ANNALS OF THE SOUTH AFRICAN MUSEUM

VOLUME 99

ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

BAND 99

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ANNALE VAN DIE SUID-AFRIKAANSE MUSEUM

VOLUME 99 BAND

THE TRUSTEES OF THE
SOUTH AFRICAN MUSEUM
CAPE TOWN

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LIST OF CONTENTS

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NEW GENERIC NAMES PROPOSED IN THIS VOLUME

	Page
Zulutrigonia Cooper, 1990	25
Rugocythereis Dingle, Lord & Boomer, 1990	318

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FISCHER, P. H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archives de zoologie expérimentale et générale* **74** (33): 627–634.
KOHN, A. J. 1960*a*. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Annals and Magazine of Natural History* (13) **2** (17): 309–320.
KOHN, A. J. 1960*b*. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bulletin of the Bingham Oceanographic Collection, Yale University* **17** (4): 1–51.
THIELE, J. 1910. Mollusca. B. Polyplacophora, Gastropoda marina, Bivalvia. *In:* SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika ausgeführt in den Jahren 1903–1905* **4** (15). *Denkschriften der medizinisch-naturwissenschaftlichen Gesellschaft zu Jena* **16**: 269–270.

(continued inside back cover)

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A NEW *AUSTROMEGABALANUS* (CIRREPEDIA, BALANIDAE) FROM THE PLIOCENE OF NAMAQUALAND, CAPE PROVINCE, SOUTH AFRICA

By

JOHN PETHER

Cape Town Kaapstad

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A NEW *AUSTROMEGABALANUS* (CIRREPEDIA, BALANIDAE) FROM THE PLIOCENE OF NAMAQUALAND, CAPE PROVINCE, SOUTH AFRICA

By

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Department of Cenozoic Palaeontology, South African Museum, Cape Town

(With 3 figures and 1 table)

[*MS accepted 14 November 1988*]

ABSTRACT

A preliminary investigation of fossil barnacles from shallow marine coastal plain deposits exposed at Hondeklip, Namaqualand coast, South Africa, revealed the presence of a new species of austral megabalanine, *Austromegabalanus (Notomegabalanus) kensleyi* sp. nov., in an Upper Pliocene formation informally termed the 50-metre Package. This is the first extinct barnacle described from South Africa and, with the possibility of additional new species being recognized in future work, the biostratigraphic utility of barnacle assemblages for nearshore deposits of the South African margin is promising.

CONTENTS

INTRODUCTION

Shallow marine deposits, ranging in age from Early Pliocene to Late Pleistocene, underlie the terrestrial cover sands of the coastal plain along the Atlantic margin of South Africa. Mining of diamonds in these marine deposits adjacent to the Namaqualand coast creates temporary exposures that provide opportunities to examine the sedimentology and sample the fossil content. Hitherto the fossil molluscs have received attention, the most recent work being that of Kensley & Pether (1986), which presents a list of taxa and discusses the composition and biogeographic affinities of the fauna. This paper describes the first new species of barnacle recognized from the coastal plain marine deposits of South Africa. The specimens were obtained from the diamond mine at Hondeklip Bay (Fig. 1). The stratigraphy, sedimentary geometry, depositional environments, and evidence for the age of the deposits in this area are summarized in Pether (1986).

Ann. S. Afr. Mus. **99** (1), 1990: 1–13, 3 figs, 1 table.

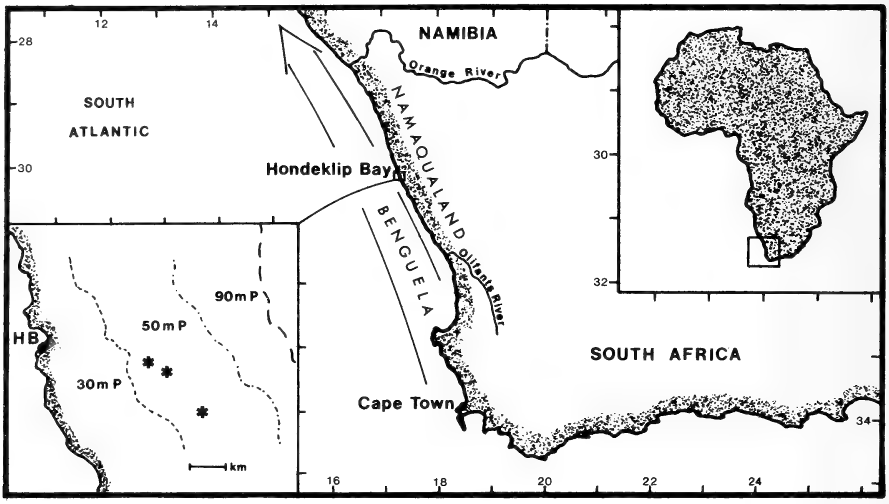

Fig. 1. Provenance of *Austromegabalanus (Notomegabalanus) kensleyi* sp. nov. Broken lines in left insert show inland (subsurface) limits (transgressive maxima) of main marine formations underlying the coastal plain. Informal formation labels record elevation of transgressive maximum, e.g. 50-metre Package. Asterisks indicate localities where the new species was obtained.

DESCRIPTION

Family **Balanidae** Leach, 1817

Subfamily Megabalaninae Newman, 1979

Genus *Austromegabalanus* Newman, 1979

Subgenus *Notomegabalanus* Newman, 1979

Austromegabalanus (Notomegabalanus) kensleyi sp. nov.

Figs 2–3

Diagnosis

Relatively small, smooth shell with single row of parietal pores and porous radii; no transverse septa in either. Thick scutum of high relief, no exterior radial sculpture; small, triangular, deeply excavated, lateral depressor pit, deep adductor muscle pit, no definite adductor ridge. Tergum not beaked and with short, broad spur at less than two-thirds its own width from basi-scutal angle; broad, very shallow spur furrow; no definite depressor crests.

Distribution

Upper Pliocene of the Namaqualand coastal plain, west coast of South Africa.

Material

Holotype. SAM–PQ–HB337a, one complete shell with opercula removed from cluster on boulder, Hondeklip Zone 12A (30°19′29″S 17°18′21″E).

Paratypes. SAM–PQ–HB337b–df, 110 complete shells from same cluster as holotype, many with opercula and bases. SAM–PQ–HB1261, cluster of approximately 30 shells on *Striostrea margaritacea* (Lamarck, 1819) valve, one of which contained an articulating opercular pair, Hondeklip Zone 4A.

Additional material. SAM–PQ–HB321, unattached cluster of 9 shells without opercula, Hondeklip Zone 12A. SAM–PQ–HB180, disarticulated shells and scuta, Hondeklip Zone 12A. SAM–PQ–AV984, 4 shells without opercula, Avontuur A, T2/3. SAM–PQ–AV1067, 3 shells without opercula, Avontuur A, T2/3.

Measurements

Holotype. Height 4,2 mm, carino-rostral diameter 11,1 mm, scutum occludent margin 3,7 mm, tergum scutal margin 2,6 mm.

Largest shell. SAM–PQ–AV984a, height 6,3 mm, diameter 14,7 mm.

Largest scutum. SAM–PQ–HB180, occludent margin 6,2 mm.

Description

Shell relatively small (~1 cm basal diameter). Specimens from smooth, uncrowded substrate (Fig. 2C) are low-conical with regular and smooth exteriors, have pentagonal to pointed-ovate, moderately toothed orifices about one-third carino-rostral diameter, and thin, flat bases. Those from uneven and crowded substrata (Fig. 3C) are more globulo-conical with relatively larger orifices, rugose exteriors and have cup-shaped bases (up to 1 cm deep), often with irregularly cellular underlayers.

Parietes with single row of open longitudinal pores, ovoid in section near apex, subrectangular near basis; internally ribbed, ribs usually on lower portion but may extend almost to sheath, short secondary ribs sometimes on larger specimens; basal denticles conspicuous with correspondingly small tapered ridges on lower ribs; sheath about half the length of plate, lower margin usually separated from wall by moderate to very shallow concavity. Many specimens still have a rose-pink hue colouring the sheath. Darker radial lines on exteriors of parietes correspond to the underlying septa. Radii inset from parietes, transversely porous although upper pores may be infilled; sutural edges regularly and densely septate with denticles on lower edges of septa (Fig. 3D), articulating surfaces on adjacent parietes with corresponding low, upward denticulations. Alae thin and broad, crenate sutural edges sometimes visible. In unabraded specimens, such as the SAM–PQ–HB337, the radii summits are obliquely truncated and the alae have steeply oblique summits, usually projecting above the opposite sloping radii. In more abraded specimens the summits are approximately parallel to the base. Basis radially porous, with shallow furrows corresponding to the underlying pores.

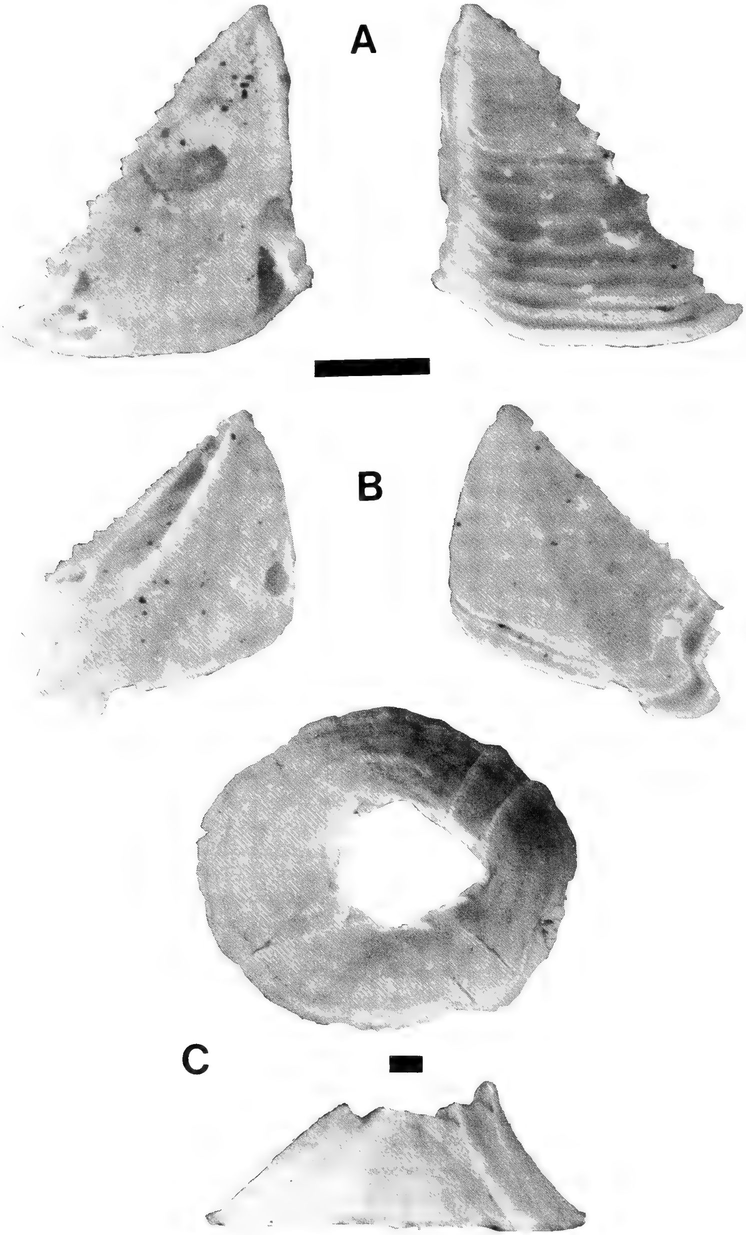

Fig. 2. Holotype of *Austromegabalanus (Notomegabalanus) kensleyi* sp. nov., SAM–PQ–HB337a. A. Interior and exterior views of scutum. B. Interior and exterior views of tergum. C. Apertural and lateral views of shell. Scales = 1 mm.

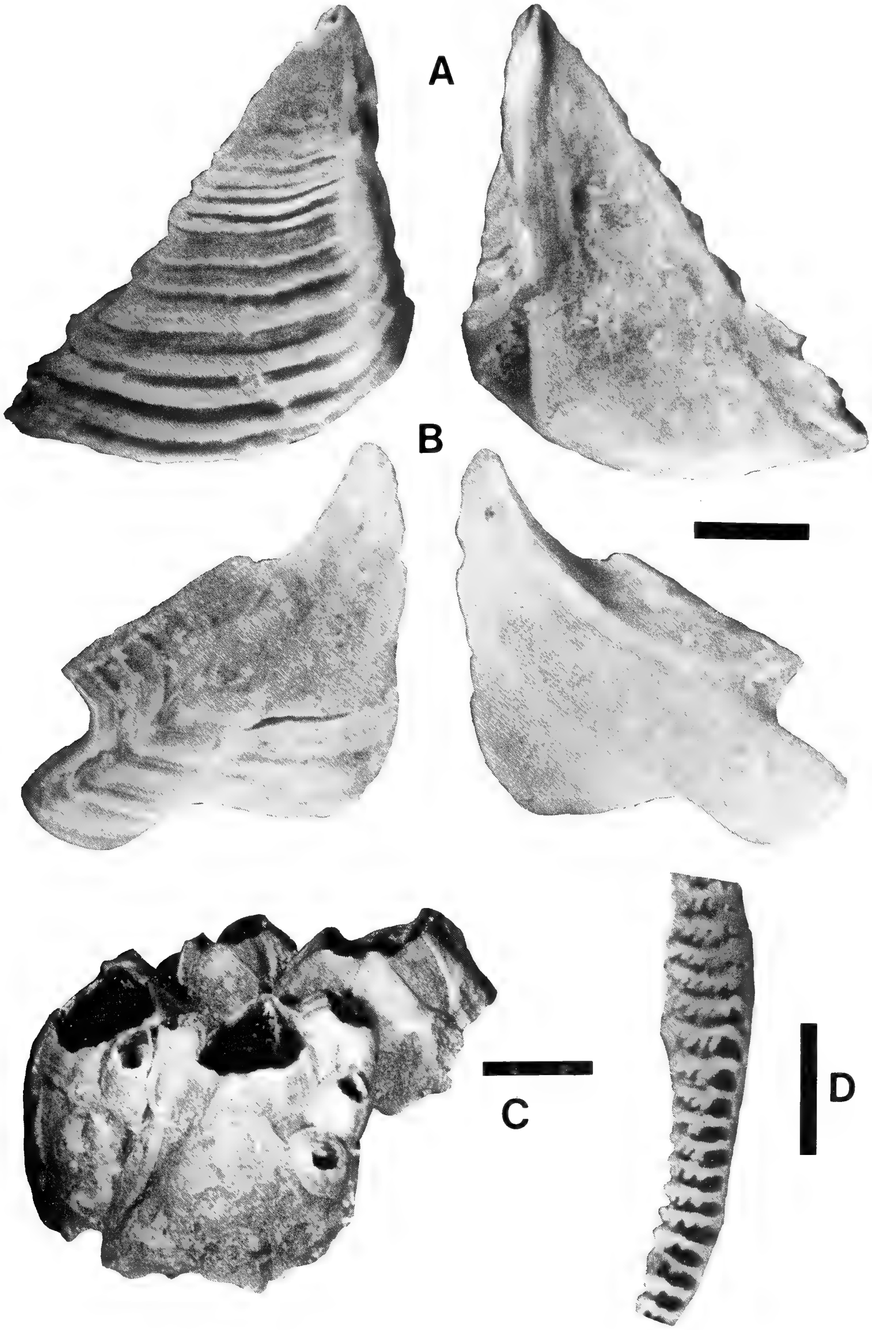

Fig. 3. *Austromegabalanus (Notomegabalanus) kensleyi* sp. nov. A–B. Large paired scutum and tergum from paratypes, SAM–PQ–HB1261. Scale = 1 mm. C. Shell cluster from same paratypes, set on *Striostrea margaritacea* valve. Scale = 5 mm. D. Sutural edge of radius showing austral megabalanine denticulation. Scale = 1 mm.

Scutum thick, of high relief; concave exterior with prominent growth ridges, every alternate one denticulating occludent margin; no radial sculpture; basal margin convex and about two-thirds length of occludent margin; tergal margin about three-quarters length of occludent margin and on exterior raised as a low ridge from apex to basi-tergal angle before being strongly but quite narrowly reflexed, the ridge enhancing the concavity of the exterior; a shallow groove is often present along the reflexed tergal segment. Articular ridge high, about four-fifths of tergal margin in length and reflexed over relatively narrow articular furrow; articular ridge thins basally, ending in a closely rounded-off corner above concave terminal edge; outer face shallowly concave and faint grooves are generally visible. Adductor muscle scar large, ovate and conspicuously deep, usually being visible without magnification, even in small scuta. No obvious adductor ridge but a low, rounded swelling is usually present beside adductor tergal margin and laps on to the basal flank of articular ridge. Lateral depressor pit small, narrowly triangular and deeply excavated, usually with slightly overhanging sides. Occludent margin interiorly reflexed, producing marginal ridge that basally overhangs rostral depressor insertion.

Tergum carinal and basal margins convex, scutal margin straight; exterior with low growth ridges, more pronounced on scutal portion; no radial sculpture. Spur furrow broad, open and very shallow to flush; margins slightly incised. Exterior carinal portion gently convex, exterior scutal portion usually slightly outwardly deflected. Articular margin quite narrowly reflexed at approximately right angle, rugose, forming ridge along scutal margin of articular furrow; articular furrow broad, moderately deep; articular ridge relatively thin, moderately high and partially overhanging furrow near apex. Apex not beaked, area of transverse ridges small; interior of valve below apex with several irregular grooves; carinal depressor crests effectively absent but faint grooving sometimes visible. Spur short and wide, approximately as long as broad; occupying from quarter to third of basal margin, situated about half to two-thirds own width from basi-scutal angle; basal margin segments slope towards spur, basi-scutal margin concave. Scutal end of spur closely rounded off, carinal corner very widely rounded off and almost a continuous curve from basal margin to scutal end. On interior of valve spur is only little raised and has a flat to slightly concave inner face. On the largest tergum available (Fig. 3B) the spur is seen to be relatively more developed than is the case in smaller specimens and the upper scutal margin is eroded.

Etymology

The species is named for Dr Brian Kensley of the Smithsonian Institution, Washington, D.C., in recognition of his contributions to the knowledge of the southern African fossil molluscan fauna.

DISCUSSION

The porous radii establish the Namaqualand specimens as belonging to a megabalanine genus. The classification system followed here is that of Newman (1979), with the modifications proposed by Buckeridge (1983). In the former work, Balanidae with porous radii were allocated to a new subfamily Megabalaninae. Taxa possessing radii with secondary denticles on the lower sides of primary denticles only were recognized as pan-austral Southern Hemisphere endemics and assigned to two new genera, *Austromegabalanus* and *Notomegabalanus*. The former genus is distinguished by beaked terga and closed spur furrows, the latter by non-beaked terga and open furrows. However, Buckeridge (1983), in his monograph on the fossil barnacles of Australia and New Zealand, expressed the opinion that the differences in tergal morphology, with respect to spur furrow and beak, between *Austromegabalanus* and *Notomegabalanus* are not sufficiently strong to justify full generic separation. He thus proposed that *Notomegabalanus* be regarded as a subgenus of *Austromegabalanus*. Furthermore, the taxa with porous outer parietal laminae were removed from *Notomegabalanus* and placed in a new genus *Fosterella*. With secondary denticles on the lower sides of the primary radii denticles only, this species from Namaqualand is confirmed as an austral megabalanine. The open spur furrow and lack of a strongly beaked tergum place it in the subgenus *Notomegabalanus*.

Listed in Table 1 are the fossil and extant species of *Notomegabalanus*, together with their approximate geological ages. *Austromegabalanus* s.s. and *Fosterella* have been included to provide a complete list of these related austral genera.

The austral megabalanines have not always been confined to the Southern Hemisphere. Fossil occurrences of *Notomegabalanus* in Tertiary deposits on both the Pacific and Atlantic coasts of North America have been recorded by Zullo & Guruswami-Naidu (1982) and Zullo (1986). As discussed by Newman & Foster (1987), this distribution suggests that *Notomegabalanus* has had a Tethyan and an amphitropical history, the present austral endemism being due to Northern Hemisphere extinction and Neogene dispersal via the West Wind Drift. *Notomegabalanus* is considered more generalized than *Austromegabalanus* s.s., whilst *Megabalanus* s.s. is the most highly evolved of the megabalanines (Newman 1979). The presence of an undescribed species of *Notomegabalanus* in the Oligocene of Oregon (Zullo 1986) is consistent with such a relationship. The Neogene radiation of these related taxa and the extinctions due to Pleistocene glaciations (which particularly affected *Fosterella* and *Notomegabalanus*), are evident in Table 1.

Austromegabalanus (Notomegabalanus) kensleyi is rendered distinct from all other species of the subgenus by its short, broad, rounded tergal spur at less than its own width from the basi-scutal angle, especially if this character is considered simultaneously with the very shallow spur furrow and subdued expression of the spur ridge on the valve interior.

The comparison of *A. (N.) kensleyi* with the austral species of *Notomegabalanus* indicates that the deep, narrowly triangular lateral depressor pit distinguishes

TABLE 1

Fossil and extant species of *Austromegabalanus* and *Fosterella*. Geographical location: N = Northern Hemisphere occurrence; S = Southern Hemisphere occurrence; WNA = Western North America; ENA = Eastern North America; IN = India; NZ = New Zealand; AUS = Australia; SAF = South Africa; SAM = South America; ANT = Antarctica; SOI = Southern Ocean Island.

Species	N/S	Loc.	Oligocene	Miocene	Pliocene	Pleistocene	Recent
Austromegabalanus (Austromegabalanus) victoriensis Buckeridge, 1983	S	AUS		—	—		
Austromegabalanus (Austromegabalanus) nigrescens (Lamarck, 1818)	S	AUS					—
Austromegabalanus (Austromegabalanus) piscoensis Carriol *et al.*, 1987	S	SAM			—		
Austromegabalanus (Austromegabalanus) psittacus (Molina, 1782)	S	SAM			—	—	—
Austromegabalanus (Austromegabalanus) cylindricus (Gmelin, 1780)	S	SAF				—	—
Austromegabalanus (Austromegabalanus) isolde (Holthuis & Sivertsen, 1967)	S	SOI					—
Austromegabalanus (Austromegabalanus) zulloi Newman, 1979	S	SOI					—
Austromegabalanus (Notomegabalanus) sp. Zullo, 1986	N	WNA	—				
Austromegabalanus (?Notomegabalanus) insperatus Zullo & Guruswami-Naidu, 1982	N	WNA		—			
Austromegabalanus (Notomegabalanus) wilsoni (Zullo, 1969)	N	WNA			—		
Austromegabalanus (Notomegabalanus) obliquus (Ross, 1964)	N	ENA			—		
Austromegabalanus (Notomegabalanus) lepidus Zullo, 1986	N	ENA			—		
Austromegabalanus (?Notomegabalanus) squillae (Daniel & Ghosh, 1963)	N	IN					—
Austromegabalanus (Notomegabalanus) miodecorus Buckeridge, 1983	S	NZ		—	—		
Austromegabalanus (Notomegabalanus) decorus argyllensis Buckeridge, 1983	S	NZ				—	
Austromegabalanus (Notomegabalanus) decorus decorus (Darwin, 1854)	S	NZ					—
Austromegabalanus (Notomegabalanus) campbelli (Filhol, 1885)	S	NZ					—
Austromegabalanus (Notomegabalanus) kensleyi sp. nov.	S	SAF			—		
Austromegabalanus (Notomegabalanus) algicola (Pilsbry, 1916)	S	SAF				—	—
Fosterella chathamensis Buckeridge, 1983	S	NZ			—	—	
Fosterella tubulatus (Withers, 1924)	S	NZ			—	—	
Fosterella tubulatoides (Newman, 1979)	S	SAM				—	
Fosterella hennigi (Newman, 1979)	S	ANT				—	

the scutum of the new species from other representatives of the subgenus. The lack of a definite adductor ridge separates the new species from all other austral *Notomegebalanus* species except *A. (N.) algicola* (Pilsbry, 1916) which, however, has a very broad scutum. The absence of scutal radial sculpture is a feature in common with *A. (N.) algicola* and *A. (N.) campbelli* (Filhol, 1885). The basal end of the articular ridge of the new species is not pointed or dependant, as is the tendency in other austral species of *Notomegabalanus*. The lack of a tergal beak distinguishes the new species from the weakly beaked *Notomegabalanus* species of New Zealand.

The shells of *A. (N.) kensleyi* are slightly larger than those of *A. (N.) algicola* but smaller than the New Zealand representatives of the subgenus, the ribbed *A. (N.) campbelli* being closest in dimensions. Whereas the latter and *A. (N.) decorus* (Darwin, 1854) have transverse septa in the parietal pores, the new species does not, a feature in common with *A. (N.) algicola* and evidently *A. (N.) miodecorus* Buckeridge, 1983.

In the Northern Hemisphere, the extant *Balanus (Megabalanus) squillae* Daniel & Ghosh, 1963, possesses austral megabalanine radii. This rather cryptic and very small species from the coast of Madras is parasitic on a stomatopod, *Squilla* sp. It is problematic in possessing a tergum that is non-beaked but has a closed spur furrow. On the basis of the overall resemblance of the opercula to those of *A. (N.) algicola*, this species has been tentatively placed in *Notomegabalanus* by Henry & McLaughlin, 1986. The small broad scutum with an adductor ridge further distinguishes it from the new species. *Austromegabalanus (N.) wilsoni* (Zullo, 1969) from the Upper Pliocene of California also possesses an unbeaked tergum with a closed spur furrow and similarly has been placed in *Notomegabalanus* on the basis of its overall resemblance to *A. (N.) algicola*. Additional discoveries of such species that do not strictly conform to the definition of *Notomegabalanus* might render a redefinition of the subgenus or erection of another subgenus advisable.

The scutum of *A. (N.) wilsoni* resembles that of *A. (N.) kensleyi* in respect of the small, deep, lateral depressor pit and lack of an adductor ridge, but differs in respect of the straight basal margin, radially aligned pits on the exterior of some specimens and overall larger size. *Austromegabalanus (N.) lepidus* Zullo, 1986, from the Pliocene of the Western North Atlantic is a species of comparable size to that of *A. (N.) kensleyi* but the scutum, although also lacking an adductor ridge, is thin with a shallow lateral depressor pit and occasionally has exterior radial striae. In addition to the deep spur furrow, the tergum of *A. (N.) lepidus* differs from the new species in the strongly concave scutal margin, presence of distinct depressor crests, and radially striate exterior scutal portion. The opercula of *A. (?N.) obliquus* (Ross, 1964) (Pliocene, Western North Atlantic) have not been recovered but that species is larger than the new species and has externally ribbed parietes with deeply inset radii. The opercular valves of *A. (?N.) insperatus* Zullo & Guruswami-Naidu, 1982 (Late Miocene, California), are also unknown but the shell is also larger than *A. (N.) kensleyi* and has prominent external ribs.

It is noteworthy that of all the representatives of *Notomegabalanus*, the opercula of the new species are overall most similar to those of the extinct genus *Fosterella* Buckeridge, 1983. This applies particularly to the deep, small, scutal lateral depressor pit (this feature having been considered a defining character of *Fosterella*) and the short tergal spur and shallow spur furrow. In general appearance the opercula of *Fosterella tubulatoides* (Newman, 1979) from the Late Pleistocene of the continental shelf off Tierra del Fuego are closest. However, several other features remain to distinguish the opercula of species of *Fosterella*, such as the presence of weak adductor ridges, pointed basal ends of articular ridges, and strongly developed tergal depressor crests (the latter not present for *F. hennigi* (Newman, 1979) but that species has very distinctive elongate opercula). Furthermore, the shells of *Fosterella* are all strongly ribbed and, in addition to the defining character of multitubate parietes, have transverse septa in the parietal pores.

GEOLOGICAL SETTING

Austromegabalanus (Notomegabalanus) kensleyi is abundantly represented in a formation informally called the 50-metre Package (Pether 1986). This formation is comprised of gravels and fine sands laid down during regressive shoreline progradation from a transgressive maximum near 50 m above present sea-level. Depositional environments include the nearshore shelf (locally preserved only), lower shoreface, upper shoreface, foreshore, and back-barrier settings. The age of the 50-m Package is not yet unequivocally determined but is constrained by the presence of a remanié vertebrate assemblage of Mio-Pliocene aspect at the base (Q. B. Hendey pers. comm.) and the occurrence of *Equus* near the top, the latter probably representing stratigraphic leakage from a closely overlying erosion surface. Furthermore, the highest elevation marine deposits (90-m Package, Fig. 1) inland of the 50-m Package have been correlated with the Early Pliocene Varswater Formation at Langebaanweg (Hendey 1981). The 50-m Package is thus considered to be Middle to Late Pliocene in age.

Austromegabalanus (Notomegabalanus) kensleyi has not been found in barnacle coquina from the 30-m Package, the regressive wedge overlying the transgressive truncation of the 50-m Package. Thus it appears to have become extinct on the Namaqualand coast around the Plio-Pleistocene. The lower limits of the new species are not yet determined, due to lack of material, but it is considered quite likely to extend into the Early Pliocene 90-m Package. At least one other species of barnacle is present in the 50-m Package. This is a non-megabalanine but opercula permitting determination have not yet been recovered.

In the barnacle coquina of the subsequent Early Pleistocene 30-m Package, disassociated opercula indicate the presence of three barnacle species, whereas parietal fragments indicate that *Austromegabalanus*, *Megabalanus* s.s. and *Balanus* species occur. The opercular material is too abraded for the purposes of unequivocal specific determination but one scutum type and one tergum type (probably from the same species) appear sufficiently unique to suggest a new species. Other fragmentary opercula suggest that the *Austromegabalanus* sp. indicated by parietes may by *Austromegabalanus* s.s. It is hoped that continued fieldwork will produce better-preserved and associated examples of these taxa.

PALAEOENVIRONMENT

The types of *A. (N.) kensleyi* were found *in situ* on a boulder resting on the gneissic bedrock. The palaeoenvironment of the type area, reconstructed from the overlying sediments, was the inner, shallow portion of a protected embayment. The boulder was at shallow subtidal palaeodepth (<–5 m) when the live barnacles were covered by fine sands—probably during or immediately subsequent to a storm. Disarticulated barnacle fragments are a major component of coarse, basal lower shoreface deposits in the deeper portion of the bay and, within the fine sandy portion of the lower shoreface bay infill, the new species is commonly found encrusting *Striostrea margaritacea* (Lamarck) valves. These oysters were swept from the lower intertidal to shallow subtidal margin of the bay during storms and deposited in deeper water. Lagoonal deposits within which barnacle coquina lenses are present represent the final infilling of the embayment. These lenses are interpreted as coarser lags accumulated along the very shallow subtidal bases of tidal creeks within the lagoonal system, with barnacle fragments likely to have been transported by flood tides from the proximal lagoon and adjacent coast.

In exposed coastal settings, detached clusters of barnacles are found in shelly lenses within the storm-deposited lower shoreface facies. Disarticulated fragments are also an important component of the cross-stratified, coarse sandy upper shoreface facies.

In all the above instances the dominant barnacle is referable to the new species and its preferred environment was evidently the intertidal to shallow subtidal of normal marine salinity. The presence of warm-water West African and southern African east-coast molluscs in the 50-m Package indicates that the sea temperature was warmer than the present interglacial, at least seasonally. However, upwelling influences were present, as is attested by the occurrence of authigenic phosphorite rinds within nearshore shelf and basal lower shoreface facies. It is likely that changes in faunal structure associated with cooling, sea-level fall, and altered shelf currents account for the extinction of *A. (N.) kensleyi*.

CONCLUDING REMARKS

It is appropriate and not unexpected that the first extinct barnacle to be described from the coastal plain deposits of South Africa is a species of *Notomegabalanus*. Newman (1979) remarked that the austral region must have been richer in austral megabalanines during the Pliocene than it is today. The subsequent discovery of *Fosterella chathamensis* Buckeridge, 1983, from the

Pliocene of the Chatham Islands, *Austromegabalanus (A.) piscoensis* Carriol *et al.*, 1987, from the Pliocene of Peru, and the present species bears out that supposition that, with inclusion of the North American fossil species, may now be amplified to include both hemispheres during the Neogene.

Another species of *Austromegabalanus* is represented in the Early Pleistocene 30-m Package and may be *Austromegabalanus* s.s., but the abraded state of the available opercula preclude unequivocal specific identification at present. Significantly, material conclusively attributable to the extant South African *Austromegabalanus* species has not been recovered from the Upper Pliocene and Lower Pleistocene deposits. This suggests that *A. (A.) cylindricus* (Gmelin, 1780) does not have a range extending from the Pliocene, in contrast to *A. (A.) psittacus* (Molina, 1782) from South America. However, the former species is well represented in Last Interglacial beach deposits at Milnerton near Cape Town (Kensley 1985) and at other Late Pleistocene outcrops in the south-western Cape. *Austromegabalanus (N.) algicola* is also present in Last Interglacial deposits at Milnerton.

This paper represents the results of an initial reconnaissance of fossil barnacles from the Hondeklip study area. The recognition of a new species of barnacle from Pliocene coastal plain deposits, with possibilities of others in the future and as yet undetermined lower limits for extant South African *Austromegabalanus* species, holds the promise that barnacles will be of value in the correlation of the Late Tertiary and Quaternary shallow marine sequences of the southern African margin. Their calcitic composition favours preservation and, together with their abundance in shallow marine deposits, barnacle assemblages should emerge as useful biostratigraphic markers in the local coastal stratigraphy.

ACKNOWLEDGEMENTS

I am indebted to Mr F. Hoffman of Transhex Group Ltd for access to the Hondeklip mine exposures and the mine manager and geologists for their hospitality; to Dr Q. B. Hendey of the South African Museum and Dr J. Rogers of the University of Cape Town, for their advice and support; to Marilyn Pether for photographic assistance; to the referees for their constructive comments, and to the CSIR and the South African Museum for financial assistance.

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6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
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full stop separates references by different authors
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In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach, Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

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(a) The Figures, Maps and Tables of the paper when referred to in the text
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Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively. The generic name should not be abbreviated at the beginning of a sentence or paragraph.

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JOHN PETHER

A NEW *AUSTROMEGABALANUS* (CIRREPEDIA, BALANIDAE) FROM THE PLIOCENE OF NAMAQUALAND, CAPE PROVINCE, SOUTH AFRICA

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CRETACEOUS FAUNAS FROM ZULULAND AND NATAL, SOUTH AFRICA. A *KOLOCERAS* (CEPHALOPODA, AMMONOIDEA) FROM THE MZINENE FORMATION (ALBIAN)

By
HERBERT CHRISTIAN KLINGER
&
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CRETACEOUS FAUNAS FROM ZULULAND AND NATAL, SOUTH AFRICA. A *KOLOCERAS* (CEPHALOPODA, AMMONOIDEA) FROM THE MZINENE FORMATION (ALBIAN)

By

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(With 2 figures)

[*MS accepted 22 September 1989*]

ABSTRACT

The monospecific, micromorphic ammonite genus *Koloceras* (of the subfamily Aconeceratinae), thus far only known from the Upper Albian of Estancia La Vega in Santa Cruz Province, Argentina, is recorded for the first time from the Upper Albian of Zululand.

CONTENTS

INTRODUCTION

On three separate occasions, micromorph, platyconic ammonites have been recorded from the Upper Albian of the Southern Hemisphere as *Borissiakoceras*—a genus generally regarded as being of Middle Cenomanian to Turonian age, but which may occur as early as the Lower Cenomanian and persist up to the Coniacian (see e.g. Kennedy & Klinger 1979: 115–116). These records are:

1. *Borissiakoceras* sp. Nullo *et al.*, 1981 (pl. 2 (fig. 9a–c)) from Patagonia, Argentina.
2. *Falciferella breadeni* Brunnschweiler, 1959 (p. 15, pl. 1 (figs 5–6)) and *Falciferella reymenti* Brunnschweiler, 1959 (p. 16, pl. 1 (figs 7–8)), both referred to *Borissiakoceras* by Cooper & Kennedy (1979: 297) from South Australia.
3. *Borissiakoceras* sp. nov. ? aff. *reymenti* Cooper & Kennedy (1979: 297, fig. 31H–I) from Porto Amboim, Angola.

Ann. S. Afr. Mus. **99** (2), 1990: 15–21, 2 figs.

Cooper & Kennedy (1979: 296–7) regarded the Angolan and Australian material as bridging the phylogenetic gap in the family Binneyitidae between the last appearance of the genus *Falciferella* Casey, 1954 (type species *F. milbournei* Casey, 1954: 271, pl. 7 (figs 1–5), text-fig. 3), in the Middle Albian and the first occurrence of *Borissiakoceras* in the Middle Cenomanian. Recent data suggest that this view seems to be too simplistic.

The Australian material was recently (McNamara 1985) referred to a new genus *Naramoceras* (type species *Falciferella breadeni* Brunnschweiler, 1959: 15, pl. 1 (figs 5–6)) in the subfamily Aconeceratinae. The Patagonian material was also referred to a new genus (Riccardi *et al.* 1987: 167), *Koloceras* (type species *Koloceras talenkanum* Riccardi *et al.*, 1987: 169, pl. 14 (figs 1–17b), text-figs 42–46), also of the subfamily Aconeceratinae.

Both *Koloceras* and *Naramoceras* have distinctive, little-incised suture lines with a trifid lateral lobe (L), which clearly separate them from *Borissiakoceras*. *Koloceras* in turn differs from *Naramoceras* in having a trifid second lateral (U_2) lobe, rather than bifid as in the latter.

The erection of these two (apparently endemic) genera casts doubt on the identity of the Angolan specimen. Is it indeed the only true Upper Albian *Borissiakoceras*, or might it belong to *Koloceras* or *Naramoceras*? Unfortunately, we have not seen the suture lines of the Angolan specimen to be able to comment further on this matter.

In Patagonia and South Australia, *Koloceras* and *Naramoceras* respectively occur in association with a diverse and distinct heteromorph ammonite fauna belonging to the subfamily Labeceratinae (see e.g. Whitehouse 1926; McNamara 1978; Aguirre Urreta & Riccardi 1988). The subfamily Labeceratinae has a typically South Gondwanid distribution, and is locally very common in Zululand and southern Mozambique (see Spath 1925; Klinger 1976; Klinger 1989). When *Naramoceras* and *Koloceras* were first described, our immediate reaction was to see if we had any representatives of either genus in our collections from *Labeceras*-bearing localities. We did not find any.

Recently, in the course of routine curation of the Van Hoepen collection, housed in the South African Museum, a small ammonite was brought to the attention of one of us (H. C. Klinger), who identified it as belonging to the genus *Koloceras*; later a second specimen was found, which is tentatively referred to that genus.

We here describe the first record of the genus *Koloceras* from South Africa. We cannot be certain whether this is only a fortuitous discovery of a post-mortem drifted occurrence of this apparently endemic, monospecific Patagonian genus, or whether it indeed represents part of a population as yet not localized. Its discovery should encourage the search for further material of both *Koloceras* and *Naramoceras* in the Southern Hemisphere, to clarify the interrelationship between these two genera and *Borissiakoceras* of the subfamily Binneyitinae.

SYSTEMATIC DESCRIPTION

Superfamily HAPLOCERATACEAE Zittel, 1884
Family **Oppelidae** Bonarelli, 1894
Subfamily Aconeceratinae Spath, 1923
Genus *Koloceras* Riccardi, Aguirre Urreta & Medina, 1987

Koloceras talenkanum Riccardi, Aguirre Urreta & Medina, 1987
Figs 1–2

Borissiakoceras sp. Nullo *et al.*, 1981: 200, pl. 2 (fig. 9a–c).
?*Falciferella* sp. Medina & Rinaldi, 1986: 16, pl. 2 (figs 3–5), pl. 4 (figs 6–9).
Koloceras talenkanum Riccardi *et al.*, 1987: 169, pl. 14 (figs 1–17b), text-figs 42–46.

Type

Holotype is the specimen (MLP 19981) figured by Riccardi *et al.* (1987, pl. 14 (fig. 15a–b)), an adult macroconch from the upper part of the Rió Mayer Formation, Estancia La Vega, Santa Cruz Province, Argentina, housed in the collections of the Museo de Ciencias Naturales, La Plata.

Material

NMB D380 (Van Hoepen Collection) from locality 51 and NMB D872 (Van Hoepen Collection) from locality 55, both from the Mzinene Formation, Albian IV–V, Zululand. (For precise locality data see Kennedy & Klinger 1975.)

Dimensions

Dimensions of specimens are in millimetres; abbreviations are as follows: D = diameter, Wb = whorl breadth, Wh = whorl height, U = umbilical diameter. Figures in parentheses are dimensions as a percentage of total diameter.

Specimen	*D*	*Wb*	*Wh*	*Wb/Wh*	*U*
D380	8,6	1,8 (20,9)	4,55 (52,9)	0,4	1,65 (19,2)
D872	7,99	1,85 (23,1)	3,6 (45,1)	0,51	1,35 (16,9)

Description

D380 (Figs 1E–F, 2A) is a microconch; the phragmocone is preserved in clear calcite and the body chamber is preserved in grey glauconitic silt and occupies half of the outer whorl. The umbilicus is partially occluded with matrix but it seems to have steep umbilical walls. The flanks are flat and parallel, and the venter rounded.

The small size, platycone shell shape, lack of ornament and simplified sutures (Fig. 2A) with a trifid lateral (L) lobe clearly identify it with Patagonian *Koloceras talenkanum*.

D872 (Fig. 1G) is part of a phragmocone preserved in sparry calcite. The sutures are not preserved well enough to permit a definite identification. The small size and shell shape suggest that it might be a macroconch of *Koloceras talenkanum*.

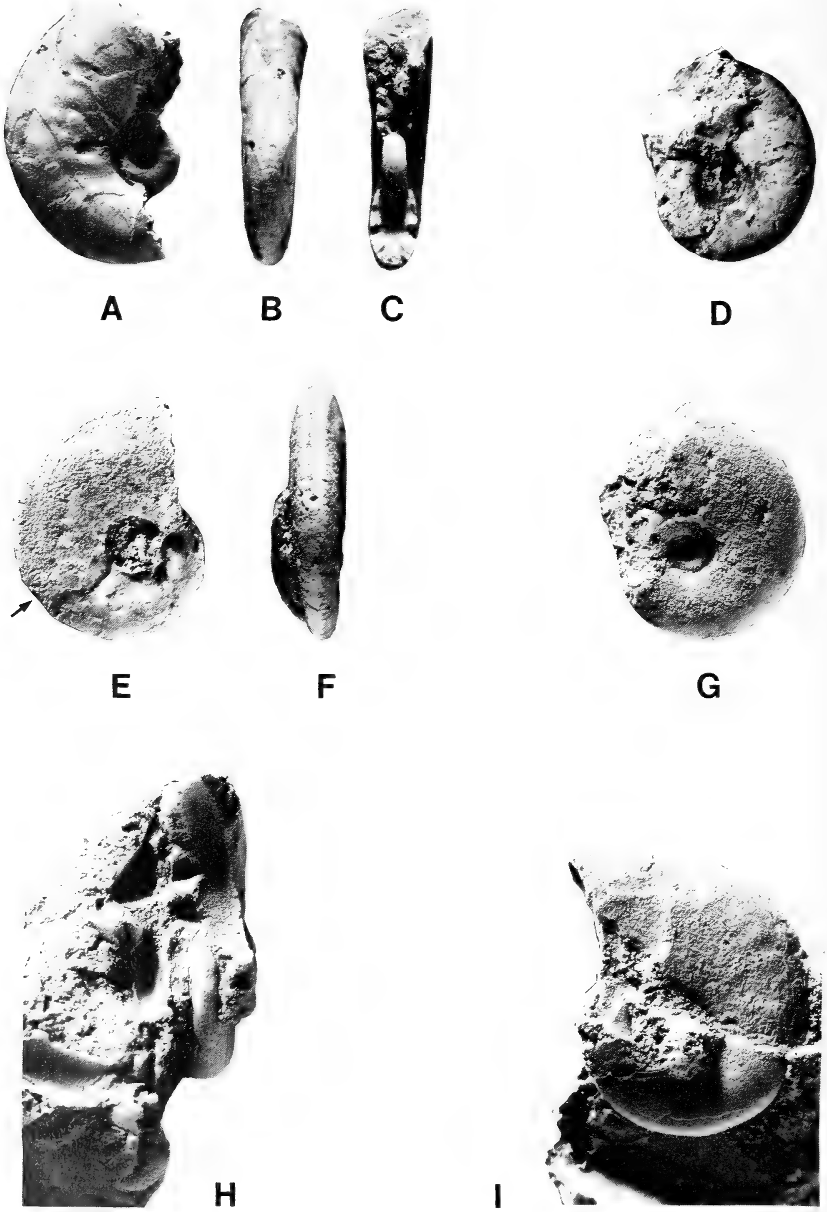

Fig. 1. *Koloceras talenkanum* Riccardi *et al.*, 1987. A–C. SAM–PC8394. D. SAM–PC8393. E–F. NMB D380. G. NMB D872. H–I. SAM–PC8392. A–D, H–I. From Estancia La Vega, Santa Cruz Province, Argentina, upper part of the Rió Mayer Formation, Late Albian. E–F. From locality 51, Zululand, Mzinene Formation, Albian IV–V. G. From locality 55, Zululand, Mzinene Formation, Albian V. All × 4.

