

## **Terrestrial Molluscs of Cabo Delgado and Adjacent Inland Areas of North-Eastern Mozambique**

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## Terrestrial molluscs of Cabo Delgado and adjacent inland areas of north-eastern Mozambique

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### ABSTRACT

Nineteen stations were surveyed and 46 species of terrestrial molluscs were recorded from an 18×55 km area in the north-eastern corner of Mozambique. Three stations on Cabo Delgado (a peninsula at the northern extremity of the Quirimbas Archipelago) yielded 19 species that were not found on the inland-sampled area and 18 species that occur inland were not found on Cabo Delgado, with nine species inhabiting both areas. The main ecological difference between Cabo Delgado and the inland area is the abundance of limestone in the former and the total lack of it in the latter. The reference to the original publication, type locality, size of the type specimen(s) and summary geographical distribution as well as colour photographs are provided for each recorded species. One new species of *Gulella* (Pulmonata: Streptaxidae) is described from Cabo Delgado.

**KEY WORDS:** Mollusca, Mozambique, Cabo Delgado, land snails, slugs, annotated checklist, *Gulella*, new species.

### INTRODUCTION

The terrestrial malacofauna of northern Mozambique was not substantially surveyed until the middle of the 19<sup>th</sup> century, when E. von Martens published a series of papers (1860, 1869a, 1879) based on the collections made by W. Peters between 1843 and 1847. The lists of terrestrial molluscs collected by Peters in Mozambique and Lorenzo Marques given by von Martens totalled 16 species. However, only ten of these were recorded from Mozambique in the strict sense (north of the Zambezi). Three species were added as the result of the collection effort of J. Kirk between 1858 and 1863, which were recorded by H. Dohrn (1865). Five species were added to the list by J.S. Gibbons (1879). F.L. Stuhlmann visited the area in 1889 and added one more species to the list (von Martens 1897). Only 24 species of terrestrial molluscs were known from Mozambique (excluding Lorenzo Marques) by the time M. Connolly published his major review on Portuguese East Africa in 1925. The latest list of non-marine molluscs of Mozambique published by L. Germain (1935) shows 46 species of terrestrial snails and slugs in the northern half of the country. The latest published record of a land snail from north-eastern Mozambique (van Bruggen 2006) is based on the collection of Dr H.E. van Hoepen made in the 1970s. Except for such scattered additions, our knowledge of the molluscan fauna of the north-eastern Mozambique is as it was 75 years ago.

In 2008, a research project “Biodiversity Survey of the Coastal Dry Forests in Northern Mozambique” was initiated and the results of the second survey of this project “Muséum National d’Histoire Naturelle de Paris / Pro-Natura International / Instituto de Investigação Agrária de Moçambique – ‘Our Planet Reviewed’ Initiative, Mozambique 2009 Cabo Delgado Expedition” are presented in this paper.

### MATERIAL AND METHODS

Nine days were spent in the field in November 2009 (dry season), and 19 stations were surveyed by the author (Fig. 1, Table 1). Station numbers were given the suffix

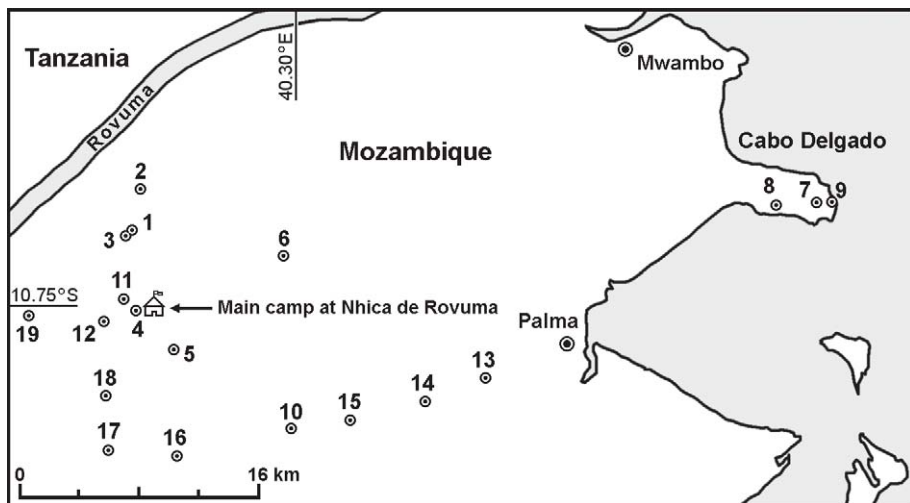


Fig. 1. Map of the sampled area with the plotted stations and the base camp. See Table 1 for additional information.

“M09” that is omitted here to save space in the tables and figure captions. Additional material was collected by I. Ineich and T. Robillard at station 4 and by A. Ohler, M. McAdam, I. Ineich and T. Robillard at station 10. All stations were within the forested areas (covering as large an area as possible) of the north-eastern part of Cabo Delgado province of north-eastern Mozambique, with three stations on Cabo Delgado itself. Living specimens and empty shells were hand-picked from under rocks and under the bark of fallen trees, on trunks and leaves, on the ground, and in leaf litter. Top layers of soil were sieved in addition to hand-collecting. Living specimens were photographed and then were frozen in a small amount of water and defrosted in 96% ethanol to ensure the preservation of DNA and a relaxed condition for future anatomical studies.

A cluster analysis was applied to the dataset (Table 2), using a Paired Group algorithm with the Simpson index for absence-presence data, which is defined as  $M/N_{min}$ , where  $M$  is the number of the same species in two compared stations and  $N_{min}$  is the number of species in the station with the smaller number of species. This index treats two stations as identical if one is a subset of the other. Thus, stations were clustered “from the molluscan point of view”.

The following acronyms and abbreviations are used:

MNHN – Muséum National d’Histoire Naturelle, Paris, France;

NMSA – Natal Museum, Pietermaritzburg, South Africa;

stn – station;  $h$  – height,  $w$  – greater diameter (both measured in standard, apertural view).

All coordinates are given in decimal degrees using WGS 84 map datum. All shell sizes are given using the following template:  $h \times w$ .

## RESULTS

The survey recorded a total of 46 species of terrestrial molluscs belonging to 15 families (Table 2), and 182 observations of these species (collection lots) were made.

TABLE 1  
Stations sampled in north-eastern Mozambique, East Africa.

Station Number	Latitude	Longitude	Altitude	Date
1	10.70556° S	40.20790° E	19 m	20 November 2009
2	10.68071° S	40.21305° E	20 m	20 November 2009
3	10.70918° S	40.20406° E	24 m	20 November 2009
4	10.75361° S	40.21111° E	127 m	20, 25 November 2009
5	10.77707° S	40.23403° E	137 m	21 November 2009
6	10.72107° S	40.30115° E	111 m	22 November 2009
7	10.68883° S	40.62806° E	11 m	23–24 November 2009
8	10.69019° S	40.60321° E	5 m	23 November 2009
9	10.68867° S	40.63751° E	5 m	24 November 2009
10	10.82460° S	40.30542° E	75 m	23, 27 November 2009
11	10.74669° S	40.20368° E	140 m	26 November 2009
12	10.76034° S	40.19139° E	128 m	26 November 2009
13	10.79458° S	40.42444° E	69 m	27 November 2009
14	10.80834° S	40.38783° E	78 m	27 November 2009
15	10.81945° S	40.34157° E	95 m	27 November 2009
16	10.84076° S	40.23583° E	80 m	27 November 2009
17	10.83779° S	40.19426° E	129 m	28 November 2009
18	10.80487° S	40.19230° E	130 m	28 November 2009
19	10.75658° S	40.19230° E	112 m	29 November 2009

More than half of the species in the study area belong to four families: Subulinidae, Streptaxidae, Helicarionidae and Urocyclidae.

Only empty shells, often in a very bad condition, were found for most of the species because the fieldwork was done at the end of the dry season and most of the molluscs were hiding deep in the ground. Sixteen (more than 36 %) of the 46 species were recorded from single stations. This suggests that we can still increase the total number of known species from the region. However, the cumulative graph of the number of species recorded sequentially at the stations in the sampled area (Fig. 2) indicates that this increase could be achieved only with significant additional

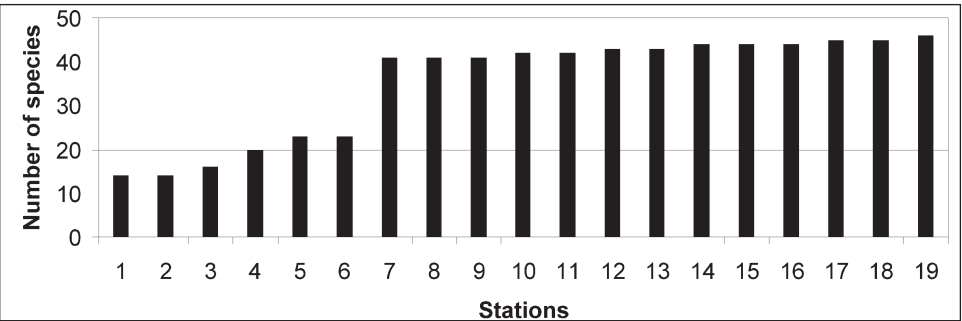


Fig. 2. Cumulative graph of the number of species recorded sequentially at the stations in the sampled area.

TABLE 2  
Occurrences of species at nineteen stations in north-eastern Mozambique.  
Abbreviation: s/s – number of stations where species is present (collection lots).

