

# Taxonomic studies on the Emarginulinae (Mollusca: Gastropoda: Fissurellidae) of southern Africa and Mozambique. *Emarginula*, *Emarginella*, *Puncturella*, *Fissurisepta* and *Rimula*

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Nineteen species (six new) of the genera *Emarginula*, *Emarginella*, *Puncturella*, *Fissurisepta* and *Rimula* are discussed; the last two genera represent new records for the area. Scanning electron micrographs of shell microsculpture, radula and protoconch are given where possible; microsculpture appears to be a particularly useful taxonomic character. New species: *Emarginula phrygium*, *E. viridicana*, *Puncturella voraginosa*, *P. serraticosta*, *Fissurisepta onychoides* and *Rimula rhips*. New synonyms: *Emarginula vadum* Barnard, 1963 = *E. undulata* Melvill & Standen, 1903; *Fissurisepta joschristiaensi* Drivas & Jay, 1985 = *Puncturella christiaensi* Kilburn, 1978. Revised combination: *oppressa* Barnard, 1963, is an *Emarginula*, not an *Emarginella*. New record: *Puncturella aethiopica* von Martens, 1902, described from the Zanzibar Channel, occurs off Natal and Transkei. Lectotypes designated and figured: *Emarginula undulata* Melvill & Standen, 1903, and *Emarginella sibogae* (Schepman, 1908).

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Negentien spesies (ses nuwes) van die genera *Emarginula*, *Emarginella*, *Puncturella*, *Fissurisepta* en *Rimula* word bespreek: die laaste twee genera verteenwoordig nuwe rekords vir die gebied. Skandeerelektronmikrograwe van skulpmikroskulptuur, raspertong en protoskulp word, waar moontlik, gegee; mikroskulptuur blyk veral 'n nuttige taksonomiese eienskap te wees. Nuwe spesies: *Emarginula phrygium*, *E. viridicana*, *Puncturella voraginosa*, *P. serraticosta*, *Fissurisepta onychoides* en *Rimula rhips*. Nuwe sinonieme: *Emarginula vadum* Barnard, 1963 = *E. undulata* Melvill & Standen, 1903; *Fissurisepta joschristiaensi* Drivas & Jay, 1985 = *Puncturella christiaensi* Kilburn, 1978. Hersiene kombinasie: *oppressa* Barnard, 1963, is 'n *Emarginula*, nie 'n *Emarginella* nie. Nuwe rekord: *Puncturella aethiopica* von Martens, 1902, beskryf van die Zanzibar Kanaal, kom by Natal en Transkei voor. Lektotipes aangewys en uitgebeeld: *Emarginula undulata* Melvill & Standen, 1903, en *Emarginella sibogae* (Schepman, 1908).

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## Introduction

### Historical review

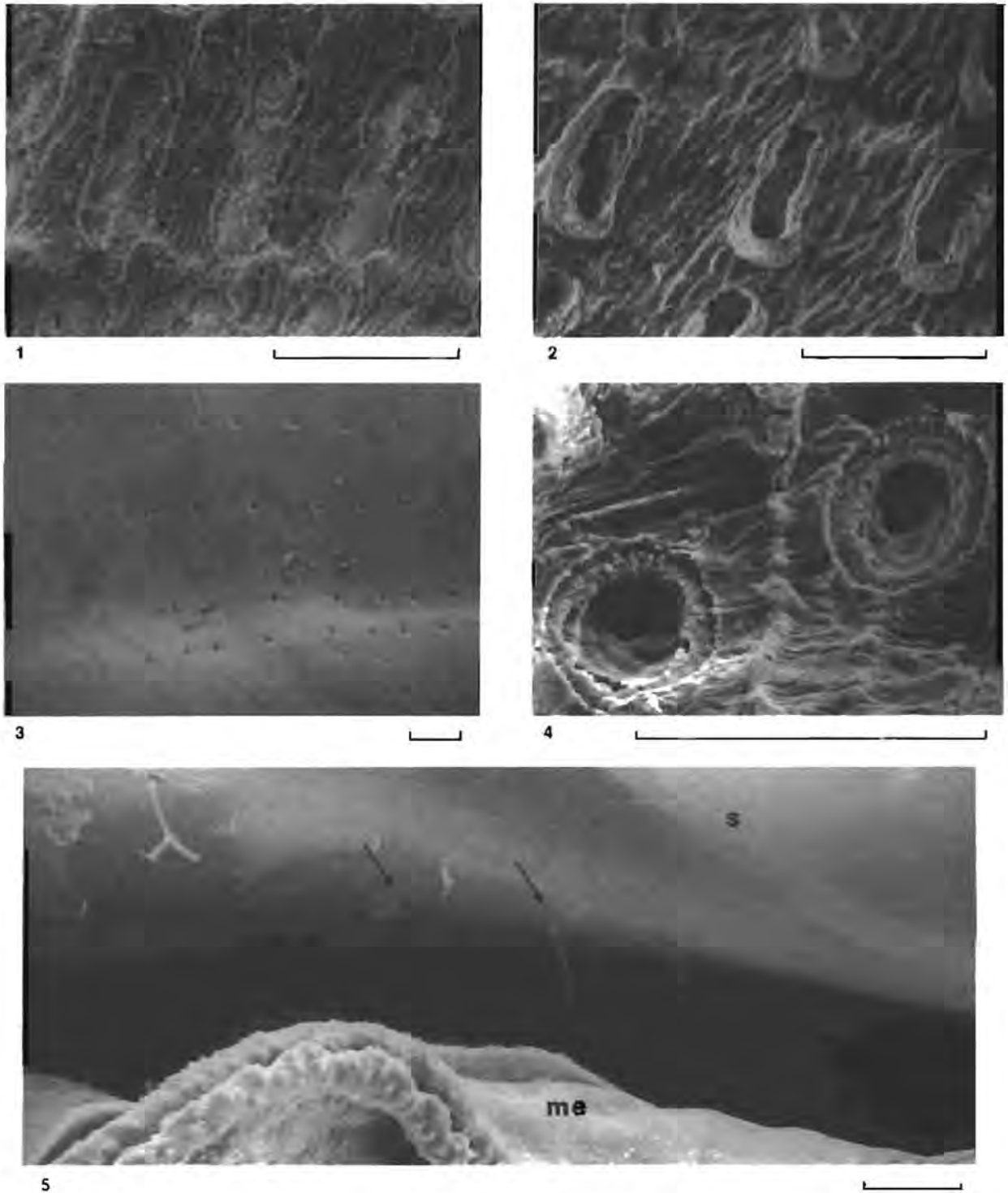
In the present revision we follow Kilburn (1978) in applying the subfamily Emarginulinae in the sense of Wenz (1938) and Keen (1960). It is noted, however, that some workers (eg. McLean 1984) follow Thiele (1929) in including the genus *Diodora* and others in the Emarginulinae, on account of similarities in radular structure.

Early records and descriptions for South African species were scattered through the literature (von Martens 1904; Smith 1910; Thiele 1925; Tomlin 1932). Barnard (1963) was the first to review the subfamily in this region, basing his study mainly on material dredged by the *S.S. Pieter Faure* (1897–1907) [SAM collection. (See list of abbreviations at end of article)]. Six members of the genera included in the present paper were covered by him, three being described as new. More recently, Kilburn (1978) examined the Emarginulinae of southern Africa and also Mozambique, adding two previously unrecorded genera, *Hemitoma* and *Emarginella*. His study was based on both NM and SAM material, the majority of new species having been sorted from bottom samples dredged by CSIR Water Research.

Subsequent to Kilburn's paper, extensive dredging work has been undertaken by the Natal Museum using the *R. V. Meiring Naudé*. This has concentrated on the continental shelf and slope off Transkei and has greatly increased the emarginuline material available. A more detailed study of the group is now possible.

### Shell microstructure

Kilburn (1978) drew attention to the possible taxonomic significance of shell microsculpture in the genus *Emarginula*. Of particular interest are the shape and distribution of small surface pits filled with a chalky material (termed intritacalx after D'Attilio & Radwin 1971). This pitting is not restricted to *Emarginula*, but occurs also in *Puncturella* and in juveniles of *Tugali* and *Emarginella*. In live-taken shells the intritacalx is readily visible under the dissecting microscope, usually appearing chalky white against the more translucent surrounding shell. With wear it may be lost and is frequently removed by ultrasonic cleaning. This exposes the underlying pits, which is advantageous in scanning electron microscopy as (in contrast to optical microscopy) the pits are more obvious when empty than when full (Figures 1, 2), particularly in *Puncturella* (Figures 62, 63). SEM reveals that each pit has near its centre a small pore, opening into a canal which passes through the shell to the interior (Figures 2, 4). On the



Figures 1–5 Intritacalx pits and shell pores. 1. Intritacalx-filled pits (*Emarginula undulata*). 2. Sonicated specimen of same species with empty pits containing pores. 3. Pores opening on to shell interior (*E. undulata*). 4. Intritacalx pits of *Puncturella aethiopica* sonicated to show pores. 5. Apparent strands of tissue (arrows) extending from pores in shell interior (me = mantle edge, s = shell), *Emarginula reticulata* Sowerby, 1813. All SEM scale bars = 100  $\mu\text{m}$ .

inner surface they appear collectively as radiating rows of microscopic punctations (Figure 3).

Similar pore-like structures have been described in *Emarginula* and *Puncturella* by Bandel (1982) who compared them with the aesthetes of chitons and the pores known to occur in certain bivalve shells. They are also evident in some of the figures given by Piani (1984). Bandel postulated that they may contain projections of the mantle which function as sense organs. Further investigation is required to confirm whether mantle tissue does actually pass into the pores, but broken tissue-like strands have been observed extending

from holes in the shell interior (Herbert, unpublished observation) (Figure 5). Although these structures may indeed prove to function as sense organs, as yet too little is known for any meaningful speculation.

The shape, orientation and distribution of intritacalx pits has been found to be of considerable value in identifying species, particularly of *Emarginula*. Furthermore, as suggested by Kilburn (1978), species can be grouped according to their pattern of intritacalx pitting. These structures may therefore also prove taxonomically useful above the species level in *Emarginula*. Currently however, details are available

for far too few species. Intritacalx pitting appears to show much less interspecific variation in *Puncturella* (at least in southern African species) and is therefore liable to be of correspondingly reduced taxonomic value. *Emarginella* needs further investigation.

The presence of intritacalx pits in at least some juvenile *Diodora* species may prove to be phylogenetically significant.

### Protoconch

Where possible micrographs of protoconchs are provided. In *Emarginula* (with the exception of *E. phrygium*) there is little or no apparent interspecific variation in protoconch shape. Too few perfect specimens are available for detailed discussion of protoconch microsculpture. Typically, although the early juvenile shell may be twisted slightly to the right, the protoconch is not twisted (or only slightly so, as in *E. macchurigi*).

Generally the protoconch is visible from both sides of the shell. In form it consists of approximately one whorl of almost uniform diameter, terminating in a thickened, sometimes collar-like lip and the tip is rounded. The protoconch in the *Puncturella* species examined is distinctly turned to the right and is clearly visible when the shell is viewed from behind (Figure 65); it can rarely be seen from the left. Furthermore it has a pointed, slightly recurved tip similar to that seen in many trochaceans. Protoconchs were not available for either *Fissurisepta* or *Rimula*.

### Radula

The fissurellid radula is rhipidoglossan with five laterals on each side of the rachidian, the outermost of which is very large; marginals are numerous, long and slender. There is an additional plate, the latero-marginal, between the base of the fifth lateral and the marginals. In most genera the radula is markedly asymmetrical, the teeth in each row being skewed such that those on the left are more anterior than those on the right. This is correlated with the presence of massive outer laterals and enables the radula to be folded in a zipper-like fashion when retracted. In *Zeidora* the obliqueness of the rows is apparently reversed (Hickman 1981).

Whenever possible we have given scanning electron micrographs of radular structure. Interspecific differences are evident, particularly with regard to the rachidian and inner laterals. The latero-marginal plate is also shown, but its structure is difficult to describe as its apparent shape varies with the angle of view.

In the Emarginulinae the rachidian is of variable width (and may even be vestigial or absent, according to Hickman 1983) with its cutting edge set obliquely to the longitudinal radular axis. The larger outer laterals have only two well developed cusps and the cutting edge of the inner laterals becomes progressively smaller from the first to the fourth (where it is very small or absent). The latero-marginal plate is rectangular to triangular, frequently with a socket on its inner face into which fits the base of the fifth lateral; a second socket on its anterior face holds the base of the first marginal. Hickman (1984) has discussed the probable articulatory function of this structure. In certain species the exposed shaft of the rachidian and some of the inner laterals appears fibrous. The marginals are numerous with many small cusps on the flattened and curled tip.

### External anatomy of the animal.

Live-taken material of *Emarginula*, *Puncturella* and *Emar-*

*ginella* has been obtained. With the exception of the last (which is described later), external anatomy is typically emarginuliform in all species examined, and a full description for each would be repetitive. Consequently only variable characters such as the number and distribution of epipodial tentacles and features of particular importance are given. For more detailed descriptions of external anatomy see Odhner (1932), Fretter & Graham (1976) and Herbert (1984). It should be noted that epipodial tentacles are often of two types, viz. long and extensile with the epipodial sense organ at the tip, or short with the epipodial sense organ on the ventral surface. An additional metapodial tentacle may be present at the posterior end of the foot, between the sole and the epipodium.

### Key to the genera of the Emarginulinae of southern Africa and Mozambique

1. Shell with a foramen on the anterior face or near the apex . . . . . 2  
 — Shell with a slit, notch or shallow indentation in the anterior margin . . . . . 4
2. Internal septum absent; foramen at or near centre of anterior face . . . . . *Rimula*  
 — Internal septum present; position of foramen variable . . . . . 3
3. Protoconch lost in adult; shell thin, high with a sculpture of chalky granules. Internal septum well developed, foramen at apex of anterior face . . . . . *Fissurisepta*  
 — Protoconch retained in adult, internal septum, sculpture and position of foramen variable . . . . . *Puncturella*
4. Shell crepiduliform, apex level or even below ventral margin . . . . . *Zeidora*  
 — Shell patelliform, variably recurved, apex above ventral margin . . . . . 5
5. Anterior margin with a distinct narrow slit and a complex selenizone . . . . . 6  
 — Anterior margin with only a notch or shallow indentation, selenizone (if present) simple . . . . . 7
6. Body larger than shell with a well-developed foot; mantle reflected over shell. Shell very depressed . . . . . *Emarginella*  
 — Body contained within shell, mantle not reflected over shell or only the very edge. Shell moderate to high, rarely depressed . . . . . *Emarginula*
7. Shell outline oblong to rectangular, very depressed, anterior margin with only a broad, shallow indentation, selenizone at most a faint furrow. Animal larger than shell, which can be covered by mantle . . . . . *Scutus*  
 — Shell outline subcircular to ovate, height variable; anterior margin with distinct notch, selenizone ridge-like . . . . . 8
8. Anterior notch relatively narrow, U-shaped; selenizone a coarse ridge; sculpture of radial ribs. Radula with fifth lateral possessing two additional small cusps on its outer edge (making a total of four) . . . . . *Hemitoma*  
 — Anterior notch relatively broad, roundly V-shaped; selenizone a broad but weak ridge; sculpture very fine or obsolete. Fifth lateral with only two cusps . . . . . *Tugali*

### Taxonomy

#### Genus *Emarginula* Lamarck, 1801

Type species (monotypy) *Emarginula conica* Lamarck, 1801.

The southern African members of this genus show variable interstitial patterns and intritacalx pitting. They can be divided into four groups as follows:

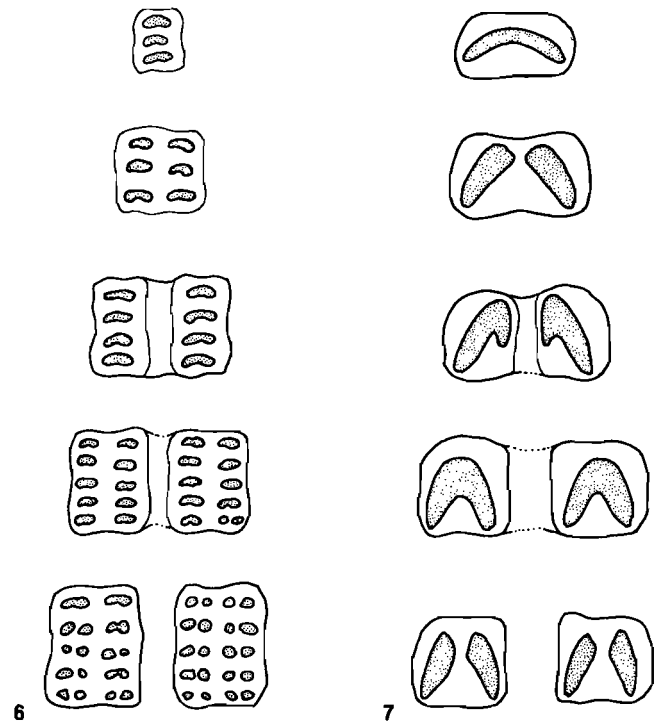
1. Sculpture not cancellate, pits concentrically elongate, arranged in radial rows; e.g. *E. undulata*.

