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A new micro-snail species of the genus *Dicharax* Kobelt & Möllendorff, 1900 (Caenogastropoda: Cyclophoridae: Alycaeinae), from sacred groves in the northern Western Ghats, India

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Abstract. We describe a new micro-snail species of the genus *Dicharax* based on 16 specimens collected from three sacred groves in Kolhapur District, in the northern Western Ghats of Maharashtra State, India. This species can be easily distinguished from its congeners in several non-overlapping morphological characters: R2 with closely spaced, blunt, elevated ribs; R3 with an inflated, blunt swelling; and basal part of the outer peristome (part close to the umbilicus) is more expanded than the rest of the outer peristome. We also describe and illustrate the living animal, operculum, radula, and jaw. This is the first report of the genus from the northern Western Ghats and extends its known geographic distribution in the Western Ghats by 370 km north. The new species highlights the importance of sacred groves as a biodiversity reservoir and emphasizes the need for in-depth investigations to uncover largely unknown biodiversity at these sites. We also discuss the need for systematic, fine-scale sampling in the northern Western Ghats to reveal mostly unknown land-snail diversity.

Key words. Biodiversity hotspot, Devrai, endemic, *Dicharax devraivasi* n. sp., taxonomy

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Introduction

Alycaeinae W.T. Blanford, 1864 is a subfamily of the terrestrial operculate snail family Cyclophoridae J.E. Gray, 1847 (Páll-Gergely *et al.* 2024). Species of Alycaeinae possess a sutural tube, which is closed at its end and connected to numerous perpendicular microtunnels enabling gas exchange when the operculum is closed (Páll-Gergely *et al.* 2016, 2024). The most species-rich genus is *Dicharax* Kobelt & Möllendorff, 1900, comprising 174 species (MolluscaBase Eds 2024). *Dicharax* is distributed in the south-eastern and south-western Himalayan region, southern India, Japan, the Malay Peninsula, and the southern arc of the Malay Archipelago, including Sumatra and Java (Godwin-Austen 1897–1914; Gude 1921; van Benthem Jutting 1948, 1959; Minato 1988; Gittenberger *et al.* 2017; Aravind & Páll-Gergely 2018; Jirapatrasilp *et al.* 2021; Páll-Gergely *et al.* 2017, 2020, 2021; Páll-Gergely & Hunyadi 2022). The genus is typically characterized by the absence of spiral striations on both the protoconch and teleoconch, but there are a few exceptions (Páll-Gergely *et al.* 2021). Based on differences in shell sculpture, three regions were distinguished by Páll-Gergely *et al.* (2017): Region 1 (R1), the initial part of the teleconch with differently ribbed portion along with suture; Region 2 (R2), the part of the body whorl differently ribbed along the sutural tube to constriction; and Region 3 (R3), that portion of the body whorl from the constriction point to the peristome. In most species, R2 bears ribs bent in the direction of aperture (Páll-Gergely *et al.* 2017, 2020). Based on the morphological variation among species, Páll-Gergely *et al.* (2020), categorized *Dicharax* into three informal groups: typical species exhibiting curved R2 ribs, atypical or questionable species lacking typical R2 sculpture, and species from Japan and Korea. There are 63 *Dicharax* species known from India, with 59 species highly concentrated in the south-eastern Himalayan region, a single species from

the south-western Himalaya, and three species from South India, disjunct from the others (Gittenberger *et al.* 2024). Among the Indian *Dicharax*, 19 species have typical R2 ribs and 44 species are atypical or questionable (Páll-Gergely *et al.* 2020).

Until recently, only a single genus, *Chamalycaeus* Kobelt & Möllendorff, 1897, belonging to the subfamily Alycaeinae was known from Peninsular India. This genus was represented by two species, *C. expatriatus* (W.T. & H.F. Blanford, 1860) and *C. footei* (W.T. & H.F. Blanford, 1861) (Raheem *et al.* 2014; Aravind & Páll-Gergely 2018). However, Aravind & Páll-Gergely (2018) transferred these species to *Dicharax* and described a new species, *Dicharax bawai* Aravind & Páll-Gergely, 2018.

