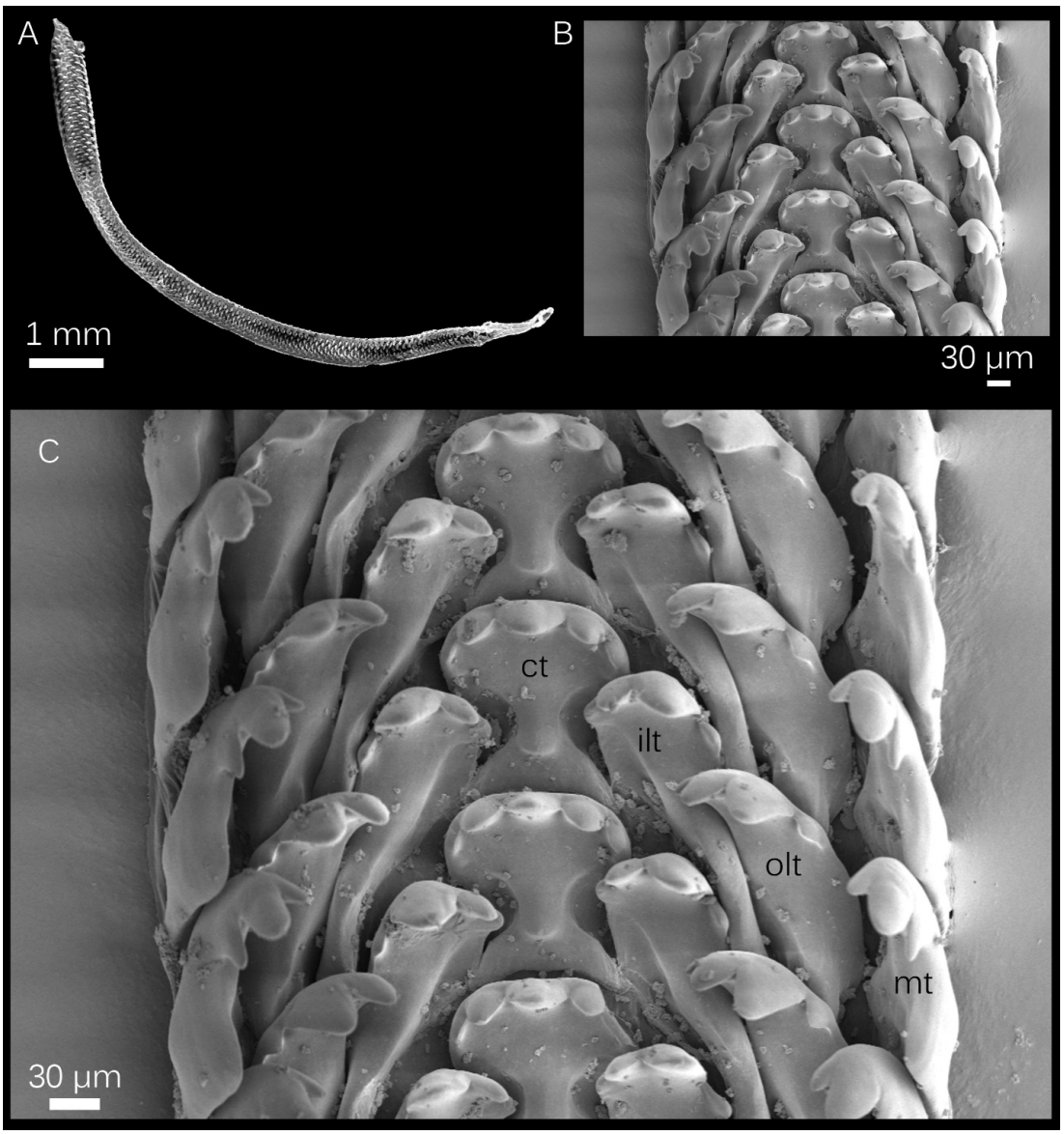

Figure 2. Radula of *Spiraculum beddomei* Blanford, 1866 (NZSI M.33336/9), **A**. Radula ribbon, **B**. **C**. radula (ct, central tooth; ilt, inner lateral teeth; olt, outer lateral teeth; mt, marginal tooth).