2. Sculpture coarsely or finely cancellate, interstices simple, i.e. with one pit or a pair of pits per interstice. This is the most common pattern, occurring in *E. natalensis*, *E. agulhasensis*, *E. connelli*, *E. oppressa*, *E. viridicana*, *E. macclurghi* and possibly *E. phrygium*.
3. Sculpture coarsely cancellate, interstices multiple, i.e. with more than one pair of pits per interstice, arranged like the dots on a die; e.g. *E. koon*.
4. Sculpture coarsely cancellate, interstices compound, i.e. large, subdivided by a single intermediary radial and several fine concentric threads to form secondary interstices, each of which possesses a pit or pair of pits. Generally the ventral pair of secondary interstices within each main interstice contain radially elongate pits. This sculpture is clearly a modification of the simple form described under 2, where some of the concentric threads have become enlarged. This produces a coarser secondary cancellation which overlies a sculpture similar to that of group 2. It is found in *E. thorektes* and *E. tenuicostata*.

Initially most species possess concentrically elongate pits in the juvenile shell (Figure 15) which gradually develop into their adult form. The above patterns of intritacalx pitting usually begin to develop near the start of the adult shell. With growth and the development of intermediary radial ribs the intritacalx pits frequently divide radially. In species with radially elongate pits this results in the formation of inverted V-shaped pits which subsequently split in two. The progressive development of interstices and intritacalx pits with growth of the shell is shown diagrammatically for *E. natalensis* and *E. koon* in Figures 6, 7.

**Key to the species of *Emarginula* in southern Africa and Mozambique**

1. Base distinctly convex in side view, concave posteriorly; apex strongly recurved, its interior not visible in ventral view; protoconch markedly offset to the right . . . . . *phrygium*  
 — Base flat or concave in side view; interior of apex visible in ventral view; protoconch not or only slightly offset . . . . . 2
2. Selenizone markedly raised, together with bordering flanges forming a distinct keel, flanges larger than radial ribs; sculpture not obviously cancellate; shell thin and fragile . . . . . 3  
 — Selenizone not, or only slightly raised, bordering flanges equal to or lower than radial ribs; sculpture cancellate, weak or strong, smooth or nodose; shell not fragile . . . . . 4
3. Outline ovate to subcircular; sculpture very finely cancellate; apex rarely near posterior margin . . . . . *macclurghi*  
 — Outline distinctly oblong-ovate; sculpture of radial ribs bearing conical nodules; apex above or behind posterior margin . . . . . *undulata*
4. Shell large, strongly and evenly cancellate, interstices multiple, set with 4–8 (rarely 10) horizontally elongate pits . . . . . *koon*  
 — Sculpture cancellate, but not as well defined or regular as above; interstices simple or compound . . . . . 5
5. Shell low ( $h/l$  less than 0,45), apex about 0,25 of length from posterior . . . . . *oppressa*  
 — Shell higher, apex usually nearer posterior margin . . . . . 6
6. Interstices simple . . . . . 7  
 — Interstices compound . . . . . 10
7. Shell height moderate to low ( $h/l$  less than 0,62); selenizone clearly sunken; sculpture finely cancellate; apex above or behind posterior margin . . . . . *natalensis*  
 — Shell low or high, selenizone not or only slightly sunken; sculpture coarser. If apex low, not situated above posterior margin . . . . . 8



**Figures 6–7** Progressive development of interstices and intritacalx pits with growth of the shell. 6. *Emarginula koon*. 7. *E. natalensis*.

8. Shell high ( $h/l$  greater than 0,70), sculpture comparatively fine . . . . . *connelli*  
 — Shell lower ( $h/l$  less than 0,65), sculpture coarse . . . . . 9
9. Selenizone slightly sunken; sculpture very coarse, ribs thicker than intervals; ventral margin coarsely crenulate . . . . . *viridicana*  
 — Selenizone not sunken, lunulae level, or nearly so, with bordering flanges; ventral margin finely crenulate . . . . . *agulhasensis*
10. Shell with flattened anterior face bordered by strong ribs; ribs coarsely nodular . . . . . *thorektes*  
 — Shell not distinctly flattened anteriorly, all first order ribs similar in size and finely nodular; glossy, green with broad, pale postero-lateral rays . . . . . *tenuicostata*

***Emarginula agulhasensis* Thiele, 1925 (Figures 8–15)**

*Emarginula agulhasensis* Thiele, 1925:38(4), pl. 13, fig. 1; Kilburn, 1978:433, pls 1, 2. Type loc.: Agulhas Bank (off Tsitsikama coast), 35°16'S/22°26'E, 155 m.

*Emarginula pulchreclathrata* Tomlin, 1932:162, fig. 4; Barnard, 1963:296, fig. 23b. Type loc.: off Saldanha Bay, 101 m.

Not *Emarginula agulhasensis*; Barnard, 1963:296, fig. 23a [= *E. thorektes* Kilburn, 1978].

**Additional notes.** A somewhat variable species; although  $h/l$  and  $w/l$  ranges are not particularly great (0,38–0,54 and 0,64–0,73 respectively), there is considerable variation in shape (Figures 8–12), particularly in the position of the apex relative to the posterior margin, and the degree of curvature of the anterior face. Slight variation also occurs in coarseness of sculpture. All extremes intergrade fully and are not thought significant. A diagnostic character of this species is the fact that in early stages the intermediary ribs are rounded, distinctly undulate and cross the concentric threads (Figure 14) instead of being crossed by them; this character is much less obvious in other local *Emarginula* species. The interstices are simple, with a pair of radially elongate intritacalx pits in each (Figure 14). From the figures given by



8



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**Figures 8–15** *Emarginula agulhasensis*. 8 & 9. Depressed specimen (NM C6813), 14,0 × 10,4 mm, height 5,9 mm. 10 & 11. Intermediate specimen (NM C3868), 15,7 × 11,1 mm, height 8,0 mm. 12. Compressed specimen (NM C6813), 12,3 × 7,7 mm, height 6,3 mm. 13. Protoconch (NM C7066), scale bar = 100 μm. 14. Microsculpture (same), scale bar = 100 μm. 15. Rear view of apex (same), scale bar = 50 μm. 13–15. SEM.

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Piani *E. christiaensi* Piani, 1984 (emend. *christaensi*), a Pleistocene fossil from the Mediterranean, appears very similar. Protoconch typically emarginuliform (Figure 13).

**Dimensions.** Largest NM specimen, 27,3 × 19,9 mm, height 13,9 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Saldanha Bay to eastern Transkei, 58–550 m.

**Additional locality data.** (All NM, dredged MN, dead) TRANSKEI: off Rame Head, 410–430 m, stones, some sand (C2028); off Whale Rock, 58–60 m, mixed sand and mud (C3109); off Nthlonyan River, 550 m, sand, stones, broken *Dendrophyllia* (C8683); off Mendu Point, 405–420 m, fine mud (C4990); off Shixini Point, 400–420 m, coarse sand, fine shell rubble (C6488); do, 500 m, muddy sand, coral rubble (C7066); off Qora River, 400 m, sand (C4881); do, 420 m, coarse slightly muddy sand (C6841); off Stony Point, 360 m, coarse sand (C6813); do, 460 m, sandy mud with stones and clay (C6671); off Sandy Point, 350 m, coarse sand and broken shell (C6772); do, 450–498 m, fine sand and stones (C4102); off Qolora River, 440–460 m, fine sand and stylasterids (C6420); off Kei River, 400 m, coarse sand, broken shell (C6615); do, 390 m, coarse sand (C3868).

***Emarginula connelli* Kilburn, 1978 (Figure 16)**

*Emarginula connelli* Kilburn, 1978:437, pl. 4b, f. Type loc.: off Sodwana Bay (Zululand), 100 m.

*Emarginula connelli*; Kilburn, 1978:432 [*laps cal.*].

**Additional notes.** Little further material has been obtained. Interstices are simple, each with a pair of radially elongate intritacalx pits (Figure 16), very similar to those of *E. natalensis*, but separating more rapidly upon division and therefore less often seen as an inverted V. *E. connelli* is by far the tallest local species with simple interstices. Protoconch very worn or missing in available material.

**Dimensions.** Largest NM specimen, 9,7 × 6,9 mm, height 7,8 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Western Transkei to northern Zululand, 100–270 m.

**Locality data.** (All NM, dredged MN, dead, unless otherwise indicated). ZULULAND: off Sodwana Bay, 100 m, CSIR Water Research, holotype (A5762/T2199). NATAL: off Margate, 100–110 m, sponge (B8755); off Park Rynie, 100 m, sand and sponge rubble (B3714); off Port Edward, 100 m, fine shell sand, CSIR Water Research, paratype 3 of *E. thorektes* (A5764/T2192). TRANSKEI: off Mtamvuna River, 111 m, sponge (C7229); off Bulungula River, 250–270 m, muddy sand, old shell debris (C2141).

***Emarginula koon* Kilburn, 1978 (Figure 6)**

*Emarginula koon* Kilburn, 1978:439, pls 5, 10. Type loc.: Shelley Beach, near Port Shepstone, Natal.

**Additional notes.** Only two further specimens have been obtained, both from the Natal south coast (Holderness collection). The interstices are multiple (see Figure 6 and Kilburn, 1978, pl. 10) with 4–8 (rarely 10) intritacalx pits in each. It is the only *Emarginula* with such distinctive interstices known from southern Africa, but a somewhat similar species (yet unidentified), has been found in material from Bassas da India in the Mozambique Channel (NM J8580,

J8631) and from Coetivy Island, Seychelles (BMNH, 1910.8.31.16.: Gardiner Collection) identified by Melvill as *E. tenuicostata* Adams & Sowerby, 1863. All *koon* material so far obtained has been found in beach-drift and is worn apically.

***Emarginula macclurgi* Kilburn, 1978 (Figures 17–20)**

*Emarginula macclurgi* Kilburn, 1978:443, pl. 7. Type loc.: off St Lucia Lighthouse (Zululand), 100 m.

**Additional notes.** A highly characteristic species, readily identifiable by its almost circular basal outline, microscopically cancellate sculpture and keel-like flanges bordering the selenizone. Previously known only from the holotype. Additional material shows variation in shell proportions, viz. h/l = 0,46–0,60; w/l = 0,74–0,88. The interstices are rectangular, shallow and simple with circular to concentrically elongate intritacalx pits (Figure 17). Protoconch emarginuliform, but clearly tilted to the right unlike most other species; evidently possesses two distinct sculptural patterns (Figure 18).

**Dimensions.** Largest NM specimen, 10,8 × 9,1 mm, height 5,8 mm.

**Radula (Figures 19–20).** Markedly asymmetrical; rachidian narrow throughout its length; cutting edge set at approximately 45° to the longitudinal radular axis, no alate process on either side; cutting edge irregularly denticulate, exposed shaft of rachidian and first and second laterals distinctly fibrous. First lateral on right with a cusp as large as that of the rachidian; cusp of fourth lateral very reduced or absent; fifth lateral bicuspid (outer cusp not visible in figure).

**External anatomy.** The single live-taken specimen obtained was found in a dried bottom sample and no details of external anatomy were apparent.

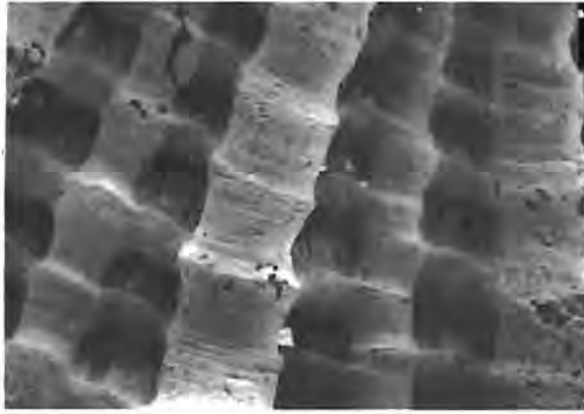
**Distribution.** Transkei to Zululand, 60–175 m (living specimen 175 m). Apparently associated with sponges.

**Additional locality data.** (All NM, dredged MN) NATAL: off Trafalgar, 120 m, sand, sponge (B8765); off Park Rynie, 120 m, rubble and solitary coral (B3824); do, 142 m, some sand, sponge rubble (B8744); off Port Shepstone (one live), 175 m, sponge and coarse rubble (B3955). TRANSKEI: off Mtamvuna River, 102–110 m (C792); off Mtamvuna and Mzamba Rivers, 100 m, large living sponges and rubble (C5428); off Mzamba River, 100 m, sponge rubble (C5488); off Mpahlana River, 100 m, sponge rubble (C5251); off Mpahlana and Umyameni Rivers, 100 m, sponge rubble (C5377); off Kwanyana River, 100 m, sponge rubble (C5337); off Ubombo, 60–62 m, coarse sand, oyster-shell conglomerate (C2478); off Sikombe River, 112 m, sponge rubble (C5356); off Port Grosvenor, 100–115 m, sand, some mud, solitary corals, shell (C1294); off Mbashe River, 100 m, live sponge (C9367).

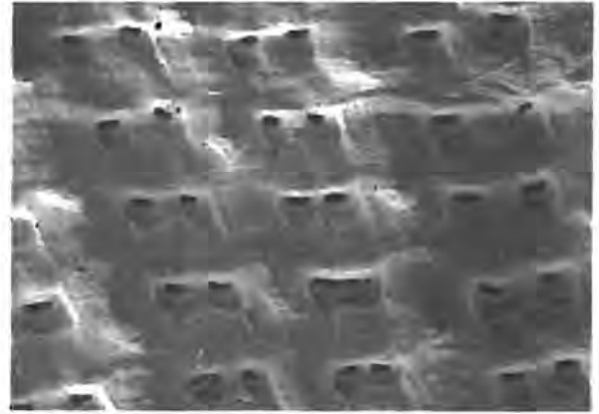
***Emarginula natalensis* Barnard, 1963 (Figures 21–25)**

*Emarginula natalensis* Barnard, 1963:297, fig. 23c; Kilburn, 1978:435, pl. 3 (lectotype). Type loc.: off Cape Morgan, 141 m.

**Additional notes.** Recent MN dredgings have provided more than 100 further specimens, some live-taken. *E. natalensis* is relatively constant in its characters, being distinguishable from other southern African species by its fine sculpture and strongly recurved apex. Some variation occurs in the degree of recurvature and the position of the apex relative to the



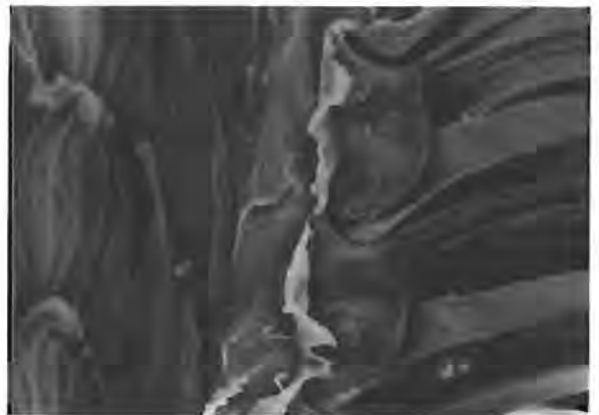
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Figures 16–20 *Emarginula connelli* and *E. macclurigi*. 16. *E. connelli*, microsculpture (NM A5764). 17–20. *E. macclurigi*. 17. Microsculpture (NM B8765). 18. Protoconch (NM B8765). 19. Latero-marginal plate of radula (NM B3955). 20. Radula. All SEM, scale bars = 100  $\mu$ m.