As part of our ongoing project on the land snails of the northern Western Ghats of Maharashtra, we surveyed seven sacred groves and adjoining forests during the monsoon season in 2024 and sampled micro-snails, which included a species of the genus *Dicharax*. Examination of shells revealed that our samples have distinctive morphology and belong to an undescribed species of atypical *Dicharax sensu lato* Páll-Gergely *et al.* (2020), which we describe herein as a new species. Additionally, we provide detailed descriptions of living animals, operculum, radula, and jaw. We illustrate the jaw of *Dicharax* for the first time. We discuss the importance of sacred groves as biodiversity reservoirs and emphasize the need for in-depth investigations to uncover the unknown diversity. We discuss how sacred groves are under threat and highlight the need for immediate attention for their protection.

Materials and Methods

We collected 16 specimens, either whole individuals or shells, of the new species from three sacred groves in Maharashtra State, India (Fig. 1). Live individuals were photographed ex-situ using a Nikon DSLR camera, then euthanized following the guidelines of the American Veterinary Medical Association (2020) and preserved in 80% ethanol for anatomical study. Images of shells were captured under a Zeiss Stemi 305 stereo zoom microscope at different planes of focus and stacked using CombineZP v. 1.0 focus-stacking software. Considering the morphological characters, the new species is placed within the atypical group of *Dicharax* genus. We restrict morphological comparisons of the new species to the three South Indian *Dicharax* species—*Dicharax bawai*, *D. expatriatus*, and *D. footei*—by referring to the publication of Arvind and Pall-Gergely (2018). We follow Cox (1960) and Páll-Gergely *et al.* (2017) for the terminology of shell morphology. Whorls were counted following Kerney & Cameron (1979). The radula was prepared following Geiger *et al.* (2007), and the operculum was cleaned with the soft painting brush and stored in 80% ethanol. The radula and shell (dorsal part) were gold-coated and photomicrographed on a TESCAN VEGA3 and JEOL JSM-IT200 SEM. The type material of the new species are deposited in the Museum and Research Collection Facility at National Centre for Biological Sciences, Bengaluru (NRC) and in the museum of Bombay Natural History Society, Mumbai (BNHS).

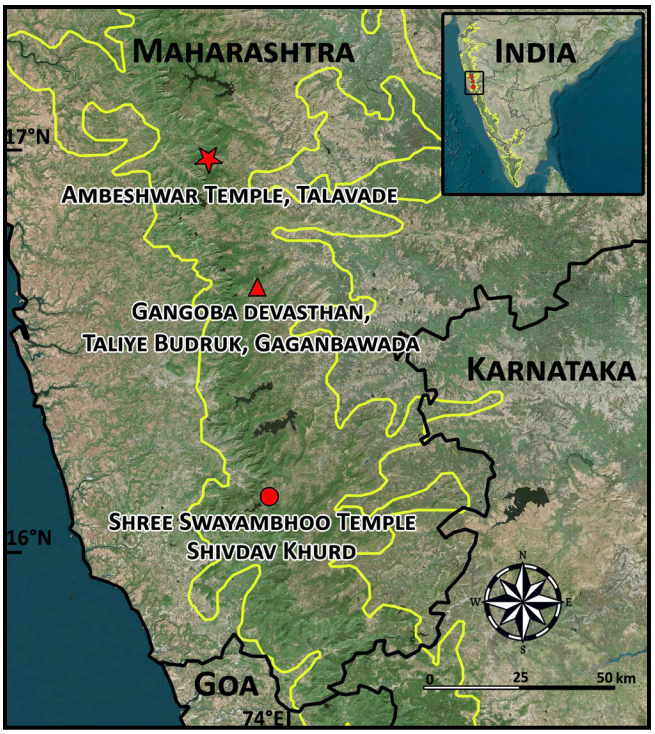

Figure 1. Distribution of *Dicharax devraivasi* n. sp. in the northern Western Ghats: ★ = type locality; ● = locality of paratypes; ▲ = additional locality of non-type material. The Western Ghats are outlined in yellow.

Results

Family Cyclophoridae J.E. Gray, 1847

Subfamily Alycaeinae W.T. Blanford, 1864

Genus *Dicharax* Kobelt & Möllendorff, 1900

Type species. *Alycaeus hebes* Benson, 1857, by subsequent designation (Gude 1921).

Description. For a description of the genus, see Páll-Gergely *et al.* (2021).

***Dicharax devraivasi* n. sp.**
Figures 2–5

ZooBank identifier. urn:lsid:zoobank.org:act:AF42A14F-74B7-4825-B153-EEC38DD21FE1

Type material. Holotype: NRC-AA-8454, Ambeshwar Temple, Talavade, near Amba, Kolhapur District, Maharashtra State, India (16°58′26.7″N, 073°48′05.7″E), *c.* 610 m a.s.l., coll. Swapnil Pawar, 5 July 2024.

