PLEISTOCENE MOLLUSCS FROM THE NAMAQUALAND COAST

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(With plates 18 to 29 and 11 figures)

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INTRODUCTION

In the course of an examination of the Tertiary to Recent sediments of the Namaqualand coast, being carried out by one of the authors (A.J.C.), a collection of fossil molluscs was assembled from the Pleistocene horizons encountered in the area.

The purpose of this paper is to introduce and describe some twenty species from this collection, including forms new to the South African palaeontological literature.

In the case of a number of these species, the present geographic ranges of the genera to which they are assigned suggests that, in the Lower Pleistocene at least, the Namaqualand coast was washed by waters markedly warmer than those which presently bound this shore.

In the areas examined, the local Archean metamorphics are overlain by a succession of marine, fluviatile and terrestrial sediments of Tertiary to Recent age.

The marine elements of this succession extend some three to five miles east of the present coastline and are the result of a series of geologically fairly recent transgressions by the sea on to the land.

The oldest sediments present, fluviatile clays, silts and sands occupying a system of partly confluent channels deeply incised in the gneissic bedrock, are succeeded by isolated remnants of a profoundly indurated phosphatic siltstone and sandy clay horizon carrying an abundance of shell casts and moulds.

Overlying these fossiliferous silts is a succession of compact, poorly cemented, marine sands and gravels associated with a series of high-level beaches, developed during Pleistocene fluctuations of sea-level resulting from the periodic wasting and renewal of high latitude, continental ice-sheets. That this succession of marine sands is of Pleistocene age seems certain. In this area, where there is no evidence of tectonic instability in Pleistocene-Recent

times, the series of fossil beaches, testifying to repeated marine transgression during which sea-levels reached altimetric maxima of 75–90 (oldest), 45–50, 29–34, 17–21, 7–8, 5 and 2 (youngest) metres, accords very nearly with the well documented succession of Pleistocene strands along the Atlantic coast of Morocco (Biberson, 1963; Butzer, 1966).

Although the coarse, porous, marine sands of the 75–90 m transgression have, so far, proved to be barren of animal remains, the succeeding beaches are abundantly fossiliferous. The oldest of these shell-bearing beds, laid down during the 45–50 m inundation, has yielded more than 120 species of molluscs of which only seventeen of the twenty forms here described, plus the previously recorded *Chamelea krigei* Haughton and *Fissurella robusta* Sowerby, are not found living in the seas surrounding the coasts of South Africa.

The stratigraphic correlation alluded to earlier, the high proportion (84%) of species extant in the present seas, the low degree of lithification and the extraordinary 'fresh' appearance of the invertebrate remains together militate against the acceptance of an age other than Pleistocene for these sands and gravels laid down during the 45–50 m transgression.

Comparison with the Mediterranean and Moroccan marine Pleistocene successions, based solely on altimetric evidence, suggests a date equivalent to the Maarifian (Morocco) or Milazzian (Mediterranean) for this high sea stand.

SUCCESSION

	Thickness	*Suggested age*
Loose surface sand	0–4 m	
— *unconformity* —		Recent
2 m Transgression complex		
Highly fossiliferous sands and gravels; berm sands..	2 — 7+m	
— *unconformity* —		
5 m Transgression complex		
Slightly calcareous sands and shelly granule gravels	2 — 3 m	
— *unconformity* —		Upper Pleistocene[1]
7–8 m Transgression complex		
Stabilised berms; calcareous, often highly garnetiferous marine sands over well-developed boulder gravels	3–5+m	
— *unconformity* —		
Terrestrial sands		(to Recent in part)
Sheet wash deposits	2–7 m	
— *unconformity* —		
17–21 m Transgression complex		
Coarse sands and grits over massive, basal boulder gravels	10–15 m	Middle Pleistocene[1]
— *unconformity* —		
29–34 m Beach		
Thin, discontinuous, shelly gravel beach	uncertain	
— *unconformity* —		
45–50 m Transgression complex		
Aeolianite and coarse regressive facies overlying locally fossiliferous, fine-grained, transgressive sands	5–25+m	Lower Pleistocene[1]
— *unconformity* —		

75–90 m Transgression complex		
Regressive aeolianite overlying coarse, marine sands and thin gravels	35+m	Basal Pleistocene[1]
—*unconformity*—		
Fossiliferous phosphatic siltstones	0–1 m	Pliocene
—*unconformity*—		
Fluviatile beds		
Linear deposits of clays and clayey sands. Unfossiliferous	up to 20 m	Mio-Pliocene?
—*unconformity*—		
Basement gneiss		Archean Complex

[1] Subdivision of the Pleistocene after Butzer, 1966.

Details of the succession given above and dating of the component horizons are based on the results of the geological survey at present being carried out by A.J.C. It is hoped that a fuller description of the geology and palaeontology of this area will be given at a later date.

The fossil species described in this paper were collected from the three localities indicated in figure 1. With the exception of a new species of *Fissurella*, all were recovered from sands deposited during the 45–50 m marine transgression.

The extreme dissimilarity in lithological character of sediments from the 45–50 m and the 17–21 m inundations is a notable feature. Typically, the shelly fore-beach deposits of the 45–50 m transgression are constituted of extremely fine-grained, moderately rounded and sorted sands and silts. Fine to laminar bedding structures are apparent and the faunule includes a strong complement of sand-dwelling bivalves of the families Mactridae, Tellinidae and Veneridae. The sedimentary characteristics of these beds, which locally yield an abundance of a new species of *Donax*, and the prevalence of burrowing bivalves point to a quiet depositional environment with low rates of both provenance and accumulation of sediment.

Conversely, the extremely coarse sediments of the 17–21 m transgression, granular, well sorted and rounded, frequently cross-bedded and with a paucity of sand-dwelling bivalve species, suggest that a more rigorous, abrasive environment with a high rate of sediment accumulation was current during the deposition of these beds.

In at least one species, it is suggested that adaption to the profound shift in the nature of the environment, inferred from the change in lithology, has progressed so far and has engendered such physical change that the final product of these adaptive trends should be accorded a separate, specific identity.

SYSTEMATIC DISCUSSION

Key to abbreviations

L. = length
B. = breadth
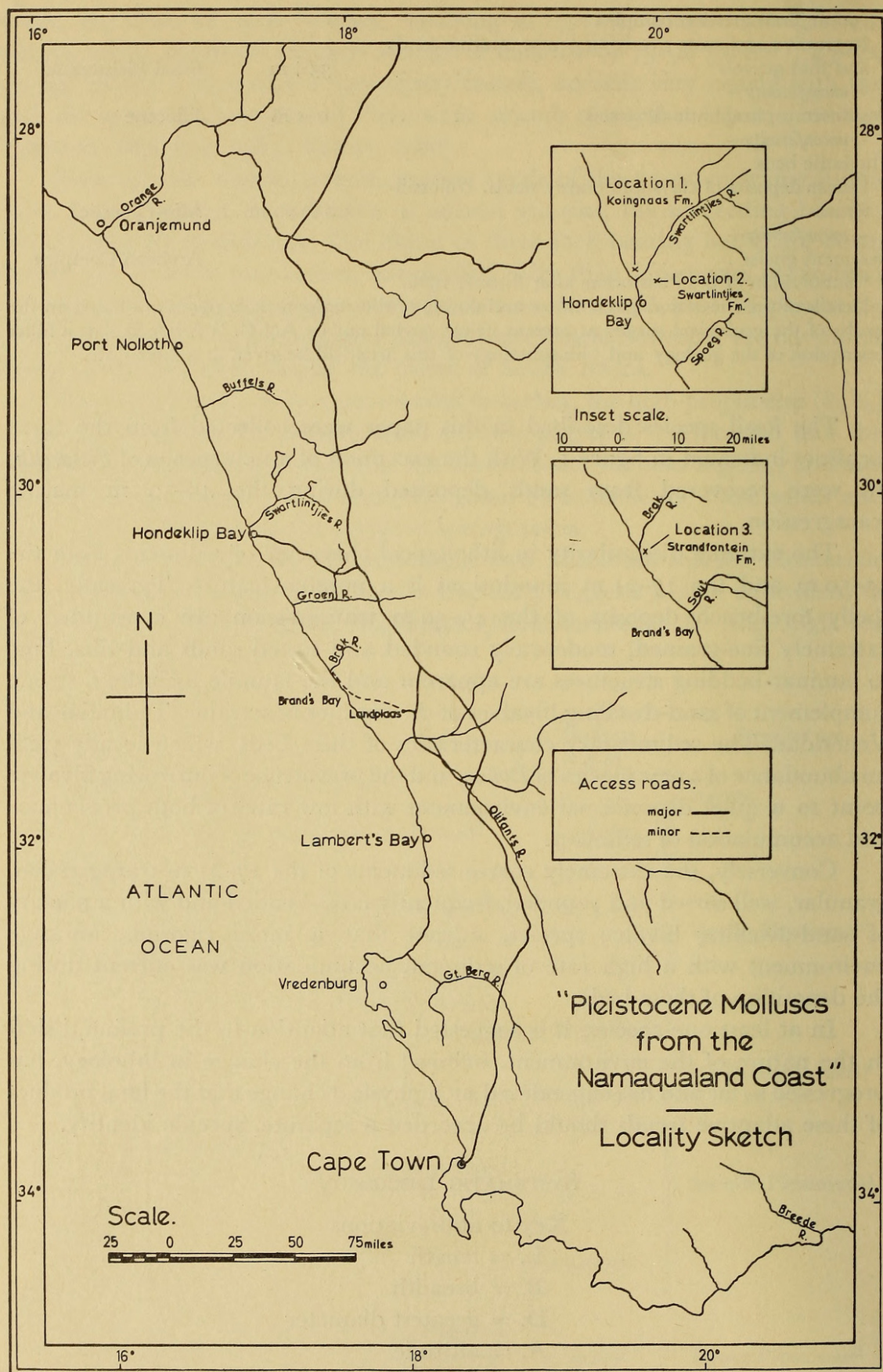D. = greatest diameter
A. = altitude
W. = width

Fig. 1

Family **Turridae**

'*Turris*' *nigrovitta* n.sp.

Pl. 18

Location 1. 45–50 m Transgression complex.
        Fore-beach environment.

Description

Protoconch eroded, possibly $1\frac{1}{2}$ whorls. Postnatal whorls 5. 1st whorl with 7 axial ribs, 5 spiral lirae, 2nd whorl with 8 axial ribs, 5–6 lirae, 3rd whorl with 8 axial ribs, 7–8 lirae, 4th whorl with 7 axial ribs, 7–8 lirae, body whorl with 7–8 axial ribs, spiral lirae obscured by erosion. Axial ribs broad. Lower body whorl and anterior canal with about 11 lirae. No sinus on outer lip. Inner area of outer lip with 8 or 9 elongate plicae. Anterior canal subequal to aperture, latter equal in length to spire.

Named from location – 'Swartlintjies', Afrikaans – 'black ribbons'.

Material

Holotype: S.A.M.   K1443   L. 27 mm   B. 12 mm
Paratype: S.A.M.   K1444   20 mm   8 mm

Remarks

With only the shell available, it is difficult to decide on generic status for this species. The main diagnostic features relating to the shell are the shape of the outer lip sinus, and the anterior canal. As there is no trace of a sinus in the present shells, choice of a subfamily is made almost impossible. The axial sculpture is similar to that found in *Turris saldanhae* Barnard and *Surcula scalaria* Barnard, but there are no other similarities. Without more material being available, the species is placed in the genus '*Turris*' merely for convenience.