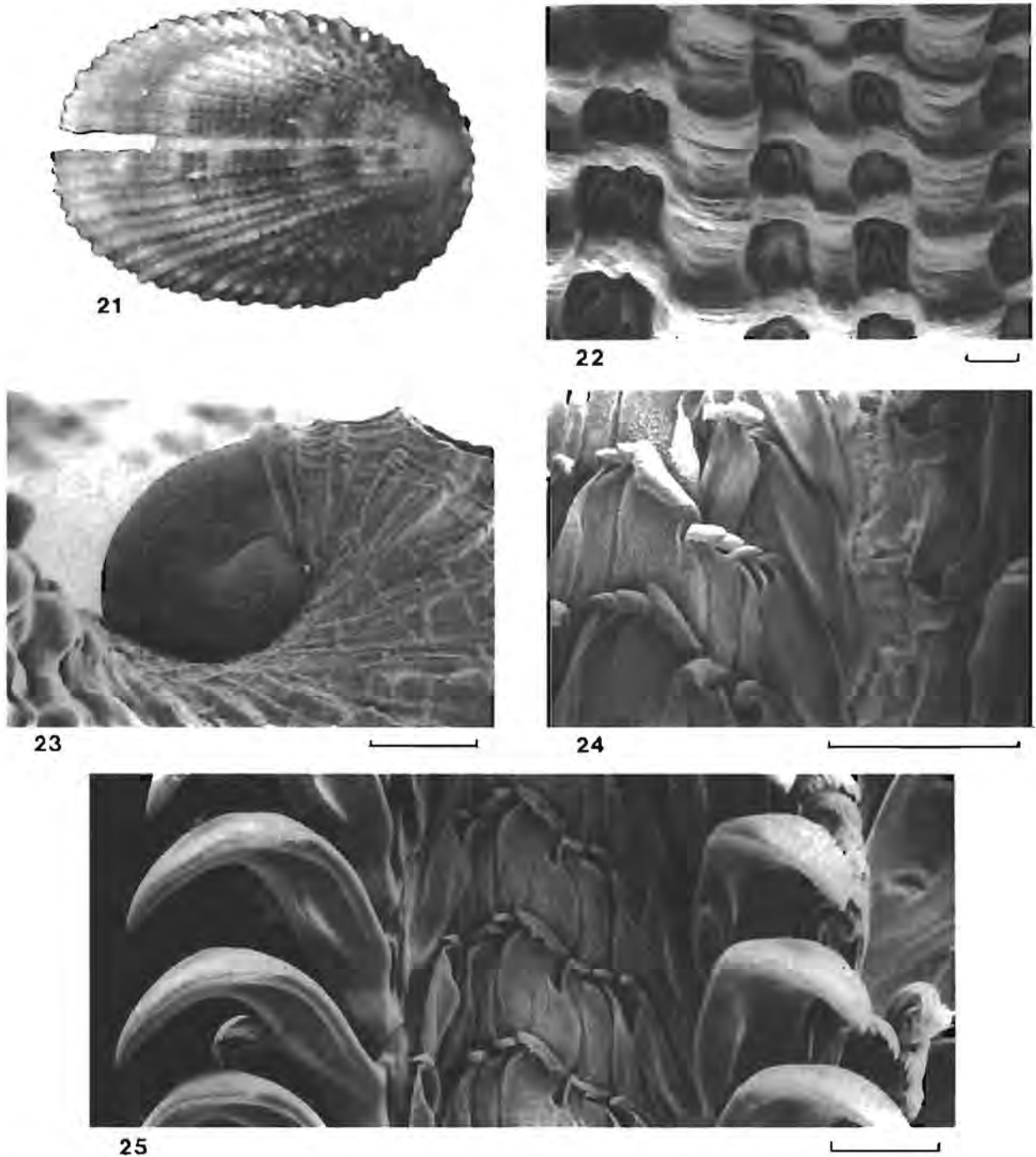
posterior margin. Old specimens appear white to brown, but fresh and live-taken shells have a yellowish-white to light green ground-colour with a pattern of darker green blotches on the anterior face, extending across the selenizone (Figure 21); flecks of pure white and/or brown may occur on the ribs. The interstices are simple with generally distinct, radially elongate intritacalx pits, frequently appearing as inverted V-shaped marks (Figure 22), described by Kilburn (1978) as resembling the hoof prints of a bovid. Protoconch typically emarginuliform (Figure 23).

**Dimensions.** Largest NM specimen, 12,3  $\times$  8,7 mm, height 6,8 mm.

**Radula.** (Figures 24, 25) Markedly asymmetrical; rachidian with cutting edge finely denticulate, pointed centrally, set at

an angle of 50° to the longitudinal radular axis; exposed shaft fibrous with a well-developed alate process on the right, behind which lies the first lateral. Inner laterals with cutting edge also denticulate, pointed toward the rachidian; cusp reduced or missing on fourth lateral; exposed shaft of first and second laterals fibrous, fourth with a broad, much folded shaft; fifth lateral bicuspid (smaller outer cusp not visible in figure).

**External anatomy.** Typically emarginuliform. Epipodial tentacles 6–8 on each side, two of which are long (usually the last and one near the centre), others short; right post-optic tentacle well developed, longer than eye stalk, spatulate distally. Metapodial tentacle present. Two pallial sense organs posterior to siphon, probably more in front. Colour white to cream.



Figures 21–25 *Emarginula notalensis*. 21. Shell showing colour pattern (NM C5376) 8,7 × 6,0 mm, height 4,6 mm. 22. Microsculpture (NM B8741). 23. Protoconch (same). 24. Latero-marginal plate of radula (NM B8739). 25. Radula. 22–25. SEM, scale bars = 100 μm.

**Distribution.** Off Eastern Cape Province to Zululand, 60–420 m, (living examples 95–140 m). Apparently associated with sponges.

**Selected locality data.** (All NM dredged MN) NATAL: off Park Rynie, living, 124 m, some sand (B8748); do, 96 m, sponge rubble with living sponges (B8568); do, living, 140 m, some sand, sponge rubble (B8741); off Port Edward, living, 120–125 m, living sponges (D1386). TRANSKEI: off Mtamvuna River, living, 100 m, stone, rock, rubble, (C7101); do, 75 m, rocks, sponge (C833); between Mpahlana and Umyameni Rivers, living, 100 m, sponge rubble (C5376); off Mzamba River, living, 100 m, sponge rubble (C5288); off Ubombo, 60–62 m, coarse sand, oyster-shell conglomerate (C2476); off Rame Head, 70 m, mud, abundant shell debris (C1912); do, 150–160 m, sponges (C1902); off Mbashe

River, 75 m, calcareous nodules (C1994); off Mendu Point, 300 m, coarse sand (C6543); off Shixini Point, 400–420 m, coarse sand, fine shell rubble (C6486); off Qora River, 400–420 m, coarse, slightly muddy sand (C6842); off Stony Point, 460 m, sandy mud with stones, some clay (C7153); off Qolora River, living, 114 m, sponge rubble (C3947); off Kei River, 138 m, coarse sand (C5074). EASTERN CAPE: off East London, 100 m, coarse sand, sponge (B8101).

**Remarks.** Kilburn (1978) compared this species with *E. curvamen* Iredale, 1924, *E. convexa* Hedley, 1902, *E. curvata* Schepman, 1908, *E. galericulata* A. Adams, 1852, *E. dahli* Thiele, 1912, and *E. harmilensis* Sturany, 1903. Type specimens of the first four have now been examined; all have simple interstices, but are distinct in having a more recurved apex and a selenizone which is not sunken below





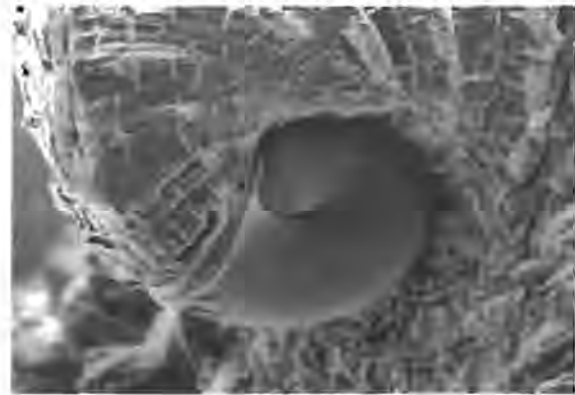
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Figures 26–29 *Emarginula oppressa*. 26 & 27. NM B8752, 16,0 × 11,2 mm, height 5,8 mm. 28. Microsculpture (NM C7105), scale bar = 200 μm. 29. Protoconch (same), scale bar = 100 μm. 28. & 29. SEM.

the general shell surface. *E. curvata* is perhaps the most similar, but in addition its ribs are narrower and more numerous, and the interstices are more sharply defined. The type material of *E. harmilensis* cannot be traced at the NMV (E. Wawra, pers. comm.).

The compressed specimen of *E. natalensis* figured by Kilburn (1978) appears atypical in its high degree of recurvature.

#### *Emarginula oppressa* Barnard, 1963 (Figures 26–29)

*Emarginula oppressa* Barnard, 1963:289, fig. 24a. Type loc.: off Cape Natal, 99 m.

*Emarginella oppressa*; Kilburn, 1978:446, pl. 8b.

**Additional notes.** The holotype is somewhat worn; fresher shells reveal simple interstices with irregularly circular intritacal pits (Figure 28). Peripherally each interstice may develop more than one pair of pits (which vary considerably in shape), becoming multiple in adults. Protoconch typically emarginuliform (Figure 29).

**Dimensions.** Largest NM specimen 22,9 × 15,4 mm, height 8,2 mm.

**Radula.** Unknown.

**External anatomy.** A single live-taken specimen, a very small juvenile, has been sorted from dried bottom samples.

Although in poor condition, the mantle and foot are not expanded, and even allowing for shrinkage do not resemble those of *Emarginella*.

**Distribution.** Western Transkei to Natal, 60–450 m.

**Additional locality data.** (All NM, dredged MN) NATAL: off Umlaas Canal, 200 m, coarse sand (D885); off Margate, 100–110 m, sponge (B8752); off Mbizane River, 100 m, coarse sand and sponge (B7230); off Port Shepstone, 70 m, shell and sponge rubble (B3647). TRANSKEI: off Port Grosvenor, 120–128 m, coarse sand (C1149); off Bulungula River, 250–270 m, muddy sand (C2142); off Qora River, 350–360 m, muddy sand (C6714); off Mtamvuna River, living, 115 m, sponge and rocks (C7105); off Mendu Point, 450 m, fine muddy sand (C6320); off Ubombo, 60–62 m, coarse sand and shell conglomerate (C2479); off Kei River, 390 m, coarse sand (C3869).

**Remarks.** This species, previously known only from the damaged holotype (SAM A9330), was originally placed under *Emarginula* by Barnard. Kilburn noted considerable similarity to the type species of *Emarginella*, *cuvieri* (Audouin, 1826), and transferred it to the latter genus. Certainly the greatly depressed form of the shell, particularly the holotype, is suggestive of *Emarginella* (h/) of currently available specimens, 0,21–0,44). The single live-taken specimen, however, appears to confirm that it is an *Emarginula*, as comparison

with two preserved *Emarginella sibogae* specimens and the type figures of *Emarginella cuvieri* given by Pallary (1926), reveals little similarity in external anatomy.

***Emarginula phrygium* sp. n. (Figures 30–34)**

**Diagnosis.** Basal outline of shell roundly oval, apex strongly recurved, reaching posterior margin, recurved portion relatively broad, height moderate ( $h/l = 0,64$ ); base convex in side view, concave posteriorly. Sculpture of about 32 first order radial ribs with intermediaries, concentric ridges widely spaced, crossing ribs to form nodules. Interstices shallow, rectangular, possibly with one intritacalx pit in each. Interior with posterior wall very sharply and smoothly curved, end of recurved apex not visible. Protoconch markedly offset, projecting postero-laterally. Length 5,8 mm.

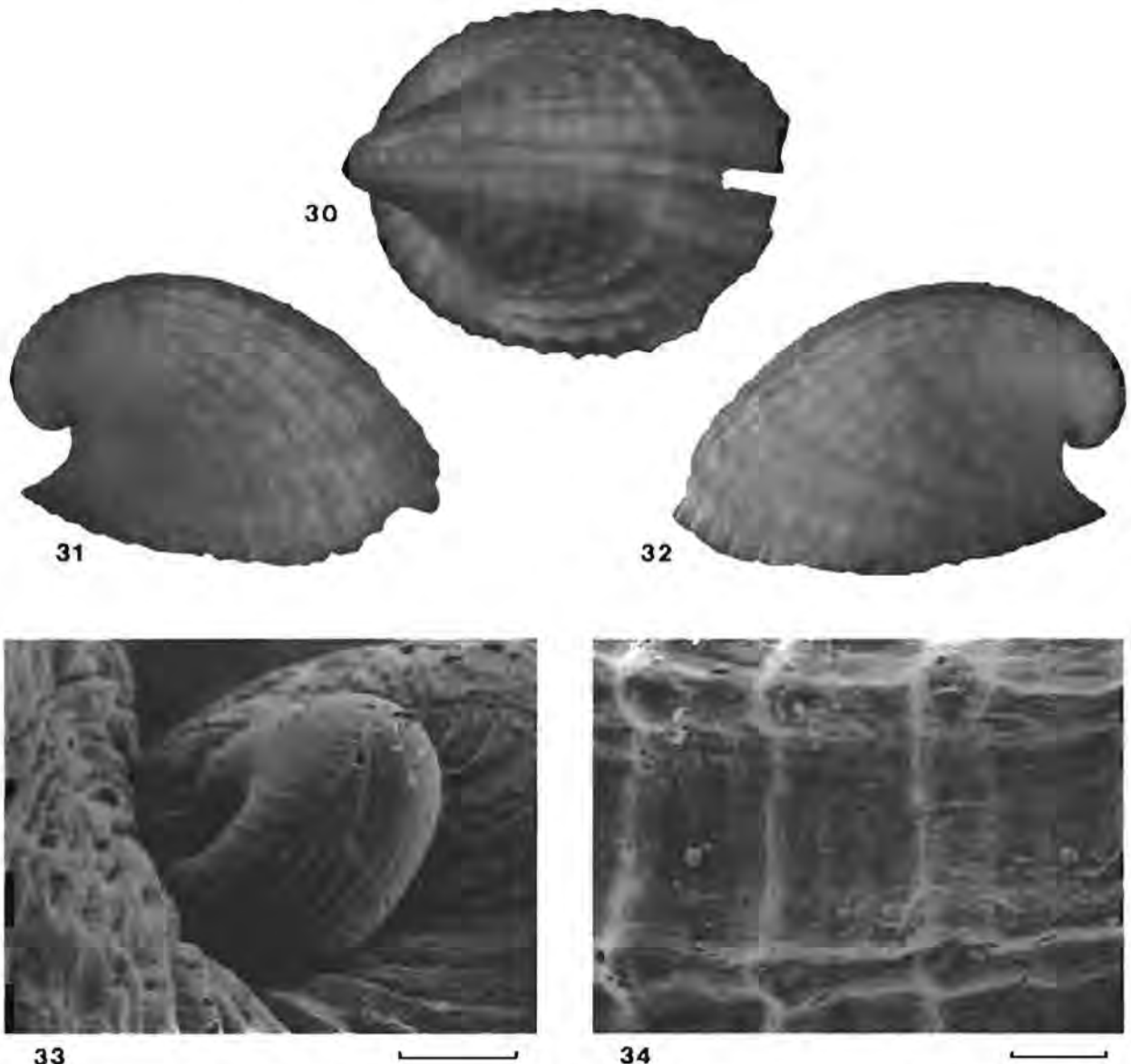
**Description.** Basal outline of shell roundly oval ( $w/l = 0,81$ ), greatest width near middle; apex strongly recurved, reaching posterior margin, recurved portion relatively broad, height moderate ( $h/l = 0,64$ ). Anterior face roundly convex, posterior face sharply concave. Base convex in side view and concave posteriorly such that the shell rests on its sides. Anal slit relatively narrow, selenizone slightly sunken; bordering

flanges raised, scarcely taller than sculptural ridges; selenizone with many very fine growth-lines, a small number of which are raised to form lunulae. Sculpture of about 32 first order radial ribs with intermediary secondaries, particularly postero-laterally. Concentric sculpture of widely spaced ridges (subequal to radial ribs) producing a weak cancellation of radially elongate, shallow, rectangular interstices (Figure 34); ridges cross ribs to form nodules. Interstices may possess one intritacalx pit each, but the specimen is somewhat worn and details are not clear. Inner margin of shell with grooves corresponding to radial ribs. Interior white, glossy; posterior wall very sharply and smoothly curved, end of recurved apex not visible in basal view. Anterior wall with a slightly thickened ridge underlying the selenizone; the anterior part of this ridge is grooved. Protoconch markedly offset postero-laterally to the right and heavily sculptured (Figure 33).

**Dimensions.** 5,8 × 4,7 mm, height 3,7 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Transkei continental slope, known only from type locality.



**Figures 30–34** *Emarginula phrygium* sp. n., holotype. 30–32. 5,8 × 4,7 mm, height 3,7 mm. 33. Protoconch, scale bar = 100  $\mu$ m. 34. Micro-sculpture, scale bar = 200  $\mu$ m 33 & 34. SEM.

**Type material.** Holotype NM C6844/T3012, dredged MN, off Qora River, Transkei (32°34,0'S/28°49,7'E), 400–420 m, coarse, slightly muddy sand.