Paratypes: NRC-AA-8455–8460 (6 specimens), same collection and locality data as holotype but 14 July 2024. BNHS GAS 206–212 (7 specimens), same collection and locality data as holotype but 6 July 2024. BNHS GAS 213 (1 specimen), Shree Swayambhoo Temple, Shivdav Khurd, near Patgaon (16°08′15.2″N, 073°57′12.1″E), *c.* 630 m a.s.l., coll. A.R. Bhosale, 16 June 2024.

Other material examined. All from Kolhapur District, Maharashtra State, India: ZSI Reg. No. Moll.1776, Moll. 1777 (2 shells), Ambeshwar Temple, Talavade, near Amba (16°58′27.2″N 073°48′06.0″E) *c.* 610 m a.s.l., coll. A. Bhosale, 11 Sep. 2017. BNHS GAS 44 & BNHS GAS 45 (2 shells), Shree Swayambhoo Temple, Shivdav (16°08′15.7″N 073°57′11.5″E), *c.* 620 m, coll. A. Bhosale, 14 July 2017. BNHS GAS 214 (1 live individual, shell damaged), Gangoba devasthan, Taliye Budruk, Gaganbawada (16°39′15.4″N, 073°55′22.5″E, *c.* 600 m a.s.l., coll. A. Bhosale, 8 Sep. 2024.

Etymology. The specific epithet is used as a noun in apposition. It is derived from the Marathi word "devrai", meaning "sacred grove", and Sanskrit word "vasi", meaning "inhabitant of", as the new species has so far only been reported from multiple sacred grove forests in Kolhapur District, northern Western Ghats of Maharashtra. The suggested English common name is Devrai micro-snail.

Diagnosis. A species having variable R1, with either fine, irregular ribs or stronger, close-spaced ribs; R2 with dense, blunt, elevated ribs; R3 with blunt swelling.

Comparison with South Indian congeners. *Dicharax devraivasi* n. sp. is superficially similar to *D. expatriatus* but can be easily distinguished in having a slightly smaller shell 4.25–4.75 × 2.73–3.01 mm (vs 4.10–5.50 × 2.70–3.10 mm in *D. expatriatus*), greater number of ribs, with 33–42 ribs on R2 (vs *c.* 34 ribs in *D. expatriatus*), and the swelling on R3 more inflated. The new species can be easily differentiated from *D. bawai* in having a slightly larger shell 4.25–4.75 × 2.73–3.01 mm (vs 3.90–4.22 × 2.32–2.85 mm in *D. bawai*), more ribs, 33–42 on R2 (vs 24–28 ribs in *D. bawai*), a more expanded outer peristome, and only a single blunt swelling on R3 (vs two swellings in *D. bawai*). *Dicharax devraivasi* n. sp. differs from *D. footei* in having a smaller shell, 4.25–4.75 × 2.73–3.01 mm (vs 5.30–6.20 × 3.40–3.50 mm in *D. footei*), more ribs, 33–42 on R2 (vs *c.* 24 ribs in *D. footei*), a lower protoconch, and a single swelling on R3 (vs two swellings in *D. footei*).

Figure 2. Living snail of *Dicharax devraivasi* n. sp. **A**, male, holotype NRC-AA-8454. **B**, female, paratype NRC-AA-8457. **C**, immature male (not collected) showing semitransparent shell. **D**, immature male, showing penis (at arrow).

Description of the holotype.

Shell depressed, 3½ whorls (width 4.05 mm, height 2.54 mm), spire slightly elevated, with obtuse apex; outline rounded from dorsal view; body whorl rounded in profile (Fig. 3A). Umbilicus narrow (Fig. 3D). Suture deep; sutural tube long. Shell whitish with reddish apex. Protoconch rather low, with 1½ whorls, glossy, smooth (without sculpture but with some parts eroded). Initial part R1 smooth and gradually developing very low, fine irregular ribs, which become stronger and more regular closed ribs; R2 with 38 blunt, elevated ribs; transition between R2 and R3 marked by a constriction; R3 with an inflated blunt swelling with fine, irregular ribs (Fig. 3C). Aperture rounded. Peristome double; inner peristome slightly protruding; outer peristome thin, expanded, but not reflected (Fig. 3B); basal part of outer peristome (close to umbilicus) more expanded than rest of outer peristome (Fig. 3A).

