

**Research article**

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**Eight new species of *Gulella* Pfeiffer, 1856 from the south-east coast of South Africa (Gastropoda: Streptaxidae)**

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**Abstract.** Eight new species of *Gulella* Pfeiffer, 1856 are described from south-eastern South Africa, occurring over a linear distance of 550 km within the Maputaland-Pondoland-Albany biodiversity hotspot. Seven species are narrow-range endemics, while *Gulella kenbrowni* sp. nov. occurs somewhat patchily over most of this distance. The very similar *G. fordycei* sp. nov. is recorded from only one small nature reserve in medium-altitude mistbelt forest. Six species, *G. crookesi* sp. nov., *G. maraisi* sp. nov., *G. mkombeni* sp. nov., *G. abbotti* sp. nov., *G. donaikeni* sp. nov. and *G. calcicola* sp. nov. each occur at one or a few isolated localities along a narrow strip of 140 km at or near the coast. The latter two are found only in the Marble Delta region, where mining has badly degraded and continues to threaten their habitat, and appear to meet the criteria for Red-Listing as Critically Endangered. Six species occur in nature reserves, highlighting the importance of small pockets of protected habitat for the conservation of terrestrial snails.

**Keywords.** Streptaxidae, new species, narrow-range endemism, priority conservation areas, Marble Delta hotspot, South Africa.

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## Introduction

*Gulella* Pfeiffer, 1856 is the most common and diverse genus of Streptaxidae in South Africa (Herbert & Kilburn 2004) and the majority are ground-dwelling, occurring in leaf-litter and under logs or rocks. Well over one hundred species have been described from the region, fifteen in the past 20 years (Herbert 2002, 2006, 2016; Bursey & Herbert 2004; Bruggen 2004, 2006; Cole & Herbert 2009), while a host of potentially new species have been earmarked for description. These recently described and potentially new species were probably overlooked in the past due to their rarity and very limited geographic ranges;

the majority are also very small. Eight species are treated herein as part of an ongoing effort to describe this undocumented diversity.

Most eastern South African *Gulella* species are referable to *Gulella* s. lat. (*sensu* Rowson & Herbert 2016), but this represents a conchologically diverse assemblage of species which, apart from a small number of lineage clusters (*Huttonella*, *Maurennea* and *Zulugulella*), shows little coherent substructure based on the limited molecular data available (Rowson & Herbert 2016). Several of the species described in this paper resemble each other in terms of their columella lamella morphology and complex, in-running labral plate, and may genuinely be related (e.g. *G. donaikeni*, *G. fordycei*, *G. kenbrowni* and *G. mkombeni*). However, although used in a recent synthesis of the Streptaxoidea (Brown 2021), we refrain from assigning our new species to subgenera. We consider it unlikely that the simplistic criteria upon which subgenera such as *Molarella* Connolly, 1922 and *Plicigulella* Pilsbry, 1919 are based (respectively a duplex and triplex columella lamella) will prove to reflect true phylogenetic relationships. Such decisions must await the availability of further molecular data.

This paper focuses on species with minute, smooth or weakly ribbed shells occurring primarily in the coastal hinterland of south-eastern South Africa, within the Maputaland-Pondoland-Albany biodiversity hotspot (Steenkamp *et al.* 2004). The majority, five species, have only been collected at isolated localities along a narrow strip of approx. 80 km, spanning the north-eastern limit of the Eastern Cape province and the southern section of KwaZulu-Natal province. This is a focal area of high diversity and narrow-range endemism in terrestrial molluscs (Herbert 2002; Burse & Herbert 2004; Herbert & Kilburn 2004; Cole 2019; Perera *et al.* 2021), but contains few formally protected reserves. By describing this undocumented diversity we hope to raise awareness of the importance of these habitats as priority areas for conservation. After formal description, these taxa will be assessed according to the IUCN Red List to evaluate whether they qualify for threatened status. Six species occur in small nature reserves, while three of these are each known exclusively from only one nature reserve, highlighting the importance of small protected areas in safeguarding the habitats of terrestrial invertebrates with limited capacity for dispersal.

## Material and methods

The material studied was derived primarily from the collection at the KwaZulu-Natal Museum and the East London Museum. This was accumulated over many years, but has been significantly augmented in the last two decades through a programme of field work targeting poorly-surveyed regions of South Africa. Live-collected samples were dried or obtained in a dry state from leaf-litter samples. In some instances whole specimens were preserved in 99% ethanol as tissue samples for on-going molecular studies, and are housed in the KwaZulu-Natal Museum tissue collection.

Shells were photographed using a Zeiss Axio Zoom V16 dissecting microscope with an Axiocam 506 digital camera or a Zeiss Discovery V12 dissecting microscope with an Axiocam 305 digital camera. Stacked images were then combined using Helicon Focus Pro (Helicon Soft Ltd) to provide extended depth of field.

Shell length and width measurements were made with the shell held in apertural view and the long axis horizontal. Holotypes were measured with the Line function of the Graphics menu available in the ZEN ver. 2.3 pro Hardware used with the Zeiss Discovery V12 dissecting microscope and rounded off to two decimal places. Other specimens were measured using an eyepiece graticule. Shell length:width ratios were calculated and the number of protoconch and teleoconch whorls were counted. The sizing guide of Herbert & Kilburn (2004) was followed.

Live-taken specimens and shells of dead specimens still in good condition were assigned as paratypes and distributed among five museums, two in South Africa and three in Europe. Shells in poor condition are listed under 'Other material' except in the case of *Gulella maraisi* sp. nov. where some fresh specimens were not included in the type material due to minor differences.

A catalogue number preceded by "prev." indicates that the specimen(s) was initially recorded in that museum and was transferred to the museum where it is currently housed.

### **Institutional abbreviations**

EKZNW	=	Ezemvelo KwaZulu-Natal Wildlife
ELM	=	East London Museum, East London, South Africa
NHMUK	=	Natural History Museum, London, United Kingdom
NMSA	=	KwaZulu-Natal Museum, Pietermaritzburg, South Africa
NMW	=	National Museum of Wales, Cardiff, United Kingdom
RMNH	=	Naturalis Biodiversity Centre, Leiden, the Netherlands

### **Results**

Class Gastropoda Cuvier, 1795  
Subclass Heterobranchia Burmeister, 1837  
Order Stylommatophora A. Schmidt, 1855  
Family Streptaxidae Gray, 1860  
Genus *Gulella* Pfeiffer, 1856

*Gulella kenbrowni* sp. nov.

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Figs 1A–D, 2

### **Diagnosis**

Shell minute, cylindrical; smooth and glossy; aperture sub-quadrate; apertural dentition seven-fold, including a parietal lamella, a large labral complex extending deeply into aperture with ridge-like upper and lower margins and hollow in centre, a low, inset transverse basal tooth to right of centre, a stronger inset basal tooth to left of centre and a large tricuspid columella lamella with two strong ridge-like teeth, and a smaller tooth below these; umbilicus widely open.

### **Etymology**

Named for Kenneth Brown, long-standing member of the Conchological Society of South Africa, and with a particular interest in Streptaxoidea.

### **Material examined**

#### **Holotype**

SOUTH AFRICA – **Eastern Cape** • Umtiza Nature Reserve, Tree Dassie Trail, East side of Buffalo Pass; 33.0144° S, 27.8081° E; 21 Apr. 2006; M. Bursey leg.; NMSA P1678/T4524, prev. ELMD 14909.

#### **Paratypes** (listed from west to east)

SOUTH AFRICA – **Eastern Cape** • 1 spec.; same collection data as for holotype; NMW.Z.2021.011.00004, prev. ELMD 14909 • 1 spec.; same collection data as for preceding; 8 Apr. 2002; M. Bursey leg.; NHMUK 20210065, prev. ELMD 13854 • 4 specs.; East London; 33.00° S, 27.93° E; J. Farquhar collection; ELMD 13413/T 209, prev. NMSA E8144 • 2 specs.; same collection data as for preceding; NHMUK 20210066, prev. ELMD 13413 • 2 specs.; Nxaxo Forest, secondary dune forest; 32.5683° S,

28.5416° E; 19 Feb. 2008; M. Cole leg.; ELMD 15770/T 210 • 1 spec.; same collection data as for preceding; RMNH.MOL.452584, prev. ELMD 15770 • 1 spec.; Nxaxo, forest West of river mouth; 32.5945° S, 28.5158° E; 21 Feb. 2008; M. Cole leg.; ELMD 15786/T 211 • 3 specs.; Ngqara, between Cebe and Mazeppa Bay, riverine forest 300 m upstream of mouth; 32.4902° S, 28.6128° E; 30 Mar. 2004; M. Bursey leg.; ELMD 13718/T 212 • 9 specs.; Mcelwana, between Cebe and Mazeppa Bay, dune forest on East bank of estuary; 32.4985° S, 28.6044° E; 15 Apr. 2005; M. Bursey leg.; ELMD 15329/T 213 • 1 spec.; Dwesa Nature Reserve, dune forest West of Kobola estuary; 32.3029° S, 28.8365° E; 1 Oct. 2017; M. Cole leg.; ELMD 18310/T 214 • 5 specs.; Cwebe Nature Reserve, East side of Mbashe River, vicinity of Mbhanyana Falls; 32.2206° S, 28.9079° E; 4 Feb. 2004; M. Bursey leg.; ELMD 13889/T 215 • 2 specs.; same collection data as for preceding; NMW.Z.2021.011.00005, prev. ELMD 13889 • 2 specs.; Cwebe Nature Reserve, East side of Mbashe River, vicinity of Mbhanyana Falls; 32.2206° S, 28.9079° E; 26 Oct. 2004; M. Bursey leg.; RMNH.MOL.452582, prev. ELMD 13889. **KwaZulu-Natal** • 6 specs.; Mtamvuna Gorge, Lourie Trail, riverine scarp forest, stn 11-08; 31.0563° S, 30.1689° E; 40 m a.s.l.; 13 Apr. 2011; D. Herbert, L. Davis, M. and Cole, R. Daniels leg.; NMSA W7906/T4480 • 2 specs.; same locality as for preceding; ELMD 18751/T 216, prev. NMSA W7906 • 3 specs.; same collection data as for preceding; 27 Dec. 2002; D. Herbert leg.; NMSA W679/T4472 • 2 specs.; Ngele Forest, mist-belt Podocarpus forest; 30.54° S, 29.65° E; ±1350 m a.s.l.; 14 Nov. 1995; D. Herbert and L. Davis leg., in leaf-litter sample; NMSA V5186/T4476 • 12 specs.; Trafalgar area, Mpenjati Nature Reserve, Yengele Trail, dune forest; 30.9691° S, 30.2820° E; 7 m a.s.l.; 28 Dec. 2002; D. Herbert leg.; NMSA W379/T4474 • 1 spec.; same collection data as for preceding; ELMD 18752/T 217, prev. NMSA W379 • 2 specs.; same collection data as for preceding; NHMUK 20210072, prev. NMSA W379 • 2 specs.; same collection data as for preceding; NMW.Z.2021.012.00001, prev. NMSA W379 • 2 specs.; same collection data as for preceding; RMNH.MOL.452583, prev. NMSA W379 • 1 spec.; same collection data as for preceding; NMSA W7443/T4475 • 3 specs.; Umdoni Nature Reserve, coastal forest, 30.39° S, 30.67° E; 28 Oct. 2001; C. Symes leg.; NMSA W857/T4482.

**Other material** (listed from west to east)

SOUTH AFRICA – **Eastern Cape** • 2 specs.; same collection data as for holotype; ELMD 14909 • 1 spec.; same collection data as for preceding; 8 Apr. 2002; M. Bursey leg.; ELMD 13854 • 2 specs.; East London Golf Club, dune forest; 32.9986° S, 27.9395° E; ±60 m a.s.l.; 3 Sep. 2007; M. Cole leg.; ELMD 15582 • 3 specs.; Ocean View Farm, Mpetu Hill; 32.6481° S, 28.0939° E; ±430 m a.s.l.; 3 Mar. 2005; M. Bursey leg.; ELMD 15308 **KwaZulu-Natal** • 1 spec.; Mtamvuna Gorge, Lourie Trail, riverine scarp forest, stn 11-08; 31.0563° S, 30.1689° E; 40 m a.s.l.; 13 Apr. 2011; D. Herbert, L. Davis, M. Cole and R. Daniels leg.; NMSA P1611, prev. NMSA W7906 • 2 specs.; Trafalgar area, Mpenjati Nature Reserve, Yengele Trail, dune forest; 30.9691° S, 30.2820° E; 7 m a.s.l.; 19 Dec. 1997; K. Cradock leg.; NMSA V6811 • 4 specs.; same collection data as for preceding; 28 Dec. 2002; D. Herbert leg.; NMSA P1609, prev. NMSA W379.

**Description**

SHELL (Fig. 1). Shell minute, cylindrical, length 1.9–2.4 mm, width 0.8–1.0 mm, L:W 2.0–2.5 (n = 25); smooth and glossy but with indistinct, microscopic growth lines. Protoconch approx. 0.8 mm in diameter, comprising approx. 2.25 whorls, smooth; junction between protoconch and teleoconch not distinct. Teleoconch comprising approx. 3.5 whorls; first two whorls roundly convex, subsequent ones more weakly convex (Fig. 1A–B). Aperture sub-quadrate, rounded at base, markedly constricted by teeth; peristome thickened and reflected, broadly interrupted in parietal region; dentition seven-fold (Fig. 1C): 1) a strong parietal lamella, outer portion oblique and then curving inward so that the remainder runs into aperture more or less at right angles; outer portion fuses smoothly with outer lip; 2) a large labral slab extending deeply into aperture, with a sharp upper margin beginning with a cusp near lip edge defining lower part of labral sinus and running into aperture more or less parallel to parietal lamella, and a blunt ridge on its lower margin not reaching lip edge; 3) a low, deeply inset transverse basal tooth just

to right of centre; 4) a less deeply inset, stronger, in-running, somewhat ridge-like, basal tooth to left of centre; 5–7) a large columella lamella with three teeth, middle and upper ones strong, with a shorter tooth below these at its base; middle tooth largest and ridge-like often curving downwards as it runs into aperture and appearing concave on its lower surface. Labral slab corresponds with a fairly shallow indentation behind outer lip (Fig. 1B). Umbilicus widely open, elongate-oval, with a deep indentation underlying columella lamella; umbilical margin with axial pleats, often irregular and rather indistinct (Fig. 1D). Shell almost transparent when fresh, orange-red or yellowish coloration of dried tissue of animal visible internally.