Shell (after Blanford, 1866)

Shell very broadly umbilicated, depressed, sub-discoidal, smooth, solid, white with transverse chesnut zigzag stripes. Spire flat or subconvex, suture deep. Whorls 5, rounded, the last cylindrical, descending gradually towards the aperture, and furnished, 7–10 millimetres behind the peristome, with a short open sutural tube, projecting forwards and upwards, not touching the penultimate whorl. Aperture diagonal, circular, peristome double, both lips continuous, the inner slightly expanded, curved back into a shallow angular sinus at the suture, the outer expanded, and inverted upon the upper and dextral margins, rising near the suture into a compressed wing, which is attached throughout on the left side to the penultimate whorl. Operculum horny, concave within, convex without, flattened near the centre, 2 or 3 outer whorls furnished with a free spiral testaceous lamelliform border (Blanford, 1866).

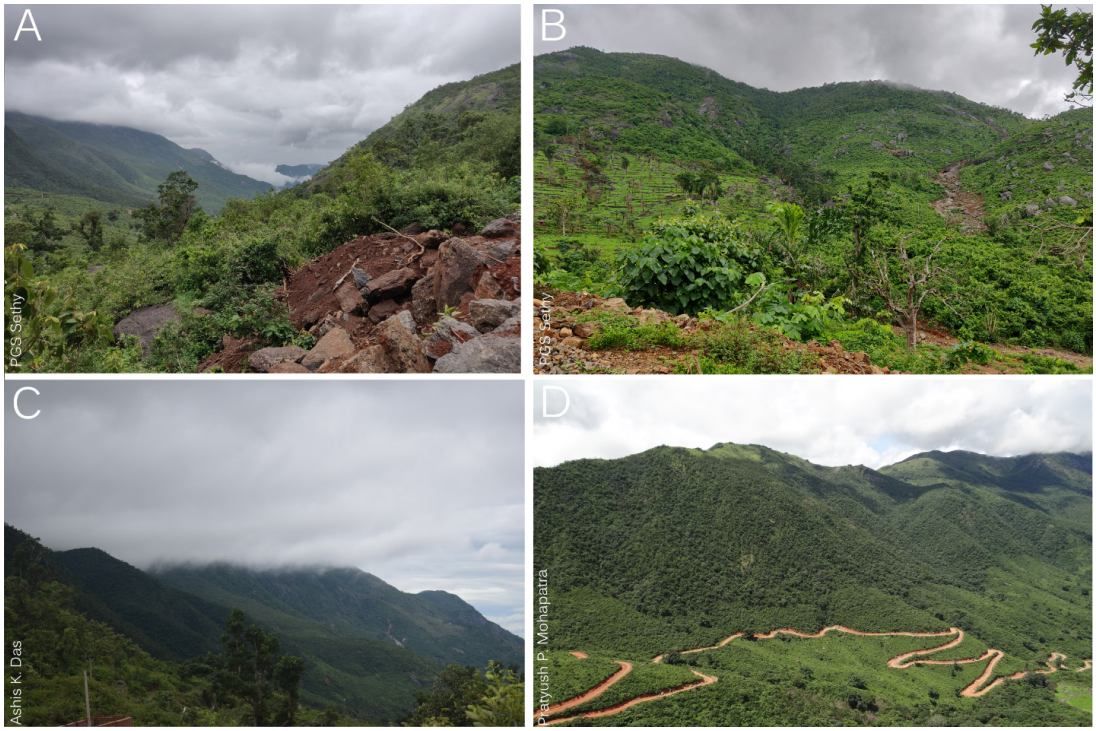

Figure 3. Extended view of the valley and peculiar habitat of *Spiraculum beddomei* Blanford, 1866 in Mahendragiri Hills, Eastern Ghats, Odisha (A–D).

Radula (NZSI M.33336/9)

The radula ribbon is large, 9 mm in length, Taenioglossate, with *ca*110 transverse rows and each row contains seven teeth with formula 1-2-1-2-1 (3-1-3), including one central tooth (ct), one marginal tooth (mt) in both side, two inner lateral teeth (ilt) in both side and two outer lateral teeth (olt). Central tooth is pentacuspid, high with pointed tips, four lateral cusps on both sides with a triangular shape and pointed tips. Inner and outer lateral teeth tetracuspid, the first and last cusp small and pointed, whereas the middle two, have large and shovel-shaped. The marginal tooth tricuspid, the side cusp small and pointed head, the middle cusp large and tongue-shaped (Figure 2A–C).

Comparison with *Spiraculum lamphunensis* (Tumpeesuwan & Tumpeesuwan, 2015)

On systematic comparison with *S. lamphunensis*, we did not found any significant difference in dentition formula, but there was the difference in the arrangement of cups and shape. The transverse rows are significantly more in *S. beddomei* than *S. lamphunensis*; thus it is presumed that the shape and arrangement of the tooth could be the possible, reliable characters for species-level identification.