STATION NUMBERS:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	s/s
	Inland; SE of Rovuma R.						Cabo Delgado			Inland; SE of Rovuma R.										
CYCLOPHORIDAE																				
<i>Cyathopoma diegoense</i>							•													1
MAIZANIIDAE																				
<i>Maizania wahlbergi</i>			•			•	•		•			•		•		•		•	•	9
POMATIASIDAE																				
<i>Tropidophora nyasana</i>							•		•											2
<i>Tropidophora ligata</i>					•		•		•	•		•					•		•	7
<i>Tropidophora insularis</i>	•			•		•					•	•		•		•				7
<i>Tropidophora zanguebarica</i>							•	•	•											3
TRUNCATELLIADAE																				
<i>Truncatella marginata</i>							•													1
PUPILLIDAE																				
<i>Pupoides coenopictus</i>							•	•	•											3
GASTROCOPTIDAE																				
<i>Gastrocopta klunzingeri</i>							•		•											2
VERTIGINIDAE																				
<i>Nesopupa pellei</i>							•													1
<i>Nesopupa corrugata</i>							•													1
<i>Nesopupa bisulcata</i>							•													1

Table 2. Continuation

STATION NUMBERS:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	s/s
	Inland; SE of Rovuma R.						Cabo Delgado						Inland; SE of Rovuma R.							
CERASTIDAE																				
<i>Gitteneduardia metuloides</i>	•																			1
<i>Rhachistia catenata</i>	•	•		•						•	•	•	•	•		•	•	•		11
<i>Rachis cunctatoris</i>					•					•	•					•				4
<i>Limicena nyasana</i>							•													1
ACHATINIDAE																				
<i>Achatina immaculata</i>	•			•	•		•			•			•							6
<i>Achatina randabeli</i>			•			•	•		•		•	•					•			7
SUBULINIDAE																				
<i>Kempioconcha</i> cf. <i>obtusa</i> auct.														•			•	•		4
<i>Kempioconcha kiki</i>				•		•	•	•	•										•	6
<i>Kempioconcha boivini</i>	•			•	•	•					•	•				•	•	•	•	10
<i>Kempioconcha</i> cf. <i>subolivacea</i>																			•	1
<i>Kempioconcha conradti</i>	•		•	•	•			•	•	•	•	•	•				•	•	•	13
<i>Curvella nyasana</i>	•			•	•									•						4
<i>Eonyma tugulensis</i>	•																		•	2
<i>Opeas hannense</i>	•																			1
<i>Allopeas</i> ? cf. <i>acmella</i>							•		•											2
STREPTAXIDAE																				
<i>Edentulina affinis</i>				•	•	•	•		•		•	•			•	•	•	•	•	12
<i>Tayloria leroyi</i>	•		•	•	•	•				•	•	•		•	•		•		•	12
<i>Gonaxis</i> cf. <i>percivali</i>	•																		•	2

Table 2. Continuation

STATION NUMBERS:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	s/s		
TAXON		Inland; SE of Rovuma R.						Cabo Delgado					Inland; SE of Rovuma R.										
STREPTAXIDAE continuation						•						•			•			•	•	•	8		
Gonaxis denticulatus		•					•			•										•	4		
Gulella sexdentata var. liedereri																					1		
Gulella subhyalina								•													1		
Gulella perissodonta																					1		
Gulella delgada sp. n.								•													1		
Streptostele herma								•	•	•											3		
EUCONULIDAE																							
Microcystina minima								•													1		
Afroguppya rumutiensis								•													1		
HELICARIONIDAE																							
"Sitata" jenyinsi					•	•		•	•	•	•	•	•				•		•		10		
Trochonanina albopicta						•					•			•				•			4		
Trochonanina bloyeti																		•			1		
Crenatinanina crenulata								•	•	•											3		
UROCYCLIDAE																							
Bukobia uhehensis		•																			1		
Elisolimax flavescens								•	•												2		
Urocyclus kiriki											•										1		
SUCCINEDAE																							
Quickia concisa								•	•	•											3		
TOTAL NUMBER OF SPECIES AT STATION:		14	1	4	11	11	8	26	10	15	9	10	9	6	7	4	6	11	9	11			

collecting effort, since only five species were added in the last twelve stations. In other words, 89% of the species collected in the sampled area were found at the first seven stations.

Three stations on Cabo Delgado (7, 8 and 9) yielded 19 species that were not found in the inland-sampled area. However, stations 8 and 9 did not add any species that were not found at station 7, which implies exhaustive sampling on Cabo Delgado.

#### ANNOTATED CHECKLIST

Visual estimation of the numbers of individuals in the sampled areas was used in addition to the number of records as a base for non-quantified remarks on abundance.

Information on general distribution was taken mainly from Connolly (1925, 1939).

Taxonomic changes have been avoided, since this paper is not a revision of the taxa included. Higher classification is based on Bouchet and Rocroi (2005).

Class Gastropoda Cuvier, 1795

Subclass Caenogastropoda Cox, 1960

Family Cyclophoridae Gray, 1847

Variable-sized operculate snails of tropical regions of Asia and Africa.

*Cyathopoma diegoense* Fischer-Piette, Blanc & Vukadinovic, 1974

Fig. 3

*Cyathopoma diegoense*: Fischer-Piette, Blanc & Vukadinovic 1974: 467, figs 2–4 (Cap Diego, northern Madagascar; c. 2×3 mm).

A single shell without an operculum, collected on Cabo Delgado, is very similar to the voucher specimen described and illustrated by Emberton (2003: 30–31, fig. 40) from the type locality. The photograph of the shell from Cabo Delgado matches the photograph of the shell from Cap Diego almost exactly when superimposed at 113% magnification. The characteristic sculpture of the spiral cords with the gap on the whorl shoulder (“missing” cord below the suture) and the minute dense axial striation between the spiral cords also can be observed on both shells. *Cyathopoma azaniense* Verdcourt, 1978 from Kenya is smaller (1.4×2.0 mm) and does not have the characteristic gap between the suture and the first spiral cord on the following whorl.

The original description of *C. diegoense* was based on a single adult specimen “environ” (*circa*) 2 mm high and 3 mm wide. The same size was repeated in comparison with *C. artatum* Sykes, 1897 on the same page just below the description. However, the figure of the holotype on the same page has a 0.88 *h/w* ratio, which clearly does not match the proportions stated in the description. Emberton (2003) did not give any explanation for his decision to include the 2.1 mm high and 2.0 mm wide *C. duboisi* Fischer-Piette, Blanc, Blanc & Salvat, 1993, as well as his 1.9 mm high and 2.9 wide “voucher specimen” in the range of variation of *C. diegoense*. Thus, the specimen from Cabo Delgado is very likely *C. diegoense sensu* Emberton, 2003 but the extent of the name *diegoense* is doubtful.

Family Maizaniidae Tieleck, 1940

Small to medium-sized operculate snails of tropical regions of Africa.

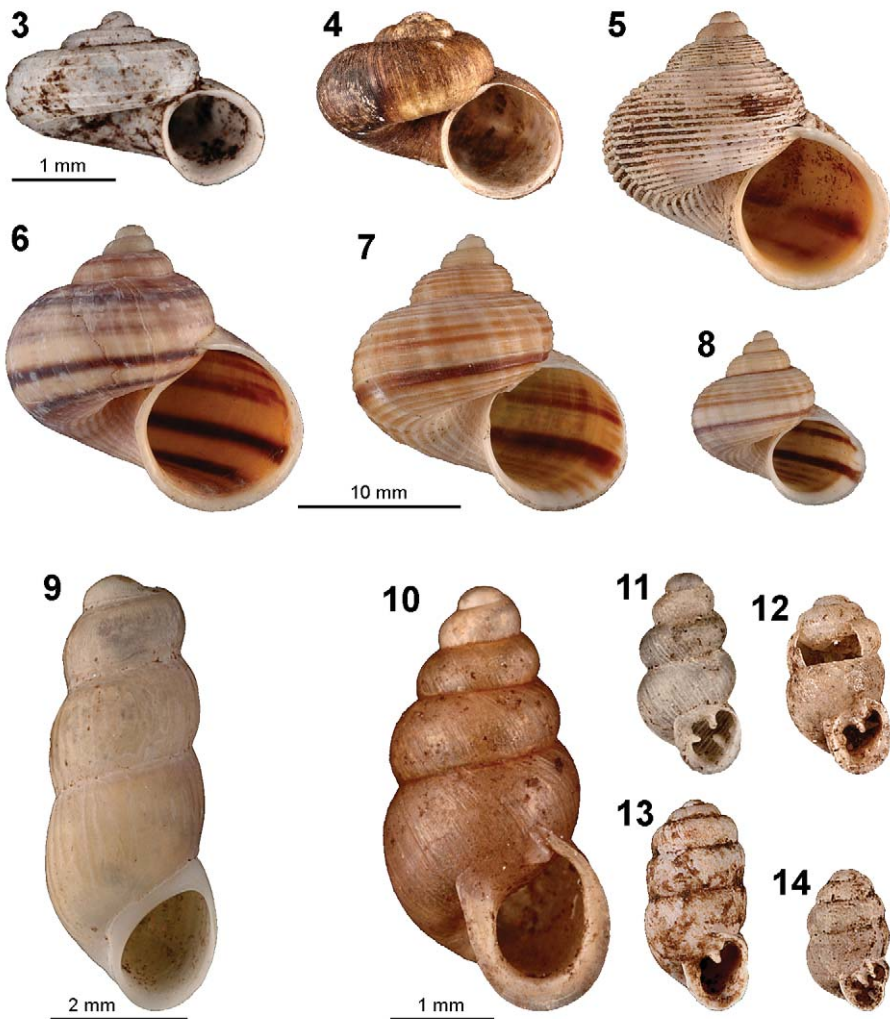


*Maizania wahlbergi* (Benson, 1852)

Fig. 4

*Cyclostoma wahlbergi*: Benson 1852: 271 (Natal; 7×14 mm).

A common species, recorded from nine stations on Cabo Delgado and inland, with a general coastal distribution from Kenya to the Eastern Cape, South Africa.



Figs 3–14. Cyclophoridae: (3) *Cyathopoma diegoense*, 1.8×2.5 mm, stn 7. Maizaniidae: (4) *Maizania wahlbergi*, 11.5×15.2 mm, stn 3. Pomatiidae: (5) *Tropidophora nyasana*, 16.7×17.7 mm, stn 7; (6) *T. ligata*, 17.5×18.3 mm, stn 17; (7) *T. insularis*, 17.2×17.0 mm, stn 4; (8) *T. zanguebarica*, 11.0×10.8 mm, stn 9. Truncatellidae: (9) *Truncatella marginata*, 6.0×2.5 mm, stn 7. Pupillidae: (10) *Pupoides coenopictus*, 4.3×2.2 mm, stn 7. Gastrocoptidae: (11) *Gastrocopta klunzingeri*, 1.8×1.0 mm, stn 7. Vertiginidae (stn 7): (12) *Nesopupa peilei*, 1.7×1.0 mm; (13) *Nesopupa corrugata*, 2.0×1.0 mm; (14) *Nesopupa bisulcata*, 1.3×0.8 mm. Scale bar 1 mm in Figs 3, 10–14; 10 mm in Figs 4–8; 2 mm in Fig. 9.

## Family Pomatiidae Newton, 1891

Medium-sized operculate snails of in tropical and subtropical regions of the Old World, with only few species reaching temperate areas in Europe and South Africa.

*Tropidophora nyasana* (Smith, 1899)

Fig. 5

*Pomatias nyasanus*: Smith 1899: 591, pl. 35, fig. 5 (Mount Chiradzulu, Nyika Range, Zomba Plateau; 20×21 mm).

Recorded from two stations on Cabo Delgado; has a general distribution in Malawi (type localities), Mozambique and Zimbabwe. Differs from the other three species of *Tropidophora* in the region by the presence of numerous regularly spaced spiral cords over the entire shell surface.

*Tropidophora ligata* (Müller, 1774)

Figs 6, 56

*Nerita ligata*: Müller 1774: 181 (12.7–23.3 × 12.7–21.2 mm).

A common species, recorded from seven stations on Cabo Delgado and inland, with a general distribution from South Africa to Tanzania as well as on Madagascar and Mauritius. Differs from the other three species of *Tropidophora* in the region by the very weak spiral sculpture on the periphery of the last whorl, with most of the shells having noticeable spiral sculpture only in the umbilical area.

*Tropidophora insularis* (Pfeiffer, 1852)

Fig. 7

*Cyclostoma insulare*: Pfeiffer 1852: 64 (“Isle de France” – error; 13½ × 17 mm).