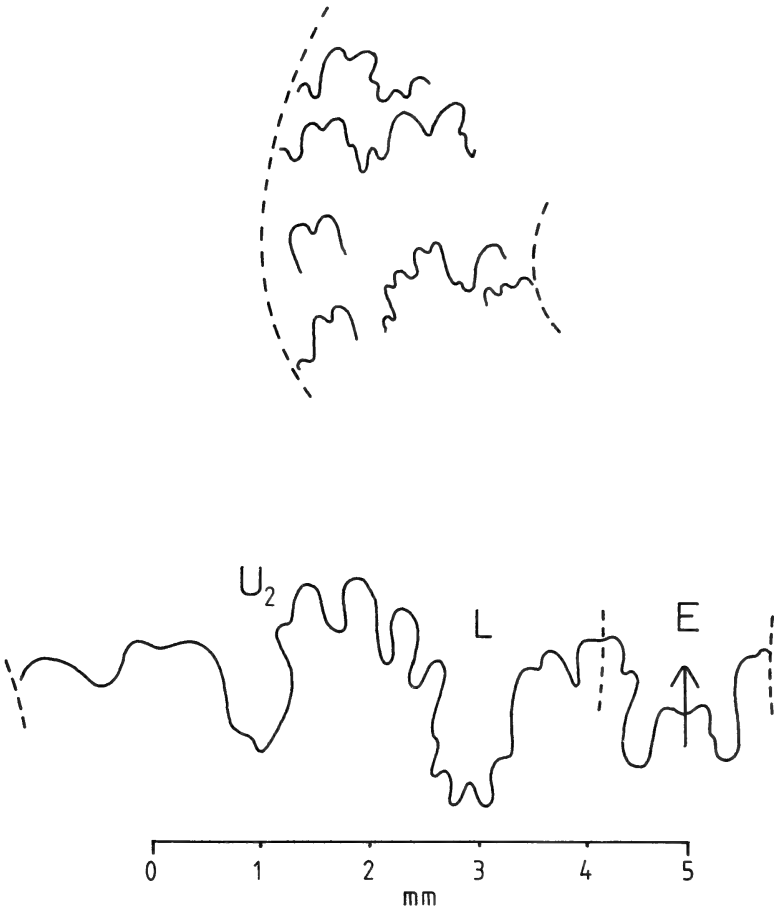

Fig. 2. External suture lines of *Koloceras talenkanum* Riccardi *et al.*, 1987. A. NMB D380. B. SAM–PC8392. Scale bar for size.

Discussion

These two specimens do not add anything to the extensive descriptions of *Koloceras talenkanum* provided by Riccardi *et al.* (1987), but they do present a palaeobiogeographic enigma.

Thus far, *Koloceras talenkanum*, or the genus *Koloceras* for that matter, were only known from a single locality, 0,7 km to the south-east of the Estancia La Vega, approximately 34 km north-west of the village of Tres Lagos, where about 30–35 metres of sediment referable to the upper part of the Rió Mayer Formation are exposed. According to Riccardi *et al.* (1987: 118), *Koloceras talenkanum* seems to occur throughout the extent of the exposure. The associated ammonite fauna consists of a strange mixture of apparent endemic, South Gondwanid, and cosmopolitan species respectively, which have been referred to the *Puzosia vegaensis* Assemblage Zone (Riccardi *et al.* 1987: 121), and includes *Puzosia vegaensis* Leanza, *Hypophylloceras lestai* Leanza, *Partschiceras* sp., *Anagaudryceras pulchrum* (Crick), *Eomarshallites espinosum* Medina & Rinaldi, *E. hibridum* Medina & Rinaldi (= *'Parasilesites' desmoceratoides* (Stolley)), *?Umsinenoceras*, *Mortoniceras (Neokentroceras) tarense* H. Leanza, *Labeceras singulare* (A. Leanza), *L. crassetuberculatum magnum* Aguirre Urreta & Riccardi, and *Myloceras (Calliscaphites) andinus* A. Leanza, (cf. A. Leanza 1970; Nullo *et al.* 1981; H. Leanza 1986; Medina & Rinaldi 1986; Riccardi *et al.* 1987; Aguirre Urreta & Riccardi 1988). The bivalve genus *Maccoyella* Etheridge (1892)—thus far only known from Patagonia, Australia and New Zealand—is also common (see Waterhouse & Riccardi 1970).

Detailed synonymies still have to be worked out for some of the above species, but cosmopolitan forms include *Phylloceras (H.)*, *Partschiceras* and *Anagaudryceras pulchrum*; the labeceratinae are typical South Gondwanid forms (see Klinger 1989 for a review); and endemic forms are *Eomarshallites* and *Koloceras* (the latter with the exception of the Zululand specimen(s?)). Representatives of the subfamily Mortoniceratinae are conspicuously rare. Up to now only a fragment of *Neokentroceras* has been recorded from Estancia La Vega (H. Leanza 1985).

Judging by the similarity of some of the labeceratine faunas (see Aguirre Urreta & Riccardi 1988; Klinger 1989), an open marine connection must have existed between part of the Patagonian Austral basin and the Zululand basin. We can think of no single factor to explain the selective barrier between the two basins, permitting free interchange of cosmopolitan and part South Gondwanid faunas but yet restricting interchange of *Eomarshallites* and *Koloceras* on the one side and Mortoniceratinae on the other. On a less negative note, we have to bear in mind that Estancia La Vega is thus far the only Upper Albian locality known in Patagonia. Future exploration may well diminish the apparent endemic character of the Upper Albian ammonoid fauna of Patagonia.

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An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

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Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

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SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach, Port Elizabeth (33°51'S 25°39'E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

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CRETACEOUS FAUNAS FROM ZULULAND AND NATAL, SOUTH AFRICA. A *KOLOCERAS* (CEPHALOPODA, AMMONOIDEA) FROM THE MZINENE FORMATION (ALBIAN)

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A NEW GENUS OF RUTITRIGONIINAE (BIVALVIA, TRIGONIACEA) FROM THE LOWER CRETACEOUS (APTIAN) OF ZULULAND

By

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Cape Town Kaapstad

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(With 1 figure)

[*MS accepted 12 September 1989*]

ABSTRACT

Trigonia (Rutitrigonia) pongolensis Rennie lacks the characters of *Rutitrigonia*, and is made the type species of the new genus *Zulutrigonia*. Other species to be referred here include *T. krenkeli* Lange and *T. kigombana* Aitken from the Neocomian–Aptian of Tanzania.

CONTENTS

INTRODUCTION

In a benchmark paper representing a marked departure from the conservative taxonomy of that period, Van Hoepen (1929) introduced a number of subfamilies and genera for trigoniid bivalves from the Cretaceous of Zululand. Among these was the genus *Rutitrigonia*, introduced for *R. peregrina* van Hoepen from the upper Middle or low Upper Albian. This taxon formed the basis for the monogeneric subfamily Rutitrigoniinae van Hoepen, corresponding broadly with the Excentrica group of Lycett (1879).

Van Hoepen's (1929) bold taxonomy failed to make immediate impact, and *Rutitrigonia* was reduced to a subgenus of *Trigonia* by Rennie (1936), whereas Cox (1952) and Aitken (1961) treated it as a subgenus of *Megatrigonia*. However, Crickmay (1932), Kobayashi (1957), Saveliev (1958), Nakano (1961, 1963, 1965, 1977), Cox (1969), Poulton (1977, 1979) and Reyes & Pérez (1978) have all used *Rutitrigonia* as a valid genus, and it is now widely accepted.

In addition to the type species, the following species have also been assigned to *Rutitrigonia*: *R. affinis* (Sowerby), *R. agrioensis* (Weaver), *R. amagensis* (Kobayashi), *R. beyrichi* (Krumbeck), *R. beyschlagi* (Müller), *R. bornhardti* (Müller),

Ann. S. Afr. Mus. **99** (3), 1990: 23–29, 1 fig.

R. coquandiana (d'Orbigny), *R. dietrichi* (Lange), *R. dunscombensis* (Lycett), *R. excentrica* (Parkinson), *R. jacksonensis* (Packard), *R. janenschi* (Lange), *R. kigombana* (Aitken), *R. laeviuscula* (Lycett), *R. lerchi* (Hill), *R. longa* (Agassiz), *R. mesembris* (Tenison-Woods), *R. niongalensis* (Lange), *R. nossae* Aitken, *R. nyangensis* Aitken, *R. pongolensis* (Rennie), *R. sanchuensis* (Nakano), *R. schwarzi* (Müller), *R. semiculta* (Forbes), *R. skorkovensis* Pugaczewska, *R. syrdariensis* (Archangelsk'ii), *R. weaveri* (Stoyanow), and *R. yeharai* Kobayashi.

In introducing the new species *Trigonia (Rutitrigonia) pongolensis*, Rennie (1936: 358) noted that '. . . It is not without some hesitation that I associate with *Rutitrigonia* the species *T. pongolensis* sp. nov. and *T. krenkeli*. The concentric ribbing of the neanic stage is of such a character in both these species as to exclude them from *Indotrigonia* in spite of adult similarities, and *Rutitrigonia* is the only term available for species of *Trigonia* having features at all like those of the last two species.'

Nakano (1963) excluded *Trigonia (Rutitrigonia) pongolensis* Rennie from his concept of *Rutitrigonia* because of its coarse oblique flank costae, referring it instead to *Megatrigonia*. Subsequently, he identified it (Nakano 1965) as *Megatrigonia? pongolensis* (Rennie).

Given the large number of *Rutitrigonia* species now known, it is clear that *Trigonia pongolensis* and its allies can no longer be accommodated satisfactorily in this genus. It is proposed, therefore, to introduce a new genus for these forms.

SYSTEMATIC DESCRIPTION

Superfamily TRIGONIACEAE Lamarck, 1819

Family **Trigoniidae** Lamarck, 1819

Subfamily Rutitrigoniinae van Hoepen, 1929

Diagnosis

Shell small to moderately large, subovate to pyriform, subtrigonal and subtrapezoidal. Typically with inner and marginal carina lacking, resulting in poor discrimination between the smooth escutcheon and area. The latter is ornamented only in the nepionic stages and may be weakly bipartite. In some taxa there is a more or less prominent umbonal ridge. Nepionic ornament comprises concentric costae that pass uninterrupted on to the area where they weaken across the longitudinal furrow. Later flank ornament comprises costae that are subconcentric anteriorly, but posteriorly may be subconcentric, strongly oblique, or effaced.

Discussion

The origins of *Rutitrigonia* are cryptic. It first appears in the Bathonian of East Africa (Venzo 1942), and its ancestry has been linked to the myophorelline *Frenguelliella* (Kobayashi 1957; Nakano 1963). However, it seems to be Gondwanic in origin and there is a noteworthy similarity with primitive *Anditrigonia* species such as the Lower Callovian *A. keideli* (Weaver) (*cf.* Leanza & Garate, 1987, pl. 3 (fig. 1)). Like Van Hoepen (1929) and Cox (1952), the writer considers the Megatrigoniinae and Rutitrigoniinae to be closely allied; they are here regarded as sister taxa.

Genus *Zulutrigonia* gen. nov.

Type species. Trigonia (Rutitrigonia) pongolensis Rennie, 1936; by original designation herein.

Diagnosis

Shell medium sized, subtrapezoidal, with inconspicuous subterminal umbones and opisthogyrous beaks. Anterior margin weakly convex, posterodorsal margin almost straight and respiratory margin obliquely truncate. Escutcheon narrow, indistinct, not sunken. Broad subtrigonal area essentially flat, meeting the posterodorsal commissure in an acute angle, so that the shell is fastigiate (roof-shaped) posteriorly. Ornament comprises coarse, robust, relatively sparse costae that are subconcentric anteriorly and curve strongly upwards posteriorly, cutting obliquely across the growth striae. Age: Lower Cretaceous (Neocomian–Aptian).

Discussion

Zulutrigonia gen. nov. is distinguished from *Rutitrigonia* by its subtrapezoidal outline, with subterminal umbones, almost straight posterodorsal margin and obliquely truncate siphonal margin. In addition, the shell is fastigiate posterodorsally, due to the broadly flattened areas meeting the commissure at an acute angle, and the coarse, robust flank costae curve strongly upwards posteriorly.

There are noteworthy similarities between *Zulutrigonia* gen. nov. and *Buchotrigonia* (*Syrotrigonia*) (Cox, 1952). Both are characterized by moderate inflation, subterminal umbones, a straight posterodorsal margin and obliquely truncate respiratory margin, an inconspicuous to near-obsolete escutcheon, and broad flattened areas that produce a strongly fastigiate profile to the shell posterodorsally. The concentric ornament of the nepionic and middle growth stages is identical. *Syrotrigonia* may be distinguished, however, by its more ovate outline, the possession of a marginal carina that becomes a tuberculate umbonal ridge in maturity, the presence of a broad shallow antecarinal sulcus in maturity across which ribbing weakens or is effaced, and the generally V-shaped costae of the adult. Significantly, however, the V-shaped costae are far from uniformly developed and in some individuals examined they simply bend strongly upwards as in *Zulutrigonia* gen. nov. Similarly, the strong marginal carina that was emphasized in the original diagnosis is not a true carina (the latter is restricted to the nepionic stages) but an umbonal ridge whose prominence is enhanced by the bounding antecarinal sulcus. Initially the tubercles on this ridge are no more than rib endings that are emphasized by the weakening of ornament across the antecarinal sulcus. Whether the similarities are due to phylogeny or are the result of convergence is, at present, unclear. *Syrotrigonia* is here elevated to full generic status because *Buchotrigonia* has radial flank costae in the early to middle growth stages, an internally crenulated posteroventral margin and transverse costellae to the escutcheon (*cf.* Pérez & Reyes 1980), characters that ally it with the Apiotrigoniinae and Pterotrigoniinae.

Zulutrigonia pongolensis (Rennie, 1936)

Fig. 1A–E

Trigonia (Rutitrigonia) pongolensis Rennie, 1936: 359, pl. 41 (figs 5–6), pl. 42 (figs 5–7).
Megatrigonia (Rutitrigonia) pongolensis (Rennie) Cox, 1952: 59.
Megatrigonia pongolensis (Rennie) Nakano, 1963: 527.
Megatrigonia? pongolensis (Rennie) Nakano, 1965: 17.

Type material

The holotype, SAM–PCZ8528, and paratype, SAM–PCZ8529, both in the South African Museum, Cape Town.

Type locality

The material was collected by Drs S. H. Haughton and A. W. Rogers along the Mfongosi stream, a tributary of the Pongola, at their locality Z2. It is from the Mlambongwenya Formation (Cooper & McCarthy 1988), which here is of late Aptian age and corresponds broadly with Locality 164 of Kennedy & Klinger (1975).

Description

Shell medium sized (maximum length about 60 mm), longer than high (H/L = 0,73–0,80), subtrapezoidal, with low subterminal umbones and incurved opisthogyrous beaks. The valves are moderately inflated (W/L = 0,20–0,22) and maximum inflation is just behind the umbones. The broad, weakly curved anterior margin is subvertical and curves evenly into the long, almost straight, ventral margin. The broad, obliquely truncate respiratory margin meets the straight posterodorsal margin in a very obtuse angle. The dorsal and ventral margins are subparallel.

The smooth, narrow, flat, lanceolate escutcheon is poorly discriminated and can be distinguished from the area only in the nepionic stages when it is ornamented. Marginal and inner carinae are lacking, but an umbonal ridge marks the position of the marginal carina. The broad subtrigonal area is weakly concave, almost flat, and with an indistinct longitudinal groove. It forms an acute angle with the opposing area at the posterodorsal commissure so that the posterodorsal part of the shell is fastigiate (roof-shaped).

The ornament of the nepionic stages comprises coarse concentric costae, broader than the interspaces, which flex slightly at the umbonal ridge before crossing onto the area. The ribs thin noticeably where they cross the longitudinal groove. Later flank costae are coarse, robust, relatively distant and slightly

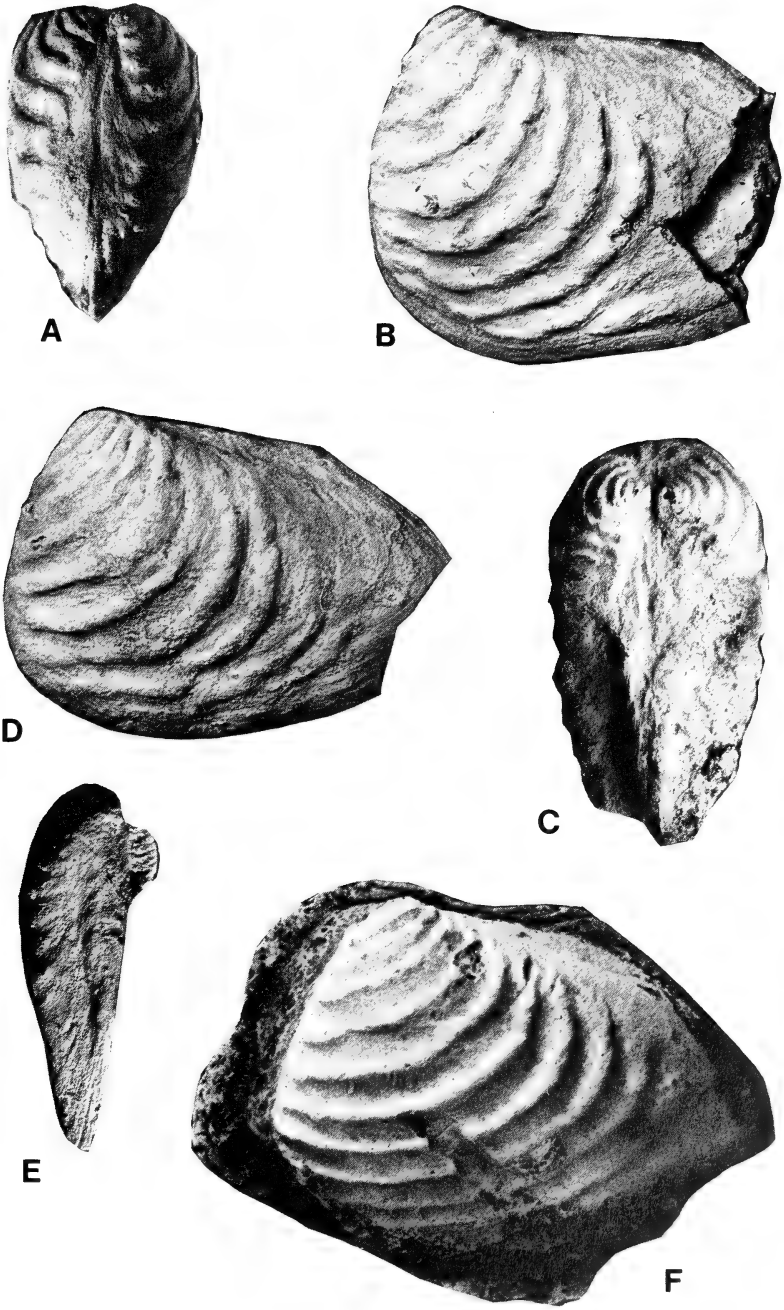

Fig. 1. A–E. *Zulutrigonia pongolensis* (Rennie). A–C. Anterior, lateral and dorsal views of the paratype, SAM–PCZ8529. D–E. Lateral and dorsal views of the holotype, SAM–PCZ8528. F. *Zulutrigonia krenkeli* (Lange). A plastercast of the holotype, in the South African Museum. All × 1.

narrower than the interspaces. They are subconcentric anteriorly but curve strongly upwards to the posterior, cutting the growth striae obliquely and approaching the area almost at right angles. In the middle growth stages the ribs terminate at the umbonal ridge but in maturity they weaken and become effaced before reaching the area. The flank costae become obsolete on the anterolateral shoulders, leaving the narrow anterior face crossed only by growth striae.

Discussion

Other species to be assigned to *Zulutrigonia* include the Tanzanian *Trigonia krenkeli* Lange (1914: 230, pl. 20 (fig. 2)) and *T. kigombana* Aitken (1961: 95, pl. 13 (fig. 3)), both from the *Rutitrigonia schwarzi* Beds of the Tendaguru succession and thus of Hauterivian age.

Zulutrigonia krenkeli (Lange) (1914: 230, pl. 20 (fig. 2)) (Fig. 1F) differs from *Z. pongolensis* in having dorsal and ventral margins that converge posteriorly and with a lower, less-fastigiate posterodorsal profile.

Zulutrigonia kigombana (Aitken) (1961: 95, pl. 13 (fig. 3)) differs from *Z. pongolensis* in being strongly produced posteriorly, with a gently concave posterodorsal margin, and with the posterior one-third of the flanks unornamented.

Trigonia inca Fritzsche (1921: 49, pl. 3 (figs 1–3)) from the Barremian of northern Peru shows some similarity to *Zulutrigonia*. However, its flank costae form distinct chevrons in maturity and hence it may be a *Syrotrigonia* (Etayo-Serna 1985; Pérez & Reyes 1986).

Occurrence

Zulutrigonia pongolensis (Rennie) is currently known only from the late Aptian of northern Zululand.

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Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers.

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach, Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

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(a) The Figures, Maps and Tables of the paper when referred to in the text
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Name of new genus or species is not to be included in the title; it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

MICHAEL R. COOPER

A NEW GENUS OF RUTITRIGONIINAE (BIVALVIA, TRIGONIACEA) FROM THE LOWER CRETACEOUS (APTIAN) OF ZULULAND

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CAPE TOWN

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Bullough, W. S. 1960. *Practical invertebrate anatomy*. 2nd ed. London: Macmillan.

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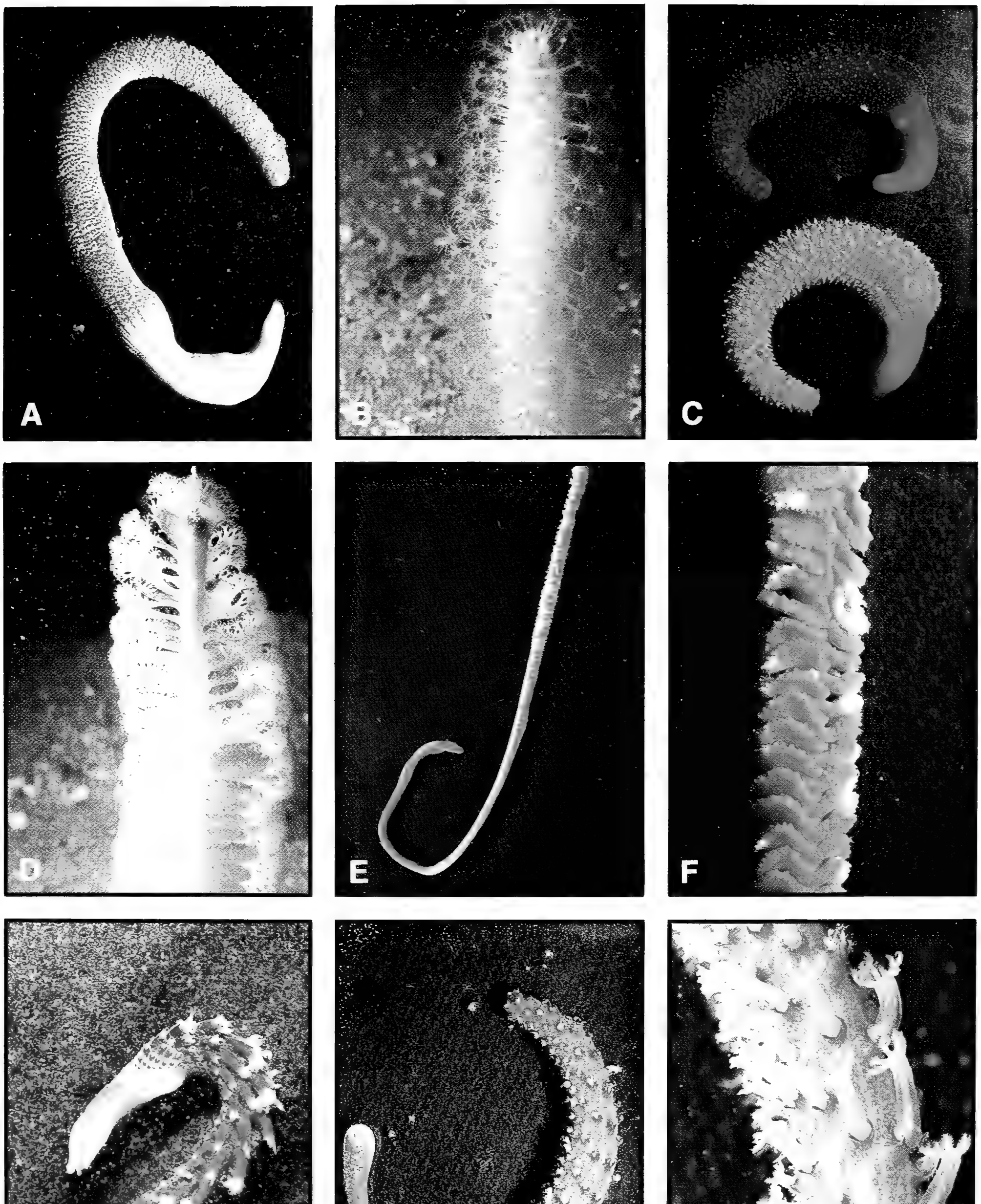

Fig. 1. Pennatulaceans of southern Africa. A–C. *Actinoptilum molle* Kükenthal, 1910). D–F. *Virgularia schultzei* Kükenthal, 1910. G. *Echinoptilum echinatum* (Kükenthal, 1910). H–I. *Echinoptilum macintoshii* Hubrecht, 1885.

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By
GARY C. WILLIAMS

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THE PENNATULACEA OF SOUTHERN AFRICA (COELENTERATA, ANTHOZOA)

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(With 41 figures)

[*MS accepted 29 April 1988*]

ABSTRACT

Nineteen species of pennatulacean octocorals from sublittoral and bathyal regions of southern African coastal waters are described and illustrated. Six additional species that are recorded in the literature are mentioned, although material was not available for examination. Two of these, *Cavernulina cylindrica* and *Virgularia juncea*, are considered dubious records and are not included in the faunal list provided for the region. Presumably young or partial colonies or problematic taxa representing seven genera (*Cavernulina*, *Kophobelemnon*, *Scleroptilum*, *Calibelemnon*, *Virgularia*, *Halipteris*, and *Pteroeides*) are not identified to species but are mentioned in the text and included in the list of species. A total of 23 determined and at least seven undetermined species representing 20 genera in 12 families are recorded. Three species that have been recorded from Angola, which is north of the geographic limit of this paper, are also mentioned: *Virgularia tuberculata*, *Pteroeides griseum*, and *Crassophyllum cristatum*; these may possibly be encountered further south.

Fourteen new geographic records are established, including the first southern African records for the following ten genera: *Cavernulina*, *Echinoptilum*, *Kophobelemnon*, *Distichoptilum*, *Scleroptilum*, *Calibelemnon*, *Chunella*, *Amphiacme*, *Scytaliopsis*, and *Halipteris*.

Scanning electron micrographs of sclerite form or axial morphology are presented for many species. A key is provided to all species treated in the present work. A brief discussion of faunistic considerations is also included.

CONTENTS

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Ann. S. Afr. Mus. **99** (4), 1990: 31–119, 41 figs.

INTRODUCTION

At present, octocoral classification is frequently an equivocal and disputatious field (Weinberg 1976: 63). It is clear that our knowledge concerning this group is far from adequate; a great deal of research needs to be accomplished in order to attain the goal of a world-wide synthesis of the biology and classification of octocorals (Bayer 1981*a*: 11). A substantial amount of confusion has arisen in the literature because of a general lack of knowledge concerning variability; some octocoral species can be exceedingly variable and many authors have described species or even genera based on intraspecific variants. Extensive collecting in many different geographical localities and detailed comparison of material is needed to assess the degree of variation in many taxa due to genetic, geographical, or ecological differences.

The goal of the present study of the systematics and faunistics is to contribute toward a world-wide synthesis of the classification and distribution of octocorals by concentrating on a localized fauna that has been previously only minimally to moderately known. This work is the first of four proposed parts describing the octocorals of southern Africa. Subsequent papers will deal with additional species of pennatulaceans from the Cape, Transkei and Zululand; stoloniferous octocorals and soft corals (families Clavulariidae, Tubiporidae, Coelogorgiidae, Alcyoniidae, and Nephtheidae); and the shallow-water gorgonians (families Anthothelidae, Melithaeidae, Keroeididae, Acanthogorgiidae, Plexauridae, Gorgoniidae, Ellisellidae, Chrysogorgiidae, Primnoidae, and Isididae). The four papers together will attempt to synthesize our knowledge of southern African octocorals. The studies exclude the deep-water gorgonians, primarily of the families Ellisellidae, Primnoidae, and Chrysogorgiidae, groups that are less well known regionally or that require large-scale revisions before accurate identifications can be made. Many octocoral species that have been collected still need to be identified and new species are continually being discovered.

The present work is intended not only for specialists in the field of octocoral systematics but also as a guide for other biologists, e.g. ecologists, fisheries biologists and biogeographers, who share the common need to identify material from benthic surveys and other studies. Southern African octocorals are of interest to non-specialists, since they comprise such a major part of the shallow-water benthic fauna. Therefore, sections have been added to the texts of these papers that would not normally be included in a work intended solely for specialists. These include brief diagnoses of the families and genera, sections on general characteristics of the octocoral groups, and illustrations of the entire colonies of all species, as well as figures depicting diagnostic features, sclerites, and other features.

The monograph by Kükenthal (1915) remains the most comprehensive work on pennatulaceans of the world and is certainly the most thorough account up to that time. Modern revisions of many of the genera are obviously needed. Other major reviews on sea pens are mainly monographs produced from the large oceanographic expeditions of the past and include Kölliker (1872*a*, 1872*b*), Kölliker (1880) (Challenger), Danielssen & Koren (1884) (Norwegian North Atlantic), Kükenthal & Broch (1911) (Valdivia), Hickson (1916) (Siboga), and Broch (1958*b*) (Discovery). Thomson (1915, 1917) described the pennatulacean fauna of South Africa known at that time and Bayer (1956) reviewed the known world genera. Tixier-Durivault (1954, 1960, 1961*a*, 1966*b*, 1972) and Tixier-Durivault & D'Hondt (1974) described material from South Africa, Mozambique, Angola, and Madagascar (including neighbouring islands). General accounts of the biology of sea pens are by Hickson (1909) and Hyman (1940). More recently, the distribution and taxonomy of pennatulaceans has been reported on by Pasternak (1960, 1961*a*, 1961*b*, 1962, 1964, 1970, 1975*a*, 1975*b*, 1980), Grasshoff (1972, 1981, 1982*a*, 1982*b*), and D'Hondt (1984*a*, 1984*b*).

Bayer (1981*a*: 7) classified various geographic regions of the world into four general categories of taxonomic knowledge pertaining to octocorals: essentially complete; moderately well known; poorly known; and minimally known. He considered South Africa, in the region of the Cape of Good Hope, to be moderately well known and described this category as follows: 'where there is extensive literature, but many more species remain to be described and taxonomic problems to be solved, and the major patterns of distribution must yet be worked out. Much descriptive work remains to be done before ecological and experimental studies can proceed at an effective level'. The rest of southern Africa is less well known and certain regions fall into Bayer's latter categories—being poorly or even minimally known. Two such regions include the Atlantic coast between 20°S and 33°S, and the northern Natal–southern Mozambique region of the Indian Ocean between 20°S and 29°S.

Southern Africa is here defined as the African coastal region that lies south of 20°S—an arbitrary limit used by Millard (1978) in a zoogeographical analysis of southern African hydroids, which are another diverse and widespread benthic group. This region extends from the Skeleton Coast of Namibia in the Atlantic, round the coast to the vicinity of Beira, Mozambique, in the Indian Ocean. Material examined in the present work was obtained throughout this range from the continental shelf, slope and rise, and from the littoral to depths of 3 000 m.

The island of Madagascar is not included here, since its affinities are strictly Indo-Pacific and not directly associated with the southern African fauna.

Pennatulaceans from geographical regions marginal or in proximity to the area of the present study have been described by Broch (1958*b*) and Tixier-Durivault (1961*a*, 1963) for Angola, and Tixier-Durivualt (1966*b*, 1972) and Tixier-Durivault & D'Hondt (1974) for Madagascar.

Of the 14 presently recognized pennatulacean families of the world, 12 (or 86 %) are represented in southern Africa, and of the 34 world genera, at least 20 (or 59 %) are known from this region. The only families not represented in the regional fauna are two monogeneric ones: the Renillidae—genus *Renilla* Lamarck, 1816, with four or five species restricted to South America and the southern part of North America; and the Stachyptilidae—genus *Stachyptilum* Kölliker, 1880, with three species presumably restricted to warmer parts of the Pacific Ocean.

The classification system used in this study at the subordinal and familial levels conforms to Kükenthal (1915) and Bayer (1956). Terminology conforms to the trilingual glossary of Bayer *et al.* (1983). All illustrations, photographs, and scanning electron micrographs are by the author. The abbreviation 'Lit.!' in a synonymy indicates where a complete or more detailed synonymy can be found. The notation *non* in the synonymies indicates a misidentification by the author cited; *partim* indicates 'in part'.

Characteristics of the Pennatulacea

The pennatulaceans, or sea pens, are considered a very distinct and greatly specialized group of octocorallian cnidarians (Hickson 1909: 358; 1930*b*: 229; Bayer 1956: 181). Unlike other octocorals, pennatulacean colonies are formed by a very large polyp, the oozooid (also known as the axial, initial, principal, or primary polyp), that by lateral budding of its body walls gives rise to all the secondary zooids of the colony. The oozooid forms a fleshy, unbranched peduncle to anchor the colony by peristaltic contractions in soft substrata such as mud, sand, or abyssal-ooze deposits. The polyps of an individual colony (excluding the oozooid) are always dimorphic, more rarely trimorphic; the distal region of the oozooid forms a rachis bearing several to many daughter polyps, which take the form of autozooids, siphonozooids, and sometimes mesozooids. Disregarding the oozooid, the autozooids (Fig. 11E) are the largest polyps in polymorphic colonies and possess eight well-developed tentacles and mesenteries; these are the feeding polyps of the colony. Siphonozooids (Fig. 11C) are much smaller than autozooids and have strongly developed siphonoglyphs that produce currents for internal water circulation; the tentacles are reduced or absent. Mesozooids (Fig. 32B, D) are polyps that are intermediate in structure between autozooids and siphonozooids.

In colonies with bilateral symmetry and well-developed polyp leaves (such as *Virgularia*, *Pennatula*, and *Pteroeides*), the dorsal side refers to the side of the rachis adjacent to the oldest (usually largest) autozooids, where the rachis appears mostly bare and uncovered by the polyp leaves; hence, the ventral side refers to the side of the rachis opposite to the dorsal side, where the polyp leaves cover most or all of the rachis surface.

Characteristics that are important in the classification of pennatulaceans include the form, number, and arrangement of autozooids; distribution of siphonozooids; the colonial symmetry, growth form, and axial development; and form and distribution of sclerites. Pennatulacean sclerites differ from those of other octocorals by commonly being smooth and unsculptured, sometimes grooved or three-flanged, with tubercles usually absent but, if present, then simply knobby or rounded, not thorny or elaborate.

MATERIALS AND METHODS

Recently procured material was collected by means of SCUBA, dredge, or beam trawl. Colonies were relaxed in a solution of magnesium chloride mixed with sea-water and preserved in 70 per cent ethanol. Small and fragile specimens were first fixed in 10 per cent formalin before transfer to ethanol. Sclerites and axial fragments were isolated by dissolving tissue in concentrated sodium hypochlorite, with repeated rinsing in water and finally in ethanol. Minute sclerites were pipetted from alcohol suspension and dropped on to stubs that had circular pieces of exposed and developed black-and-white photographic paper glued to them. After evaporation of the alcohol, the sclerites adhered well to the paper surface. Large sclerites and fragments of axial material were applied directly to the stub surface with SEM glue. Specimens were coated with gold/palladium (Au/Pd). Cambridge S200 and S180 scanning electron microscopes were used to examine sclerites and axial fragments.

All material examined is housed in the marine invertebrate collection of the South African Museum (SAM), Cape Town.

SYSTEMATIC ACCOUNT

KEY TO THE FAMILIES OF PENNATULACEA FROM SOUTHERN AFRICA

1A. Adjacent polyps free, not fused to any degree. 2
1B. Proximal portions of adjacent polyps fused to some degree, forming polyp leaves or raised ridges, or joined only at the bases 9
2A. Polyps crowded and distributed on all sides of rachis, or rachis with a single longitudinal furrow or V-shaped region without polyps 3
2B. Polyps confined to a terminal cluster, arranged biserially along rachis, or in groups of two to four arranged sparsely along rachis 4
3A. Polyps without calyces . . . . **Veretillidae**
3B. Polyps with non-retractile bifurcated calyces . . . . **Echinoptilidae**
4A. Polyps arranged in a terminal cluster at the end of a long slender stalk . . . . **Umbellulidae**
4B. Polyps arranged along the sides of the rachis. 5
5A. Colonies clavate, distal portion of rachis distinctly wider than rest of colony . . . . **Kophobelemnidae**
5B. Colonies not clavate, but are long, thin and whip-like or staff-like 6

6A. Polyps numerous (>40) and contiguous, arranged in two longitudinal series along rachis. Sclerites dense. Polyps retractile into calyces. 8
6B. Polyps few (<40), arranged sparsely in clusters of 2–4 at intervals along rachis. Calyces and sclerites not apparent. 7
7A. Polyp pairs 10–20. Intervals between polyp pairs <10 mm . . **Scleroptilidae**
7B. Polyp clusters <5. Intervals between clusters of 1–4 polyps is >20 mm . . . . **Chunellidae**
8A. Calyx with eight terminal teeth . . . . **Funiculinidae**
8B. Calyx with 0–6 terminal teeth. . . . . **Protoptilidae**
9A. Polyps non-retractile, calyces absent. Adjacent polyps united at their bases only, not forming polyp leaves or raised ridges . . . . **Anthoptilidae**
9B. Polyps retractile into calyces or into margins of fleshy polyp leaves or raised ridges 10
10A. Polyps have tubular calyces with eight terminal teeth . . . . . . **Pennatulidae**
10B. Polyps have calyces with two terminal teeth, or calyces absent 11
11A. Polyp leaves stiffened with large white needle-like sclerites up to 10 mm that form projecting supporting rays . . . . **Pteroeididae**
11B. Polyp leaves soft without sclerites, or polyps arranged in raised ridges with calyces having two terminal teeth . . . . **Virgulariidae**

KEY TO THE SPECIES OF PENNATULACEA FROM SOUTHERN AFRICA

1A. Adjacent polyps free, not united to any degree. Individual polyps arise directly from the surface of the rachis (e.g. Fig. 11A) 2
1B. Proximal portions of adjacent polyps fused to some degree, often forming flattened expansions (polyp leaves, e.g. Fig. 32A, D), raised ridges or swellings that emanate laterally from the rachis (e.g. Fig. 30B, D), or joined only at their bases with major portions of polyps free (e.g. Fig. 17B) 20
2A. Polyps crowded and distributed evenly on all sides of rachis, or rachis with a single longitudinal furrow or elongate V-shaped region devoid of polyps. Colony radially symmetrical or somewhat bilaterally symmetrical, capitate, clavate, or digitiform 3
2B. Polyps restricted to a limited portion of rachis, arranged biserially along rachis, or concentrated in a terminal cluster, or in groups of two to four distributed sparsely along rachis 11
3A. Polyps without calyces 4
3B. Polyps with non-retractile bifurcated calyces 9
4A. Sclerites are smooth ovals, rods that are bilobed or branched at the ends, or spindles up to 0,4 mm in length. Colonies clavate or capitate 5
4B. Sclerites are small flat plates (<0,1 mm in length) medially constricted with rounded ends or with terminal denticles. Colonies cylindrical to elongate clavate 7
5A. Rachis sclerites are primarily rods with bilobed or branched ends . . . . *Cavernulina* sp.

5B. Rachis sclerites are ovals or spindles that are usually not bilobed or branched 6
6A. Internal axis absent. Sclerites are mostly spindles . . . *Cavernularia elegans*
6B. Internal axis present. Sclerites are mostly ovals . . . . *Cavernularia dayi*
7A. Colonies elongate clavate. Sclerites are small biscuit-shaped plates, many with terminal denticles . . . . *Lituaria valenciennesi*
7B. Colonies cylindrical or elongate clavate. Sclerites are flat plates with medial constrictions and smooth, rounded ends 8
8A. Colonies plump and cylindrical with stalk shorter than rachis. Siphonozooids aligned in longitudinal rows. Colour yellowish to orange-yellow . . . . *Veretillum cynomorium*
8B. Colonies long and narrow, clavate, with stalk equal to or longer than rachis. Siphonozooids not aligned in longitudinal rows. Colour cream to greyish-white . . . . *Veretillum leloupi*
9A. Colonies radially symmetrical; polyps evenly distributed and covering all sides of rachis. Calyces often not conspicuous with unaided vision. Colonies usually straight or sometimes curved . . . . *Actinoptilum molle*
9B. Colonies bilaterally symmetrical; rachis curved, concave side with longitudinal furrow or V-shaped region near base of rachis free of polyps. Calyces conspicuous giving colony a spiny appearance 10
10A. Calyx length approximately three times the width. Calyx teeth long and thin, lanceolate. Peduncle sclerites are small ovals 0,04–0,15 mm in length. Colour of rachis often brick-red or deep reddish-purple . . . . *Echinoptilum echinatum*
10B. Calyx length approximately twice the width. Calyx teeth conical or deltoid. Peduncle sclerites are rods or spindles 0,07–0,47 mm in length. Colour of rachis orange to reddish-brown . . . . *Echinoptilum macintoshii*
11A. Polyps arranged in a terminal cluster at the distal end of a long naked peduncle 12
11B. Polyps arranged along the sides of the rachis 13
12A. Polyps and distal portion of stalk with sclerites . . . . . *Umbellula thomsoni*
12B. Colony lacking sclerites altogether . . . . *Umbellula lindahli*
13A. Colonies clavate, distal portion of rachis wider than rest of colony; terminal end obtuse. Polyps large (>10 mm), non-retractile, without calyces . . 14
13B. Colonies not clavate, but are long, thin and uniform. Distal portion of rachis not wider than rest of colony 15
14A. Polyps 2 or 3 near terminal end of rachis . . . . *Kophobelemnon* sp.
14B. Polyps numerous and arranged biserially along rachis . . . . *Kophobelemnon stelliferum*
15A. Polyps numerous (usually >40) and contiguous, arranged along rachis in two longitudinal series. Polyps retractile into distinct calyces 16
15B. Polyps few (<40), arranged sparsely in clusters or whorls of 2–4 at intervals along rachis. Calyces absent 18
16A. Calyx with 2–8 terminal teeth 17

16B. Calyx without terminal teeth . . . . *Scleroptilum* sp.

17A. Calyx with eight terminal teeth . . . . *Funiculina quadrangularis*

17B. Calyx usually with 2–6 terminal teeth. . . . . *Distichoptilum gracile*

18A. Polyps number 20–40, generally arranged in 10–20 pairs with 5–7 mm intervals of bare rachis between each pair. Colonies very delicate, usually <120 mm in length . . . . *Calibelemnon* sp.