### **Distribution** (Fig. 2)

Recorded on the coast of the Eastern Cape from East London northwards and in southern KwaZulu-Natal, where it is also recorded inland in the Kokstad area (1350 m a.s.l.). The latter locality is somewhat unexpected since the species is usually collected in close proximity to the coast.

### **Habitat**

Coastal forest, including several classification types: Southern Coastal Forest, Scarp Forest, Transkei Dune Forest, Indian Ocean Coastal Belt (Mucina & Geldenhuys 2006; von Maltitz *et al.* 2003) and Southern Mistbelt Forest (Ngele near Kokstad) (Mucina & Geldenhuys 2006); in leaf-litter and under logs.

### **Remarks**

*Gulella kenbrowni* sp. nov. has been treated as *G. sylvia* (Melvill & Ponsonby, 1903) (Herbert & Kilburn 2004), although it was noted that Transkei and southern KwaZulu-Natal material might turn out to be a separate, unnamed species upon further study. *Gulella kenbrowni* sp. nov. resembles *G. bomvana* Cole & Herbert, 2009, which occupies a small area within the range of *G. kenbrowni* sp. nov., but the latter is larger, its basal tooth is further to the left of centre, and its umbilicus is widely open. *Gulella kenbrowni* sp. nov. also closely resembles *G. fordycei* sp. nov. described below; differences are discussed thereunder. The labral slab resembles that of *Gulella tietzae* Cole & Herbert, 2009, but it is smaller than that of both *G. bomvana* and *G. tietzae*.

### **Conservation**

*Gulella kenbrowni* sp. nov. occurs over a relatively wider range than the other species described in this paper and many other South African Streptaxidae (Herbert & Kilburn 2004; Bursey & Herbert 2004; Cole & Herbert 2009). There are several small nature reserves within its range, but uncontrolled human access and trampling by cattle are commonplace. Forests in this region remain habitats of conservation concern.

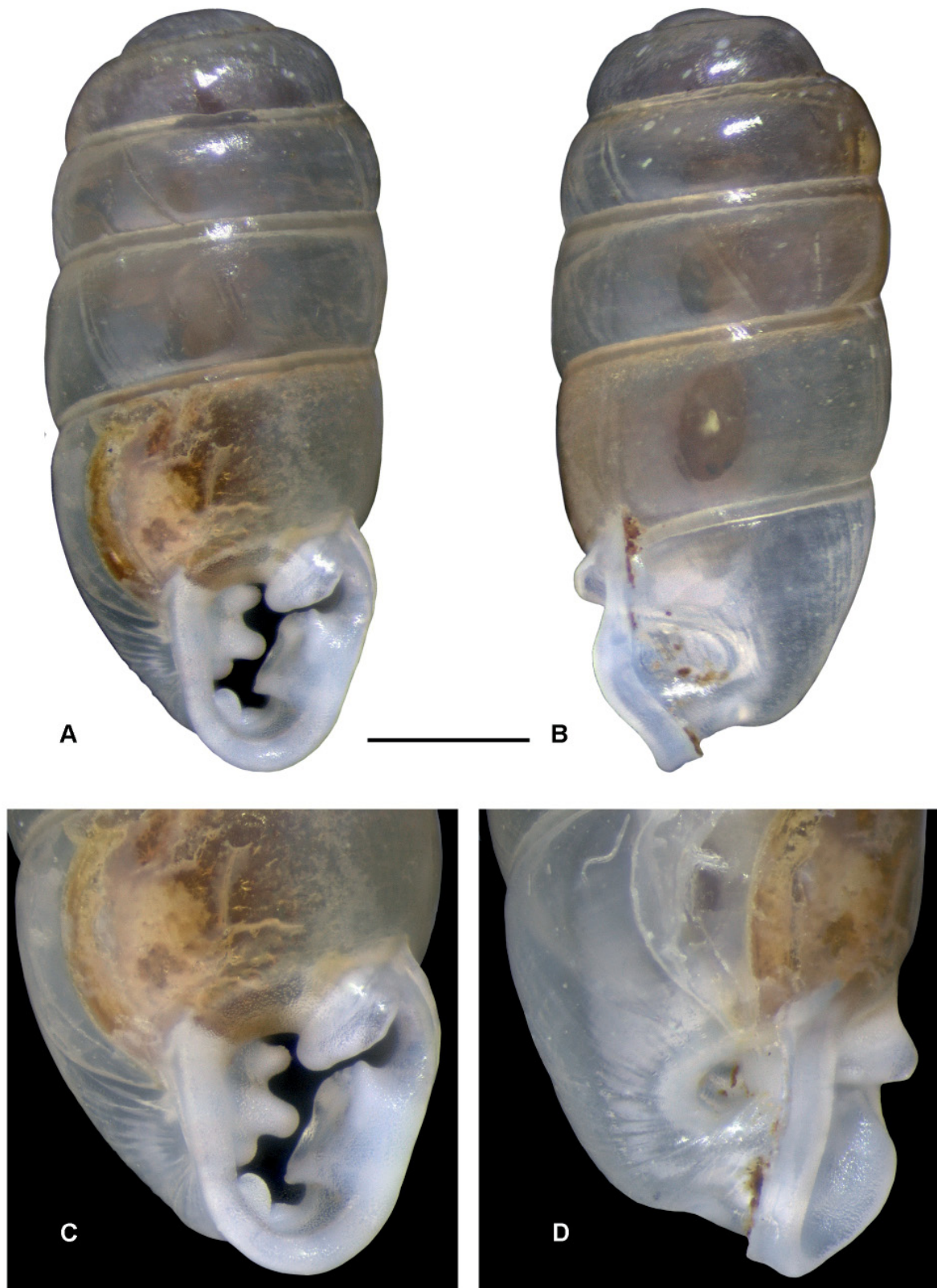
### *Gulella fordycei* sp. nov.

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Figs 2, 3A–D

### **Diagnosis**

SHELL minute, cylindrical; smooth and glossy, but with weak axial riblets below suture; apertural dentition seven-fold, including a sinuous parietal lamella, a large labral complex extending deeply into aperture with ridge-like upper and lower margins and a groove in centre, a low, deeply inset transverse basal tooth to right of centre, a ridge-like basal tooth to left of centre beginning close to lip edge and a large inset tricuspid columella lamella; umbilicus widely open.



**Fig. 1.** *Gulella kenbrowni* sp. nov., holotype (NMSA P1678/T4524), length 2.20 mm, width 0.95 mm. **A.** Aperture view. **B.** Side view. **C.** Oblique view into aperture. **D.** Oblique view of base showing umbilicus. Scale bar = 0.5 mm.

**Etymology**

Named after the type locality, Fort Fordyce.

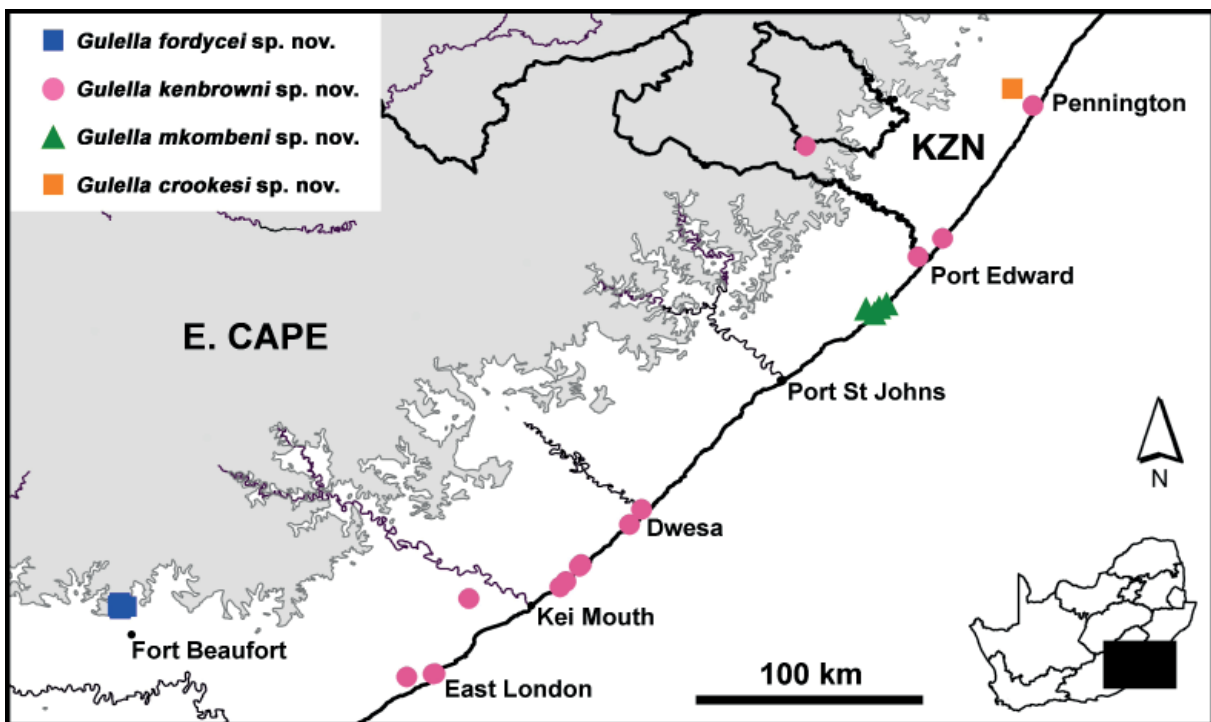
**Material examined**

**Holotype**

SOUTH AFRICA – **Eastern Cape** • Fort Fordyce Nature Reserve, kloof with watercourse and sheer krantz; 32.6881°S, 26.5130°E; 915 m a.s.l.; 31 Mar. 2016; M. Cole leg.; NMSA P1679/T4525, prev. ELMD 18109.

**Paratypes**

SOUTH AFRICA – **Eastern Cape** • 4 specs.; Fort Fordyce Nature Reserve, near Harris Hut; 32.6834°S, 26.4767°E; 1072 m a.s.l.; 5 Oct. 2009; M. Cole leg.; ELMD 16088/T 218 • 2 specs.; Fort Fordyce Nature Reserve, south-facing slope behind lookout; 32.6956°S, 26.4857°E; 1120 m a.s.l.; 3 Jan. 2010; M. Cole leg.; ELMD 16317/T 219 • 2 specs.; same collection data as for preceding; NMSA P1616/T4498, prev. ELMD 16317 • 2 specs.; same collection data as for preceding; NMW.Z.2021.011.00002, prev. ELMD 16317 • 6 specs.; Fort Fordyce Nature Reserve, kloof with watercourse and sheer krantz; 32.6881°S, 26.5130°E; 915 m a.s.l.; 29 Dec. 2008; M. Cole leg.; ELMD 16377/T 220 • 2 specs.; same collection data as for preceding; RMNH.MOL.452585, prev. ELMD 16377 • 3 specs.; same collection data as for preceding; 6 Oct. 2009; ELMD 16073/T 221 • 1 spec.; same collection data as for preceding; NHMUK 20210067, prev. ELMD 16073 • 3 specs.; same collection data as for preceding; 17 Jan. 2015; ELMD 17842/T 222 • 3 specs.; same collection data as for preceding; NMSA P1615/T4497, prev. ELMD 17842 • 1 spec.; same collection data as for preceding; NHMUK 20210068, prev. ELMD 17842 • 2 specs.; Fort Fordyce Nature Reserve, between Harris Hut and dam; 32.6825°S, 26.4794°E; 1117 m a.s.l.; 18 Jan. 2015; M. Cole leg.; ELMD 17864/T 223.



**Fig. 2.** Distribution map of *Gulella kenbrowni* sp. nov. (pink circles), *G. fordycei* sp. nov. (blue squares), *G. mkombeni* sp. nov. (green triangles) and *G. crookesi* sp. nov. (orange square). Contour at 1000 m.

### Other material

SOUTH AFRICA– **Eastern Cape** • 2 specs.; Fort Fordyce Nature Reserve, kloof with watercourse, east-facing; 32.6704° S, 26.4851° E; 1137 m a.s.l.; 29 Dec. 2008; M. Cole leg.; ELMD 16083 • 2 specs.; Fort Fordyce Nature Reserve, south-facing slope behind lookout; 32.6956° S, 26.4857° E; 1120 m a.s.l.; 30 Dec. 2008; M. Cole leg.; ELMD 16085.

### Description

SHELL (Fig. 3). Shell minute, cylindrical, length 2.2–2.5 mm, width 1.0–1.1 mm, L:W 2.1–2.3 (n = 6). Protoconch approx. 1 mm in diameter, comprising approx. 2.25 whorls, smooth and glossy; junction between protoconch and teleoconch evident. Teleoconch comprising approx. 3.5–4 whorls; first whorl convex, remaining ones weakly so; weak axial riblets extend more or less half-way down each whorl, stronger immediately below sutures (Fig. 3B). Aperture sub-quadrate, rounded basally, markedly constricted by teeth; peristome thick and reflected, broadly interrupted in parietal region; dentition eight-fold (Fig. 3C): 1) a strong parietal lamella with inner portion which runs into aperture somewhat sinuous, outer portion curving to right; parietal lamella projects well beyond profile of aperture in side view; 2) a large labral slab extending into aperture beyond columella lamella (in apertural view), with ridges on its upper and lower margins, bordering a V-shaped central groove, upper ridge sharp with a cusp near lip edge in close proximity to parietal lamella; 3) a low, deeply inset transverse basal tooth to right of centre; 4) an in-running basal ridge to left of centre beginning near lip edge; 5–7) a large columella lamella with three teeth, upper two ridge-like and lowest one small, sometimes little more than a low bulge, middle one largest and extending closer to lip edge. Labral slab corresponds with a deep pit behind outer lip (Fig. 3B); basal ridge with a shallow indentation behind lip. Umbilicus widely open, elongate-oval, with a deep indentation underlying columella lamella, indistinct axial pleats around umbilicus (Fig. 3D). Shell almost transparent when fresh, orange-red coloration of dried tissue of animal visible internally.