**Remarks.** No truly comparable species can be traced. Among southern African *Emarginula*, *E. phrygium* is the most recurved, being the only species in which the interior of the apex is not visible in ventral view. Likewise the convex base and the offset protoconch are unique among local species and certainly unusual in the genus as a whole.

The curvature of the base of this shell suggests a somewhat unusual mode of life. Limpet-like shells with a similar-shaped base are often found attached to cylindrical objects (e.g. *Patella compressa* Linne, 1758, which lives on *Ecklonia* and *Macrocystis stipes*) or to the shells of other molluscs (e.g. *Hipponix* spp.). The depth at which this specimen was found indicates that attachment to algae is improbable. Less likely is the possibility that the basal shape reflects the fact that the body of the animal is larger than the shell, as in *Amblychilepas* and *Pupillaea*.

**Etymology.** *Phrygium* (L.), a Phrygian cap, referring to the strongly recurved shell apex.

***Emarginula tenuicostata* Adams & Sowerby, 1863 (Figure 37)**

*Emarginula tenuicostata*; Kilburn, 1978:442, pl. 4c, d, g.

**Additional notes.** Interstices compound (Figure 37), divided into circa 4–6 smaller, secondary interstices by a single intermediary radial and fine concentric threads (microlirae).

Each secondary interstice is simple, possessing a single intritacalx pit or pair thereof. The lower (ventral) pits of each main interstice are radially elongate and frequently paired. Protoconch worn or missing in available material.

**Remarks.** This species requires further study and will be treated in greater detail elsewhere. A description of the sculpture is given as an example of compound interstices.

***Emarginula thorektes* Kilburn, 1978 (Figures 35, 36, 38)**

*Emarginula thorektes* Kilburn, 1978:440, pl. 6. Type loc.: Shelley Beach near Port Shepstone, Natal.

*Emarginula thorektes* Kilburn, 1978:433 [*laps cal.*].

*Emarginula agulhasensis* (non Thiele); Barnard, 1963:296, fig. 23a.

**Additional notes.** Somewhat variable in height (compare Figures 35, 36 with figure of holotype),  $h/l = 0,46-0,75$ . Interstices compound (Figure 38), divided into 6–8 unequal secondary interstices by a central intermediary radial and fine concentric threads. Each secondary interstice is simple with a pit or pair of pits. Within each main interstice the lower (ventral) secondary interstices possess radially elongate pits. Separated from *E. tenuicostata* by coarser sculpture and frequently flattened anterior face. Protoconch worn or missing in available material.

**Dimensions.** Largest NM specimen, 12,0 × 6,5 mm, height 7,5 mm.

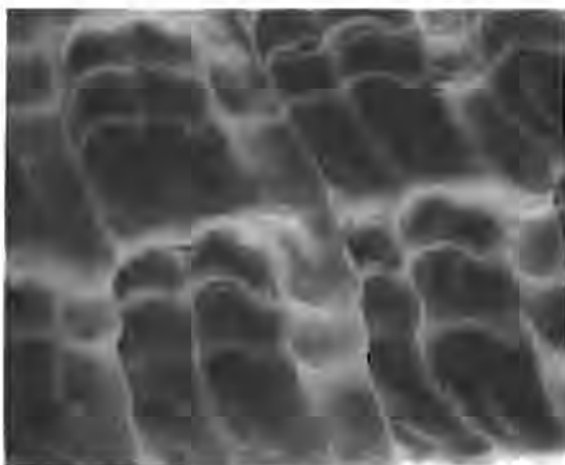
**Radula and external anatomy.** Unknown.



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**Figures 35–38** *Emarginula thorektes* and *E. tenuicostata*. 35, 36 & 38. *E. thorektes*. 35. Elevated specimen, NM C6640, 9,7 × 7,0 mm, height 7,0 mm. 36. Same, NM C4342, 8,6 × 5,7 mm, height 5,5 mm. 38. Microsculpture (NM C4621). 37. *E. tenuicostata*, NM B2716, microsculpture. 37. & 38. SEM, scale bars = 100 μm.

**Distribution.** Eastern Cape to northern Zululand, littoral to about 500 m.

**Additional locality data.** (All NM dredged MN, dead) NATAL: off Park Rynie, 142 m, some sand, sponge rubble (B8743); off Melville, 380–420 m, coarse sand, sandstone (B8828). TRANSKEI: off Mbashe River, 450–500 m, coarse sand, some mud (C9034); off Stony Point, 395 m, sponge and stone (C4342); off Qolora River, 440–446 m, fine sand, branching coral (C4621); off Qora River, 450–460 m, sandy mud (C6640).

***Emarginula undulata* Melvill & Standen, 1903 (Figures 1–3, 39–44)**

*Emarginula undulata* Melvill & Standen, 1903:290, pl. 20, fig. 1. Type loc.: Gulf of Oman (24°58'N/56°54'E), 285 m.

*Emarginula vadum* Barnard, 1963:297, figs 23d, 24b; Kilburn, 1978:444, pl. 4a, e. Type loc.: off Cape Vidal, Zululand, 146–183 m. (syn. nov.).

**Additional notes.** Intritacalx pits concentrically elongate, arranged in rows both radially and concentrically in a highly regular fashion (Figures 1–3, 41); this sculpture is not produced by the interaction of radial ribs and concentric threads and is therefore not cancellate. The very numerous growth-lines reported by Barnard (1963) are simply smooth concentric strips between the intritacalx pits. True growth-lines are few and concentric sculpture is limited to relatively infrequent, low undulations which produce conical nodules where they cross the radial ribs. Protoconch typically emarginuliform (Figure 42).

**Dimensions.** Largest NM specimen 10,2 × 5,6 mm, height 4,4 mm, h/l = 0,43–0,53, w/l = 0,54–0,67.

**Radula.** (Figures 43, 44) Rachidian very broad basally with lateral processes, narrower apically with the cutting edge lying at 60–65° to the longitudinal radular axis; cutting edge denticulate and distinctly pointed medially. First and second laterals with prominent denticulate cusps, exposed shaft not obviously fibrous; third and fourth laterals with cusps reduced or missing. Latero-marginal plate with distinct socket on the anterior of its medial face.

**External anatomy.** Typically emarginuliform. Epipodial tentacles 7–9 on each side, the central and last tentacles long. Right postoptic tentacle well developed, broadly spatulate distally. Metapodial tentacle long, equalling the long epipodial tentacles; an additional smaller tentacle may be present above the main one. A pair of pallial sense organs posterior to siphon, another pair in front. Colour white to pink.

**Distribution.** Gulf of Oman to western Transkei, 60–420 m (living examples 100–120 m).

**Type material.** Lectotype (Figures 39, 40), Gulf of Oman (24°58'N/56°54'E), 285 m, leg. F. Townsend, Melvill-Tomlin collection, NMW 1955.158.95. Paralectotypes, 3 specimens, same data and accession no.: paralectotypes, 2 specimens, same data, NMW 1955.158.94. Holotype of *E. vadum*, SAM A9329.

**Regional locality data.** (All NM, dredged MN, unless indicated otherwise) ZULULAND: Sodwana Bay, 100 m, CSIR Water Research (A5761). NATAL: off Umlaas Canal, 75 m, muddy sand (D731); do, 100 m, coarse sand (D1211); do, 140 m, sand and pebbles (D1124); do, 200 m, coarse sand (D886); off Amanzimtoti, 115–125 m, medium sand

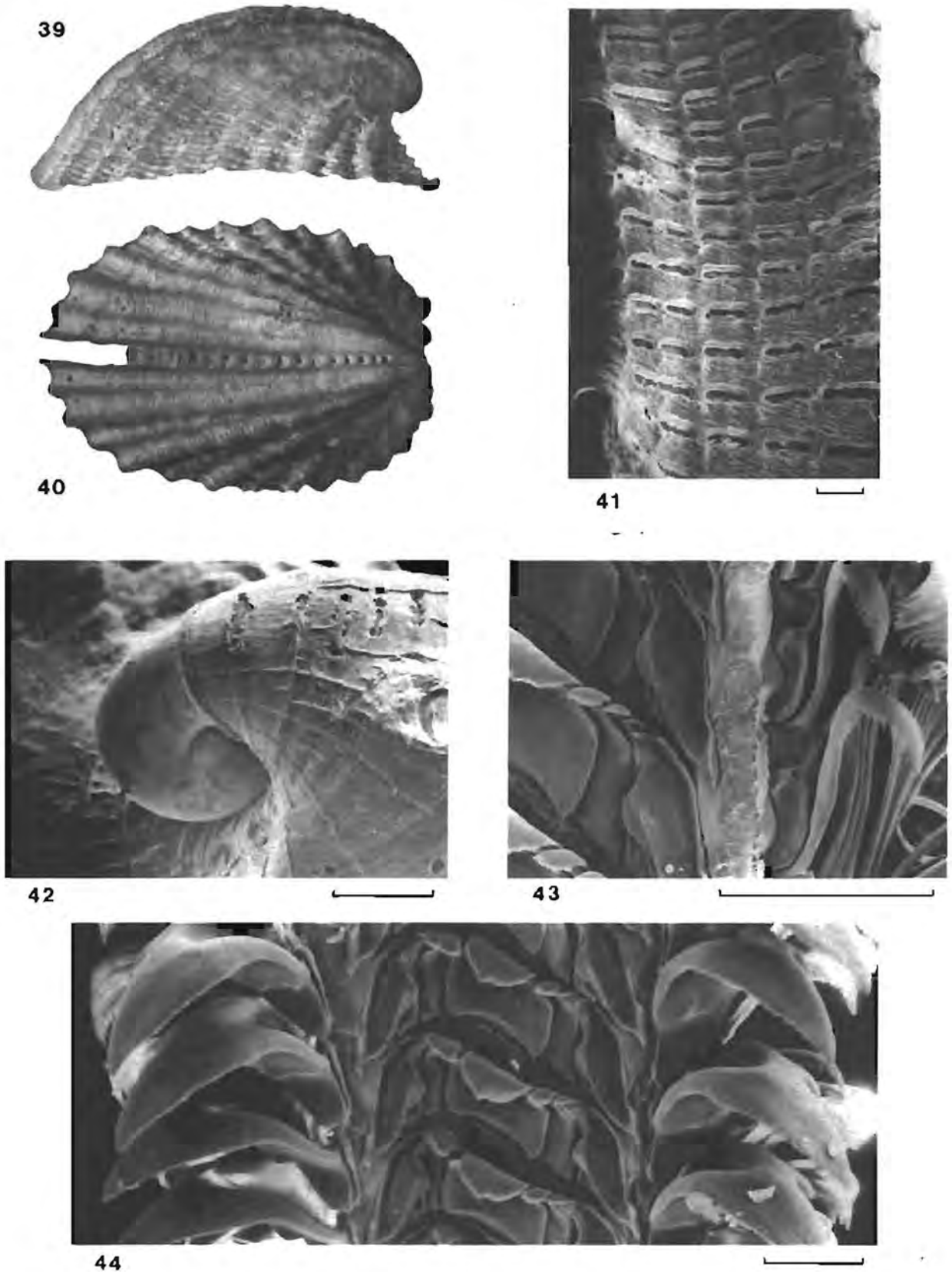
(D1266); off Park Rynie, living, 120 m, rubble and solitary coral (B3801); do, 100 m, sand and sponge rubble (B3715); do, 110–130 m, eroded shell and conglomerate (B3598); off Scottburgh, 100 m, dredged A. Connell (B3464); off Trafalgar, 120 m, sand and sponge (B8764); off Margate, 100–110 m, sponge (B8753); off Port Edward, 120–140 m, sponge rubble (B8756); off Mbizane River, 100 m, coarse sand, some sponge (B8767). TRANSKEI: off Mtamvuna, 137 m, rocks and sponge (C870); do, 102–110 m (C791); do, living, 100 m, large sponges, rubble (C7103); off Port Grosvenor, 82 m, worn calcareous nodules (C662); do, 80 m, calcareous nodules, lithothamnion sheets (C7106, C7110); off Ubombo, 60–62 m, coarse sand, oyster-shell conglomerate (C2477); off Bulungula River, 250–270 m, muddy sand, old shell debris (C2144); off Shixini Point, 400–420 m, coarse sand, fine shell rubble (C6487); off Mpahlana River, 100 m, sponge rubble (C4986); off Mtamvuna and Mzamba Rivers, 100 m, large sponges, rubble (C5426); off Mzamba River, 100 m, sponge rubble (C5289); between Mpahlana and Umyameni Rivers, living, 100 m, sponge-rubble (C5375); off Qolora River, 290–300 m, fine muddy sand, broken shell (C6967).

**Remarks.** Barnard (1963) compared his *E. vadum* with *E. undulata* from the Gulf of Oman, but stated that the former had fewer ribs. Six syntypes of *E. undulata* from the NMW have been examined, the best of which we designate here as lectotype. It is clear from this examination that *vadum* is synonymous with *undulata*. The rib number given by Melvill & Standen ('ad 40') is misleading. The types of *undulata* are smaller than southern African specimens, and possess 25–27 radial ribs; local specimens of similar size bear 22–28 ribs.

***Emarginula viridicana* sp. n. (Figures 45–50)**

**Diagnosis.** Basal shell outline oblong-ovate, height moderate to elevated (h/l = 0,45–0,65); apex recurved, 0,20–0,25 of length from posterior end; anal slit deep, selenizone slightly sunken. Sculpture coarsely and irregularly cancellate; 45–52 first and second order radial ribs which are broader than the intervals between them; concentric threads cross ribs forming nodules; interstices simple. Basal margin concave in side view, deeply crenulate. Yellowish green, slightly mottled, interior white with two red to orange marks, one each side of the selenizone ridge. Length 15,1 mm.

**Description.** Basal shell outline oblong-ovate, greatest width more or less median, height moderate to elevated (h/l = 0,45–0,65), apex recurved, 0,20–0,25 of total length from posterior margin; base concave, shell resting on its ends. Anal slit moderately deep (0,25–0,35 of length), selenizone slightly sunken with lunulae not corresponding to concentric sculpture; bordering flanges steep-sided medially, rounded laterally, irregular and often broken. Inner end of anal slit V-shaped internally, selenizone marked by a thickened ridge. Sculpture coarsely and irregularly cancellate, produced by radial ribs and concentric threads; 45–52 first and second order ribs with occasional tertiary intermediaries; ribs broader than intervals between them; concentric threads cross ribs to form nodules which become progressively stronger toward the periphery. Growth stages marked by deep concentric grooves. Interstices simple (Figure 49), square to rectangular, variable; each with two radially elongate intritacalx pits; pits occasionally joined, sometimes forming an inverted V. Internally glossy white, basal margin deeply crenulate with alternating large and



Figures 39–44 *Emarginula undulata*. 39 & 40. Lectotype (NMW) 5,3 × 3,7 mm, height 2,4 mm. 41. Microsculpture (NM C5375). 42. Protoconch (same). 43. Latero-marginal plate of radula. 44. Radula (NM B3801). 41–44. SEM, scale bars = 100 μm.

small U-shaped bays, each corresponding to a radial rib; muscle scar not clear (at least in fresh specimens); radial rows of minute punctations underlie intervals between external ribs. Colour [ISCC-NBS (1965) system] externally greyish-greenish-yellow to greyish-yellowish-green, mottled with darker and lighter shades; interior translucent white,

with two faint radially elongate dark reddish-orange marks on either side of the selenizone ridge. Protoconch emarginuliform, but worn in all available specimens.

*Dimensions*. Holotype, 15,1 × 10,6 mm, height 9,4 mm.