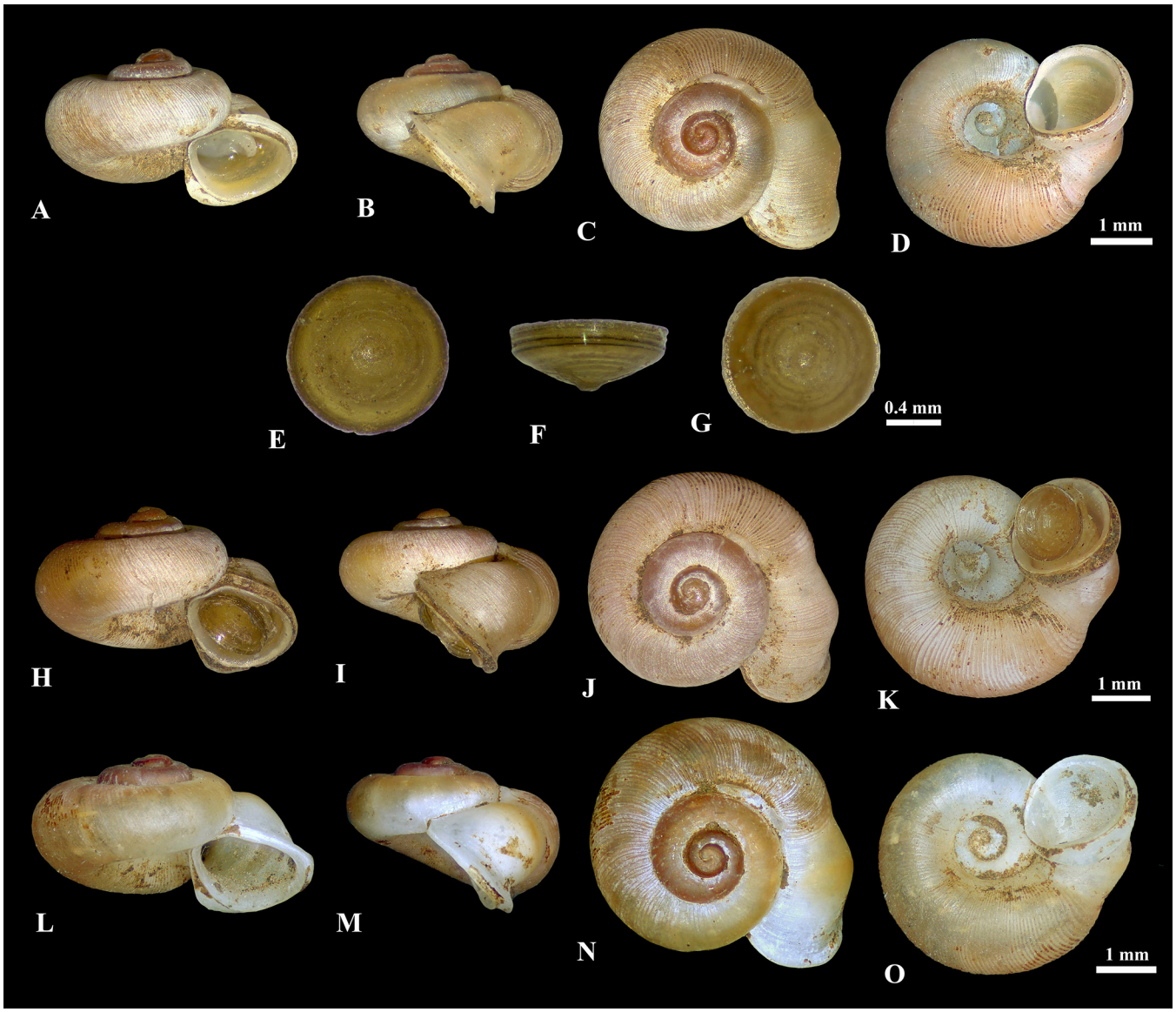

Figure 3. Shell and operculum of *Dicharax devraivasi* n. sp. **A–G,** holotype NRC-AA-8454. **H–K,** paratype NRC-AA-8455. **L–O,** paratype BNHS GAS 213. **A, H, L,** apertural view; **B, I, M,** lateral view; **C, J, N,** dorsal view; **D, K, O,** ventral view. **E,** outer surface; **F,** lateral view; and **G,** inner surface.

Operculum discoid, brownish, and multispiral, with *c.* 8 whorls; without elevated lamella but edge of operculum elevated. Outer surface concave; inner surface correspondingly convex, with a moderately prominent nipple in nuclear region (Fig. 3E–G).