A common species, recorded from seven inland stations, with a general distribution from South Africa to Kenya. “Described from a set in the Cuming collection labelled “Mauritius,” a locality which Pfeiffer amended to “Natal” in his own working copy of his Monograph” (Connolly 1939: 547). Similar to, and probably a sister species of, *T. ligata*, with different ecological preferences since they do not co-occur at least in north-eastern Mozambique. Cases of co-occurrence in South Africa should be re-evaluated. Can easily be distinguished from *T. ligata* by the fairly strong spiral sculpture on the periphery as well as on the rest of the shell, the sculpture being weaker and not as dense and regular as in *T. nyasana*. It is much larger but otherwise very similar to the following species.

*Tropidophora zanguebarica* (Petit, 1850)

Figs 8, 57

*Cyclostoma zanguebarica*: Petit 1850: 53, pl. 3, fig. 5 (Ile de Zanzibar; 10–12 × 10–12 mm).

Recorded from all three stations on Cabo Delgado, with a general coastal distribution from Kenya to Mozambique. Its relations with *T. letourneuxi* (Ancey in Bourguignat, 1887) should be re-evaluated (see remarks in Rowson 2007: 432). I prefer to use the earlier name here since variability of the shells from Cabo Delgado allows the application of both names. Resembles a small *T. insularis* but, unlike that species, co-occurs with *T. ligata*. Possibly just a coastal variation of *T. insularis* with size variability from 10.5×10.5 to 13.0×12.0 mm at a single locality.

## Family Truncatellidae Gray, 1840

Small operculate snails with a worldwide tropical and subtropical distribution.

*Truncatella marginata* Küster, 1855

Fig. 9

*Truncatella marginata*: Küster 1855: 12, pl. 2, figs 24–26 (5.3×2.0 mm).

Common amphibious, semi-marine species with a general coastal distribution from South Africa to the South Pacific. A single shell found on Cabo Delgado.

## Subclass Heterobranchia Burmeister, 1837

## Clade Pulmonata Cuvier, 1814

## Family Pupillidae Turton, 1831

Small snails with a worldwide distribution.

*Pupoides coenopictus* (Hutton, 1834)

Fig. 10

*Pupa coenopicta*: Hutton 1834: 85, 93 (Beana, India; height c. 5.29 mm).

A common, widespread species recorded in large numbers from all three stations on Cabo Delgado, with a general distribution in tropical Asia and Africa.

## Family Gastrocoptidae Pilsbry, 1918

Small snails with a worldwide distribution.

*Gastrocopta klunzingeri* (Jickeli, 1873)

Fig. 11

*Pupa klunzingeri*: Jickeli 1873: 106 (Abyssinia; 2.25×1.25 mm).

Recorded from two stations on Cabo Delgado, with a general distribution from Eritrea (type localities) to Mozambique. Differs from similar sized species of Vertiginidae by the fused angular and parietal lamellae, the narrow apex and the strongly convex whorls separated by a deep suture.

## Family Vertiginidae Fitzinger, 1833

Small snails with a worldwide distribution.

*Nesopupa (Insulipupa) peilei* Madge, 1938

Fig. 12

*Nesopupa peilei*: Madge 1938: 16, pl. 3, fig. 2 (Flic-en-Flac, Mauritius; 2.1×1.1 mm).

A common species on the Mascarene Islands, where it appears to be restricted to the coastal and drier areas inland (Griffiths & Florens 2006: 85). A single shell found on Cabo Delgado. Can be separated from the following species by the less elongated shell.

*Nesopupa (Insulipupa) corrugata* (Preston, 1912)

Fig. 13

*Jaminia corrugata*: Preston 1912: 71, fig. 4 (Victoria Falls; 2.25×1.00 mm).

A single, heavily worn shell found on Cabo Delgado. Previously recorded from the area near the type locality. There is also a single shell in the Natal Museum (L6653) collected on 19 February 1963 by A.C. and W.H. van Bruggen in the forest east of Gôndola in Central Mozambique. Characteristic strong corrugation (of the periostracum) can be observed only on fresh shells, and “a small, rather indistinct basal denticle situated well within and rather on the right-hand side of the shell” (Preston 1912: 71) can be missing (Pilsbry & Cooke 1920: 362, pl. 34, fig. 15). The shell from Cabo Delgado has just barely noticeable thickening in place of the lower palatal tooth, with a corresponding slight indentation on the outer surface of the last whorl. *N. corrugata* has a stronger corrugated periostracum and is proportionally higher than the preceding species.

*Nesopupa (Afripupa) bisulcata* (Jickeli, 1873)

Fig. 14

*Pupa bisulcata*: Jickeli 1873: 107 (Abyssinia; 1.9×1.0 mm).

A widespread but not very common species with a general distribution from Eritrea (type localities) to Mozambique. A single shell found on Cabo Delgado. Differs from both preceding species of *Insulipupa* by its smaller size and stronger angular tooth, which is almost as large as the parietal lamella.

Family Cerastidae Wenz, 1923<sup>1</sup>

Small to medium arboreal snails of tropical and subtropical regions of the Old World.

*Gittenedouardia metuloides* (Smith, 1899)

Fig. 15

*Buliminus (Conulinus) metuloides*: Smith 1899: 587, pl. 33, fig. 43 (Zomba Plateau; 10×6 mm).

A widespread but not very common species with a general distribution in Zambia, southern Malawi (type locality), Mozambique, Zimbabwe and the northern part of South Africa. A single worn shell (juvenile), found about 30 km inland, is noticeably wider than *Bulimus badiolus* Morelet, 1881 described from the Comoros and just slightly more slender than four specimens of *G. metuloides* in the Natal Museum (No. 2786, ex. coll. Connolly 1920) from the Victoria Falls. Differs from the three following species of Cerastidae by the slender shell with a deep suture.

*Rhachistia catenata* (Martens, 1860)

Figs 16, 58

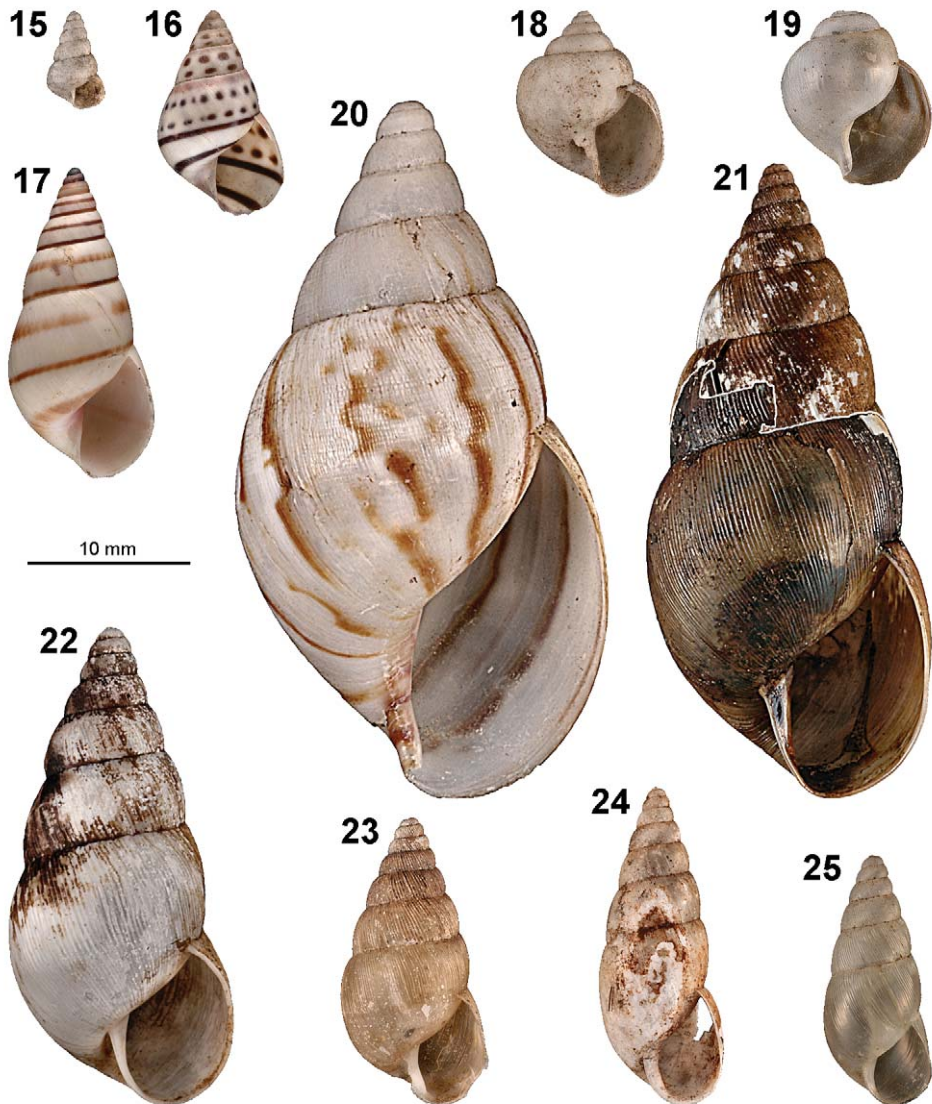
*Bulimus (Rhachis) catenatus*: Martens 1860: 212, pl. 2 fig. 7 (Querimba Islands; 14×8 mm).

A common species, previously known only from the type locality ~150 km south of the study area. Found at 11 stations inland. Quite variable. Some shells (but not the one illustrated) match the outlines of the original figure of the type and the photograph of the paratype in Connolly (1925: 161) almost exactly. Von Martens (1869b: 150), in the original description of his *Buliminus (Rhachis) braunsii* from Zanzibar (~475 km north of the study area), did not compare it with his earlier described *catenatus*. Both species

<sup>1</sup> Junior synonyms Pachnodidae Steenberg, 1925 and Cerastuidae Wenz, 1930 are often used, even in recent publications.



look quite similar and I provisionally choose the older name from the closest type locality until a proper revision of the group is made. Differs from the following species by its relatively wider shell, the dark band below the suture, and (in typical specimens) by the presence of the dark spots arranged in two lines above the periphery.



Figs 15–25. Cerastidae: (15) *Gittenedouardia metuloides*, 6.0×3.6 mm, subadult, stn 1; (16) *Rhachistia catenata*, 13.2×7.8 mm, stn 11; (17) *Rachis cunctatoris*, 19.1×8.6 mm, stn 5; (18) *Limicena nyasana*, 11.8×9.1 mm, subadult, stn 7. Achatinidae: (19) *Achatina immaculata*, 11.3×9.3 mm, juvenile, stn 1; (20) *A. randabeli*, 43.8×23.0 mm, stn 9. Subulinidae: (21) *Kempioconcha* cf. *obtusata*, 39.1×17.5 mm, two shells composite subadult, stn 14; (22) *K. kirki*, 30.2×13.9 mm, stn 6; (23) *K. boivini*, 17.8×9.1 mm, stn 5; (24) *K. cf. subolivacea*, 19.6×7.3 mm, stn 19; (25) *K. conradti* (von Martens, 1895), 15.4×6.4 mm, stn 5.