18B. Polyps fewer than 15. Generally <7 polyp clusters per colony with intervals between clusters >20 mm. Mature colonies >120 mm in length. 19

19A. Polyps of rachis arranged in pairs. Distal end of colony with a single, well-developed, somewhat asymmetrical terminal polyp. . . . . *Amphiacme abyssorum*

19B. Polyps of rachis in clusters of one to four, but usually three. Distal end of colony with terminal polyp highly reduced or absent . . *Chunella gracillima*

20A. Polyps non-retractile, without calyces. Sclerites not evident. Adjacent polyps united at their bases only, major portion of polyps are free . . . . *Anthoptilum grandiflorum*

20B. Polyps retractile into conspicuous calyces or into margins of fleshy polyp leaves. Fused proximal portions of adjacent polyps form prominent polyp leaves, ridges, or basal swellings which emanate laterally from rachis in two longitudinal series 21

21A. Polyps arranged in short oblique rows of four to six polyps in two longitudinal series. Adjacent polyps united at their bases only, often forming a common raised ridge or basal swelling. Polyps possess calyces that each have two terminal teeth . . . . *Halipterus africana*

21B. Adjacent polyps united most of their length to form distinct and flattened lateral expansions (polyp leaves) that emanate from the rachis 22

22A. Colonies lack visible sclerites (sclerites too small to be seen with unaided eye). Peduncles usually thin and flexible or limp and worm-like 23

22B. Colonies with numerous and conspicuous sclerites (sclerites easily seen with unaided eye). Peduncles thick and rigid 26

23A. Polyps usually 5–12 per leaf. Polyp leaves sparsely arranged, with conspicuous intervals of bare rachis between leaves 24

23B. Polyps >12 per leaf. Polyp leaves densely situated, often overlapping one another with little or no interval of bare rachis between leaves. 25

24A. Polyps never more than five per leaf. Peduncle somewhat stiff. Adjacent polyps of a particular leaf gradually become larger from the innermost to the outermost polyp. Gradual transition between peduncle and rachis . . . . *Scytaliopsis djiboutiensis*

24B. Polyps 5–12 per leaf. Peduncle long and thin, vermiform. All polyps of a given leaf approximately same size. Peduncle and rachis abruptly delimited . . . . *Virgularia mirabilis*

25A. Polyps 50–200 per leaf . . . . *Virgularia gustaviana*

25B. Polyps 15–35 per leaf . . . . *Virgularia schultzei*

26A. Polyps possess tubular calyces with eight terminal teeth and dense sclerites of three-flanged spindles. Sclerites usually orange in colour. . . . . *Pennatula inflata*

26B. Polyps retract directly into outer margin of polyp leaf. Sclerites of polyp leaves are white or transparent spine-like needles up to 10 mm in length that align to form projecting supporting rays. Sclerites not three-flanged. Colour of colonies pale yellowish-grey or brownish-grey . . . . . *Pteroeides isosceles*

LIST OF THE PENNATULACEA RECORDED FROM SOUTHERN AFRICA

Order PENNATULACEA Verrill, 1865

Suborder SESSILIFLORAE Kükenthal, 1915

Family **Veretillidae**

* *Lituaria valenciennesi* D'Hondt, 1984
Cavernulina sp.
* *Veretillum cynomorum* (Pallas, 1766)
* *Veretillum leloupi* Tixier-Durivault, 1960
Cavernularia dayi Tixier-Durivault, 1954
Cavernularia elegans (Herklots, 1858)

Family **Echinoptilidae**

Echinoptilum macintoshii Hubrecht, 1885
Echinoptilum echinatum (Kükenthal, 1910)
Actinoptilum molle (Kükenthal, 1910)

Family **Kophobelemnidae**

Kophobelemnon stelliferum (Müller, 1776)
Kophobelemnon sp.

Family **Anthoptilidae**

Anthoptilum grandiflorum (Verrill, 1879)

Family **Funiculinidae**

* *Funiculina quadrangularis* (Pallas, 1766)

Family **Protoptilidae**

Distichoptilum gracile Verrill, 1882

Family **Scleroptilidae**

Scleroptilum sp.
Calibelemnon sp.

* Literature records only; material not available for examination.

Family **Chunellidae**

Chunella gracillima Kükenthal, 1902
Amphiacme abyssorum (Kükenthal, 1902)

Family **Umbellulidae**

Umbellula thomsoni Kölliker, 1874
Umbellula lindahli Kölliker, 1874

Suborder SUBSELLIFLORAE Kükenthal, 1915

Family **Virgulariidae**

Subfamily Virgulariinae

Virgularia schultzei Kükenthal, 1910
Virgularia mirabilis (Müller, 1776)
Virgularia gustaviana (Herklots, 1863)
Virgularia sp.
Scytaliopsis djiboutiensis Gravier, 1906

Subfamily Balticininae

Halipteris africana (Studer, 1879)
Halipteris spp.

Family **Pennatulidae**

Pennatula inflata Kükenthal, 1910

Family **Pteroeididae**

Pteroeides isosceles Thomson, 1915
Pteroeides spp.

DESCRIPTIONS

Family **Veretillidae** Herklots, 1858

Colonies radially symmetrical without a trace of external bilateral symmetry. Colony cylindrical, clavate (club-shaped), or capitate (forming a head). Autozooids without calyces, completely retractile. Siphonozooids numerous between the autozooids. Axis developed to varying degrees: conspicuous, minute, or absent. Sclerites are plates, platelets, ovals, rods or spindles; none are three-flanged.

Distribution widespread in shallow tropical and subtropical seas, mostly from the Atlantic and Indo-Pacific, shallow sublittoral to approximately 190 m in depth. Five genera, four of which are included below, in addition to *Pollicella* Gray, 1870.

Genus *Cavernularia* Valenciennes *in* Milne Edwards & Haime, 1850

Veretillum: Philippi, 1835: 277. Gray, 1870: 28.
Cavernularia Valenciennes *in* Milne Edwards & Haime, 1850: 84. Kükenthal & Broch, 1911: 180 (Lit.!). Kükenthal, 1915: 12.
Sarcobelemnon Herklots, 1858: 25.
Stylobelemnon Kölliker, 1872*a*: 336. Balss, 1910: 79.
?*Fusticularia* Simpson, 1905: 561. Balss, 1910: 80.
?*Parabelemnon* J. A. Thomson & Simpson, 1909: 307.

Diagnosis

Colonies cylindrical, clavate or capitate. Sclerites are smooth ovals, rods or spindles; many are irregular in shape. Siphonozooids numerous and minute (< 0,3 mm in diameter). Autozooids with or without sclerites. Axis variable; large to very small or absent. Colour usually white to cream, yellowish or greyish-white.

A genus of approximately 14 species. Indo-Pacific, west coast of Africa, Mediterranean Sea, and Bay of Biscay.

Type species. *Cavernularia obesa* Valenciennnes *in* Milne Edwards & Haime, 1850; Indian Ocean.

Cavernularia dayi Tixier-Durivault, 1954

Figs 2, 3, 38

Cavernularia Dayi Tixier-Durivault, 1954: 626, fig. 1.

Material

SAM–H3594 and SAM–H3595, off East London (33°02′S 27°56′E), 25–30 m, 16 July 1984, 6 specimens, dredge; G. C. Williams, R.V. *Meiring Naude*. SAM–H3817 and H3818, off Umlaas River, Natal (29°58′S 31°01′E), 50 m, 10 July 1985, 2 colonies, dredge; G. C. Williams, R.V. *Meiring Naude*.

Description

The colonies examined include three complete colonies, 23 mm, 30 mm and 70 mm in length, and five larger colonies, which have the proximal portions of the peduncles missing. These partial colonies are between 30 mm and 62 mm in length. Colonies club-shaped with tapering peduncle, length of which is 0,9–1,8 times the rachis length. Rachis conspicuously wider than peduncle. Autozooids concentrated on distal half of rachis; capable of complete retraction into rachis. Retracted autozooids less than 1,5 mm in diameter. Siphonozooids numerous, minute, *c*. 0,16 mm in diameter. Siphonozooids may extend down proximal portion of rachis, but are not conspicuous. Axis is a short rod (*c*. 8 mm long and 0,8 mm wide) in the centre of the proximal portion of the rachis. It is roughly circular in cross-section. The surface of the axis may be partially impregnated with oval sclerites. Axis length is less than 15 per cent of total colony length.

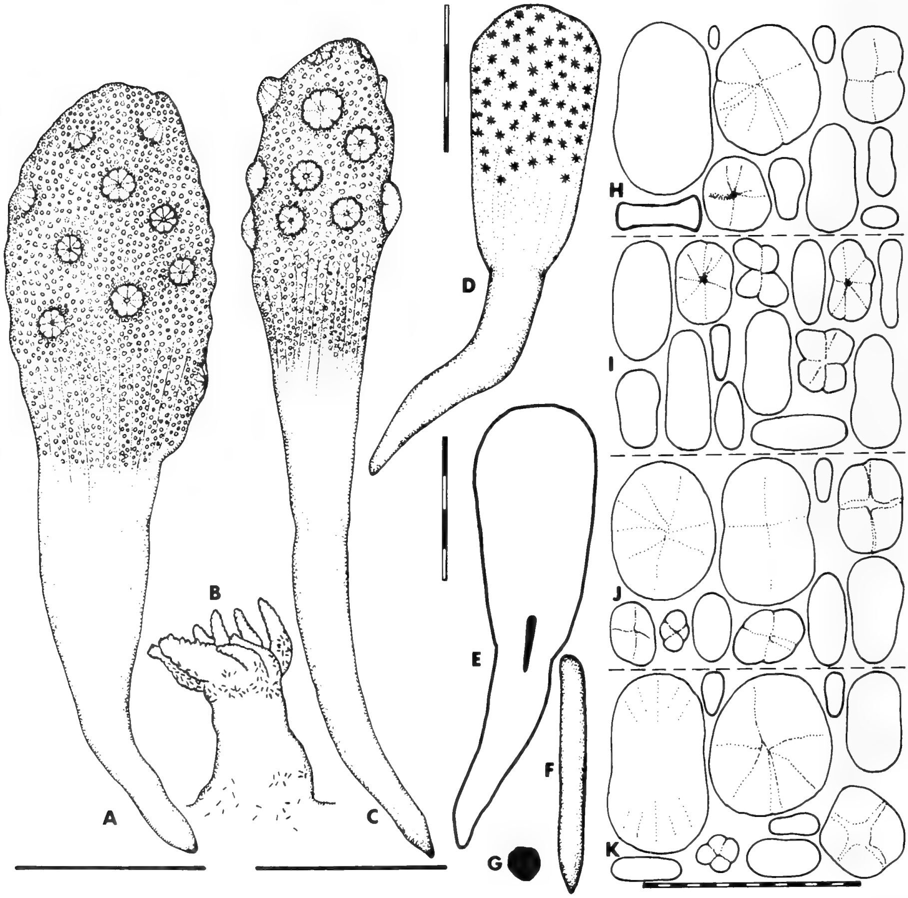

Fig. 2. *Cavernularia dayi*. A. Entire colony. Scale = 5 mm. B. Single autozooid showing placement of sclerites; polyp length 2,5 mm. C. Entire colony. Scale = 6 mm. D. Entire colony. Scale = 20 mm. E. Longitudinal section of a colony showing position of axis. Scale = 20 mm. F. Axis, length 8,0 mm. G. Cross section of axis, diameter 0,8 mm. H. Sclerites from surface of rachis. I. Sclerites from interior of rachis. J. Sclerites from surface of peduncle. K. Sclerites from interior of peduncle. Scale: H–K = 0,15 mm.

Sclerites are mostly small ovals, or elongate rods, usually 0,12 mm or less in length. They are present both in the rachis exterior and interior, as well as the peduncle exterior and interior. Some ovals may have a cross-pattern originating in the centre. Some sclerites of the rachis may be constricted in the middle with rounded or truncate ends. Sclerites are densely distributed, and are more or less consistent in shape throughout the colony. They vary from 0,02–0,13 mm in length. Autozooids may have a few scattered sclerites at the bases, extending up to less than one-third total length of polyp. The tentacles have many rod-like sclerites, 0,06 mm in length.

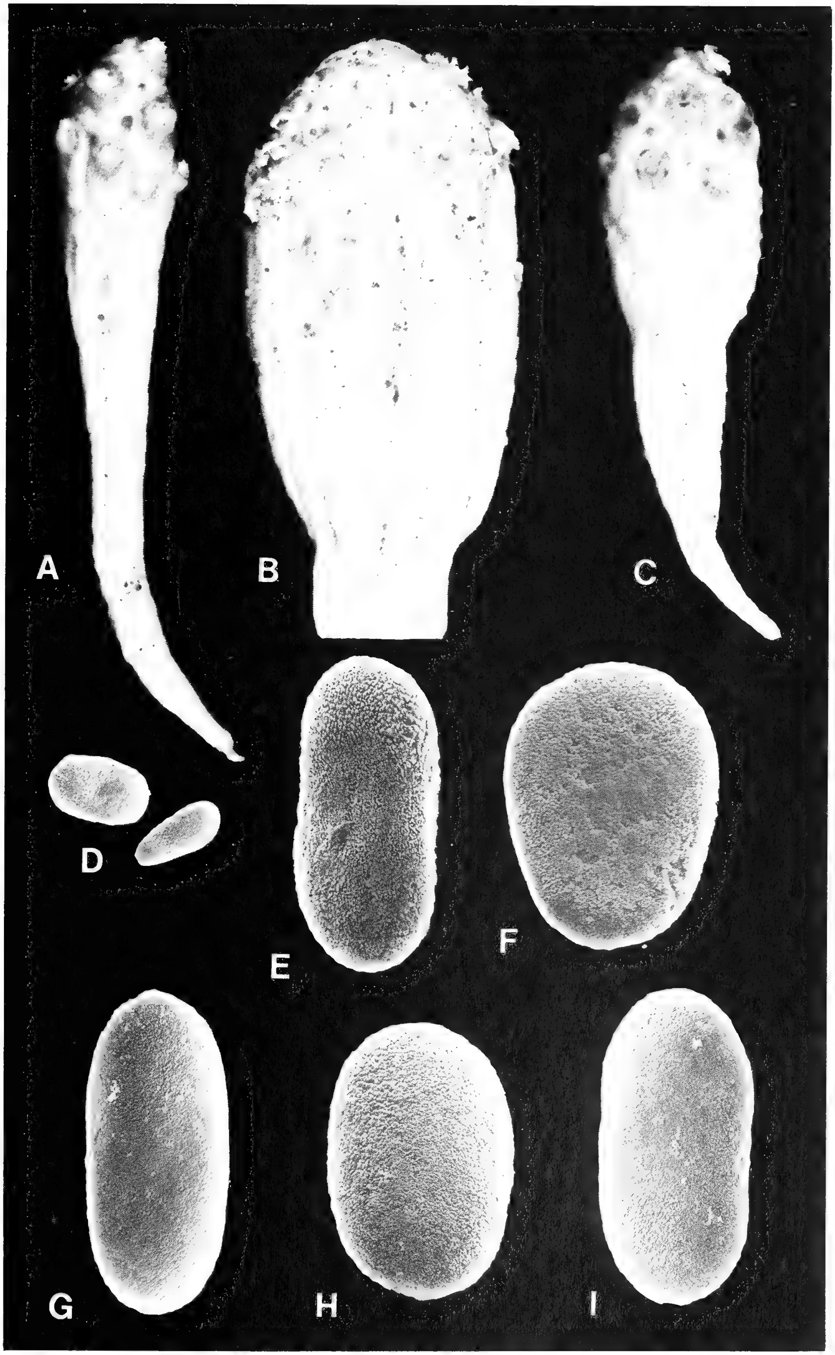

Fig. 3. *Cavernularia dayi*. A. Entire colony, length 30 mm. B. Partial colony, length 60 mm; peduncle absent. C. Entire colony, length 23 mm. D–I. Scanning electron micrographs of sclerites. D–F. From surface of peduncle. D. 0,04 mm. E. 0,03 mm. F. 0,03 mm. G–I. From surface of rachis. G. 0.04 mm. H. 0,03 mm. I. 0,07 mm.

Colour greyish-white in life. Neck zones of autozooids may have eight longitudinal subcutaneous regions of deep purple pigmentation, which is conserved in alcohol.

Distribution (Fig. 38)

East London to the northern Natal coast, 25–50 m depth. Tixier-Durivault (1954: 626) described the type locality from off Lake St. Lucia, Natal at 27 m depth. The present study extends the range from the type locality south-west to the eastern Cape Province, and north to Hully Point, Zululand. This species is possibly a southern African endemic but many more records are necessary to accurately establish its geographical distribution.

Remarks

Cavernularia dayi is distinguished from other southern African species of *Cavernularia* by its clavate shape, small axis, and short, robust, oval or rod-like sclerites of the rachis and peduncle.

Cavernularia elegans (Herklots, 1858)

Figs 4, 40

Sarcobelemnon elegans Herklots, 1858: 25, pl. 7 (fig. 3).
Veretillum elegans Richiardi, 1869: 127, pl. 13 (fig. 112).
Cavernularia elegans Kölliker 1872*a*: 165, pl. 23 (figs 207–208). Kükenthal & Broch, 1911: 185, text-figs 13–15, pl. 18 (fig. 29). Kükenthal, 1915: 16, fig. 20. Broch, 1958: 249.
Cavernularia elegans (*non* Herklots, 1858) Hickson, 1900: 89. J. A. Thomson & Simpson, 1909: 303. Balss, 1910: 86, figs 26–28.

Material

SAM–H3871, 67 km west of Cape Fria, Namibia (18°25′S 11°15′E), 274 m, May–June 1982, 9 colonies, trawl; collector unidentified.

Description

Colonies examined are 29–58 mm in length. Axis absent. Colonies clavate, with peduncle as long as the rachis or somewhat longer. Autozooids usually *c*. 1,3 mm in diameter. Siphonozooids conspicuous and numerous, in more or less longitudinal rows between autozooids, 0,1 mm in diameter. Peduncle slightly swollen near junction of rachis, with longitudinal striations on the external surface. Sclerites from base of autozooids as well as the surface of the rachis and peduncle are smooth elongate rods and spindles, 0,30–0,42 mm long. These are not three-flanged and may have bluntly rounded or somewhat pointed ends. In the rachis interior, similar sclerites are common; 0,2–0,4 mm long. The interior of the peduncle contains minute ovals, 0,01 mm in length.

Colour yellowish-white with some brownish pigmentation in the polyps below the tentacles.

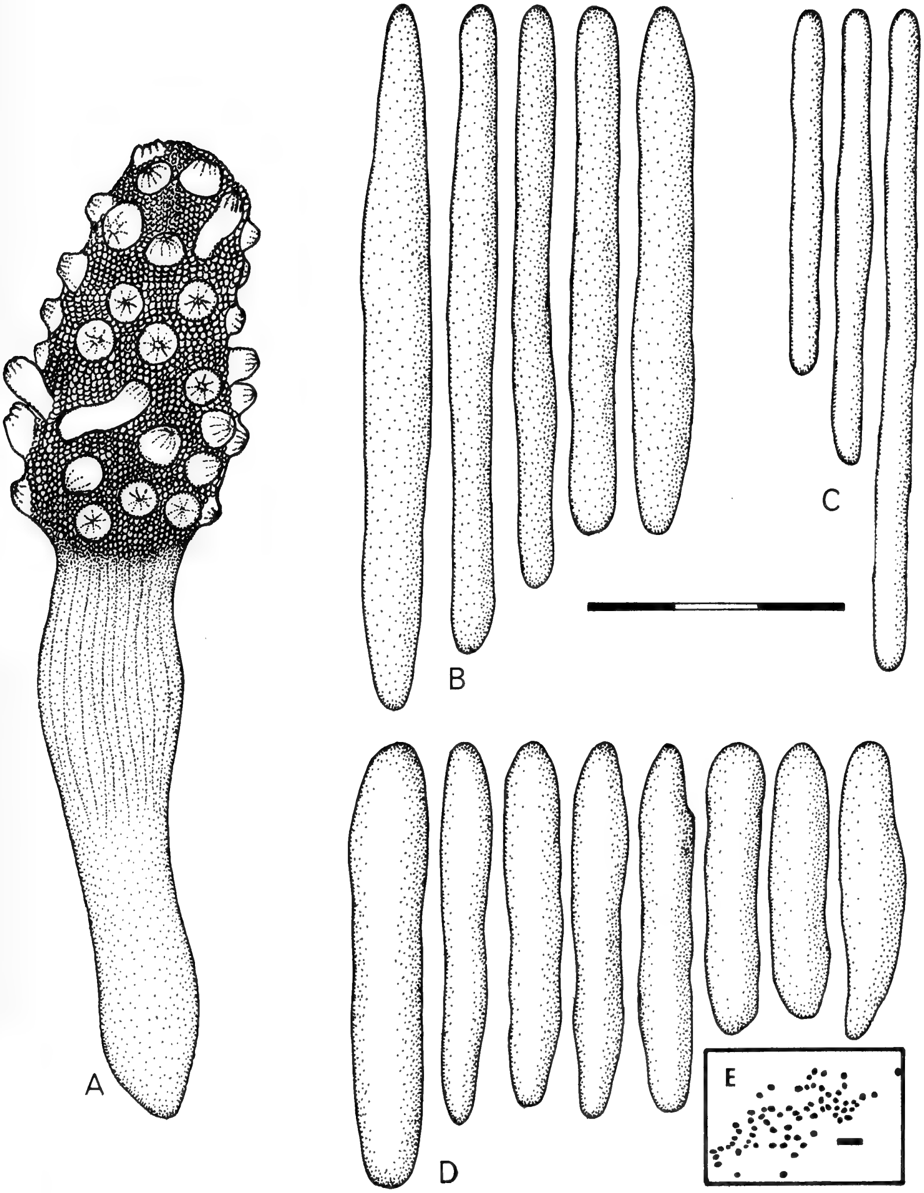

Fig. 4. *Cavernularia elegans*. A. Entire colony, total length 40 mm. B. Sclerites from surface of rachis. C. Sclerites from interior of rachis. D. Sclerites from surface of peduncle. B–D. Scale = 0,15 mm. E. Sclerites from interior of peduncle. Scale = 0,01 mm.

Distribution (Fig. 40)

Along the west African coast from Morocco to northern Namibia. The present study extends the range south from near Luanda, Angola, to the Skeleton Coast of Namibia, and represents a new record for southern Africa. The type locality is an unspecified station off the west African coast.

Remarks

One colony of *Cavernularia elegans* (Herklots, 1858) was recorded by Broch (1958: 249) from a depth of 65 m off the coast of Luanda, Angola. Tixier-Durivault (1963: 72) recorded one specimen as *C. pusilla* (Philippi, 1835) from Lobito Bay, Angola, at 35 m depth. These two species, together with *C. madeirensis* Studer, 1878, were considered synonymous by Broch (1958: 250), yet he retained *C. elegans* (instead of *C. pusilla*) as the correct binomial. I here consider *C. elegans* and *C. pusilla* as separate. Kükenthal (1915: 13) maintained that *C. pusilla* has irregular rod-shaped sclerites in the peduncle surface, whereas *C. elegans* has spindles. Balss (1910: 86) repeated Hickson's (1900: 89) misidentification of *Actinoptilum molle* as *C. elegans*, from 45 m depth off the Cape of Good Hope. Records of *C. elegans* from Japan (Balss 1910) and the Indian Ocean (J. A. Thomson & Simpson 1909) were considered dubious by Kükenthal (1915: 16). *Cavernularia elegans* is characterized by Kükenthal (1915: 13, 16) as having dense spindles at the surface of the peduncle, whereas these sclerites are absent in the peduncle interior; axis absent; sclerites from the surfaces of the peduncle and rachis are predominantly elongate rods and spindles. The rachis interior has similar sclerites but the peduncle interior has minute ovals. *Cavernularia obesa*, from the Indo-West Pacific, also lacks an axis, but possesses sclerites in the interior of the peduncle that are similar to those from the surface (according to Kükenthal, 1915: 13; also see D'Hondt 1984*b*: 634). *Cavernularia elegans* is distinguished from other southern African species of the genus by its clavate growth form, absence of an axis, and sclerites of elongate rods and spindles.

Remarks on the genus Cavernularia

Day *et al.* (1970: 17) listed *Cavernularia luetkeni* Kölliker, 1872, from 80–102 m depth in False Bay, near Cape Town. Since the specimen upon which this identification was made cannot be traced and since no description or figure is provided, it must be considered a dubious record. A 19-mm long specimen collected at Algoa Bay, near Port Elizabeth (SAM–H3236), was originally identified by Tixier-Durivault as *C. luetkeni*. I have examined this specimen and found the polyps to contain small bifurcated calyces. I therefore identify it as a young colony of *Actinoptilum molle* (Kükenthal, 1910). Tixier-Durivault (1960: 366) listed *C. luetkeni* from Inhaca Island, southern Mozambique. Material of *C. luetkeni* is not available at present for examination. Kükenthal (1915: 14) distinguished the species by the possession of a small axis in the base of the rachis and top part of the peduncle; stalk sclerites <0,19 mm long; and rachis sclerites <0,31 mm long.

Approximately 18 species of the genus have been named. Of these, four were considered dubious species or synonyms by Kükenthal (1915). Most of the recognized species are from the eastern Atlantic or Indo-West Pacific, and one is from the Pacific coast of Central America and the Galapagos Archipelago. The genus is in need of revision, since clear distinctions between some species are not evident from the literature. A comparison of type material is necessary to establish the validity of certain members of the genus.

Other species of the family Veretillidae

Four additional veretillid species have been recorded from southern Africa, but for three of these material is not presently available to the author for examination, and in one species only partial material is available.

Genus *Veretillum* Cuvier, 1798

Pennatula: Pallas, 1766: 177 (*partim*).
Alcyonium Linnaeus, 1767: 342 (*partim*).
Veretillum Cuvier, 1798: 675. Herklots, 1858: 26. Gray, 1870: 33. Kölliker, 1872*a*: 324. Balss, 1910: 79. Kükenthal & Broch, 1911: 175. Kükenthal, 1915: 11.

Diagnosis

Colonies cylindrical and plump or elongate and clavate. Size of axis variable, or altogether absent. Autozooids are distributed over surface of rachis; siphonozooids are contained in longitudinal rows between the autozooids. Sclerites are small plates (<0,1 mm), unbranched, often bone-shaped, biscuit-shaped, or at least constricted in the middle to some degree.

Three species from southern Europe, west coast of Africa, southern Mozambique and the Malay Archipelago.

Type species. *Pennatula cynomorium* Pallas, 1766; Europe.

Veretillum cynomorium (Pallas, 1766)

Figs 38, 40

Pennatula cynomorium Pallas, 1766: 177.
Alcyonium epipetrum Linnaeus, 1767: 1294.
Veretillum cynomorium Kükenthal & Broch, 1911: 176, pl. 13 (fig. 1), pl. 18 (figs 32–36) (Lit.!). Kükenthal, 1915: 12, figs 12, 13. Broch, 1958: 249. Tixier-Durivault, 1960: 362.

Material

Material was not available for examination.

Remarks

According to Kükenthal (1915: 11–12) colonies are cylindrical and plump, sausage-shaped, with rachis longer than peduncle. Siphonozooids in longitudinal rows. Sclerites are thin flat plates (<0,06 mm), usually medially constricted with ends rounded.

Broch (1958: 249–250) recorded this species from the Atlantic and Mediterranean coasts of southern Europe, and along the west African coast as far south as Walvis Bay, Namibia; the latter record follows Kükenthal & Broch (1911: 177). Molander (1929: 15) extended the range south to the mouth of the Orange River (border of Namibia and South Africa), 13 m depth. Tixier-Durivault (1960: 362) recorded a colony from Inhaca Island, southern Mozambique. The known depth range is 13–91 m.

Veretillum leloupi Tixier-Durivault, 1960

Fig. 38

Veretillum leloupi Tixier-Durivault, 1960: 363, figs 1–2.

Material

Material was not available for examination.

Remarks

According to Tixier-Durivault (1960: 363–365), colonies are long and narrow, clavate with stalk length equal to or longer than rachis. Siphonozooids not aligned in longitudinal rows. Sclerites are bone-shaped, not flattened, with medial constrictions and rounded ends, up to 0,1 mm in length.

The species is known only from the type locality at Inhaca Island, southern Mozambique, in the western Indian Ocean; depth not recorded.

Genus *Cavernulina* Kükenthal & Broch, 1911

Cavernularia J. A. Thompson & Simpson, 1909: 302 (*partim*).
Cavernulina Kükenthal & Broch, 1911: 172. Kükenthal, 1915: 9.

Diagnosis

Colonies clavate. Axis present. Sclerites of the rachis are mainly rods with bilobed or branched ends, usually $<0,4$ mm in length. Peduncle sclerites are smooth rods and spindles, most of which are not bilobed at the ends, and are mostly $<0,2$ mm in length. Polyps without sclerites.

Three species from the Indo-West Pacific.

Type species. Cavernularia cylindrica Kükenthal & Broch, 1911; Malay Archipelago.

Remarks

Cavernulina cylindrica Kükenthal & Broch, 1911, was listed without description or figures by Day *et al.* (1970: 17) from 33–36 m in False Bay, near Cape Town, as *Cavernularia cylindrica*. Since the specimen upon which this record was based is not available for examination and since this is the only False Bay record of the species known, it must be considered a dubious record. It is probable that small specimens from the Cape region, previously identified as species of *Cavernularia*, may in fact be young colonies of *Actinoptilum molle* in which the bifurcate calyces are neither prominent nor conspicuous, but present nonetheless. Two species were considered valid by Kükenthal (1915: 9): *Cavernulina cylindrica* and *C. orientalis* (Thomson & Simpson, 1909), both from the Indian Ocean. A third species, *C. grandiflora* D'Hondt, 1984, has recently been described from New Caledonia. See D'Hondt (1984*b*: 629) for a comparison of these three species.

Cavernulina sp.

Fig. 38

Remarks

A partial colony, in which only a 30 mm long rachis is present, recently collected from 62 m depth off the Durban region of Natal, possesses bilobed sclerites 0,1–0,25 mm in length. These sclerites are similar in shape and size to those figured by Kükenthal (1915: 10) for *C. cylindrica* and by D'Hondt (1984*b*: 628) for *C. grandiflora*. I therefore believe that this specimen belongs to the genus *Cavernulina*, but a proper identification to species is not possible due to the fragmentary nature of the material, in which the peduncle is entirely missing. The present study establishes the genus *Cavernulina* as a new record for southern Africa.

Genus *Lituaria* Valenciennes *in* Milne Edwards & Haime, 1850

Pennatula: Pallas, 1766: 179 (*partim*).
Veretillum: Lamarck, 1816: 420 (*partim*).
Lituaria Valenciennes *in* Milne Edwards & Haime, 1850: 84. Gray, 1870: 33. Kölliker, 1872*a*: 135. J. A. Thomson & Simpson, 1909: 311. Balss, 1910: 78. Kükenthal, 1915: 7.
Clavella Gray, 1870: 33. Kölliker, 1872*a*: 144. J. A. Thomson & Simpson, 1909: 311. Balss, 1910: 78.

Diagnosis

Colonies clavate. Axis contained in rachis, length variable, four-angled. Siphonozooids very numerous between the autozooids. Sclerites are small biscuit-shaped plates, many of which possess short branches or denticles at the ends. Other sclerites may be crosses or rods with warty ends.

Nine species of the Indo-Pacific. See Light (1921: 248) for a key to the species, and D'Hondt (1984*b*: 636) for a discussion of the type species.

Type species. *Pennatula phalloides* Pallas, 1766; Indian Ocean.

Lituaria valenciennesi D'Hondt, 1984*b*

Lituaria phalloides (*non* Pallas, 1766) Valenciennes *in* Milne Edwards & Haime, 1850: 84. Kölliker, 1872*a*: 313. Kükenthal, 1915: 8, fig. 6.
Lituaria valenciennesi D'Hondt, 1984*b*: 636, fig. 9.

Material

Material was not available for examination.

Remarks

According to Kükenthal (1915: 8), colonies are clavate with rounded distal ends. Polyps mostly without sclerites. Sclerites of the rachis and stalk are small flat plates up to 0,1 mm long, many with terminal denticles.

The species is recorded from Mozambique (undesignated station), the Malay Archipelago, the Andaman Islands, and Sri Lanka; shallow sublittoral.

Family **Echinoptilidae** Hubrecht, 1885

Colony digitiform or cylindrical. Axis absent. Rachis generally longer than peduncle. Colonies radially (Fig. 11B) to bilaterally symmetrical (Fig. 9B). Autozooids with distinctive, non-retractile, bifurcated calyces that are heavily armed with sclerites (Fig. 9A, E). Sclerites mainly smooth three-flanged rods or spindles, ovals and platelets (Fig. 13).

Two genera from the Indo-West Pacific to south-western Africa; shallow sublittoral to 835 m.

Genus *Echinoptilum* Hubrecht, 1885

Echinoptilum Hubrecht, 1885: 512. Balss, 1910: 37. Kükenthal & Broch, 1911: 196. Kükenthal, 1915: 18.
Actinoptilon Kükenthal, 1910: 54 (*partim*).

Diagnosis

Colony digitiform, commonly curved. Concave side with a longitudinal groove or furrow, and inverted V-shaped region at the base of the rachis devoid of polyps. This furrow may extend full length of rachis in small specimens (less than 40 mm). Proximal portion of rachis therefore bilaterally symmetrical. Distal portion of rachis may be radially symmetrical with polyp-bearing region continuous in larger specimens (over 40 mm). Autozooids with prominent bifurcated calyces, giving rachis a spiny or prickly appearance. Two terminal teeth of calyx deltoid to needle-like. Larger autozooids may be concentrated in two lateral series of longitudinal rows in colonies less than 40 mm long. Autozooids capable of total retraction into calyces. Siphonozooids numerous at base of autozooids; also with non-retractile, bifurcated calyces. Sclerites numerous; those of calyx are long three-flanged spindles, peduncle with ovals or three-flanged rods and spindles.

A genus of six species, Indo-West Pacific—Hawaii to eastern Africa.

Type species. Echinoptilum macintoshii Hubrecht, 1885; Japan.

Echinoptilum macintoshii Hubrecht, 1885

Figs 1H–I, 5, 6, 7A–C, 8D–F, 39

Echinoptilum macintoshii Hubrecht, 1885: 512, text-figs 1–3, pl. 30 (figs 1–8), pl. 31 (figs 9–14).
Echinoptilum macintoshi: Nutting, 1908: 561; 1912: 48. Balss, 1910: 38, pl. 2 (figs 1–3), pl. 5 (figs 1, 3–5). Kükenthal, 1915: 19. Utinomi, 1961: 221.
Echinoptilum Macintoshii: Kükenthal & Broch, 1911: 197.
Echinoptilum M'Intoshii: Hickson, 1916: 57–62.
Echinoptilum mackintoshi: J. A. Thomson & Rennet, 1927: 121, pl. 9 (fig. F). Bayer, 1956: 226.

Material

SAM–H3683, off Mbotyi, Transkei (31°32′S 29°50′E), 150–170 m, August 1981, 2 colonies, dredge; Natal Museum, R.V. *Meiring Naude*. SAM–H3685, off Port St. Johns, Transkei (31°39′S 29°35′E), 50–70 m, 14 August 1981, 1 colony, dredge; Natal Museum, R.V. *Meiring Naude*. SAM–H3819, off Mgazi River,

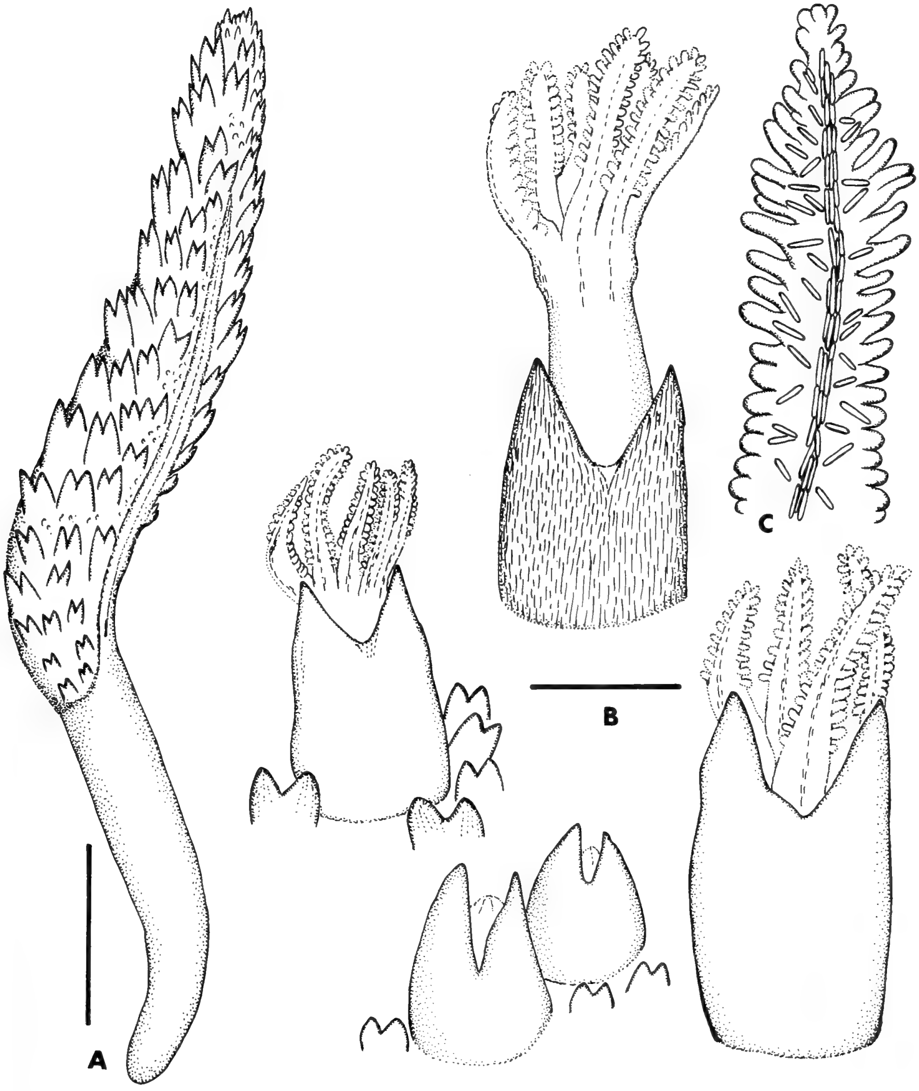

Fig. 5. *Echinoptilum macintoshii*. A. Entire colony, lateral view. Scale = 5 mm. B. Five autozooids with eight siphonozooids; sclerites shown in calyx of top autozooid only. Scale = 1 mm. C. Single tentacle (length 1,3 mm) showing alignment of sclerites.

Transkei (31°43,7′S 29°31,9′E), 140–145 m, 4 July 1985, 8 colonies, dredge; G. C. Williams, R.V. *Meiring Naude*.

Description

Specimens examined are 10–84 mm in length. Colonies curved with ventral groove on concave side. Calyx teeth conical to deltoid, 0,4–0,8 mm in length. Calyx length approximately twice the width. Entire calyces 1,2–2,3 mm in length. Siphonozooids have two broad teeth, often with obtuse tips.

Sclerites of the calyces are smooth three-flanged spindles 0,17–1,07 mm in length (Fig. 6A); aboral surface of each tentacle with a conspicuous longitudinal medial band of red-orange three-flanged rods, which extend into the base of the

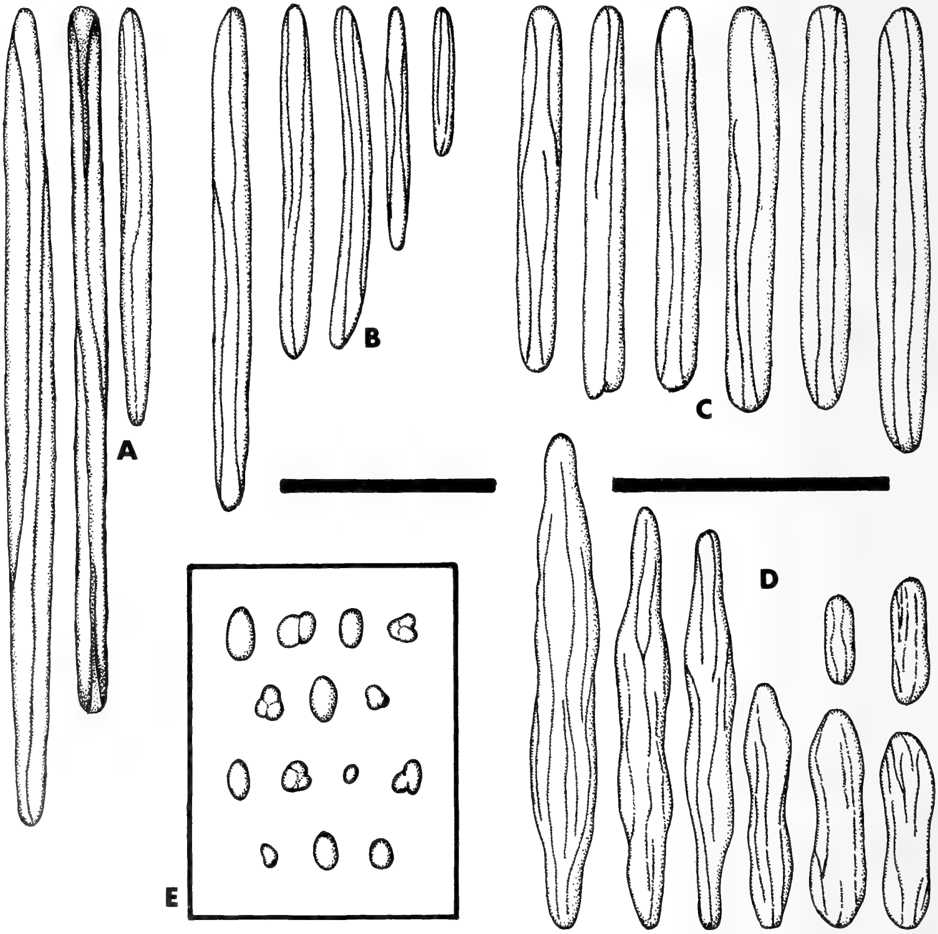

Fig. 6. *Echinoptilum macintoshii*. A. Calyx sclerites. B. Sclerites from surface and interior of rachis. C. Tentacular sclerites. D. Sclerites from surface of peduncle. E. Sclerites from interior of peduncle. Scales: A–B, D (left) = 0,2 mm; C, E (right) = 0,1 mm.

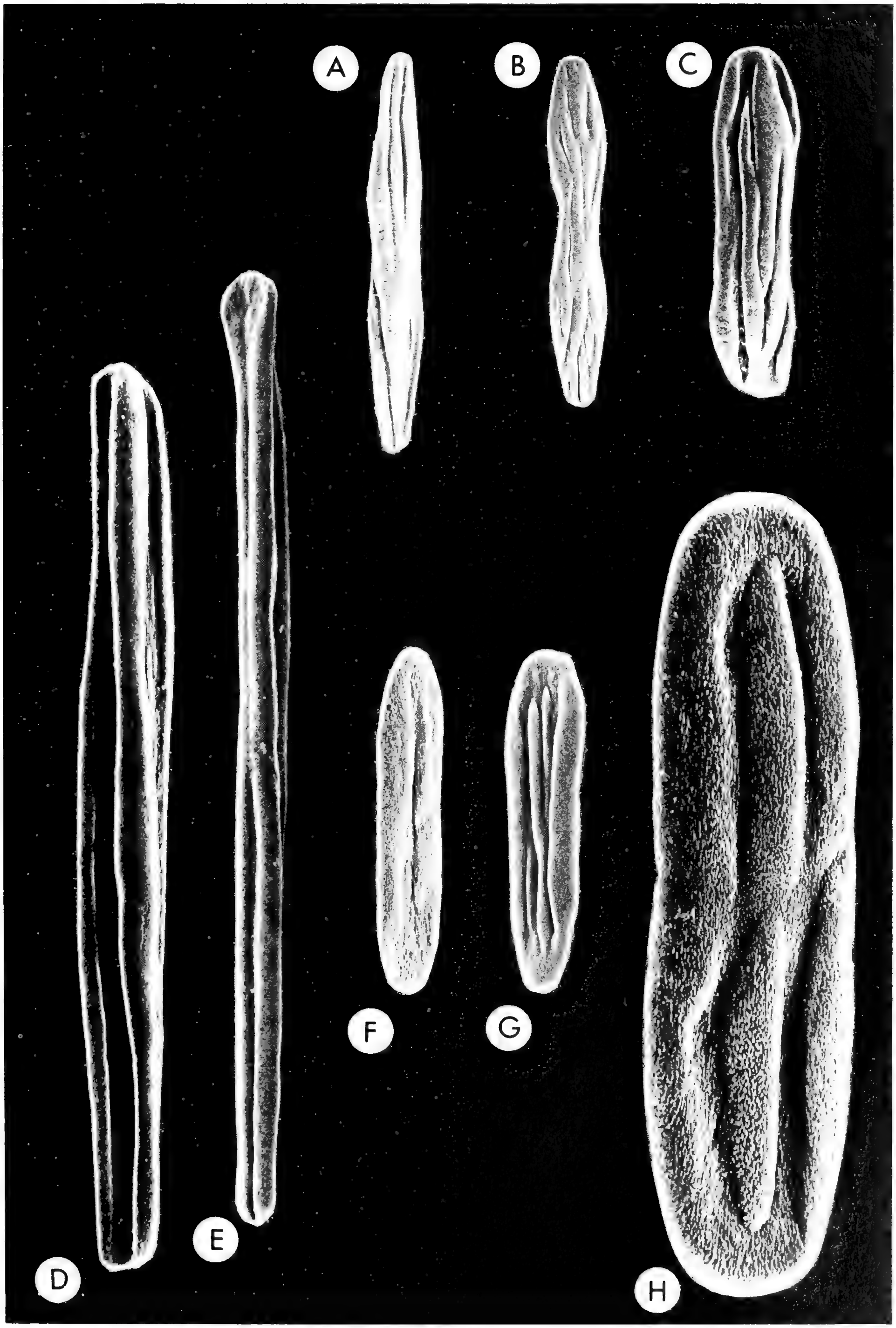

Fig. 7. Scanning electron micrographs of sclerites. A–C. *Echinoptilum macintoshii*. From surface of peduncle: 0,33 mm; 0,31 mm; 0,16 mm.D–H. *Echinoptilum echinatum*. D–E. From calyx: 0,17 mm; 0,55 mm. F–H. From surface of peduncle: 0,11 mm; 0,11 mm; 0,09 mm.

anthocodia. These are all arranged parallel to the axis of each tentacle and form a band 2–3 sclerites in width. Similar but colourless rods are found at various oblique angles to the axis, near the bases of the pinnules (Fig. 5C). The rods of the tentacles vary in length from 0,13–0,17 mm (Fig. 6C). Bare areas of the rachis surface, as well as the rachis interior, possess three-flanged spindles and rods 0,13–0,50 mm in length (Fig. 6B). Sclerites from the surface of the peduncle are longitudinally grooved (but not three-flanged) spindles or ovoid rods, 0,07–0,47 mm in length, often with undulate margins and tapering ends (Figs 6A–C, 6D). The tissues of the peduncular interior possess scattered sclerites of minute ovals 0,008–0,020 mm in length (Fig. 6E).