### Distribution (Fig. 2)

Endemic to the Fort Fordyce Nature Reserve, considered part of the Amathole Mountains; at altitudes between 900 m and 1150 m above sea level.

### Habitat

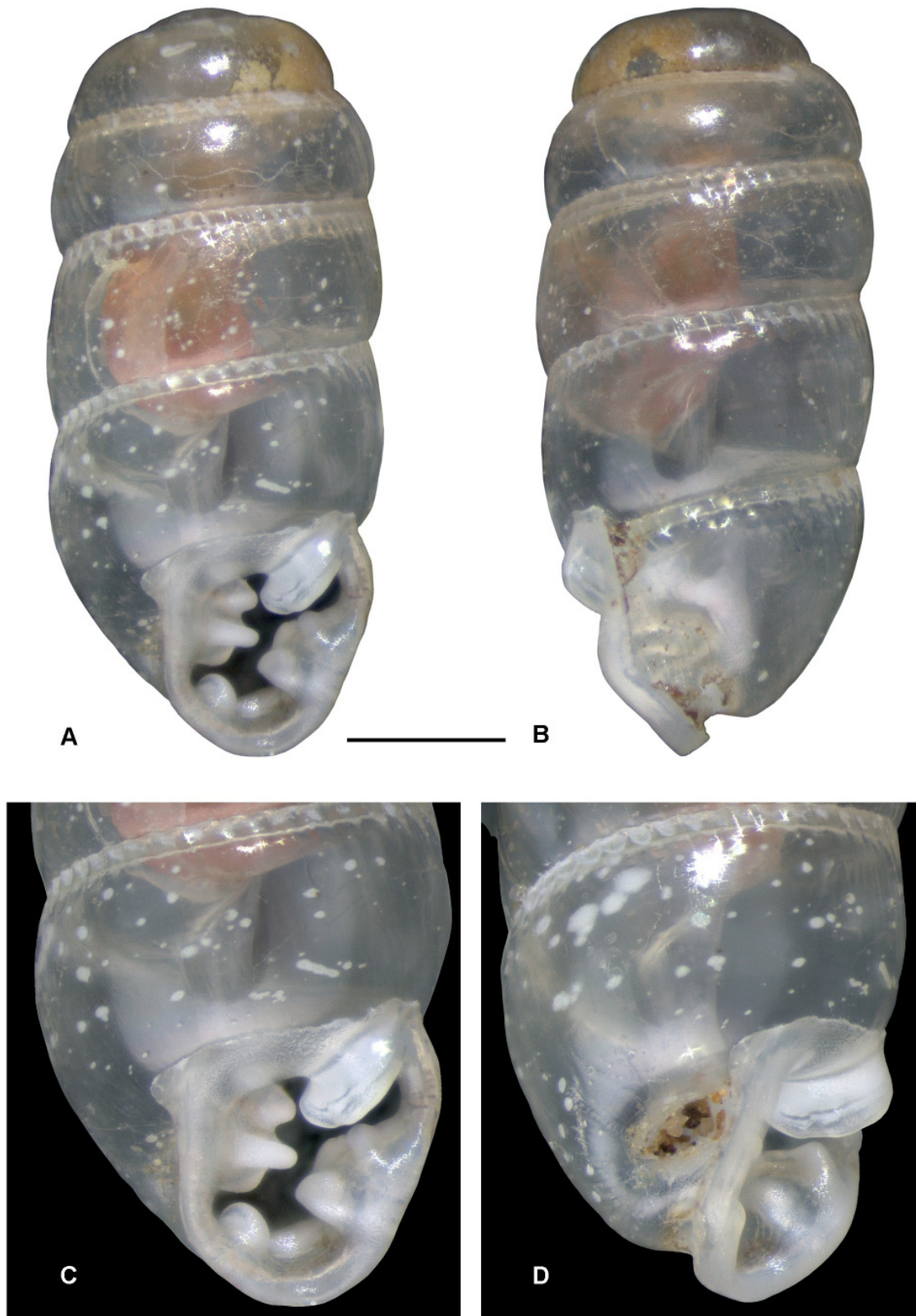
Amathole Mistbelt Forest (Southern Mistbelt Forest group) (von Maltitz *et al.* 2003); in leaf-litter and under logs.

### Remarks

*Gulella fordycei* sp. nov. is very similar to *G. kenbrowni* sp. nov. except that it has weak subsutural riblets and is larger (mean length 2.3 mm and 2.1 mm, respectively). The parietal lamella does not run parallel to the upper ridge of the labral slab, but the lowest point of its edge is in close proximity to the labral slab in the vicinity of the cusp. The labral complex is slightly differently shaped; the ridges of the labral slab have a V-shaped groove between them in *G. fordycei* sp. nov. The basal ridge to left of centre commences close to the lip edge and causes a shallow external furrow behind the lip, absent in *G. kenbrowni* sp. nov. In addition, the ridge-like middle tooth of the columella lamella is closer to the columella lip. Compared to other species described herein, the protoconch of *G. fordycei* sp. nov. is large relative to the size of its shell.

The labral slabs of *Gulella fordycei* sp. nov. and *G. kenbrowni* sp. nov. closely resemble those of *G. bomvana* and *G. tietzae* from the Eastern Cape coast and several narrow-range species endemic to Zululand, *G. genialis* (Melvill & Ponsonby, 1903), *G. laevorsa* Burnup, 1925 and *G. vallaris* (Melvill & Ponsonby, 1907) (see *Gulella* Group 9 in Herbert & Kilburn 2004). These Zululand species, however, all possess strong axial riblets running from suture to suture. The tricuspid





**Fig. 3.** *Gulella fordycei* sp. nov., holotype (NMSA P1679/T4525), length 2.34 mm, width 1.06 mm. **A.** Aperture view. **B.** Side view. **C.** Oblique view into aperture. **D.** Oblique view of base showing umbilicus. Scale bar = 0.5 mm.

columella lamella of *G. fordycei* sp. nov. and *G. kenbrowni* sp. nov. closely resembles that of *G. bomvana* and several other smooth-shelled *Gulella* species from the Eastern Cape coast with a tricuspid columella, *Gulella aprosdoketa* Connolly, 1939, *G. tietzae* and *G. ndibo* Cole & Herbert, 2009, but in the latter three species the columella lamella extends to the lip edge.

### Conservation

*Gulella fordycei* sp. nov. has been found only at Fort Fordyce Nature Reserve, an outlier of the Amathole Mountains, despite extensive collecting efforts throughout the region. It therefore appears to be a very narrow-range endemic. Fort Fordyce is a protected area under the jurisdiction of the Eastern Cape Parks and Tourism Agency. It is known for endemism of other terrestrial molluscs, viz. *Amatholedonta fordycei* Herbert, 2020 (Charopidae) and an undescribed species of *Fauxulus (Anisoloma)* (Fauxulidae). Furthermore, specimens of another litter-dwelling invertebrate, the velvet worm *Peripatopsis sedgwicki* (Purcell, 1899) from Fort Fordyce were genetically and morphologically distinct, suggesting the presence of a novel lineage at Fort Fordyce (Daniels *et al.* 2017).

### *Gulella mkombeni* sp. nov.

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Figs 2, 4A–D

### Diagnosis

Shell minute, cylindrical; smooth and glossy; apertural dentition seven-fold, including a parietal lamella with a notch in its lower margin, a large labral complex extending deeply into aperture with ridge-like upper and lower margins bounding a broad sunken mid region, a low, inset transverse basal tooth to right of centre, an inset oblique ridge-like basal tooth to left of centre and a columella lamella set with two ridge-like teeth, the lower stronger and extending to near lip edge; umbilicus widely open with distinct peri-umbilical pleats.

### Etymology

Xhosa for ‘place of the ikomba palm’, or Pondo palm (*Jubaeopsis caffra* Becc.), another of the several species narrowly endemic to the Mkambati Nature Reserve and immediate vicinity.

### Material examined

#### Holotype

SOUTH AFRICA – **Eastern Cape** • Mkambati Nature Reserve, “Superbowl” Forest, 5 km upstream of Msikaba River mouth, East side of Msikaba River, below steep krantzies along rim of bowl; 31.2978°S, 29.9293°E; 5 Mar. 2001; D. Herbert leg.; NMSA P1674/T4518.

#### Paratypes

SOUTH AFRICA – **Eastern Cape** • 1 spec.; same collection data as for holotype; NMSA V8921/T4479 • 1 spec.; same collection data as for preceding; NMW.Z.2021.012.00002, prev. NMSA V8921 • 1 spec.; same collection data as for preceding; M. Bursey leg.; ELMD 13693/T 224 • 1 spec.; same collection data as for preceding; NHMUK 20210069, prev. ELMD 13693 • 1 spec.; same collection data as for preceding; NMW.Z.2021.011.00001, prev. ELMD 13693 • 1 spec.; same locality as for preceding, prev. litter; 7 Mar. 2001; M. Bursey leg.; ELMD 14257/T 225 • 1 spec.; same locality as for preceding; 18 Oct. 2005; M. Bursey leg.; ELMD 15588/T 226 • 6 specs.; Mkambati Nature Reserve, Gwe Gwe Forest; 31.2904°S, 29.9897°E; 4 Mar. 2004; D-J. Hodgkinson leg.; ELMD 14258/T 227 • 1 spec.; Mkambati Nature Reserve, East bank of Mkambati River, between Mkambati and Strandloper waterfalls; 31.2738°S, 30.0236°E; 17 Mar. 2019; M. Cole leg.; ELMD 18473/T 228 • 1 spec.; same collection data as for preceding; NHMUK 20210070, prev. ELMD 18473 • 1 spec.; same collection

data as for preceding; RMNH.MOL.452586, prev. ELMD 18473 • 2 specs.; Mkambati Nature Reserve; 31.2734° S, 30.0233° E; 10 m a.s.l.; 27 Jan. 2008; Earthwatch ECMF13 leg.; NMSA W6462/T4481; • 1 spec.; same collection data as for preceding; RMNH.MOL.452587, prev. NMSA W6462 • 1 spec.; Mkambati Nature Reserve; 31.2980° S, 29.9283° E; 186 m a.s.l.; 31 Jan. 2008; Earthwatch ECMF26 leg.; NMSA W6470/T4478 • 1 spec.; Mkambati Nature Reserve; 31.3171° S, 29.9676° E; 28 m a.s.l.; 28 Jan. 2008; Earthwatch ECMF11 leg.; NMSA W6438/T4523 • 1 spec.; Mkambati Nature Reserve; 31.2903° S, 29.9903° E; 50 m a.s.l.; 26 Jan. 2008; Earthwatch ECMF11; NMSA W6443/T4477.

### Other material

SOUTH AFRICA—**Eastern Cape** • 3 specs.; NMSA P1610 ex NMSA V8921 • 1 spec.; Mkambati Nature Reserve; East bank of Mkambati River, between Mkambati and Strandloper waterfalls; 31.2738° S, 30.0236° E; 15 Feb. 2011; M. Cole leg.; ELMD 18753 • 1 spec.; Mkambati Nature Reserve; 31.2734° S, 30.0233° E; 10 m a.s.l.; 27 Jan. 2008; Earthwatch ECMF13 leg.; NMSA P1612, prev. NMSA W6462 • 1 spec.; Mkambati Nature Reserve; 31.3171° S, 29.9676° E; 28 m a.s.l.; 28 Jan. 2008; Earthwatch ECMF11 leg.; NMSA P1677, prev. NMSA W6438.

### Description

**SHELL** (Fig. 4). Shell minute, cylindrical, length 2.3–2.7 mm, width 1.0–1.3 mm, L:W 2.0–2.4 (n = 16); smooth and glossy with microscopic growth lines. Protoconch approx. 0.7 mm in diameter, comprising approx. 2.25 whorls, smooth; junction between protoconch and teleoconch not distinct. Teleoconch comprising approx. 4 whorls; first two whorls roundly convex, subsequent ones weakly convex (Fig. 4A, B). Aperture sub-quadrate, rounded at base, markedly constricted by teeth; peristome thickened and reflected; dentition seven-fold (Fig. 4C): 1) an oblique parietal lamella usually with a notch in its lower margin; 2–3) a large labral complex extending deeply into aperture; a ridge on lip edge more or less in centre of labral complex curves upwards and outwards and continues inwards as a sharp upper margin, a small cusp near lip edge defines lower part of labral sinus; lower margin of labral complex more rounded and does not reach lip edge, becoming narrower further into aperture; upper and lower ridges do not quite meet at inner end of labral slab; between ridges is a wide, sunken area; 4) a low, deeply inset transverse basal tooth to right of centre; 5) an inset oblique ridge-like basal tooth to left of centre which runs inwards and upwards beneath columella lamella; 6–7) a large columella lamella set with two ridge-like teeth, the lower one larger, almost reaching lip edge. Labral complex corresponds with a shallow indentation behind outer lip (Fig. 4B); basal tooth to left of centre corresponds with an external furrow (Fig. 4D). Umbilicus widely open with a deep indentation underlying columella lamella, peri-umbilical region with distinct axial pleats (Fig. 4D). Shell almost transparent when fresh, orange-red coloration of dried tissue of animal visible internally.