*Rachis cunctatoris* Van Bruggen, 1975

Fig. 17

*Rachis cunctatoris*: Bruggen 1975: 217, figs 7–9 (Lower Shire Valley, southern Malawi; 18.7×8.1 mm).

A rather uncommon species previously known only from the dry lowlands of Malawi. Found at four stations inland. Differs from the previous species by the more slender shell, with not more than two dark bands (on the periphery and just above the suture) and by the complete absence of spotted coloration.

*Limicena nyasana* (Smith, 1899)

Fig. 18

*Buliminus (Conulinus) nyasanus*: Smith 1899: 586, pl. 33, figs 41, 42 (Nyika Plateau, Mount Chiradzulu and Zomba Plateau; 21×15 mm).

A widespread but not very common species, with a general distribution from southern Tanzania to southern Zambia, Malawi (type localities) and Mozambique. Found at one station on Cabo Delgado. Differs from the three preceding species of Cerastidae by the wider bulimoid shell with a cylindrical umbilicus, and by the characteristic protoconch sculpture of seven strong spiral ridges well illustrated by Mordan (1998: 62, fig. 3).

## Family Achatinidae Swainson, 1840

Large and medium snails of tropical and subtropical regions of Africa.

*Achatina immaculata* Lamarck, 1823

Figs 19, 59

*Achatina immaculata*: Lamarck 1822: 128 (height c. 152 mm).

A common, widespread eastern African species. Found at five stations inland and at one station on Cabo Delgado. Differs from all other species in the area by its large size (shell up to 200×120 mm). Fresh shells differ from the similar most common *A. fulica* Bowdich, 1822 (not found in north-eastern Mozambique so far) by the pink columellar margin. Juvenile shells are even more common and can easily be separated from all other shells in the region by the large smooth protoconch.

*Achatina randabeli* Bourguignat, 1889

Fig. 20

*Achatina randabeli*: Bourguignat 1889: 84, pl. 5, fig. 6 (Tabora, Ounyanyembé; 55×28 mm).

A rather uncommon species, previously known only from the type locality in central Tanzania. Found at five stations inland and two station on Cabo Delgado. One of the smaller species of *Achatina*. The largest shell from north-eastern Mozambique is 51×26 mm. *Achatina arctespirata* (57×32 mm) described by Bourguignat (1889: 83, pl. 5, fig. 7) from the southern region of Tanganyika is probably a synonym based on a freak specimen. Both species were considered subspecies of the Tanzanian *A. craveni* Smith, 1881 (type: 81×37 mm) by Bequaert (1950: 50). Differs from all other species of the genus by the narrow-conical apex with straight outlines. Can easily be separated from similar sized species of *Limicolaria* by the strongly truncated columella.

## Family Subulinidae P. Fischer et Crosse, 1877

Small to medium snails with a worldwide tropical and subtropical distribution.

Genus *Kempioconcha* Preston, 1931

The space between the axial ribs on the apical whorls, although generally being wider than on the lower whorls, varies significantly even within a single population. Subadults have a much more elongated aperture with a straight columellar margin and a noticeable columellar-basal angle. These “characters” caused some confusion in the earlier works on this genus (often been treated as a subgenus of *Pseudoglessula*).

*Kempioconcha* cf. *obtusa* auct. non (Boettger, 1913)

Fig. 21

*Pseudoglessula* cf. *obtusa*: Verdcourt 1967: 50–52, fig. 23.

A rare and possibly not previously recognised species. Only a few damaged shells were found at four stations in a 6×20 km area west of Palma. The size of the shell varies significantly, the largest (8 whorls; subadult) being 40×20 mm. The same-sized *Krapfiella magnifica* Preston, 1913a has a spirally sculptured protoconch. Differs from all other large species of *Kempioconcha* by the narrowly conical apex. Apparently the largest species of the genus. Verdcourt (1967: 50–52, fig. 23) most probably illustrated the same species (7 whorls subadult) from the Rondo Plateau in south-western Tanzania and gave the following shell dimensions (26.0–29.5 × 12.0–15.0 mm) for this species, which he called “cf. *obtusa* Boettger” and suspected that it “will prove to be conspecific” with true *obtusa* Boettger, 1913 and *obesa* Germain, 1916. However, *Kempioconcha obtusa* (Boettger, 1913), the largest known species of the genus (32.0×15.5 mm, with *obesa* apparently being a synonym), has a noticeably wider, obtuse apex, which is the defining character of that species according to Boettger (1913: 352, pl. 17, fig. 2).

*Kempioconcha kirki* (Dohrn, 1865)

Fig. 22

*Buliminus kirki*: Dohrn 1865: 232 (Cabaçeira, Mozambique; 23.8×11.1 mm).

A common species, with a general distribution in Mozambique and Zimbabwe. Found at three stations inland and three on Cabo Delgado. The type (7 whorls) is slightly smaller than most of the shells of this species in the study area. However, the *h/w* ratio is almost exactly the same in the type (2.14) and in the shell illustrated here (2.17). It is smaller than the preceding species and much larger than any of the following species of the family.

The type locality of *Buliminus liederi* Martens, 1895 in south-eastern Tanzania (Kitoau on the plateau between Ukuledi and Umbekuru, District Mgao) is only about 150 km northwest of the study area. It has a more elongated shell (*h/w* 2.55): 28×11 mm with 7½ whorls in the original description (von Martens 1895: 180). Van Bruggen (2008: 360–368, fig. 10) reported *Pseudoglessula* (*Kempioconcha*) *liederi* (8 whorls subadult: 27.6×12.1 mm) from Malawi. However, he followed the Verdcourt (1967) key where *liederi* is separated from the similarly sized *K. kirki* (Dohrn, 1865) only by “apical whorls with costae only slightly more widely spaced than on the lower whorls”. This

character was mentioned by von Martens in comparison with “*Limicolaria borellii*” (= ? *Glandina boivini* Morelet, 1860, see Connolly 1925: 171) and *Pseudoglessula conradi* in his second description of *liederi* (von Martens 1897: 61, pl. 3, fig. 32) and he separated *Buliminus* from *Pseudoglessula* based on this character, in addition to the truncated columella in the latter (von Martens 1897: 116). However, in the same work von Martens (1897: 62) classified *kirki* Dohrn, 1865 as *Buliminus*, thus acknowledging that the axial ribs are not stronger and wider spaced on the apical whorls in both *liederi* and *kirki*. Unfortunately, he did not compare these two species, concentrating his attention on the penultimate whorl sculpture of his apparently subadult specimen of *kirki*.

I prefer to use the earlier name here, since variability of the shells from station 6 allows the application of both names, pending a proper revision of the genus.

*Kempioconcha boivini* (Morelet, 1860)

Figs 23, 60

*Glandina boivini*: Morelet 1860: 72, pl. 5, fig. 5 (mainland Kenya coast near Mombasa; 18×8 mm).

A common East and Central African species. Found at ten stations inland. Differs from the following two species of the genus by the proportionally wider shell.

*Kempioconcha* cf. *subolivacea* (Smith, 1890)

Fig. 24

A single shell found inland is about the same size but not as widely conical with straight outlines as in the original description of *Buliminus olivaceus* J.S. Gibbons in Taylor 1877 preoccupied: 253, pl. 2, fig. 5; (19.35×7.92 mm) from “Bawri Island, Zanzibar, Channel”. Differs from the following species by the proportionally higher shell with much smaller apical whorls.

*Kempioconcha conradi* (von Martens, 1895)

Figs 25, 61

*Pseudoglessula conradi*: von Martens 1895: 184; 1897: 62, 116, pl. 5, fig. 13 (Usambara, north-eastern Tanzania; 14×6 mm).

A common eastern African species, with a general distribution in Tanzania and Mozambique. Found at 11 stations inland and at two stations on Cabo Delgado. The shell illustrated here is quite similar in size and proportions to the type. However, only a few shells from north-eastern Mozambique have as widely spaced axial ribs on the apical whorls as von Martens (1895, 1897) highlighted.

*Curvella nyasana* Smith, 1899

Fig. 26

*Curvella nyasana*: Smith 1899: 588, pl. 33, fig. 44 (Mount Chiradzulu [Zomba Plateau]; Masuku Plateau; Nyika Range; 12.5×6.5 mm).

A common eastern African species, with a general distribution in Tanzania, Malawi and Mozambique. Found at four stations inland. Can easily be separated from juveniles of *Kempioconcha* by its non-ribbed apex. Differs from other Subulinidae in the area by the pronounced axial sculpture on the teleoconch and by the relatively large body whorl.



*Euonyma tugelensis* (Melvill & Ponsonby, 1897)

Fig. 27

*Subulina tugelensis*: Melvill & Ponsonby 1897: 637, pl. 17, fig. 9 (Lower Tugela River, Natal; 14×4 mm).

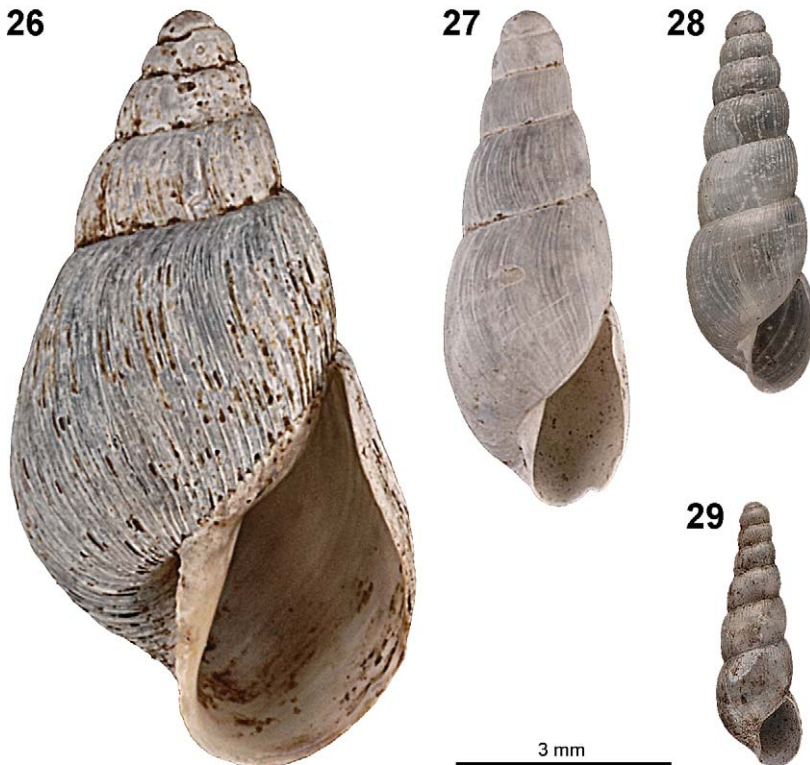
Five damaged shells found at two stations inland, although similar in size to *Opeas cressyi* Connolly, 1922 (type: 10.8×2.8 mm) from central Mozambique, are not as elongated as that species. The largest (damaged) shell from the study area measures 8.2×3.1 mm and is similar in size and proportions to *Opeas durbanense* (8.7×3.3 mm) described by Sturany (1898: 61, pl. 2, figs 42–44) from the coast of KwaZulu-Natal. Herbert and Kilburn (2004: 133) treated *durbanense* as a synonym of *tugelensis*. Differs from the following species, as well as from common and similarly sized *Allopeas clavulinum* (Potiez & Michaud, 1838), by the extremely narrow umbilical slit.