Rachis rust-orange to light reddish-brown. Peduncle and naked region of rachis whitish or cream. Calyces reddish-brown, often with margins edged in white. Colour of colony permanent, originating within the sclerites.

Distribution (Fig. 39)

Transkei coast, Japan and Hawaii. This study establishes a new record for the African coast and extends the range of the species to the western Indian Ocean. Colonies from south-eastern Africa are known from 50–170 m depth. Hubrecht (1885: 512) reported the type locality as the Sea of Japan, 130 m in depth. Nutting (1908: 561) recorded the species from the Hawaiian Archipelago, 225–258 m, and again off Japan, 150 m (Nutting 1912: 48).

Remarks

Echinoptilum macintoshii is distinguished from other members of the genus by having sclerites in the tentacles, and triangular calyx teeth $<0,8$ mm long.

Echinoptilum echinatum (Kükenthal, 1910)

Figs 1G, 7D–H, 8G–H, 9, 10, 39

Actinoptilon echinatum Kükenthal, 1910: 57.
Echinoptilum echinatum Kükenthal & Broch, 1911: 197, pl. 13 (fig. 3), pl. 18 (figs 38, 39), pl. 19 (figs 40–43). Kükenthal, 1915: 19 (fig. 21). Hickson, 1916: 57–62.

Material

SAM–H1595, off Durban (30°20′S 30°51′E), 406 m, 23 July 1964, 1 colony, dredge; Division of Sea Fisheries. SAM–H3680, off Mendu Point, Transkei (32°23′S 29°00′E), 450 m, 13 July 1984, 1 colony; G. C. Williams, R.V. *Meiring Naude*. SAM–H3681, off Qolora River, Transkei (32°48′S 28°37′E), 510 m, 14 July 1904, dredge; G. C. Williams, R.V. *Meiring Naude*. SAM–H3682, off Qora River, Transkei (32°35′S 28°49′E), 450–460 m, 14 July 1984, dredge; G. C. Williams, R.V. *Meiring Naude*. SAM–H3684, off Qora River, Transkei (32°34′S 28°50′E), 400–420 m, 12 July 1984, dredge; G. C. Williams, R.V. *Meiring Naude*. SAM–H3820, off Mbashe River, Transkei (32°23,6′S 28°59,2′E), 350 m maximum, 6 July 1985, 1 colony, dredge; G. C. Williams, R.V. *Meiring Naude*.

Description

Specimens examined are 30–80 mm in length. Colonies curved with ventral groove on concave side. Calyx teeth lanceolate to needle-like, 1,0–1,6 mm in length. Total calyx length (approximately 3 mm) is more than twice and often three times the width. Siphonozooids possess two narrow teeth with acute tips.

Sclerites of the calyces are narrow, three-flanged spindles 0,14–0,86 mm long (Figs 7D–E, 10A). The aboral surface of each tentacle has a medially placed longitudinal row of 1–20 sclerites, arranged more-or-less parallel to the axis of the tentacles (Fig. 9C–D). These are three-flanged rods 0,10–0,16 mm in length (Fig. 10C). Bare regions of the surface of the rachis, as well as the interior of the rachis, possess elongate three-flanged rods 0,06–0,35 mm in length (Fig. 10B). The peduncular surface sclerites are oval finger-biscuits with longitudinal striation (but not three-flanged) 0,04–0,15 mm in length (Figs 7F–H, 10D). The tissues of the interior of the peduncle possess minute ovals 0,009–0,014 mm in length (Fig. 10E).

Calyces and rachis are brick red or deep reddish-purple to cream. Peduncle, as well as the naked longitudinal track on the concave side of the rachis are whitish to cream, often with reddish longitudinal lines. Colour permanent due to pigmentation of the sclerites.

Distribution (Fig. 39)

Transkei and Natal coasts to Somalia. South-east African specimens from 350–510 m depth. Kükenthal & Broch (1911: 197) reported the type locality as off the Somalia coast at 628 m depth. The present study extends the range of the species southward along the coast of east Africa, and represents a new record from southern Africa.

The two south-east African species of *Echinoptilum* apparently show divergent bathymetric ranges: *E. macintoshii* has a shallow-water distribution, being encountered at depths of 130–258 m, whereas *E. echinatum* is presumably a deeper-water form, known only between 350 m and 628 m in depth.

Remarks

Echinoptilum echinatum is distinguished from other species of the genus by having sclerites in the tentacles, and lanceolate calyx teeth up to 1,6 mm long.

Remarks on the genus Echinoptilum

Four other species of *Echinoptilum* were described by Hickson (1916) from the Malay Archipelago: *E. elongatum*, *E. minimum*, *E. roseum*, and *E. asperum*. These species have not been recorded outside their respective type localities.

Hickson (1916: 62) presented a key to the six described species. *Echinoptilum macintoshii* is characterized by having pronounced curvature, spicules in the tentacles, and small calyxes, whereas *E. echinatum* is also described as being curved with spicules in the tentacles, but with large calyces. The southern African material agrees with Hickson's descriptions of these two species, as well as the

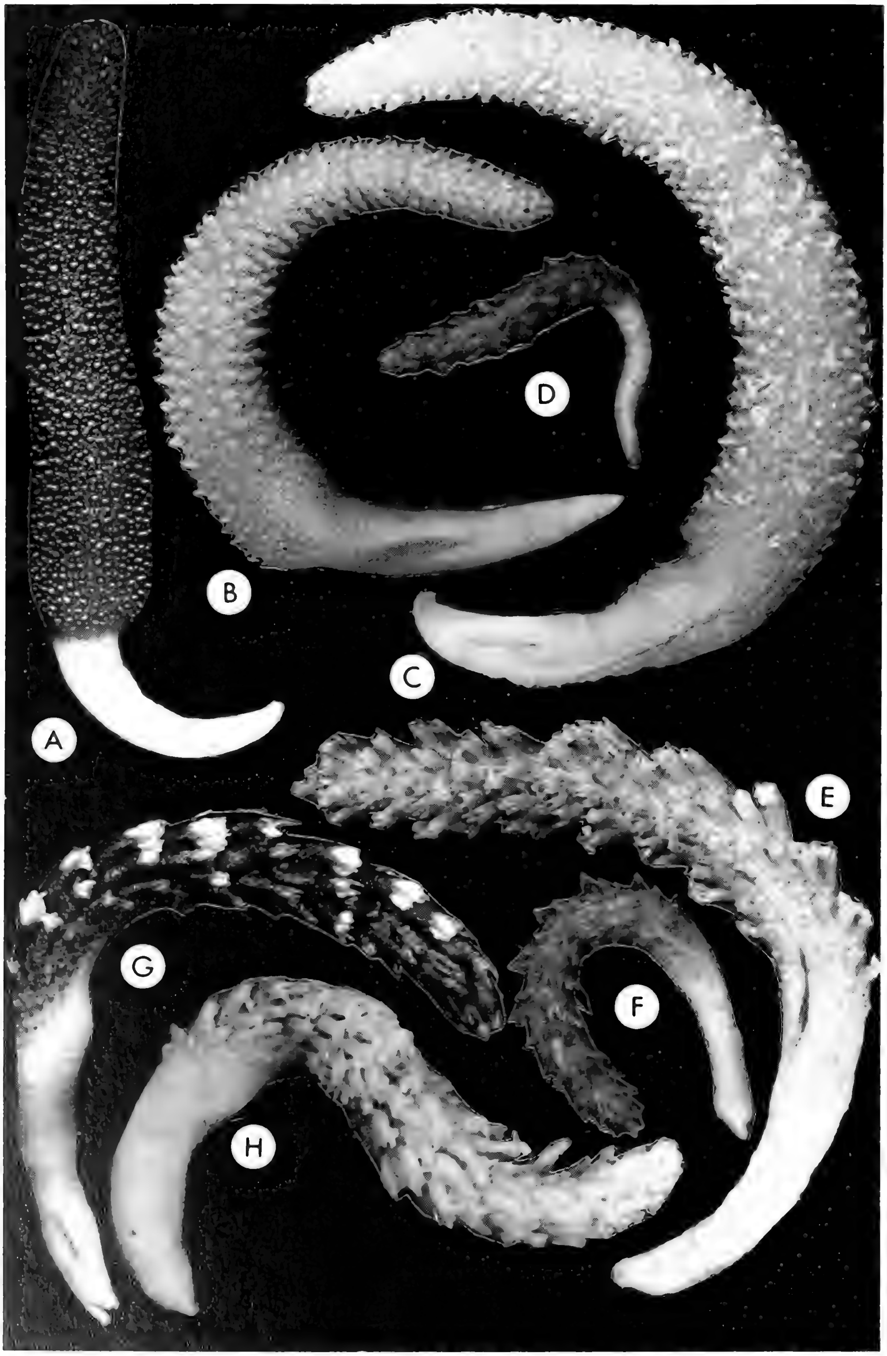

Fig. 8. A–C. *Actinoptilum molle* colonies. A. 70 mm. B. 65 mm. C. 85 . D–F. *Echinoptilum macintoshii*. D. 25 mm. E. 45 mm. F. 35 mm. G–H. *Echinoptilum echinatum*. G. 40 mm. H. 55 mm.

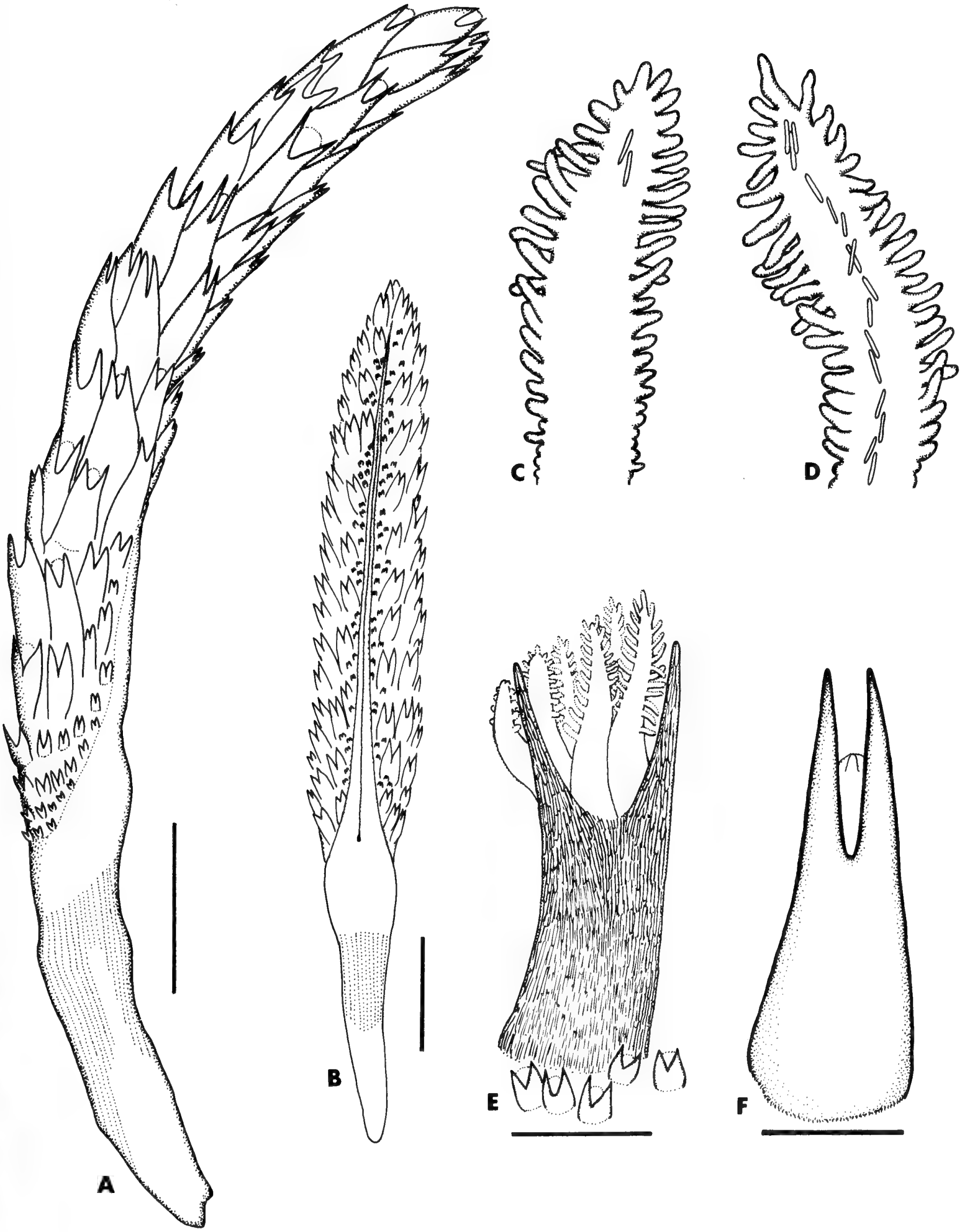

Fig. 9. *Echinoptilum echinatum*. A. Entire colony, lateral view. Scale = 5 mm. B. Ventral view of colony showing naked tract. Scale = 5 mm. C–D. Two tentacles, showing variation in sclerite density and placement. Each tentacle is 2,0 mm in length. E. Single autozooid, partially retracted; calyx sclerites shown, five siphonozooids at base. Scale = 1 mm. F. Single bifurcated calyx of a retracted autozooid; sclerites omitted. Scale = 1 mm.

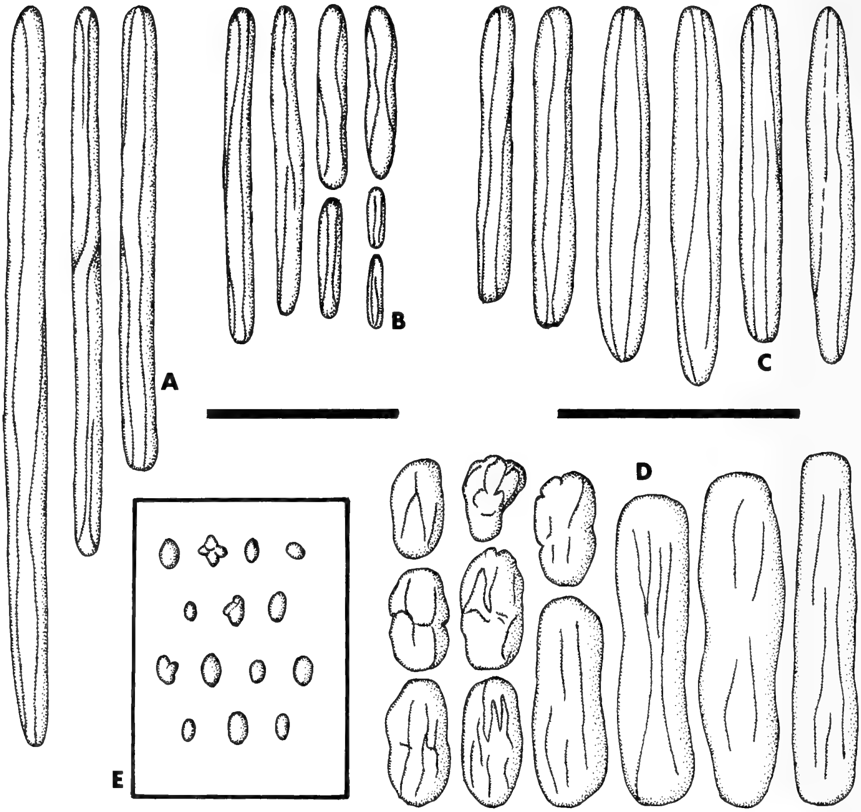

Fig. 10. *Echinoptilum echinatum*. A. Calyx sclerites. B. Sclerites from surface and interior of rachis. C. Tentacular sclerites. D. Sclerites from surface of peduncle. E. Sclerites from interior of peduncle. Scales: A, B (left) = 0,2 mm; C, D, E (right) = 0,1 mm.

detailed descriptions of Hubrecht (1885: 512) and Kükenthal & Broch (1911: 197).

The distinctions between the various groups may not be consistent or marked enough to warrant specific separation. Hickson (1916: 58) raised the possibility that the genus *Echinoptilum* is monospecific and that the six described species may in fact represent one highly variable and widespread species. A comparative examination of type specimens and other known material is needed. However, the differences between *E. macintoshii* and *E. echinatum*, based upon comparison of the available southern African material, are marked and consistent.

Genus *Actinoptilum* Kükenthal, 1911

Cavernularia (*non* Valenciennes *in* Milne Edwards & Haime, 1850) Hickson, 1900: 89, 92.
Actinoptilon Kükenthal, 1910: 56.
Actinoptilum Kükenthal & Broch, 1911: 201. Kükenthal, 1915: 20.
Actinoptinum Day *et al.*, 1970: 17.

Diagnosis

Colony cylindrical with rachis radially symmetrical. Polyps evenly distributed and completely covering surface of rachis. Calyces of autozooids usually less than 3 mm in length, bifurcate. Terminal teeth short and conical to deltoid or broadly lanceolate and acute. Inside of each tooth often with a fleshy rounded protuberance near the apex.

A monospecific genus restricted to southern Africa and possibly Madagascar.

Type species. Actinoptilon molle Kükenthal, 1910; South Africa.

Actinoptilum molle (Kükenthal, 1910)

Figs 1A–C, 8A–C, 11–13, 39

Cavernularia obesa (*non* Valenciennes *in* Milne Edward & Haime, 1850) Hickson, 1900: 92, pl. 3 (figs A–B).

Cavernularia elegans (*non* Herklots, 1858) Hickson, 1900: 89.

Actinoptilon molle Kükenthal, 1910: 57 (*partim*). Tixier-Durivault, 1960: 366. Tixier-Durivault & D'Hondt, 1974: 259.

Actinoptilum molle Kükenthal & Broch, 1911: 201, pl. 13 (figs 3–4), pl. 18 (fig. 37). Kükenthal, 1915: 20, figs 22–24. J. S. Thomson, 1915: 3. 1924: 81. Hickson, 1916: 41. Molander, 1929: 15. Tixier-Durivault, 1954: 628. Broch, 1958*b*: 251.

Actinoptilum molle var. *maculatum* J. S. Thomson, 1915: 5.

Actinoptilum molle var. *intermedium* J. S. Thomson, 1915: 7.

Actinoptilum molle var. *zonatum* J. S. Thomson, 1915: 8.

Actinoptinum molle Day *et al.*, 1970: 17.

Material

SAM–H3254, Port Elizabeth Harbour (33°58′S 25°38′E), 20–25 m, February 1984, 2 colonies, small dredge; W. R. Liltved. SAM–H3263, Algoa Bay (33°59′S 25°42′E), 20 m, February 1984, 2 colonies, SCUBA; W. R. Liltved. SAM–H3164, off Jeffrey's Bay (34°00′S 25°10′E), 30 m, August 1980, 6 colonies, dredge; W. R. Liltved, R.V. *T.B. Davie*. SAM–H3272, False Bay (34°09′S 18°27′E), 26 February 1984, 12 m, 1 colony, small dredge; W. R. Liltved. SAM–H3339, Algoa Bay (33°59′S 25°42′E), 16 m, 17 May 1984, 3 colonies, SCUBA; G. C. Williams.

Description

Colonies examined range in length between 12 mm and 240 mm. Colony cylindrical, plump, sausage-shaped. Peduncle thick, tapering gradually, usually one-fifth to one-third total colony length. Rachis tapering gradually to a rounded apex. Rachis entirely covered with dimorphic polyps; thus the polyp-bearing surface of the rachis is radially arranged. Siphonozooids crowded between bases of autozooids with minute bifurcated calyces. Rachis surface often with longitudinal lines between columns of autozooids. Calyces of autozooids usually not conspicuous, bifurcate, non-retractile. Autozooids capable of total retraction into calyces. Calyx teeth variable in shape and length.

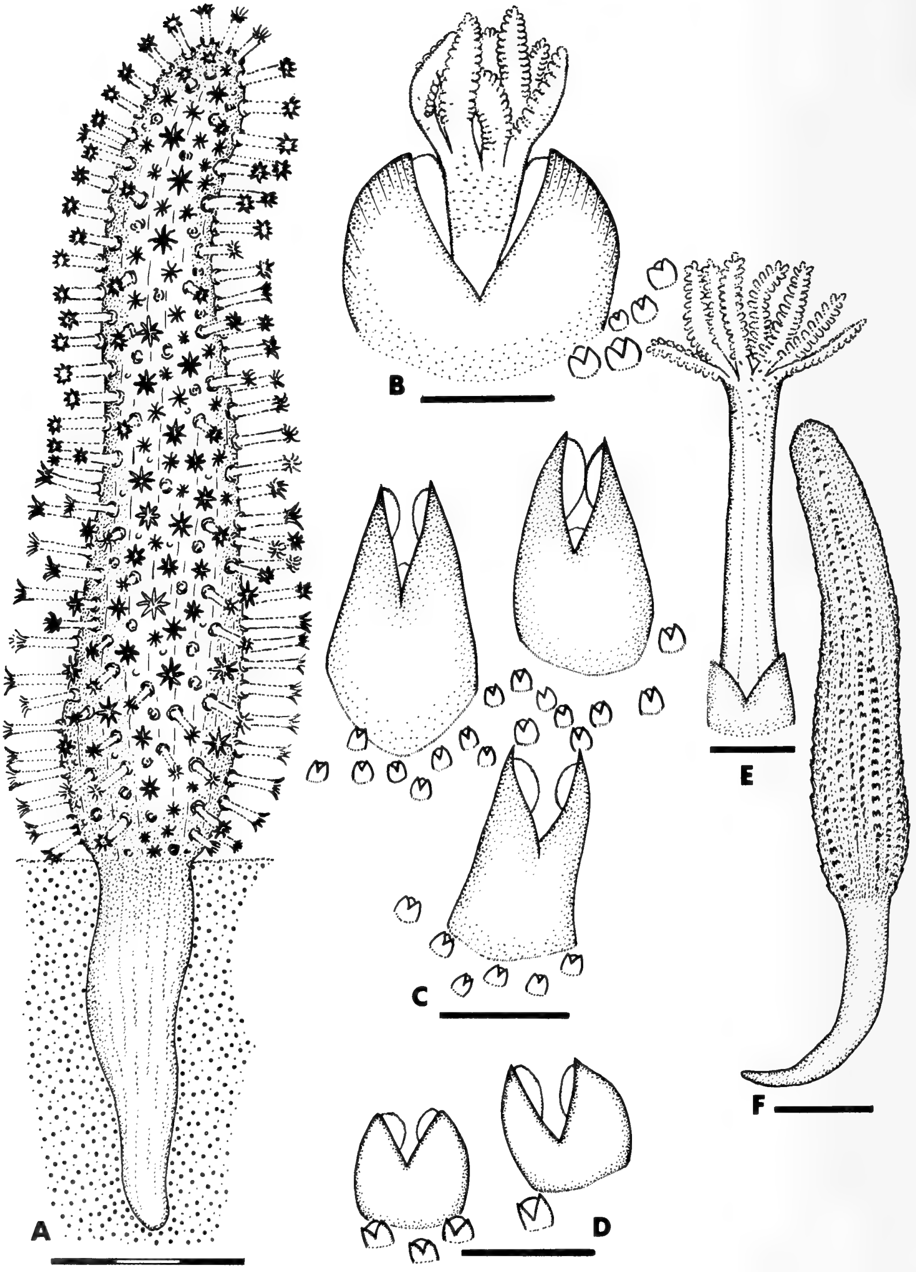

Fig. 11. *Actinoptilum molle.* A. Expanded colony *in situ*. Scale = 30 mm. B. Single autozooid and five siphonozooids. C. Three autozooids retracted into calyces, and numerous siphonozooids. D. Two autozooid calyces with four smaller siphonozooids. Scales: B–D = 0,8 mm. E. Expanded autozooid. Scale = 1,8 mm. F. Preserved colony with retracted polyps. Scale = 10 mm.

Sclerites of the calyx are smooth three-flanged spindles 0,18–0,85 mm long (Figs 12A, 13A–D). Anthocodia (distal part of polyp that contains the tentacles, mouth, and neck zone) with small ovals or platelets in neck zone and base of tentacles, 0,02–0,04 mm in length (Figs 12B, 13E). The surface of the rachis has three-flanged spindles and rods 0,22–0,42 mm in length (Figs 12C, 13F, H–I). The tissues of the interior of the rachis possess similar sclerites 0,22–0,41 mm in length (Fig. 12D). The surface of the peduncle has ovoid finger biscuit-shaped sclerites with longitudinal surface striations 0,03–0,20 mm long (Figs 12E, 13G). The tissues of the peduncular interior possess minute ovals 0,005–0,020 mm in length (Fig. 12F).

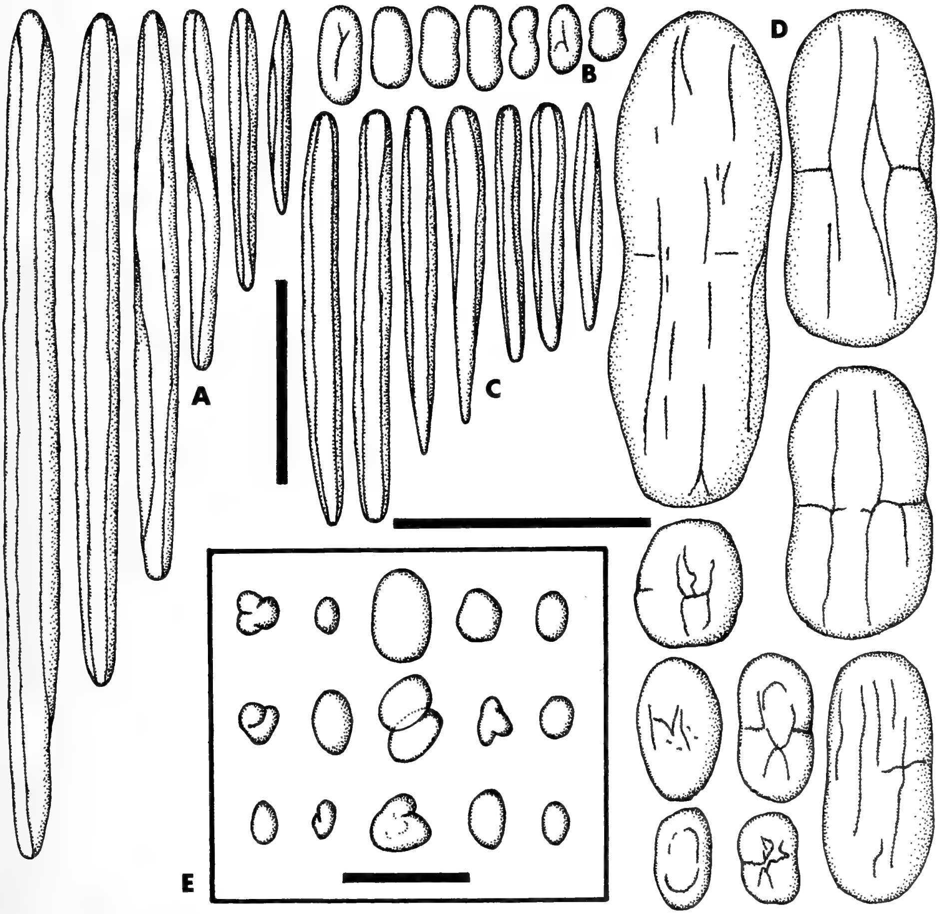

Fig. 12. *Actinoptilum molle*. A. Calyx sclerites. B. Sclerites from anthocodial wall. C. Sclerites from rachis surface and interior. D. Sclerites from surface of peduncle. E. Sclerites from interior of peduncle. Scales: A, C (left) = 0,2 mm; B, D (right) = 0,1 mm; E = 0,02 mm.

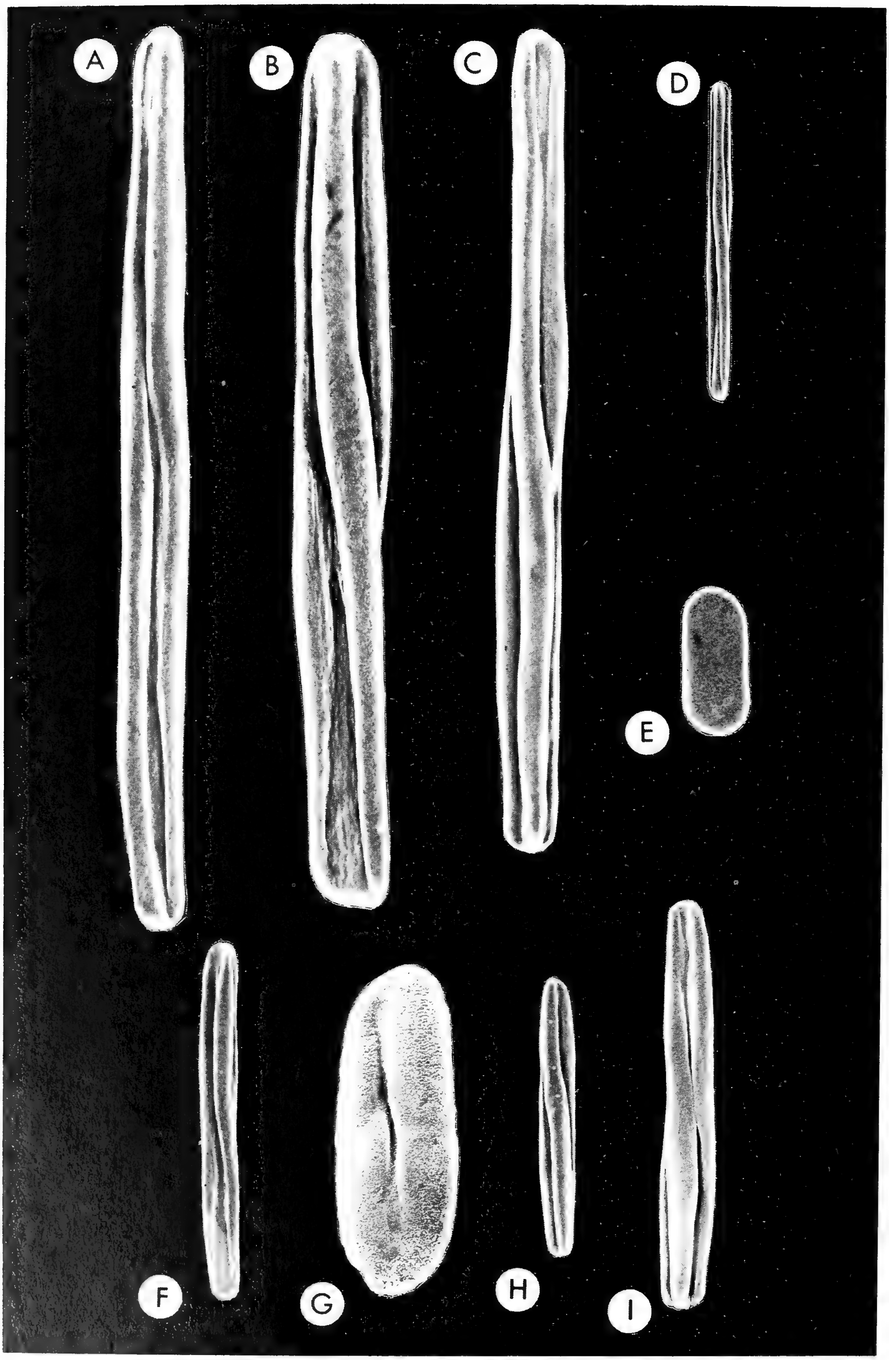

Fig. 13. Scanning electron micrographs of sclerites of *Actinoptilum molle*. A–D. From calyx: 0,41 mm; 0,21 mm; 0,45 mm; 0,44 mm. E. From tentacle: 0,04 mm. F, H, I. From surface of rachis: 0,2 mm; 0,15 mm; 0,2 mm. G. From surface of peduncle: 0,07 mm.

Colour highly variable; individual colonies may be entirely yellow, white to cream, reddish-brown, pinkish or mauve; or colonies with rachis deep-purple to reddish-purple, and peduncle yellow, white, pinkish or brownish. Colour permanent, originating within the sclerites.

Distribution (Fig. 39)

This species is presumably a southern African endemic, known from off Cape Columbine on the west coast of South Africa to Inhaca Island, Mozambique, at depths ranging from 12 m to 333 m. However, Tixier-Durivault & D'Hondt (1974: 259) recorded, without description or figures, seven colonies from north-eastern Madagascar between 200 m and 605 m in depth. The species is perhaps the most frequently encountered pennatulacean in South African coastal waters.

Observations

A 60-mm long live colony from False Bay (SAM–H3272), which was kept in a bucket of sea-water at night, was observed to luminesce vigorously when agitated; the rachis sparkled throughout with minute pinpoints of green light.

SCUBA divers have observed this species inhabiting rocky reefs off Cape Agulhas at 48 m depth. A colony was observed in a small depression in rocky substratum that was filled with fine sediment (W. R. Liltved pers. comm.). Divers have also observed extensive sandy areas at 20 m depth in False Bay with a density of 4–5 colonies per square metre (P. Williams pers. comm.).

Remarks

Thomson (1915: 1–13) named three varieties of *Actinoptilum molle* based primarily on differences in external coloration: *A. molle* var. *maculatum*, *A. molle* var. *intermedium*, and *A. molle* var. *zonatum*. Because of the wide range of colour variability observed throughout the geographic extent of the species and many gradations between various colonies or populations, I believe that formal subspecies or varieties should not be designated. This species can be regarded as yet another example of the extreme range of variability exhibited by sedentary benthic organisms such as octocorallians. Thomson (1915: 8) observed a slight trace of a groove on the rachis of four white colonies that he referred to *A. molle* var. *intermedium*. A conspicuous groove or furrow on the concave side of the rachis is considered diagnostic of the genus *Echinoptilum*. However, according to Thomson, the four specimens show typical characteristics of *Actinoptilum*, such as smaller inconspicuous calyces and numerous polyps arranged almost completely radially, as well as the form, dimensions, and distribution of sclerites being similar to those described by Kükenthal for *A. molle*. Calyx length is also quite variable, ranging from 1 mm to 3 mm. In some colonies the calyx teeth are only visible with the aid of a hand lens or dissecting microscope, whereas in others they are very conspicuous and easily seen with the unaided eye.

Kükenthal (1915: 20) stated that the polyps are without sclerites. The density of sclerites in the anthocodiae is variable; in a single colony some anthocodiae may contain sclerites, whereas others may contain none. The number of ovals present in a particular anthocodia is also quite variable.

Actinoptilum molle is distinguished from other southern African sea pens by having radial symmetry of the rachis, in which the polyps are distributed evenly on all sides, and the possession of generally inconspicuous calyx teeth.

Family **Kophobelemnidae** Gray, 1860

Colonies clavate (club-shaped). Axis present. Polyps arranged bilaterally along rachis; rachis may show a tendency toward radial symmetry. Autozooids large, without calyces. Siphonozooids with calyces, at base of autozooids. Rachis with sclerites of three-flanged or tuberculate spindles, or plate-like, biscuit-shaped or bone-shaped rods.

Four genera from the Atlantic, Mediterranean and Indo-Pacific: *Mesobelemnon* Gravier; 1907; *Sclerobelemnon* Kölliker, 1872*a*; *Kophobelemnon* Asbjørnsen, 1856; and *Malacobelemnon* Tixier-Durivault, 1966*a*. The present study represents the first record of the family for southern Africa.

Genus *Kophobelemnon* Asbjørnsen, 1856

Kophobelemnon Asbjørnsen, 1856: 81. Kükenthal & Broch, 1911: 219. Kükenthal, 1915: 29 (Lit.!).
Bathyptilum Kölliker, 1872: 200.
Gunneria Danielssen & Koren, 1884: 58.

Diagnosis

Colony clavate, elongate, stiff. Distal end slightly expanded and rounded, knob-like, or slightly pointed at the tip. Rachis and stalk about equal in length. Axis thin, often slightly quadrangular in transverse section. Sclerites are mostly three-flanged spindles that may possess tubercles.

A genus of eight to ten species. Atlantic, Mediterranean, and Indo-Pacific; mostly deep sea, 40–4 400 m.

Type species. Pennatula stellifera Müller, 1776; northern Atlantic.

Kophobelemnon stelliferum (Müller, 1776)

Figs 14–16, 40

Pennatula stellifera Müller, 1776: 255.
Kophobelemnon stelliferum Kükenthal & Broch, 1911: 224, figs 54–60. Kükenthal, 1915: 29, figs 40–41 (Lit.!).

Material

SAM–H3707, off Skeleton Coast, Namibia (20°59′S 12°23′E), 486–605 m, 20 August 1982, 1 colony, bottom trawl; Sea Fisheries Research Institute, Crab Survey. SAM–H4026 off Skeleton Coast, Namibia (*c.* 21°00′S 12°00′E),

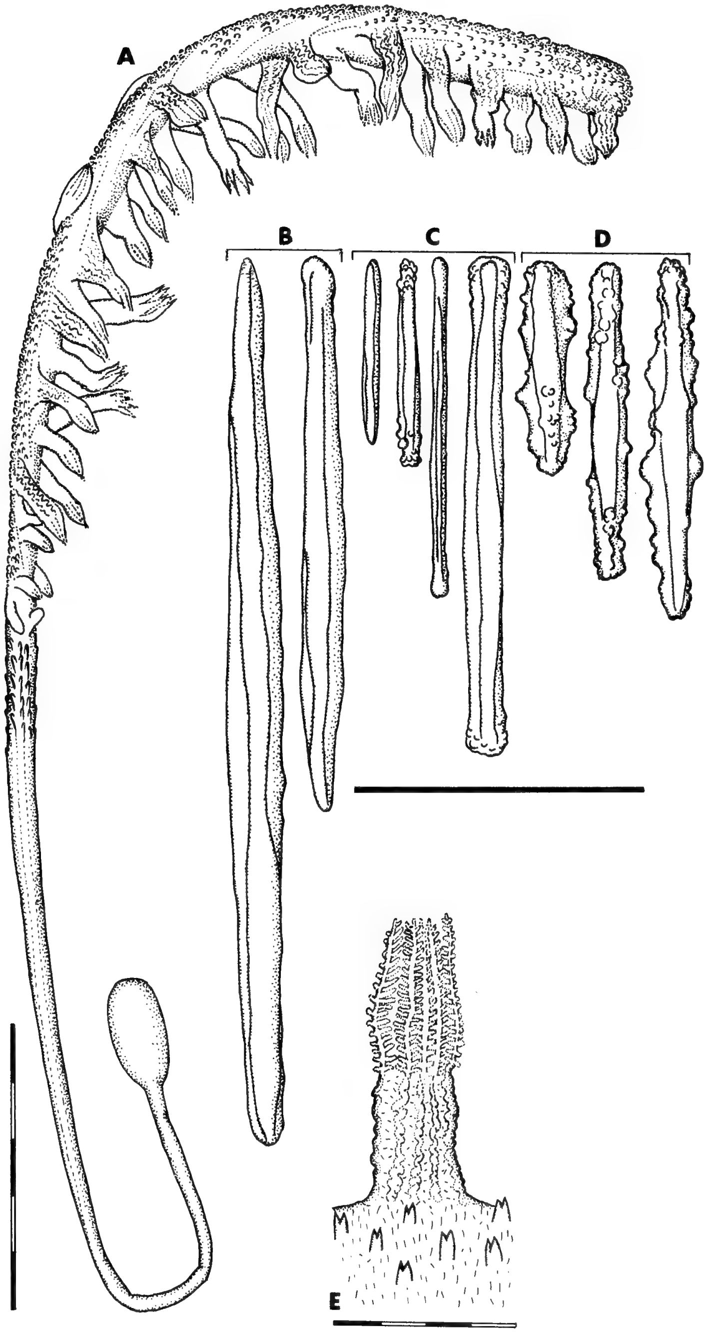

Fig. 14. *Kophobelemnon stelliferum*. A. Entire colony. Scale = 50 mm. B. Sclerites from surface of rachis. C. Sclerites from wall of an autozooid. D. Sclerites from surface of peduncle. Scale: B–D = 0,2 mm. E. Detail of single autozooid and seven siphonozooids. Scale = 8 mm.

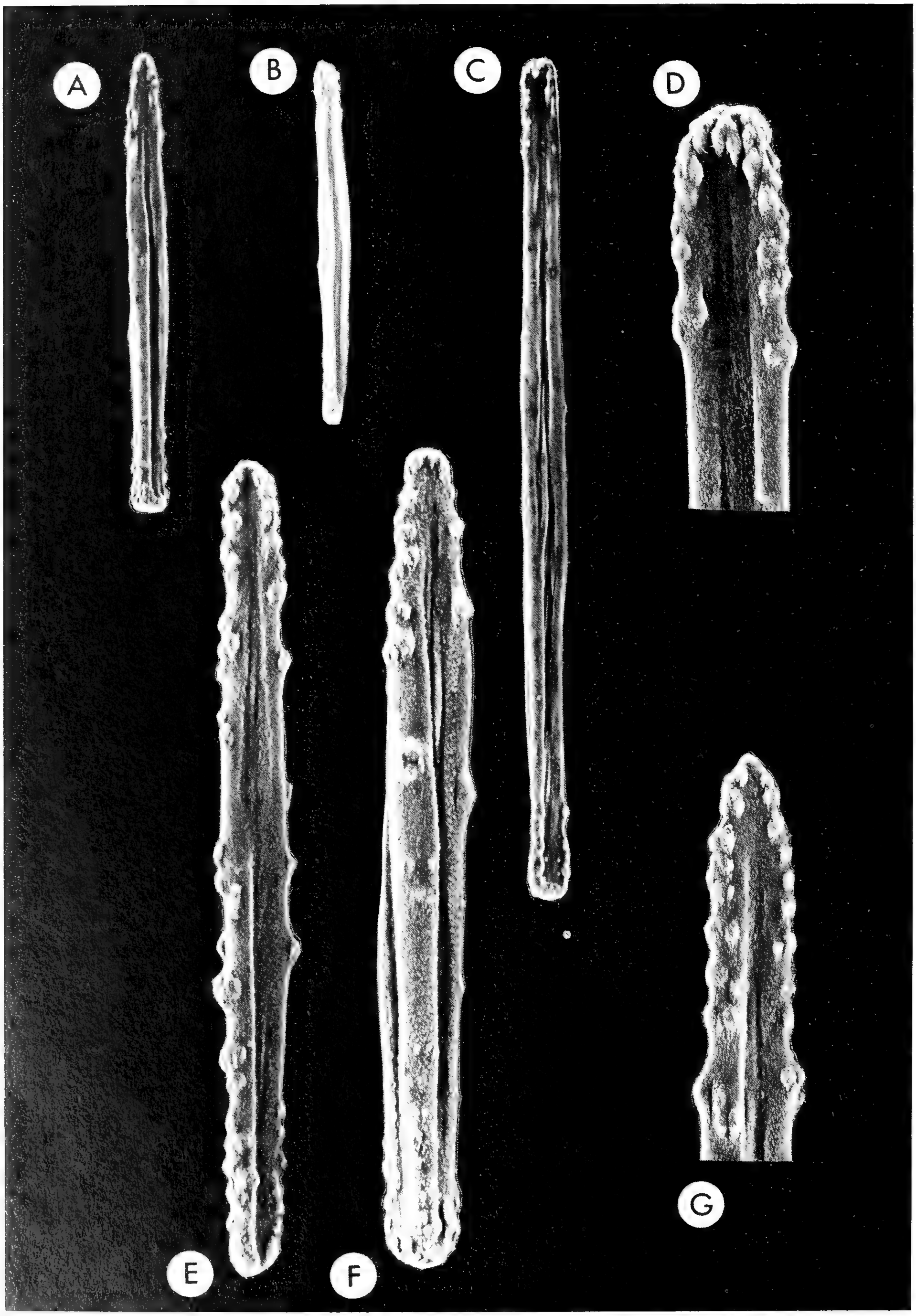

Fig. 15. Scanning electron micrographs of sclerites of *Kophobelemnon stelliferum*. A–C. From rachis: 0,32 mm; 0,33 mm; 0,59 mm. D. Tip of rachis sclerite: 0,08 mm. E–F. From peduncle: 0,26 mm; 0,24 mm. G. Tip of peduncle sclerite: 0,1 mm.