### Distribution (Fig. 2)

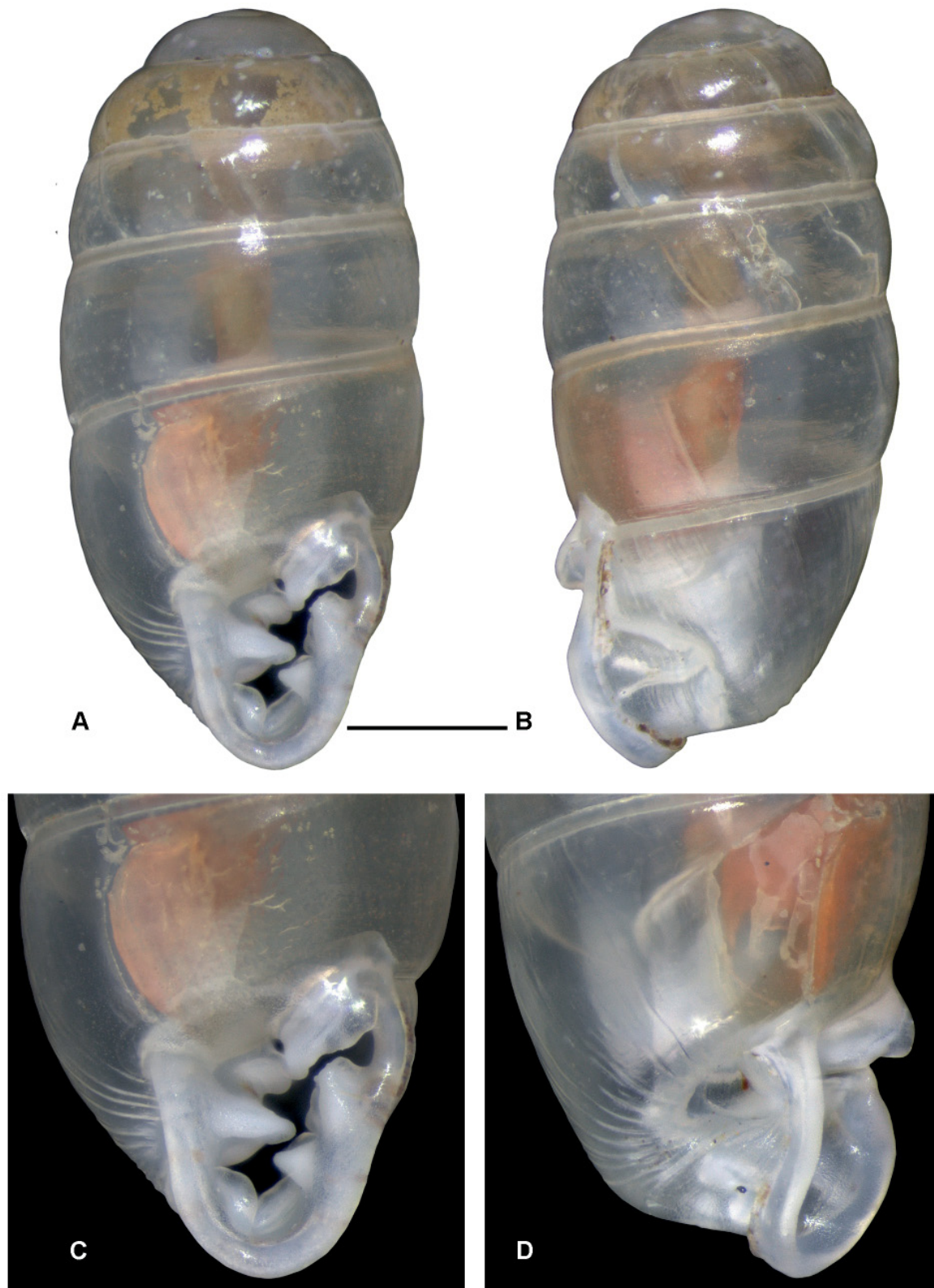
Recorded only from the Mkambati Nature Reserve in Pondoland on the north-eastern coast of the Eastern Cape.

### Habitat

Pondoland Scarp Forest (Mucina *et al.* 2018a; von Maltitz *et al.* 2003); in leaf-litter and under logs.

### Remarks

*Gulella mkombeni* sp. nov. closely resembles *G. kenbrowni* sp. nov. which occurs to the north and south of the Mkambati Nature Reserve, but has not been recorded in the reserve itself. *Gulella mkombeni* sp. nov. is distinguished by the ridge-like lower tooth on the columella lamella which extends much closer to the lip edge. Other differences are that it is larger, the upper and lower margins of the labral complex do not meet within the aperture, the parietal lamella usually has a notch in its lower



**Fig. 4.** *Gulella mkombeni* sp. nov., holotype (NMSA P1674/T4518), length 2.45 mm, width 1.14 mm. A. Aperture view. B. Side view. C. View into aperture. D. Oblique view of base showing umbilicus. Scale bar = 0.5 mm.

margin, and the peri-umbilical region is more strongly pleated. Additionally, the basal tooth to the left of centre is longer, extending beneath the columella lamella. The columella lamella is also reminiscent of that of *G. tietzae*, *G. ndibo* and *G. aprosdoketa*, in which the columella lamella extends to the lip edge, but in these three species it is tricuspid.

### Conservation

*Gulella mkombeni* sp. nov. is to date known only from the Mkambati Nature Reserve, despite reasonable collecting efforts along the coast of the Eastern Cape and KwaZulu-Natal. Other taxa also occur only in Mkambati, e.g., *G. newmani* Bursey & Herbert, 2004. This region, known as Pondoland, has been shown to be an important centre of cladogenic events in rhytidid molluscs (Herbert & Moussalli 2010; Moussalli *et al.* 2009). Pondoland Scarp Forests are known for their diversity and endemism of plants (van Wyk & Smith 2001; Mucina *et al.* 2018a) and molluscs (Herbert & Kilburn 2004; Bursey & Herbert 2004; Herbert & Moussalli 2010; Cole & Herbert 2009; Cole 2019). Mkambati is the only officially protected section of this region, under the authority of the Eastern Cape Parks and Tourism Agency. Many of the remaining Pondoland Scarp Forests are under threat and deserve protection (Mucina *et al.* 2018a). The small Mkambati Nature Reserve appears relatively better protected than other small reserves on the Eastern Cape coast due to a buffer zone between local communities and the reserve. This hotspot of biodiversity and endemism extends into southern KwaZulu-Natal and includes two other small reserves, the Mtamvuna Nature Reserve and Oribi Gorge Nature Reserve, but *G. mkombeni* sp. nov. has not been found outside Mkambati.

### *Gulella donaikeni* sp. nov.

urn:lsid:zoobank.org:act:1AB31B08-9507-4F43-9560-87DAC90A52C5

Figs 5A–D, 6A–B

### Diagnosis

Shell minute, cylindrical; smooth and glossy; apertural dentition seven-fold, including a parietal lamella with outer portion oblique and then curving inward, the labral lip is thickened with a cusp at upper and lower ends and a large scoop-shaped plate extending deeply into aperture, a low, inset transverse basal tooth to right of centre, an inset basal tooth to left of centre and a large columella lamella with two rounded teeth, the lower large and broad and the upper relatively small; umbilicus widely open.

### Etymology

Named for Don W. Aiken (1930–1988), an enthusiastic collector of South African land snails and author of two important publications dealing with South African Streptaxidae (Aiken 1981, 1995).

### Material examined

#### Holotype

SOUTH AFRICA – **KwaZulu-Natal** • Port Shepstone area, Marble Delta, Simuma Hill, scarp forest; 30.6679° S, 30.3471° E; 255 m a.s.l.; Dec. 2013; D. Herbert leg.; NMSA W9640/T4521.

#### Paratypes

SOUTH AFRICA – **KwaZulu-Natal** • 1 spec.; Port Shepstone area, Marble Delta, South side of Simuma Hill, woodland/forest, stn S1; 30.6683° S, 30.3470° E; 237 m a.s.l.; Feb. 2012; J. Harvey leg.; NMSA W8785/T4468 • 2 specs.; same locality as for preceding; NHMUK 20210073, prev. NMSA W8785 • 1 spec.; same collection data as for preceding; RMNH.MOL.452588, prev. NMSA W8785 • 1 spec.; same collection data as for preceding, stn S3; 30.6666° S, 30.3447° E; 257 m a.s.l.; NMSA W8788/T4465 • 2 specs.; same collection data as for preceding, stn S6; 30.6687° S, 30.3466° E; 207 m a.s.l.; Feb. 2012; J. Harvey leg.; NMSA W8787/T4470 • 1 spec.; same collection data as for preceding; NHMUK 20210074,

prev. NMSA W8787 • 1 spec.; same collection data as for preceding, stn S2; 30.6672° S, 30.3443° E; 230 m a.s.l.; NMSA W8789/T4469 • 1 spec.; same collection data as for preceding; NMW.Z.2021.012.00003, prev. NMSA W8789 • 1 spec.; same collection data as for preceding; RMNH.MOL.452589, prev. NMSA W8789 • 1 spec.; Marble Delta, North side of Mzimkulwana River, base of Simuma Hill, dense riverine thicket/woodland, heavily invaded with *Lantana* and *Chromolaena*; 30.6727° S, 30.3427° E; 72 m a.s.l.; 5 Nov. 2001; D. Herbert leg.; NMSA V9640/T4471 • 3 specs.; Marble Delta; Hlokohloko Valley, middle section, riverine/scarp forest, stn H1; 30.6608°S, 30.3326°E; 188 m a.s.l.; Feb. 2012; J. Harvey leg.; NMSA W8732/T4464 • 1 spec.; same collection data as for preceding; NMW.Z.2021.012.00004, prev. NMSA W8732 • 2 specs.; same collection data as for preceding, stn H3; 30.6622°S, 30.3386°E; 145 m a.s.l.; NMSA W8767/T4467 • 1 spec.; same collection data as for preceding; ELMD 18759/T 229, prev. NMSA W8767 • 1 spec.; Hlokohloko Valley, lower section, riverine/scarp forest, stn H5; 30.6589°S, 30.3426°E; 122 m a.s.l.; Feb. 2012; J. Harvey leg.; NMSA W8768/T4463 • 1 spec.; Port Shepstone area, Four Man's Hill, scarp forest, stn S3; 30.6736°S, 30.3360°E; 98 m a.s.l.; Dec. 2013; D. Herbert leg.; NMSA W9596/T4466 • 1 spec.; same collection data as for preceding, stn S5; 30.6721°S, 30.3348°E; 127 m a.s.l.; NMSA W9601/T4473.

#### Other material

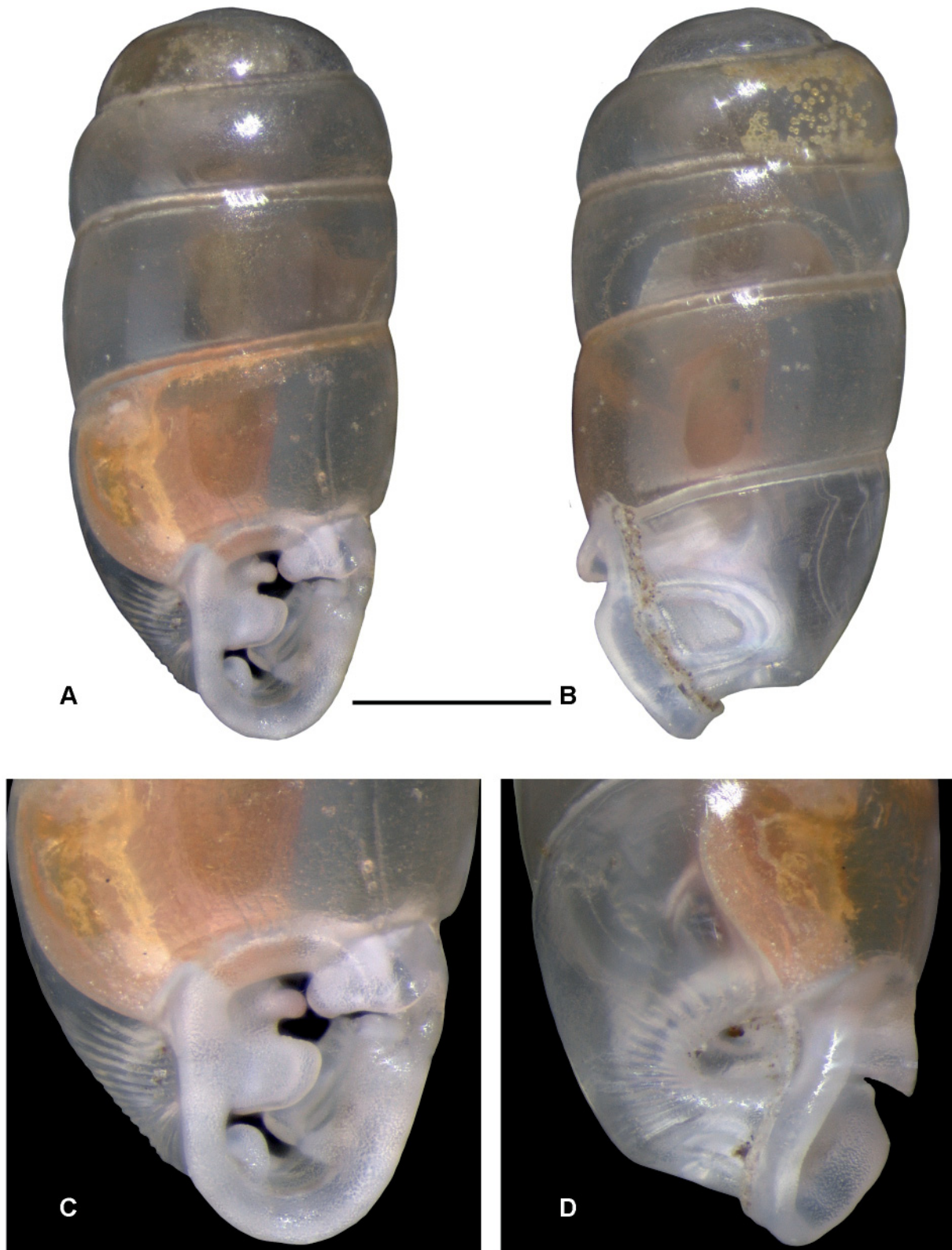
SOUTH AFRICA– **KwaZulu-Natal** • 4 specs.; Port Shepstone area, Marble Delta, Hlokohloko Valley, lower section, riverine/scarp forest, stn H4; 30.6609°S, 30.3416°E; 130 m a.s.l.; Feb. 2012; J. Harvey leg.; NMSA W8769 • 3 specs.; Simuma area, Hlokohloko Valley, 08-036, scarp forest; 30.6512°S, 30.3443°E; ca 110 m a.s.l.; 5 May 2008; D. Herbert and L. Davis leg.; NMSA W6279 • 2 specs.; Port Shepstone area, Four Man's Hill, scarp forest, stn S5; 30.6721°S, 30.3348°E; 127 m a.s.l.; Dec. 2013; D. Herbert leg.; NMSA P1608, prev. NMSA W9601.