Family **Fasciolariidae**

Fasciolaria sp.

Pl. 18

Location 1. 45–50 m Transgression complex.
        Beach environment.

Description

Aperture slightly shorter than spire. Shell $5\frac{1}{2}$ whorls, protoconch and first 3 whorls eroded. 9–10 spiral lirae commencing on latter part of 3rd whorl, 11–12 on 4th whorl, 12–15 on 5th whorl. Outer lip with 28–32 lirae, internally plicate in the larger shell. Exact number of lirae on outer lip difficult to determine as lirae divide into two at upper and lower portions of whorls and each may again divide. Latter divisions not as obvious in middle portion of whorl

where erosion has occurred. Profile of whorls smoothly convex, lower two with very slight shoulder. No columella pleats present, no axial sculpture apart from irregular growth lines.

Material

    S.A.M. K1445 L. 61·0 mm B. 26·5 mm (outer lip broken)
    S.A.M. K1446   66·0 mm   33·0 mm (very worn)

Remarks

In general shape, these shells are typical of the genus *Fasciolaria* and resemble *F. lugubris* Reeve very closely. There are, however, several points of difference. The columella is not as sinuous anteriorly as in *F. lugubris*. The latter usually has several columella pleats in the region of the anterior canal while near the suture of the body whorl with the preceding one, there are usually several small pleats on the columella. In the present shells there is only a slight nodule on the upper columella. The sculpturing differs from *F. lugubris*, which usually has the outer lip with 22 broad spiral lirae, alternating with finer lirae. The broad lirae are each made up of 5–7 fine lirae while the narrow lirae are made up of 2–3 finer ones. The 4th whorl has 9 broad lirae. The present species, however, has 28–32 lirae on the outer lip, 11–12 on the 4th whorl, while each lira is made up of 2 finer ones, or, if the lirae are split, 4 each.

The present shells are perhaps a form of *F. lugubris* which has been recorded from the Pleistocene deposits of the Saldanha Bay area, but without more material being available, their status is difficult to determine.

Fusus faurei Barnard, 1959
Pl. 18

Fusus faurei Barnard, 1959: 94.
Location 1. 45–50 m Transgression complex.
             Beach environment.

Material
    One specimen: L. 42·2 mm B. 20·5 mm

Previous records
    Alive, off Cape Point.

Remarks

The present shell agrees almost exactly with the description of *F. faurei* Barnard, the only difference being in the number of axial ribs. The penultimate whorl of *F. faurei* Barnard has 14–15 axial ribs, while the present shell has 12–14 ribs. The earlier whorls also have fewer ribs. The spiral sculpture is, however, almost identical and there can be no doubt that this shell is a form of *F. faurei* Barnard.

Family **Nassidae**

Nassa litorafontis n.sp.

Pl. 18

Location 3. 45–50 m Transgression complex.
Early transgression beach.

Description

Protoconch $1-1\frac{1}{2}$ whorls, $4\frac{1}{2}-5$ post-natal whorls, first four post-natal whorls with strong axial sculpture, about 20–24 axial ribs on 1st whorl, crossed by 4 spiral lirae. 2nd whorl with 25–30 axial ribs, 4 main lirae, very fine intermediate lirae starting between major ones. 30–35 ribs on 3rd whorl, 6–7 lirae. 4th whorl with about 28 axial ribs, becoming broader and rounder and less distinct, finally obsolete on body whorl. Latter with about 25–27 lirae on outer lip, upper ones broad, lower ones narrow. Axial ribs in general stronger on the lower part of the whorls than on the upper. Aperture slightly shorter than spire. Inner margin of outer lips smooth except near junction with columella, where a single nodule is followed by a very low, smooth ridge. Columella smooth; just below junction with body whorl, an acute raised ridge, just opposite the nodule of the outer lip. Anterior end of columella carinate. Outer lip excavate at anterior junction of columella.

Named from location – coastal farm Strandfontein – 'Strandfontein', Afrikaans – 'beach fountain'.

Material

Holotype: S.A.M. K1441 L. 28·0 mm B. 12·5 mm
Paratype: S.A.M. K1442   22·0 mm   10·0 mm

Remarks

In general shape, the present species most closely resembles one of the South African representatives of the genus *N. bicallosa* Smith, recorded from the Natal coast, although the figure given with the original description (Smith, 1876) is of a more squat shell. The sculpture of axial whorls is similar but *N. bicallosa* has fewer ribs (13–17, as opposed to up to 35 in *N. litorafontis*). In *N. bicallosa* there is both an external parietal callus and an internal callus, while the columella is denticulate, and the outer lip plicate. *N. litorafontis* has a single callus, a smooth columella, and no plications on the outer lip. In the latter species, the single ridge near the fusion of the outer lip and the columella is more developed than in *N. bicallosa*.

Latiaxis sp.

Pl. 19

Location 2. 45–50 m Transgression complex.
Fore-beach environment.

Description

Shell broken, very eroded, 4 whorls extant. Aperture longer than existing spire. Profile of whorls with prominent angular shoulder. Sutures undulate. Very faint indications of axial ribs on earlier whorls. Strong parietal callus, narrow umbilicus. Rostrum present, but very worn.

Material

S.A.M. K1447 L. 62·5 mm B. 37 mm (outer lip missing)

Remarks

This specimen agrees with Thiele's (1929) definition of the genus. Specific status, however, cannot be accorded this shell, due to its very incomplete state. In general shape it resembles *Latiaxis tortilis* H. & A. Adams, which has been recorded once in the South African region, from west of Cape Point. None of the characteristic axial and spiral sculpture of this species is discernible in the present shell. The undulations of the sutures may seem to indicate that there were fairly strong axial ribs present. The genus appears to be characteristic of the Indo-Pacific region. Barnard (1959) remarked on the unusualness of the occurrence of *L. tortilis* from the west coast of the Cape Peninsula. This record from the Namaqualand coast would serve as yet another indication of the presence of a warm-water fauna on this coast during the period under discussion.

Family **Muricidae**

Tritonalia bonaccorsii n.sp.

Pl. 19

Location 1. 45–50 m Transgression complex.
Back-beach environment.

Description

Spire slightly longer than aperture. Protoconch of 2–2½ whorls, 4–4½ post-natal whorls. First 3 whorls bicarinate, the 2 carinae formed by 2 strong spiral lirae. 4–5 fine lirae between upper carina and suture. 3rd whorl with 3 fine lirae between the 2 major lirae, 2 fine lirae between lower carina and suture. Cancellate sculpture on first three whorls formed by axial ribs crossing lirae. 1st whorl with 10–12 axial ribs, 11–12 on 2nd and 3rd whorls. Lower carina on last whorl not stronger than rest of lirae, body whorl therefore unicarinate. Body whorl with 9 lirae above the carina, 16–19 below. Outer lip with about 8 plicae on inner margin. Short open anterior canal, strong parietal callus, very slight umbilicus, slight rostrum with 3 worn squamae.

Named after donor, Dr. G. Bonaccorsi.

Material

Holotype: S.A.M.   K1436   L. 34·2 mm   B. 17 mm

Remarks

The strong spiral sculpture, which forms a cancellate decoration with the axial ribs, is characteristic of several genera of the Muricidae. The tall spire, egg-shaped aperture, very convex body whorl, and short anterior canal bent to the left would seem to indicate the genus *Tritonalia*. The present shell lacks the strong axial sculpture of *T. decussata* Gmelin or *T. fasciata* Sowerby of west Africa and *T. kieneri* (Reeve) and *T. scrobiculata* (Dunker) of the South African region. Similarly, *T. bonaccorsii* lacks the axial sculpture of *T. purpuroides* (Reeve), known from the Pleistocene deposits of Saldanha Bay. The early whorls of this latter species, however, resemble the earlier whorls of the present shell in possessing a cancellate sculpture, and two strong spiral lirae per whorl. *T. sperata* (Cossman) of the east coast has a much longer anterior canal; this, and a nodulose axial sculpture, separates it from the present shell. The latter most closely resembles *T. puncturata* (Sowerby), recorded from the east coast as well as from the west coast of the Cape Peninsula. This latter species occasionally shows a tendency towards carination, particularly in the earlier whorls, where the sculpture is cancellate. The aperture of *T. puncturata* is usually more elongate, while the penultimate and body whorl never have so strong a carina as in *T. bonaccorsii*.

There is a superficial similarity between the present shell and *Cancellaria lyrata* (Brocchi), but the former lacks the columella pleats and prominent spined axial ribs of the latter species. There is also a slight, superficial similarity between *Latiaxis rosaceus* Smith and the present shell but the former is more squat, and has blunt, nodulose axial ribs. From the above, it is obvious that some doubt exists as to the generic status of this shell. Without more material being available, greater certainty is not possible.

NAMAMUREX n.gen

Description

Shell of 4 or 5 whorls. Varices 3 per whorl, connecting with those of previous whorls. No sculpture between varices. Outer lip with 8 submarginal nodules, one prominent erect tooth near base of nodules. Aperture longer than spire. Anterior canal open, slightly shorter than rest of aperture.

Generic name in part a contraction of the general location — Namaqualand.

Discussion

The presence of strong varices, a well-marked anterior canal, a toothed outer lip, and a prominent tooth on the lower outer lip, make it seem certain that this shell is a member of the family Muricidae.

The presence of a spine on the outer lip is characteristic of several genera

of the Muricidae, viz. *Acanthina, Ceratostoma, Pterorytis, Jaton.*

The genus *Acanthina* is known living from the west coast of North and South America, especially from the Californian coast. Apart from the presence of the spine on the outer lip, the present shells bear little resemblance to any of the forms of *Acanthina,* all of which are rather *Thais*-like.

The genus *Ceratostoma,* as defined by Vokes (1964), includes the species *C. nuttalli* (Conrad) from the Californian coast, which the present shells most closely resemble. *C. nuttalli* has three well-developed almost foliose varices per whorl, and in addition, single elongate axial nodules between the varices. The absence of these nodules in the present shells, as well as the absence of the prominent spiral ridges, excludes these shells from the genus *Ceratostoma.* The latter genus invariably has a closed anterior canal, quite different from *Namamurex.* The genus *Ceratostoma* is a Pacific form, being found on the west coast of North America, and in the Japanese region (Hall, 1959).

The genera *Jaton* and *Pterorytis,* both of which have a denticulate outer lip, are typical Atlantic forms. The former, having 3 or 4 wide transverse plications separated by deep, slightly striated grooves, contains the single species, *J. decussata* (Linnaeus) from west Africa (*vide* Vokes, 1964: 21). *Pterorytis,* defined as being fusiform, with 6 prominent recurved foliated ribs, and having a closed anterior canal, is known only from the Miocene and Pliocene of the Atlantic coastal plain of the United States. The present shells are thus eliminated from both these genera, and as they conform with none of the recognized general of the Muricidae, it is necessary to erect a new genus, as defined above.

Namamurex odontostoma n.sp.

Pls 20–21

Location 2. 45–50 Transgression complex.
              Fore-beach environment.

Description

Shell of 4 or 5 whorls, protoconch eroded. 3 prominent varices per whorl, continuous with those of previous whorls. Outer lip, at formation of varix, having 8 slightly raised nodules on inner margin. Near base of latter nodules, a prominent erect spine. Latter spine also visible on two earlier varices, slightly embedded in following portion. A shallow groove, becoming almost a line, running from tooth along following portion of whorl. Profile of earlier whorls with slight shoulder, later whorls becoming smoothly rounded. No sculpture other than faint growth lines.