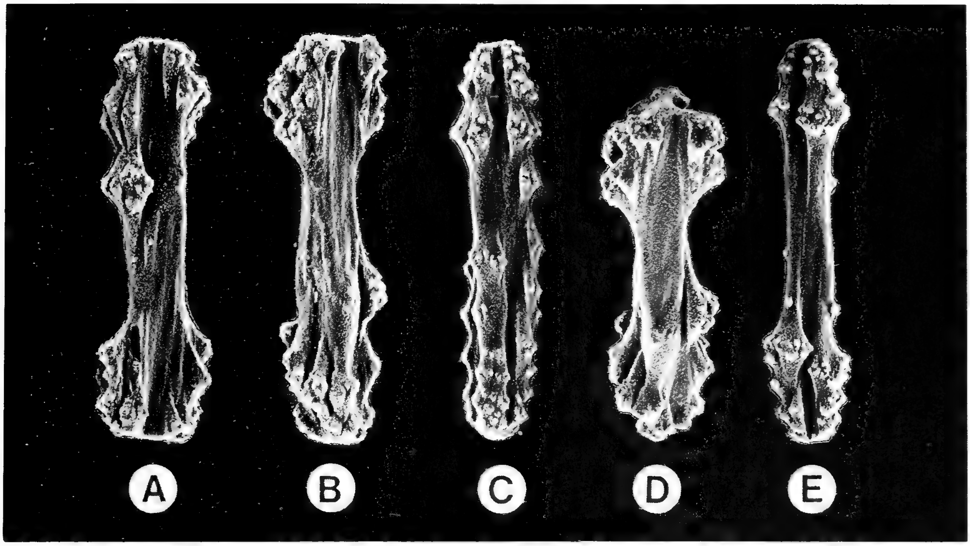

Fig. 16. *Kophobelemnon stelliferum*. Scanning electron micrographs of sclerites from base of peduncle: A. 0,14 mm; B. 0,14 mm; C. 0,16 mm; D. 0,13 mm; E. 0,19 mm.

450–650 m, February 1987, 10 colonies, bottom trawl, R. Melville Smith, Sea Fisheries Research Institute, Crab Survey.

Description

The colony, SAM–H3707, is 340 mm in length, tip of peduncle missing. Colony elongate, slender, curved. Rachis expands gradually toward distal end, which is obtuse and knob-like. Autozooids 10–15 mm long, *c.* 50 in number, in two longitudinal rows along the concave face of the rachis. Convex side of rachis is free of autozooids but is quite rough and has a granular appearance due to the presence of the spiculated calyces of numerous siphonozooids. These zooids are also found at the base of the autozooids. Colony densely spiculated throughout.

Sclerites are tuberculated three-flanged spindles varying in length from 0,1 mm to 0,6 mm. The longer sclerites from the polyps and rachis are tuberculate only at the ends. The shorter spindles of the peduncle may have tubercles throughout the entire length but mostly concentrated at the ends. Tubercles rounded and prominent. The appearance, size, and distribution of these sclerites agrees with those figured by Kükenthal & Broch (1911: 228) for the species.

Colour in alcohol is brownish-grey.

Distribution (Fig. 40)

Atlantic Ocean from the Norwegian Sea to Namibia, and at scattered locations in the Pacific. In southern Africa it is known only from off the Skeleton

Coast of Namibia (450–650 m). This study establishes a new record for southern Africa. The type locality is the Grand Banks, south-east of Newfoundland.

Remarks

The form of the sclerites of this specimen agrees with those figured by Kükenthal & Broch (1911: 228). They are slender and many have knobby protuberances at each end. *Kophobelemnon heterospinosum* Kükenthal, 1910, has similarly shaped sclerites but without prominent tuberculation. *Kophobelemnon affine* Studer, 1894, has tubercles on the peduncular sclerites, but the colonial sclerites as a whole are more stout, being proportionally wider than those of *K. stelliferum*.

Kophobelemnon stelliferum is distinguished from other southern African sea pens by its elongate clavate appearance with rachis that gradually widens distally, 20–40 polyps arranged biserially, and peduncular sclerites that are rods with knobby tubercles.

Kophobelemnon sp.

Fig. 38

Remarks

A 50-mm long colony, possessing only two antozooids, has recently been collected from off Durban, Natal, at 820 m in depth. Four species are characterized by having a reduced number of autozooids: *Kophobelemnon hispidum* Nutting, 1912; *K. pauciflorum* Hickson, 1916; *K. molanderi* Pasternak, 1975*b* nom. nov. (= *K. pauciflorum* Molander, 1929); and *K. macrospinosum* J. A. Thomson, 1927 (= *K. biflorum* Pasternak, 1960). The unavailability of pertinent literature sources precluded the making of necessary comparisons.

Family **Anthoptilidae** Kölliker, 1880

Colonies long and whip-like, bilaterally symmetrical with polyps in two longitudinal series. Polyps in oblique rows, non-retractile, calyces absent. Siphonozooids are numerous on the rachis situated between the oblique rows of autozooids. Sclerites are absent except for minute ovals of the stalk interior. Axis present; round to somewhat quadrangular in cross section. Peduncle stout to robust, not more than one-fifth total colony length.

A monogeneric family of the Atlantic Ocean and Arctic region 238–2 744 m.

Genus *Anthoptilum* Kölliker, 1880

Virgularia (*non* Lamarck, 1816) Verrill, 1879: 239.
Anthoptilum Kölliker, 1880: 13. Jungersen, 1904: 65. Kükenthal & Broch, 1911: 232. Kükenthal, 1915: 32 (Lit!). Hickson, 1916: 138. Grasshoff, 1982*b*: 954.
Benthoptilum Verrill, 1885: 510.
Stephanoptilum Roule, 1905: 455.
Thesioides J. A. Thomson & Henderson, 1906: 91.

Diagnosis

The characters of the family.

Two species of the Atlantic and Arctic.

Type species. Virgularia grandiflora Verrill, 1879; northern Atlantic.

Anthoptilum grandiflorum (Verrill, 1879)

Figs 17, 40

Virgularia grandiflora Verrill, 1879: 239.

Anthoptilum thomsoni Kölliker, 1880: 13, pl. 4 (figs 16–18). J. A. Thomson & Rennet, 1927: 123.

Anthoptilum grandiflorum: Jungersen, 1904: 66. Hickson, 1904: 233, pl. 8 (fig. 14). Kükenthal & Broch, 1911: 233, pl. 14 (figs 5–7), pl. 19 (figs 44–46) (*partim*). J. S. Thomson, 1915: 17. Kükenthal, 1915: 32, fig. 44 (*partim*) (Lit!). Tixier-Durivault, 1954: 629. Grasshoff, 1982*a*: 741, 750; 1982*b*: 954, fig. 35 (Lit!).

Anthoptilum sertum: Kükenthal, 1915: 33.

Material

SAM–H1213, off Lion's Head, Cape Peninsula (33°55′S 17°55′E), 313 m, 16 March 1900, 2 colonies, large dredge, S.S. *Pieter Faure* survey, station PF 2156.

Description

Colonies examined are 400–1 050 mm in length. Polyps 5–10 per row, 8–25 mm in length. Adjacent polyps may be joined proximally, forming a common base for an entire oblique row, or only two or three polyps in a row may be joined, this group being free from the rest of the polyps in the row. Colour often bright red in life, yellowish brown in alcohol.

Distribution (Fig. 40)

In southern Africa, known from off the west coast of the Cape Peninsula, at 238–348 m. The species is also recorded from the western, eastern, and southern Atlantic, as well as the Arctic region. Recorded depth range is 238–2 500 m.

Remarks

This species is distinguished from other southern African pennatulaceans by its whip-like appearance, lack of calyces and sclerites, and with adjacent polyps united at their bases into groups of 5–10 polyps forming short oblique rows.

Family **Funiculinidae** Gray, 1870

Elongate, whip-like colonies with polyps arranged biserially, often covering the lateral and ventral surfaces of the rachis. Polyps are retractile into tubular, eight-toothed calyces, which may be arranged irregularly or in somewhat oblique rows. Siphonozooids few. Sclerites numerous; three-flanged spindles, rods, and ovoid plates.

A monogeneric family of cosmopolitan distribution.

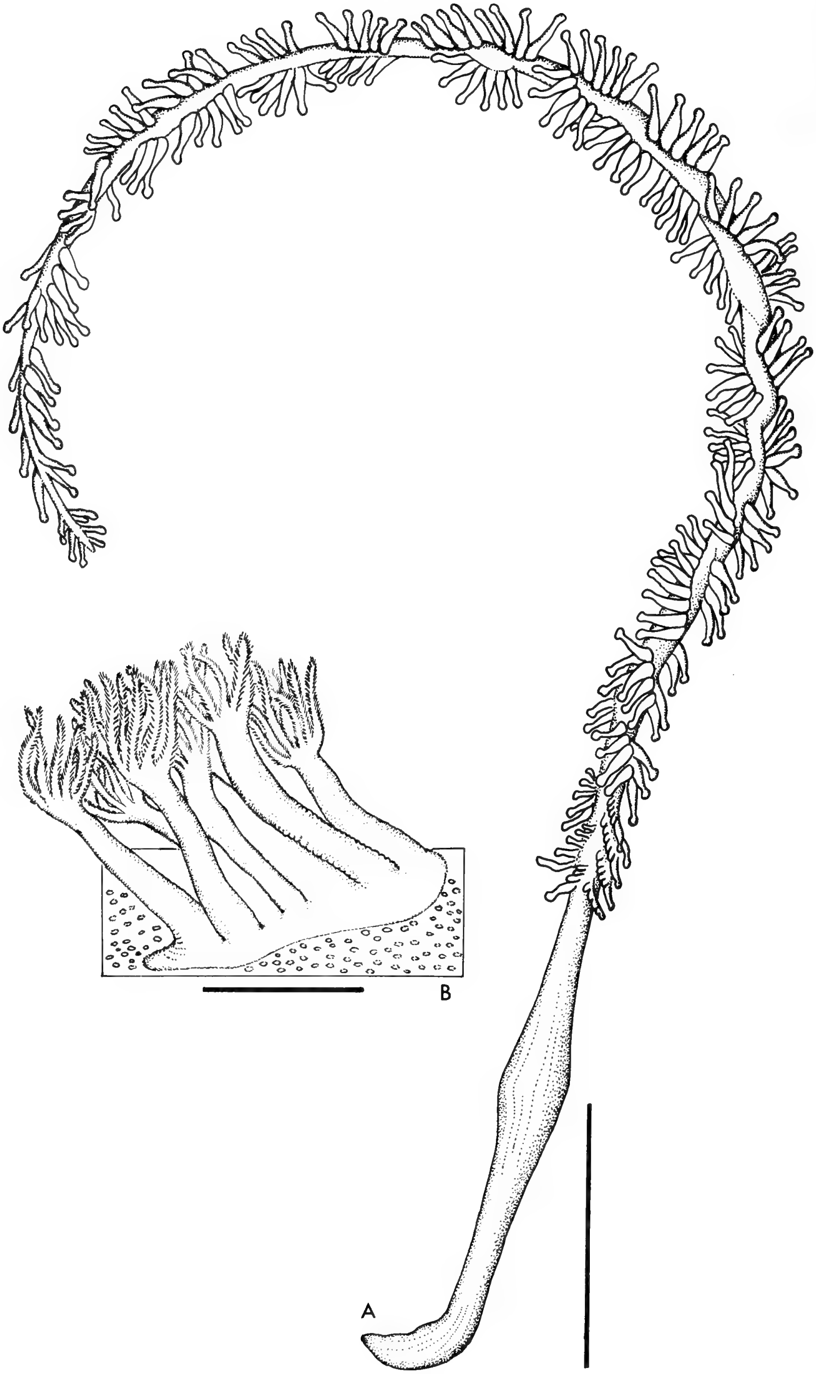

Fig. 17. *Anthoptilum grandiflorum.* A. Entire colony. Scale = 50 mm. B. Detail of group of autozooids with numerous siphonozooids at base. Scale = 10 mm.

Genus *Funiculina* Lamarck, 1816

Funiculina Lamarck, 1816: 422. Herklots, 1858: 8. Kölliker, 1872: 250. Kükenthal & Broch, 1911: 241. Kükenthal, 1915: 34 (Lit!). Manuel, 1981: 53.
Leptoptilum Kölliker, 1880: 27.
Trichoptilum Kölliker, 1880: 29.

Diagnosis

The characters of the family.

Three species are recognized worldwide.

Type species. Pennatula quadrangularis Pallas, 1766.

Funiculina quadrangularis (Pallas, 1766)

Fig. 38

Pennatula quadrangularis Pallas, 1766: 372.
Funiculina quadrangularis Jungersen, 1904: 49. Kükenthal & Broch, 1911: 243, pl. 15 (fig. 12) (Lit.!). Kükenthal, 1915: 34, figs 45–46. J. S. Thomson, 1915: 15, figs 45–46. Pasternak, 1975*b*: 104. Manuel, 1981: 53, fig. 14. Grasshoff, 1981: 227.

Material

Material was not available for examination.

Distribution (Fig. 38)

Cosmopolitan, recorded up to 2 300 m in depth.

Remarks

Thomson (1915: 15) recorded one 490-mm specimen from 146–183 m off Cape Vidal, Natal (28°10′S 32°40′E). According to Manuel (1981: 53), Kükenthal (1915: 34), and the above reference, the species is characterized by having a distinctly quadrangular axis covered with a thin coenenchyme. Colonies may reach 2 199 mm in length. Distal portions of colonies are flexible and often tend to curve or coil spirally. Peduncular interior with ovoid plate-like sclerites. Calyces with elongate, three-flanged spindles (up to 0,63 mm in length) forming eight, pointed terminal teeth and a transverse band of similar sclerites surrounding the base of the teeth. The surface of the rachis possesses three-flanged rod-like sclerites.

Family **Protoptilidae** Kölliker, 1872

Colonies elongate, slender, bilateral. Autozooids arranged in one to three longitudinal series, retractile into spiculate calyces. Sclerites are numerous, three-flanged, mostly spindles. Axis prominent and rounded in cross-section.

Three genera of the Atlantic and Indo-Pacific: *Protoptilum* Kölliker, 1872*a*; *Distichoptilum* Verrill, 1882, and *Helicoptilum* Nutting, 1912. The present study represents the first records of the family for southern Africa.

Genus *Distichoptilum* Verrill, 1882

Distichoptilum Verrill, 1882: 362. Kükenthal, 1915: 39. Hickson, 1916: 101.
Juncoptilum J. A. Thomson & Henderson, 1905: 555.

Diagnosis

Polyps arranged in two longitudinal series. No polyps on ventral surface. Axial side of calyces appressed to lateral margin of rachis. The siphonozooids are two per autozooid, placed on the rachis directly above the mouth of each autozooid, one on the dorsal side and one on the ventral side of the calyx.

A monospecific genus.

Type species. Distichoptilum gracile Verrill, 1882; eastern North America.

Distichoptilum gracile Verrill, 1882

Figs 18, 19H–I, 40

Distichoptilum gracile Verrill, 1882: 362. Jungersen, 1904: 62. J. A. Thomson & Henderson, 1906: 87. Kükenthal, 1915: 39 (Lit.!). Pasternak, 1975*b*: 106. Grasshoff, 1982*a*: 738, 741–742, map 8; 1982*b*: 955, figs 38–39.
Juncoptilum Alcocki J. A. Thomson & Henderson, 1905: 555.

Material

SAM–H3163, west of Table Bay, western Cape Province (33°49′S 16°30′E), 2 744 m, 27 August 1959; many fragments of several colonies, 15-foot beam trawl, Division of Sea Fisheries.

Description

Colonies examined are perhaps up to 1 000 mm in length and 4 mm in width. Polyps in two longitudinal series, alternate or sub-opposite, retractile into prominent calyces. Distance between polyps along rachis 4–7 mm. Calyces 2–4 mm long. Calyces adhere to rachis along their inner proximal portions and face upward. Calyces usually with two terminal teeth, but these are sometimes obscure in autozooids of the lower rachis. Sclerites of the calyces are large spindles (up to 0,5 mm in length), three-flanged and smooth. Peduncular sclerites are shorter and inconspicuously three-flanged. Calyces orange, rachis yellowish to cream.

Distribution (Fig. 40)

Previously recorded from the eastern Pacific, Indian, and northern Atlantic Oceans, 793–4 300 m. This work represents the first record of the genus and species in southern Africa, and extends the range in the Atlantic southward from Europe and eastern North America.

Remarks

A considerable amount of variation is evident in this species. Kükenthal (1915: 40) stated that the calyces possess six terminal teeth and the length of calyx sclerites is up to 1,0 mm. Jungersen (1904: 62) regarded number of calyx teeth as

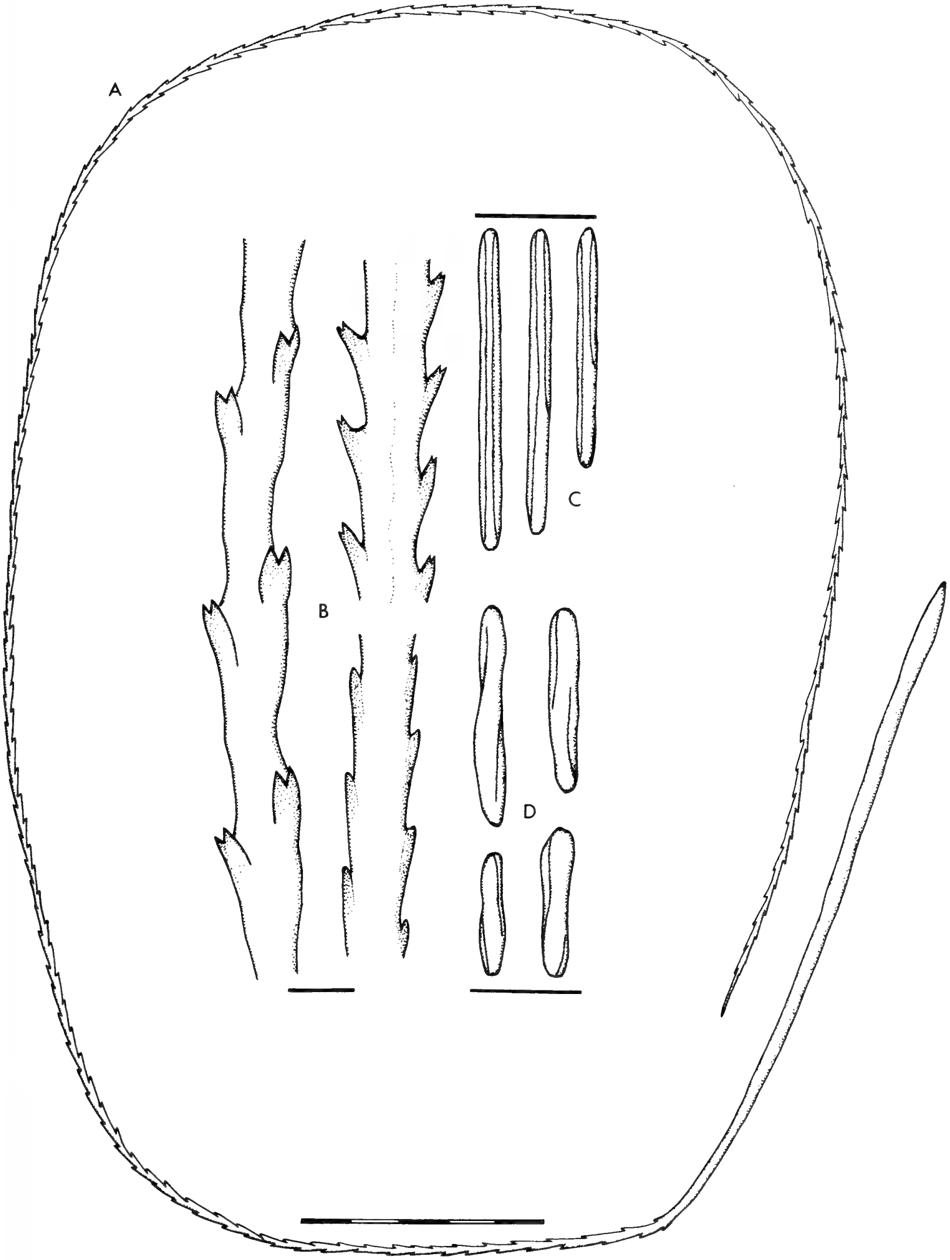

Fig. 18. *Distichoptilum gracile*. A. Entire colony. Scale = 50 mm. B. Detail of colony from three different parts of rachis showing calyces. Scale = 2 mm. C. Sclerites from calyx. Scale = 0,2 mm. D. Sclerites from peduncle. Scale = 0,1 mm.

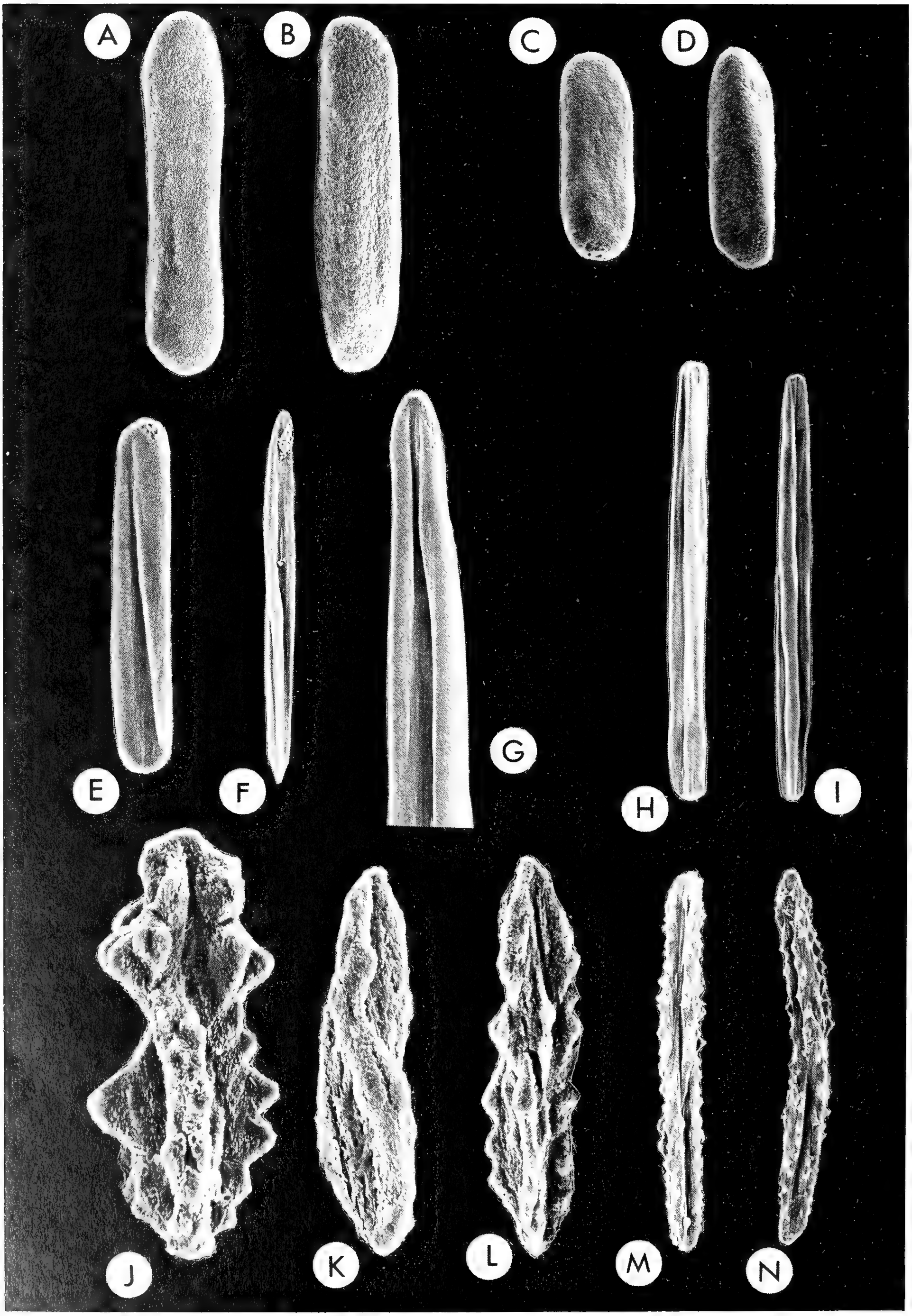

Fig. 19. Scanning electron micrographs of sclerites. A–G. *Halipteris africana*. A–D. From peduncle: 0,07 mm; 0,05 mm; 0,04 mm. E. From tentacle: 0,11 mm. F. From calyx: 0,58 mm. G. Tip of calyx sclerite: 0,2 mm. H–I. *Distichoptilum gracile*. From calyx: 0,36 mm; 0,44 mm. J–N. *Umbellula thomsoni*. J–L. From anthocodial neck zone: 0,05 mm; 0,05 mm; 0,06 mm. M–N. From tentacle: 0,2 mm; 0,24 mm.

a matter of the degree of contraction of the polyps, as some highly contracted polyps show two lobes, whereas partially contracted polyps often exhibit six distinct teeth. He also stated that the length of calyx sclerites varies between 0,528 and 0,800 mm. The calyces of the southern African material show two large teeth only and the sclerites vary from 0,28–0,50 mm in length.

Distichoptilum gracile is distinguished from other southern African sea pens by its thin whip-like appearance, small polyps retractile into permanent calyces that are appressed close to the surface of the rachis and are arranged biserially in two longitudinal rows.

Family **Scleroptilidae** Jungersen, 1904

Polyps usually situated in pairs or groups of three along rachis, separated by intervals of bare rachis. Axis thin and delicate, extending entire length of colony. Siphonozooids few and scattered on rachis. Calyces absent. Sclerites present or absent.

A family of two genera from the North Atlantic and Indo-Pacific.

Genus *Scleroptilum* Kölliker, 1880

Scleroptilum Kölliker, 1880: 30. Balss, 1910: 24. Kükenthal & Broch, 1911: 265. Kükenthal, 1915: 43.

Diagnosis

Sclerites (rods or three-flanged spindles) are present in the walls of the autozooids.

A genus of at least two or three species from the northern Atlantic and Indo-Pacific.

Type species. *Scleroptilum grandiflorum* Kölliker, 1880; Japan.

Scleroptilum sp.

Fig. 38

Remarks

Five colonies, 35–50 mm in length, have recently been collected from off the Transkei coast at 510 m in depth. These colonies can be assigned to the genus *Scleroptilum* by the arrangement of the polyps in whorls or clusters of 2–3 (each cluster separated by bare areas of rachis), lack of calyces, and the possession of sclerites in the walls of the polyps. The sclerites differ from those of *Scleroptilum grandiflorum* Kölliker, 1880, and the material has not been identified to species. This represents the first record for the family and genus in southern Africa.

Genus *Calibelemnon* Nutting, 1908

Calibelemnon Nutting, 1908: 562. Balss, 1910: 70. Kükenthal, 1915: 44.
Prochunella Balss, 1909: 426.

Diagnosis

Sclerites completely absent or with small bodies restricted to the peduncle. A genus of perhaps two species of the Indo-Pacific.

Type species. Protocaulon indicum J. A. Thomson & Henderson, 1906; Bay of Bengal.

Calibelemnon sp.

Fig. 38

Remarks

Several colonies were collected in 1975 from near Cape Vidal, Natal, at 740 m in depth. Unlike *Calibelemnon indicum* (J. A. Thomson & Henderson, 1906), in which sclerites are completely absent, these colonies possess small sclerites in the peduncle, and therefore probably represent an undescribed species. This represents a new record of the genus in southern Africa and extends the range to the south-western fringe of the Indo-Pacific region.

Family **Chunellidae** Kükenthal, 1902

Rachis slender. Axis quadrangular. Polyps in well-separated whorls. One to four polyps per whorl. Polyps without calyces. Siphonozooids few and inconspicuous, on rachis between autozooids. Sclerites absent except for minute oval bodies in the interior of the peduncle.

Two genera of the Indian Ocean. The present study represents the first record of the family in southern Africa.

Genus *Chunella* Kükenthal, 1902

Chunella Kükenthal, 1902: 302; 1915: 45. Kükenthal & Broch, 1911: 271.

Diagnosis

With terminal autozooid highly reduced or absent. Whorls with 1–4 autozooids.

A genus of three nominal species, from the eastern coast of Africa to the Malay Archipelago.

Type species. Chunella gracillima Kükenthal, 1902; East Africa.

Chunella gracillima Kükenthal, 1902

Figs 20, 38

Chunella gracillima Kükenthal, 1902: 302; 1915: 45, fig. 53. Kükenthal & Broch, 1911: 272, pl. 15 (fig. 13). Bayer, 1956: 227.

Material

SAM–H3735, off Port Durnford, Natal (28°37,8′S 32°38,4′E), 1 000–1 200 m, 25 May 1976, 8 whole colonies, beam trawl, South African Museum R.V. *Meiring Naude* cruises. SAM–H4029, one whole colony, same data as SAM–H3735.

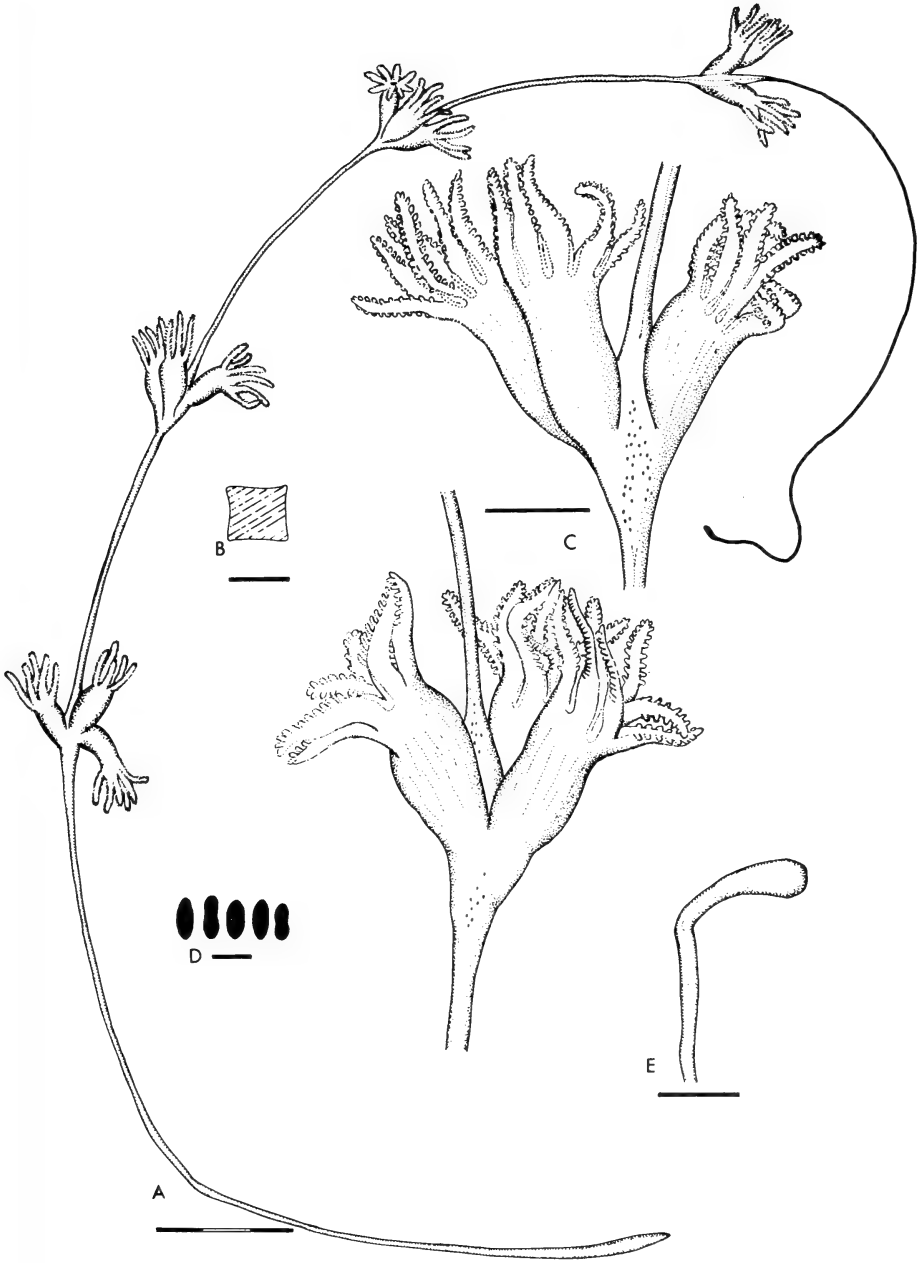

Fig. 20. *Chunella gracillima*. A. Entire colony. Scale = 30 mm. B. Transverse section of axis. Scale = 0,7 mm. C. Two groups of three autozooids with minute siphonozooids on rachis. Scale = 5 mm. D. Minute sclerites from lower peduncle. Scale = 0,02 mm. E. Rudimentary polyp from distal tip of colony. Scale = 1,2 mm.

Description

Colonies examined vary in length from 320–550 mm. Number of autozooids per whorl varies from one to four (most commonly three). Whorls 3–7 per colony separated by 30–60 mm intervals of bare rachis. Autozooids vary from 3 mm to 15 mm in length in a preserved state. Siphonozooids few and inconspicuous on the rachis at each autozooid whorl, consistent in form and size throughout the colony. Axis conspicuously quadrangular, 0,5–1,5 mm in width. Peduncle up to 50 mm in length and 3–4 mm in width. Sclerites absent except for minute oval bodies up to 0,02 mm long in the interior of the lower peduncle of all colonies examined. Autozooids greyish with brown tentacles, rachis and peduncle cream.

Distribution (Fig. 38)

Equatorial eastern Africa and Natal, 818–1 200 m. This is the first record of the genus and species in southern Africa. The type locality is Pemba Island, border of Kenya and Tanzania, 818 m in depth.

Remarks

This species is distinguished from other southern African sea pens by its 3–7 demarcated clusters of 2–4 polyps and possession of a single rudimentary terminal polyp.

Remarks on the genus Chunella

Kükenthal & Broch (1911: 275) described *Chunella quadriflora* for colonies with lower whorls of four autozooids, from the same locality as *C. gracillima*. Hickson (1916) described *C. biflora* (from the Malay Archipelago) for colonies with two autozooids per whorl. Kükenthal (1915: 45) characterized *C. gracillima* as having three autozooids per whorl.

Of the eight colonies from the same trawl sample that I have examined, one has four autozooids in a lower whorl and three in an upper whorl. Another colony has two autozooids in upper whorls and three in lower whorls. Some whorls in other colonies may have one, two, or three autozooids per whorl. It therefore seems that, since the number of autozooids per whorl is not consistent in a given colony, the character can hardly be used to separate species. As a result, I suspect that the three species may in fact be conspecific but the pertinent type material is presently unavailable for comparative examination.

Kükenthal & Broch (1911, pl. 20 (fig. 49)) showed a photograph labelled '*Chunella quadriflora*'. The specimen appears to possess three whorls of two autozooids each and a single well-developed terminal autozooid. The photograph therefore appears to be that of a colony of *Amphiacme abyssorum* and not *Chunella quadriflora*.

Genus *Amphiacme* Kükenthal, 1903

Amphianthus Kükenthal, 1902: 303.
Amphiacme Kükenthal, 1903: 275; 1915: 46. Kükenthal & Broch, 1911: 276.

Diagnosis

With a single terminal autozooid that is well-developed and somewhat asymmetrical. Autozooids in pairs. Siphonozooids present on the keel of the terminal autozooid as well as on the rachis between the individual autozooids of each pair.

A monospecific genus of the eastern African coast.

Type species. Amphianthus abyssorum Kükenthal, 1902; East Africa.

Amphiacme abyssorum (Kükenthal, 1902)

Figs 21, 38

Amphianthus abyssorum Kükenthal, 1902: 302.

Amphiacme abyssorum: Kükenthal, 1903: 275; 1915: 47, fig. 54. Kükenthal & Broch, 1911: 276, pl. 15 (fig. 14). Tixier-Durivault, 1972: 52. Tixier-Durivault & D'Hondt, 1974: 260.

Material

SAM–H3736, off Jesser Point, Natal (27°38,6′S 32°52,6′E), 860 m, 21 May 1976, 1 whole colony, beam trawl, South African Museum R.V. *Meiring Naude* cruises. SAM–H3737, off Port Durnford, Natal (28°37′S 32°38′E), 1 000–1 200 m, 25 May 1976, 2 whole colonies, beam trawl, South African Museum R.V. *Meiring Naude* cruises.

Description

The colonies examined are 230–250 mm in length. Axis conspicuously quadrangular, usually <1 mm in width. Autozooids in two or three pairs along rachis, at intervals of 30–50 mm. Autozooids about 10 mm in length preserved. Terminal autozooid bilaterally symmetrical or somewhat asymmetrical, 8–10 mm long with a ventral keel. Peduncle 10–12 mm in length and 1–2 mm in width. Siphonozooids few, located on the rachis at each whorl and on the keel of terminal autozooid. Sclerites absent except for oval bodies (<0,02 mm) in peduncle. Polyps brownish-grey, rachis cream or tan, peduncle brownish.

Distribution (Fig. 38)

The Indian Ocean coast of Africa, from the equator to Natal, and Madagascar; 760–1 200 m. The present study represents a new record for southern Africa and extends the range of the genus and species south to South Africa. The type locality is the coastal region near the border of Kenya and Tanzania, 818–1 019 m in depth.

Remarks

Amphiacme abyssorum is distinguished from other southern African pennatulaceans by the arrangement of the polyps in two or three demarcated pairs along the rachis, and the possession of a single modified terminal polyp.

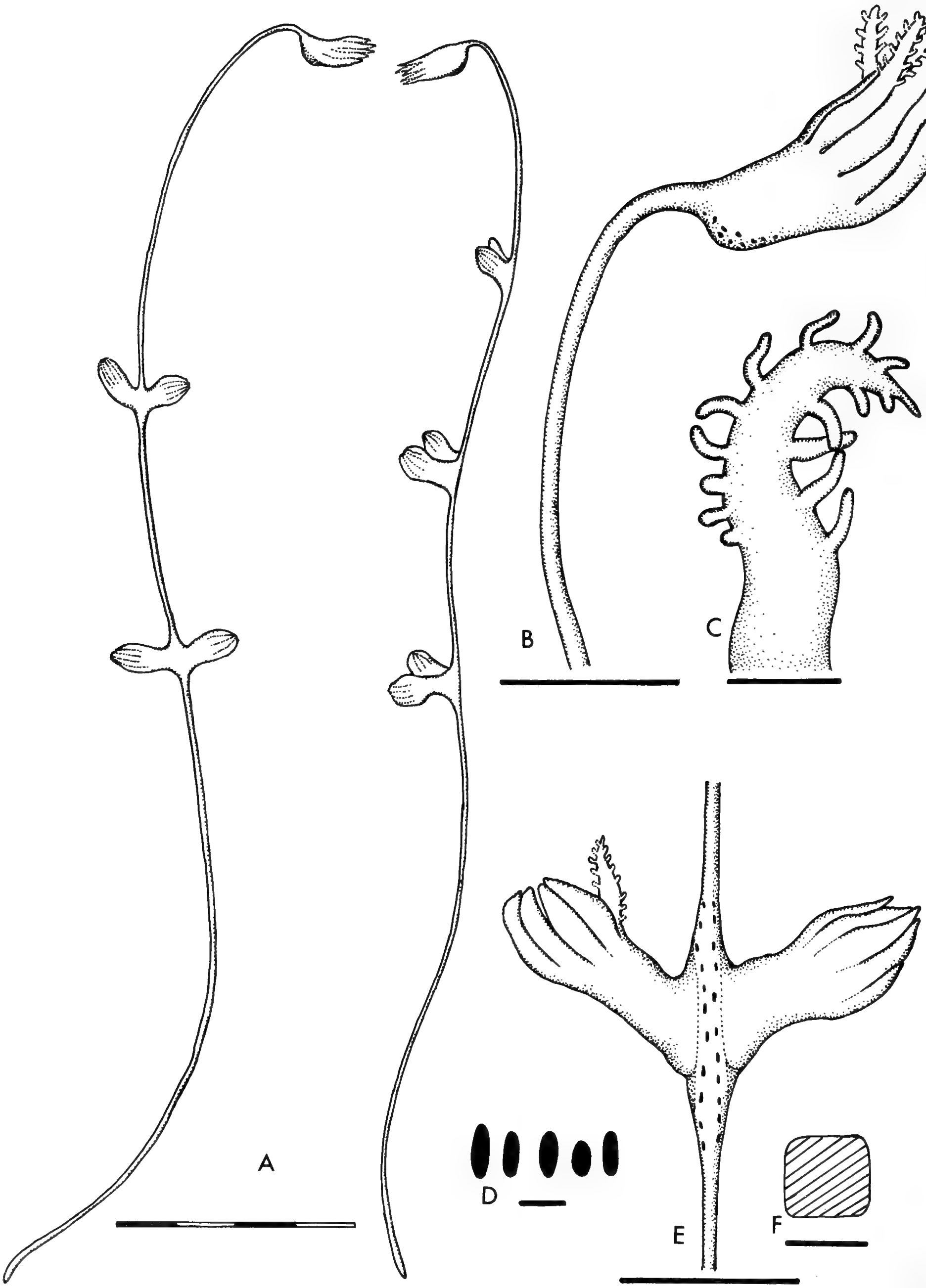

Fig. 21. *Amphiacme abyssorum.* A. Two entire colonies. Scale = 40 mm. B. Terminal autozooid with ten minute siphonozooids on keel. Scale = 10 mm. C. Single tentacle from autozooid. Scale = 1 mm. D. Sclerites from peduncle. Scale = 0,02 mm. E. Detail of rachis with a pair of autozooids and several siphonozooids. Scale = 10 mm. F. Transverse section of axis. Scale = 0,5 mm.

Family **Umbellulidae** Lindahl, 1874

Rachis long and slender. Axis quadrangular to round in cross section. Autozooids restricted to the distal terminus, usually forming an umbellate cluster. Siphonozooids are present on the rachis at the base of the autozooids or on bare parts of the rachis. Sclerites present in peduncle and terminal cluster, or totally absent. When present, sclerites are rods, spindles or needles, three-flanged round in cross-section.

A monogeneric family.

Genus *Umbellula* Cuvier, 1798

Isis Linnaeus, 1758: 800 (*partim*).
Pennatula Pallas, 1766: 335 (*partim*).
Vorticella Linnaeus, 1767: 1317.
Ombellula Cuvier, 1798: 675.
Umbellularia Lamarck, 1816: 436. Kölliker, 1872*a*: 203.
Umbellula Gray, 1870: 39. Kölliker, 1875: 11. Kükenthal & Broch, 1911: 282 (Lit!). Broch, 1957: 350; 1958*a*: 267; 1958*b*: 251. Grasshoff, 1982*b*: 956.

Diagnosis

Characters of the family.

A genus of perhaps 12 valid species. Cosmopolitan distribution; deep sea, 250 m to over 6 100 m.