#### Description

SHELL (Fig. 5). Shell minute, cylindrical, length 1.8–2.3 mm, width 0.8–0.9 mm, L:W 2.2–2.6 (n = 16); smooth and glossy with microscopic growth lines. Protoconch approx. 0.7 mm in diameter, comprising approx. 2.5 whorls, smooth; junction between protoconch and teleoconch not distinct. Teleoconch comprising approx. 3.5 whorls; whorls relatively flat-sided (Fig. 5A–B). Aperture sub-quadrate, rounded at base, markedly constricted by teeth; peristome thickened and reflected, broadly interrupted in parietal region; dentition seven-fold (Fig. 5C): 1) a parietal lamella, outer portion strongly oblique (almost transverse) and then curving inward; 2–3) labral lip thickened, forming a vertical ridge which bears a cusp at its upper and lower ends, each inside aperture edge, the upper cusp defines lower part of labral sinus; beginning just behind thickened labral lip a large, shallow scoop-shaped plate with a sharp ridge around its border extends deeply into aperture beyond level of columella lamella in aperture view; 4) a low, deeply inset transverse basal tooth to right of centre; 5) an inset oblique basal tooth to left of centre; 6–7) a large columella lamella with two well-spaced rounded teeth, the lower one large, broad and sloping outward toward outer lip, the upper one smaller and more deep-set. Labral tooth corresponds with a shallow indentation behind outer lip (Fig. 5B); basal tooth to left of centre corresponds with a narrow external furrow (Fig. 5D). Umbilicus open, relatively wide and deep with a conspicuous pit underlying columella lamella, approx. 0.2 mm across, peri-umbilical region with distinct axial pleats (Fig. 5D). Shell almost transparent when fresh, orange-red coloration of dried tissue of animal visible internally.

#### Distribution (Fig. 6)

Known only from an area approx. 16 km NW of Port Shepstone in southern KwaZulu-Natal, mainly from the Marble Delta, and the neighbouring Four Man's Hill and Hlokohloko Valley. *G. donaikei* sp. nov. has only been recorded south of the Mzimkulu River and *G. calcicola* sp. nov. (see below) only north of the river.



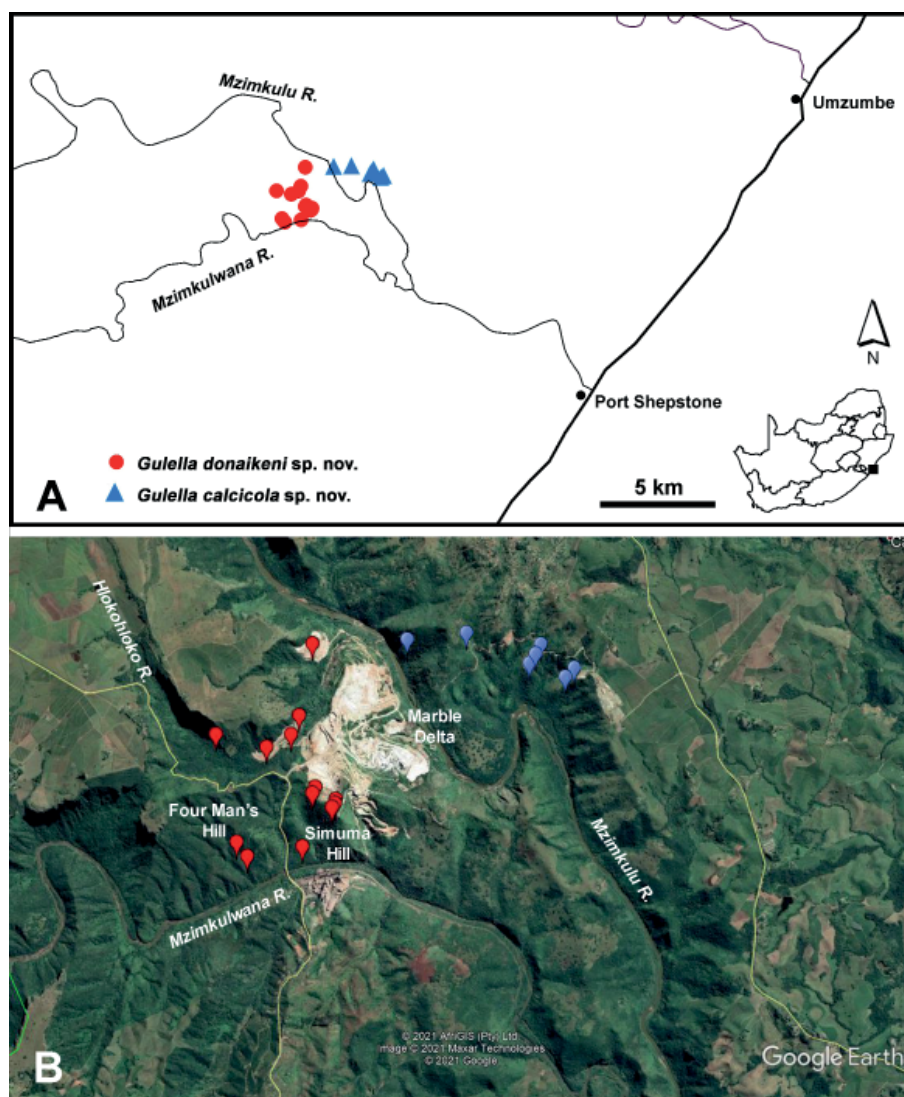
**Fig. 5.** *Gulella donaikei* sp. nov., holotype (NMSA W9640/T4521), length 1.85 mm, width 0.84 mm. **A.** Aperture view. **B.** Side view. **C.** Oblique view into aperture. **D.** Oblique view of base showing umbilicus. Scale bar = 0.5 mm.

### Habitat

Patches of dense valley thicket (Low & Rebelo 1996), also referred to as Eastern Valley Bushveld (Rutherford *et al.* 2006) and KwaZulu-Natal Scarp forest (Mucina *et al.* 2018b); in leaf-litter and under logs. The indigenous vegetation has been heavily invaded by alien plants, notably *Chromolaena odorata* (L.) R.M.King (Asteraceae), and *Lantana camara* L. (Verbenaceae), both from South and Central America.

### Remarks

In terms of its minute size, smooth glossy shell and dentition, *Gulella donaikeni* sp. nov. resembles *G. tietzae*, *G. kenbrowni* sp. nov. and *G. mkombeni* sp. nov. It is distinguished from *G. tietzae* by the large rounded lower tooth on the columella lamella and the presence of a low inset basal tooth to



**Fig. 6.** **A.** Distribution map of *Gulella donaikeni* sp. nov. (red circles) and *G. calcicola* sp. nov. (blue triangles) in the Marble Delta region of southern KwaZulu-Natal. **B.** Google Earth image of distribution of *G. donaikeni* (red symbols) south of the Mzimkulu River and *G. calcicola* (blue symbols) north of the Mzimkulu River.



the right of centre. The labral complex extends further into the aperture than that of *G. kenbrowni* sp. nov., and *G. mkombeni* sp. nov. and the lower columella tooth is rounded and not ridge-like.

### Conservation

*Gulella donaikei* sp. nov. has been found in a very small, degraded area and its habitat continues to be threatened by mining. The lower portion of the HlokoHloko Valley has been sacrificed to provide a waste rock dump for the quarry. The species evidently meets the criteria for red-listing as Critically Endangered. Conservation remarks pertaining to *Gulella calcicola* sp. nov. (see below) also apply to *G. donaikei*.

### *Gulella crookesi* sp. nov.

urn:lsid:zoobank.org:act:DFA049BF-A8B0-4B47-B04C-E6EB64CEE8F0

Figs 2, 7A–D

### Diagnosis

Shell minute, sub-cylindrical; smooth and glossy; aperture markedly constricted by teeth and narrower towards base; apertural dentition nine-fold, including an oblique parietal lamella with a notch in its lower margin, a large triangular labral tooth, its upper margin sinuous, and with a denticle near lip edge and another further into aperture, three inset basal teeth in close apposition, a low, broad rounded denticle on columella lip and a large inset tricuspid columella lamella; umbilicus widely open and with distinct peri-umbilical pleats.

### Etymology

Named for the type locality, the Vernon Crookes Nature Reserve, KwaZulu-Natal.

### Material examined

#### Holotype

SOUTH AFRICA – **KwaZulu-Natal** • Vernon Crookes Nature Reserve, 13.5 km WNW of Scottburgh, scarp forest; 30.2728°S, 30.6052°E, 410 m a.s.l.; 12 Jan. 2010; M. and K. Cole leg.; NMSA P1680/T4526, prev. ELMD 16438.

#### Paratypes

SOUTH AFRICA – **KwaZulu-Natal** • 1 spec.; same collection data as for holotype; NMSA P1617/T4499, prev. ELMD 16438 • 4 specs.; same collection data as for holotype; ELMD 16438/T 230 • 2 specs.; same collection data as for holotype; NHMUK 20210071, prev. ELMD 16438 • 2 specs.; same collection data as for holotype; NMW.Z.2021.011.00003, prev. ELMD 16438 • 1 spec.; same collection data as for holotype; RMNH.MOL.452590, prev. ELMD 16438 • 1 spec.; same locality as for holotype, Station 11-14; 15 April 2011; D. Herbert, L. Davis, M. Cole and R. Daniels leg.; NMSA W8095/T4484.

### Description

SHELL (Fig. 7). Shell minute, sub-cylindrical to squat, length 2.4–2.6 mm, width 1.1–1.2 mm, L:W 2.0–2.2 (n = 7). Protoconch approx. 0.9 mm in diameter, comprising approx. 2.5 whorls, smooth; junction between protoconch and teleoconch not distinct. Teleoconch comprising approx. 4 whorls; whorls weakly convex; smooth and glossy but with fine growth lines (Fig. 7A, B), surface often eroded and pitted even in live-collected shells; axial pleats on lower half of last whorl and around umbilicus (Fig. 7D), extending to adapical suture just prior to outer lip (Fig. 7B). Aperture narrower towards base on right hand side (in aperture view); peristome thickened and reflected; aperture markedly constricted by teeth, dentition nine-fold (Fig. 7C): 1) a parietal lamella, with outer portion markedly oblique and then curving inward so that remainder runs into aperture, and with a notch in its lower margin; 2) a large

triangular labral tooth, its upper margin sinuous and with a denticle near lip edge and another further into aperture; 3, 4 and 5) two deeply inset ridge-like basal teeth in close apposition plus one behind labral tooth, visible through translucent shell, 6) a low, broad rounded denticle at base of somewhat thickened columella lip, and in some specimens, an even less prominent one at top of columella lip; 7–9) a large inset tricuspid columella lamella, the upper and middle teeth large and rounded (particularly the middle one), the lower one smaller, often little more than a bump. Labral tooth corresponds with a deep pit behind outer lip (Fig. 7B). Umbilicus widely open, elongate-oval, approx. 0.2 mm in length (Fig. 7D). Shell almost transparent when fresh, orange-red coloration of dried tissue of animal visible internally.

### **Distribution** (Fig. 2)

Known only from Vernon Crookes Nature Reserve, in southern KwaZulu-Natal; at approx. 400 m above sea level.

### **Habitat**

Patches of KwaZulu-Natal Scarp forest (Mucina *et al.* 2018b); in leaf-litter and under logs.

### **Remarks**

The two closely adpressed, ridge-like basal teeth are unusual; in taxa with a basal tooth to the right of centre, it is usually low and transverse, not in-running. The tricuspid columella lamella of *Gulella crookesi* sp. nov. resembles that of *G. fordycei* sp. nov. and several species from the Eastern Cape coast, particularly *G. bomvana* and *G. kenbrowni* sp. nov. The latter two taxa are also smooth and glossy. The labral tooth of *G. crookesi* sp. nov. is relatively larger than that of *G. fordycei* sp. nov., obstructing the aperture to a larger degree and obscuring the details of the columella lamella. The labral tooth of *G. bomvana* is also very large, but it extends behind the columella lamella.

*Gulella crookesi* sp. nov. also resembles the variable species, *G. farquhari* (Melvill & Ponsonby, 1895), but the two basal teeth and tricuspid columella lamella immediately distinguish *G. crookesi* sp. nov.

### **Conservation**

*Gulella crookesi* sp. nov. has been found only at Vernon Crookes Nature Reserve, a protected area under the jurisdiction of Ezemvelo-KZN Wildlife. The south coast of KwaZulu-Natal and hinterland have been extensively modified by sugarcane farming and development. Vernon Crookes Nature Reserve, although small, is a very important haven for biodiversity in the region. Twenty-nine species of terrestrial Mollusca have been recorded, including *Chlamydephorus dimidius* (Watson, 1915), listed as Vulnerable and several other narrow-range species. It is the type and only known locality of two species of microchaetid earthworm, and the major locality for a third species which has also been recorded just outside the reserve (Plisko 1998). The reserve is surrounded by sugarcane farms and rural villages, and portions of the fence are missing, enabling cattle to enter, which poses a threat to the integrity of the indigenous forest patches and the well-being of their litter-dwelling invertebrates.