Material

Holotype: S.A.M.   K1437   L. 55·0 mm   B. 30·0 mm
                                 Aperture   L. 36·4 mm

Other specimens: L. 54·0 mm   B. 36·0 mm

                              64·5 mm   40·5 mm

                              51·0 mm   35·5 mm

                              39·0 mm   25·0 mm

(Latter two specimens with 4 varices per whorl on earlier whorls, varices not meeting, shoulder between varices almost joining to form a ridge.)

S.A.M.   9925   L. 68·0 mm B. 43·0 mm

(Collected by Haughton, very eroded, 3 varices per whorl.)

Family **Eratoidae**

Subfamily *Eratoinae*

Hespererato oppenheimeri n.sp.
Pl. 19

Location 3. 45–50 m Transgression complex.
      Early transgression beach.

Description

Shell small, sub-conical, inflated posteriorly, attenuated anteriorly. Posterior extremity of outer lip angular and projecting.

Spire small, eroded in the present specimens, but quite definitely pro jecting above the terminal whorl; apparently non-granulate.

Surface smooth, possibly glossy in life; non-sulcate.

Outer lip sharply incurved, attaining its greatest thickness in the central region; externally thickened at margin. Incurved marginal area bearing a series (*circa* 10) of equal, regularly spaced, plicate ridges, giving a denticulate aspect to outer lip.

Posterior canal very poorly defined, virtually obsolete; ill-defined oblique ridge marking the left border.

Aperture slightly curved, rather narrow posteriorly, becoming considerably wider anteriorly before being constricted by the terminal flexure of the columella lip.

Anterior edge of columella lip obliquely truncated, bounded by two closely spaced terminal ridges.

A series (*circa* 8) of elongate subequal plicae, regularly spaced, traverses the columella lip of the labrum. Plicae approximately at right angles to the axial plane of the shell, their alignment markedly dissimilar to the oblique trend of the terminal ridges, tending to be discontinuous along the central portions, forming two parallel rows of elongate columella and labral denticles. Between the most anterior of these denticles and the terminal ridges, a distance

of approximately one fifth the length of the inner lip, the columella is smooth and non-denticulate. The series of plicae persists to the posterior end of the columella lip, being there less strongly developed, the columellar denticles becoming subordinate to those on the labrum.

Extreme anterior area of shell squarely terminated, no obvious concavity, fossula obsolete.

Named after the late Sir Ernest Oppenheimer, past Chairman of Anglo American Corp. S.A.

Material

Holotype:	S.A.M.	K1428	L.	12 mm	B.	8 mm
Paratype:	S.A.M.	K1429		13 mm		9 mm
Other specimen:				10 mm		7 mm

Remarks

The general shape of the shell, the numerous transverse denticles arming the columella and labrum, the character of the aperture, which is not axial, and the form of the spire, which projects above the terminal whorl, suggest that the present species should most properly be assigned to the sub-family Eratoinae (Eratoidae) rather than to the genus *Persicula* (Marginellidae), or to the sub-family Triviinae (Eratoidae).

In his monograph on the Eratoinae, Schilder (1933) recognizes four genera and three sub-genera. Regarding the generic position of the present species within the sub-family, the following characters of this species appear to be of diagnostic importance:

  (i) dorsum smooth;
 (ii) fossula almost obsolete;
(iii) two terminal ridges on columella lip;
 (iv) columellar denticles transverse, quite definitely not parallel with terminal ridges;
  (v) anterior columellar denticles develop some distance away from the terminal ridges.

Characters (i)–(iv) suggest that the present species best fits into the genus *Hespererato* Schilder.

It is notable that the hiatus between the terminal ridges and the columellar denticles (v) seen in the present species is a character held in common by a number of species within the genus *Hesperato* and one which is not apparent in any of the three other genera in this sub-family. Similarly, a sinuous columellar outline and an outer lip bearing fewer but larger denticles are features borne by several species within this genus.

Of the 99 fossil and living species listed by Schilder, none is exactly similar to the present form. The strongest resemblance is to *H. vitellina* (Hinds), a Californian form, and the type species of the genus. Representatives of this genus are known from Miocene to Recent and range from the west coast of the Americas to France and Italy.
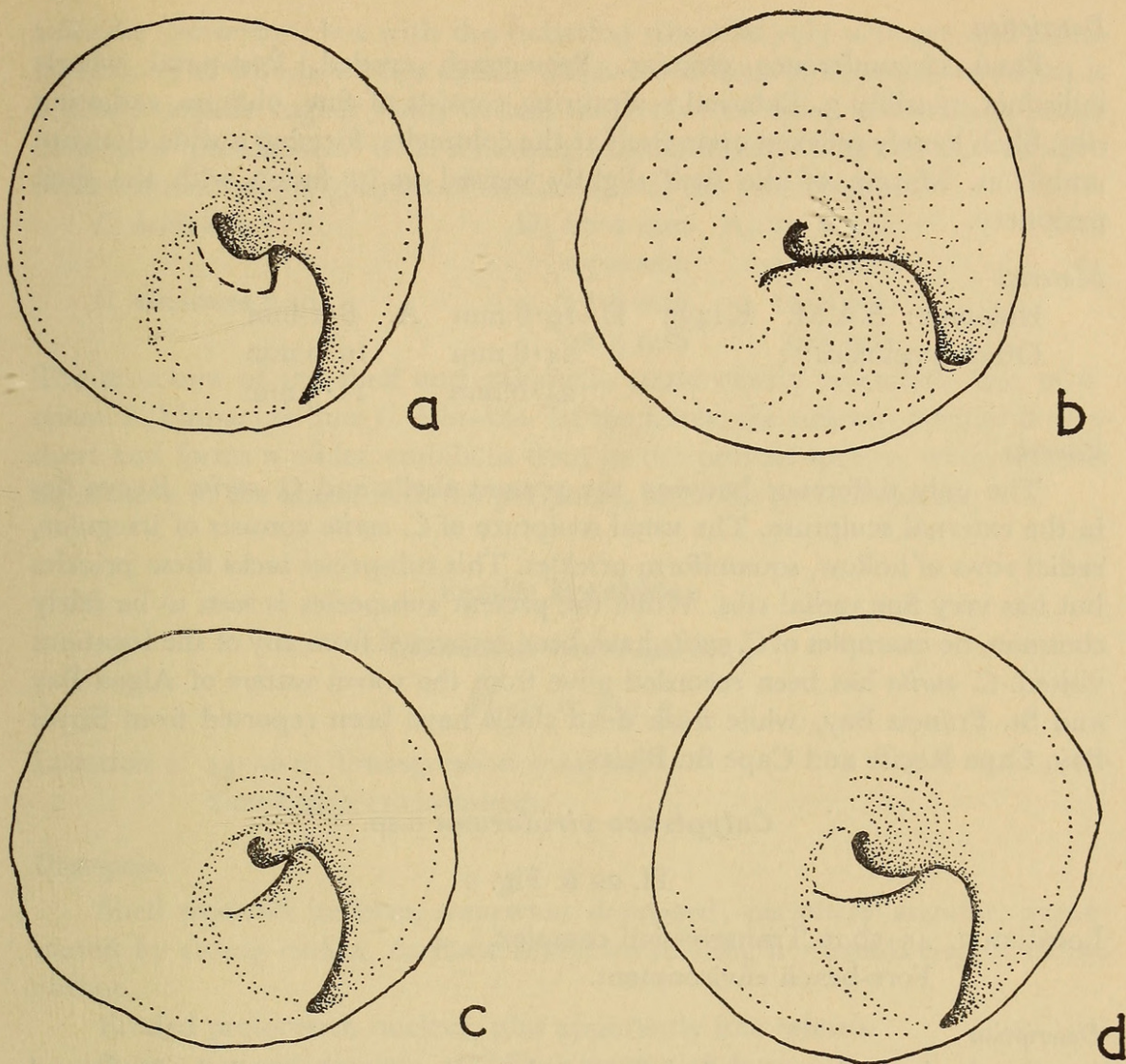
Fig. 2. Ventral views: a. *Calyptraea viridarena* n.sp. Holotype. b. *C. helicoidea* (Sowerby). c. *C. aurita striata* n.subsp. Holotype. d. *C. aurita* Reeve.

It is of interest to note that the local contemporary form *Proterato* (*P.*) *sulcifera* (Sowerby) is a member of the sub-genus *Proterato* Schilder, found only in the Indo-Pacific and Australasian areas. The presence of apparently generically different forms in Lower Pleistocene and Recent seas around the South African coasts and the surprising distribution of the genus *Hespererato* (west coast of America, Antilles, and Europe) may perhaps suggest that the phylogenetic aspects of one, at least, of these generic divisions are not of profound significance.

Family **Calyptraeidae**
Calyptraea aurita striata n.subsp.
Pl. 22 & Fig. 2

Location 2. 45–50 m Transgression complex.
        Fore-beach environment.

Description

    Basal circumference circular. Protoconch eroded. Post-natal whorls indistinct, possibly 3. External sculpturing consists of fine, oblique, radiating ribs. Shelf loosely reflexed upon itself at the columella, forming a wide elongate umbilicus. Margin of the shelf slightly incised at its fusion with the shell periphery.

Material

Holotype: S.A.M.	K1433	D. 19·6 mm	A.	8·1 mm
Other specimens:		24·8 mm		10·0 mm
		24·0 mm		11·5 mm

Remarks

    The only difference between the present shells and *C. aurita* Reeve lies in the external sculpture. The usual sculpture of *C. aurita* consists of irregular, radial rows of hollow, squamiform prickles. This subspecies lacks these prickles but has very fine radial ribs. While the present subspecies is seen to be fairly common, no examples of *C. aurita* have been recovered from any of the locations visited. *C. aurita* has been recorded alive from the warm waters of Algoa Bay and St. Francis Bay, while fresh dead shells have been reported from Struis Bay, Cape Recife and Cape St. Blaize.

Calyptraea viridarena n.sp.

Pl. 22 & Fig. 2

Location 2. 45–50 m Transgression complex.
                Fore-beach environment.

Description

    Basal circumference of shell circular. Protoconch eroded. Post-natal whorls 3–4. External sculpture consisting of strong oblique radiating ribs, close together. Internal shelf reflexed on itself at junction with columella, forming a slit-like umbilicus. Reflexed portion about 0·3–0·4 of length of shelf at its widest. Outline of shelf curved. Shelf somewhat incised at peripheral junction.
    Name descriptive of the colour characteristic of the enveloping sands.

Material

Holotype: S.A.M.	K1432	D. 27·8 mm	A.	10·1 mm
Other specimens:		27·5 mm		12·0 mm
		29·9 mm		13·0 mm
		22·5 mm		9·5 mm
		20·0 mm		7·0 mm

Remarks

    The present species differs significantly from living southern African representatives of the genus. The sculpturing is very similar to that of *C.*

helicoidea (Sowerby), but with the radiating ribs relatively stronger and closer together. The whorls are less clearly demarcated than in *C. helicoidea*, which is a proportionally higher shell, with a more obvious spire and with a better developed protoconch. The following measurements indicate the relative differences in height of shells of similar size of the two species:

C. helicoidea	D.	27·0 mm	A.	14·0 mm
		23·0 mm		11·3 mm
C. viridarena n.sp.		27·5 mm		12·0 mm
		22·5 mm		9·4 mm

The structure of the shelf and columella more closely resembles that of *C. chinensis* (Linnaeus) than *C. helicoidea*. In the latter, the reflexed portion is very short and forms a wider umbilicus than in the present species, while there is no incision at the fusion with the periphery, as in the present species.