Type species. Isis encrinus Linnaeus, 1758; Arctic Ocean.

Umbellula thomsoni (Kölliker, 1874)

Figs 19J–N, 22, 23, 40

Umbellularia Thomsonii Kölliker, 1874: 13.
Umbellula Thomsonii: Kölliker, 1875: 11.
Umbellula thomsonii: Broch, 1958: 253, figs 2, 4 (Lit!). Grasshoff, 1972: 2, fig. 1.
Umbellula Guntheri Broch, 1913: 3, pl. 1 (fig. 1).
Umbellula aciculifera J. S. Thomson, 1915: 20 (and text-fig. on p. 21), pl. 2 (figs 1–2).
Umbellula thomsoni: Kölliker, 1880: 19. Kükenthal, 1915: 54. Pasternak, 1970: 240, fig. 2; 1975*b*: 106. Grasshoff, 1982*a*: 753, map 11; 1982*b*: 958.

Material

SAM–H1166, south-west of Cape Point (34°40′S 17°45′E), 1 650 m, 21 July 1903, 1 colony, shrimp trawl, S.S. *Pieter Faure* survey, station PF 17026. (Holotype of *Umbellula aciculifera* Thomson, 1915.)

Description

The colony examined is about 475 mm in length. The axis is 3 mm in diameter, rounded quadrangular near the terminal cluster. Umbellate cluster composed of 10 autozooids, each 15–20 mm long. Sclerites conspicuous and numerous. Terminal end of rachis, polyp walls, and proximal portions of tentacles with knobby, three-flanged rods and spindles (<0,3 mm). Aboral surface of tentacles and pinnules with spindles (0,5–1,3 mm); round in cross-section, not

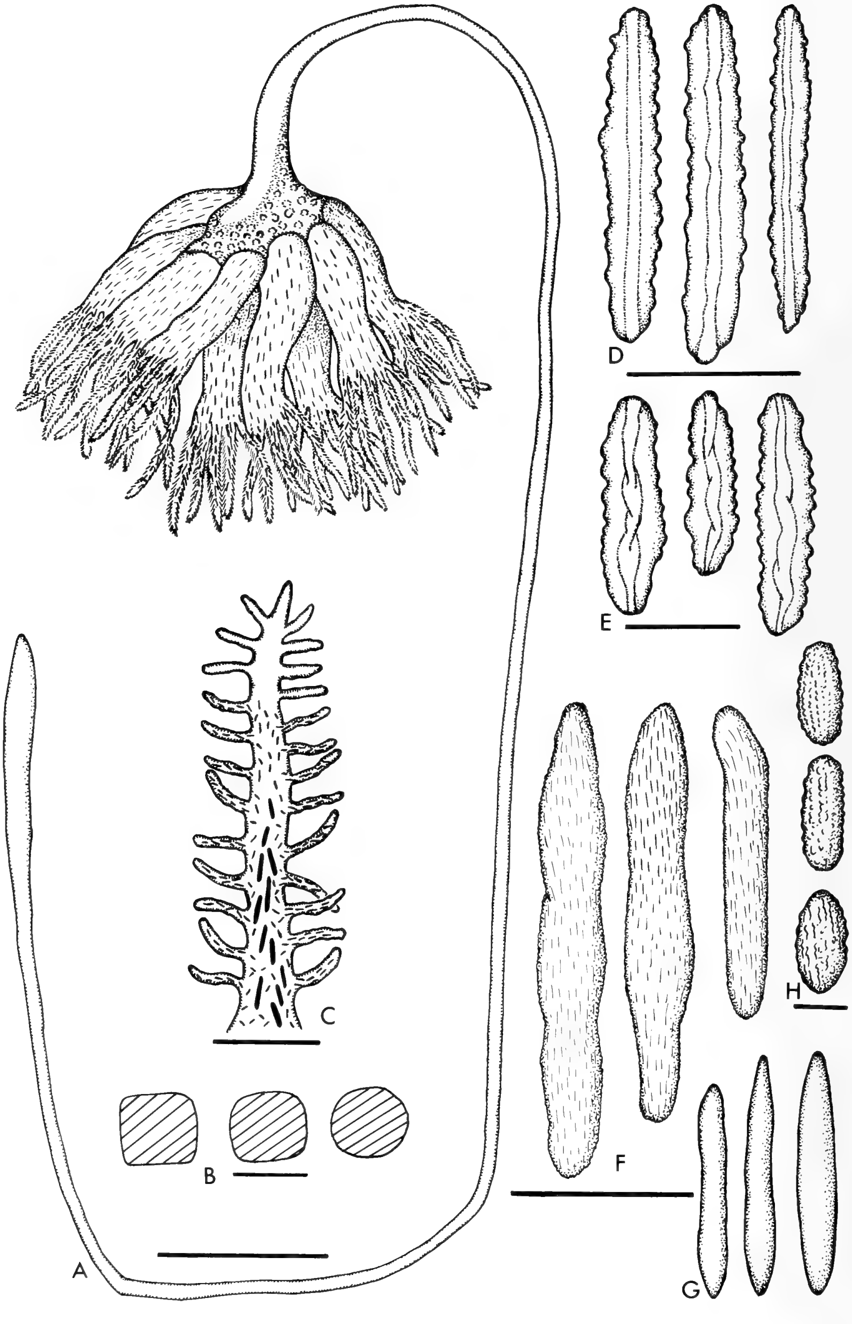

Fig. 22. *Umbellula thomsoni*. A. Entire colony. Scale = 20 mm. B. Transverse sections through three different areas of axis. Scale = 2 mm. C. Single tentacle. Scale = 3 mm. D. Small sclerites from proximal portion of tentacle. Scale = 0,1 mm. E. Sclerites from body wall of autozooid. Scale = 0.02 mm. F. Large sclerites from proximal portion of tentacle. G. Sclerites from pinnule. F–G. Scale = 0,5 mm. H. Sclerites from peduncle. Scale = 0,04 mm.

three-flanged. Peduncle with rough ovals or rods (0,08–0,11 mm in length), having numerous low, rounded knobs or tubercles.

Distribution (Fig. 40)

Apparently cosmopolitan, 1 300–6 200m. This specimen is the only known southern African record, first described by J. S. Thomson (1915) as *Umbellula aciculifera* (type specimen). The type locality of *U. thomsoni* is the north Atlantic.

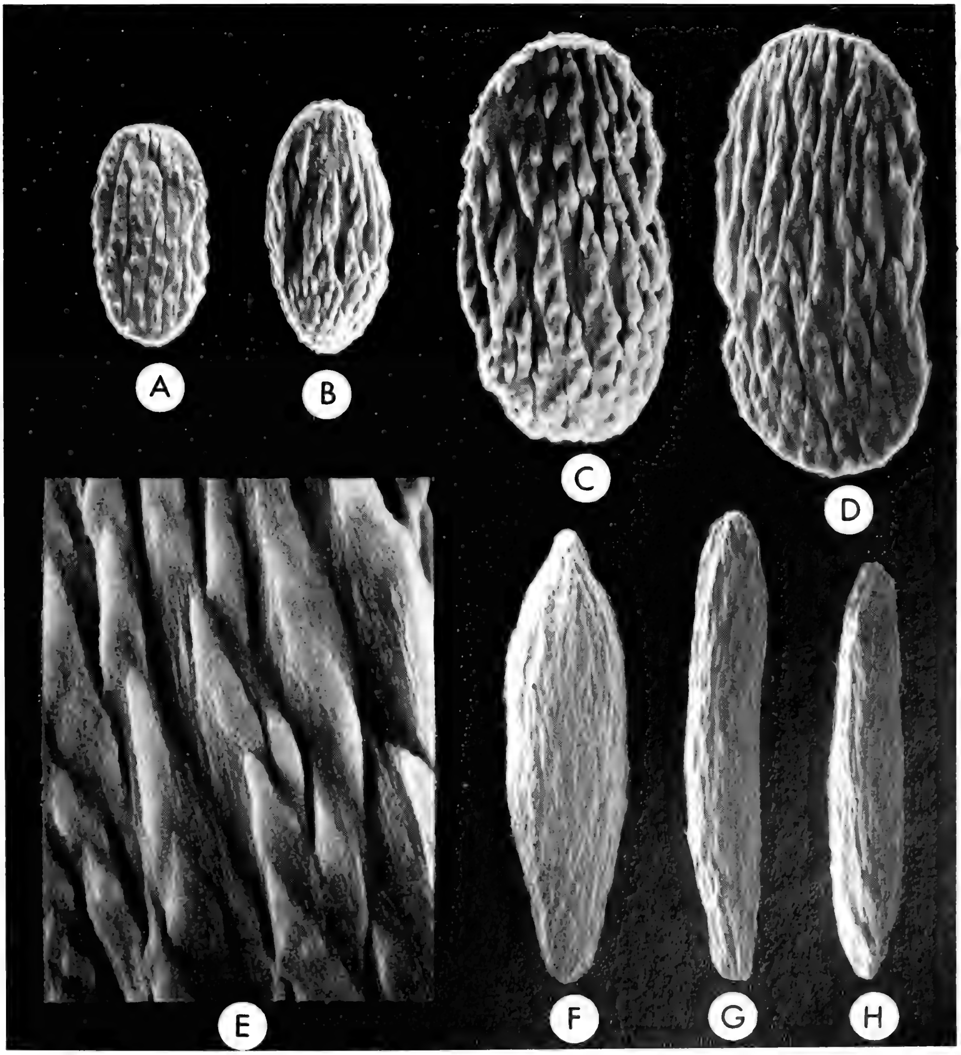

Fig. 23. Scanning electron micrographs of sclerites of *Umbellula thomsoni*. A–D. From peduncle: 0,08 mm; 0,09 mm; 0,1 mm; 0,11 mm. E. Detail of surface of D; length of micrograph 0,04 mm. F–H. Large sclerites from tentacle: 0,7 mm; 0,8 mm; 0,7mm.

Remarks

The colony has five solitary epizoic zooanthids (species indeterminate) attached to bare areas of the upper rachis. They vary from 5–15 mm in diameter and 10–12 mm in length (zooanthids not shown in Fig. 22A).

This species is distinguished from other southern African sea pens by having the autozooids restricted to a cluster at the distal end of an elongate colony, and the possession of sclerites in the autozooids.

Umbellula lindahli Kölliker, 1874

Figs 24, 40

Umbellula lindahlii Kölliker, 1874: 12. Jungersen, 1904: 75, pl. 3 (figs 37–46). Kükenthal, 1915: 48.
Umbellula miniacea Lindahl, 1874: 12, pls 1–2.
Umbellula pallida Lindahl, 1874: 13, pl. 3.
Umbellula lindahli: Broch, 1958: 262 (Lit.!). Grasshoff, 1982*a*: 741–742, 753; 1982*b*: 958, fig. 43. Pasternak, 1975*b*: 109.

Material

SAM–H3738, off the Cape of Good Hope Peninsula (34°37′S 17°03′E), 2 890–2 963 m, 8 December 1959, 2 colonies, beam trawl, Division of Sea Fisheries Survey, station A315. SAM–H3739, west of Dassen Island, western Cape Province (33°36′S 16°15′E), 2 780–2 872 m, 26 August 1959, 2 colonies, beam trawl, Division of Sea Fisheries Survey. SAM–H4028, south of False Bay (35°22,3′S 18°45,4′E), 490 m, 6 July 1986, 22 colonies, beam trawl, Rob Lesley (Sea Fisheries Research Institute, West Coast Biomass Survey, station A4305046).

Description

Colonies examined are 770–900 mm in length. Axis conspicuously quadrangular, 1–2 mm in width. Peduncle up to 150 mm long by 6 mm in width. Umbellate terminal cluster with 8–10 autozooids, each 20–30 mm long. Siphonozooids numerous on keel-like terminus of rachis. Sclerites totally absent.

Distribution (Fig. 40)

Cosmopolitan up to 6 100 m in depth. In southern Africa, the species is presently known only from the south-western Cape (490–2 963 m). This study represents a new record of the species to southern Africa. The type locality is the Arctic region of Greenland.

Remarks

This species is differentiated from other southern African sea pens by the restriction of the autozooids to a cluster at the terminal end of an elongate colony, and the complete absence of sclerites.

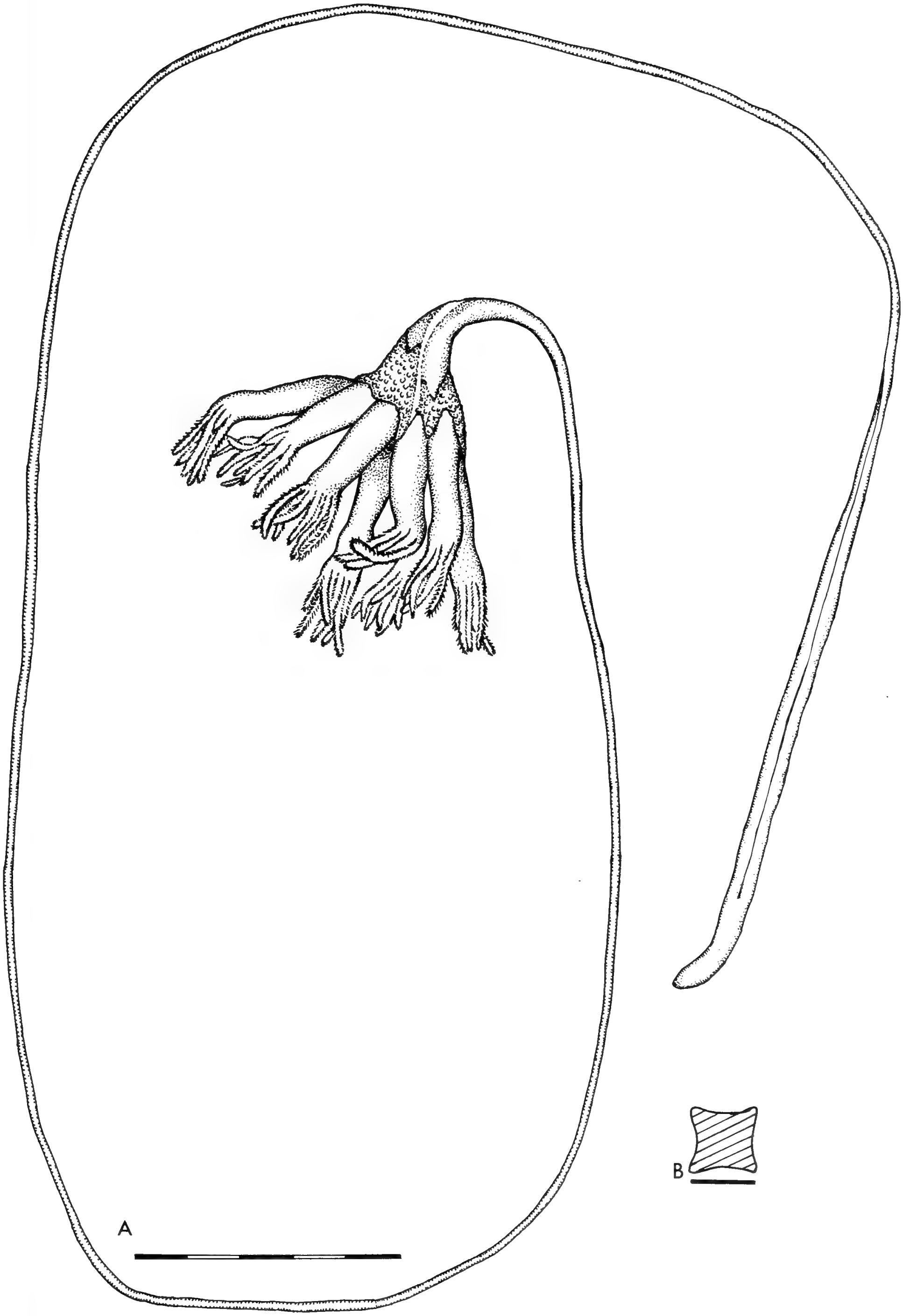

Fig. 24. *Umbellula lindahli*. A. Entire colony. Scale = 50 mm. B. Transverse section through peduncle. Scale = 1,5 mm.

Remarks on the genus Umbellula

Grasshoff (1972) recognized three species of the genus that have sclerites in the terminal autozooid region. *Umbellula monocephalus* Pasternak, 1964 (jun. syn. *U. thieli* Grasshoff, 1972) has only a single autozooid; the other two species both have multiple autozooids—*U. durissima* Kölliker, 1880, has both axis and sclerites that are round in cross section, whereas *U. thomsoni* has three-flanged sclerites and a quadrangular axis. I have found that shape of the axis in cross-section is an invalid differentiating character with regards to *U. thomsoni*, since different parts of the axis of the colony examined (SAM–H1166) are round or rounded quadrangular, but never sharply quadrangular (Fig. 22B). Also, the large sclerites of the tentacles and pinnules (>0,5 mm) are round in cross-section, whereas the small sclerites (<0,3 mm) of the proximal regions of the tentacles and of the entire polyp body wall are conspicuously three-flanged (Figs 19J–N, 22D–E, 23F–H). Thus, this specimen (which is the type upon which the des-cription of *U. aciculifera* Thomson, 1915, was based) possesses characteristics intermediate between *U. durissima* and *U. thomsoni*. In addition, Grasshoff (1972, fig. 2B) showed three-flanged spindles from the polyp walls of *U. durissima*. These facts tend to negate distinctions between the two species. Examination of type material and a variety of specimens is necessary to determine if we are dealing with two distinct species or a single variable one. This material is presently unavailable to me for comparison.

Broch (1958*b*) revised the genus *Umbellula* and recognized five species without sclerites in the terminal cluster. *Umbellula hemigymna* Pasternak, 1975*a*, was subsequently added from the Caribbean Sea. Of these six, *U. lindahli* is characterized by having quadrangular axis, large autozooids on a tassel not especially crowded, and full-grown colonies >400 mm in length. Broch (1961) compared specimens of *U. encrinus* (Linnaeus, 1758) with those of *U. lindahli* and considered them conspecific, thereby making the latter a junior synonym of *U. encrinus*. Subsequent workers, including Pasternak (1961*b*, 1964, 1975*b*, 1980) and Grasshoff (1982*a*, 1982*b*), did not recognize this synonymy and considered the two species as distinct. I have retained this distinction here. Grasshoff (1982*b*: 957–958) distinguished the two species as follows: *U. encrinus*—stalk thick, polyps stocky; *U. lindahli*—stalk thin, polyps slender.

Family **Virgulariidae** Verrill, 1868

Colonies bilateral, long and slender to whip-like. Axis well-developed, present throughout length of colony. Adjacent autozooids fused proximally, forming polyp leaves or low ridges that are arranged in transverse or oblique rows along rachis. Sclerites three-flanged spindles, minute plates, or entirely absent.

The family is of cosmopolitan distribution, with two subfamilies and six genera.

Subfamily Virgulariinae Verrill, 1868

Autozooids form low to well-developed polyp leaves (flattened expansions) by fusion of their proximal portions.

Five genera, two of which are included below, in addition to *Acanthoptilum* Kölliker, 1870, *Scytalium* Herklots, 1858, and *Stylatula* Verrill, 1864.

Genus *Virgularia* Lamarck, 1816

Virgularia Lamarck, 1816: 429. Kükenthal & Broch, 1911: 323. Kükenthal, 1915: 71 (Lit!).
Lygus Herklots, 1858: 11.
Halisceptrum Herklots, 1863: 33.
Sceptonidium Richiardi, 1869: 63.
Cladiscus Koren & Danielssen, 1877: 101.
Protocaulon Kölliker, 1880: 26.
Svava Danielssen & Koren, 1884: 57.
Deutocaulon Marshall & Fowler, 1888: 453.
Svavopsis Roule, 1908: 181.

Diagnosis

Colonies long and slender, often vermiform. Peduncle and rachis usually abruptly delimited. Autozooids form polyp leaves that are arranged in two longitudinal series along rachis. Autozooids retractile into fleshy calyces. Siphonozooids are present on polyp leaves below the free parts of the autozooids or on the rachis between the polyp leaves. Sclerites absent except for minute ovals and plates of the peduncle interior. Axis present throughout entire length of rachis and upper portion of peduncle, often projecting beyond apex of rachis.

A genus of about 20 species, in need of revision. Cosmopolitan.

Type species. *Pennatula mirabilis* Linnaeus, 1758; North Atlantic.

Virgularia schultzei Kükenthal, 1910

Figs 1D–F, 25, 28C–D, 41

Virgularia schultzei Kükenthal, 1910: 53; 1915: 72, figs 72, 73 (Lit.!). Kükenthal & Broch, 1911: 326, figs 124–125, pl. 17 (figs 21–22). J. S. Thomson, 1915: 16. Broch, 1939: 30. Tixier-Durivault, 1954: 630.
Virgularia Reinwardti (*non* Herklots, 1858) Hickson, 1900: 87. Balss, 1910: 47 (*partim*).
Virgularia spec. (juv.) Broch, 1910: 231.

Material

SAM–H3387, off Danger Point, Cape Province (34°37′S 19°24′E), 19 m, 11 April 1984, 11 colonies, SCUBA, W. R. Liltved. SAM–H3159, off Koeberg Power Station, western Cape Province (33°40′S 18°26′E), 6–20 m, 24–26 November 1981, 8 colonies, SCUBA, W. R. Liltved. SAM–H3338, Algoa Bay, eastern Cape Province (33°50′S 25°40′E), 16 m, 17 May 1984, 1 colony, SCUBA, G. C. Williams.

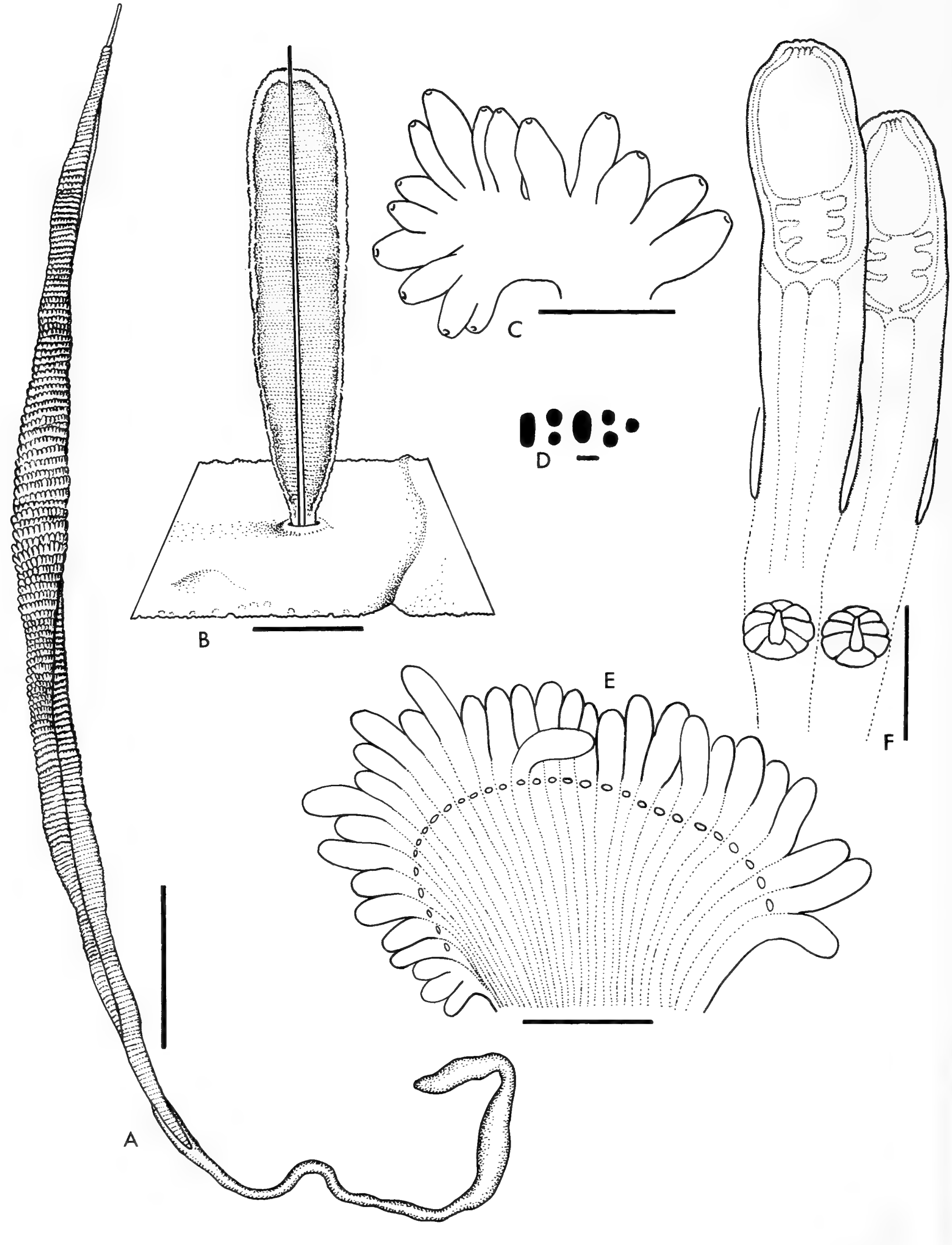

Fig. 25. *Virgularia schultzei.* A. Entire preserved colony. Scale = 20 mm. B. Expanded colony *in situ*. Scale = 20 mm. C. Polyp leaf from a 120 mm long colony. Scale = 1 mm. D. Peduncle sclerites. Scale = 0,005 mm. E. Lower surface of a polyp leaf from middle of rachis of a 400-mm long colony. Scale = 2 mm. F. Two retracted polyps from a polyp leaf showing siphonozooids at base. Scale = 0,5 mm.

Description

Colonies examined ranged in length from 85–500 mm, and 5–12 mm in width. Peduncle long and flexible. Axis up to 1,5 mm in diameter, round in cross-section. Surface of axis often with numerous perforations (canals of Kölliker) 0,003–0,004 mm in diameter. Polyp leaves well developed, numerous, transparent. Autozooids 15–35 per polyp leaf. Siphonozooids are present on the lower surface of the polyp leaves, usually one per autozooid in a band below the calyx-like free portions of the autozooids. Sclerites absent except for minute ovals of the peduncle interior (*c.* 0,005 mm in length). Colour variable, cream or white to yellowish or orange; uniformly coloured or distinctly mottled.

Distribution (Fig. 41)

Apparently endemic to southern Africa, from Lüderitz Bay, Namibia, to at least as far as Kosi Bay, littoral to 222 m in depth. Day (1974*b*: 35) listed the species from Inhambane, Mozambique. This species is one of the most frequently encountered sea pens in South Africa.

Observations

SCUBA divers have observed this species with patchy or localized distribution and high population density. An extensive patch about 50 m in depth off Hout Bay, Cape Peninsula, has numerous colonies that are spaced relatively uniformly (about 0,5 m apart) in what appears to be a relatively regular pattern of spacing (P. A. Hulley pers. comm.).

Remarks

Virgularia schultzei is distinguished from other southern African species of *Virgularia* by having siphonozooids on the lower surfaces of the polyp leaves, below the free distal ends of the autozooids, and 15–35 autozooids per polyp leaf.

Virgularia mirabilis (Linnaeus, 1758)

Figs 26, 41

Pennatula mirabilis: Linnaeus, 1758: 819. Müller, 1776: 255.

Virgularia mirabilis Lamarck, 1816: 431. Kükenthal & Broch, 1911: 329, fig. 126. Kükenthal, 1915: 73, fig. 76 (Lit.!). Manuel, 1981: 54, fig. 15. Tixier-Durivault, 1961*b*: 254, figs 17–18; 1963: 72. Tixier-Durivault & D'Hondt, 1974: 262.

Material

SAM–H3240, mouth of False Bay, western Cape Province (34°22,7′S 18°43,1′E), 78 m, 10 September 1953, 1 colony, dredge, University of Cape Town Ecological Survey. SAM–H3746, off Stony Point, Transkei (32°38,9′S 28°45,0′E), 360 m , 17 July 1984, 1 partial colony, dredge; G. C. Williams, R.V. *Meiring Naude*. SAM–H3869, 67 km west of Cape Fria, Namibia (18°25′S 11°15′E), 274 m, May–June 1982, many colonies, trawl.

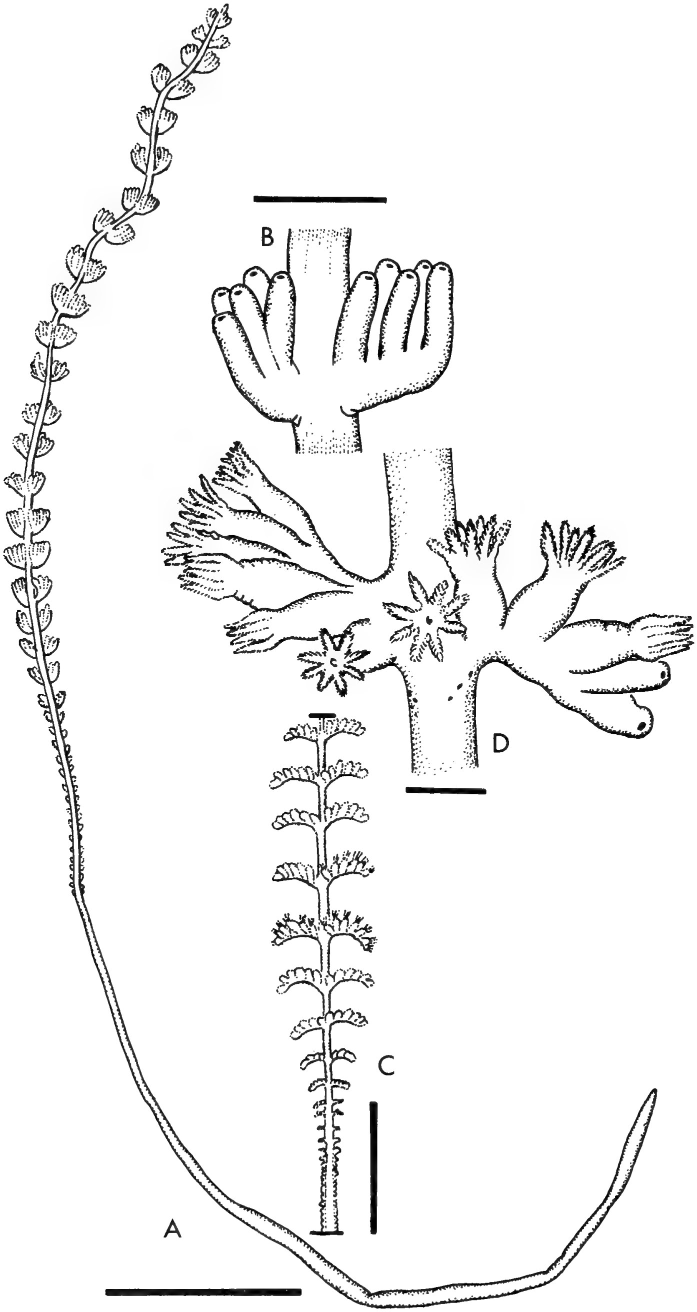

Fig. 26. *Virgularia mirabilis*. A. Entire colony. Scale = 10 mm. B. Detail of rachis with retracted polyps. Scale = 1 mm. C. Part of rachis from colony with expanded polyps. Scale = 10 mm. D. Detail of rachis showing expanded polyps. Scale = 1 mm.

Description

The colonies examined are up to 95 mm long, vermiform, very slender and delicate. Polyp leaves small and not crowded. Autozooids 5–12 per polyp leaf. Autozooids globular or long and narrow, about 1,0 mm long and 0,2 mm wide. Siphonozooids inconspicuous on the sides of the rachis below the polyp leaves and do extend on to the dorsal surface of the rachis. Peduncle about as long as rachis. Sclerites absent except for minute ovals (approximately 0,005 mm in length) from interior of peduncle. Colour yellowish to cream.

Distribution (Fig. 41)

Atlantic Ocean, including the Arctic region, Mediterranean Sea, northern and western Africa, and the south-western Indian Ocean, 9–400 m in depth. Known in southern Africa from Cape Fria and Walvis Bay, Namibia; the Cape of Good Hope region, Cape Province, and the Transkei coast, 78–360 m in depth. Tixier-Durivault (1963: 73) recorded the species from just south of Walvis Bay, Namibia. Tixier-Durivault & D'Hondt (1974: 262) reported the species from Tulear, Madagascar. The type locality is the northern Atlantic.

Remarks

Virgularia mirabilis is distinguished from other southern African species of the genus by the often limp and vermiform appearance of the colonies, with 5–12 autozooids per polyp leaf. Kükenthal (1915: 34) stated that up to 16 autozooids per polyp may be present.

Virgularia gustaviana (Herklots, 1863)

Figs 27, 28A–B, 41

Halisceptrum gustavianum Herklots, 1863: 31.
Virgularia gustaviana Kükenthal & Broch, 1911: 334. Kükenthal, 1915: 74, fig. 77 (Lit.!). Tixier-Durivault, 1954: 630; 1960: 366.

Material

SAM–H1193, Durban Bay (29°50′S 31°00′E), 23 May 1929, 3 colonies. SAM–H1199, off Salisbury Island, Durban Bay, Natal (29°50′S 31°00′E), 4 July 1927, 1 colony. SAM–H1509, Durban Bay (29°50′S 31°00′E), 1 colony.

Description

Colonies examined range between 140–419 mm in length and 10–20 mm in width. Colonies are robust and firm, tapering gradually or abruptly at the apical end. Polyp leaves large, numerous and crowded, placed opposite each other. Autozooids highly congested, more than 50 per leaf (often up to 100 or more). Siphonozooids are inconspicuous on the lateral and dorsal surfaces of the rachis between the polyp leaves. Peduncle length varies from one third to one half of total colony length. Peduncle may have a conspicuous end bulb. Sclerites are minute ovals (*c.* 0,01 mm) restricted to the peduncle interior. Colour yellowish.

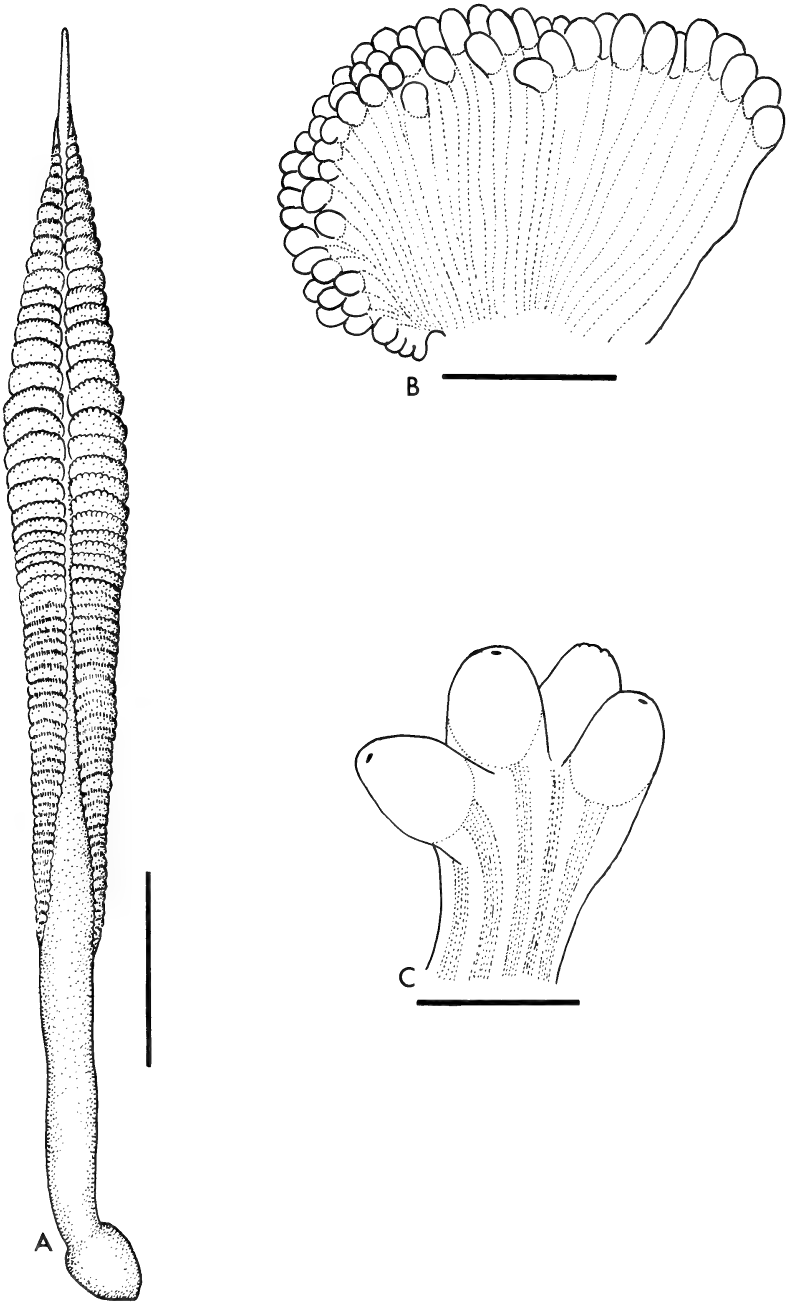

Fig. 27. *Virgularia gustaviana.* A. Entire colony. Scale = 20 mm. B. Single entire polyp leaf. Scale = 3 mm. C. Four adjacent polyps from a polyp leaf. Scale = 1 mm.

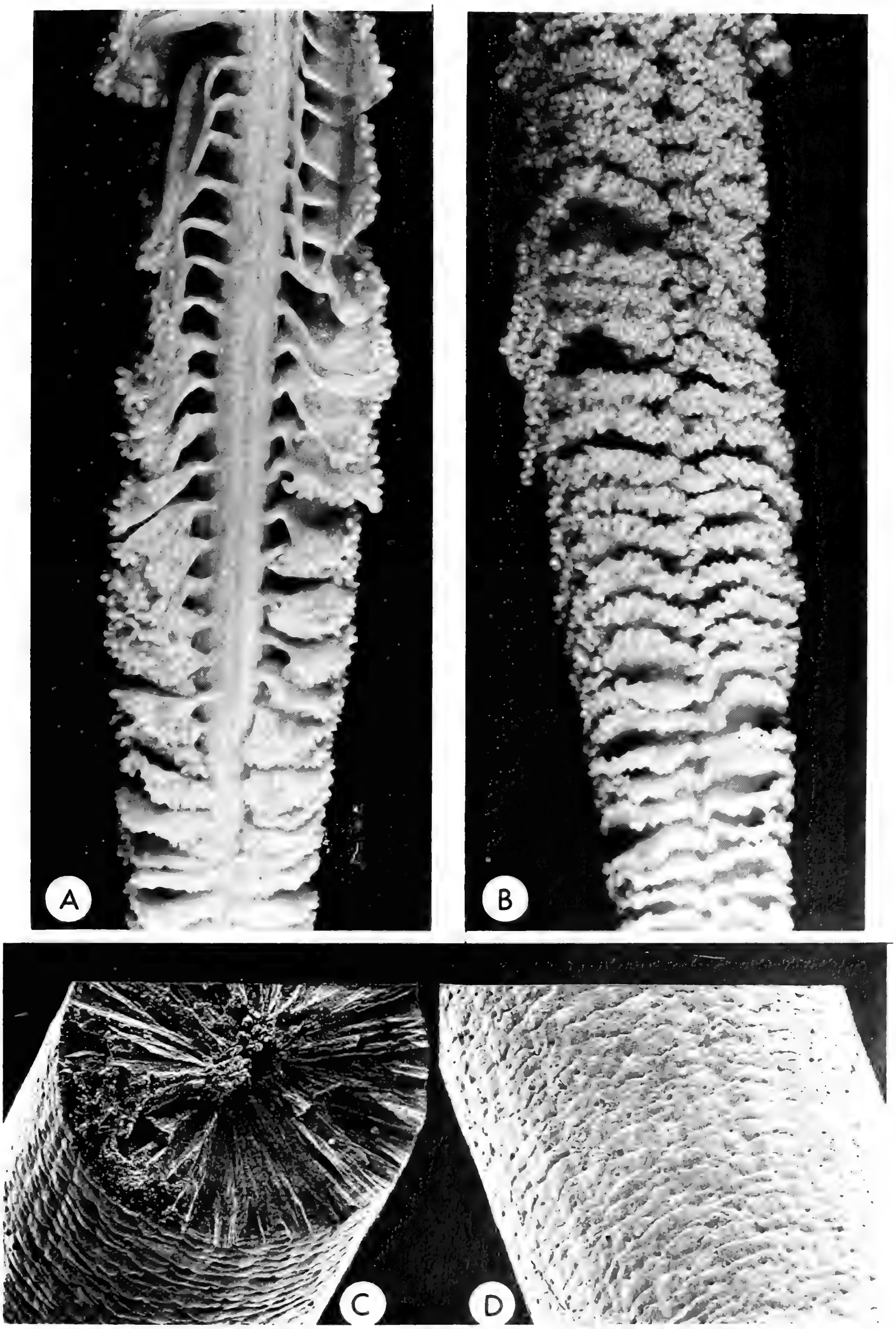

Fig. 28. A–B. *Virgularia gustaviana*. A. Dorsal view of rachis. B. Ventral view of rachis; length of photographs = 80 mm. C–D. *Virgularia schultzei*. C. Broken end of axis; diameter = 0,36 mm. D. Detail of axial surface; width of axis = 0,36 mm.

Distribution (Fig. 41)

Indo-West Pacific. Known in southern Africa only from Inhaca Island, Mozambique, and Durban Bay, Natal; littoral and shallow sublittoral.

Remarks

Virgularia gustaviana is distinguished from other southern African species of *Virgularia* in having 50–200 autozooids per polyp leaf.

Virgularia sp.

Fig. 41

Remarks

Four colonies, 40–80 mm in length, have recently been collected from off the eastern Cape and Transkei (60–410 m in depth). These colonies are fragmentary, therefore assignment to species is untenable at present. The thick and firm appearance of the polyp leaves clearly separates this species from the other southern African forms of *Virgularia*.

Other species of Virgularia

Tixier-Durivault & D'Hondt (1974: 262) listed Port Natal (Durban) as a locality of the Indo-Pacific species *Virgularia juncea* (Pallas, 1766). Since no description or figures of colonies from this locality are given, and since there are no other records or material of *V. juncea* known from southern Africa, I here consider this as a dubious record.

Tixier-Durivault (1963: 73) recorded *Virgularia tuberculata* Marshall, 1887, from northern Angola. This is outside the geographical limit of the present work, but is mentioned here nonetheless as a species that may possibly be encountered further south. It is distinguished by having tubercles or small teeth on the terminal rim of the calyx and only 3–6 autozooids per polyp leaf.

Genus *Scytaliopsis* Gravier, 1906

Scytaliopsis Gravier, 1906: 293; 1908: 237. Kükenthal, 1915: 67.

Diagnosis

Colony firm. Axis circular in cross-section. Gradual transition between rachis and peduncle. Small polyp leaves in pairs, separated by areas of bare rachis. Autozooids 4–5 per polyp leaf. Innermost autozooids of each polyp leaf smaller than adjacent ones. Anthocodiae are retractile into the globular, fleshy bases of autozooids. Siphonozooids few and inconspicuous, situated on rachis between leaves. Sclerites absent.

A monospecific genus of the western Indian Ocean and Red Sea.

Type species. Scytaliopsis djiboutiensis Gravier, 1906; Djibouti (Red Sea).

Scytaliopsis djiboutiensis Gravier, 1906.

Figs 29, 41

Scytaliopsis djiboutiensis Gravier, 1906: 293; 1908: 237. Kükenthal, 1915: 67 (figs 66, 67).

Material

SAM–H3711, off Qora River, Transkei (32°35,4′S 28°49,2′E), 450–460 m, 14 July 1984, 1 colony, dredge, G. C. Williams, R.V. *Meiring Naude*.

Description

The colony is 92 mm in length; rigid, straight, and shaft-like. Peduncle shorter than rachis. Polyp leaves arranged in 15–20 pairs, each leaf with not more than five autozooids. Adjacent autozooids gradually increase in size from innermost to outermost. Intervals of bare rachis up to 3 mm. Siphonozooids are very sparse and inconspicuous, usually not more than two are present on the rachis below each pair of polyp leaves. Sclerites entirely absent. Colour brownish.

Distribution (Fig. 41)

East African coast, littoral to 460 m in depth. This is the first record of the genus and species for southern Africa and extends the range southward from the Red Sea to the Transkei coast. The type locality is Djibouti, Red Sea.

Remarks

This species is differentiated from other southern African pennatulaceans by having 5 polyps per polyp leaf, which grade in size from the smallest on the dorsal side of each leaf to the largest on the ventral side.