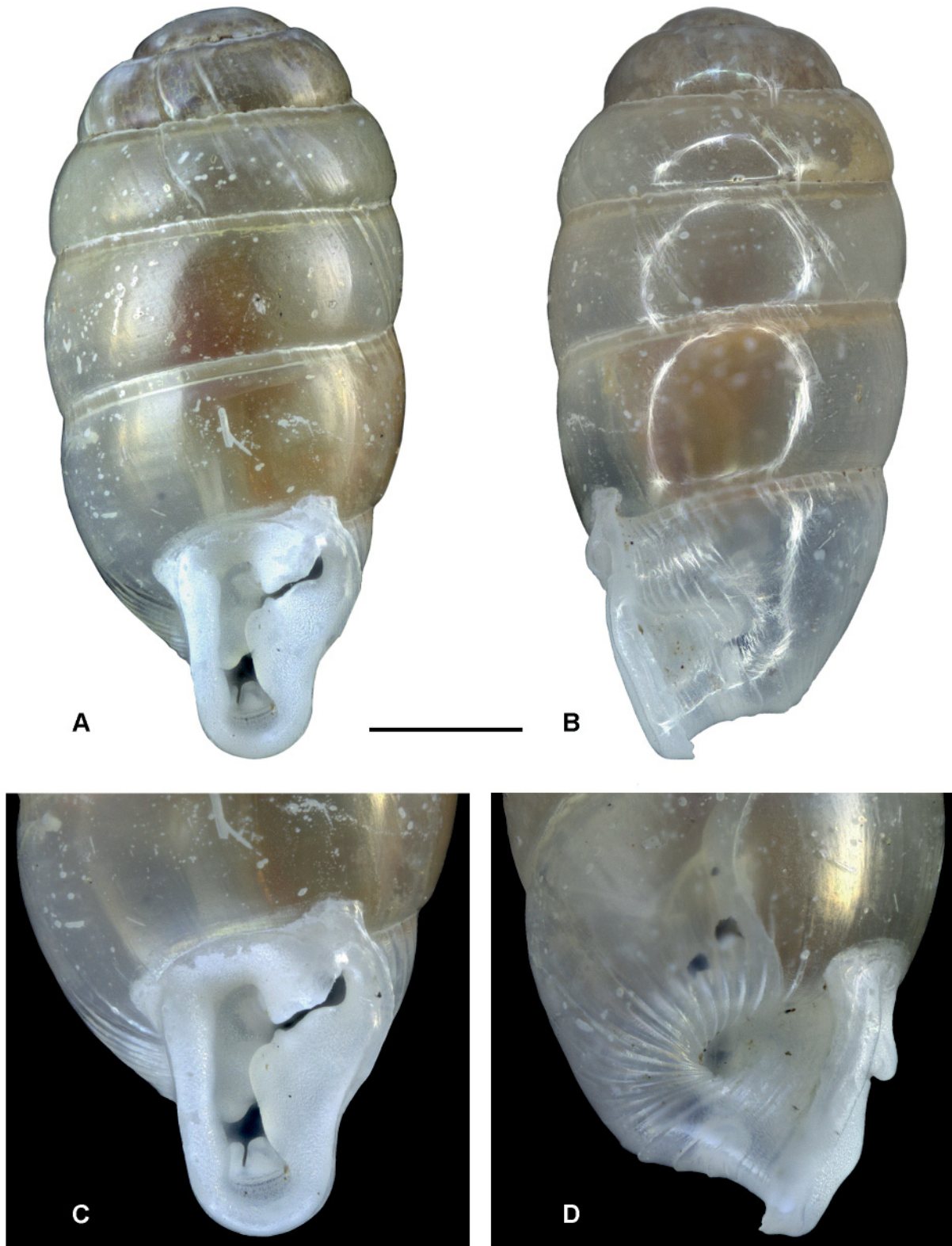
### *Gulella calcicola* sp. nov.

urn:lsid:zoobank.org:act:6A1FFB5F-2C72-45C8-AB35-25939FC90636

Figs 6A–B, 8A–D

### **Diagnosis**

Shell minute, sub-cylindrical; smooth and glossy; aperture markedly constricted by teeth, slightly deflected to left in apertural view, peristome thickened and reflected. Apertural dentition four-fold including a parietal lamella, with outer portion oblique and then curving inward, a large, square labral tooth, its upper margin sinuous and with a small denticle near lip edge and another further into aperture,



**Fig. 7.** *Gulella crookesi* sp. nov., holotype (NMSA P1680/T4526), length 2.44 mm, width 1.17 mm. A. Aperture view. B. Side view. C. View into aperture. D. Oblique view of base showing umbilicus. Scale bar = 0.5 mm.

a deeply inset basal peg-like tooth, and a very large inset scoop-shaped columella lamella; apertural tube behind columella lip somewhat inflated and collar-like; umbilicus very small and comma-shaped.

### Etymology

From '*calx*' (Latin) = 'lime' and '*-cola*' (Latin) = 'an inhabitant', with reference to its distribution at the Marble Delta, KwaZulu-Natal, the largest and most important limestone outcrop in the province.

### Material examined

#### Holotype

SOUTH AFRICA – **KwaZulu-Natal** • Port Shepstone area, Marble Delta, immediately upstream of confluence of Mzimkulu and Mzimkulwana Rivers, between Port Shepstone and Oribi Gorge Nature Reserve, on northern bank of Mzimkulu River, dense valley thicket, heavily invaded with *Lantana* and *Chromolaena*; 30.6509° S, 30.3560° E; 5 Dec. 2001; D. Herbert leg.; NMSA P1675/T4519.

#### Paratypes

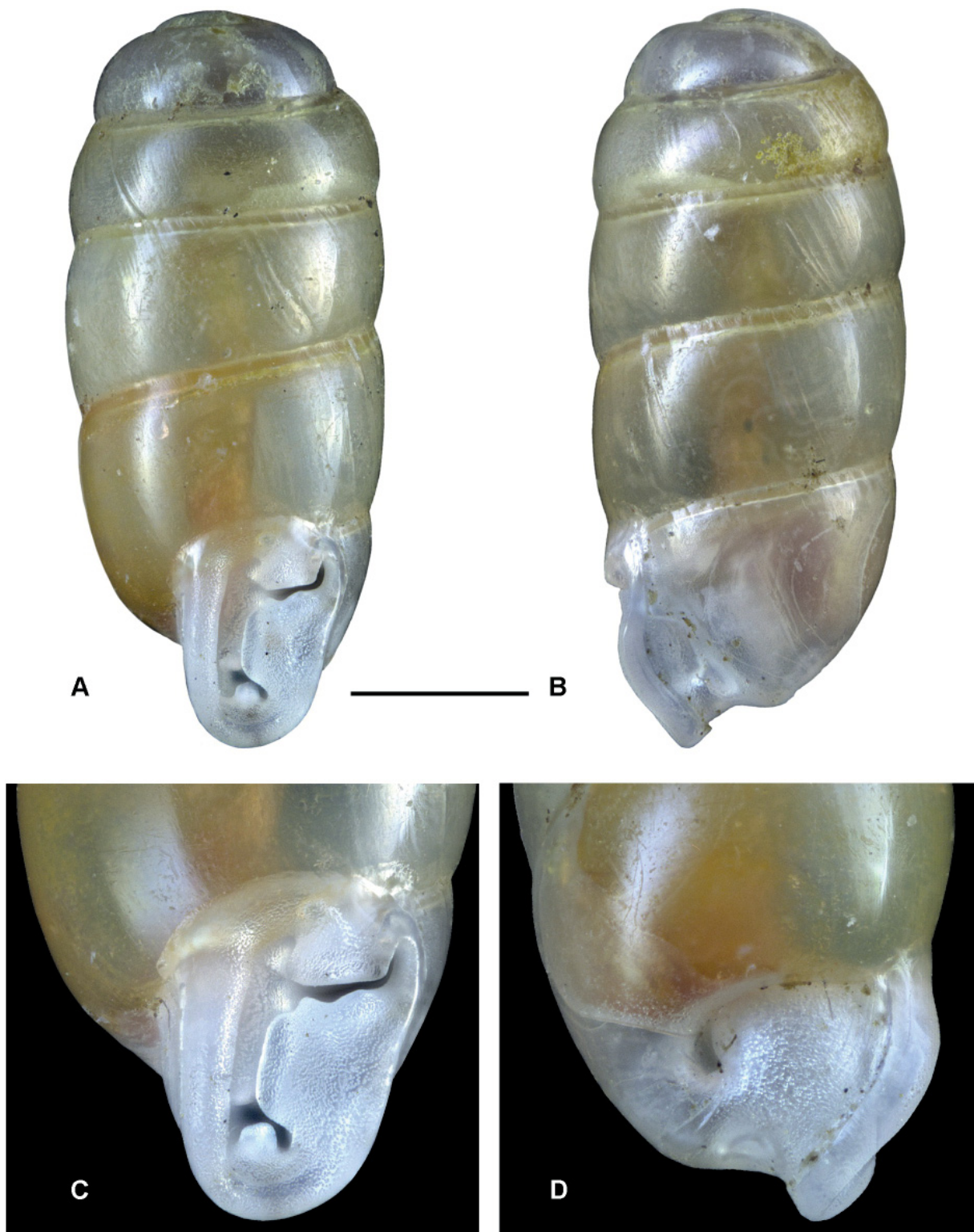
SOUTH AFRICA – **KwaZulu-Natal** • 6 specs.; same collection data as for holotype; NMSA V9686/T4492 • 2 specs.; same collection data as for holotype; NMW.Z.2021.012.00005, prev. NMSA V9686 • 1 spec.; same collection data as for holotype; RMNH.MOL.452591, prev. NMSA V9686 • 1 spec.; same locality as for holotype; 5 Oct. 2001; Herbert and M. Burse leg. D.; NMSA V9401/T4491 • 1 spec.; same collection data as for preceding; ELMD 18760/T231, prev. NMSA V9401 • 1 spec.; Marble Delta, North side of Mzimkulu River, Q5, steep indigenous forest; 30.655371° S, 30.37531° E; 4 May 2011; leg. J. Harvey; NMSA W8103/T4489 • 2 specs.; Marble Delta, north side of Mzimkulu River, Q14, indigenous forest, slightly rocky; 30.6519° S, 30.3724° E; 4 May 2011; J. Harvey leg.; NMSA W8068/T4517 • 2 specs.; Marble Delta, North side of Mzimkulu River, Q8, steep indigenous forest; 30.6545° S, 30.3764° E; 4 May 2011; J. Harvey leg.; NMSA W8073/T4493 • 2 specs.; Marble Delta, North side of Mzimkulu River, Q12, rocky indigenous forest; 30.653754° S, 30.370989° E; 4 May 2011; J. Harvey leg.; NMSA W8067/T4490 • 3 specs.; Marble Delta, North side of Mzimkulu River, Q13, indigenous forest, slightly rocky; 30.6529° S, 30.3717° E; 4 May 2011; J. Harvey leg.; NMSA W8062/T4488 • 2 specs.; same collection data as for preceding; NHMUK 20210075, prev. NMSA W8062.

#### Other material

SOUTH AFRICA – **KwaZulu-Natal** • 3 specs.; Port Shepstone area, Marble Delta, North side of Mzimkulu River, Q18, thicket; 30.6506° S, 30.3633° E; 4 May 2011; J. Harvey leg.; NMSA W8069 • 3 specs.; Marble Delta, North side of Mzimkulu River, Q8, steep indigenous forest; 30.6545° S, 30.3764° E; 4 May 2011; J. Harvey leg.; NMSA P1614, prev. NMSA W8073.

### Description

SHELL (Fig. 8). Shell minute, sub-cylindrical, length 1.9–2.2 mm, width 0.8–1.0 mm, L:W 2.1–2.5 ( $n = 13$ ). Protoconch approx. 0.7 mm in diameter, comprising approx. 2.5 whorls, smooth; junction between protoconch and teleoconch not distinct. Teleoconch comprising approx. 3.5 whorls; convex; smooth and glossy but with weak axial pleats around umbilicus (Fig. 8A–B, D). Aperture markedly constricted by teeth, slightly deflected towards left in apertural view; peristome thickened and reflected (Fig. 8A, C). Apertural dentition four-fold (Fig. 8C): 1) a parietal lamella, with outer portion oblique and then curving inward so that remainder runs into aperture, lower margin sometimes weakly notched; 2) a large square labral tooth, its upper margin sinuous and with a small denticle near lip edge and another further into aperture; 3) a deeply inset peg-like basal tooth; 4) a very large, even more deeply inset rounded, scoop-shaped columella lamella, largely obscured by labral tooth. Labral tooth corresponds with a deep pit behind outer lip (Fig. 8B). Apertural tube behind columella lip somewhat inflated and



**Fig. 8.** *Gulella calcicola* sp. nov., holotype (NMSA P1675/T4519), length 2.05 mm, width 0.90 mm. A. Aperture view. B. Side view. C. View into aperture. D. Oblique view of base showing umbilicus. Scale bar = 0.5 mm.

collar-like; umbilicus very small and comma-shaped (Fig. 8D). Shell almost transparent when fresh, orange-red coloration of dried tissue of animal visible internally.

#### **Distribution** (Fig. 6)

Known only from the Marble Delta, an area of ca 40 km<sup>2</sup> at the junction of the Mzimkulu and Mzimkulwana Rivers, inland of Port Shepstone in southern KwaZulu-Natal. Based on existing records, it occurs only on the portion of the limestone deposit that lies to the north-east of the Mzimkulu River.

#### **Habitat**

Patches of valley thicket (Low & Rebelo 1996), also referred to as Eastern Valley Bushveld (Rutherford *et al.* 2006) and KwaZulu-Natal Scarp forest (Mucina *et al.* 2018b); in leaf-litter and under logs. The indigenous vegetation has been heavily invaded by alien plants, notably *Chromolaena odorata* (L.) R.M. King (Asteraceae), and *Lantana camara* L. (Verbenaceae), both from South and Central America.

#### **Remarks**

The labral complex of *Gulella calcicola* sp. nov. resembles that of *G. crookesi* sp. nov., particularly due to the upper margin with a denticle near the lip edge and another further into the aperture. However, the portion furthest into the aperture is square in *G. calcicola* while that of *G. crookesi* sp. nov. is triangular. The other apertural teeth all differ between these two species. *Gulella farquhari* is also somewhat similar, but possesses axial sculpture (if only subsutural riblets) and its labral tooth is proportionally smaller and does not obscure the columella lamella to such an extent.