*Radula* (Figures 48, 50). Markedly asymmetrical; rachidian



45



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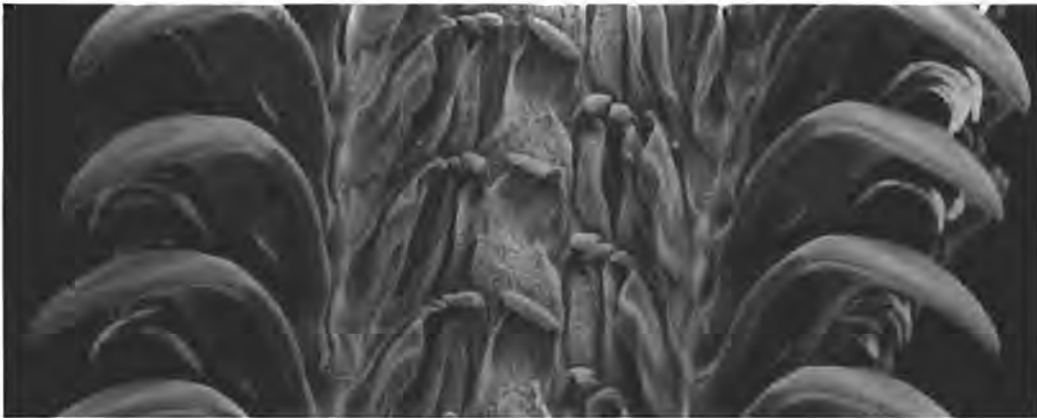
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Figures 45–50 *Emarginula viridicana* sp. n. 45 & 46. Holotype, 15,1 × 10,6 mm, height 9,4 mm. 47. Paratype 6, depressed specimen, 13,6 × 9,3 mm, height 6,4 mm. 48. Latero-marginal plate of radula. 49. Microsculpture (paratype 9). 50. Radula (paratype 10). 48–50. SEM, scale bars = 100 μm.

narrowing slightly toward apex with a small alate process on the right; cutting edge denticulate and set at 50–60° to the longitudinal radular axis. Inner three laterals with cutting edge denticulate and pointed toward rachidian; fourth lateral lacking a cusp; fifth lateral bicuspid (smaller outer cusp not visible in figure). Exposed shaft of rachidian and first lateral fibrous, second lateral slightly so, latero-marginal plate with a pronounced anterior socket into which fits the

base of the first marginal.

*External anatomy.* Typically emarginuliform. Epipodial tentacles 10–16 on each side, of which two are long (usually the penultimate one and another, situated 3–4 tentacles further forward); short tentacles variable in size. Middle mantle fold with small papillate lobes which fit into the crenules on the shell margin. Metapodial tentacle not

discernible. One pair of pallial sense organs posterior to the siphon; one or more pairs in front. Colour white to cream.

**Distribution.** Southern Natal coast to eastern Transkei, 100–142 m (living examples, 100–120 m). Apparently associated with sponges.

**Type material.** (All NM, dredged MN) Holotype (Figures 45, 46), B8749/T3021, off Park Rynie (approx. 30°21'S/30°51'E), living, 110 m, sponge rubble; paratype 1, B9937/T3022, off Park Rynie, living, 110 m, sponge rubble; paratypes 2 and 3, B8750/T3023, off Park Rynie, living, 100 m, sand and sponge rubble; paratypes 4 and 5, B3800/T3024, off Park Rynie, living, 120 m, rubble and solitary coral; paratype 6, B8745/T3025, off Park Rynie, 142 m, some sand, sponge rubble; paratype 7, B8762/T3026, off Trafalgar, 120 m, sand, sponge; paratype 8, C1557/T3027, off Park Rynie, 101 m, some sand, sponge rubble; paratype 9, B8541/T3028, off Park Rynie, 105 m, sponge rubble; paratype 10, B8746/T3029, off Park Rynie, living, 100 m, sand; paratype 11, B3726/T3036, off Park Rynie, 100 m, sand, sponge rubble; paratype 12, C7102/T3035, off Mzamba River, Transkei, 100 m, sponge rubble.

**Remarks.** *E. viridicana* is somewhat variable in terms of shell height. Most specimens are rather elevated (though not as high as *E. connelli*), while others are more depressed (Figure 47). The sculpture is also variable, but is always coarse and the radial ribs well developed. The interstices are deep and frequently partly obscured by the rib nodules. Few species appear similar; the shape resembles that of *E. fissura* (Linné, 1767) from the Mediterranean, as figured by Thiele (1913), but the sculpture is very different. *E. crassicostata* Sowerby, 1863, from unknown locality, has a similar shape and sculpture, but has fewer ribs. Sculpturally the most similar species is *E. imaizumi* Dall, 1926, from Japan, but that is much more depressed.

**Etymology.** *Viridis* (L.), green + *canus* (L.), grey; referring to shell colour.

### Genus *Emarginella* Pilsbry, 1890

Type species (o.d.) *Emarginula cuvieri* Audouin, 1826.

**Diagnosis.** Shell emarginuliform, but greatly depressed. Animal (even in preserved state) voluminous; foot steep sided, raising shell well off substratum; mantle edge well developed with middle fold partly reflected over shell. Epipodial tentacles short and stout, numerous.

**Notes.** This genus is separated from *Emarginula* almost entirely on the grounds of its unusual external anatomy. To date few *Emarginella* species have been recorded, but many depressed *Emarginula* species, currently known only from the shell, may actually belong to *Emarginella*, as shell characters at present do not seem a reliable guide at the genus level.

### *Emarginella sibogae* (Schepman, 1908) (Figures 51–56)

*Emarginula* (*Emarginella*) *sibogae* Schepman, 1908:92, pl. 8, fig. 1; Thiele, 1915:99, pl. 12, figs 1,2 (after Schepman). Type loc.: Lirung, Salibabu Island, Indonesia, 36 m (here restricted).

*Emarginella sibogae*; Kilburn, 1978: 445, pl. 8a, fig. 1.

*Emarginula sibogae* [sic]; Drivas & Jay, 1985:6, fig. 13.

**Additional notes.** The majority of available specimens are worn, and sculptural details (particularly intritacalx pitting) are not clear. The single live-taken individual from Mozam-

bique shows, on the earlier half of the shell, simple interstices, each containing a pair of subcircular pits. These become progressively less obvious with growth and appear to be lost in the adult, where peripherally the interstices are sculptured only by growth-lines. H/l = 0,14–0,33. Protoconch lost in material available.

**Dimensions.** Largest NM specimen, 18,7 × 11,7 mm, height 6,2 mm.

**Radula.** (Light microscope preparation figured by Kilburn 1978.) Asymmetrical, but less so than in *Emarginula*. Rachidian a tall trapezoid, cutting edge finely denticulate and set at 60–70° to the longitudinal axis of radula. Inner three laterals with finely denticulate cutting edges of similar size to one another; fourth lateral with cutting edge reduced or absent; fifth lateral very large, bicuspid. Latero-marginal plate rhomboidal.

**External anatomy.** (NM specimen, Figure 55.) Cephalic tentacles prominent, stout and minutely papillate; eye-stalk short, fused to cephalic tentacle; eye black; snout relatively short, broad, flaring laterally, no papillae or fringes; lips almost triangular, incomplete posteriorly, mouth subcircular; right post-optic tentacle absent; neck short, without lobes; epipodial fold a broad but very shallow ridge, approximately half-way between the sole and the mantle; epipodial tentacles numerous, tending to alternate in size, the first 9–10 on each side present as short triangular structures, folded over ventrally, others simply slight bumps in the epipodial fold, but becoming larger again posteriorly; presence of epipodial sense organs uncertain; foot with smooth sides, truncated anteriorly with a prominent groove associated with the anterior pedal mucous gland; mantle edge well developed, inner mantle fold a broad muscular sheet, not obviously papillate, but pigmented ventrally; middle fold well developed, reflected dorsally so as to partly cover the shell; outer fold thin, covered by middle fold; siphon present, presence of pallial sense organs uncertain. General colour pale brown to white.

**Distribution.** Indonesia to Reunion Island, Mozambique, and Transkei.

**Additional locality data.** (All NM, dead) NATAL: off Park Rynie, 140 m, some sand, sponge rubble (B8747), dredged MN. TRANSKEI: Mzamba, beach drift (C4534), leg. R. Kilburn.

**Remarks.** The figured specimen of *E. sibogae* (Figures 53, 54, 56) from stat. 133 of the Siboga Expedition is here designated as lectotype; data: Lirung, Salibabu Island, Indonesia, 36 m, hard sand, 11,0 × 7,8 mm, height 2,6 mm; ZMA. The remaining specimen listed by Schepman from this station appears to be lost (R.G. Moolenbeek, pers. comm.). Comparison of southern African material (Figures 51, 52, 55) with the lectotype indicates considerable similarity, but noticeable differences exist. Thus the lectotype has fewer, more evenly sized and better defined epipodial tentacles (13–14 on each side), a sunken selenizone and a thinner, more rounded and evenly crenulate shell margin (although the last may be due to its smaller size). Considerable variation however, occurs within southern African specimens and it would seem incautious to describe a new species on the basis of a single perfect specimen.

### Genus *Puncturella* Lowe, 1827

Type species (monotypy) *Patella noachina* Linné, 1771.

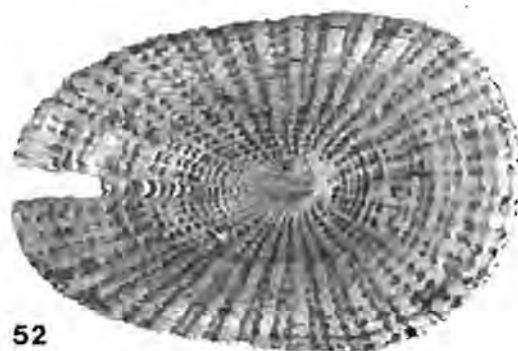
Members of all described subgenera of *Puncturella* (other



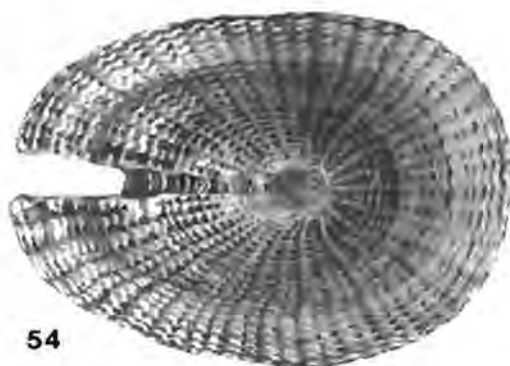
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Figures 51–56 *Emarginella sibogae*. 51, 52 & 55. Bazaruto Island, Mozambique, NM G9056, 15,2 × 10,1 mm, height 2,9 mm. 53, 54 & 56. Lectotype (ZMA), 10,8 × 7,7 mm, height 2,7 mm. 55. Left side of preserved animal. 56. Right side of preserved lectotype, shell removed.

than *Rixa* Iredale, 1924) have now been found in southern Africa, viz. *Puncturella*, *Cranopsis*, *Rimulanax* and *Vacerrana*. *Fissurisepta*, for reasons given later, is now regarded as a full genus.

As in *Emarginula*, the shell is sculptured by microscopic intritacalx-filled pits with pores passing through to the interior (Figures 4, 80, 81). Although there may be some variation in density of pitting between species, for the most part the pits are of much less taxonomic value in this genus than in *Emarginula*. Typically the pits are arranged in radial rows and are generally circular.

#### Key to subgenera of *Puncturella* in southern Africa

1. Intritacalx composed of oblong granules and covering most of shell surface . . . . . *Vacerrana*  
— Intritacalx confined to surface pits . . . . . 2
2. Foramen near middle of anterior face, selenizone long . . . . . 3  
— Foramen at or near apex, selenizone short or absent . . . . . *Puncturella*
3. Shell low to moderate, rapidly expanding peripherally to form a broad flattened internal margin . . . . . *Rimulanax*  
— Shell moderate to high, forming a more regular cone, without a broad internal margin . . . . . *Cranopsis*

#### Subgenus *Puncturella* s.s.

**Diagnosis.** Anal foramen on anterior face, at or very near the apex; with or without a selenizone; protoconch retained

in adult; sculpture variable; internal septum well developed, in section U-shaped or flat.

**Notes.** This subgenus shows considerable variation in shell morphology. It would appear to comprise two species-complexes, one containing the nominate *P. noachina* (Linné, 1771), the other the very different *P. sportella* Watson, 1883. Members of the former complex are generally larger with an obviously convex anterior face, an elongate foramen, a short, but distinct selenizone and an internal septum that is anteriorly concave. The *sportella*-like species are smaller, have a more conical, less recurved profile, a circular to oval foramen, virtually no selenizone and a well-developed, flat internal septum. Future study may show *sportella* and its allies to form a valid taxonomic grouping, perhaps more closely allied to *Fissurisepta* than to *Puncturella*.

Of southern African species, *P. capensis* is *noachina*-like, while *P. voraginosa* resembles *P. sportella*.

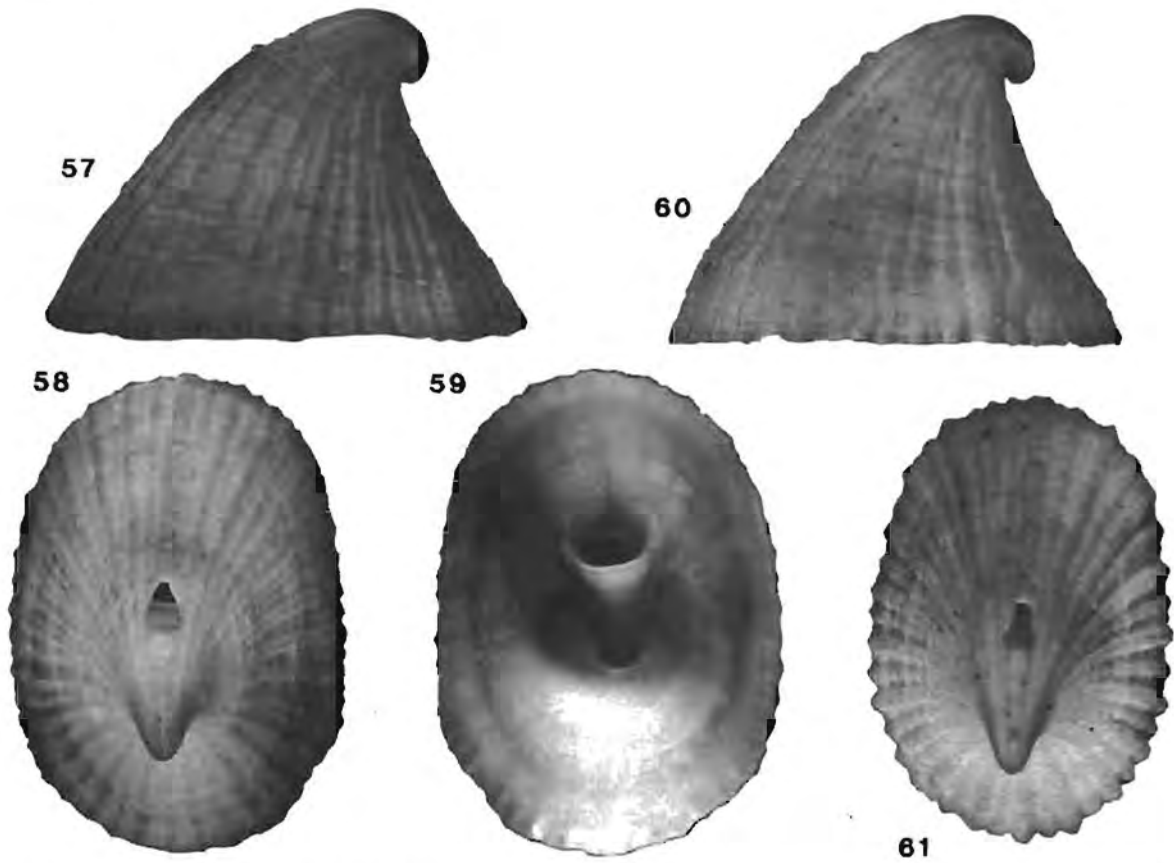
#### *Puncturella* (*Puncturella*) *capensis* Thiele, 1919 (Figures 57–65)

*Puncturella capensis* Thiele, 1919:164, pl. 19, figs 15, 16; Kilburn, 1978:448, pl. 9, a, b. Type loc.: Simon's Bay (False Bay), 70 m.

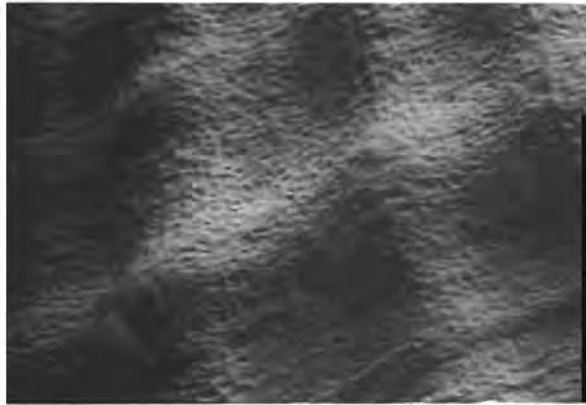
*Puncturella noachina* (non Linné); Sowerby 1903:231; Barnard, 1963:295.

*Puncturella fastigiata* (non A. Adams); von Martens, 1904:50.