Family **Trochidae**

Clanculus murrayi n.sp.

Pl. 23 & Fig. 3

Location 2. 45–50 m Transgression complex.
         Fore-beach environment.

Description

Shell trochoid in form, somewhat depressed; periphery angular, accentuated by strong carina, carinate sculpture lending a turreted aspect to the outline.

Eroded protoconch nucleus, plus apparently four whorls.

Suture non-canaliculate, umbilicus open and deep.

A single carina on the early whorls, located slightly below the midline, accompanied on the penultimate and last whorls by a second carina, developing from the suprasutural lira on the penultimate whorl and forming the shell periphery on the last whorl. Carinae equal to sub-equal in strength; where subequal, the upper, non-peripheral member always the stronger. Carinae composed of closely spaced oval to sub-rectangular granules with long axes sub-parallel to the vertical axis of the shell; granules slightly inclined on earlier whorls. Granulate radial lirae apparently present on all whorls; granules sub-circular on earlier whorls becoming more elongate along the vertical axis and eventually oval to sub-rectangular on the final whorl. In the largest specimens, areas between lirae with raised threads. On the 2nd whorl, approximately 5 lirae and a single carina; on the 3rd, 5–6 lirae and 2 carinae; 4th whorl 4–5 supra-carinate lirae, 2 carinae separated by 2–3 lirae with approximately 7 lirae on base of shell.

Specimens show a tendency for the body whorl to drop away from the periphery of the preceding whorl.

Outer lip of aperture strongly plicate, bearing 10–15 dentiform plicae. A prominent, ridged denticle present at the anterior end of the inner lip, protruding into the aperture; a second, smaller denticle, also pointing into the aperture on the posterior portion of the inner lip. Two small denticles, often elevated on a narrow ridge running into the umbilicus, on the median portion of the inner lip, pointing away from the aperture. On the larger specimens, dentiform plicae present on the margin of the umbilicus.

Named after Dr. L. G. Murray, Consulting Geologist, Anglo American Corp. S.A.

Material

Holotype: S.A.M. K1434 D. 17·6 mm A. 11·8 mm
Paratype: S.A.M. K1435   17·0 mm   14·0 mm

Remarks

The trochoid form, open umbilicus and denticulate aperture suggest that this species should be assigned to the genus *Clanculus*, having strong affinities with the local species *C. miniatus* (Anton).

The present species differs from all the South African representatives of the genus in having a generally depressed form and a strongly turreted outline. The presence of strongly developed carinae distinguishes the present species from the non-carinate *C. atricatena* Tomlin and *C. puniceus* (Philippi), both of which exhibit a more complex and pronounced plication of the aperture lips. The non-canaliculate suture, amongst other features, serves to distinguish the present species from *C. waltonae* Sowerby, and *C. mixtus* Smith. In *C. miniatus*, carinate forms are common. However, such forms carry only a single carina
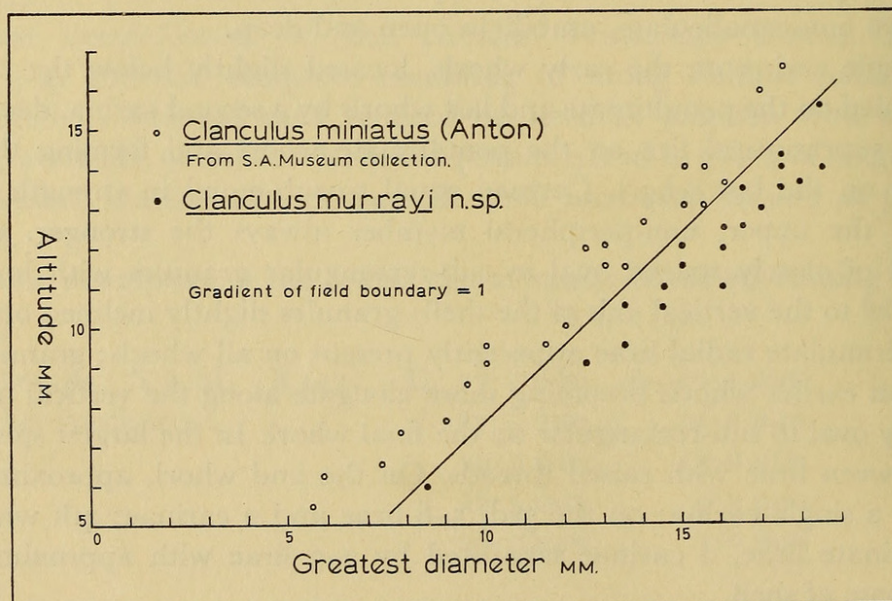

Fig. 3. Comparison of altitude/diameter ratios in *Clanculus miniatus* (Anton) and *C. murrayi* n.sp.

on the last whorl, at the shell periphery. In some of the specimens of *C. miniatus* examined, the mid-whorl granules on the last whorl are more strongly developed than their neighbours but are never sufficiently prominent to produce a bicarinate aspect. It is notable that in the present species, where the carinae are subequal, the mid-whorl member is always the stronger.

The depressed form of the present species in comparison with *C. miniatus* is illustrated by figure 3 and is possibly linked to the fewer whorls borne by this new species.

C. villanus Phillipi, reported from Angola by Paes-da Franca (1960), is another elevated member of the genus having a denticulate aperture but lacking the single, large, prominent tooth on the anterior area of the columella lip.

The new form shows little affinity with the west African representatives of the genus (*C. kraussi* Philippi, and *C. guineensis* Gmelin) noted by Nicklès (1950), both of which lack a prominent denticle on the inner lip and a strong peripheral carina.

Calliostoma depressa n.sp.

Pl. 23

Location 2. 45–50 m Transgression complex.
              Fore-beach environment.

Description

Shell a wide cone, apical angle greater than 90°, profile straight. Protoconch smooth, 2 whorls, $4\frac{1}{2}$–5 post-natal whorls. Profile of body whorl smoothly rounded. Sculpture consisting of very fine growth lines and spiral lirae. Latter formed by single strand of knobs connected by a low ridge. Body whorl with 19 lirae (counted at aperture). Penultimate whorl and preceding whorl with 7 lirae, first two postnatal whorls with 4–5 lirae, latter all of equal strength. Each lira separated from the next by a definite regular space. Each knob distinct, not touching the following or preceding one. Umbilicus closed, columella smooth.

Material

    Holotype: S.A.M. K1440   D. 21 mm   A. 15 mm
    Paratype: S.A.M. K1453   37 mm   30 mm

Remarks

Compared with the known living forms of this genus from southern Africa, this species is a much flatter shell with fewer whorls, most of the other species having 6–8 post-natal whorls. The sculpture, spiral lirae with knobs, is typical of the genus. The present species, in general shape, most resembles *Calliostoma eucosmia* Bartsch, particularly the 'low' form mentioned by Barnard (1963). The latter, however, is a more elevated shell, with the lirae much closer together and usually having strong lirae alternating with weaker ones,

the knobs crowded on each other. *C. eucosmia* usually has a definite shoulder to the last whorl, although some forms approach the present species in having an almost smoothly rounded body whorl. The latter type of body whorl is characteristic of *C. multiliratum* (Sowerby), but the sculpture of this species is distinctive and very different from *C. depressa*. In the latter only a suggestion of a shoulder is present where the outer lip joins the preceding whorl. *C. africanum* Bartsch has sculpturing similar to the present shell, but with the knobs closer together. In the older shells of *C. africanum* the knobs tend to coalesce to form a solid raised lira. In *C. depressa*, the knobs remain distinct. There is little similarity between this shell and any of the west African, Angolan, or Moçambique species. Apart from *C. perfragile* Sowerby, which has been taken alive from the west coast of the Cape Peninsula, the genus is not known from the west coast of South or South West Africa. Further north the genus is again encountered in warm Angolan waters, where it is represented by *C. granulatum*.

Family **Fissurellidae**

Fissurella glarea n.sp.

Pl. 24

Location 3. 29–34 m Beach.

Description

Margin of shell egg-shaped, anterior end narrower than posterior. Lateral margins ventrally convex. Foramen elongate oval, lateral margins slightly concave, situated anterior to midline. Sculpture only of concentric irregular growth lines. No sign of radial sculpture. Dark radiating bands (*circa* 23–26) imposed on lighter background, stretching from foramen to margin.

Name descriptive of the gravelly nature of the enveloping sediment.

Material

Holotype:	S.A.M.	K1438	L. 39·0 mm	B. 27·5 mm
Paratype:	S.A.M.	K1439	76·0 mm	59·5 mm

Remarks

The following are the species of *Fissurella* which have been recorded from the South African region:
F. robusta Sowerby, known only as a fossil from the Pleistocene deposits of the west coast and Algoa Bay.
F. mutabilis Sowerby, known living from the west coast, False Bay, east coast, Madagascar, etc. Fossil from Pleistocene of Algoa Bay and Little Brak River.
F. natalensis Krauss, known living from the east coast, fossil from the Pleistocene of Algoa Bay.

The present species most closely resembles *F. robusta*, of which several undamaged specimens are available. This resemblance is most apparent in the

young stages, older shell being obviously different. The marginal outline is very similar, the foramen is in the anterior portion of the shell in both species, and the sculpturing is similar. There are, however, several differences. The foramen in *F. robusta* has slightly convex sides, whereas in the present species, the sides are slightly concave (this portion of the shell is particularly subject to erosion, resulting in a variety of shapes, the true form being apparent only in unworn specimens). The profile of *F. robusta*, from posterior margin to foramen, is never straight. In younger specimens it is slightly convex, while in older specimens, the shells are distinctly arched, almost 'humped'. The posterior profile of the present species is never curved. *F. robusta* is a proportionally higher and heavier shell than the present species, which seems, if anything, to become flatter with age. Young specimens of *F. robusta* occasionally show faint radial lines. These are not apparent in the present species. The dark radial bands of the outer layers of the shell of the present species are not apparent in *F. robusta*, except in one specimen, which has a slightly curved posterior profile.

F. glarea differs from *F. mutabilis* Sowerby, which has radial costae, and no convexity of the margins, i.e. the entire margin touches a flat substrate. The shape of the foramen also differs. *F. mutabilis* does not have the dark radial bands of the present species.

F. natalensis is a rugose shell with almost nodulose radial costae, and with fine concentric lines, subordinate to the radial sculpture; all very different from *F. glarea*. Further differences include the overall shape of the shell (*F. natalensis* rests on the anterior and posterior ends of the shell), and the shape of the foramen.

F. dubia Reeve, from Moçambique, also has radial costae and the foramen is placed more or less centrally.

F. tanneri Verril, from Angola, has fine radial lines and an almost circular foramen. Both *F. coarctata* King and *F. nubecula* Linnaeus of west Africa have strong radial sculpture.

Family **Arcidae**

Arca avellana Lamarck, 1819

Pl. 25

Arca avellana Lamarck, Barnard, 1961: 192; 1964: 369. Boshoff, 1965: 109.
Arca acuminata Krauss, 1848: 14.
Navicula kraussii (Philippi), Cox, 1930: 154.

Location 3. 46–50 m Transgression complex
            Early transgression beach.

Description

Cardinal area flat, triangular, the angle at the umbo 90°, marked with divergent ligament grooves. Umbo eroded in all except youngest valve.