*Opeas hannense* (Rang, 1831)

Fig. 28

*Helix (Cochlicella) hannensis*: Rang 1831: 41, pl. 3, fig. 8 (Cape Verde peninsula, West Africa; 4–5 × 1.5–2 mm).

One of the most common and widespread (mostly through introduction) tropical species; found at one station inland. This is apparently the first record of this species



Figs 26–29. Subulinidae: (26) *Curvella nyasana*, 10.6×5.7 mm, stn 1; (27) *Euonyma tugelensis*, 7.2×2.6 mm, sub-adult, stn 1; (28) *Opeas hannense*, 5.4×1.8 mm, stn 1; (29) *Allopeas*? cf. *acmella*, 4.0×1.2 mm, stn 7.

from eastern Africa. The illustrated shell is almost the same in size and proportions as *Opeas araeum* Connolly, 1923: 652, pl. 19, fig. 35 (type: 5.3×1.8 mm from Kenya), which is possibly a synonym of *hannense*. Can be easily separated from the two other small subulinids in the area by the narrow but decisively open umbilicus.

*Allopeas* ? cf. *acmella* (Morelet, 1885)

Fig. 29

A few shells found at two stations on Cabo Delgado are similar in size and proportions to the type of *Stenogyra acmella* Morelet, 1885 (4.50×1.25 mm) from the area near Mayumba, West Africa, but *acmella* is umbilicate and does not have a sub-truncated columella. The shells from Cabo Delgado are also similar to Jamaican *Leptopeas robertsi* (Pilsbry, 1907), but smaller than that species, which measures 4.9×1.3 mm. Thus, the identification of these shells remains tentative until the comparison with the types of all small subulinids can be made.

Family Streptaxidae Gray, 1860

Variably-sized and shaped carnivorous snails that prey on the other snails and other invertebrates. Live in a variety of habitats in tropics and subtropics of South America, Africa and Asia.

*Edentulina affinis* Boettger, 1913

Fig. 30

*Edentulina affinis*: Boettger 1913: 349, pl. 15, fig. 8 (Kipatimu, eastern Tanzania; 31.5×15.0 mm).

A common East African species, with a general distribution from Kenya to Mozambique. Found at ten stations inland and two stations on Cabo Delgado. The convexity of the whorls significantly varies amongst the shells from Mozambique and most of the shells do not have whorls “flatter” than in Comorian *E. ovoidea* (Bruguère, 1789), as stated in the original description of *affinis*.

*Tayloria (Colpanostoma) leroyi* (Bourguignat, 1889)

Fig. 31

*Colpanostoma leroyi*: Bourguignat 1889: 43, 48, pl. 1, figs 1–3 (Nguru Mountains, eastern Tanzania; 20×25 mm).

A common species found at 12 stations inland, previously known only from eastern Tanzania. The sculpture below the periphery is much less pronounced. Some of the shells are practically smooth basally. The shell illustrated here has a 0.69 *h/w* ratio. However, some other shells collected in the region are proportionally higher. An unfigured shell from station 17, for example, has similar proportions (17.0×21.5 mm, *h/w* 0.79) to the type (*h/w* 0.80). Another two similar Tanzanian species: *T. usambarica* Craven, 1880 and *T. helicoides* (Boettger, 1913) do not have a sinuous lip.

*Gonaxis* cf. *percivali* (Preston, 1913)

Fig. 32

A few damaged shells found at two stations inland. Quite similar in size and proportions to *Streptaxis percivali* described by Preston (1913b: 194, pl. 32, fig. “4” –

should be 5) from north-central Kenya (9.25×7.00 mm) and *S. woodhousei* Preston (1913b: 194, pl. 32, fig. “5” – should be 4) from Uganda (9.5×7.0 mm). The numbers of the figures have been erroneously switched in the original descriptions. The transverse radial sculpture is coarser in *woodhousei* and the umbilicus is wider (although still narrow) in *percivali*. According to Germain (1923: 12) as well as Bequaert and Clench (1936: 269) these two are synonyms. Germain (1923: 12) even suggested that *Gonaxis cavallii* (Pollonera, 1906), with a much more open umbilicus, could be the same species. However, all shells from north-eastern Mozambique are smooth except for the minutely serrated suture and have the umbilicus completely sealed in all the adults. Thus the identification of these shells remains tentative until the range of variation in *percivali*, *woodhousei* and *cavallii* is re-evaluated.

Can easily be separated from all other (except the following) species in the area by the distorted shell. It is much larger than the following species.

*Gonaxis denticulatus* (Dohrn, 1878)

Fig. 33

*Streptaxis denticulatus*: Dohrn 1878: 152 (Mombasa, south-eastern Kenya; c. 7.0×4.5 mm).

A widespread, common East African species with a general distribution from Kenya to Mozambique. Found at eight stations inland. This species is smaller and has a less distorted axis than the preceding species. It differs from other similarly sized *Gonaxis* by the smooth shell with a strongly serrated suture.

Dohrn had a quite unusual way of measuring distorted shells. He gave “Diam. maj. 7, min. 4½, alt. 3½ mill.” in the original description of *denticulatus*. Apparently, he let the shell lie down freely on the flat surface and measured the height of the shell above the surface, calling that measurement “alt.”, which corresponds to the minor diameter in modern terminology. Then his “diam. maj.” roughly corresponds to the height (being slightly larger) and “diam. min.” roughly corresponds to the major diameter (being slightly smaller). Thus, the size from the original description in modern terminology would be: height ~7 mm, diameter major ~4.5 mm and diameter minor – 3.5 mm. (This became apparent in the original description of the similarly sized but much stronger sculptured *Streptaxis kirkii* Dohrn, 1865, where he added the diameter of the aperture: “Diam. maj. 5/16, min. 3/16, alt. 3/16, apert. diam. 1/8 poll.” (Dohrn 1865: 232), which corresponds to: height – 7.94 mm, diameter major and minor – 4.76 mm, aperture diameter – 3.18 mm in modern terminology.)

Surprisingly, von Martens (1897: 30, 32) copied the dimensions given by Dohrn into his comparison table, which is probably the reason why he listed separately the very similar *Streptaxis ordinarius* Smith, 1890. The latter species measures 6.5×4.0 mm in the original description (Smith 1890: 160, pl. 6, figs 2 and 2a) and was synonymised with *Streptaxis denticulatus* by Thiele (1911: 186), who apparently compared the types of both species.

The similarly sized *Gonaxis gibbonsi* Taylor, 1877 (7.0×4.4 mm) has a proportionally more elongated and slightly more distorted shell. *G. cressyi* Connolly, 1922 is smaller (6.2×3.8 mm) and has slightly less distorted shell. *G. mozambicensis* (Smith, 1881) is slightly larger: 7.5×4.5–4.8 mm (Smith 1881: 280, pl. 32, figs 6, 6a) but may prove to be a synonym of *denticulatus*.

*Gulella (Molarella) sexdentata* (von Martens, 1869)

Fig. 34

*Ennea laevigata* var. *sexdentata* von Martens, 1869b: 154 (Zanzibar; 9.5×4.0 mm).*Ennea sexdentata*: von Martens, 1897: 22.*Ennea sexdentata* var. *liederi* von Martens, 1897: 22 (Kitohai on the plateau between Ukuledi and Umbe-kuru, District Mgao; 12×6 mm).

A common eastern African species with a general distribution from northern Tanzania to the Save River in central Mozambique. Found at three stations inland and one on Cabo Delgado. Differs from other Streptaxidae in the area by the smooth oval-cylindrical shell with a single large curved parietal lamella, three to four palatal teeth, one basal tooth and a small cusp situated on top of the large horizontal columellar lamella. It is represented in the studied area by the var. *liederi* von Martens, 1897. Typical shells of *sexdentata* var. *liederi* (Fig. 34) were found at three stations inland. The illustrated shell has a barely noticeable fourth palatal lamella, which is completely absent in all other shells from inland stations. All four shells from the easternmost station on Cabo Delgado have a well-developed fourth short palatal lamella just below the regular three, and I consider these shells to be another variety not deserving a separate name.

Var. *liederi* was described from south-eastern Tanzania only about 150 km north-west of the study area. It differs from typical *Gulella sexdentata* by the presence of a small cusp on top of the much stronger columellar lamella. Germain (1935: 4) agreed with von Martens (1897: 22) that the 10×5 mm *Ennea hanningtoni* described by Smith (1890: 161, pl. 6, fig. 4) from northern Tanzania is a synonym of *sexdentata*. Connolly (1925: 117; 1939: 62) also treated *hanningtoni* as a synonym of *sexdentata*. He gave a 7.7–10.5 × 3.7–5.0 mm size range for this species and indicated the rare presence of “a minute additional denticle on the columellar lip” as well as occasionally lacking an upper palatal tooth (Connolly 1939: 62).

*G. sexdentata* (von Martens, 1869) is part of the complex of allied species inhabiting East and Central Africa. It is replaced by *G. ugandensis* (Smith, 1901) (syn. *Ennea optata* Preston, 1911) in Kenya and *G. aliciae* (Melvill & Ponsonby, 1907) in northern KwaZulu-Natal.

*Gulella (Molarella) subhyalina* (Smith, 1890)

Fig. 35

*Ennea subhyalina*: Smith 1890: 165, pl. 6, fig. 13 (Mamboya, north-eastern Tanzania; 6.00×2.25 mm).

A not very common eastern African species, with a general distribution from northern Tanzania to northern Mozambique. Found at one station inland. Differs from other Streptaxidae in the area by the smooth cylindrical shell with a single large parietal lamella, two upper palatal, one deeply positioned lower palatal, one basal lamella and two columellar lamellae.

The type of *Ennea subhyalina* does not have the lower palatal tooth. There are several other species and forms with a smooth cylindrical shell and similar dentition. *Ennea ingens* described by Sturany (1898: 23, pl. 1, fig. 9) from the coast of KwaZulu-Natal (Durban) is much larger (9.0×3.2 mm) and also has only two palatal teeth. *Ennea gwendolineae* described by Preston (1910: 527, fig. 3) from Shimba Hills south-west of Mombasa in south-eastern Kenya, also has only two palatal teeth and is smaller

(5.0×1.5 mm) but otherwise very similar to *subhyalina*. Surprisingly, Preston did not mention *subhyalina* in the original description of *gwendolineae*, instead comparing his new species with the much more different *E. subflavescens*, which was described by Smith (1890: 165, pl. 6, fig. 14) on the same page with *subhyalina* and illustrated next to it. Connolly (1922b: 501, pl. 14, fig. 27) described *G. (M.) gwendolineae scissidens* from Tanzania (Dar es Salaam) with an additional “more deep-set” lower palatal tooth. With the exception of its much smaller size (4.1×1.6 mm), *scissidens* is otherwise almost identical in shell shape, dentition and lack of sculpture to *subhyalina* from north-eastern Mozambique. Considering the very close similarities between *gwendolineae* + *scissidens*, and *subhyalina* + shells with an additional lower palatal tooth from north-eastern Mozambique, it is quite possible that all of them may well be just variations of one species with a distribution from south-eastern Kenya to north-eastern Mozambique. Therefore, it seems unnecessary to give a separate name to the seven-toothed variety from north-eastern Mozambique.