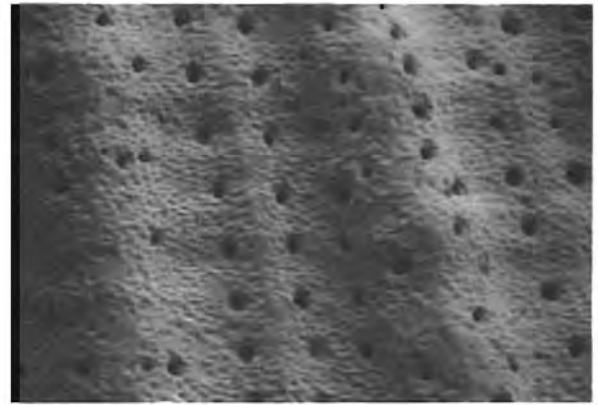




Figures 57–61 *Puncturella capensis*. 57–59. Weakly ribbed specimen, NM C7063, 59, shell interior, 8,7 × 5,9 mm, height 5,8 mm. 60 & 61. Coarsely ribbed specimen, also NM C7063, 7,9 × 5,4 mm, height 5,8 mm.



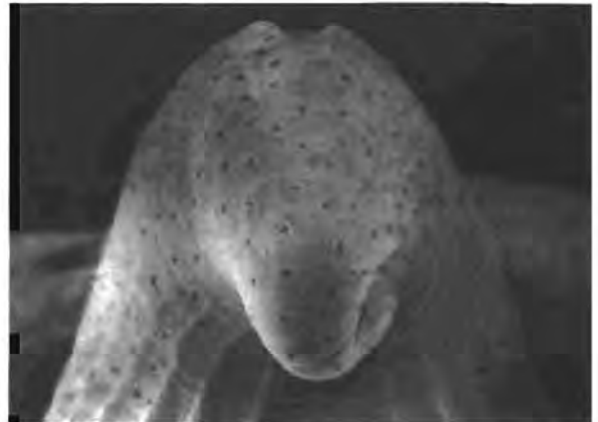
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Figures 62–65 *Puncturella capensis*. 62. Microsculpture (NM C6839). 63. Microsculpture after sonication (NM C4433). 64. Protoconch (NM C6839). 65. Rear view of apex (NM C4433). All SEM, scale bars = 100 μm (Figures 62–64), 1,0 mm (Figure 65).

**Diagnosis.** Shell oblong-ovate, somewhat laterally compressed, apex recurved, approximately 0,20–0,25 of length from posterior end, moderate to high ( $h/l = 0,56-0,75$ ). Anal foramen on anterior face level with apical whorls, lanceolate. Sculpture of predominantly radial ribs, of two alternating orders, numbering 35–45, of which approximately 20 are first order, microsculpture of radial rows of minute intritacalx pits. Interior with broad U-shaped septum underlying foramen, no lateral buttresses. White. Length up to 13,4 mm.

**Description.** (NM material) Shell with basal outline oblong-ovate, somewhat laterally compressed ( $w/l = 0,62-0,77$ ); apex recurved, approximately 0,20–0,25 of length from posterior end; protoconch and early teleoconch displaced to the right and tilted downwards; apex moderate to high ( $h/l = 0,56-0,75$ ) (0,82 *vide* Thiele); anterior face progressively more convex toward the apex, posterior face straight or slightly concave; base flat. Anal foramen on anterior face level with apical whorls, selenizone expanding and deepening rapidly, with low, curved growth-lines or weak lunulae; a single lunule well developed where selenizone meets internal septum; foramen lanceolate, broadest above internal septum in apical view. Sculpture of predominantly radial ribs of varying strength, with a small number of weak concentric growth-lines; ribs smooth, of two generally alternating orders with additional finer intermediaries, 35–45 first and second order ribs (of which 18–20 are first order); a single anterior rib in line with foramen is frequently broader than the others, and may be shallowly bifid. Microsculpture of many rows of small, circular, intritacalx pits, most obvious in intervals, but also present on sides of ribs (rarely on crests) (Figure 63). Ventral margin crenulate, size and position of crenules correlating with external ribbing, sometimes absent in large specimens. Interior glossy, with many rows of microscopic pores corresponding to intritacalx pits on exterior. Internal septum (Figure 59) broadly U-shaped in section with distinct growth-lines when viewed through the foramen, no side buttresses; a shallow groove runs from the foramen toward, but rarely reaching, the anterior margin. White, slightly translucent. Protoconch puncturelliform, projecting to the right (Figures 64, 65).

**Dimensions.** Holotype: 5,5 × 3,5 mm, height 4,5 mm (*vide* Thiele), length 5,5 mm, height 5,0 mm (*vide* von Martens). Largest NM specimen 13,4 × 8,6 mm, height 7,8 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Transkei to Table Bay, 70–550 m.

**Additional locality data.** (All NM, dredged MN, dead) TRANSKEI: off Mgazi River, 350 m, glutinous black mud, stones (C8854); off Nthlonyan River, 550 m, sand, stones, broken *Dendrophyllia* (C8684); off Qora River, 450–460 m, sandy mud (C6639); do, 400–420 m, coarse, slightly muddy sand (C6839); off Shixini Point, 400 m, sand (C4433); do, 500 m, muddy sand, coral rubble (C7063); off Qolora River, 510 m, sandy mud (C6597); do, 440–460 m, fine sand and stylasterids (C4619); off Stony Point, 460 m, sandy mud with stones, some clay (C6666); off Sandy Point, 480–490 m, fine sandy mud, stones and clay (C6939); off Kei River, 490–500 m, sandy mud (C6919); do, 390 m, coarse sand (C3866).

**Remarks.** Although Thiele compared his *Puncturella capensis* in some detail with *P. fastigiata* (A. Adams, 1853), with

which it was confused by von Martens (1904), he gave little other descriptive data. Kilburn (1978) commented on the apparent discrepancy between Thiele's description and figure regarding rib strength. The present material, however, shows considerable variation in this respect (Figures 57, 58, 60, 61) and the above detail now seems of little importance. Alternation of first and second order ribs is obvious in some specimens and less so in others, although it is generally clearer in earlier stages. Likewise some specimens are more strongly ribbed with a correspondingly crenulate margin, while others possess only weak ribs and an almost smooth margin. Farfante (1947) noted similar variation in *P. noachina* (Linné, 1771).

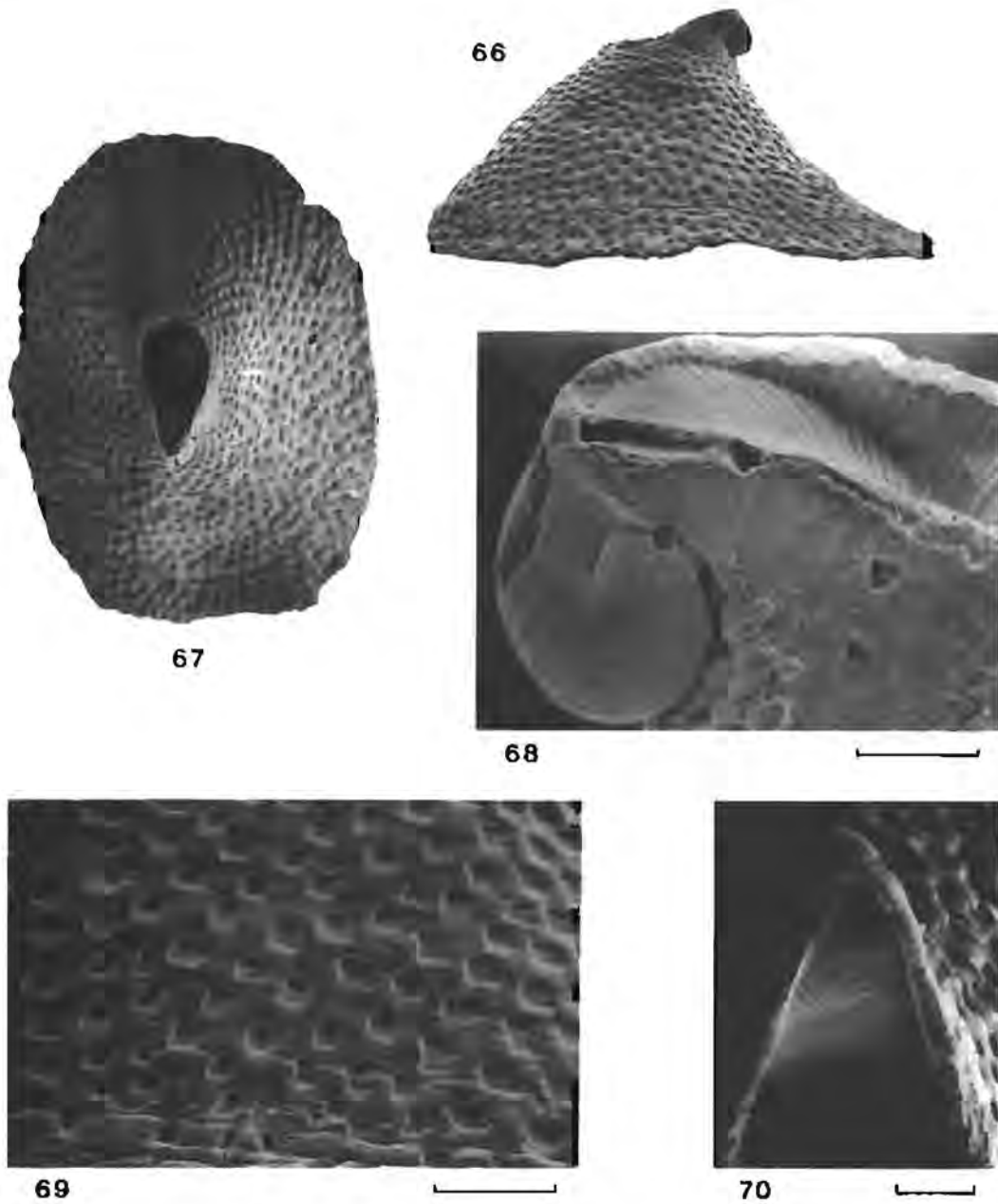
Barnard (1963), unaware of Thiele's description of *P. capensis*, recorded the southern African species as *P. noachina*. The present species differs from *P. noachina* in possessing slightly fewer ribs, more numerous intritacalx pits and a broader internal septum, and in always lacking septal buttresses, even in adults. Furthermore, Farfante (1947) and Powell (1951) considered *P. noachina* to be restricted to the northern Atlantic, and the latter author synonymized the southern *noachina*-type taxa with *P. conica* (d'Orbigny, 1841). Thiele's figure of *P. conica* indicates it to be much taller than the present species (though this is not borne out by the measurements given by Powell). *P. analoga* von Martens, 1904, from Kerguelen Island, appears similar to *P. capensis*, but Thiele (1919) synonymized it with *P. noachina* and made no reference to it with regard to his *P. capensis*.

As pointed out by Kilburn (1978), the measurements given by Thiele and von Martens differ slightly from one another, but both indicate a higher apex than in the material here regarded as *capensis*; the larger series now available confirms the latter difference. This difference ( $h/l$  0,82 or 0,91 as against 0,62–0,77 for our material) is no greater than that found in other *Puncturella* species, e.g. 0,60–0,85 for *P. noachina* (Farfante 1947), 0,75–1,00 [0,56 if the measurements given by Habe (1951) are accepted] for *P. fastigiata*. Perhaps differences in height in *P. capensis* are bathymetric, the type locality being at 70 m, while NM examples come from 400–510 m.

***Puncturella (Puncturella s.l.) voraginosa* sp. n. (Figures 66–70)**

**Diagnosis.** Basal shell outline oblong-ovate, sides almost parallel; height moderate ( $h/l = 0,45-0,62$ ), conical, apex weakly recurved; anal foramen at top of anterior face, broad, oval, selenizone very short, triangular with very weak curved lunulae and raised bordering flanges. Protoconch turned to the right. Sculpture of numerous square to rectangular pits, no ribbing. Interior with well-developed, flattened septum. White. Length 2,9 mm.

**Description.** Basal shell outline oblong-ovate ( $w/l = 0,69-0,74$ ), sides almost parallel, base slightly concave in side view; height moderate ( $h/l = 0,45-0,62$ ), conical, apex weakly recurved, anterior face very slightly convex, posterior face straight or concave, sides marginally indented. Anal foramen at top of anterior face, broad, oval. Selenizone very short (Figure 70), triangular, running smoothly into internal septum, posterior end sharply rounded, lunulae extremely fine and curved; bordering flanges raised. Sculpture of numerous, randomly arranged, square to rectangular pits (Figure 69), no radial ribs, but occasional weak concentric growth-lines. Little evidence of intritacalx pits. Interior with a well-developed, flattened, transverse septum, approximately in the middle of the shell, extending vertically to half shell height, ventral margin of septum slightly concave.



Figures 66–70 *Puncturella voraginosa* sp. n., holotype. 66 & 67.  $2.3 \times 1.7$  mm, height 1.3 mm. 68. Protoconch. 69. Microsculpture. 70. Apex. All SEM, scale bars =  $100 \mu\text{m}$ .

Anterior and posterior walls of interior with thin opaque radial striations; no groove from foramen to anterior margin. Colour white, slightly translucent. Protoconch projecting to the right, typically puncturelliform (Figure 68).

**Dimensions.** Holotype,  $2.3 \times 1.7$  mm, height 1.3 mm. Paratype 1,  $2.9 \times 2.0$  mm, height 1.8 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Known only from Transkei, outer continental shelf and upper slope, 100–430 m.

**Type material.** Holotype NM C1296/T3020, off Port Grosvenor, Transkei ( $29^{\circ}57.6'S/31^{\circ}26.2'E$ ), 100–115 m, sand, some mud, solitary corals and shells, paratype 1, NM C7045/T3019, off Rame Head, Transkei, 410–430 m, stones and some sand; paratype 2, NM C7203/T3032, same data as paratype 1; paratype 3, NM C7355/T3040, off Mgazi River, 180 m, soft mud; paratype 4, NM C8824/T3083, off Mgazi River, 370 m, soft black mud, few rocks, large crinoids;

paratype 5, NM C7998/T3089, same data as paratype 1. All material dredged MN, dead.

**Remarks.** The shape of the shell and the well-developed, flattened septum clearly ally this species to *P. sportella* Watson, 1883, and similar species from the western Atlantic (see Farfante 1947). Sculpturally, however, the present species is quite distinct.

**Etymology.** *Voraginosus* (L.), full of pits.

**Subgenus *Cranopsis* A. Adams, 1860**

*Craniopsis* Wenz, 1938:181. [*nom. null.*]

Type species (monotypy) *Puncturella (Cranopsis) pelex* A. Adams, 1860.

**Diagnosis.** Anal foramen on anterior face, generally central, elongate, frequently narrowed anteriorly with a slight cleft running toward the anterior margin. Selenizone well developed; internal septum small, curved, covering only the

apical portion of the foramen. In young shells foramen sometimes open anteriorly as in *Emarginula*.

**Notes.** The distinction between *Cranopsis* and *Puncturella* s.s. has been made generally on the basis of the location of the anal foramen (Keen 1960; Farfante 1947). Other given characters such as the presence or absence of a selenizone, and of a groove on the interior from the foramen to the anterior shell margin, seem to be variable. Cowan & McLean (1968) stated that a more useful character was the presence in *Cranopsis* of a major double rib, produced by the split mantle, extending from the foramen to the anterior margin. This is certainly very clear in strongly ribbed species such as *P.(C.) cucullata* (Gould, 1846) and *P.(C.) multi-striata* Dall, 1914, but is less so in smoother forms, such as *P.(C.) serraticosta* sp. n. Moreover the anterior rib in some typical *Puncturella* species (e.g. *P. capensis*) is broader than the others and may be shallowly bifid. It would seem that the most reliable features remain the position of the foramen and the degree of development of the internal septum, which is always much smaller in *Cranopsis*. Presence or absence of a split mantle is potentially useful, but has been investigated in too few species.

***Puncturella (Cranopsis) serraticosta* sp. n. (Figures 71–74)**

**Diagnosis.** Shell oblong-ovate, sides almost parallel, moderate to high ( $h/l = 0,58–0,64$ ), apex strongly recurved, 0,1–0,2 of length from posterior end. Anal foramen in middle of anterior face, anterior end approximately 60% of height from base, elongate. Bordering flanges of selenizone well developed, forming a keel. Sculpture of ca. 25 first order radial ribs with intercalating secondaries and numerous fine tertiaries; concentric sculpture of many very fine threads, which cross ribs to produce irregular serrations when viewed in profile. Microsculpture of radial rows of circular intritacalx pits. Internal septum short, curved. White. Length 10 mm.