Material

    L. 44·00 mm (broken valve)
        29·6 mm
        28·2 mm
        28·0 mm
        20·0 mm
        19·6 mm

Previous records

    Living: Inhaca Island, Inhambane, Bazaruta, Durban.
    Fossil: Pleistocene: Redhouse, Zwartkops River.
              Post Pliocene: Inhambane.
              Pliocene: Zwartkops.

Remarks

    Cox (1930) described an abnormal right valve of *Navicula krausii* (Philippi) from the Pliocene deposits of Zwartkops, near Port Elizabeth. The present valves (with the exception of the smallest) all agree with Cox's description, in hinge details, sculpture, and general shape. The smallest valve is a typical *Arca avellana* without any distortion. All the complete valves show, to some degree, the septum-like platform in the anterior corner, as was noted in Cox's specimen. The ventral marginal area is narrow and concave, forming a large byssal gape. Boshoff (1965) notes that as this species frequents crevices, the valves are often distorted.

    This species, in its present geographic distribution, is restricted to the warm waters of the Indian Ocean.

Arca (Acar) halmyrus n.sp.

Pl. 24

Location 3. 46–50 m Transgression complex.
             Early transgression beach.

Description

    Shell longer than high, umbo anterior to middle of shell. Fairly prominent posterior ridge present. Well-developed concentric and radial sculpture. Nearer the umbo, radial ribs more prominent than concentric lines. Anterior 7 or 8 ribs strong, increasing in thickness ventrally. Posterior 6 or 7 radial ribs similarly prominent, the largest forming the posterior ridge. Where concentric ridges cross anterior and posterior ribs, distinct knobs formed. Radial ribs of mid-region fine, an almost cancellate sculpture formed with the concentric growth lines. Intermediate radial ribs developing as growth proceeds. Cardinal area very narrow, 5 narrow, oblique grooves in posterior region, ending just posterior to umbo. Hinge slightly curved dorsally with 12 or 13 anterior teeth,

the most anterior 4 or 5 being oblique. Median teeth reduced and almost absent in some. 10 or 11 posterior teeth, almost all oblique. Inner surface of valves with fine radiating lines. Inner margin of shell crenulate.

Named from the location — 'Brak', Afrikaans — 'brack' river.

Material

Holotype: S.A.M. K1448 L. 26 mm A. 15 mm
Other specimens: 23 mm   11 mm
                                21 mm   12 mm
                                16 mm   8 mm

Remarks

These shells are placed in the subgenus *Acar* as defined by Thiele (1929), as there is a posterior ridge present, the sculpture being knobbed, the umbo anterior to the midline of the shell, the dorsal plane small, the median hinge teeth weak/rudimentary and the outer teeth oblique. The present species differs from *Arca (Acar) plicata* Dillwyn, which it most strongly resembles, in the following respects: the present shell is flatter than *A. (A.) plicata* and has well-developed anterior and posterior radiating, nodulose ribs which *A. (A.) plicata* lacks. In the region of the posterior ridge, *A. (A.) plicata* usually has prominent squamae instead of the nodules of the present species. In the hinge area, the dorsal plane of *A. (A.) plicata*, which is wider than in the present species, has 10 or more oblique/elongate grooves, the more medial ones extending the entire length of the hinge area; *A. (A.) halmyrus* however, has only about 5 oblique grooves, none extending beyond the umbo. The angle of the posterior ribs radiating from the umbo differs considerably in these species.

Family **Condylocardiidae**

Carditella calipsamma n.sp.

Fig. 4

Location 1. 45–50 m Transgression complex.
           Back-beach environment.
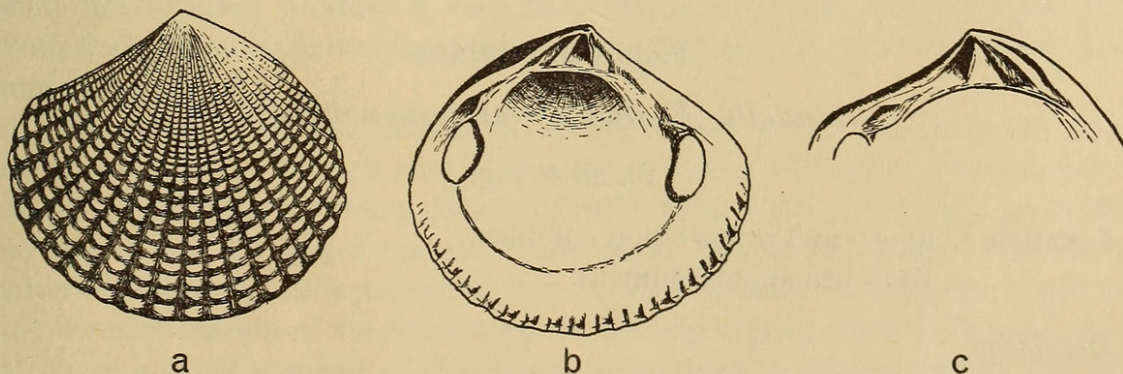
Fig. 4. *Carditella calipsamma* n.sp. Holotype. a. Right valve in external view. b. Right valve in internal view. c. Hinge of left valve.

Description

Valves equilateral, prodissoconch eroded. 23–27 radial ribs with low nodules. Latter oval near apex, becoming transversely rectangular nearer margin. Grooves between ribs becoming wider and shallower towards margin. Very fine concentric growth lines present, more apparent in grooves on younger portion. 4–5 growth lines per nodule. Ventral inner margin of shell crenulate, mantle line uninterrupted. Left valve with two cardinal teeth, anterior tooth a low ridge, posterior tooth prominently triangular. Right valve with 2 cardinal teeth, separated by a deep triangular pit. Low ridge present in front of anterior tooth. Each valve with a single anterior and posterior lateral tooth.

Name descriptive of the local lithology.

Material

Holotype:	S.A.M.	K1449	L. 11·9 mm	A.	12·3 mm
Paratype:	S.A.M.	K1450	9·2 mm		9·2 mm
Other specimens:			12·8 mm		12·8 mm
			12·5 mm		12·7 mm
			11·8 mm		12·2 mm

Remarks

The sculpture of this species resembles that of *Carditella similis* Jaeckel & Thiele, *Carditopsis dartevellei* Nicklès and to some extent *Cuna gambiensis* Nicklès. *C. gambiensis* differs from the present species in that the grooves separating the radial ribs are relatively narrower. The dorsal profile of *C. gambiensis* is more acute (90° as compared with *circa* 110°). The west African species also appears to lack lateral teeth (see Nicklès, 1955). The present species is more closely related to *Carditopsis dartevellei* Nicklès, 1952, recorded from the Quaternary deposits of Gabon, but this differs in possessing fewer rays (14–16) and in being a much smaller shell (2·5 × 2·6 mm being the largest). The adductor muscle scars of the present species are not as obviously reniform as those in *C. dartevellei*. *Carditella similis* differs from the present species in possessing fewer ribs (20–21), in the older nodules being more obviously rectangular and flattened and in being a smaller shell (3·5 × 7·3 mm being the largest).

Family **Mactridae**

Standella (*Eastonia*) *namaquensis* n.sp.

Pl. 26 & Fig. 5

Location 1. 45–50 m Transgression complex.
            Back beach environment.

Description

Ovate, inequilateral, equivalve, transversely elongate. Umbones small, slightly incurved, located anterior to mid-line of shell. Anterior end rounded,
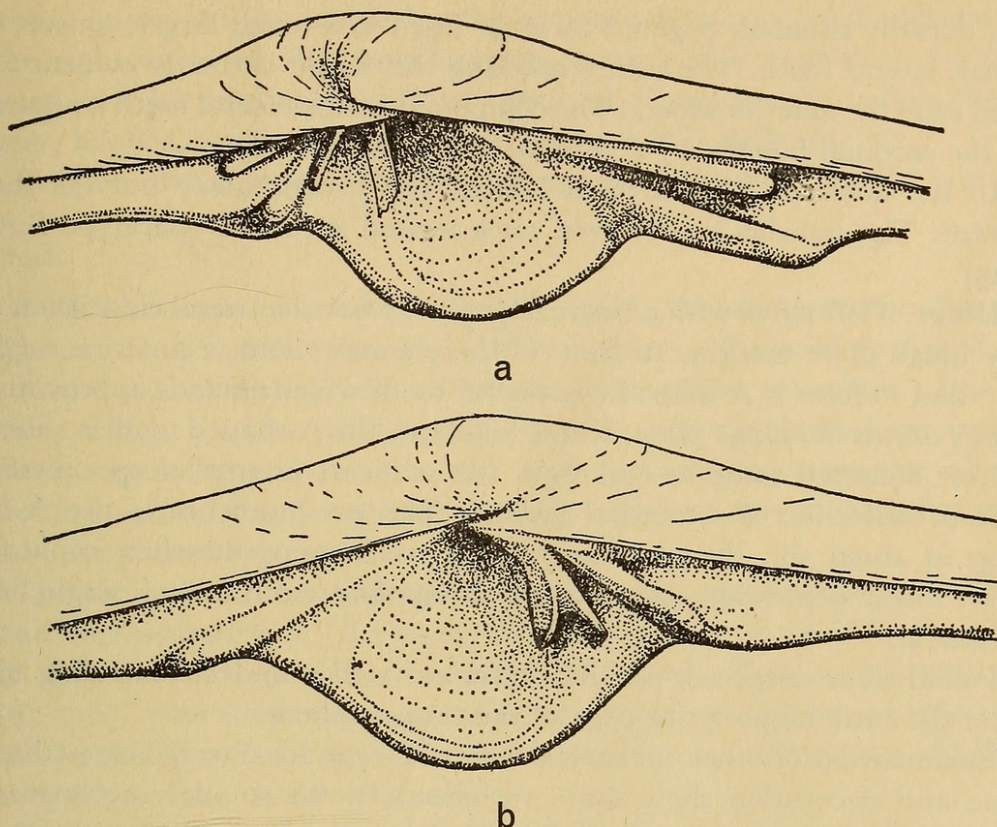
Fig. 5. *Standella (Eastonia) namaquensis* n.sp. Hinge details: a. Right valve. b. Left valve.

posterior end subtruncate. Dorsal outline, posterior to umbones, very slightly concave. Valve interior moderately concave; posteriorly the concavity diminishes, the posterior termini becoming flattened, with a narrow gape. A weak dorsal ridge runs from the umbo to the posterior end of the shell, fairly close to the postero-dorsal angle. Lunule poorly defined. Outline non-crenulate.

Sculpture of concentric growth lines, raised and sub-lamelliform on the ventral periphery. Radial sculpture of numerous, very fine, plicate ribs, irregularly spaced, slightly sinuous, often showing random bifurcation and fusion, frequently discontinuous across growth ridges. The radial and concentric sculpture together produce a very fine, highly irregular, reticulate pattern. Posteriorly, the surface becomes slightly rugose, the growth lines correspondingly more sinuous.

Hinge plate robust, carrying a chondrophore projecting backwards but torted towards the median area of the ventral margin. Distal outline of chondrophore smoothly rounded. Hinge of right valve with 2 elongate, posterior lateral teeth; the larger ventral tooth erect, the dorsal tooth suberect. 3 anterior dental elements present; a thin cardinal lamella, running the length of the anterior margin of the chondrophore, leaning slightly towards the mid-line to cover a small segment of that hinge component, a narrow lateral aligned close to the dorsal margin of the hinge plate and a large, erect, apparently bilobed, cardio-lateral tooth. This last element appears to be compounded of a

small, dorsally situated, trigonal cardinal fused to a much larger, longer, sub-trigonal, lateral tooth. The suture marking this fusion is clearly evident when viewed from the anterior aspect. The compound cardio-lateral tooth is separated from the cardinal lamella by a narrow, triangular pit.