*Gulella perissodonta* (Sturany, 1898)

Fig. 36

*Ennea perissodonta*: Sturany 1898: 1898: 26, pl. 1, fig. 18 (Delagoa Bay, Mozambique; 4.2×2.1 mm).

Found at one station on Cabo Delgado. Two shells (2.7×1.4 mm) were collected by van Hoepen (van Bruggen 2006: 124) on Ilha Vumba only 49 km south of station 7 on Cabo Delgado. Prior to that, *perissodonta* was known only from south-eastern Mozambique, Swaziland and north-eastern KwaZulu-Natal where it is quite common. The type, described from the area near Maputo, is larger than illustrated here, but the shells from northern KwaZulu-Natal vary from 3.2×1.7 to 6.2×2.5 mm (van Bruggen 1969: 47).

***Gulella delgada* sp. n.**

Figs 37, 39–45

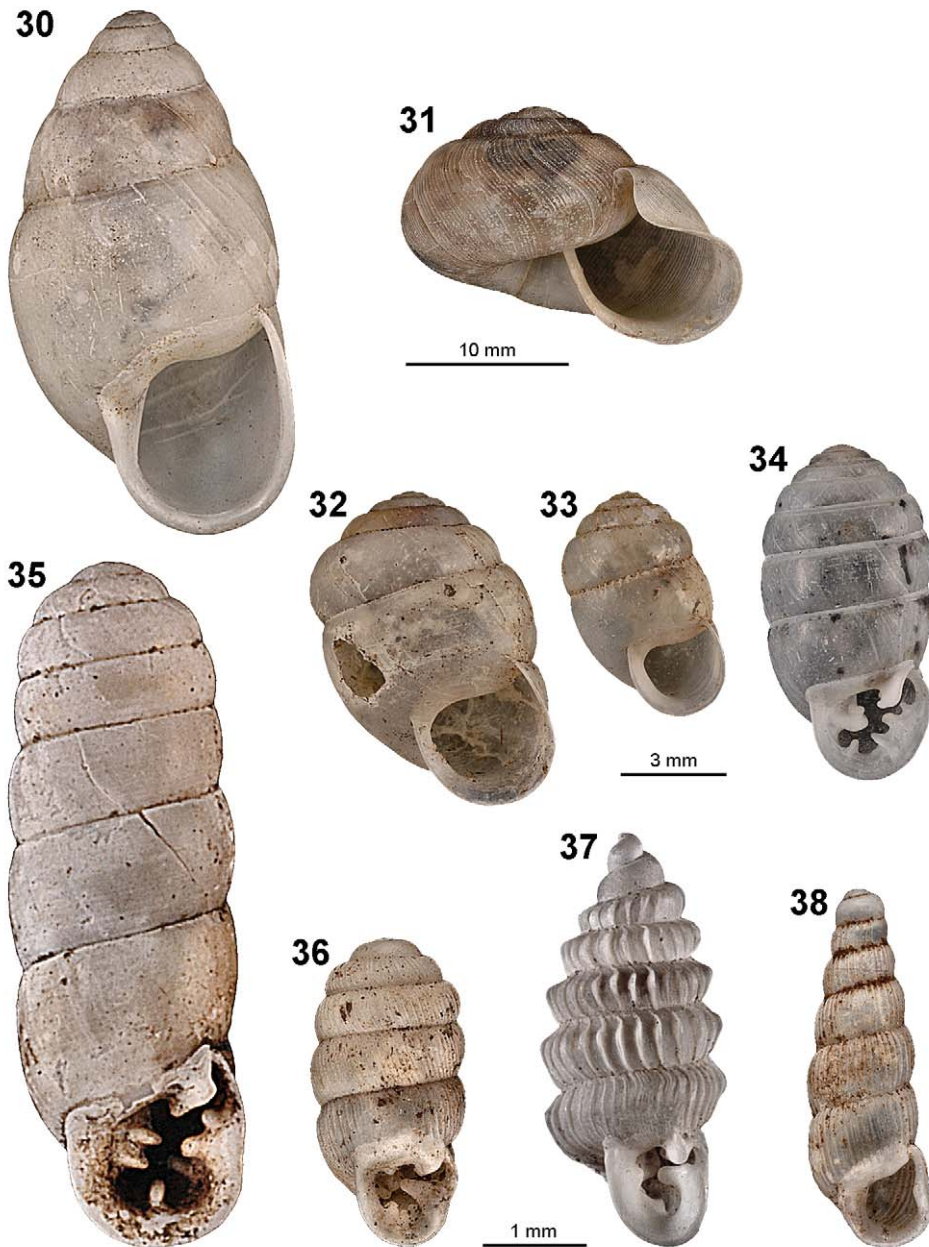
**Etymology:** From Portuguese *delgada* (slender, elongated) and Cabo Delgado; with reference to the overall appearance of the shell and the name of the type locality.

**Diagnosis:** Elongated shell with narrow umbilicus and acuminate smooth apex; with large, widely spaced axial ribs on teleoconch; large short parietal lamella, long palatal lamella (which consists of low distal and large proximal parts), small columellar cusp and large, obtuse, rounded, deeply set columellar tooth.

**Description:**

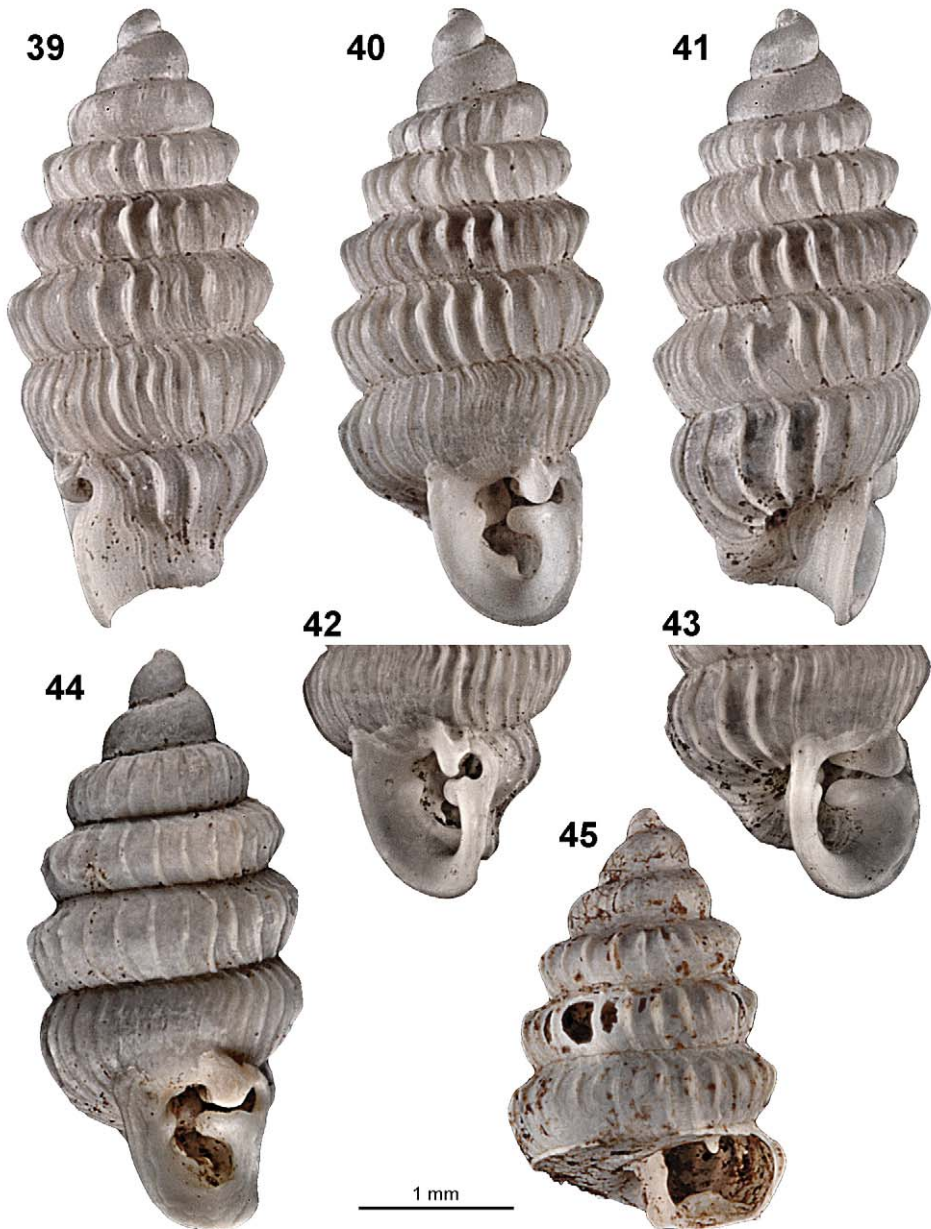
Shell semi-translucent, white, elongated acuminate-ovate, with narrow umbilicus and acute apex. Protoconch (~2.5 whorls) smooth. Teleoconch consists of 4–5 convex whorls, slightly angulated above the periphery, separated by deep suture; with strong, widely spaced axial ribs accentuated just above the periphery of the whorls and less developed above the aperture (width of ribs on average three times less than width of intercostal spaces). Last whorl not ascending towards apex, height is less than half (about 45%) of shell height. Aperture oval, with very narrowly reflected columellar, basal and palatal margins, incised just below the suture of preceding whorl in the area of pneumostome. Apertural dentition of (1<sup>st</sup>) large parietal lamella that suddenly starts a short distance forward of columellar plane, very slightly curves towards the area of





Figs 30–38. Streptaxidae: (30) *Edentulina affinis*, 33.4×17.6 mm, stn 5; (31) *Tayloria leroyi*, 14.4×21.0 mm, stn 5; (32) *Gonaxis* cf. *percivali*, 9.4×6.9 mm, stn 1; (33) *G. denticulatus*, 7.0×4.6 mm, stn 11; (34) *Gulella sexdentata* var. *liederi*, 9.4×4.8 mm, stn 1; (35) *G. subhyalina*, 6.5×2.3 mm, stn 1; (36) *G. perissodonta*, 3.2×1.5 mm, stn 7; (37) *Gulella delgada* sp. n., 4.0×1.8 mm, 1<sup>st</sup> syntype, stn 7; (38) *Streptosteles herma*, 3.8×1.2 mm, stn 7. Scale bar 10 mm in Figs 30–31; 3 mm in Figs 32–34; 1 mm in Figs 35–38.

pneumostome and reaches apertural edge; (2<sup>nd</sup>) palatal lamella about half a whorl long, reaches apertural margin, low in its first half, then suddenly becomes the same size as parietal lamella in the same area where parietal lamella starts (distal portion of palatal lamella is cross-symmetrical with parietal lamella); (3<sup>d</sup>) basal lamella low, about a



Figs 39–45. *Gulella delgada* sp.n., stn 7: (39–43) 1<sup>st</sup> syntype, 4.0×1.8 mm, five views; (44) 2<sup>nd</sup> syntype, 3.8×1.8 mm; (45) 3<sup>rd</sup> syntype, 2.7×1.8 mm.

quarter of a whorl long, situated closer to columella, ascends towards small columellar cusp and gradually disappears a short distance from it; (4<sup>th</sup>) small columellar cusp positioned about two-thirds of distance between columellar edge and large, obtuse, rounded, deeply set (5<sup>th</sup>) columellar tooth. Juvenile with small parietal tooth, large basal lamella (positioned parallel to basal edge of aperture) and slight thickening in middle of columella. No internal dentition in upper whorls.