Subfamily Balticininae Gray, 1870

Fusion of proximal portions of adjacent autozooids forms raised ridges or swellings that emanate laterally from the rachis. Siphonozooids few and inconspicuous between autozooids.

One genus of the Atlantic and Indo-Pacific oceans.

Genus *Halipteris* Kölliker, 1869

non *Virgularia* Lamarck, 1816: Koren & Danielssen, 1847: 269.
Halipteris Kölliker, 1869: 124.
Pavonaria Kölliker, 1869: 123 (*non* Schweigger, 1820; see Bayer, 1956: F228). Kükenthal & Broch, 1911: 305. Kükenthal, 1915: 60 (Lit!).
Balticina Gray, 1870: 13.
Norticina Gray, 1870: 13.
Osteocella Gray, 1870: 40.
Lygomorpha Koren & Danielssen, 1877: 99.
Stichoptilum Grieg, 1887: 15.

Diagnosis

Colonies long and slender. Axis conspicuous, extending entire length of colony, round in cross-section. Autozooids arranged in numerous oblique rows in

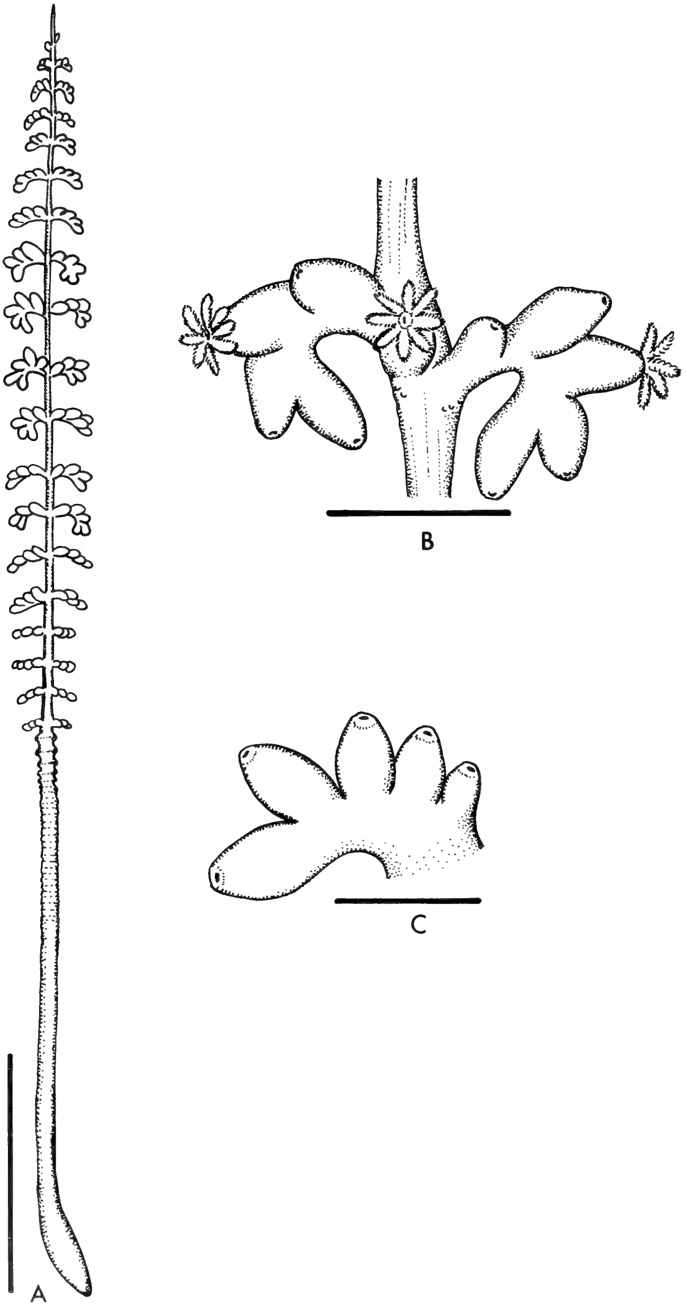

Fig. 29. *Scytaliopsis djiboutiensis*. A. Entire colony. Scale = 20 mm. B. Detail of rachis showing two polyp leaves. Scale = 2 mm. C. Single polyp leaf showing gradation in size of adjacent autozooids. Scale = 2 mm.

two longitudinal series. Adjacent autozooids sometimes fused at their bases, often forming ridges or swellings that emanate laterally from the rachis. Autozooids with two-toothed calyces. Anthocodia retractile into calyces. Sclerites numerous; three-flanged spindles in calyx and tentacles, smooth rods or spindles in peduncle.

A genus of five species; Atlantic, Pacific and Western Indian oceans.

Type species. *Virgularia finmarchica* Sars, 1851; northern Atlantic.

Halipteris africana (Studer, 1879) comb. nov.

Figs 19A–G, 30, 40

Halipteris sp. Studer, 1878: 139.
Pavonaria africana Studer, 1879: 672, pl. 5 (fig. 41). Kükenthal, 1915: 61.

Material

SAM–H3237, north-west of Lamberts Bay, western Cape Province (31°29,7′S 16°03,4′E), 459 m, 15 August 1947, 1 colony, dredge, University of Cape Town Ecological Survey, AFR730G. SAM–H4027, off Namaqualand (30°00,5′S 14°53,6′E) 461 m, 20 July 1986, 8 colonies, bottom trawl, Rob Leslie (Sea Fisheries Research Institute, West Coast Biomass Survey, station A4373046).

Description

Colonies whip-like, up to 1 550 mm in length and averaging 10 mm in width. Axis round to rounded quadrangular, approximately 5 mm in diameter. Peduncle stout, approximately 200 mm long and up to 15 mm wide. Peduncle distinctly quadrangular. Autozooids arranged in numerous oblique rows, 3–7 (usually 4–6) per row. Some rows form basal ridges by fusion of proximal regions of autozooids. In some rows, circular or elliptical walls of the basal ridge surround individual autozooids or groups of two or three. Aboral surface of tentacles with densely set three-flanged spindles, 0,10–0,15 mm in length, arranged longitudinally. Calyx with numerous three-flanged spindles 0,12–0,60 mm long. Terminal teeth of calyx sometimes blunt or indistinct. Peduncle with smooth spindles or rods 0,04–0,07 mm in length. Rachis and peduncle pale red to white, calyx light blue, polyps brown.

Distribution (Fig. 40)

Atlantic coast of Africa, 459–659 m in depth. This study represents a new record from southern Africa and extends the range of the species south from the Senegal–Guinea region to the Namaqualand coast, South Africa. The type locality is tropical west Africa.

Remarks

Gray (1870: 13) described two genera: *Balticina* for *B. finmarchica* (Sars, 1851) and *Norticina* for *N. christii* (Koren & Danielssen, 1848), presumably after

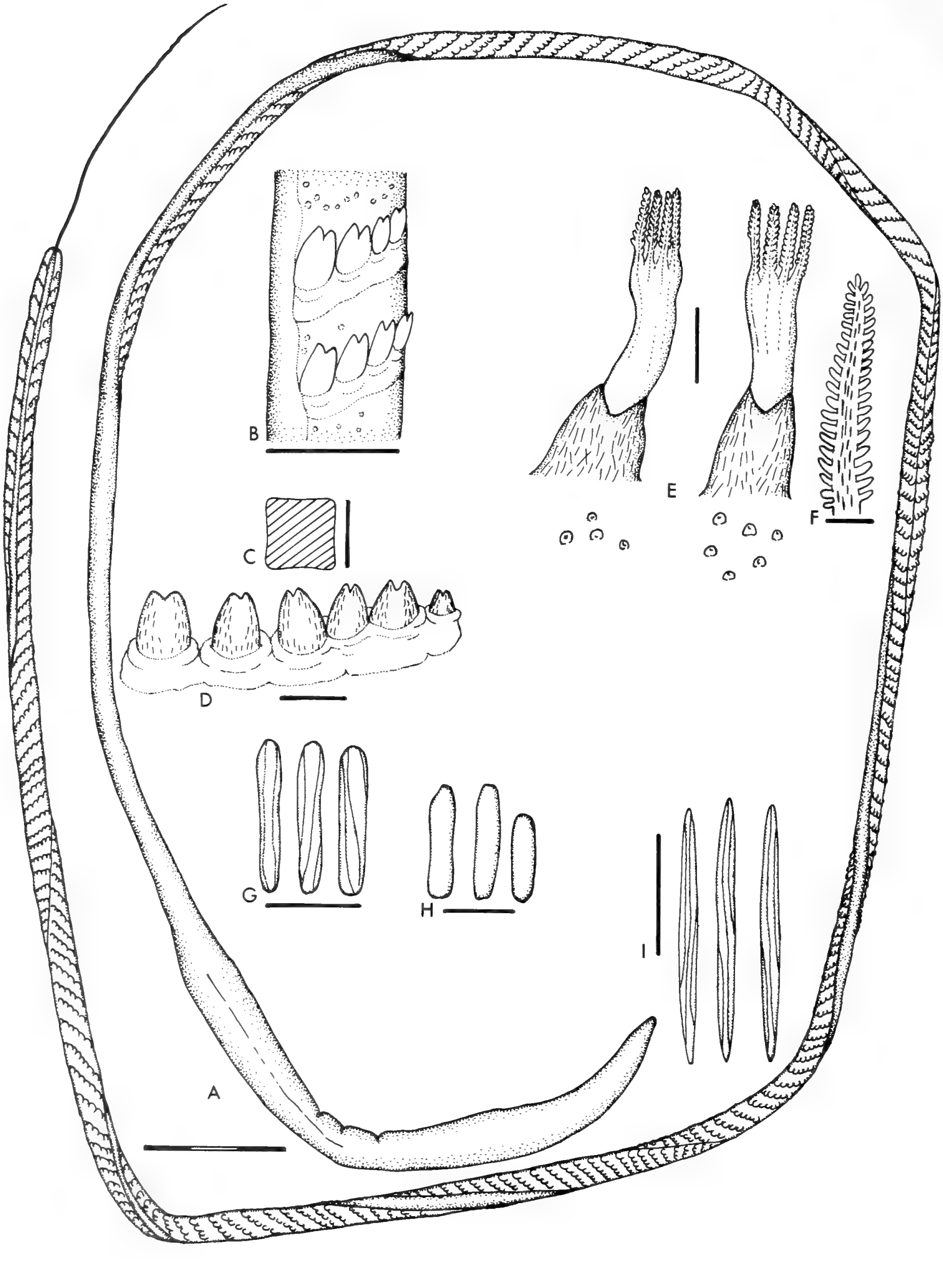

Fig. 30. *Halipteris africana*. A. Entire colony. Scale = 30 mm. B. Detail of rachis. Scale = 7 mm. C. Transverse section of axis. Scale = 7,5 mm. D. Group of six autozooids with common basal ridge. Scale = 2 mm. E. Two autozooids with ten siphonozooids at their bases. Scale = 2 mm. F. Single tentacle with sclerites. Scale = 0,5 mm. G. Sclerites from tentacle. Scale = 0,1 mm. H. Sclerites from peduncle. Scale = 0,04 mm. I. Sclerites from calyx. Scale = 0,25 mm.

the Baltic and Nordic (North) seas, respectively. Both genera are considered synonyms of *Pavonaria* Kölliker, 1869, by Kükenthal (1915: 60). However, *Pavonaria* was found by Kükenthal (1915: 60) and Bayer (1956: 228) to be preoccupied by *Pavonaria* Schweigger, 1820, a synonym of *Funiculina*. Therefore the name *Halipteris* Kölliker, 1869, which is synonymous with *Pavonaria* Kölliker, 1869, is the valid generic name (M. Grasshoff pers. comm.).

Tixier-Durivault made the original determination for this specimen and identified it as *Funiculina armata* Verrill, 1879. However, the possession of ridges in oblique rows, which unify the fused bases of adjacent autozooids, and the autozooids with calyces of two terminal teeth prove this to be a misidentification. Tixier-Durivault (1954: 629) also listed *F. armata* from South Africa based on two specimens collected on the same day and in the same vicinity as the present specimen. I consider this a dubious record until these specimens can be examined.

Kükenthal (1915: 60–61) distinguished *B. africana* by the possession of five or six autozooids per row, and the presence of contiguous distal portions of the basal swellings of the polyp leaves that may surround the proximal regions of several adjacent autozooids. This latter feature is common in autozooids of the colony examined but is not universal (Fig. 31D).

Jungersen (1904: 43) maintained that *B. africana* is probably not a distinct species but rather a southern form of the common Atlantic species, *B. finmarchica* (Sars, 1851). However, he did not make a formal synonymy. The distinguishing characters recognized by Studer (4–6 autozooids per row and low ridges with wall-like extensions around individual autozooids) may indeed not be sufficient for specific differentiation. A comparison of many specimens from various localities is necessary.

Remarks on the genus Halipteris

Three additional colonies assignable to the genus *Halipteris* are present in the South African Museum's collection. They are from the Natal south coast (900–625 m), the Transkei coast (300 m), and the Namaqualand coast (457 m). The three colonies are relatively small (105–220 mm in length) and apparently represent at least two species, which have not been identified at present.

Family **Pennatulidae** Ehrenberg, 1834

Colonies bilateral with large polyp leaves. Autozooids in one or more rows on margin of polyp leaves. Anthocodia retractile into calyces with marginal teeth. Siphonozooids confined to rachis. Mesozooids may be present. Sclerites numerous; mostly three-flanged needles, rods, plates, or ovals.

Three genera: *Pennatula* Linnaeus, 1758, of cosmopolitan distribution; and *Leioptilus* Gray, 1860, and *Ptilosarcus* Gray, 1860, both restricted to the Pacific coast of North America.

Genus *Pennatula* Linnaeus, 1758

Pennatula Linnaeus, 1758: 818. Kükenthal & Broch, 1911: 348. Kükenthal, 1915: 81 (Lit.!). Grasshoff, 1982*b*: 959.
Penna Bohadsch, 1761: 98 (*partim*).

Diagnosis

Calyces usually with eight terminal teeth. Calyces tubular with numerous sclerites, which are three-flanged needles. Inconspicuously three-flanged spindles and plates occur in peduncle.

A cosmopolitan genus of probably 12 to 15 valid species and many uncertain or dubious ones.

Type species. Pennatula phosphorea Linnaeus, 1758.

Pennatula inflata Kükenthal, 1910

Figs 31A–B, 32, 33A–C, 34, 35, 40

Pennatula inflata Kükenthal, 1910: 52; 1915: 83, figs 81–83. Kükenthal & Broch, 1911: 350, pl. 17 (fig. 25), pl. 22 (figs 61, 62).
Pennatula phosphorea (*non* Linnaeus, 1758) Tixier-Durivault, 1954: 630.

Material

SAM–H3238, north-west of Lambert's Bay (31°43,6′S 16°13,2′E), 457 m, 9 June 1947, 2 colonies, trawl, University of Cape Town Ecological Survey.

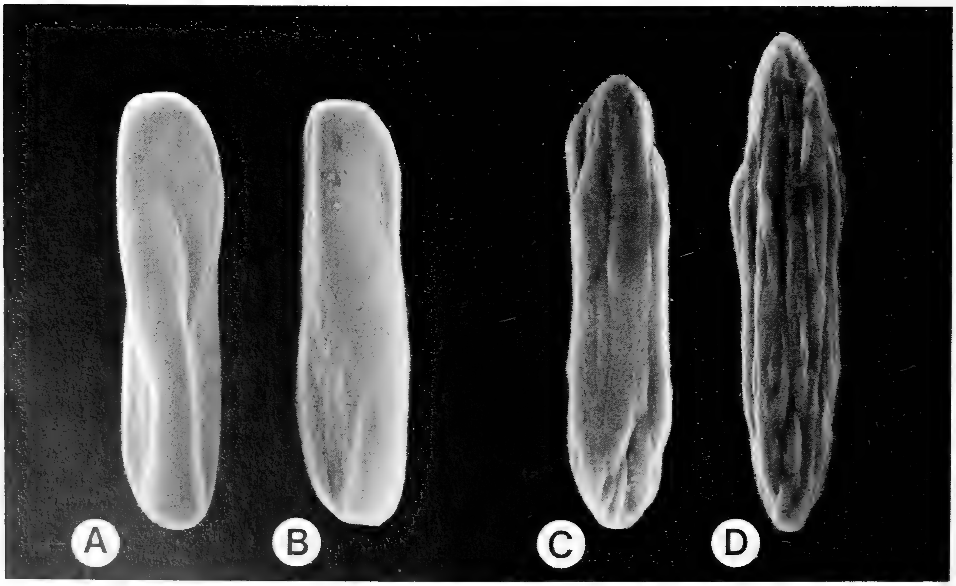

Fig. 31. Scanning electron micrographs of sclerites. A–B. *Pennatula inflata*. From surface of peduncle: 0,1 mm; 0,08 mm. C–D. *Pteroeides isosceles*. From surface of peduncle: 0,08 mm; 0,1 mm.

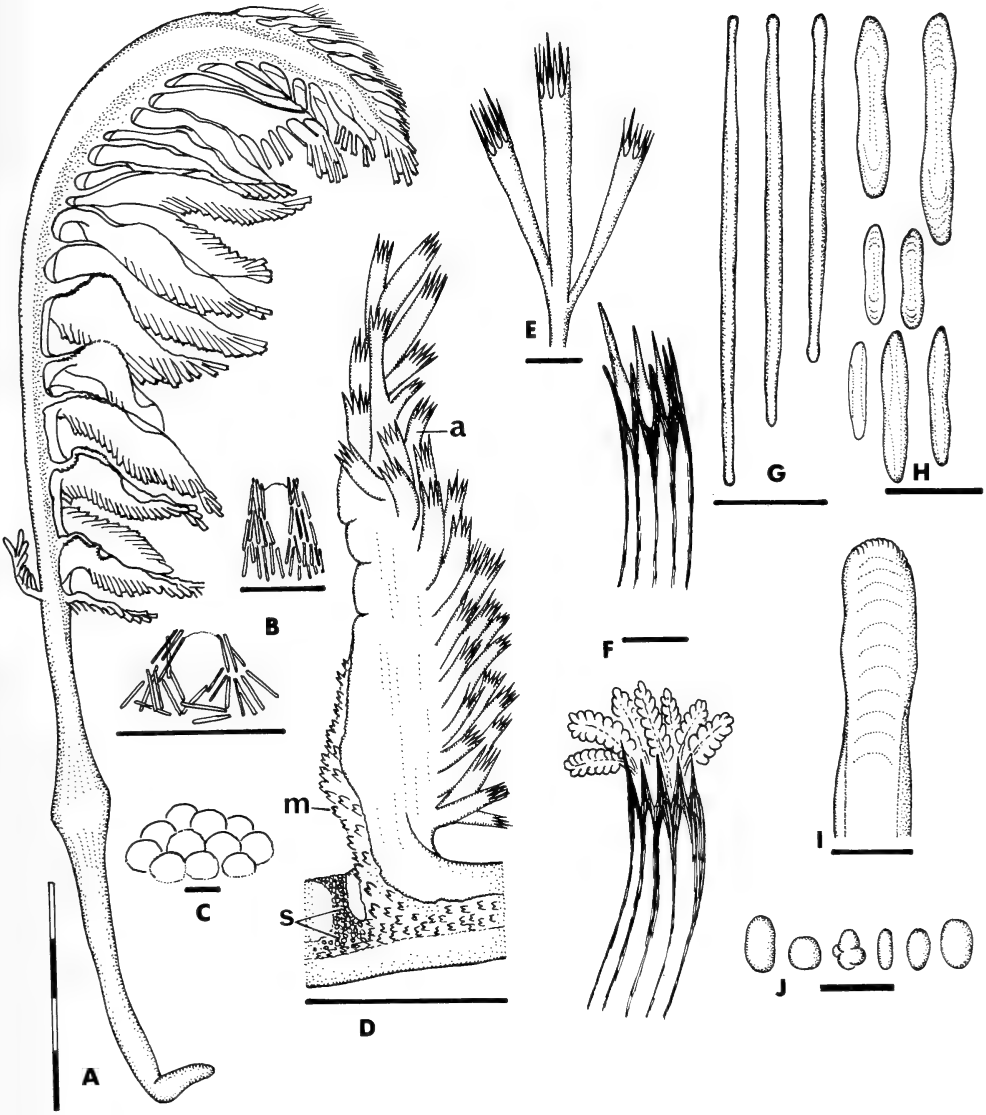

Fig. 32. *Pennatula inflata*. A. Entire colony, lateral view. Scale 40 mm. B. Two mesozooids with sclerites. Scale = 0,3 mm. C. Group of siphonozooids. Scale = 0,2 mm. D. Single polyp leaf showing positions of autozooids (a), mesozooids (m), and siphonozooids (s). Scale = 8,8 mm. E. Group of three retracted autozooids. Scale = 1,6 mm. F. Two autozooids showing sclerite arrangement. Scale = 1 mm. G. Three sclerites from calyx. Scale = 0,3 mm. H. Seven sclerites from surface of peduncle. Scale = 0,1 mm. I. Terminal tip of a calyx sclerite. Scale = 0,035 mm. J. Sclerites from interior of peduncle. Scale = 0,03 mm.

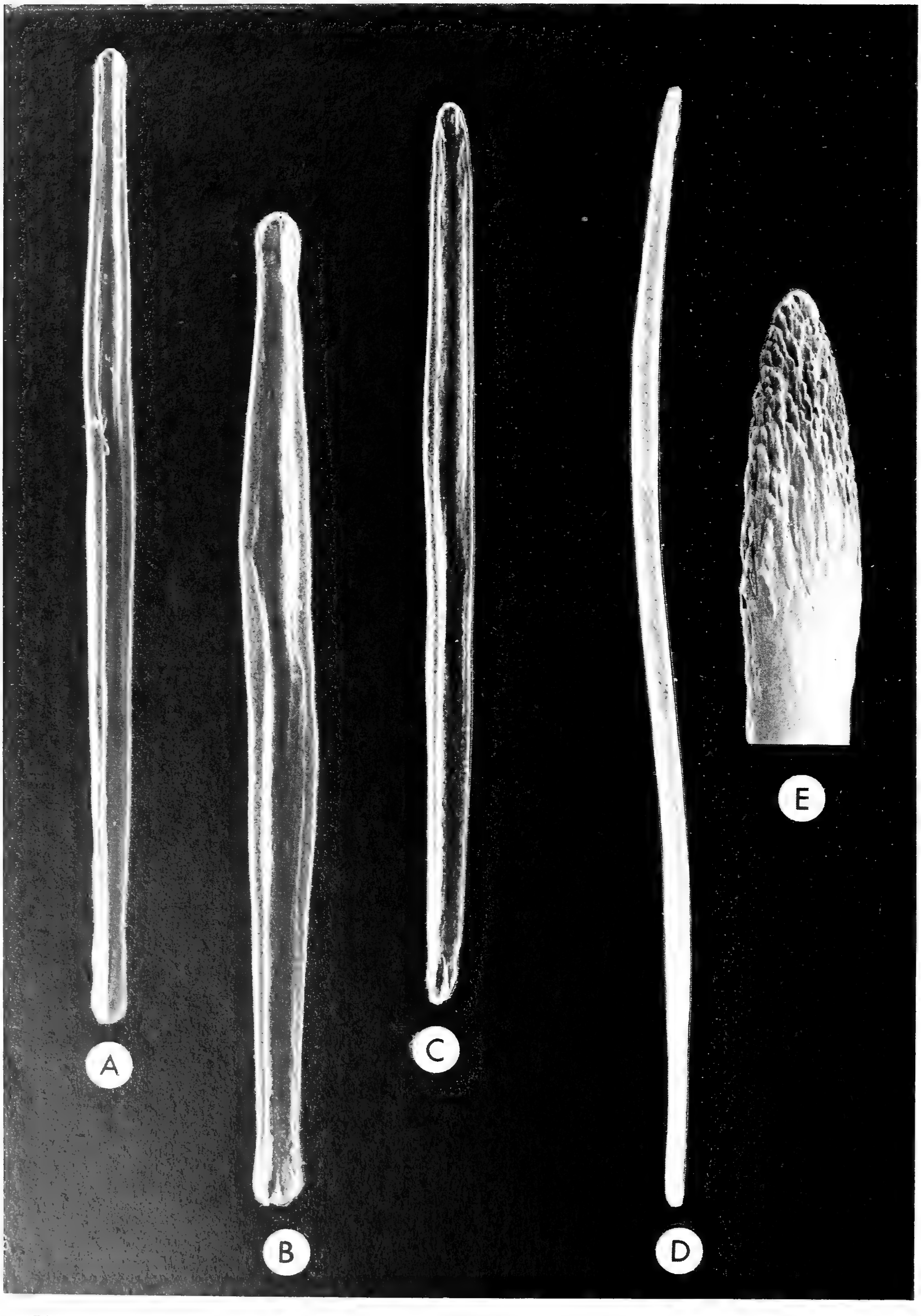

Fig. 33. Scanning electron micrographs of sclerites. A–C. *Pennatula inflata*. From calyx: 0,8 mm; 0,6 mm; 0,8 mm. D–E. *Pteroeides isosceles*. D. Needle from supporting ray of polyp leaf: 7 mm. E. Terminal tip of needle from supporting ray: 1,3 mm.

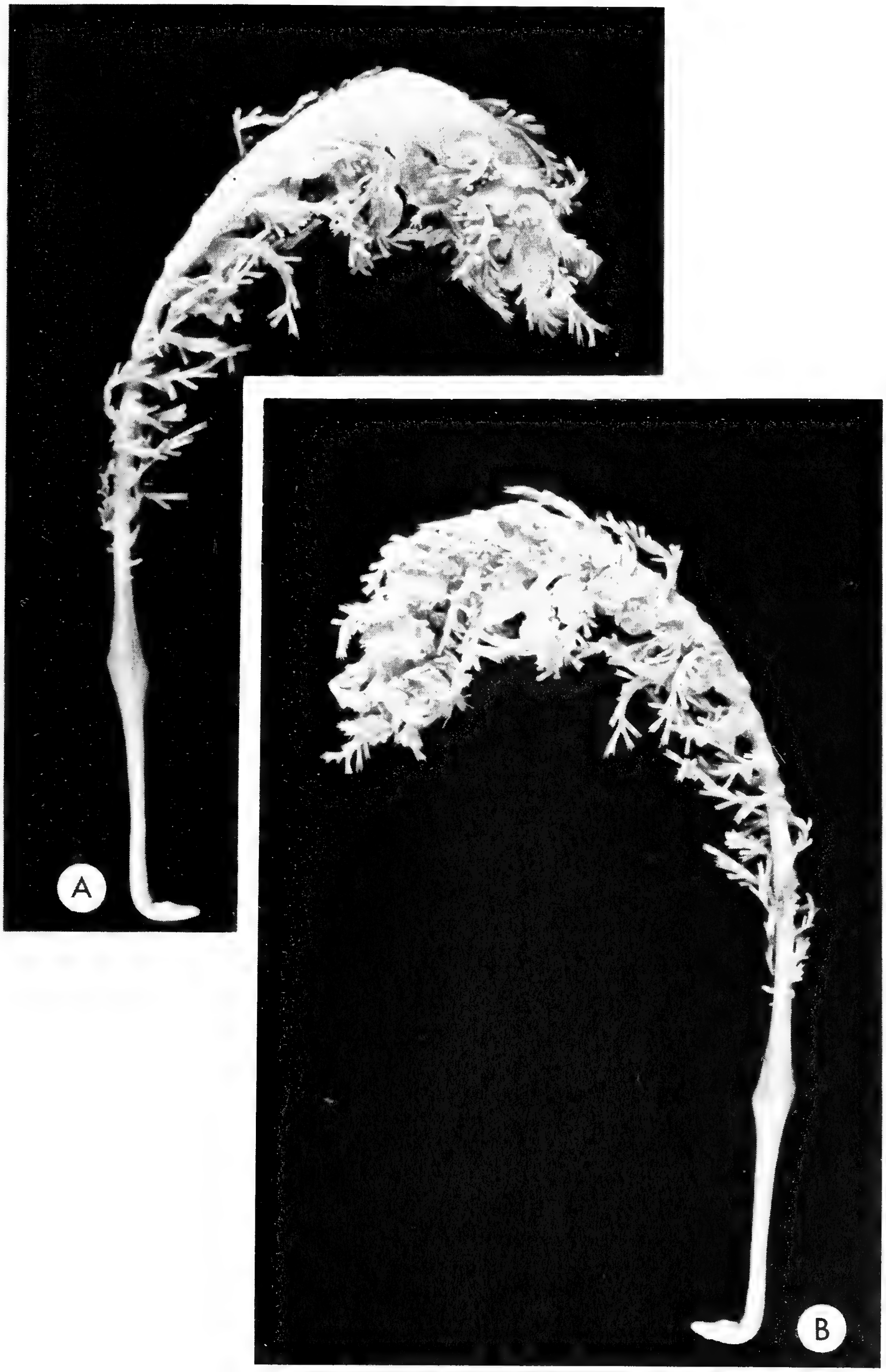

Fig. 34. *Pennatula inflata*. Entire colony; length 220 mm. A. Dorsal view. B. Ventral view.

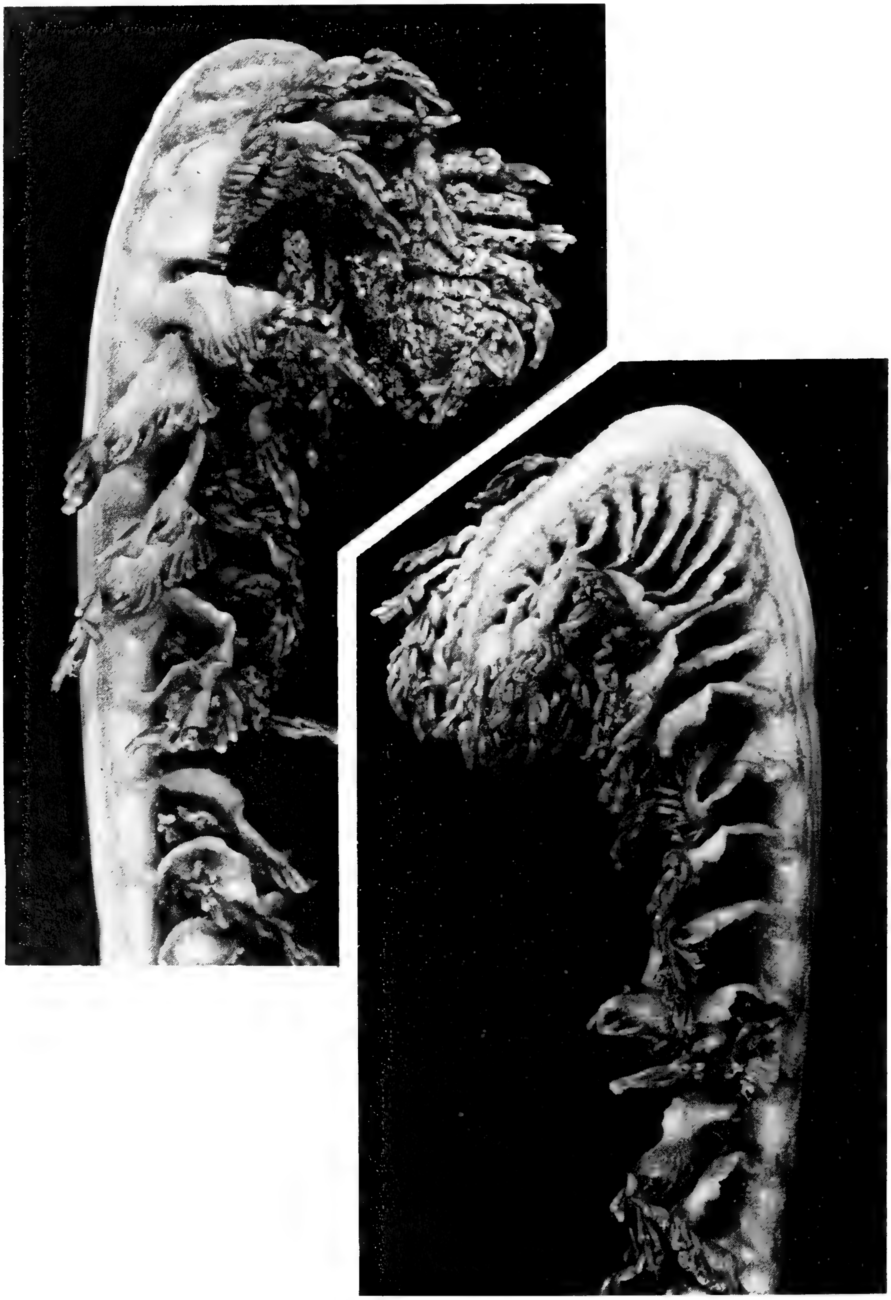

Fig. 35. *Pennatula inflata*. Two views of distal portion of rachis. Length of rachis portion shown is 150 mm.

Description

The colonies examined are 220 mm and 400 mm in length. Peduncle stout, rigid, one-third total length of colony, oval in cross-section. Prominent bulb about midway on peduncle. Rachis spongy and flexible, with naked dorsal tract up to 10 mm in width. This tract is widest in the distal half of the rachis. Polyp leaves well developed, up to 40 mm in length and 16 mm in width, 26–37 pairs of polyp leaves per colony. Autozooids 29–42 per polyp leaf, in usually 2 or 3 ill-defined rows. Calyces tubular, up to 10 mm long, eight-toothed, with teeth equal to subequal; many calyces with one tooth more strongly developed than the others. Zooids dimorphic, dense and numerous on two narrow marginal tracts bordering dorsal face of rachis. Mesozooids with two tooth-like points composed of sclerites, common in a row along the basal dorsal margin of each polyp leaf. Siphonozooids without sclerites, crowded in narrow band on rachis above each polyp leaf. Colonies with 26–37 rows of siphonozooids on each side, representing one row per polyp leaf. Sclerites numerous; three-flanged needles in calyx, up to 1,2 mm in length; inconspicuously three-flanged spindles of peduncular surface up to 0,2 mm in length; minute oval plates in peduncular interior 0,015–0,025 mm long. Colour of peduncle, rachis and leaves yellowish-white to reddish-orange, sclerites of autozooids and mesozooids orange, siphonozooids white.

Distribution (Fig. 40)

East African coast and south-west coast of South Africa, 457–741 m in depth. The present study establishes a new record for southern Africa and extends the range south-west from Somalia to the Namaqualand coast, South Africa. It is the first record of the species for the Atlantic Ocean. The type locality is Somalia (Indian Ocean), 628–741 m in depth.

Remarks

Tixier-Durivault (1954: 630) identified these specimens as *P. phosphorea*. However, the possession of mesozooids on the dorsal edge of the polyp leaves proves this to be a misidentification. According to Kükenthal (1915: 82), *P. phosphorea* does not possess mesozooids and does not possess more than 20 polyps per mature polyp leaf.

Day (1974*b*: 35) recorded several unidentified species of the genus *Pennatula* from Delagoa Bay, Mozambique.

Of the twelve species of *Pennatula* considered to be valid by Kükenthal (1915: 81), six possess between 3 and 20 polyps per polyp leaf—*P. aculeata* Danielssen, 1860; *P. indica* J. A. Thomson & Henderson, 1906; *P. murrayi* Kölliker, 1880; *P. pearceyi* Kölliker, 1880; *P. phosphorea* Linnaeus, 1758; and *P. prolifera* Jungersen, 1904. Six additional species have 30–100 polyps per polyp leaf—*P. fimbriata* Herklots, 1858; *P. grandis* Ehrenberg, 1834; *P. inflata* Kükenthal, 1910; *P. moselyi* Kölliker, 1880; *P. naresi* Kölliker, 1880; and *P. rubra* (Ellis *in* Bohadsch, 1761). Of these, only *P. inflata* possesses a wide naked dorsal tract of the upper rachis with a spongy texture, and many calyces have one tooth more strongly pronounced than the others.

A certain amount of variation occurs with regard to the calyx teeth in *P. inflata*. In the present specimens, the development of the calyx teeth is variable—many autozooids examined possess eight equal or subequal teeth. However, in a few polyps, one, two, three, or four of the teeth may be somewhat larger in size than the remaining teeth; and in many polyps one tooth is slightly or distinctly larger than the other seven teeth.

Family **Pteroeididae** Kölliker, 1880

Colonies bilateral, possessing well-developed and rigid polyp leaves with long stout sclerites that are not three-flanged. Siphonozooids crowded in proximal region of leaves. Autozooids retractile into fleshy distal region of polyp leaves, or into rounded calyces that are not composed of dense sclerites.

Three genera of the Atlantic and Indo-Pacific: *Pteroeides* Herklots, 1858; *Sarcoptilus* Gray, 1848; and *Crassophyllum* Tixier-Durivault, 1961*a*.

Genus *Pteroeides* Herklots, 1858

Pteroeides Herklots, 1858: 19. Kölliker, 1872*a*: 124. Gray, 1870: 24. Kükenthal & Broch, 1911: 395. Kükenthal, 1915: 97.
Godeffroyia Kölliker, 1869: 222.
Argentella Gray, 1870: 22.
Pteromorpha Gray, 1870: 23.
Crispella Gray, 1870: 25.

Diagnosis

Polyp leaves with supporting rays composed of long needle-like sclerites. Needles of supporting rays smooth, except for terminal ends that are somewhat tuberculated. Sclerites of peduncle are rods or spindles.

A genus of over 80 named species, including many uncertain or dubious ones; Atlantic, Mediterranean, and Indo-Pacific.

Type species. *Penna grisea* Bohadsch, 1761 (= *Pennatula spinosa* Ellis, 1764); Europe.

Pteroeides isosceles Thomson, 1915

Figs 31C–D, 33D–E, 36, 37, 38

Pteroeides isosceles J. S. Thomson, 1915: 17, pl. 1.

Material

SAM–H1207, off East London (33°00'S 28°00'E), 58–69 m, 28 November 1906, 1 colony, large trawl, S.S. *Pieter Faure* Survey, P.F. 19061 (holotype).

Redescription of the holotype

The colony is 170 mm long and up to 40 mm in width. Peduncle 18–20 mm in diameter and slightly more than half the length of the colony. Rachis with 22 pairs of polyp leaves. Larger leaves 20 mm in width by 35 mm in length, 15–18 rays per leaf in leaves from the middle region of the rachis. Rays extend through the entire length of a particular leaf and may extend 1–2 mm beyond the margin. Rays not visible in the basal plate of siphonozooids. Autozooids restricted to the outer margin of each leaf to 5 mm below the margin on both the upper and lower surfaces of each leaf; retractile directly into pockets of the fleshy leaf margin. Autozooid zone relatively free of smaller spindles. The autozooids are not arranged in distinct rows, but 5–8 autozooids are usually scattered between two adjacent rays. Mesozooids not apparent. Siphonozooids are densely arranged and restricted to a plate about 12 mm broad in the proximal region of each leaf. Needles of rays up to 10 mm long. Spindles of dorsal surface of polyp leaves 0,2–0,4 mm in length. Rods and spindles of peduncular surface are longitudinally grooved but not distinctly three-flanged, 0,10–0,17 mm long. Sclerites of peduncular interior absent. Peduncle gray, leaves cream with yellowish siphonozooids and white rays.

Distribution (Fig. 38)

Known only from the type locality off East London, South Africa, 58–69 m depth.

Remarks

This species can be differentiated from other southern African sea pens by having autozooids without calyces united into thick, fleshy polyp leaves, 11–18 conspicuous rays per leaf, and siphonozooids densely set but restricted to a plate near the base of each leaf.

Remarks on the genus Pteroeides

Recent collections from northern Zululand have yielded several colonies of a species distinct from *P. isosceles*, which has not been identified. Several damaged or presumably young colonies of *Pteroeides* from Natal are also present in the South African Museum collection that can not presently be identified to species but seem to be distinct from *P. isosceles*. It is likely that several species of the genus can be expected to occur in southern African waters. The genus is in much need of revision; well over 80 specific names can be found in the literature at present.

Broch (1958: 278) recorded *Pteroeides griseum* (Bohadsch, 1761) from off the Angola/Namibia border region at 80–91 m. This is just north of the geographic range of the present work, but is mentioned since the species may be encountered further south. It is distinguished from *P. isosceles* by having numerous spindles in the autozooid zone, independent of the ray needles. In *P. isosceles* the ray

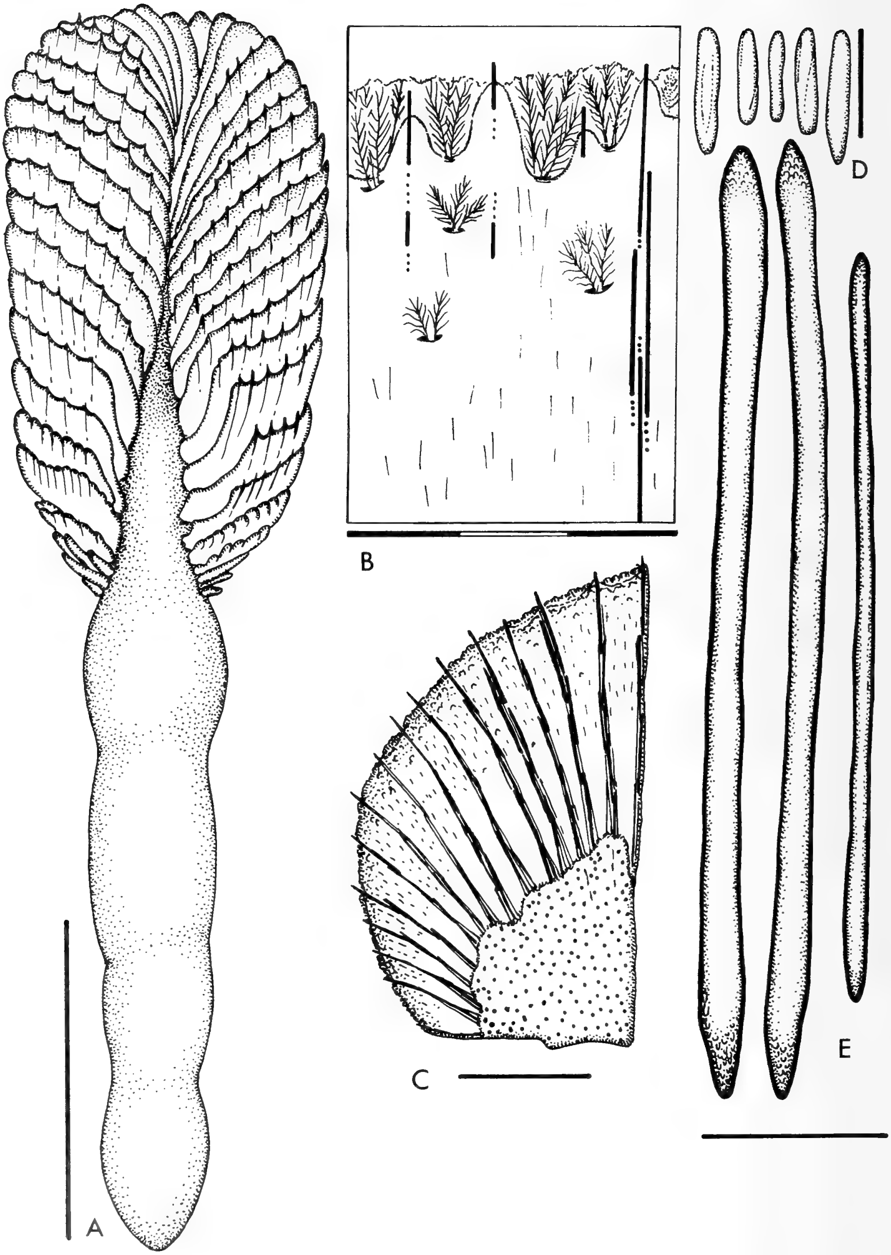

Fig. 36. *Pteroides isosceles*. A. Entire colony, ventral face. Scale = 60 mm. B. Detail of margin of polyp leaf, upper surface. Scale = 3 mm. C. Entire polyp leaf, lower surface. Scale = 10 mm. D. Peduncular surface sclerites. Scale = 0,1 mm. E. Ray needles from polyp leaf. Scale = 2 mm.