#### **Conservation**

*Gulella calcicola* sp. nov. has been found only at the Marble Delta, which stands out as the largest and most important limestone outcrop in the province, with a calcium concentration of ca 4000 mg/l (Herbert 2002). Like *G. salpinx* Herbert, 2002, it appears to be a holoendemic taxon (sensu Richardson 1978; Van Wyk & Smith 2001) that has evolved in response to the environmental conditions prevailing in the Marble Delta, perhaps chiefly those associated with soil chemistry. Much of the Marble Delta is now badly degraded as a result of mining operations and the invasion of alien plants. Mining continues in the area and the habitat of the species must thus be considered threatened. The species meets the criteria for red listing as Critically Endangered. A recommendation made by Herbert (2002) is echoed here, namely that mining operations not be conducted on a section of the northern bank of the Mzimkulu River, in an attempt to preserve the habitat as much as possible (acknowledging that alien plants will already have altered this to some extent). Some local indigenous habitat is formally preserved at Oriibi Gorge Nature Reserve, upstream on the Mzimkulwana River, but this does not lie within in the Marble Delta area and its soils, derived from decomposed granite and sandstone, have a much lower calcium content (Herbert 2002). No specimens of *Gulella calcicola* sp. nov., *G. salpinx* or *G. donaikei* sp. nov. have been found in the Oriibi Gorge reserve despite its malacofauna being relatively well-known.

#### ***Gulella abbotti* sp. nov.**

urn:lsid:zoobank.org:act:374C7E0D-187B-4EEE-A8C8-AE04AC64118B

Figs 9 A–D, 10

#### **Diagnosis**

Shell minute, cylindrical; spire whorls with weak subsutural riblets developing into stronger axial riblets on final half whorl; aperture sub-quadrate, little obstructed by teeth; dentition five-fold, including a parietal lamella, a simple trigonal labral tooth extending from lip edge, a small basal tooth well to left of centre, a broad, low swelling in middle of columella lip and a round columella lamella; umbilicus closed.

### Etymology

Named for the late Tony Abbott (1936–2013), a respected farmer and conservationist who lived on the border of the Mtamvuna Nature Reserve and possessed considerable expertise in the vegetation of subtropical forests in the deep gorges of Pondoland and the Ugu District of KwaZulu-Natal.

### Material examined

#### Holotype

SOUTH AFRICA – **KwaZulu-Natal** • Port Shepstone area, Four Man’s Hill, S5, scarp forest; 30.672094°S, 30.334831°E, 127 m a.s.l.; Dec. 2013; D. Herbert leg.; NMSA W9602/T4522.

#### Paratypes (listed north to south)

SOUTH AFRICA – **KwaZulu-Natal** • 1 spec.; Port Shepstone area, Four Man’s Hill, S4, scarp forest; 30.67284°S, 30.335312°E, 112 m a.s.l.; Dec. 2013; D. Herbert leg.; NMSA W9600/T4496 • 1 spec.; Mtamvuna Gorge, Lourie Trail, riverine scarp forest; 31.056297°S, 30.168879°E, 40 m a.s.l.; 13 Apr 2011; D. Herbert, L. Davis, M. Bursey and R. Daniels leg.; NMSA W7913/T4495 • 1 spec.; same collection data as for preceding; NHMUK 20210076, prev. NMSA W7913 – **Eastern Cape** • 1 spec.; Mzamba, beach drift; 31.100°S, 30.175°E; Oct. 1979; J. P. Marais leg.; NMSA V6350/T4494.

#### Other material

SOUTH AFRICA – **KwaZulu-Natal** • 1 spec.; Mzamba, beach drift; 31.100°S, 30.175°E; Apr. 1988; J. P. Marais leg.; NMSA V3985.

### Description

SHELL (Fig. 9). Shell minute, elongated and cylindrical, length 2.3–2.7 mm, width 0.8–1.0 mm, L:W 2.6–3.1 (n = 6). Protoconch approx. 0.8 mm in diameter, comprising approx. 2.5 whorls, smooth; junction between protoconch and teleoconch not distinct. Teleoconch comprising approx. 4.25 whorls; first whorl convex, others weakly so, suture not strongly indented; mostly smooth and glossy, but with weak subsutural axial riblets, these stronger on last whorl and extending from suture to suture, some specimens more or less smooth with only periodic growth lines (Fig. 9A, B); axial riblets prominent and pleat-like in umbilical region. Peristome fused with base of penultimate whorl in parietal region; peristome thickened (Fig. 9C). Aperture sub-quadrate, not extensively obstructed by teeth; apertural dentition five-fold (Fig. 9C): 1) an oblique parietal lamella which curves and runs into aperture; 2) a simple, roundly trigonal labral tooth beginning at lip edge; 3) a small, rounded basal tooth well to left of centre; 4) a broad, low swelling on columella lip; 5) an evenly rounded columella lamella. Labral tooth corresponds with a pit behind outer lip (Fig. 9B). Columella corresponds with a pit behind columella lip, but umbilicus closed (Fig. 9D). Shell translucent, uniformly milky-white when fresh.

### Distribution (Fig. 10)

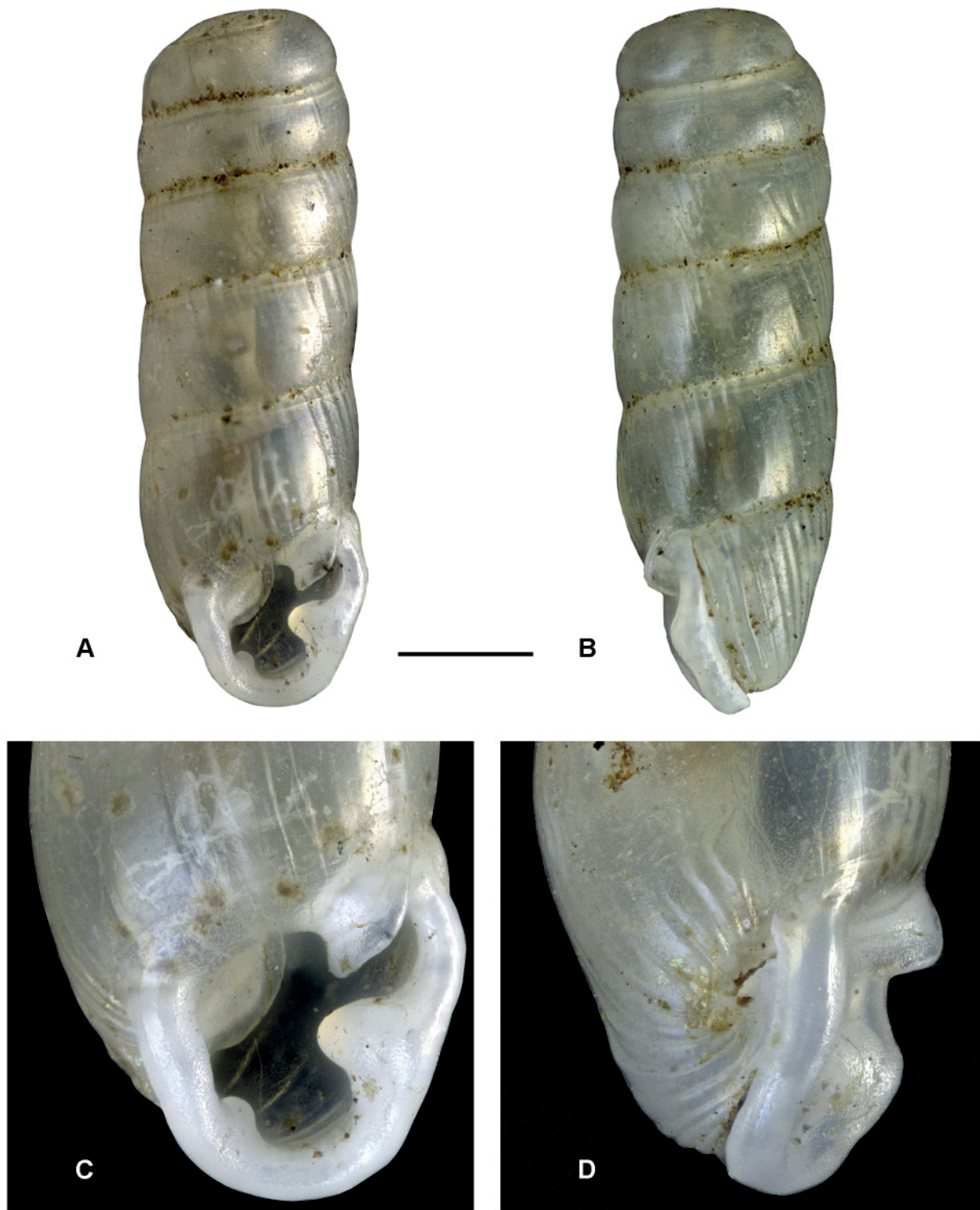
Endemic to a narrow range in southern KwaZulu-Natal, from the coast up to approx. 130 m above sea level.

### Habitat

KwaZulu-Natal Scarp Forest and Pondoland Scarp Forest (Mucina *et al.* 2018a,b); in leaf-litter and under logs.

### Remarks

*Gulella abbotti* sp. nov. resembles three other *Gulella* species occurring in KwaZulu-Natal. *G. bushmanensis* Burnup, 1926 from inland regions in the north of the province, although also elongate and cylindrical, lacks axial sculpture, has two fused labral teeth, a roundly quadrate and almost mammillate



**Fig. 9.** *Gulella abbotti* sp. nov., holotype (NMSA W9602/T4522), length 2.55 mm, width 0.81 mm. **A.** Aperture view. **B.** Side view. **C.** View into aperture. **D.** Oblique view of base showing umbilicus. Scale bar = 0.5 mm.



columella lamella, and lacks a low swelling on the columella lip. The widespread *G. pentheri* (Sturany, 1898), again elongate and cylindrical, is smooth and it has only three apertural teeth of much smaller size. *Gulella appletoni* van Bruggen, 1975, from coastal localities in northern Zululand, has similar five-fold apertural dentition, but it is smooth, less elongate and smaller (length <2.0 mm), and it has a larger tooth on the columella lip and a strong quadrate columella lamella.

### Conservation

*Gulella abbotti* sp. nov. appears to be a very rare species, with few records despite the streptaxid fauna of the KwaZulu-Natal south coast being relatively well known (see Discussion). The only formally conserved area in which it has been found is the Mtamvuna Gorge Nature Reserve. Aside from specimens collected in beach drift, it has been collected at two localities approx. 40 km apart, but not in the Oribi Gorge Nature Reserve which lies immediately west of the type locality. It also does not appear to extend into coastal forest of the relatively recent Indian Ocean Coastal Belt (von Maltitz *et al.* 2003).

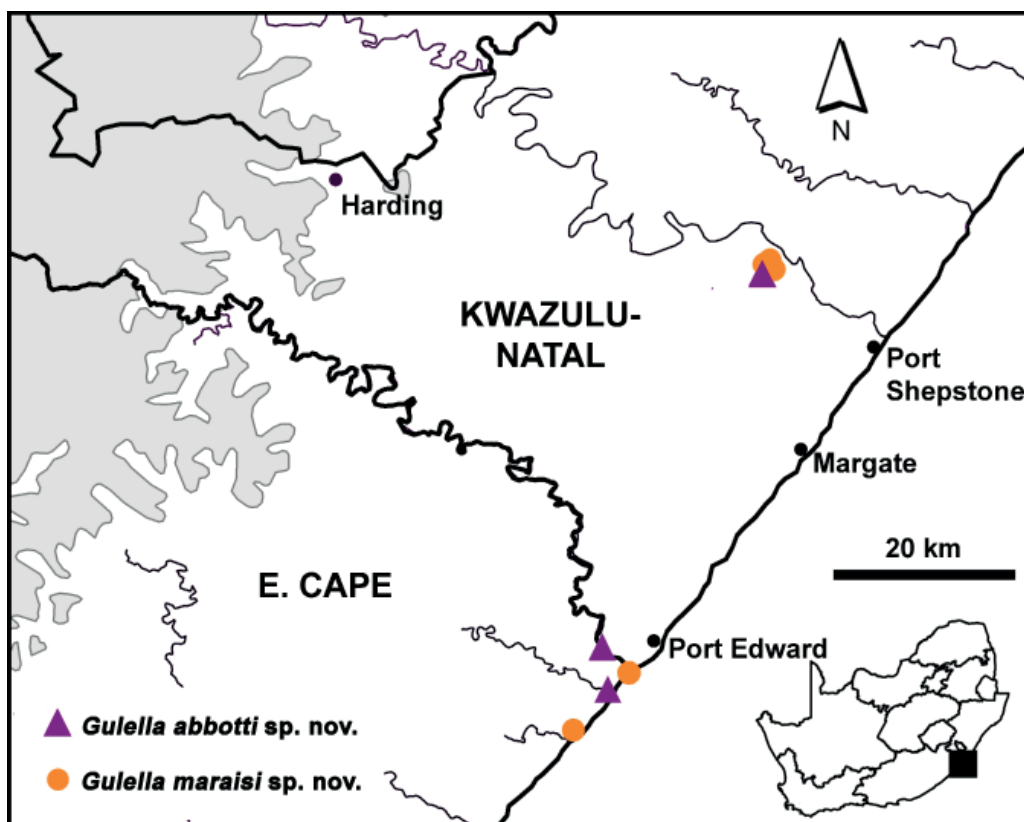
### *Gulella maraisi* sp. nov.

urn:lsid:zoobank.org:act:1D02CEC4-33FC-48DD-86EF-592869390159

Figs 10, 11A–D

### Diagnosis

Shell small, cylindrical; sculptured by axial ribs that extend to mid-whorl on spire whorls and from suture to suture on last whorl; aperture little obstructed by teeth; dentition typically three-fold, including



**Fig. 10.** Distribution map of *Gulella abbotti* sp. nov. (purple triangles) and *G. maraisi* sp. nov. (orange circles). Contour at 1000 m.

a parietal lamella, a simple labral tooth and a quadrate columella lamella; sometimes with an additional small basal tooth just left of centre; umbilicus small, elongate-ovate.