In the holotype, the cardinal lamella has broken away but the scar is apparent. The lamella is preserved on a second specimen (paratype S.A.M. K1425).

Hinge of left valve with a single, elongate, posterior lateral ridge extending to the hinge plate margin. In front of the chondrophore, 2 anterior cardinal teeth fused to form a Λ-shaped compound tooth which extends approximately half way across the hinge plate. In the holotype, the Λ-shaped tooth is suberect, the crest deflected some 20–30° from the vertical; in smaller specimens the degree of deflection is somewhat greater. The two branches of the Λ-tooth diverge at about 30°, the posterior branch overhanging the chondrophore. A narrow, linear depression separates this compound tooth from a single, large, erect lateral.

Pallial sinus deep, sub-parallel; terminus well rounded, extending to the level of the extreme posterior edge of the chondrophore.

Examination of other specimens from the type locality indicates that the outline and decoration show some variation. In the smaller specimens, the valves are less elongate and slightly donaciform. In some specimens the sculpture is apparently muted with concentric growth lines dominant. Examination of such forms indicates that the fine, radial elements of the reticulate sculpture have been preserved in depressions in the somewhat rugose surface of the extreme posterior areas of the valves. It is supposed that the destruction of these delicate plicate ribs is the result of abrasion encountered during transport of the valves along the beach. It is notable, in this context, that discrete, separated valves are more profoundly affected in this respect than the holotype, recovered with both valves together.

Named from the general location – Namaqualand.

Material

Holotype: S.A.M. K1424 L. 68 mm A. 43 mm W. 28 mm
(both valves)

Other specimens: 51 mm   34 mm
                                     43 mm   31 mm
Paratype (hinge fragment): K1425

Remarks

As regards dentition, the present species more closely resemble Lamy's figure (1918: 383) of *Eastonia rugosa* (Helbling) than it does his figure (p. 382) of *Standella pellucida* (Chemnitz). The two branches of the Λ-shaped compound cardinal tooth in the left valve as noted above, diverge at an acute angle, the posterior branch overhanging a segment of the chondrophore. Despite the

degree of fusion, it is suggested that the compound anterior cardio-lateral tooth in the right valve of the present species more nearly resembles the closely apposed anterior cardinal and lateral teeth of *E. rugosa* than it does the continuous, bilobed, anterior cardio-lateral element in *S. pellucida*.

For the above reasons the present species is assigned to the sub-genus

Eastonia.

S. (E.) namaquensis is unlike the only South African representative of the sub-genus, viz. *Standella (Eastonia) solanderi* (Gray). (Barnard (1964) suggests that *S. nicobarica* (Gmelin) falls outside the limits of the sub-genus.) In *S. (E.) solanderi*, which is a far smaller form bearing a strong radial ornament of relatively regular, continuous ribs, the Λ-shaped tooth occupies the full width of the hinge-plate; the divergence of the branches of this tooth being greater than in the present species.

The similarity in hinge detail between *S. (E.) namaquensis* and the west African representative *S. (E.) rugosa* has been noted above. The two species differ as regards decoration, the last named, according to Nicklès' figure (1950: 210), possessing a strong radial ornament of regular, closely spaced costae. In this figure, the terminus of the pallial sinus attains the level of the anterior edge of the chondrophore.

In Lamy's figure (p. 383) of *S. (E.) rugosa*, the anterior lateral tooth in the left valve appears oblique, not erect as in the present species.

S. (E.) rugosa is a Mediterranean species extending into the Atlantic ocean along the Portuguese and west African coasts. It is known from the Pliocene and Pleistocene of France.

Nicklès (1950: 210) suggests, by his terminology, that *S. senegalensis* Philippi is not to be included in the sub-genus. The outline and decoration of this shell is markedly different from the present species.

The Philippine forms *S. (Merope) plicatilis* (Deshayes) and *S. (Merope) capillacea* (Deshayes), according to Deshayes (1854: 69), have an irregular, reticulate sculpture of fine plicate ribs like that possessed by the present species. In *M. plicatilis* however, the pallial sinus is trigonal, terminating at an obtuse angle.

<div align="center">

Family **Donacidae**

Donax haughtoni n.sp.

Pls 27–28 & Figs 6–9

</div>

Location 2. 45–50 m Transgression complex.
          Fore-beach environment.

Description

Shell equivalve, inequilateral, greatest pre-umbonal length longer than greatest post-umbonal length. Shell anteriorly smooth, posterior ridge not very distinct, with fine concentric lines sometimes posteriorly present; rest of shell
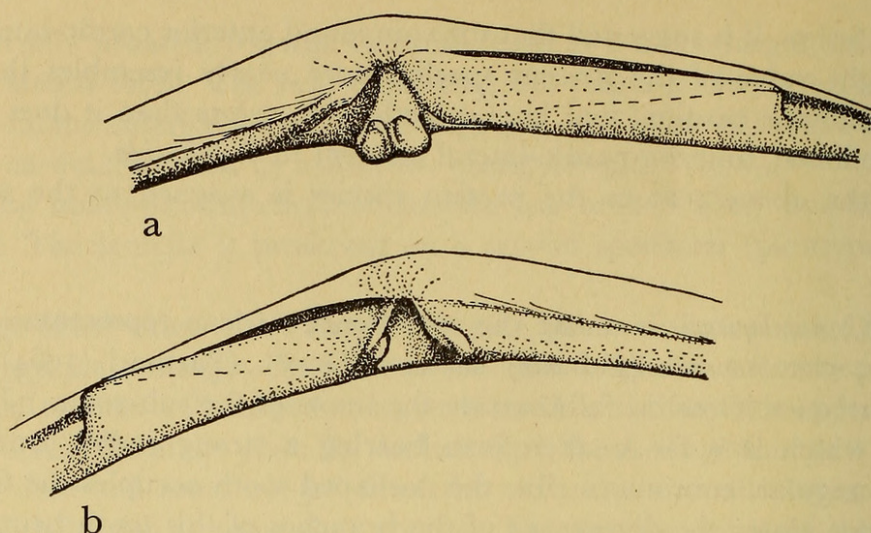
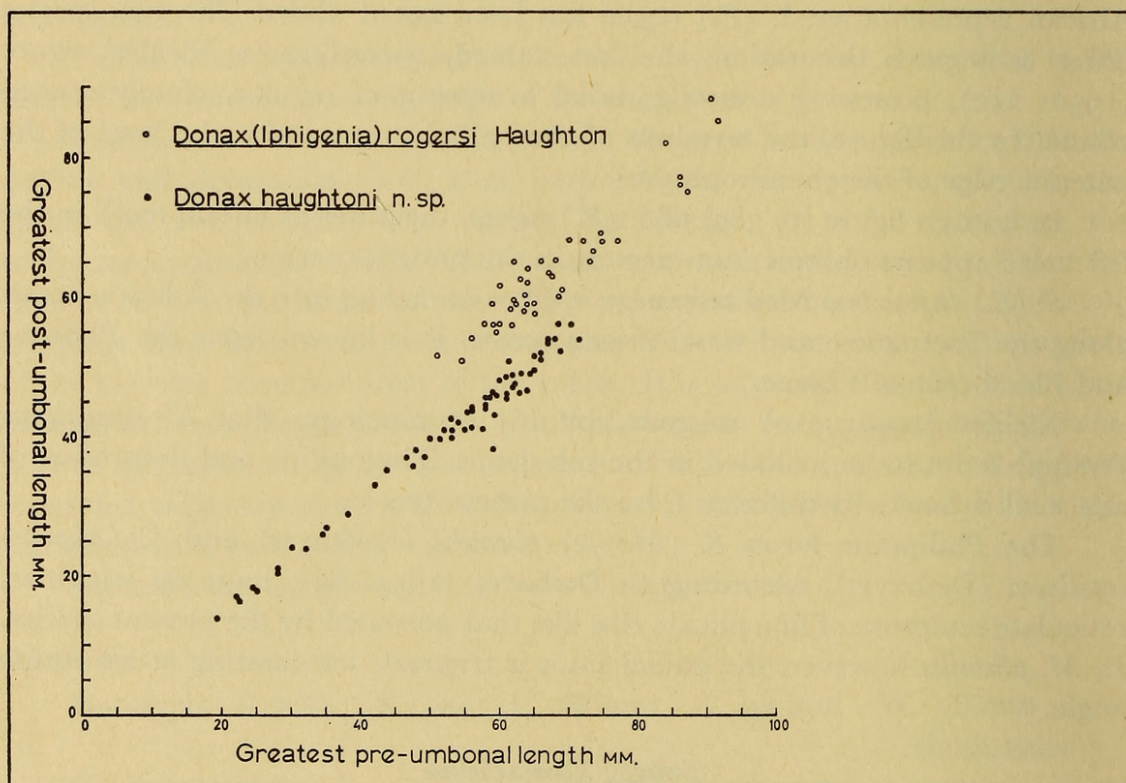Fig. 6. *Donax haughtoni* n.sp. Hinge details: a. Right valve. b. Left valve.

Fig. 7

surface smooth. Inner margin smooth. Antero-ventral margin smoothly rounded, postero-ventral margin with a slight corner in older valves. Hinge of left valve with 2 cardinal teeth with triangular pit between. Anterior tooth slightly broader than posterior. Hinge of right valve with a low anterior ridge and a prominent, broad cardinal tooth. Latter apically bifid. Rectangular flattened process, posterior to umbo in both valves, at least three times longer than wide.

Named after Dr. S. H. Haughton.
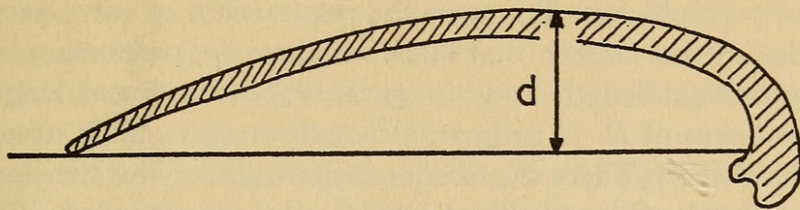
Fig. 8. *Donax haughtoni* n.sp. Diagrammatic cross-section of valve to illustrate distance d—greatest width, hinge excluded.

Material

Holotype: S.A.M. K1430   L. 97·0 mm   A. 61·0 mm
Paratype: S.A.M. K1431   70·5 mm   44·0 mm
(A complete range of valves from 20 mm to 97 mm in length, in the South African Museum.)