Animal white (Fig. 2A). Head with a pair of tentacles with dark eyespots at their outer base. Tentacles yellow on lower ⅔, tips pale brown. Muzzle blunt. Tail short. In adult male, penis external on right side of head posterior to right eye and tentacle; penis flat, elongate, large, and trapezoidal.

Additional information from paratypes. Shell width 4.25–4.75 mm wide, height 2.73–3.01 mm (n = 15); whorls 3¼–3¾; protoconch finely pitted with 1¼–1¾ whorls (Fig. 4A, B). R2 with 33–42 blunt, elevated ribs (Fig. 3A, D). All paratypes resemble the holotype shell except as follows: short suture tube observed two paratypes (NRC-AA-8455, NRC-AA-8460). The cross-section of the R2 (BNHS GAS 210, Fig. 3E) shows the anterior crust folds over the posterior crust and together form blunt ribs; micro-tunnels narrowly oval or slit-like.

Radula (BNHS GAS 212) taenioglossate, with seven teeth (2-1-1-1-2) in each row. Central tooth pentacuspid; median cusp strong, and bluntly pointed, with two smaller cusps on either side. Lateral teeth with four cusps, one outer

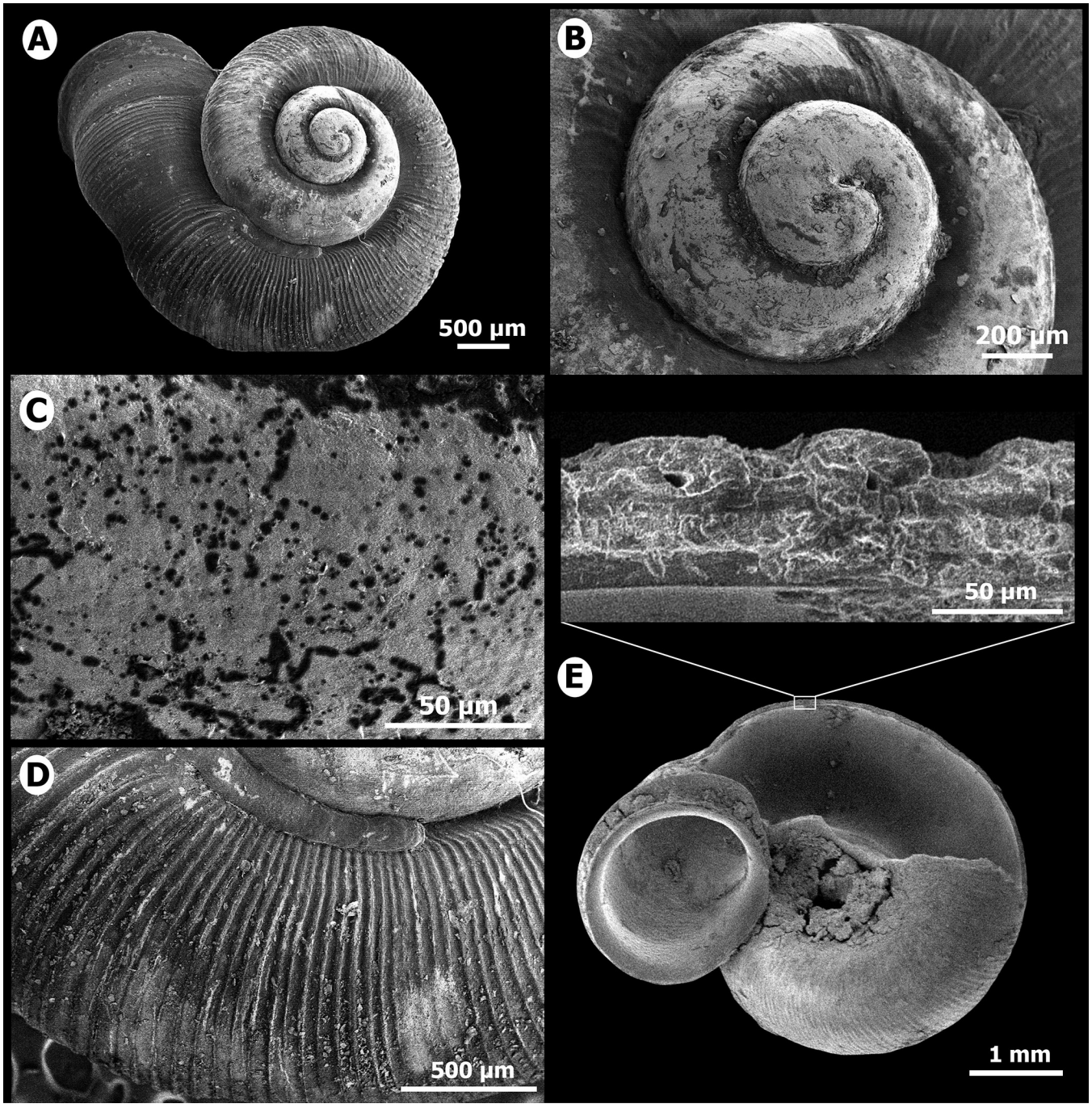

Figure 4. SEM images of shell of *Dicharax devraivasi* n. sp. **A–D,** paratype BNHS GAS 209. **E**, paratype BNHS GAS 210. **A**, dorsal view. **B**, protoconch, with (**C**) detail of surface. **D**, surface of R2. **E**, ventral view of shell with cross-section enlarged.

and two inner cusps smaller, whereas second one from outside cusp much broader than others. Inner marginal teeth tetracuspid, blunt, with middle two cusps larger than others. Outer marginal teeth tricuspid, with cusp longer and pointed and middle cusp largest (Fig. 5A, B).

Jaw (BNHS GAS 211) consists of two triangular symmetrical parts connected centrally with a deep groove; jaw simple and thin with serrated cutting edges; jaw sculptured with regular and irregular rectangular plates varying in size (Fig. 5 C–F).

Distribution and natural history. *Dicharax devraivasi* n. sp. is endemic to the northern Western Ghats, India, and currently known from the three sacred groves within 90 km of each other: Ambeshwar Temple, Talavade, near Amba