Measurements of the shells: 1<sup>st</sup> syntype: 7.5 whorls, height 4.0 mm, major diameter 1.8 mm; 2<sup>nd</sup> syntype: 6.5 whorls, height 3.8 mm, major diameter 1.8 mm; 3<sup>rd</sup> syntype (juvenile): 5.5 whorls, height 2.7 mm, major diameter 1.8 mm.

Type material: 1<sup>st</sup> syntype (MNHN: 23097), 2<sup>nd</sup> syntype (NMSA: L8003/T2583), 3<sup>rd</sup> syntype (juvenile) (NMSA: L8004/T2584); all from MOZAMBIQUE: *Cabo Delgado*: 1.1 km WNW of lighthouse, 19 km NE of Palma, 10.68883°S:40.62806°E, alt. 11 m, 24.xi.2009, I.V. Muratov.

Distribution: Known so far only from the type locality in north-eastern Mozambique.

Remarks: Designation of syntypes is necessary because of significant differences in the dentition of the adult and juvenile shell. All three shells are worn, without any periostracum. The larger adult (1<sup>st</sup> syntype – Figs 37, 39–43) has a slightly bent shell axis in the area of the third whorl, which is not the case in the other two shells. The smaller adult (2<sup>nd</sup> syntype – Fig. 44) and the juvenile (3<sup>rd</sup> syntype – Fig. 45) both have two large holes at the back of the shell as the result of pre-collection damage.

There are four other species currently in the genus *Gulella* with an acuminate apex and similar dentition: *Pupa minuscula* described by Morelet (1877: 340, pl. 12, fig. 5; 3×2 mm) from Anjouan, Comoros, *Ennea radius* described by Preston (1910: 529, fig. 8; 3.25×2.00 mm) from the Shimba Hills in south-eastern Kenya, *Gulella cuspidata* described by Verdcourt (1962: 3, 27; pl. 3, fig. 2; 4.8×2.5 mm) from the Usambara Mountains in north-eastern Tanzania and *Gulella browni* described by van Bruggen (1969: 69, figs 25–26; 3.0×1.7 mm) from the east shore of Lake Sibayi in northern KwaZulu-Natal. *G. delgada* differs from all four by the more elongated shell with wider spaced axial ribs on teleoconch, as well as by the much longer palatal and basal teeth.

### *Streptostele (Raffraya) herma* Connolly, 1912

Fig. 38

*Streptostele (Raffraya) herma*: Connolly 1912: 89, pl. 2, fig. 3 (Victoria Falls; 4.5×1.3 mm).

A rather uncommon East African species, with a general distribution from south-eastern Kenya to north-eastern parts of South Africa. All shells found at all three stations on Cabo Delgado are slightly smaller than the type of this species. Differs from all other snails in the area by the small, elongated shell with a weak parietal tooth and slight palatal thickening.

### Family Euconulidae Baker, 1928

Minute to medium-sized snails, inhabiting damp leaf litter and damp soil worldwide.

### *Microcystina minima* (Adams, 1867)

Fig. 46

*Macrochlamys minima*: Adams 1867: 303, pl. 19, fig. 2 (near Port Louis, Mauritius; c. 1.3×0.5 mm).



A single shell was found on Cabo Delgado. Previously known only from the Mascarene Islands where it is quite common and recently recorded from Zanzibar (Rowson *et al.* in press). The smallest species in the study area. Can be easily distinguished from the following species by the lack of spiral sculpture.

The shell was originally described "... *depressa, discoidea* ... Diam.  $1\frac{1}{3}$ , alt.  $\frac{1}{2}$  mill." and the apex is not visible on the original illustration. The measurements in the original description were clearly approximate. Griffiths and Florens (2006: 130, pl. 27, fig. E) illustrated *M. minima* with a protruding apex and gave "Diameter: 1.3 mm; height 0.5 mm" for the size of the shell. However, if calculated from the proportions of that illustration, assuming that diameter is 1.3 mm, the height of the shell would be 0.82 mm. Thus, in view of the fact that there are no other shells with a narrow umbilicus, without any spiral sculpture and 1.3 mm in diameter found so far on Mauritius, it would be safe to assume that *M. minima* has variably protruding apical whorls.

*Afroguppya rumrutiensis* (Preston, 1911)

Fig. 47

*Thapsia rumrutiensis*: Preston 1911: 466, pl. 11, fig. 9 (NW of Mount Kenya; 1.25×2.50 mm).

A common East African species with a general distribution from Kenya to the Eastern Cape in South Africa. A few damaged shells were found at one station on Cabo Delgado. Differs from the preceding species by the slightly larger shell with an angulated periphery and an always clearly visible microscopic spiral sculpture.

Family Helicarionidae Bourguignat, 1877

Medium to large snails with a well developed shell, as well as various semi-slugs and slugs. Live in tropical and subtropical areas except Australia and America.

"*Sitala*" *jenynsi* (Pfeiffer, 1845)

Figs 48, 62

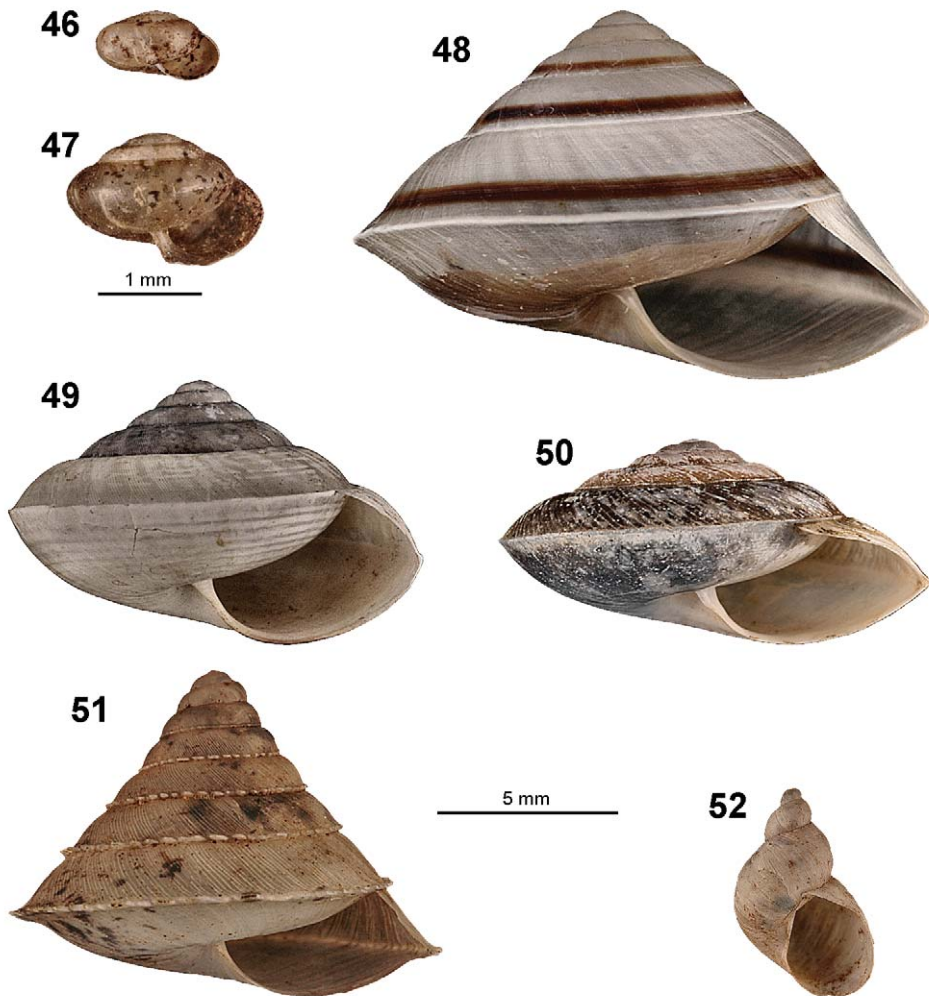
*Helix jenynsi*: Pfeiffer 1845: 131 (Collection of H. Cuming; 7.5×12.0 mm).

A common East African species, with a general distribution from Kenya to central Mozambique. Found at seven stations inland and at all three stations on Cabo Delgado. Pfeiffer (1845) described the shell as "... *turbiniformi*, ... *carinata*, ..." from unknown locality and unfortunately did not give any illustrations. Reeve (1853: pl. 150, fig. 979) reported this species from New Caledonia and illustrated a shell with a more angulated periphery but still not as carinated as illustrated here. Von Martens (1867: 254) then reported it from Java and New Hebrides, as well as from the Querimba Islands (just south of Cabo Delgado). All shells from Cabo Delgado have an obtusely angulated periphery, similar to that illustrated by Philippi (1847: 86; *Helix* pl. 7, fig. 8). Philippi's figures were copied by Pfeiffer (1852: pl. 129, figs 23, 24; 1853: 321) and Tryon (1886: 50; pl. 24, figs 87, 88).

A live-collected subadult from station 10 has essentially the same genitalia as illustrated by Verdcourt (1963: 191, fig. 1), who treated *jenynsi* as *Sitala* following Thiele (1931). This species does not have any penial appendages besides a small flagellum, which prevents its formal placement into *Trochonanina*. However, the penial retractor

is connected at the base of flagellum and the vagina is long – characters that prevent its formal placement in *Sitala*. The shell is clearly much more similar to *Trochonanina* than to *Sitala*. I suspect that *jenynsi* in fact should have remained in *Trochonanina* (perhaps as a separate subgenus). However, I do not have any choice but to treat it as “*Sitala*” since this paper is not a taxonomic revision.

It differs from three following species by the slightly larger shell with microscopic spiral sculpture on the entire surface and a chestnut line above the periphery as well as above the suture of the apical whorls. The shells from Cabo Delgado have a shape quite similar to that of the following species.