Remarks

This species most closely resembles *Donax (Iphigenia) rogersi* Haughton, from the coastal deposits of Doornbaai. Haughton's material in the South African Museum, however, includes both *D. (I.) rogersi* and *D. haughtoni.* Haughton (1931: 36), states that the smaller shells obtained from The Point, Van Rhynsdorp, have the umbo well in advance of the midline of the shell but that the umbo's position 'accords well with that in equivalent growth stages of the larger shells from Doornbaai and Alexander Bay, and these specimens fall therefore within the limits of the species'. With more material now available it would seem that this smaller and more elongate form mentioned by Haughton is the present species and not a young form of *D. (I.)*
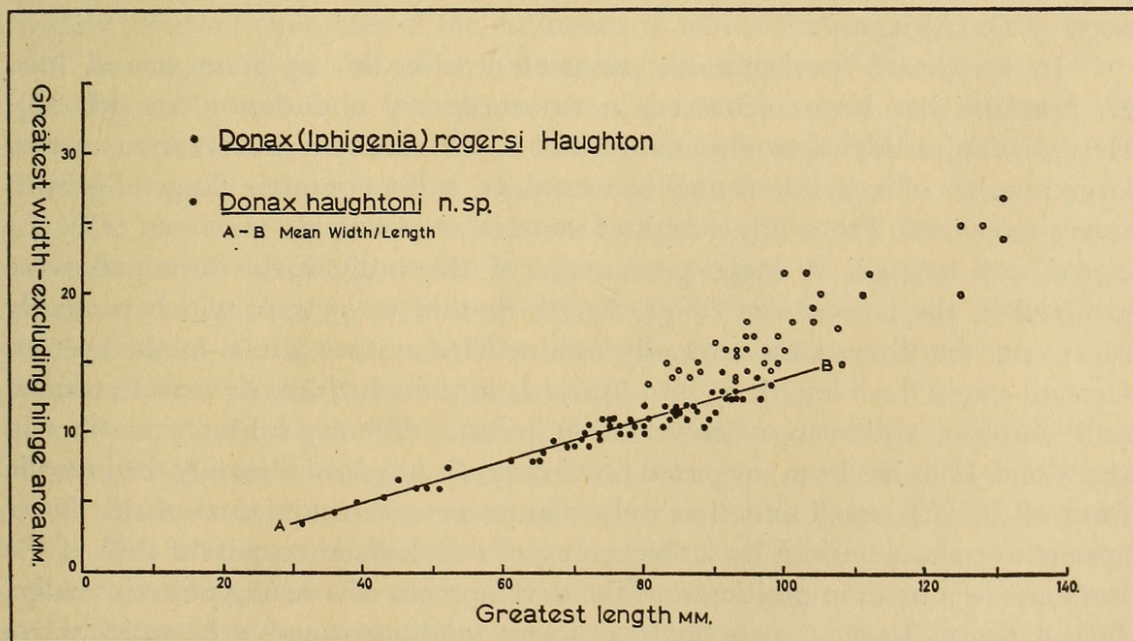
Fig. 9. Comparison of greatest length/greatest width (hinge excluded) ratios in *Donax (I.) rogersi* Haughton and *D. haughtoni* n.sp.

rogersi. Figure 7 graphically illustrates the relationship of valve proportions in the two species. It can be seen that in *D. haughtoni* the proportion between the greatest pre-umbonal length and the greatest post-umbonal length is fairly constant. Specimens of *D. (I.) rogersi*, although more variable, usually have a more equilateral shell. There is a distinct separation of the two species in the region of the graph where shells of similar size are recorded. The elongate anterior region of *D. haughtoni* is thus an almost constant feature of the species.

Other differences between the species include the strength of the posterior ridge, hinge details, and relative thickness of the shell.

In *D. (I.) rogersi* the posterior ridge is far more pronounced than in *D. haughtoni*. This results in a relatively wider shell. In an attempt to illustrate this graphically, total shell length was plotted against the width of the shell. This latter parameter, the distance 'd', was measured at right angles to a line connecting the ventral and dorsal margins but excluding the immediate hinge areas, as the teeth especially are subject to erosion. Figure 9 illustrates this relationship. This character would seem to be rather variable, especially in *D. rogersi*. Almost all the *D. (I.) rogersi* lie above a line representing the mean for *D. haughtoni*, thus showing that *D. rogersi* usually has a relatively wider shell.

Although Haughton in his description of *D. (I.) rogersi* stated that the central tooth of the right valve was not bifid, examination of less eroded material shows that this tooth is indeed bifid, but not as markedly so as in *D. haughtoni*.

The rectangular process just posterior to the cardinal teeth in *D. (I.) rogersi* is about twice as long as wide. All the specimens of *D. (I.) rogersi* are massive shells, much thicker than shells of comparable size of *D. haughtoni*. The stratigraphical distribution of the two forms is perhaps the most telling point in favour of according a specific identity to Haughton's '*young growth stages of D. (I.) rogersi*'.

In fore-beach environments associated with the 45–50 m strand line, *D. haughtoni* has been recovered in extraordinary abundance (see pl. 28). Here, owing to this super-abundance and to the excellent preservation, a very large number of individuals may be examined and a complete range of growth stages recovered. From this wealth of material, not a single specimen of *D. (I.) rogersi* was located. A large percentage of the individuals examined were grouped in the largest size range, length 80 mm to 95 mm, which probably represents the dimensions normally attained by mature adults of the species. Growth stages from length 20 mm upwards to the adult length were examined and found to exhibit no major variation in form, differing from one another in size alone. If, as has been suggested previously, *D. haughtoni* is merely the juvenile form of *D. (I.) rogersi* and that only mature or senescent forms of this latter species are characterised by a thickening of the shell, an apparent shift of the umbones to a median position and the development of a strong posterior ridge, then a few at least of such 'mature' forms might reasonably be expected to appear in the assemblage. None was apparent.

In the transgressive gravels and the coarse back-beach sediments of the

45–50 m strand, representatives of the genus were not commonly found, those located were usually fragmental. Of these, the few entire individuals and occasional shards collected could all be assigned to *D. haughtoni*. Fragments or entire valves of *D. (I.) rogersi* were not recorded.

At the localities investigated, the species *D. (I.) rogersi* is found associated with the extremely coarse, granular to pebbly, back-beach deposits relating to the 17–21 m sea stand. At this elevation numerically large concentrations of individuals of this species are met with (pl. 28), all such individuals being ascribed to the species *D. (I.) rogersi*; not a single individual of the proposed *D. haughtoni* was noted. The degree of preservation of the shells is rather poor, much of the material being chipped or badly broken and often of a fragile, powdery or flaky consistency. The fractured nature of the shells, from coarse breakage to fine comminution, may be attributed to the extremely rigorous environment which existed during the time of entombment and is testified to by the coarse grain size of the sediments. The powdery, fragile condition of the shells points to subsequent leaching of carbonate by solutions percolating through the very coarse, highly permeable, enveloping granular sediment.

It is suggested that this compounding of rigorous depositional environment and post-depositional leaching is, in large measure, responsible for the virtual absence of young growth stages of *D. (I.) rogersi* in the assemblages.

It seems apparent that there are stratigraphical as well as purely morphological differences between *D. (I.) rogersi* and the proposed *D. haughtoni* — the former flourishing at the time of the 17–21 m marine transgression, the latter being prevalent during an earlier encroachment by the sea on to the land.

It is possible that *D. haughtoni* eventually gave rise to *D. (I.) rogersi*, the change being conditioned by a profound shift in environment indicated by the widely different character of the sediments in which the two species are found.

As suggested in the opening remarks, the nature of the 45–50 m transgression sediments may indicate a slow accumulation of very fine grained material producing an environment favourable to sand dwelling bivalves and one allowing fairly thin-walled, elongate shells to flourish.

In the case of those sediments comprising the 17–21 m beach, the abundance of coarse, granular horizons up to 5 m above the basal gravel suggests that molluscs inhabiting the littoral during those times were obliged to withstand a rigorous, abrasive environment, characterized by a rapid accumulation of coarse sediment.

In this habitat, the thin-shelled form would be under stress and liable to breakage. Accordingly, by a process of selection, communities containing individuals tending towards a more robust and resistant form became dominant. The shell of the average individual became thicker, with a powerful hinge placed at the mid-dorsal point of the shell, producing a structure more suited to withstand vertical stresses in a plane at right angles to the surface of the shell. Similarly, stresses parallel with the short axis of the shell were countered by the development of the strong posterior ridge.

The placing of *D. rogersi* in the subgenus of *Iphigenia* must now be considered in the light of this new information. If *Donax* (*Donax*) *haughtoni* gave rise to the later *D.* (*I.*) *rogersi*, it would seem unlikely that the same subgenus (*Iphigenia*) would also occur in the Miocene deposits of Venezuela, where *D.* (*I.*) *olssoni* Hodson, 1931, was recorded. The subgenus *Iphigenia* is also represented by the living *D.* (*I.*) *rostrata* Römer, *D.* (*I.*) *laevigata* (Gmelin) and *D.* (*I.*) *truncata* (Monterosato) in west Africa.

In this particular case, it would seem that the division of the southern African members of the genus *Donax* is an artificial one and that *D. rogersi* probably does not fall into the subgenus *Iphigenia*.

Paes-da Franca (1960) records the discovery at Baia dos Tigres, Angola, of a single valve, 77 mm long, of *Donax serra* Chemnitz. The accompanying plate portrays a sub-donaciform shell having a smooth, non-crenulate ventral outline. The angle between the postero-dorsal and antero-dorsal margins is rather high, certainly greater than that normally exhibited by *D. serra*. The arena behind the dorsal ridge is fairly smooth, prominent crenulation of the growth lines in this region, so typical of *D. serra*, being apparently absent. It is suggested that Paes-da Franca has recovered a valve of *D. haughtoni*, probably washed out of a local Pleistocene horizon and not a specimen of *D. serra*.

Family **Tellinidae**

Gastrana rostrata n.sp.

Pl. 29 & Fig. 10

Location 1. 45–50 m Transgression complex.
    Fore-beach environment.

Description

Shell moderately large, thin-walled, elongate, inequilateral, equivalve. Anteriorly rounded, posteriorly strongly rostrate. Median areas of valves vaulted, posteriorly the degree of concavity reduced, the rostrate regions becoming flattened along a plane separating the valves, forming a small gape. Dorsal outline behind umbones concave; ventral outline smooth.

Umbones small, not inflated, slightly forward of the median dorsal area; external surface of shell hardly visible in interior view. A weak dorsal ridge running from the umbonal region to the posterior ventral angle.

Lunules moderately long, narrow, and well-defined; ligament mainly external.

Sculpture of concentric growth lines which become raised to sub-lamelliform towards the periphery, also microscopic radial striae, entirely subordinate to the concentric sculptural elements.

Hinge areas extremely small in relation to the size of the shell.