**Description.** Basal outline of shell oblong-ovate, sides almost parallel ( $w/l = 0,66–0,69$ ), greatest width median, moderate to high ( $h/l = 0,58–0,64$ ), apex strongly recurved, 0,1–0,2 of length from posterior margin, protoconch and early teleconch slightly displaced to the right; base flat, anterior face roundly convex, posterior face slightly concave. Anal foramen in middle of anterior face, anterior end ca. 0,6 of height from base, elongate, 2 mm long, more sharply rounded anteriorly. Selenizone sunken, bordering flanges well developed, sharp, forming a keel; sculptured only with fine concave growth-lines; a single lunule where selenizone meets internal septum. General sculpture of approximately 25 first order radial ribs with intercalating secondaries and numerous very fine tertiaries; anterior rib from foramen to base broad, apparently double. Concentric sculpture of many very fine threads (subequal to tertiaries), producing a microcancellation; threads cross ribs to form irregular serrations when viewed in profile. Microsculpture of circular intritacalx pits, arranged in radial rows between ribs, generally one pit per microinterstice, occasionally two (Figure 74). Periods of growth marked by concentric lines; ventral margin irregularly crenulate. Interior glossy, with numerous microscopic punctations corresponding to intritacalx pitting; apical portion of foramen covered by a short, curved, internal septum which forms a ridge to the apex; septal growth-lines distinct; a groove extends from foramen toward and almost reaching the anterior margin. White,

slightly translucent. Protoconch (Figure 73) typically puncturelliform.

**Dimensions.** Holotype: 10,0 × 6,9 mm, height 6,4 mm. Paratype: 9,3 × 6,1 mm, height 5,4 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Transkei continental slope, known only from type locality.

**Type material.** (Dredged MN, dead). Holotype, NM C7064/T3013, off Shixini Point, Transkei (32°31,6'S/28°53,0'E), 500 m, dredged MN, dead. Paratype, NM C7155/T3014, same data as holotype.

**Remarks.** Few *Cranopsis* species are as elevated as *P. serraticostata*. *P. indica* Smith, 1899, from southern India, and *P. fornicata* Locard, 1898, from the eastern Atlantic both have a similar overall shape, but have an arched base, a longer foramen and coarser sculpture.

**Etymology.** *Serratus* (toothed like a saw) and *costa* (a rib), L.

**Subgenus *Rimulanax* Iredale, 1924**

*Rimulanax* Iredale, 1924:218. Type species (monotypy) *Puncturella (Cranopsis) corolla* Verco, 1908.

*Kira* Habe, 1951:120. Type species (o.d.) *Puncturella (Cranopsis) dorcas* Kira & Habe, 1949.

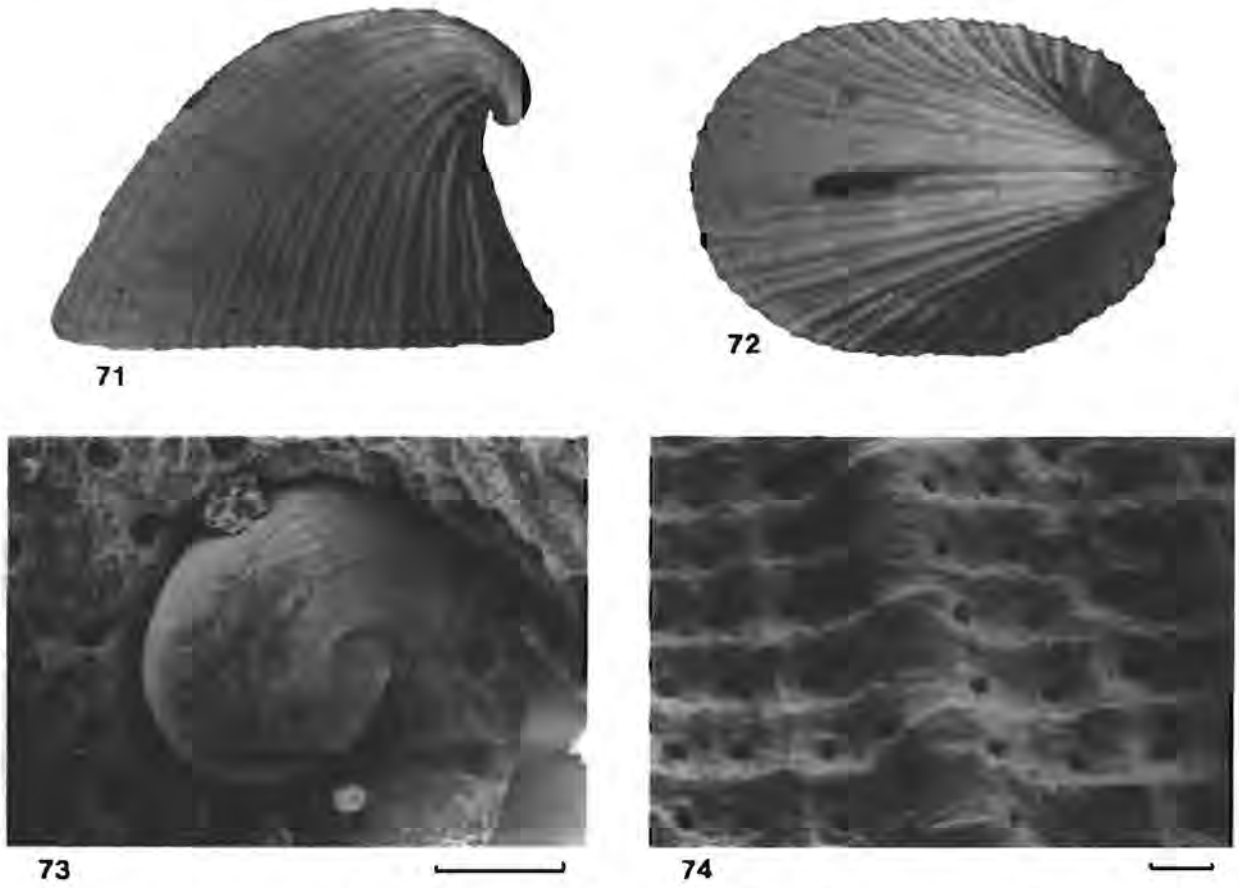
**Diagnosis.** Shell similar to *Cranopsis* in that the anal foramen is placed approximately in the middle of the anterior face. Characterized by the rapidly expanding shell which forms a broad, flattened internal margin. Generally somewhat depressed, circular to oval in outline, not strongly recurved (apex not near posterior margin), with a sculpture of many narrow but well-defined radial ribs and fine concentric threads.

**Notes.** *Rimulanax* was proposed for deep-water southern Australian forms of *Cranopsis*, of which subgenus most authors have regarded it as a synonym (Wenz 1938; Farfante 1947; Keen 1960). Habe (1951) proposed a new subgenus, *Kira*, for Japanese species of similar morphology. This was not recognized by Kira (1962). It would seem that there is a complex of species in the Indo-West Pacific which share the above characters, particularly the flared shell aperture. These comprise *P. dorcas* Kira & Habe, 1949, and *P. teramachii* Kira & Habe, 1949, from Japan, *P. corolla* Verco, 1908, from southern Australia, *P. gigantea* Schepman, 1908, from Indonesia and *P. aethiopica* von Martens, 1902, from the Zanzibar Channel. Further study may extend the group to include *P. asturiana* Fischer, 1882, and *P. antillana* Farfante, 1947, from the western Atlantic, and *P. expansa* Dall, 1896, from West America, all of which are moderately deep-water species.

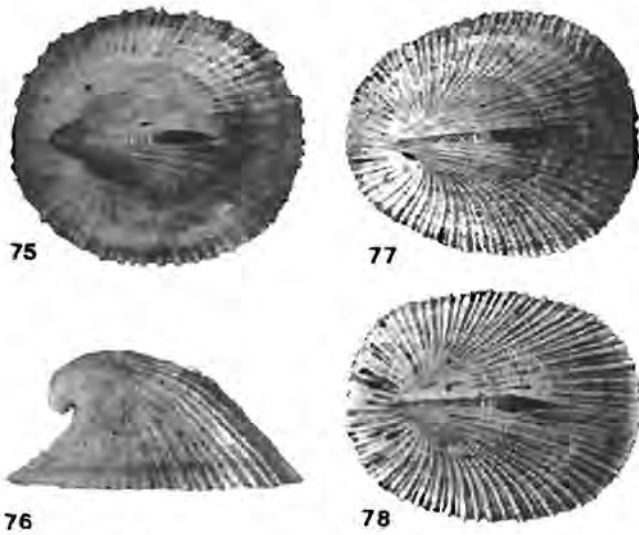
***Puncturella (Rimulanax) aethiopica* von Martens, 1902 (Figures 75–83)**

*Puncturella (Cranopsis) aethiopica* von Martens, 1902:242; *idem*, 1904:128, pl. 5, fig. 9; Thiele, 1904:14, pl. 7, fig. 35, 36 (anatomy); *idem*, 1919:146, pl. 16, figs 17–19; *idem*, 1925:39(5). Type loc.: Zanzibar Channel, 463 m.

**Diagnosis.** Basal outline of shell oval to subcircular ( $w/l = 0,78–0,91$ ); rapidly expanding peripherally to form a broad flattened rim; depressed ( $h/l = 0,36–0,46$ ); anal foramen central on anterior face, elongate, rounded posteriorly, narrow anteriorly; selenizone long, bordering flanges raised, lunulae well developed. Radial sculpture of ca. 25 first order



Figures 71–74 *Puncturella serraticosta* sp. n., holotype. 71 & 72. 9,9 × 6,9 mm, height 6,3 mm. 73. Protoconch. 74. Microsculpture. 73 & 74. SEM, scale bars = 100 μm.



Figures 75–78 *Puncturella aethiopica*. 75 & 76. Rounded specimen (NM C6838), 10,8 × 9,4 mm, height 4,8 mm. 77. Ovate specimen (NM C6578), 10,7 × 8,8 mm, height 4,4 mm. 78. Oblong specimen (also NM C6578), 11,1 × 8,7 mm, height 4,4 mm.

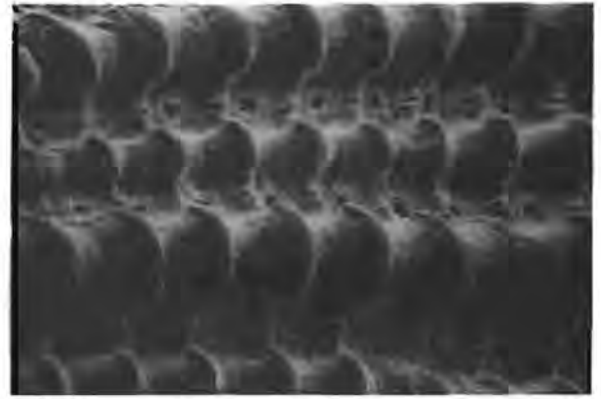
ribs; anterior rib from foramen to margin double; concentric sculpture of fine threads producing a weak cancellation. Interstices shallow, generally with one intritacalx pit in each. Internal septum small, curved. White. Length 16 mm.

**Description.** Basal outline of shell oval to subcircular ( $w/l = 0,78-0,91$ ), with considerable variation in the position of the widest point (Figures 75, 77, 78); base flat or slightly

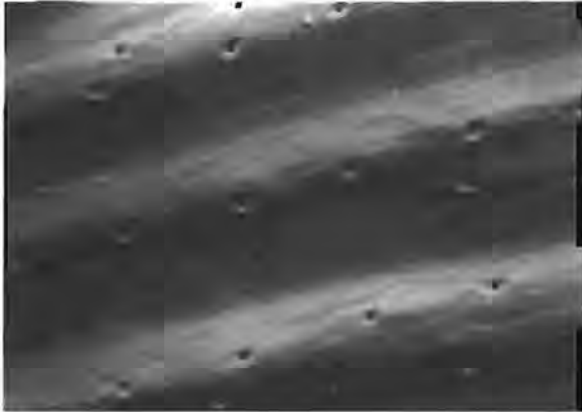
convex in lateral view, posterior end marginally raised; shell rapidly expanding peripherally to form a broad flattened rim; depressed ( $h/l = 0,36-0,46$ ), apex recurved, approximately 0,1–0,2 of length from posterior end. Anterior face convex from apex to lower end of foramen, straight from there to the base; posterior face concave particularly below apical whorls, becoming progressively less so toward the base. Anal foramen approximately central on anterior face, elongate, rounded posteriorly, narrowing anteriorly to a cleft between fused shell ribs; side walls of lower portion of foramen markedly raised. Selenizone well developed, bordering flanges elevated, almost keel-like, frequently broken; lunulae pronounced but thin, square-set to curved, not correlating with concentric threads, anterior ones often fused. Sculpture of ca. 25 first order radial ribs with intercalating second and third order; second order ribs subequal to first at the periphery of adult shells. Anterior rib from lower end of foramen to anterior margin clearly double. Concentric sculpture of numerous fine threads producing a weak cancellation; threads cross ribs forming radial pronounced ridges. Interstices shallow, square to rectangular, with one intritacalx pit in each, occasionally two as new ribs arise (Figure 80). Ventral margin thin and delicate, noticeably crenulate. Interior glossy, with radial grooves corresponding to external ribs. Internal septum small, curved, covering only the upper quarter of the foramen; continued toward apex as a thickened ridge. A groove extends from the lower end of the foramen toward the shell margin, often becoming a ridge ventrally. Radial rows of minute punctations occur on ridges between internal grooves corresponding to intritacalx pits (Figure 81). Interior of apex not visible in ventral



79



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82



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**Figures 79–83** *Puncturella aethiopica*. 79. Protoconch (NM C938). 80. Microsculpture (NM C938). 81. Shell interior (NM C6993). 82. Latero-marginal plate of radula (NM C6993). 83. Radula. All SEM, scale bars = 100  $\mu$ m (Figures 79, 81–83); 200  $\mu$ m (Figure 80).

view; the sharp change in shell curvature produces an angular ridge inside the margin, particularly at the posterior end. White, somewhat translucent. Protoconch typically puncturelliform (Figure 79).

**Dimensions.** Holotype, 16,0  $\times$  14,5 mm, height 6,0 mm. Largest NM specimen, 12,3  $\times$  10,4 mm, height 4,5 mm.

**Radula.** (Figures 82, 83) Markedly asymmetrical, rachidian narrowing apically, cutting edge set at 40–50° to the longitudinal axis. First and second laterals with well-developed cutting edges (subequal to that of rachidian); third lateral with only a small cusp; fourth lateral broad and folded, but lacking cutting edge; fifth lateral large, bicuspid (smaller cusp not visible in figure). Successive rows of inner teeth do not overlap. Latero-marginal plate with a pronounced

curved ridge.

**External anatomy.** Thiele (1904) described the external anatomy of this species, which is typically puncturelliform. Our material agrees. The mantle remains split below the anal foramen, and there is a discrete siphon with one pair of pallial sense organs posterior to it and up to four pairs anteriorly. The epipodial fold forms a constricting girdle around the upper part of the foot and bears 7–10 tentacles on each side. The majority of these tentacles are short, except for the penultimate one on each side which is long; however, the first short tentacle may be larger than the other short ones. The right postoptic tentacle is well developed and often spatulate distally, but occasionally long and slender; this is not linked to sex. No metapodial tentacle is

apparent. Colour white.

**Distribution.** Zanzibar Channel to Natal and Transkei, 295–550 m (living examples, 350–550 m).

**Regional locality data.** (All NM, dredged MN) NATAL: off Amanzimtoti, 300–305 m, medium sand (D1313). TRANSKEI: off Rame Head, 410–430 m, stones, some sand (C2026); do, 380 m, coarse sand, old shell debris (C2072); off Whale Rock, living, 400–420 m, coarse sand, old shell debris, stones (C2039); do, 400 m, fine muddy sand, (C9396); do, 430–450 m, fine muddy sand (C8895); do, 500 m, fine sandy mud (C9249); off Nthlonyane River, living, 550 m, sand, stones, broken *Dendrophyllia* (C8685); off Mbashe River, 295–300 m, old shell rubble (C8987); do, 295–350 m, coarse sand (C9095); do, living, 450–500 m, coarse sand, some mud (C9074); do, living, 465–500 m, coarse sand (C9385); off Mendu Point, 405–420 m, fine sand (C4989); do, 450 m, fine muddy sand (C6317); off Shixini Point, 400 m, sand (C4429); do, 400–420 m, coarse sand, fine shell rubble (C6484); do, 500 m, muddy sand, coral rubble (C7065); off Qora River, living, 350–360 m, muddy sand, small quantity broken shell (C6713); do, living, 400–420 m, coarse slightly muddy sand (C6838); do, 450–460 m, sandy mud (C6638); off Stony Point, living, 390–400 m, muddy sand, small stones (C6993); do, 510 m, mud (C6950); do, 510 m, mud (C6667); off Sandy Point, 450 m, muddy sand, stones (C6872); do, 480–490 m, fine sandy mud, stones, clay (C6938); off Qolora River, 440–446 m, fine sand and branching coral (C4056); do, 340–350 m, coarse sand, broken shells (C6704); do, 510 m, sandy mud (C6578); off Kei River, 490–500 m, sandy mud, coral rubble (C6920); do, 400 m, coarse sand, broken shell (C6616).