Shell Dimension

(1) Syntype NZSI M.33334/9, D: 27.7 mm, W: 11.9 mm, AH: 10.4 mm, AW: 10.4 mm, N: 5½.
(2) NZSI M.33335/9 (two shells) D: 27.8–30.2 mm, W: 13.1–13.2 mm, AH: 10.1–12.4 mm, AW: 10.1–12.4 mm, N: 5½.
(3) NZSI M.33336/9 (single shells) D: 26.1 mm, W: 15.0 mm, AH: 10.1 mm, AW: 10.1 mm, N: 5½.

Comparison with 'syntype'

The recent specimen collected from Mahendragiri Hills, compared with the syntype NZSI M.33334/9 and NHMUK 1906.1.1.942 corresponds with type specimen, the most reliable characters being the direction of the sutural tube, which move towards the peristome. Specimens from type locality have flattened spire, whereas recent findings, we notice that the species had elevated spire. This species is easily distinguished by remarkably forward direction of the sutural tube (Figure 2A–C).

Habitat and Natural History

The syntypes (NZSI M.33334/9 and NHMUK 1906.1.1.942) were collected by Beddome from the Eastern Ghats range of Kimeky Hills near Vishakhapatnam and this hill is connecting Odisha and Andhra Pradesh state

politically and cover with continuous forests and hill range of Eastern Ghats. In Odisha, this species was only reported from semi-evergreen forest of Mahendragiri Hills in the Gajapati district 1400–1500m ASL (Ball, 1880) and this area received an annual rainfall of ~ 2000 mm (http://cgwb.gov.in). The existing habit in the study area has undergone tremendous modifications in the past from silviculture to shifting cultivation and in recent years, cash crop plantations in the hilltops, particularly coffee, cotton and cashew as well as cardamom (Figure 3A–D). This alteration in the habitat has brought changes in the soil structure and composition as well as rainfall patterns (Agarwal *et al*., 2012). However, in our recent investigation, we observed the species crawling on decaying litter on moist area of the woodland in higher elevation zone of the hills of Mahendragiri in the relatively less human-disturbed areas.

Discussion

This is the first confirm record of *Spiraculum beddomei* in the last 150 years. *S. beddomei* was not recorded in previous surveys of this area by malacologist, leaving malacologist to ponder if this species was extinct (Godwin-Austen, 1917; Annandale & Prashad, 1920; Subba Rao *et al*., 1989; Mitra *et al*., 2005; Prakasa Rao *et al*., 2013; Sajan *et al*., 2018; Tripathy *et al*., 2018b). Geographically, the Eastern Ghats with long discontinuous mountains range extending from the Western Ghats to Gangetic plains along the eastern coast of Deccan peninsula act as a corridor for movement of Malayan fauna and also act as highways for the Western Ghats and Indo-Burmese species (Blanford, 1866, 1876; Agarwal *et al*., 2012; Tripathy *et al*., 2018b). The operculate land snail of genus *Spiraculum* is having evidence of sporadic distribution pattern in India (Gude, 1921; Ramakrishna *et al*., 2010; Tripathy *et al*., 2018b). While most species are reported from northeast regions and eastern Himalaya (9 species), which are considered as part of the Indo-Burma and Himalaya Biodiversity hotspot (Myers *et al*., 2000), the other two species *S. travancoricum* Blanford, 1881 and *S. fairbanki* Blanford, 1869 are distributed in the Western Ghats. The *S. beddomei* Blanford, 1866 was considered to be restricted to the Eastern Ghats (Blanford, 1866, 1876; Ball, 1880; Ramakrishna *et al*., 2010). Nevertheless, the finding of the present study indicate also the gap in the documentation of land snails in the Eastern Ghats, much of which was recorded during the colonial period and thereafter not been sampled the area, possibly because of declining the taxonomic experts for invertebrates,or the priority shifted to mega fauna (Eisenhauer *et al*., 2019). On the other hand, we are in the wave of sixth mass extinction, where the invertebrate conservation hampers globally and the defaunation process triggering rapidly due to several anthropogenic activities (Cardoso *et al*., 2011; Dirzo *et al*., 2014). Thus, the extensive field surveys within the Eastern Ghats could reveal the exact population size and understand the distribution pattern of other least known species. Also, emphasis should be given to capacity building among the young researchers and students to attract them into the field of taxonomy and natural history for carrying out further future research and conservation of the poorly known invertebrate taxa.

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