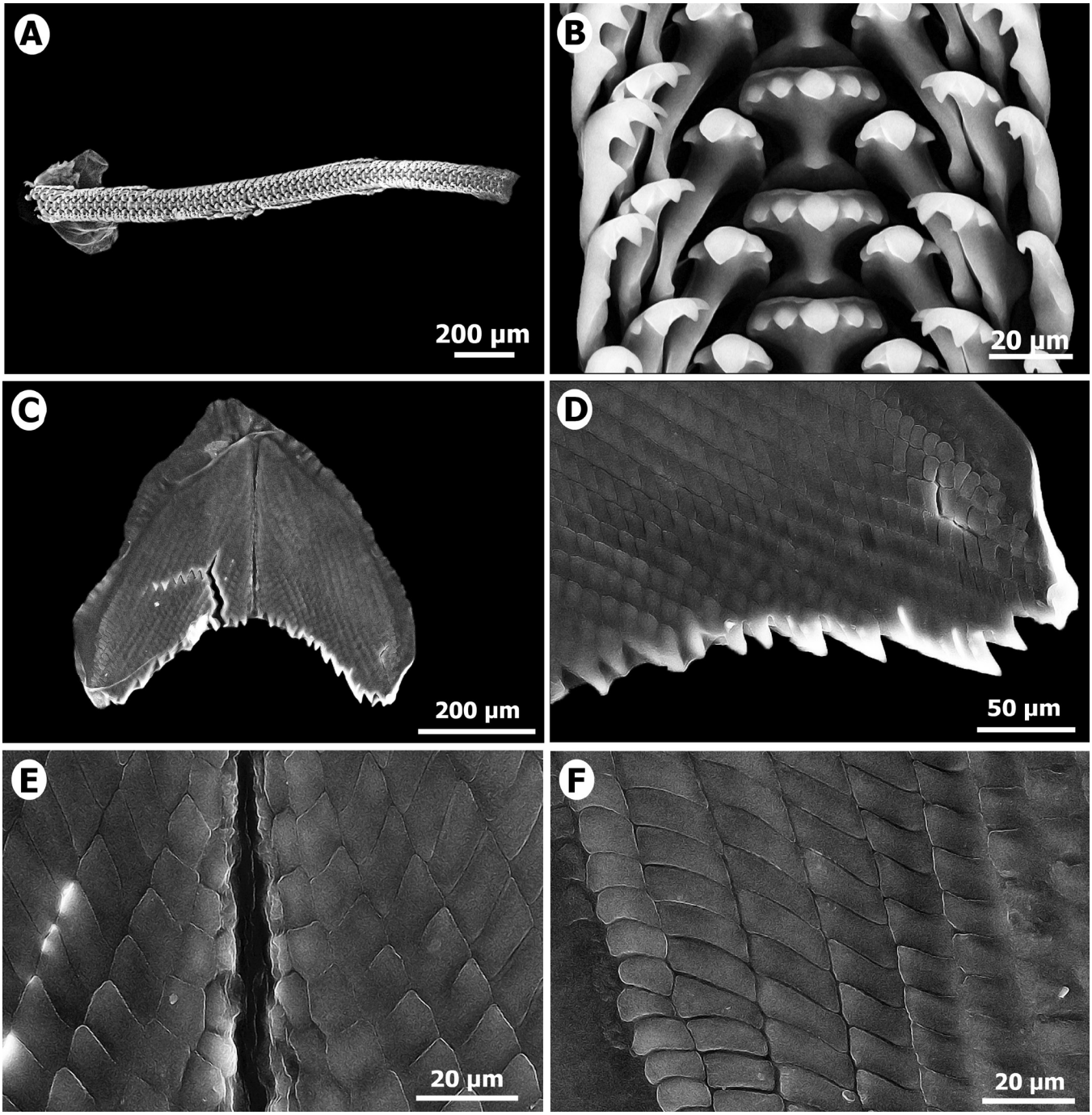

Figure 5. SEM images of radula and jaw *Dicharax devraivasi* n. sp. **A**, **B**, paratype (BNHS GAS 212): (**A**) whole radula; (**B**) portion of radula showing several rows of teeth. **C**–**F,** paratype (BNHS GAS 211): (**C**) jaw; (**D**) serrated cutting edges of jaw; (**E**) middle region of jaw showing regular to irregular rectangular plates; (**F**) right-side edge of jaw.

(5.65 ha in area); Shree Swayambhoo Temple, Shivdav Khurd, near Patgaon (2.28 ha); and Gangoba devasthan, Taliye Budruk, Gaganbawada (2.1 ha). All known localities of this species are in Kolhapur District, Maharashtra State (Fig. 1). The species occurs primarily in tropical semi-evergreen woodland patches (Fig. 6A, B). The new species was active both during the day and at night. At the type locality, new species was found in forest patches on both sides of the footpath that lead towards the temple (Fig. 6A, B), at the bases of trees, on the undersides of logs, on moss-covered rocks, in leaf litter on the forest floor; at Shree Swayambhoo Temple, Shivdav Khurd, a single individual was found in

Figure 6. Habitat of *Dicharax devraivasi* n. sp. **A**, forest at Ambeshwar Temple, Talavade, near Amba, Kolhapur District, Maharashtra, India (type locality). **B**, forest at Shree Swayambhoo Temple, Shivdav Khurd, near Patgaon Kolhapur District, Maharashtra, India.