### **Etymology**

Named for Dr Johan P. Marais, a very productive conchologist who collected much material for the KwaZulu-Natal Museum, including specimens of this species.

### **Material examined**

#### **Holotype**

SOUTH AFRICA – **KwaZulu-Natal** • Mtamvuna River mouth beach drift; 31.083° S, 30.197° E; Jun. 1996; leg. J. P. Marais; NMSA P1676/T4520.

#### **Paratypes** (listed south to north)

SOUTH AFRICA – **KwaZulu-Natal** • 3 specs.; Mtamvuna River mouth beach drift; 31.083° S, 30.197° E; Jun. 1996; J. P. Marais leg.; NMSA V3993/T4485 • 1 spec.; same collection data as for preceding; NHMUK 20210077, prev. NMSA V3993 • 1 spec.; Port Shepstone, Simuma area, Hlokohe Valley, degraded riverine forest; 30.65898° S, 30.34292° E, ca 130 m a.s.l.; 6 May 2008; D. Herbert and L. Davis leg.; NMSA W6277/T4486 • 1 spec.; Port Shepstone, Simuma area, Hlokohe Valley, stn 11-001, riverine forest; 30.66310° S, 30.33685° E, ca 150–200 m a.s.l.; 5 Mar. 2011; D. Herbert and L. Davis leg.; NMSA W7831/T4487 • 1 spec.; Port Shepstone area, Marble Delta, South side of Simuma Hill, woodland/forest, in leaf-litter, stn S1; 30.6683° S, 30.3470° E; 237 m a.s.l.; Feb. 2012; J. Harvey leg.; NMSA W8786/T4483.

#### **Other material**

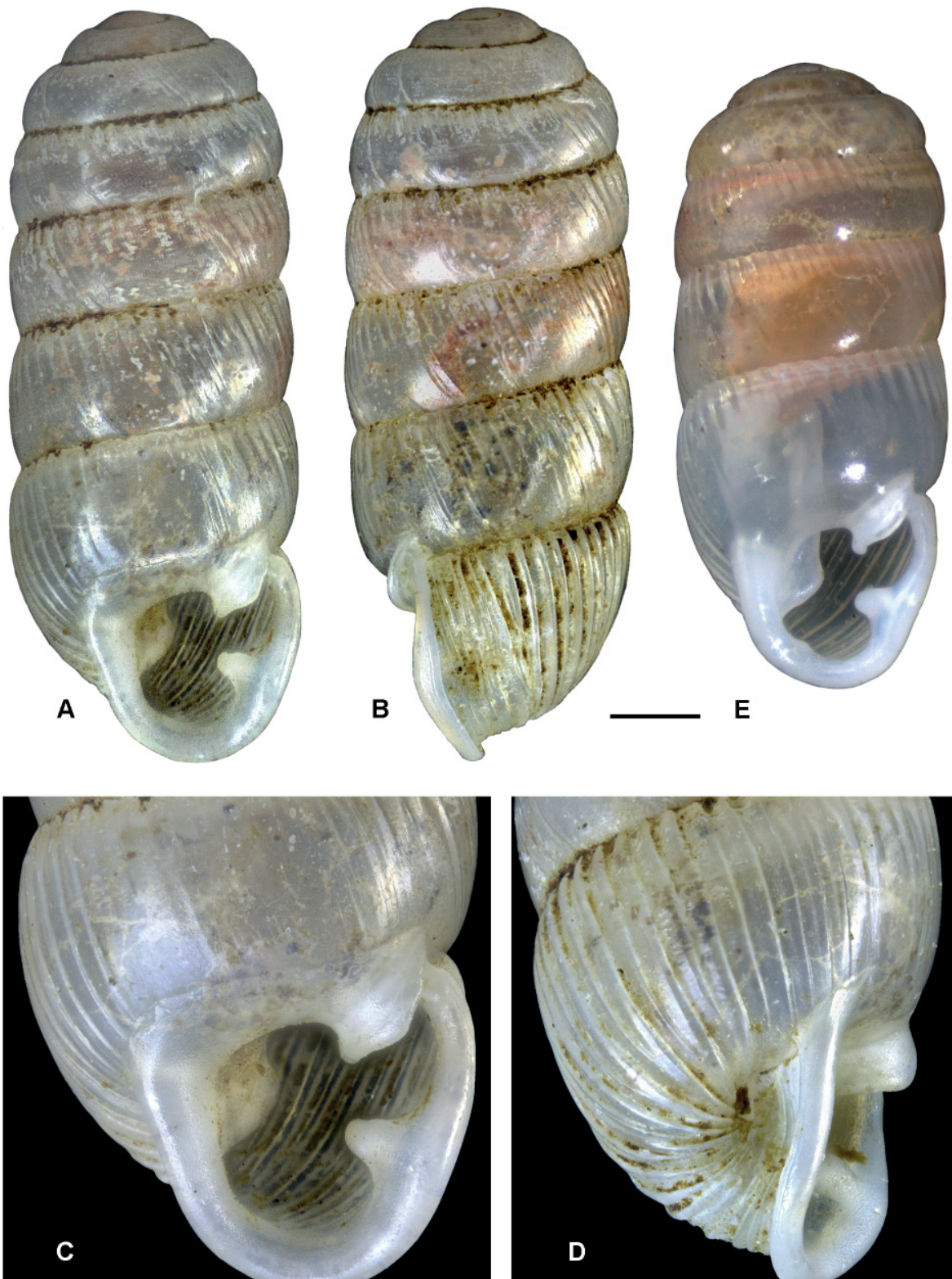
SOUTH AFRICA – **KwaZulu-Natal** • 2 specs.; Mtamvuna River mouth beach drift; 31.083° S, 30.197° E; Jun. 1996; J. P. Marais leg.; NMSA P1613 prev. NMSA V3993. **Eastern Cape** • 1 spec.; Mkambati Nature Reserve, East bank of Mkambati River, between Mkambati and Strandloper waterfalls; 31.2738° S, 30.0236° E; 15 Feb. 2011; M. Cole leg.; ELMD 18754 • 1 spec.; same locality as for preceding; 17 Mar. 2019; M. Cole leg.; ELMD 18475 • 4 specs.; Mkambati Nature Reserve, gorge of Daza River, East side; 31.3000° S, 29.9879° E; 16 Feb. 2011; M. Cole leg.; ELMD 18756.

### **Description**

SHELL (Fig. 11). Shell small, cylindrical, length 3.5–4.2 mm, width 1.5–1.7 mm, L:W 2.3–2.6 (n = 11). Protoconch 1.1 mm in diameter, comprising approx. 2.5 whorls, smooth; junction between protoconch and teleoconch distinct. Teleoconch comprising approx. 5 whorls; whorls moderately convex; sculptured by subsutural axial riblets extending to mid-whorl on earlier whorls, but strong on last whorl and running from suture to suture (Fig. 11A, B); axial pleats prominent on base, running into umbilicus (Fig. 11D). Peristome thickened, interrupted in parietal region and with a hiatus behind parietal lamella (Fig. 11C). Aperture little obstructed by teeth; apertural dentition three- or four-fold (Fig. 11C, E): 1) an oblique parietal lamella which begins above insertion of labrum and curves and runs into aperture; 2) a simple in-running, ridge-like mid-labral tooth; 3) a small basal tooth just to left of centre near the lip edge in the Eastern Cape population (Fig. 11E); 4) a quadrate columella lamella. Labral tooth corresponds with a shallow pit behind outer lip (Fig. 11B). Umbilicus very small, elongate-ovate (Fig. 11D). Shell translucent, uniformly milky-white when fresh, reddish-pink dried tissue of animal visible internally.

### **Distribution** (Fig. 10)

Recorded at isolated localities in southern KwaZulu-Natal and northeast Eastern Cape provinces, from the coast up to approx. 130 m above sea level.



**Fig. 11.** *Gulella maraisi* sp. nov., holotype (NMSA P1676/T4520), length 4.12 mm, width 1.63 mm. **A.** Aperture view. **B.** Side view. **C.** View into aperture. **D.** Oblique view of base showing umbilicus. **E.** Specimen from Eastern Cape population (ELMD 18754), length 3.57 mm, width 1.55 mm. Scale bar = 0.5 mm.

### Habitat

KwaZulu-Natal Scarp Forest and Pondoland Scarp Forest (Mucina *et al.* 2018a, 2018b); in leaf-litter and under logs.

### Remarks

Specimens collected at Mkambati Nature Reserve are slightly smaller, appear to have one less whorl and have a small basal tooth to the left of centre, absent in all the specimens collected in KwaZulu-Natal. In other respects specimens from both areas appear to be identical. The Eastern Cape population is considered here to be *Gulella maraisi* sp. nov., but due to the differences mentioned above, these specimens are not included in the type material.

*Gulella maraisi* sp. nov. superficially resembles *G. petheri*, but is larger and has axial sculpture, while *G. petheri* is narrower and smooth. The parietal lamella of *G. maraisi* sp. nov. extends to the edge of the labrum and curves strongly before running into the aperture, a feature not present in *G. petheri*. In respect of its apertural dentition and the short axial riblets, *G. maraisi* sp. nov. resembles *G. inhluzeniensis*, but in the present species the columella lamella is much larger and the last whorl has much stronger axial ribs. *Gulella maraisi* sp. nov. also resembles *G. abbotti* sp. nov., but the latter is smaller, narrower and has a more substantial labral tooth as well as a basal tooth. Species in the *Gulella infans* group (Herbert & Kilburn 2004) are larger, generally broader, have a less prominent columella lamella and weaker axial sculpture.

### Conservation

*Gulella maraisi* sp. nov. appears to be a very rare species with few records. It has been collected alive at only two localities approx. 75 km apart. One of these is under threat from mining since the lower HlokoHloko Valley is being sacrificed as a waste rock dump. It has not been found in Oribi Gorge Nature Reserve immediately to the west. The other locality is in a protected area, the Mkambati Nature Reserve. It has been collected in beach drift at the mouth of the Mtamvuna River, but as yet not in the Mtamvuna Gorge Nature Reserve upstream.

### Discussion

The streptaxid fauna of the KwaZulu-Natal south coast is relatively well known, having been sampled extensively during the first half of the twentieth century by Henry Burnup and a number of other local streptaxid enthusiasts (Herbert 2002). The discovery of seven undescribed species in the area, six described herein plus the enigmatic “*Gulella*” *salpinx* Herbert, 2002, is thus surprising. (*Gulella salpinx* does not belong in *Gulella* s. lat. (Rowson & Herbert 2016).) The Marble Delta and its immediate vicinity is confirmed to be a hotspot of narrow-range endemism in molluscs. Two of the species described herein, *G. calcicola* sp. nov. and *G. donaikei* sp. nov. are evidently restricted to this area and are of genuinely very limited range. There appears to be a definite segregation between populations of these two species, with *G. calcicola* restricted to the limestone deposits of the Marble Delta north of the Mzimkulu River and *G. donaikei* found south of the Mzimkulu River in limestone and peripheral soils. These species are not known from any formally protected area, and their habitat continues to be threatened by mining. The Marble Delta and vicinity are also among the very few localities where *G. abbotti* sp. nov. and *G. maraisi* sp. nov. occur.

The Vernon Crookes Nature Reserve is about the same distance from the coast as the Marble Delta, approx. 15 km, and is the only locality where *G. crookesi* sp. nov. has been recorded, in addition to several point-endemic earthworms (Plisko 1998). This and the four species discussed above all occur in scarp forest and have not been found in coastal forest. Scarp forest is a forest type occurring on south- and east-facing slopes and gorges of the first plateau escarpment inland of the eastern seaboard

(300–1100 m) (Mucina *et al.* 2006). Scarp forests support a high diversity of fauna and flora, including more ancient Afrotemperate and more recent Indian Ocean Coastal Belt elements, and a large number of endemics (Mucina *et al.* 2006, 2007; Lawes *et al.* 2007). An isolated population of the tree *Colubrina nicholsonii* (Rhamnaceae), considered to be an ancient relict and otherwise endemic to the Pondoland Centre of botanical endemism, occurs at Vernon Crookes Nature Reserve (Van Wyk & Smith 2001). In contrast, *Gulella kenbrowni* sp. nov. does occur in coastal forest of the south coast of KwaZulu-Natal, but has not been found at any of the localities where the five new *Gulella* species discussed above were recorded. It is the only relatively widespread species described in this paper, recorded in coastal, scarp and mist-belt forest over a linear distance of 450 km. However, it does not occur throughout this range, but is concentrated in the northern and southern parts, with an intervening gap apparent in the north-eastern Eastern Cape province traditionally known as Pondoland.

Another very narrow-range endemic, *G. mkombeni* sp. nov., has been recorded only in the Mkambati Nature Reserve in Pondoland. The south coast of KwaZulu-Natal and adjacent Pondoland have been shown to be a focus of endemism in Mollusca (Herbert & Kilburn 2004), with at least eleven species endemic to the region (excluding the species described herein) (Herbert & Kilburn 2004; Bursey & Herbert 2004; Herbert 2017; Cole 2019) and several other near-endemic species, the core distribution of which lies in this region. It is a well-known centre of botanical endemism with a large proportion of palaeoendemics and neoendemics, as well as a number of undescribed plant species, concentrated in scarp forests in deep gorges (van Wyk & Smith 2001; Mucina *et al.* 2018a).

*Gulella fordycei* sp. nov. is also known from a single nature reserve, Fort Fordyce, an outlier of the Amathole Mountains supporting several taxa not recorded elsewhere (Herbert 2020; Daniels *et al.* 2017). These observations suggest that historic contractions and expansions of forests in this region have had a significant and complex impact on the phylogeography of low-vagility organisms (Daniels *et al.* 2017).

Seven of the eight species described here are narrow-range endemics. Two are not found in formally protected areas, and their conservation merits urgent attention. Mechanisms for the protection of small parcels of land targeted at the conservation of narrowly endemic and less vagile invertebrates need to be included in conservation planning (Perera *et al.* 2021). Six species described here are found in small nature reserves highlighting the importance of even small formally protected areas for the conservation of terrestrial molluscs and other moisture-dependent taxa with limited capabilities of dispersal.

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