Left valve with 2 cardinal teeth, very unequal in size. Posterior tooth

small, erect, lamelliform, situated very close to the anterior end of the ligament and obliquely set. Anterior cardinal tooth centrally situated on hinge plate, relatively large, wedge shaped, squarely set pointing just anterior to the median portion of the ventral outline. A deep, narrow groove running along the upper surface, giving a profoundly bifid appearance to the tooth. 2 raised processes, separated by this groove, situated on the extreme distal portion of the tooth.
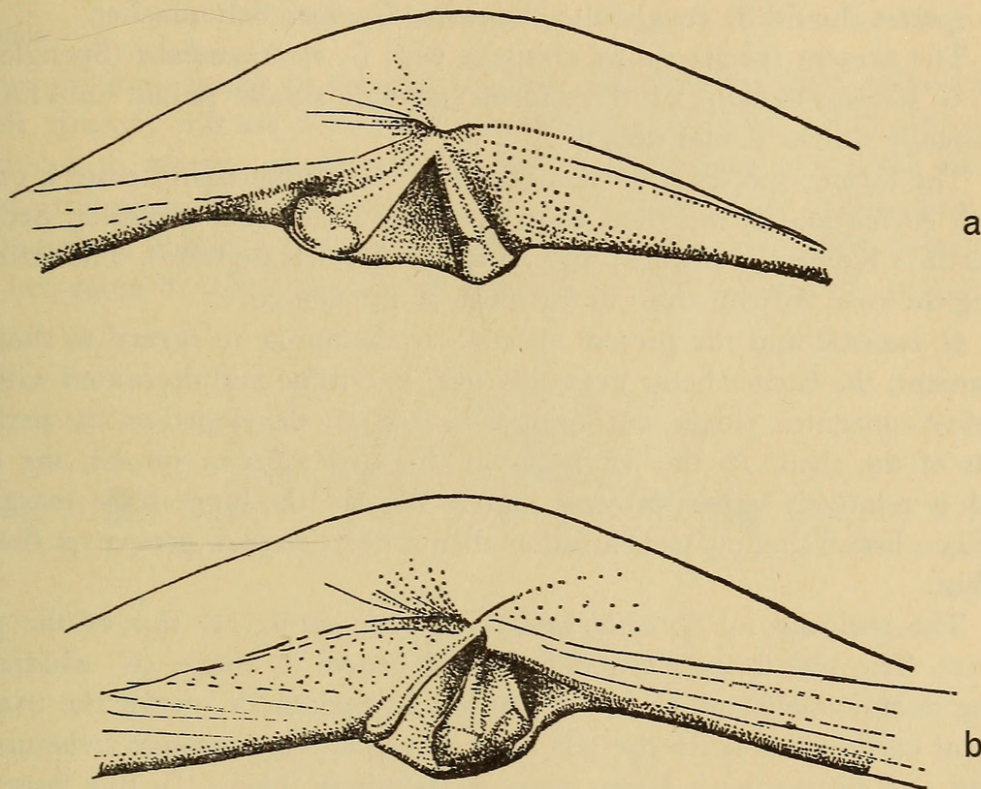

Fig. 10. *Gastrana rostrata* n.sp. Hinge details: a. Right valve. b. Left valve.

Terminal area of this large cardinal not projecting beyond the hinge plate and obliquely truncated, sloping posteriorly. Cardinal teeth separated by a deep triangular pit.

Right valve with 2 moderately large, divergent cardinal teeth; sub-equal, the anterior member somewhat broader; both erect, narrowly wedge-shaped and patently bifid, each with a longitudinal groove on the upper surface. A broad, deep triangular pit, accommodating the large cardinal tooth of the left valve, separating the two teeth.

Pallial sinus deep, passing beyond the level of the hinge; sides not parallel, the dorsal margin sloping steeply downwards; terminus poorly rounded. Ventral margin running close to, and parallel with, pallial line.

Material

     Holotype: S.A.M. K1426 L. 67·0 mm A. 39·5 mm
     Paratype: S.A.M. K1427   64·5 mm   43·5 mm

Paratype: S.A.M. K1445   L. 62·0 mm   A. 68·0 mm
Paratype: S.A.M. K1446   66·0 mm   43·0 mm

Remarks

The presence of two cardinal teeth in each valve, the absence of laterals, the gross inequality of the cardinal teeth in the left valve, the bifid nature of the teeth and the form of the ornament and the pallial sinus suggest that this new species should be assigned to the genus *Gastrana* Schumacher.

The present species shows affinities with *G. abildgaardiana* (Spengler) and with *G. matadoa* Gmelin, all three forms having a similar pallial sinus form and a basically similar dental design.

The former species is an inhabitant of the southern and eastern coasts of South Africa and is recorded from the local Pleistocene deposits; Sedgefield (Martin); Knysna (Schwarz) and Saldanha Bay (Haughton). The latter lives along the west African coast as far south as the Congo.

G. matadoa and the present species are dissimilar in regard to shape and ornament, the former being generally oval in outline and decorated with more massive concentric ridges, becoming very strongly developed on the peripheral parts of the shell. In the left valve of the west African species, the central tooth is relatively larger, projects slightly beyond the hinge-plate margin and carries a broad shallow trench rather than a deep, narrow groove on the upper surface.

The sculpture of *G. abildgaardiana* is very similar to that of the present species. The two forms show definite differences in shape (*G. abildgaardiana* being ovato-cuneiform) and in dentition. In Spengler's species the triangular central cardinal tooth in the left valve is a relatively massive structure, very broad and occupying a larger area of the hinge region. In this large tooth, which projects well beyond the hinge margin, the bifid condition is only poorly developed.

In the right valve the subequal cardinals show only poor bifidity. In both *G. matadoa* and *G. abildgaardiana* the umbones are moderately inflated.

The difference in shape and size of the dental elements suggests that the present form is specifically different from both *G. abildgaardiana* and *G. matadoa* and not simply an aberrant rostrate form of one or the other. In this context it is interesting to note that the present species is to be found in abundance in certain localities at the horizon noted above. From these localities, *G. abildgaardiana* has not been recovered; a single, small, left valve of *G. matadoa* has, however, been found amongst the hundreds of individuals of *G. rostrata*. This valve bears the ovato-cuneiform outline and the strong, concentric sculpture ridges of the contemporary *G. matadoa* as figured by Nicklès (1950: 220, fig. 426). A broad, shallow groove runs along the upper surface of the central cardinal tooth which projects beyond the hinge-plate margin.

Deeply abraded, exceptionally thick-walled and heavy, ovate specimens of *G. abildgaardiana* are found in the very coarse sediments of the 17–21 m beach.

Family **Aloididae**

Aloidis palaegialus n.sp.

Pl. 25 & Fig. 11

Location 3. 45–50 m Transgression complex.
Early transgression beach.

Description

Inequilateral, umbo in front of middle. Inequivalve, right valve larger than left, strongly vaulted. Both valves posteriorly with blunt carina stretching from umbo to margin, posteriorly slightly beaked. Antero-ventral margin smoothly rounded. Ventral edge of right valve very thin, overlapping left valve, mainly in posterior region. Sculpture of not very regular, fine, concentric ridges, becoming stronger ventrally. Umbonal region almost smooth. Internally,
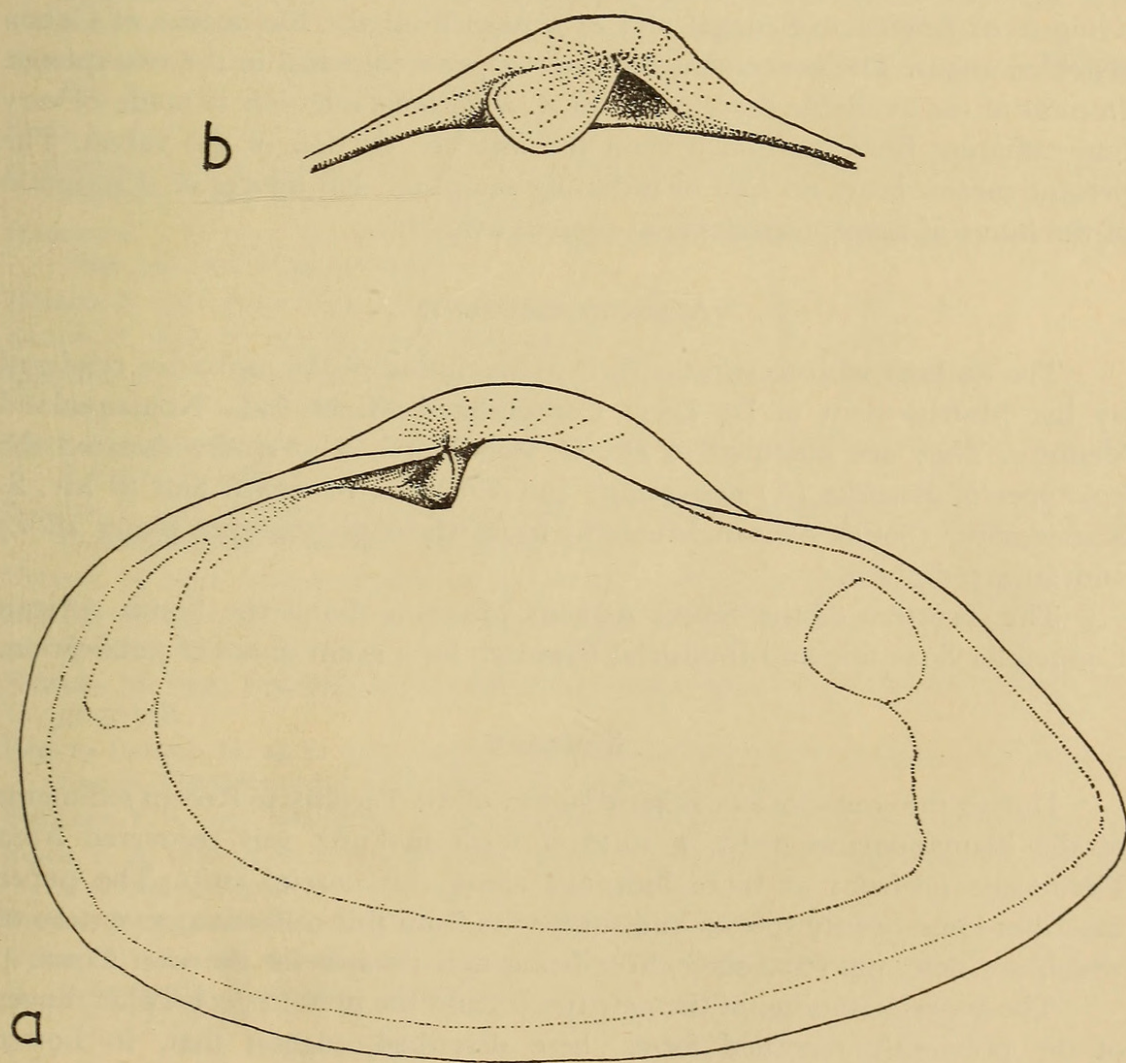
Fig. 11. *Aloides palaegialus* n.sp. Hinge details: a. Right valve. b. Left valve.

overlapping portion of right valve clearly demarcated from rest of valve. Anterior and posterior muscle scars present, pallial line uninterrupted, no pallial sinus; posteriorly, pallial line turns upwards at right angles, to meet the posterior adductor muscle scar. Hinge of right valve with prominent triangular tooth, a low ridge running anteriorly. Just posterior to the strong cardinal tooth, a deep ligamental pit, set well under the umbo. Hinge of left valve with an anterior triangular pit (to accommodate the cardinal tooth of the right valve) just posterior to which, a large, spatulate, triangular ligament support.

Material

Holotype: S.A.M. K1451 L. 15·5 mm A. 9·8 mm
Paratype: S.A.M. K1452 16·2 mm 10·0 mm

Remarks

This species is very similar in shape to *Aloides striatissima* Lamy, known living from Angola to Senegal and as a fossil from the Pleistocene of Gabon (Nicklès, 1952). The concentric sculpture appears identical in the two species. In most of the available descriptions of *A. striatissima* mention is made of very fine radiating lines, particularly on the anterior portion of the valves. The present species bears no sign of radiating sculpture. No figures or description of the hinge of Lamy's species is at present available.

SUMMARY

During the course of a geological survey of the Tertiary to Recent sediments of the Namaqualand coast, a suite of fossil molluscs was recovered from Pleistocene horizons at three locations along this coastal strip. The paper describes some twenty species and subspecies from this collection, seventeen of which are new, the remaining three being new records for the west Coast.

The generic affinities of the new species and the present geographic ranges of the previously recorded forms, here described, suggest that, in Lower Pleistocene times at least, the waters bounding this coast were considerably warmer than those presently washing this shore.

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