leaf litter specifically on the right side of the temple steps; at Gangoba devasthan, Taliye Budruk, a single individual was collected from under rock surrounded by leaf litter. Live individuals were seen only in the monsoon and post-monsoon seasons, from July to October. The body of a live young individual (immature, not collected) was visible through its delicate, semi-transparent shell, and its tentacles were wholly pale yellow (Fig. 2C). Sympatric snails sighted at the type locality and other recorded localities of the new species include *Ariophanta* sp., *Cyathopoma* sp., *Cyclophorus* sp., *Eurychlamys* sp. *Glessula* sp., and *Nicida* sp.

Discussion

The genus *Dicharax* is characterised by the absence of spiral striations on the shell and typically has R2 ribs curved towards the aperture (Páll-Gergely *et al.* 2017; Aravind & Páll-Gergely 2018; Páll-Gergely *et al.* 2020). The three previously known south Indian species are provisionally assigned to *Dicharax* due to a lack of spiral striations but possess blunt, low ribs not curved in any direction, which is atypical of the genus according to Aravind & Páll-Gergely (2018) and Páll-Gergely *et al.* (2020). *Dicharax devraivasi* n. sp. is also placed in the atypical group based on the lack of spiral striations and curved R2 ribs. The new species occurs far north of its three geographically closest congeners, *D. bawai*, *D. expatriatus*, and *D. footei*, which are 600, 370, and 370 km away, respectively. This suggests the possibility that the large tracts of suitable, unexplored habitat both south and further north of the known localities of *D. devraivasi* n. sp. might have additional undescribed *Dicharax* species. *Dicharax devraivasi* n. sp. has so far been only recorded from a narrow elevational range (600–620 m a.s.l.), in contrast to other South Indian *Dicharax* species (700–1900 m a.s.l.).