Figs 46–52. Euconulidae: (46) *Microcystina minima*, 0.68×1.20 mm, stn 7; (47) *Afroguppya rumrutiensis*, 1.3×1.9 mm, stn 7; Helicarionidae: (48) “*Sitala*” *jenynsi*, 10.5×16.0 mm, stn 12; (49) *Trochonanina albopicta*, 7.5×11.5 mm, stn 5; (50) *T. bloyeti*, 5.8×12.0 mm, stn 17; (51) *Trochozonites crenulata*, 9.3×12.0 mm, subadult, stn 7; (52) *Quickia concisa*, 6.0×3.9 mm, stn 7. Scale bar 1 mm in Figs 46–47; 5 mm in Figs 48–52.

*Trochonanina albopicta* (von Martens, 1869)

Fig. 49

*Nanina mossambicensis* var. *albopicta*: von Martens 1869a: 56, pl. 1, fig. 2 (East Africa; 11×18 mm).  
*Ledoulxia albopicta* (von Martens, 1869): Connolly 1925: 135.

A common East African species, with a general distribution from southern Kenya to central Mozambique. Found at four stations inland. Possibly just a colour variety of *Trochonanina mossambicensis* (Pfeiffer, 1855), as it was originally described by von Martens. Can easily be recognized by the characteristic pattern of lighter, non-translucent specks oriented in spiral lines on a darker, semi-translucent, corneous background, as well as alternating zones of lighter and darker close-set axial riblets on the upper side of the shell with only microscopic spiral striation on the base. The shell illustrated here is much faded.

*Trochonanina bloyeti* Bourguignat, 1889

Fig. 50

*Trochonanina bloyeti*: Bourguignat 1889: 21 (Near Kondo, Usambara, north-eastern Tanzania; 7×15 mm).

A rare eastern African species, with a general distribution from northern Tanzania to central Mozambique. A single shell found inland. Quite similar to the preceding



Figs 53–55. *Trochozonites* (*Crenatinanina*) *crenulata*, 8.2×12.8 mm, subadult, three views, stn 9.



species, differing from it by the wider spaced, stronger axial ribs on the upper side of the more depressed, uniformly coloured shell. The shell illustrated here has lighter spots in places of the damaged periostracum.

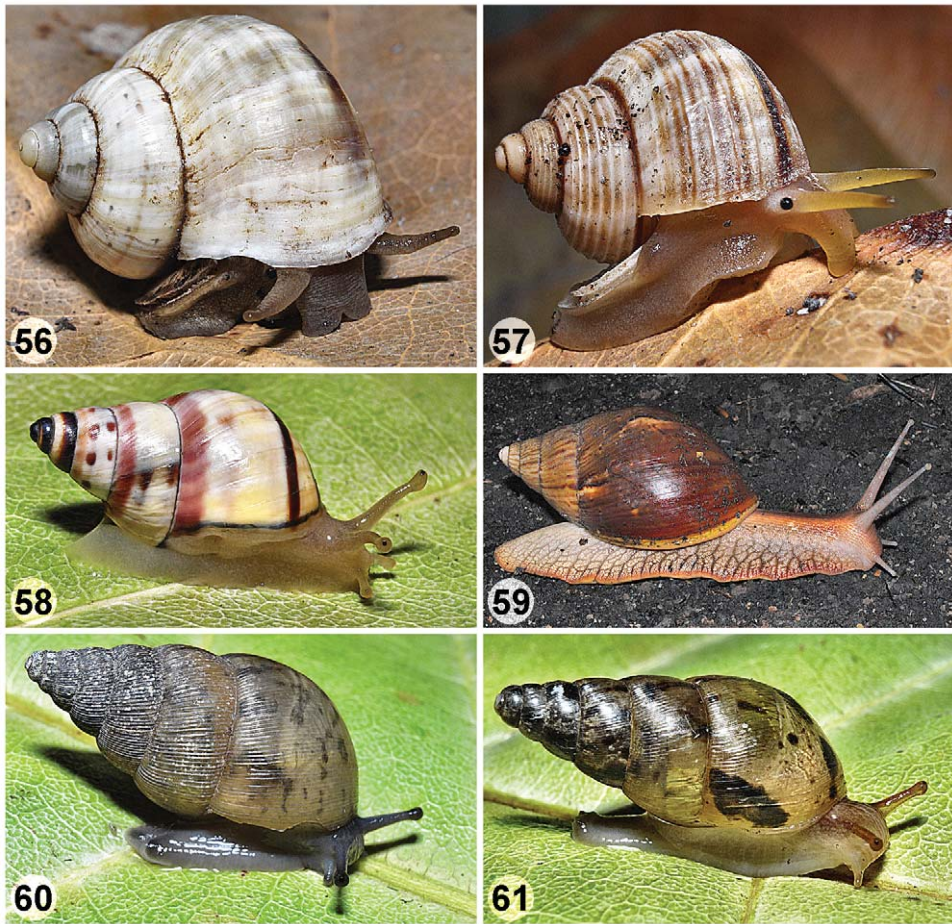
*Trochozonites (Crenatinanina) crenulata* (Germain, 1905)

Figs 51, 53–55

*Trochonanina crenulata*: Germain 1905: 484 (Environs de Zanzibar; 11.0×15.5 mm).

*Trochonanina (Crenatinanina) crenulata*: Germain 1920: 75, pl. 4, figs 3–5 (Zanzibar; 10.0×15.5 mm, erroneously said to be “grandeur naturelle” in figures captions).

This appears to be a rediscovery of the species collected by Raffray in 1891 and not seen since 1920. The type, according to Germain in MNHN, could not be found there (Rowson 2007: 451).



Figs 56–61. Pomatiidae: (56) *Tropidophora ligata*, shell 15.5×15.3 mm, stn 7; (57) *T. zanguebarica*, shell 10.0×9.5 mm, stn 7; Cerastidae: (58) *Rhachistia catenata*, shell 10.0×6.3 mm, subadult, stn 1; Achatinidae: (59) *Achatina immaculata*, shell 102×56 mm, stn 1; Subulinidae: (60) *Kempioconcha boivini*, shell 16.0×8.4 mm, stn 1; (61) *K. conradi*, shell 13.7×6.2 mm, stn 8.

Embryonic whorls (destroyed in the type and thus not previously described) with weak close-set microscopic axial riblets cut by much finer spiral lines.

All shells found at the three stations on Cabo Delgado are proportionally higher than the type, but some worn adult shells are up to  $10.3 \times 15.2$  mm, approaching the size and proportions of the type. The shell illustrated in Figs 53–55 is faded, smaller than the type but similar in shape.

#### Family Urocyclidae Simroth, 1889

Medium to large slugs. Inhabit tropical and subtropical areas of Africa. External characters should be used with caution for identification, especially in the case of juveniles.

#### *Bukobia uhehensis* Verdcourt, 1965

Fig. 63

*Bukobia uhehensis*: Verdcourt 1965: 282, fig. 8 (Iringa, Tanzania; length 49 mm, sole width 6 mm).

A rare eastern African species, previously known by a single specimen from the type locality in central Tanzania, about 600 km NW of the study area. Found at one station inland. Differs from all other species of the genus *Bukobia*, as well from two following species of the family, by the presence of a single large soft stimulator without any calcareous elements inside the shortly elongated diverticulum of the atrium.



Figs 62–65. Helicarionidae: (62) “*Sitala*” *jenynsi*, shell  $7.9 \times 11.0$  mm, subadult, stn 8. Urocyclidae: (63) *Bukobia uhehensis*, length 35 mm, stn 1; (64) *Elisolimax flavescens*, length 40 mm, stn 8; (65) *Urocylus kirki*, length 75 mm, stn 10.

*Elisolimax flavescens* (Keferstein, 1866)

Fig. 64

*Parmarion flavescens*: Keferstein 1866: 70, pl. 2, figs 2–8 (Inhambane, Mozambique; length 35 mm – contracted).

A common eastern African species, with a general distribution from southern Tanzania to the Eastern Cape in South Africa. Found at two stations on Cabo Delgado. Differs from other continental species of the genus *Elisolimax*, as well as from the preceding and the following species of the family, by the long, narrow diverticulum of the atrium with two large longitudinal folds inside.

*Urocyclus kirki* Gray, 1864

Fig. 65

*Urocyclus kirki*: Gray 1864: 251 (Near the mouth of the River Zambezi, Mozambique).

A common eastern African species, with a general distribution from southern Tanzania to Zululand in South Africa. Found at a single station inland. Differs from all other species of the family by the large, muscular diverticulum of the atrium with a single large calcareous dart inside.

## Family Succineidae Beck, 1837

Small to medium sized snails with worldwide distribution.

*Quickia concisa* (Morelet, 1848)

Fig. 52

*Succinia concisa*: Morelet 1848: 351 (Gabon; 7×4 mm).

A common African species, with a general distribution in tropical areas from Sierra Leone to Kenya and Tanzania, as well as on the Comoros, Seychelles and Mascarene Islands. Found at all three stations on Cabo Delgado.

## DISCUSSION

The majority of the species found in north-eastern Mozambique have an eastern African general distribution. *Nesopupa peilei* and *Microcystina minima*, previously recorded mostly from the Mascarene Islands, probably will be found in many other localities on the coast of the African mainland when proper surveys of the coastal areas (with soil sieving) are done. *Cyathopoma diegoense*, previously known only from northern Madagascar, obviously could be found in other coastal areas as well, considering that all three species are under 3 mm in size and thus can be dispersed with the soil.

Terrestrial molluscs can be used as indicators of environmental conditions since many of them have very specific ecological preferences. Molluscs with similar ecological preferences frequently can be found living together, forming an ecological association in particular type of habitat.

The cluster analysis reveals two main groups of stations (24.662% similarity) inhabited by terrestrial molluscs: all three stations on Cabo Delgado (7, 8 and 9) in one group and all the other stations further inland in another group.



There are 28 species of molluscs on Cabo Delgado and 27 species inland, but only nine species were found in both regions. Nineteen species that occur on Cabo Delgado are not present inland and 18 species that occur inland are not present on Cabo Delgado. The most noticeable (very abundant) species on Cabo Delgado, *Pupoides coenopictus*, apparently does not extend its range in north-eastern Mozambique more than a few kilometres inland. On the other hand, *Rhachistia catenata*, which is quite common inland, does not occur on Cabo Delgado.

The main ecological difference between Cabo Delgado and the inland study area is the abundance of limestone in the former and the total lack of it in the latter. In fact, the entire Cabo Delgado is an elevated ancient coral reef with only in its western (inland) part covered by the sandy soil. This porous limestone accumulates rainwater and slowly releases it, keeping a constant humidity favourable for the snails, as well as providing calcium carbonate for shell construction and abundant shelters.

The difference between Cabo Delgado and inland study areas may have a zoogeographical component as well, since Cabo Delgado was isolated from the mainland long enough to be populated by 19 species of terrestrial molluscs unique to the region.

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