**Remarks.** Von Martens (1904) compared his *aethiopica* with *P.(C.) indica* Smith, 1899, from southern India, but the latter species, though probably sculpturally similar, is much more elevated and lacks the flange-like margin to the shell. Of the species here placed in *Rimulanax*, *P. dorcas* Kira & Habe, 1949, and *P. teramachii* Kira & Habe, 1949, appear most similar. *P. dorcas*, however, is less recurved and *P. teramachii* has an evenly convex anterior face. *P. corolla* Verco, 1908, has fewer ribs. Schepman (1908) allied his *P. gigantea* with *P. aethiopica*, but noted the former to be larger (29 mm long) and more elongate with finer sculpture. The asymmetrical anal foramen recorded by von Martens is abnormal but not infrequent, usually resulting from damage during earlier stages.

#### Subgenus *Vacerrera* Iredale, 1958

*Vacerra* Iredale, 1924 (*non* Godman, 1900):221.

*Vacerrera* Iredale, 1958:104 (*nom. subst*)

Type species (o.d.) *Vacerra demissa menda* Iredale, 1924.

**Diagnosis.** Shell very small, apex strongly recurved, above or behind the posterior margin. Foramen on anterior face close to apex, horizontal or even posteriorly sloping. Internal septum well developed, transverse, following shell curvature, blocking foramen in apical view. Sculpture variable but generally of weak radial ribs or undulations. Microsculpture of numerous small oblong granules covering the entire surface.

**Notes.** Iredale proposed *Vacerra* at the generic level for certain small Australasian *Puncturella* spp., but gave no characteristic features. Thiele (1929), Wenz (1938) and Powell (1979) regarded *Vacerrera* as a subgenus of *Puncturella*, while Keen (1960) synonymized it with that. Wenz

and Powell both described gross shell morphology but failed to mention the unusual microsculpture of 'a caducous ochraceous epidermis disposed in oblong grains' noted by Hedley (1907) and regarded as diagnostic by Kilburn (1978). The subgenus remains poorly known and few species at present can be assigned to it with any degree of certainty.

#### *Puncturella (Vacerrera) christiaensi* Kilburn, 1978

*Puncturella (Vacerrera) christiaensi* Kilburn, 1978:448, pl. 9c,e. Type loc.: off Sodwana Bay, Zululand, 50 m.

*Fissurisepta joschristiaensi* Drivas & Jay, 1985:6, text figs. Type loc.: Reunion Island. (*syn. nov.*)

**Additional notes.** Only one further specimen has been obtained. Kilburn (1978) compared this species with *P. demissa* Hedley, 1904, from New Zealand and *P. (demissa) menda* (Iredale, 1924), from New South Wales. Greater similarity exists with *P. galerita* Hedley, 1902, from the Torres Strait, particularly regarding shell height and the posteriorly tilted foramen region. *P. christiaensi* has fewer and less prominent ribs, save for the median anterior rib which is distinctly larger. Protoconch in *christiaensi* worn, but emarginuliform rather than puncturelliform; slightly turned to the right, but not projecting to the right in posterior view; visible from both sides of the shell. From specimens (NM K901: J. Drivas) *Fissurisepta joschristiaensi* is identical.

**Radula and external anatomy.** Unknown.

**Distribution.** Known only from northern Zululand (Kosi Bay to Sodwana Bay), 50–100 m, and Reunion, 45 m (*F. joschristiaensi*).

**Additional locality data.** Off Kosi Bay, 100 m, dredged CSIR Water Research (NM D157).

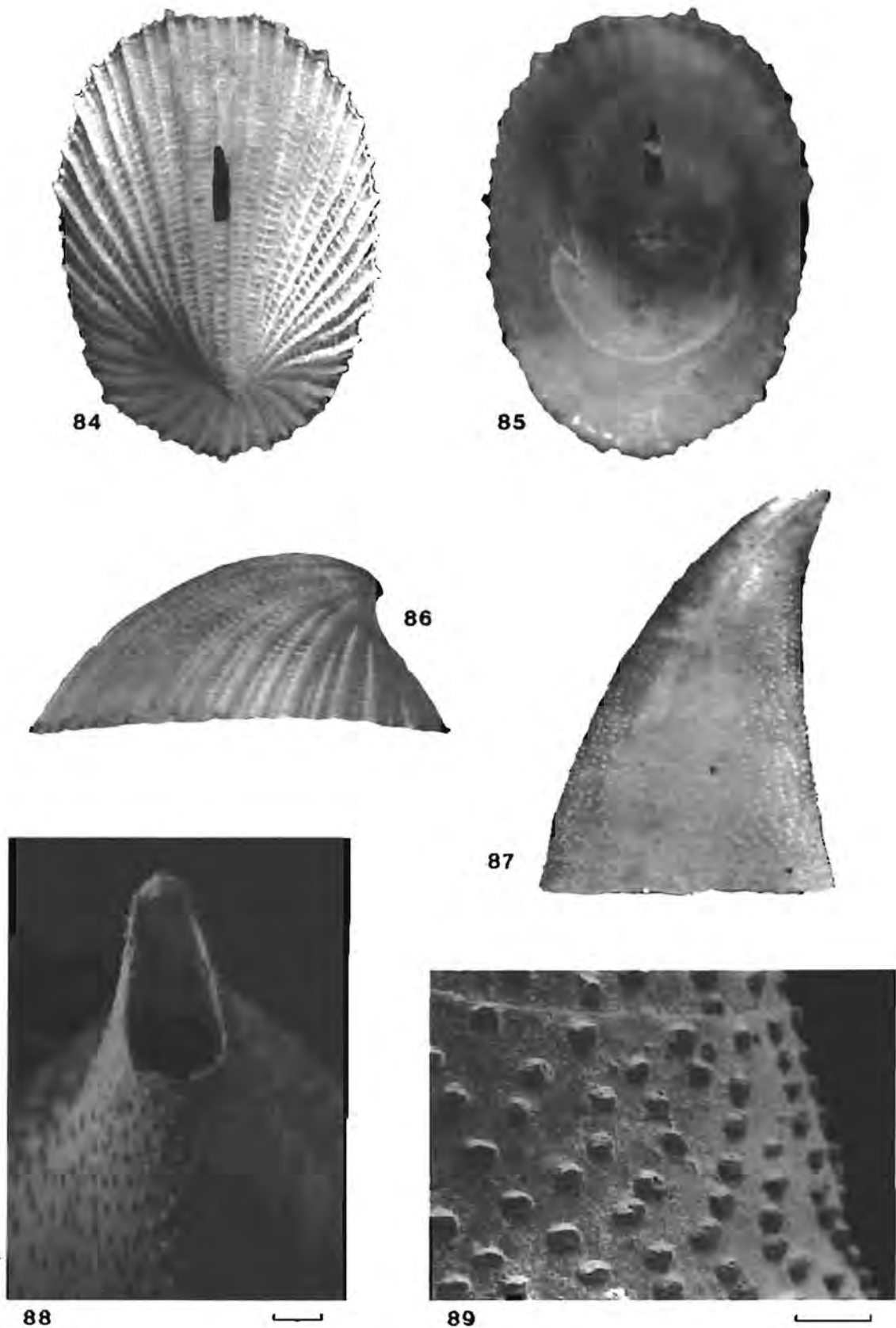
#### *Fissurisepta Seguenza, 1862*

Type species (s.d. Woodring, 1928); *Fissurisepta papillosa* Seguenza, 1862.

**Diagnosis.** A small group of species with conical shells possessing an apical foramen and frequently a well-developed internal septum. Protoconch lost in adult. Sculpture variable, of radial ribs and concentric threads, or small granules (tubercles), or smooth. Reported bathymetric range for the genus 50–4585 m.

**Notes.** Most early workers treated *Fissurisepta* as a subgenus of *Puncturella*. Cowan (1969), however, has demonstrated the presence of monopectinate ctenidia, unique amongst fissurellids, and consequently suggested full generic status for *Fissurisepta*. Warén (1972) confirmed Cowan's findings, though with some modification regarding tentacles. Ghisotti & Giannini (1983) published a useful catalogue of described species; to this should be added *Fissurisepta antarctica* Egorova, 1972, from Antarctica. Hickman (1983) has described the radula of *F. granulosa* Jeffreys, 1883, noting the lack of both shaft and cusp on the rachidian (unlike *Puncturella*).

The only *Fissurisepta* previously recorded from near the southern African region is *F. agulhasae* (Clarke, 1962); the name, referring to the Agulhas Basin, is perhaps unfortunate as the type locality lies 1000 miles off Cape Town in 4585 m. Such abyssal species are not normally included in the southern African fauna.



Figures 84–89 *Rimula rhips* sp. n. and *Fissurisepta onychoides* sp. n. 84–86. *R. rhips*, holotype, 9,4 × 6,7 mm, height 4,1 mm. 87–89. *F. onychoides*; 87. holotype, 3,6 × 2,6 mm, height 4,9 mm; 88. foramen (paratype 1); 89. microsculpture (same). 88 & 89. SEM, scale bars = 200 μm.

***Fissurisepta onychoides* sp. n. (Figures 87–89)**

**Diagnosis.** Basal outline of shell oblong-ovate; high ( $h/l = 1,1-1,4$ ), conical; apex strongly recurved, almost level with the posterior margin. Internal septum well developed, transverse; foramen on anterior face of apex, posterior border much higher than anterior, forming a beak-like

projection. Sculpture of numerous small granules. White, slightly translucent, granules chalky white. Height 5,3 mm.

**Description.** Basal outline of shell oblong-ovate with slight flattening postero-laterally; high ( $h/l = 1,1-1,4$ ), conical; apex strongly recurved, level or nearly so with the posterior



margin; anterior face markedly convex, posterior face concave; ventral margin flat. Internal septum well developed, transverse, situated one third of length from anterior end, extending for over half the height of the shell following the curvature of the anterior face; septum visible through translucent shell, free margin concave. Foramen on anterior face of apex (Figure 88), posterior border formed by septum much higher than anterior, forming a beak-like projection; gently notched in side view; apex subcircular in section; viewed apically foramen and posterior beak form a rounded isosceles triangle. Sculpture of numerous small granules (Figure 89), most obvious in profile, generally randomly distributed, but linearly (radially) aligned in places; concentric growth-lines present both externally and on septum. White, becoming translucent toward the apex; granules chalky white. Protoconch missing in adult.

**Dimensions.** Holotype 3,6 × 2,6 mm, height 4,9 mm. Largest NM specimen, 4,5 × 3,2 mm, height 5,3 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Natal and Transkei, continental shelf and upper slope, 250–430 m.

**Type material.** Holotype NM C6365/T3017, off Shixini Point, Transkei (32°31,2'S/28°52,2'E), 300 m, coarse sand, broken shell; paratype 1, NM C7156/T3016, off Rame Head, Transkei, 380 m, coarse sand, old shell debris; paratype 2, NM C2092/T3015, data as paratype 1; paratype 3, NM C7201/T3031, off Rame Head, Transkei, 410–430 m, stones, some sand; paratype 4, NM C7161/T3033, off Whale Rock, Transkei, 400–420 m, coarse sand, old shell debris, stones; paratypes 5–7, NM C7175/T3034, off Stony Point, Transkei, 390–400 m, muddy sand, small stones; paratype 8, NM C8823/T3086 off Mgazi River, Transkei, 370 m, soft black mud, few rocks, large crinoids; paratypes 9–11, NM C9096/T3087, off Mbashe River, Transkei, 295–350 m, coarse sand; paratypes 12–17, NM D1421/T3085, off Umlaas Canal, Natal, 250 m, coarse sand; paratypes 18–25, NM D1312/T3084, off Amanzimtoti, Natal, 300–305 m, medium sand. All material dredged MN, dead.

**Remarks.** The majority of *Fissurisepta* species occur in the northern hemisphere and the present species represents the first record of the genus in the Indian Ocean. *F. joschristiaensi* Drivas & Jay, 1985, for reasons already given herein, should be assigned to *Puncturella*. *F. onychoides* is an elevated species and as such may be compared with *F. crossei* Dautzenburg & Fischer, 1896, from the Azores, *F. festiva* Crozier, 1966, from New Zealand and tall forms of *F. acuminata* (Watson, 1883) from the western Atlantic. All these species have a height/length ratio of more than 1,0. The most similar species is *F. crossei* which would seem almost identical in shape and sculpture, but its internal septum is long, extending almost to the ventral margin. *F. agulhasae* (Clarke, 1962) is clearly separable from the present species by its cancellate sculpture.

**Etymology.** *Onyx* (Gk) meaning a claw or talon; referring to the recurved shape.

### ***Rimula* DeFrance, 1827**

Type species *Rimula blainvillii* DeFrance, 1827 (s.d. Gray 1847).

This genus is characterized by the possession of a shell with a foramen placed near the middle of the anterior face. In this respect it is similar to *Puncturella* (*Cranopsis*) and *P.*

(*Rimulanax*), but it always lacks any form of internal shelf or septum. Previously recorded from Western Atlantic, West America and Indo-West Pacific. Status in the Indian Ocean unknown, but has been reported from the Persian Gulf (Melville & Standen 1901) and Reunion (Drivas & Jay 1985). Reported bathymetric range 1–420 m.

In addition to *R. rhips*, two further unidentified species have been obtained from Mozambique, one a juvenile and the other a very worn beached shell (NM G3727, F8233).

### ***Rimula rhips* sp. n. (Figures 84–86)**

**Diagnosis.** Basal shell outline oblong-ovate, base concave; depressed ( $h/l = 0,44$ ), apex recurved, 0,15–0,25 of length from posterior end. Foramen central on anterior face, elongate; selenizone with numerous lunulae, bordering flanges diverging slightly below foramen. No internal septum. Sculpture of ca. 21 first order radial ribs with intercalating second and third order ribs; concentric sculpture of numerous threads producing a fine cancellation. White. Length 9,4 mm.

**Description.** Basal shell outline oblong-ovate, greatest width level with foramen, base concave, shell rests on its ends; depressed, apex recurved, 0,15–0,25 of length from posterior margin; anterior face evenly convex, posterior face mostly straight, but sharply concave below apex. Foramen central on anterior face, elongate, narrowing and becoming asymmetrical anteriorly. Selenizone with numerous lunulae, not consistently aligned with growth-lines: bordering flanges similar to radial ribs, becoming wider anterior to the foramen and diverging slightly. Sculpture of prominent radial ribs and weaker concentric threads producing a fine cancellation; first order ribs ca. 21 with intercalating second, third and occasionally fourth order ribs; at ventral margin ribs (particularly first order ones) project slightly; concentric threads numerous, weakly crossing ribs. No internal septum or raised rim around foramen. Interior with a distinct muscle scar delineating a central mushroom-shaped area (Figure 85); two finely grooved regions one each side of the foramen. Interior of apex filled in, forming a smooth curve at the deepest point of the interior; a shallow groove extends from the lower end of the foramen toward, but not reaching the anterior shell margin. White. Protoconch missing in holotype.

**Dimensions.** Holotype 9,4 × 6,7 mm, height 4,1 mm.

**Radula and external anatomy.** Unknown.

**Distribution.** Transkei continental shelf, known only from the type locality.

**Type material.** Holotype NM C1192/T3018, off Port Grosvenor, Transkei (39°57,2'S/31°25,9'E), 120–128 m, coarse sand, some mud, solitary coral, shells. Dredged MN, dead.

**Remarks.** This species may be compared with *R. exquisita* A. Adams, 1853, from the Philippines, *R. mariei* Crosse, 1866, from New Caledonia and *R. paeteli* Thiele, 1917, possibly also from the Philippines. Examination of the syntypes of *R. exquisita* (BMNH 1981191) indicates the present species to have a finer sculpture with more numerous concentric threads and less nodular ribs. *R. mariei* would appear from the type figure to possess more numerous first order radial ribs. Possibly the most similar species is *R. paeteli* and from Thiele's meagre description it is difficult to find features for distinction. It is extremely unlikely however, that Paetel would have been in possession of material from the depth and area from which our sample originated.

**Etymology.** *Rhyps* (Gk) meaning wickerwork; referring to the cancellate sculpture.

### Abbreviations

- AMS — Australian Museum, Sydney.  
 BMNH — British Museum, Natural History.  
 CSIR — Council for Scientific and Industrial Research, South Africa.  
 MN — R.V. Meiring Naudé.  
 NM — Natal Museum, Pietermaritzburg.  
 NMV — Naturhistorisches Museum, Vienna.  
 NMW — National Museum of Wales, Cardiff.  
 SAM — South African Museum, Cape Town.  
 ZMA — Zoölogisch Museum, Universiteit van Amsterdam.

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