The taenioglossate type radula of *Dicharax devraivasi* n. sp. has seven teeth (a rhachidian tooth pentacuspid, a lateral tooth tetracuspid, inner marginals tetracuspid and outer marginals tricuspid) in each row. This teeth arrangement similar to three typical *Dicharax* species, *D. cristatus* (Möllendorff, 1886), *D. depressus* (Bavay & Dautzenberg, 1912), and *D. fimbriatus* (Bavay & Dautzenberg, 1912), as illustrated by Páll-Gergely *et al.* (2017), and two atypical *Dicharax* species, *D. alticola* Páll-Gergely & Hunyadi, 2017 and *D. immaculatus* Páll-Gergely, 2017. The jaw of *D. devraivasi* n. sp. is sculptured with irregularly shaped, rectangular plates. The sculpture of jaw of a new species is similar to *Alycaeus eydouxi* Venmans, 1956, which was figured by Venmans (1956). However, this characteristic is also seen in *Theobaldius* species from the northern Western Ghats (Bhosale *et al.* 2025) and some *Cyclophorus* species from Thailand (Nantarat *et al.* 2014, 2019).

Dicharax devraivasi n. sp. is the 64th species of the genus reported from India and fourth from Peninsular India. It is also the first species of *Dicharax* to be reported and described from the northern Western Ghats, as well as from Maharashtra State. Thus, the new species extends the known distribution of the genus in the Western Ghats to the north by 370 km. Systematic sampling of invertebrates and smaller terrestrial vertebrates in the northern Western Ghats has resulted in the description of staggering 34 and 26 endemic species respectively in the last decade alone. Additionally, recent studies mainly on smaller vertebrates and invertebrates has demonstrated that the low diversity in the northern Western Ghats compared to the central and southern Western Ghats could be partially due to lack of systematic sampling in the region (Khandekar *et al.* 2019, 2021, 2024a, 2024b). This trend suggests that the low number of land snail species in the northern Western Ghats may be due to incomplete sampling in the region. Our ongoing project

on land snails of the northern Western Ghats of Maharashtra has already resulted in description of a new genus, and four species from the region over a short time (Bhosale *et al.* 2021a, 2021b, 2022, 2025). Large tracts of suitable and unexplored habitats, specifically north of Mahabaleshwar, remain to be surveyed. Extensive systematic sampling in these regions will certainly result in many more new species of land snails.

Dicharax devraivasi n. sp. is the second species of land snail described from sacred groves; the first was *Perrottetia rajeshgopali* Bhosale, Thackeray & Rowson, 2021. Sacred groves are patches of forest surrounding a temple and rich in their vegetation and associated biodiversity. For spiritual and religious purposes, sacred groves have been protected by local people. The groves are dedicated to local deities and harbour wild habitat outside the formally protected areas (Gadgil and Vartak 1975; Malhotra *et al.* 2001; Khan *et al.* 2008; Ray *et al.* 2014). There are about 100,000–150,000 sacred groves in India (Malhotra, 1998; Malhotra *et al.* 2007), but especially in the Central Indian Plateau, Coastal Region, Himalayan region, Western Ghats, Eastern Ghats, and Western Desert. The sacred groves of India exhibit a high concentration of rare and threatened species (Boraiah *et al.* 2001, 2003; Airi *et al.* 2000; Malhotra *et al.* 2001; Khumbongmayum *et al.* 2005; Ray 2011). In Maharashtra state, sacred groves are known as *Devrai*, *Dev-rahati*, *Devgudi*, etc. (Gadgil and Vartak, 1975; Malhotra *et al.* 2001), and a total of 2820 sacred groves are known, with the highest concentration in the northern Western Ghats, ranging with size from 0.1 ha to 60 ha. In recent years, several new species have been described from the sacred groves including a species of land snail (Bhosale *et al.* 2021b). India's sacred groves are threatened by deforestation, land-conversation to agriculture, increased fragmentation, introduction of invasive species, cattle grazing, collection of firewood, over-visitation by large numbers of worshippers and tourists, and the gradual loss of cultural beliefs (Malhotra *et al.* 2001; Ray *et al.* 2014; Patwardhan *et al.* 2021). These small, sacred groves are crucial in offering protection to biodiversity, and it is essential to acknowledge their significant contribution in this respect. There is an urgent need to estimate the hidden diversity of sacred groves and apply proper strategies to conserve and protect them.

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