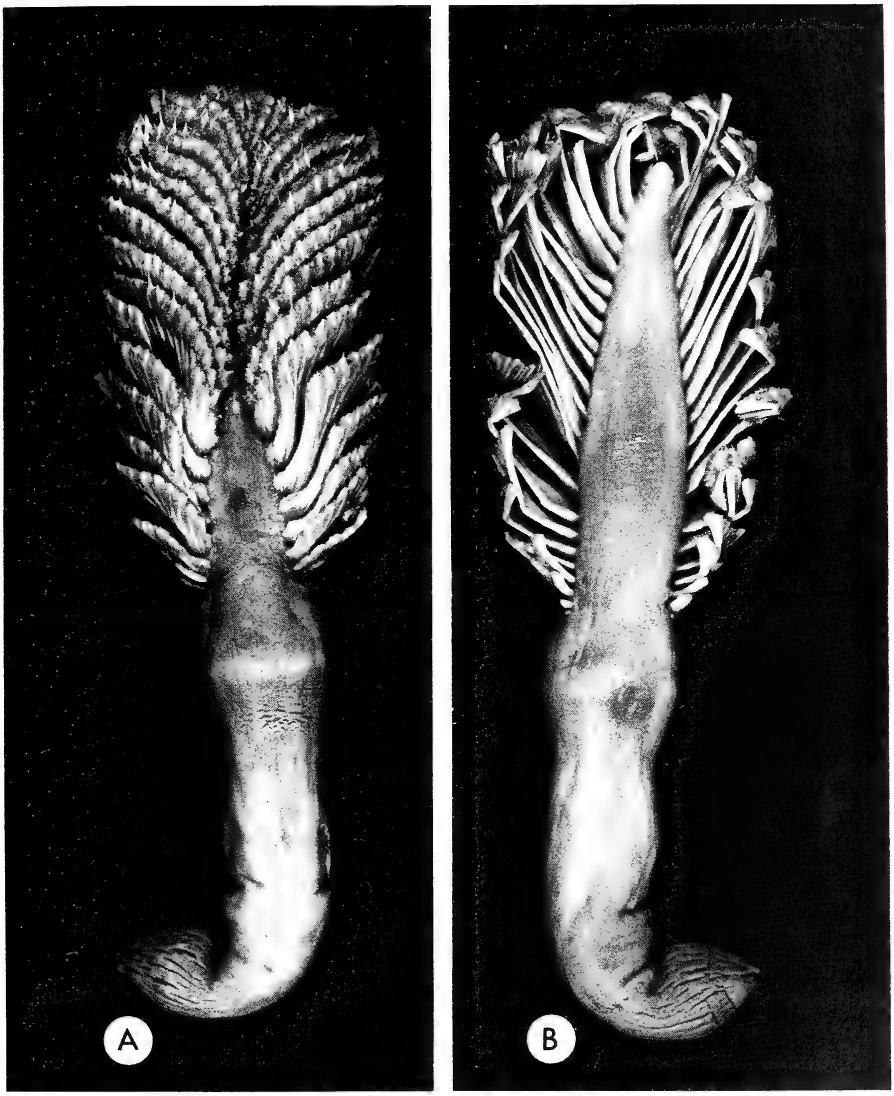

Fig. 37. *Pteroeides isosceles*. Entire colony, length 170 mm. A. Ventral view. B. Dorsal face.

needles are pointed and similar at both ends; the autozooid margins may have only scattered sclerites that differ from the ray needles; the siphonozooid and autozooid zones have a distinct boundary.

J. S. Thomson (1915: 17) described a damaged colony from the type locality of *Pteroeides isosceles* as *Pteroeides* sp. An examination of this specimen has shown that it closely resembles the holotype of *P. isosceles* and thus the two specimens are very likely conspecific.

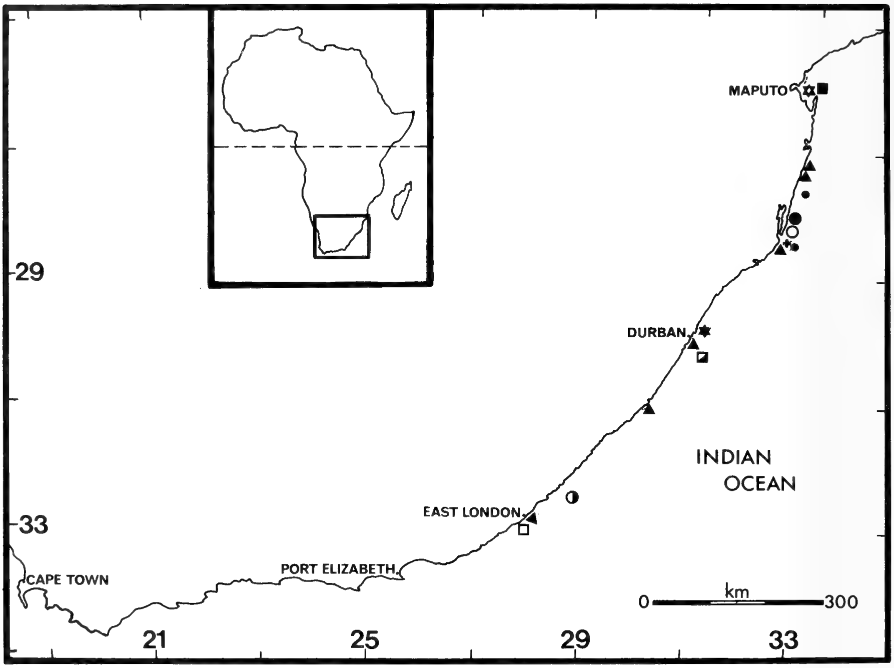

Fig. 38. Map of south-eastern Africa showing known collecting stations for twelve pennatulacean species: *Amphiacme abyssorum* (•); *Calibelemnon* sp. (●); *Cavernularia dayi* (▲); *Cavernularia lutkenii* (☆); *Cavernulina* sp. (★); *Chunella gracillima* (+); *Funiculina quadrangularis* (○); *Kophobelemnon* sp. (◪); *Pteroeides isosceles* (□); *Scleroptilum* sp. (◑); *Veretillum leloupi* and *V. cynomorium* (■).

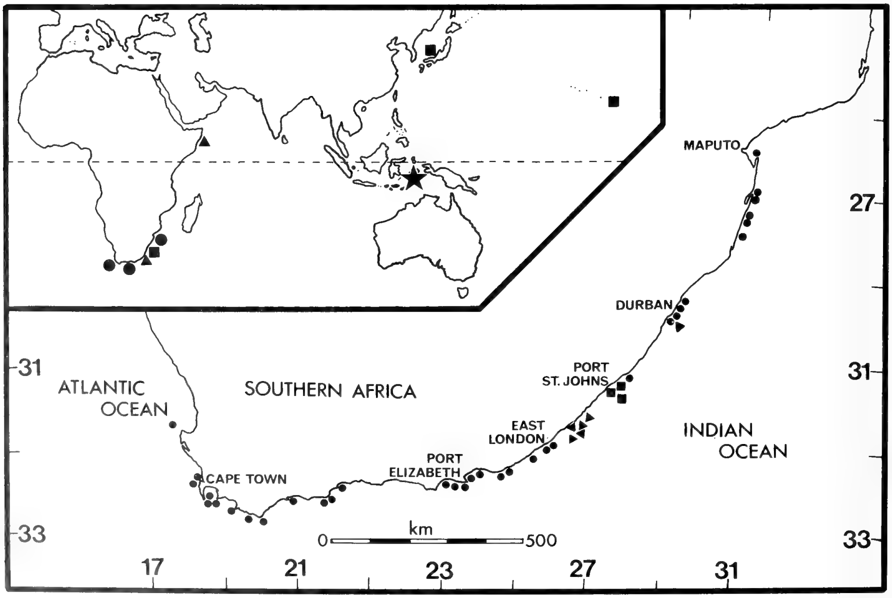

Fig. 39. Map showing known distribution of the family Echinoptilidae: *Actinoptilum molle* (●); *Echinoptilum echinatum* (▲); *Echinoptilum macintoshii* (■); *Echinoptilum asperum*, *E. elongatum*, *E. minimum*, *E. roseum* (★).

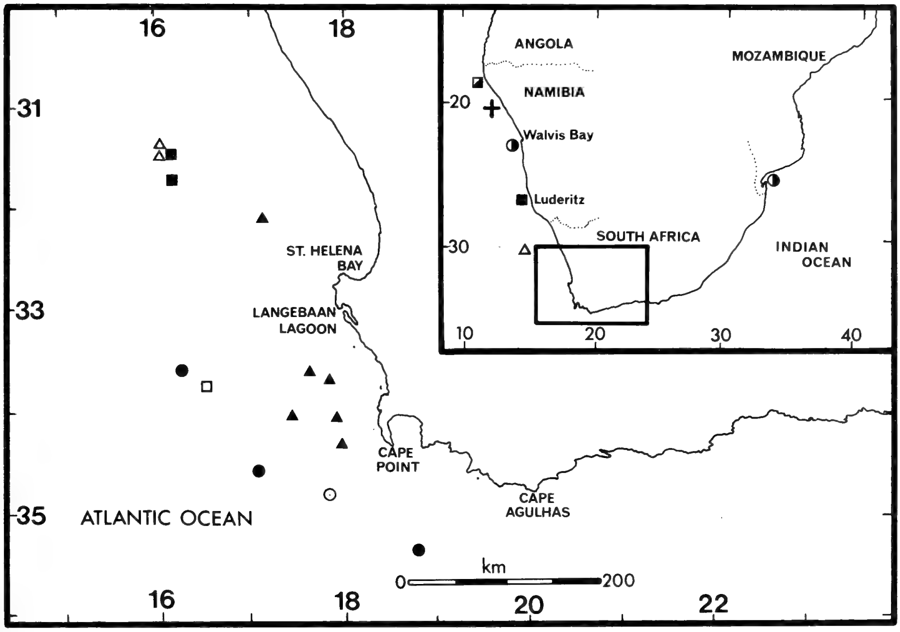

Fig. 40. Map of south-western Africa showing known collecting stations of eight pennatulacean species: *Anthoptilum grandiflorum* (▲); *Cavernularia elegans* (◩); *Distichoptilum gracile* (□); *Halipteris africana* (△); *Kophobelemnon stelliferum* (+); *Pennatula inflata* (■); *Umbellula lindahli* (●); *Umbellula thomsoni* (○); *Veretillum cynomorium* (◑).

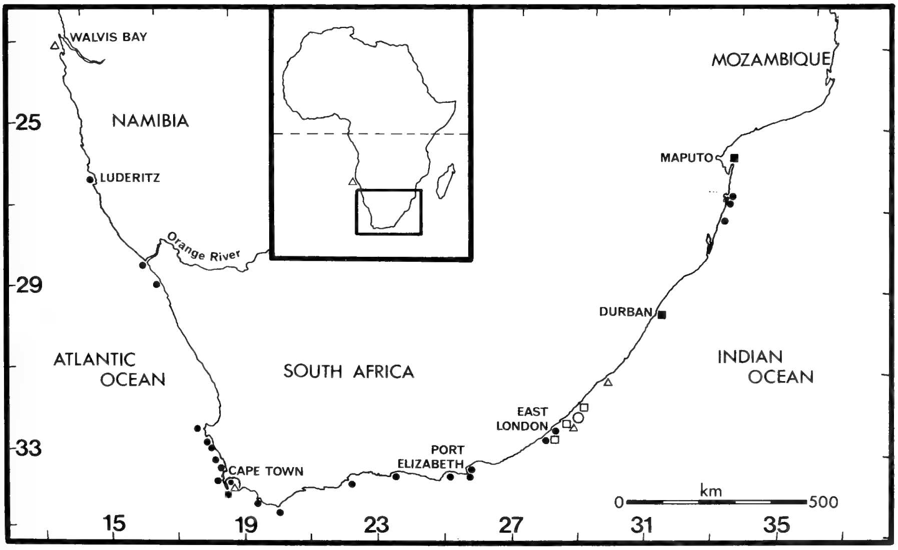

Fig. 41. Map showing known collecting stations for the family Virgulariidae (subfamily Virgulariinae) in southern Africa: *Scytaliopsis djiboutiensis* (○); *Virgularia gustaviana* (■) *Virgularia mirabilis* (△); *Virgularia schultzei* (●); *Virgularia* sp. (□).

Remarks on the genus Crassophyllum

Tixier-Durivault (1961*a*: 428) described a new genus and species, *Crassophyllum cristatum*, from northern Angola. It is mentioned here since it may possibly be encountered further south. This form is distinguished by the lack of supporting rays in the polyp leaves, but possesses scattered spindles and needles in the region between the siphonozooid plate and the polyp leaf margin.

DISCUSSION

ZOOGEOGRAPHY

The littoral and sublittoral benthic regions of southern Africa constitute a remarkably diverse and biogeographically unique area. The region is made up of cold-water and warm-water temperate elements, as well as a tropical component. In particular, the southernmost coast (the region between the Cape Peninsula and Port St. Johns) has a high degree of endemism in the invertebrate fauna (Ekman 1953: 189; Day *et al.* 1970: 2). This region is referred to as the 'Agulhas Province' by Briggs (1974: 149), the 'Cape Fauna' by Stephenson & Stephenson (1972: 101), and the 'South Coast' fauna by Ekman (1953: 187) and Millard (1978).

The peculiarities of this region and the composition of the fauna are due to a number of factors. Most important of these are: (1) the isolated, peninsular nature of southern Africa, which is bounded by two oceans, and the extensive area of continental shelf known as the Agulhas Bank, which is a probable centre of adaptive radiation (Millard 1978, fig. 1); and (2) the convergence of oceanic waters of divergent temperatures and origins in the vicinity of the Cape Peninsula, via the colder Benguela Current of the South Atlantic and the warmer Agulhas Current of tropical Indian Ocean influence (Branch & Branch 1981: 14).

A zoogeographical analysis of the southern African octocoral fauna will be dealt with in a subsequent paper.

AFFINITIES OF THE FAUNA

Shallow-water benthic invertebrates of southern Africa are generally recognized to have four major zoogeographical components: temperate Atlantic, Subantarctic, Indo-Pacific, and endemic (Millard 1978; Gosliner 1987). Many deep-water species have more scattered or cosmopolitan distributions. Several species of the west and south coasts, such as *Lituaria valenciennes*, extend further north into the Mediterranean Sea. Similarly, a number of species of the east coast, such as *Calibelemnon indicum*, have wider distributions in the tropical Indo-Pacific. At least 20 species of hydroids from southern Africa have Antarctic or Subantarctic affinities (Millard 1978: 171–172). Gosliner (1987), in considering the sister relationships in opisthobranch molluscs, regarded the Subantarctic influence as perhaps the oldest influence, which may be associated with the break-up of Gondwanaland. In regard to sea pens, the cosmopolitan *Umbellula lindahli* is known from throughout Antarctic waters (Grasshoff 1982*a*: 753, map 11). However, no truly Subantarctic component is presently recognized within the southern African fauna. Endemic species, such as *Virgularia schultzei* and *Actinoptilum molle*, are found throughout the region, with the centre of distribution along the south coast (the region between the Cape Peninsula and the Transkei coast).

SUMMARY AND CONCLUSION

The present study is the first in a two part series of a comprehensive survey of pennatulaceans from the subcontinent of southern Africa. It has increased in the number of identified species in the region from 12 to 23, the number of genera from 10 to 20, and the number of families from 8 to 12.

The families recorded from southern Africa for the first time are the Kophobelemnidae, Protoptilidae, Scleroptilidae, and Chunellidae. The eleven species newly recorded for the region are *Cavernularia elegans*, *Echinoptilum macintoshii*, *Echinoptilum echinatum*, *Kophobelemnon stelliferum*, *Distichoptilum gracile*, *Chunella gracillima*, *Amphiacme abyssorum*, *Umbellula lindahli*, *Scytaliopsis djiboutiensis*, *Halipteris africana*, and *Pennatula inflata*. The genera *Cavernulina*, *Sclerobelemnon*, and *Calibelemnon* are recorded for the first time from the region.

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6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers.

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach, Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

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7. SPECIAL HOUSE RULES

Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text
e.g. '. . . the Figure depicting *C. namacolus* . . .': '. . . in *C. namacolus* (Fig. 10) . . .'

(b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene

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'Revision of the Crustacea. Part VIII. The Amphipoda.'

Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively. The generic name should not be abbreviated at the beginning of a sentence or paragraph.

Name of new genus or species is not to be included in the title; it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

GARY C. WILLIAMS

THE PENNATULACEA OF SOUTHERN AFRICA (COELENTERATA, ANTHOZOA)

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ANNALS
OF THE SOUTH AFRICAN MUSEUM

CAPE TOWN

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3. MANUSCRIPT, to be submitted in triplicate, should be typewritten and neat, double spaced with 3 cm margins all round. First lines of paragraphs should be indented. Tables and a list of captions for illustrations should be typed separately, their positions indicated in the text. All pages should be numbered consecutively.

Major headings of the paper are centred capitals; first subheadings are shouldered small capitals; second subheadings are shouldered italics; third subheadings are indented, shouldered italics. Further subdivisions should be avoided, as also enumeration (never roman numerals) of headings and abbreviations.

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The number of the figure should be lightly marked in pencil on the back of each illustration.

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KOHN, A. J. 1960*a*. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Annals and Magazine of Natural History* (13) **2** (17): 309–320.

KOHN, A. J. 1960*b*. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bulletin of the Bingham Oceanographic Collection, Yale University* **17** (4): 1–51.

THIELE, J. 1910. Mollusca. B. Polyplacophora, Gastropoda marina, Bivalvia. *In:* SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika ausgeführt in den Jahren 1903–1905* **4** (15). *Denkschriften der medizinisch-naturwissenschaftlichen Gesellschaft zu Jena* **16**: 269–270.

(continued inside back cover)

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FORAMINIFERA FROM THE LATE PLEISTOCENE (LATEST EEMIAN TO EARLIEST WEICHSELIAN) SHELLY SANDS OF CAPE TOWN CITY CENTRE, SOUTH AFRICA

By
I. K. McMILLAN

Cape Town Kaapstad

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FORAMINIFERA FROM THE LATE PLEISTOCENE (LATEST EEMIAN TO EARLIEST WEICHSELIAN) SHELLY SANDS OF CAPE TOWN CITY CENTRE, SOUTH AFRICA

By

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(With 20 figures and 4 tables)

[*MS accepted 29 March 1989*]

ABSTRACT

Samples from shelly sands exposed during deep trenching in Cape Town city centre have yielded diverse and relatively well-preserved foraminifera faunas. Fifty-three species are recognized, of which four are reworked from older deposits; none are new. The total assemblage is very similar to ones from off the mouth of the Orange River, substantially further north. From foraminiferal and geological considerations, a latest Pleistocene (latest Eemian to earliest Weichselian) age is proposed for the sequence, which is regarded as having acccumulated during the fall in sea-level at the end of the Eemian. The foraminifera lived in a wave-dominated, littoral environment, and the clean sands in which they occur are considered to be part of an extensive, regressive sheet sand that originally covered almost the entire continental shelf off all three coasts of South Africa, and which is still widely preserved. Similar shelly sands, also attributable to the latest Eemian–earliest Weichselian sea-level fall, occur in the coastal parts of both the 'Bredasdorp Formation' and the 'Alexandria Formation' (both termed Unit III), as well as along the Gamtoos coast (Unit III), at Durban (the Bluff Sandstone Formation), and extensively over the Zululand coastal plain (the Uloa Formation). Variable diagenesis has resulted in considerable cementing of these deposits at some localities. The foraminifera of the same sequence at several localities on the west coast are given in three appendices: for the Llandudno–Sandy Bay coast, Cape Peninsula, the Berg River mouth, and the Hoedjiespunt Peninsula, Saldanha.

CONTENTS

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* Present address: SOEKOR (Pty) Ltd, P. O. Box 307, Parow 7500, South Africa.

Ann. S. Afr. Mus. **99** (5), 1990: 121-186, 20 figs, 4 tables.

INTRODUCTION

During deep trenching by the Municipality along several of Cape Town's city centre streets in late 1986, clean white, rather bleached, shelly quartz sands were exposed. These deposits appear to be confined to the more seawards parts of the city (Fig. 1). The sands are distinctly bedded, and undisturbed; human interference is confined to a distinct zone overlying the sands. Despite the clean and somewhat coarse nature of the sands, studied samples yielded a fairly well-preserved and diverse foraminifera fauna that contains a number of age-diagnostic species. The whole assemblage is almost identical to that described by McMillan (1987*b*) from the Late Pleistocene (latest Eemian to earliest Weichselian) deposits occurring on the inner Orange Shelf, just to the north of the Orange River mouth. A summarized stratigraphic column, based on observations by Mr V. H. Valicenti of SOEKOR (Pty) Ltd, Cape Town, at the time the trench was open, is given in Figure 2. The total thickness of the Cape Town sequence is not known. Two samples each were collected at the corner of Hertzog Boulevard and Oswald Pirow Street, and at the corner of Oswald Pirow and Martin Hammerschlagweg. Results of the foraminifera study are given in Table 1.

PREVIOUS WORK

Studies of Quaternary foraminifera in South Africa were initiated by Chapman (1907), who examined samples from a drill hole in the bed of the Buffalo River, East London. The precise age of the sequence, studied to a depth of 33,2 m below the bed of the river, is probably partly of Holocene, but mostly of latest Eemian–earliest Weichselian age. The latter age is indicated by the presence of *Elphidium crispum* (Linné) (given as *Polystomella crispa* by Chapman) through most of the studied sequence, suggesting that the Holocene is less than 4,57 m thick. Further comments on the use of *Elphidium crispum* as a zone fossil for the latest Eemian to earliest Weichselian deposits of South Africa are given below in the section on stratigraphy (see p. 129).

Most later work has involved lists of foraminifera species only, but Biesiot (1957) illustrated a number of the *in situ* foraminifera of the Uloa Formation at its type locality (see McMillan 1987*a*); these include the species of *Amphistegina*, *Elphidium*, and perhaps some of the miliolids, together with *Eponides zuluensis* Biesiot, *?Eponidella* sp. sensu Biesiot, *Rotalia beccarii* sensu Biesiot, *Cibicides lobatulus* (Walker & Jacob), and possibly *Nonion elongatum* sensu Biesiot.

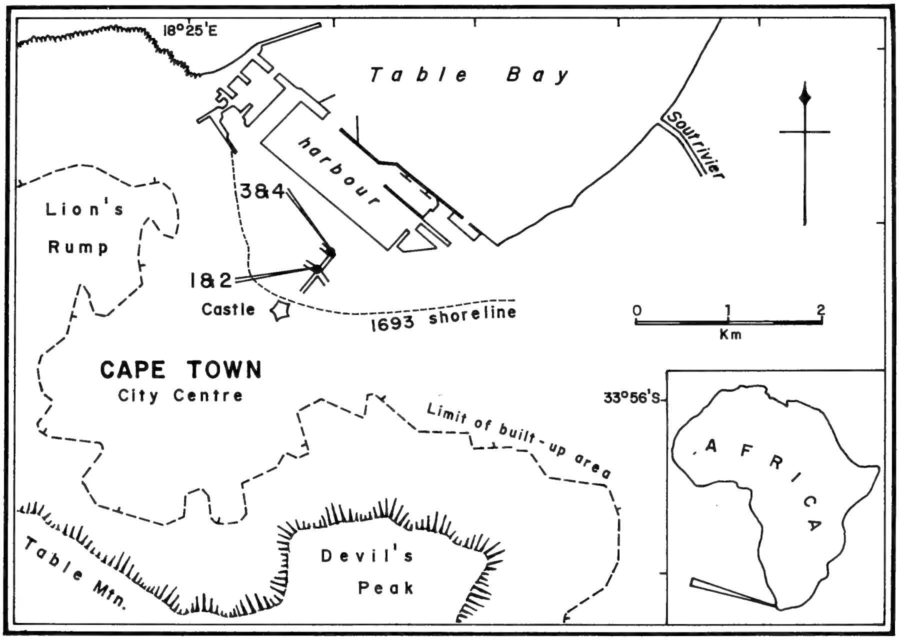

Fig. 1. Location of studied samples from the latest Eemian–earliest Weichselian regressive shelly sands (Unit III) beneath Cape Town city centre. Samples 1 and 2 are from the corner of Oswald Pirow Street and Hertzog Boulevard; 3 and 4 from the corner of Oswald Pirow Street and Martin Hammerschlagweg. Based on 1 : 50 000 topographic sheet 3318CD (Cape Town), 4th edition.

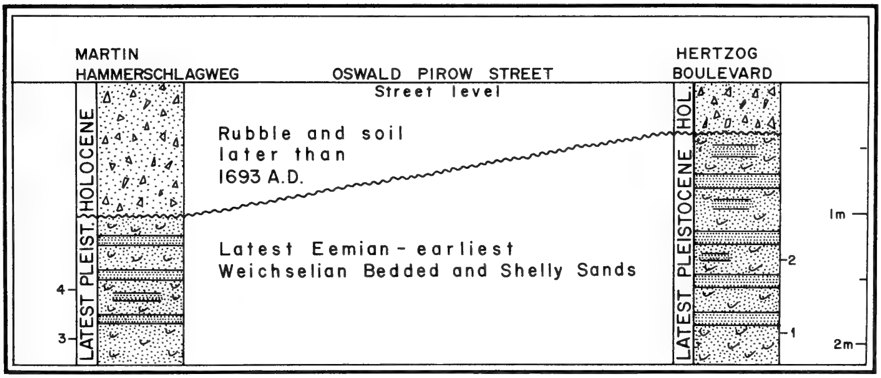

Fig. 2. The stratigraphy of exposures in deep trenches in Oswald Pirow Street, Cape Town city centre, as measured in November 1986, by Mr V. H. Valicenti, SOEKOR (Pty) Ltd. Sampled horizons are indicated (CTC 1 to 4).

TABLE 1

Distribution of foraminifera in studied samples from the latest Eemian–earliest Weichselian sands of Oswald Pirow Street, Cape Town city centre.

Sample number				Sp. no.	Species
CTC-1	CTC-2	CTC-3	CTC-4		
	1		1	1	*Spiroplectammina* sp.
		1	1	2	*Quinqueloculina contorta*
8	6	18	28	3	*Quinqueloculina dunkerquiana*
			2	4	*Quinqueloculina isabellei*
2			2	5	*Quinqueloculina* cf. *Q. lata*
1	1	1	5	6	*Quinqueloculina seminulum*
			11	7	*Quinqueloculina triangularis*
	1	2		8	*Quinqueloculina* cf. *Q. undulata*
4	6	24	34	9	*Quinqueloculina* spp. (broken)
		2	4	10	*Siphonaperta* sp.
2	1	2	3	11	*Miliolinella subrotunda*
		1		12	?*Dentalina* sp. (reworked)
		1		13	*Lagena semilineata* var.
			1	14	*Lenticulina* sp.
			1	15	*Oolina squamososulcata*
		1	3	16	*Oolina* sp. A
		1		17	*Fissurina lucida*
		1		18	*Fissurina* cf. *F. marginata*
		2		19	*Fissurina* spp. (reworked)
		1	1	20	*Guttulina* spp. (broken)
			1	21	*Bulimina marginata*
		1		22	*Uvigerina* sp. (reworked)
			1	23	*Trifarina angulosa*
		1		24	*Bolivina* sp.
		1		25	*Brizalina spathulata*
		16	8	26	*Cassidulina laevigata*
		1		27	*Cassidulina crassa* s.l.
		1		28	?*Gavelinopsis* sp. (reworked)
		1		29	*Planulinoides biconcavus*
		1	1	30	*Rosalina bradyi*
		1		31	*Rosalina* sp.
	2	22	10	32	*Glabratella australensis*
		3		33	*Cibicides fletcheri* s.l.
5	2	24	13	34	*Cibicides lobatulus*
		4	4	35	*Cibicides* spp. (reworked)
2	5	9	3	36	*Cibicidoides* sp.
		1		37	*Hyalinea balthica*
1	1	1		38	*Sphaerogypsina globulus*
	1			39	?*Acervulina* sp.
		14	3	40	*Elphidium advenum*
		6	1	41	*Elphidium* sp. A
		1	4	42	*Elphidum articulatum*
54	26	131	137	43	*Elphidium crispum* s.l.
	2	6	13	44	*Elphidium macellum* s.l.
		1		45	*Elphidium* sp. B
			1	46	*Astrononion echolsi*
		9	2	47	*Ammonia japonica*
1	1	3	6	48	*Ammonia parkinsonia* s.l.
11	16	105	146	49	*Pararotalia nipponica*
			1	50	indeterminate reworked rotalid
		1		51	*Globigerina (G.) bulloides*
		2		52	*Globorotalia (G.) inflata*
		4		53	*Neogloboquadrina* cf. *N. pachyderma*
91	72	429	452		Total number of tests

All the remaining fossils detailed by Biesiot (1957) are reworked from the Early and Middle Miocene (McMillan 1987*a*).

Lists of foraminifera from the coastal 'Bredasdorp Formation' and the coastal 'Alexandria Formation' were given by Rümke, in Spies *et al.* (1963) and Engelbrecht *et al.* (1962). Some of the samples described by Parr (1958), including those from the Bluff at Durban, are also of this age.

It is now certain that the *Pararotalia* cf. *P. inermis* (Terquem) emend. Le Calvez, and the *Ammonia beccarii* (Linné) var. 2 sensu McMillan (1974), from the Agulhas Bank, are also of latest Eemian–earliest Weichselian age. The former can now be referred to *Pararotalia nipponica* (Asano), whereas the latter are poorly preserved tests of the *Ammonia* sp. C (Alexandria) detailed by McMillan (1987*a*).

McMillan (1987*a*) illustrated *Ammonia* species from a variety of South African Pleistocene, Holocene and Pliocene localities as a preliminary attempt to correlate the many, geographically disparate deposits of these ages. McMillan (1987*b*) described in detail the stratigraphy and foraminiferal assemblages of the latest Eemian–earliest Weichselian and the Holocene silts and sands of the Orange Shelf, southern Namibia continental margin. Diagnostic zone foraminifera from the different aged rock units that comprise the 'Alexandria Formation' have been illustrated by McMillan (in press).

THE FORAMINIFERA ASSEMBLAGES

All four Cape Town samples yielded faunas dominated by the benthonic species *Elphidium crispum* (Linné) s.l. and *Pararotalia nipponica* (Asano). As is the case with all of the Pleistocene marine sand deposits preserved on the South African continental margin, planktonic foraminifera are rare. Species of the benthonic genera *Elphidium*, *Ammonia*, *Pararotalia* and *Cibicides* predominate, again in keeping with other Pleistocene marine sequences.

ENVIRONMENT OF DEPOSITION

A littoral, wave-influenced environment of deposition is indicated from both the foraminifera and the sediments. The clean nature of the sands, the abrasion and breakage of some foraminifera tests, and the presence of a number of foraminifera species that in life attach to a substrate, all clearly reflect a turbulent sea-floor, with highly oxygenated conditions both on the sea-bed and in the water column. A water depth of 10 m or less is suggested. The attached species include *Cibicides lobatulus* (Walker & Jacob), *Rosalina* sp., *Rosalina bradyi* (Cushman), *Glabratella australensis* (Heron-Allen & Earland) and *Sphaerogypsina globulus* (Reuss), and possibly *Cibicides fletcheri* Galloway & Wissler s.l. The macrofaunal remains in the sands, mainly bivalve and echinoid debris, are substantially comminuted.

It appears likely that the foraminifera tests, while evidently *in situ* in a stratigraphical sense, were much transported before coming to their final rest. It seems likely that these foraminifera lived in a sublittoral environment, possibly a kelp-bed, and were swept shorewards after death by wave action, to be incorporated into truly littoral deposits accumulating as the shoreline retreated. The retreat of the sea at this time would seem to have occurred over a fairly short interval (perhaps well within 5 000 years, if an analogy with the Holocene transgression holds good), so that the littoral sands laid down at any one locality may have soon no longer been subject to wave- and swell-induced abrasion, lying instead in coastal sand flats or dunes.

The presence of *Ammonia parkinsoniana* (d'Orbigny) s.l. in small numbers in the Cape Town samples suggests that the assemblage, if regarded as from one environment, derives from an area of slightly reduced salinity conditions. Thus, river output or other run-off affected the habitats of the studied foraminifera, but the lack of land-derived plant debris, seeds, charophyte oogonia and so on, together with the relatively small numbers of *Ammonia parkinsoniana*, clearly indicate the freshwater influence to have been an insubstantial one, perhaps as is the case in the Cape Town part of Table Bay at the present day. It seems that a comparison of numbers of *Ammonia japonica* (Hada), typical of shelf environments, with numbers of *Ammonia parkinsoniana*, characteristic of estuarine and littoral environments, may provide a simplified environmental indicator for these latest Pleistocene accumulations around the west and south coasts of South Africa.

Since most of the foraminifera species encountered in the Cape Town sands are known to live off the western Cape coast at the present day, it would appear that sea temperatures at the end of the Eemian were much the same as they are at present. However, until the full geographic ranges of the various species around the South African coast are better known, an improved understanding of water temperatures cannot be attempted.

STRATIGRAPHY AND CORRELATION

The foraminifera of the Cape Town sands show varying similarities to those of older Pleistocene deposits, those of deposits of the same age, and those of the Holocene. Generalized locations are given in Figure 3.

SYNCHRONOUS DEPOSITS OF THE SOUTH AFRICAN CONTINENTAL MARGIN

The Cape Town shelly sands can be correlated with ease to the sands and silts occurring to a considerable thickness (about 70 m according to Hoyt *et al.* 1969) off the mouth of the Orange River, based on the very close similarity of their foraminiferal faunas (see McMillan 1987*b*). Correlation is also possible with a number of deposits preserved about 8 m above high sea-level at the Hoedjiespunt Peninsula, Saldanha, along the Sandy Bay to Llandudno coastline, Cape

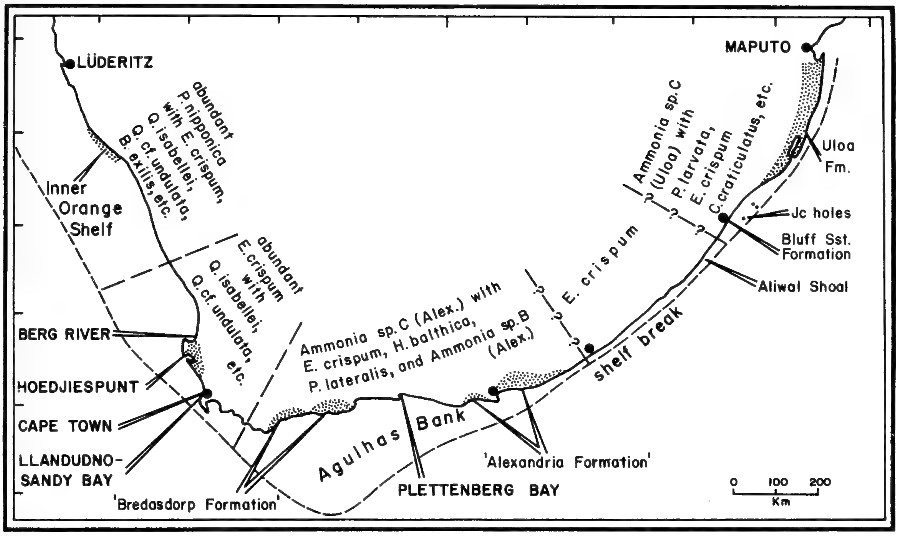

Fig. 3. Distribution of latest Eemian–earliest Weichselian deposits around the South African coast, of equivalent age to the shelly sands of Cape Town centre. The areas shown for the Varswater Formation, the 'Bredasdorp Formation', and the 'Alexandria Formation' are for the entire sequence, Unit I to Unit III. In all these areas Unit III occurs as a narrow strip along the present coast. The major foraminiferal facies, based mainly on *Ammonia* and *Elphidium* species are also shown. Species listed distinguish the Unit III sands from both older Pleistocene and Holocene deposits.

Peninsula, and below the level of the present Berg River mouth (see Appendices A, B, C).

Deposits of the same age also occur along the south coast of South Africa: the latest, most coastal portion of the 'Bredasdorp Formation' between Cape Agulhas and Mossel Bay, below the mouth of the Keurbooms and Bietou rivers at Plettenberg Bay and onshore adjacent to the estuary, and the latest, most coastal portion of the 'Alexandria Formation' between Port Elizabeth and Port Alfred, as well as the whole of the smaller area of 'Alexandria Formation' along the Gamtoos coast. Deposits of this age have been termed Unit III informally by the present author (see McMillan in press). It is now known that Unit III and Unit IV of the 'Alexandria Formation' are slightly different facies of the same rock sequence, and are of the same age (see McMillan in press). Unit III in the eastern Cape is characterized by polished foraminifera tests, with many normal marine shelf species, and the distinctive *Ammonia* sp. C (Alexandria) is common and widespread. Unit IV, seen only at Woody Cape, contains foraminifera assemblages dominated by miliolids, together with *Poroeponides lateralis* (Terquem), that derive from a more exclusively littoral environment.

Off the south coast, Unit III sediments are extensively preserved as a thin veneer over the majority of the Agulhas Bank. The sequence has been frequently encountered in borehole tops as far offshore as the outermost shelf, down to a water depth of about 200 m. Foraminifera faunas remain uniform and distinctive throughout, and are easily correlated with those deposits occurring onshore at the present day. At borehole F–A 13, the latest Eemian–earliest Weichselian shelly deposits, together with the overlying Holocene interval (the two are separated by an unconformity), are no more than 0,5 m thick. *Ammonia* species from F–A 13 and E–B 1 have been previously discussed by McMillan (1987*a*). Where the latest Eemian–earliest Weichselian Unit III deposits unconformably overlie the shelly white limey clays of the Early Miocene (Burdigalian) over most of the middle and outer shelf on the Agulhas Bank, much reworking of the Miocene has occurred, so that the latest Pleistocene sediments are often white clays, with abundant Miocene foraminifera in some cases.

The thin sliver of coastal deposits preserved along the East London to Durban coast have only been examined for foraminifera by Parr (1958); the species listed by him from near Bats Cave, East London, are insufficient to determine what part of the Pleistocene (but presumably Unit III) is represented here. It seems certain now that most, possibly all, of the Bluff Sandstone Formation at Durban and the Uloa Formation, extensively developed over the Zululand coastal plain, are of the same age—latest Eemian to earliest Weichselian. Although very much thinner offshore, the sequence also occurs in the borehole tops of Jc–A 1, Jc–B 1 and Jc–C 1, where it lies unconformably between the Holocene and Middle or Early Miocene, and consists of a loose shelly sand. The eastern offshore sequence thus exactly duplicates that seen on the Agulhas Bank. Again, there is little change in the littoral, benthonic foraminifera of this unit, and *Ammonia* sp. C (Uloa) (possibly referable to *Challengerella persica* Billman, Hottinger & Oesterle), *Elphidium crispum* (Linné) s.l., *Planorbulinella larvata* (Parker & Jones) and *Cellanthus craticulatus* (Fichtel & Moll) have proved useful local indicators for Unit III from Durban northward.

Earlier comments on the age of the Uloa Formation have been made by McMillan (1987*a*), who suggested reasons for a probable middle Pleistocene age. However, the presence of *Elphidium crispum* s.l., together with feathered-suture *Ammonia*s in the east-coast and the south-coast sequences, as well as their unconsolidated nature on the outer shelf off both the east and south coasts, clearly argues for the two to be of the same age. Since the offshore deposits remain unconsolidated for the most part, it is clear that they have never been subjected to a major regression of the sea and the surf-zone, and must thus date from the last fall in sea-level at the end of the Eemian. It is clear from study of the Holocene sequences around South Africa that the early Holocene transgression, in strong contrast, was a very mild event in terms of its erosive power.

On the basis of the presence of *Elphidium crispum* (Linné), the Aliwal Shoal, south of Durban (Carter 1966; McCarthy 1967), would appear to be also of Unit III age.

In all of the above rock sequences, correlation of this youngest regressive event can be achieved in part by its contained littoral foraminifera, particularly the species of *Elphidium* and *Ammonia*, and partly by its stratigraphical relationships. Although, on following Unit III around the continental margin of South Africa, the foraminifera faunas change substantially, nevertheless with sufficient density of samples, key species can be traced until they overlap with other key species, and correlation is thus maintained. *Elphidium crispum* (Linné) s.l. has proved the most reliable species for identifying Unit III, though there are subtle differences in test morphology between east- and west-coast examples that remain to be defined. The major foraminiferal facies recognized in Unit III deposits so far, together with *local* age-diagnostic species, are shown in Figure 3.

McMillan (1987*a*) has proposed the use of different *Ammonia* species to identify the various latest Cainozoic (Pliocene, Pleistocene and Holocene) marine deposits of southernmost Africa. Subsequent unpublished work on the *Elphidium* species has indicated that they are morphologically more diverse and often more distinctive than the *Ammonia* species, and thus would seem to be a more useful group for correlation purposes. Perhaps in response to the changing environments available for occupation during high (glacial minima) and low (glacial maxima) sea-level stands by species of the two genera, it would seem that appearances of new species are more frequent than in the planktonic foraminifera (Globigerinacea) over the timespan of the Quaternary. Particularly in *Ammonia*, but also in *Elphidium*, the historical view has been that species of these genera show much morphological variation in their tests. On the contrary, intraspecific variation is as limited as in most other rotalid species, but the number of species in both genera is unusually large, and most appear to have survived for relatively short time periods, often markedly less than one million years in duration.

COMPARISON WITH OLDER PLEISTOCENE DEPOSITS

The regressive littoral sands of the end of the last interglacial can be identified as such in a number of ways. From a foraminiferal point of view, they contain the greatest number of species in common with extant littoral assemblages around South Africa. The foraminifera of the earlier Pleistocene and Pliocene deposits show a progressive decline in similarity with increasing age. A typical example of this is given by McMillan (in press) for the 'Alexandria Formation'. In both the oldest, Pliocene part of the 'Alexandria Formation', and the Pliocene of the Orange Shelf (McMillan 1987*b*), the benthonic foraminifera show no similarity with living South African species, though in deeper-water assemblages some conservative forms persist (e.g. *Pullenia*, *Gyroidina*).

Secondly, the latest Eemian–earliest Weichselian deposits can be recognized because they consist of unconsolidated or poorly cemented shelly sand, up to 86 m thick in the coastal 'Alexandria Formation', but often less than 1 m, that covers most of the South African continental margin, though there are large areas where it is missing off the west coast. This sheet sand has suffered relatively little from later erosion. In contrast, relatively little now remains of the earlier Pleistocene regressive deposits, the remnants usually being unusually thick because of local, mild subsidence prior to deposition, and uplift after deposition has removed them from the erosive activities of subsequent regressions. Earlier Pleistocene deposits of this type are known from the west coast, especially in the vicinity of Saldanha and Langebaan, and in the older 'Bredasdorp Formation' and 'Alexandria Formation', inland from the present coast. It seems probable that the older, higher terraces (A to C) of the Oranjemund to Chameis Bay coast in southern Namibia should be included here, but foraminiferal study of them has not yet been attempted.

Thirdly, there is a tendency for the Unit III shoreline at maximum advance in the Eemian to be similar to the present shoreline, with the only major difference occurring on the Zululand coastal plain, which was entirely inundated during the Eemian. With the older Pleistocene and Pliocene deposits, a progressive divergence away from the present shoreline can be seen, which by Pliocene times was quite substantial, notably in the eastern Cape.

Off the south and west coasts of South Africa, the marine deposits of the latest Eemian to earliest Weichselian can be distinguished from older units by the particular presence of *Elphidium crispum* (Linné) s.l., as well as *Elphidium macellum* (Fichtel & Moll) s.l., *Ammonia japonica* (Hada), and *Ammonia parkinsoniana* (d'Orbigny) s.l. (see McMillan 1987*a*, 1987*b*). In addition, *Astrononion echolsi* Kennett, *Quinqueloculina isabellei* d'Orbigny, *Oolina* sp. A, *Elphidium* cf. *E. advenum* (Cushman) and *Cassidulina crassa* d'Orbigny s.l., as well as the very distinctive *Quinqueloculina* cf. *Q. undulata* d'Orbigny, are all unique to the latest Eemian to earliest Weichselian of the west coast (McMillan 1987*b*). Also characteristic of these youngest marine Pleistocene deposits is the widespread presence of mollusc shell retaining its life colours: purples, blues and pinks seem the most commonly preserved. In earlier Pleistocene deposits, all the mollusc shell is white.

Preliminary examination of the Varswater Formation (here regarded as later Early Pleistocene) at a number of localities, as well as the phosphatic lithofacies termed the 'Saldanha Formation' by Tankard (1975), has revealed the following foraminifera species: *Ammonia* sp. (similar to *Ammonia japonica*), *Elphidium* sp. (within the *Elphidium crispum–macellum* group), *Glabratella australensis* (Heron-Allen & Earland) locally in abundance, *Planulina* cf. *P. ariminensis* d'Orbigny and *?Gavelinopsis* sp. Most of these are unknown in the latest Eemian to earliest Weichselian of both the Orange Shelf (McMillan 1987*b*) and Cape Town city centre. The Pelletal Phosphorite Member of the Varswater Formation in phosphate exploration borehole Q12 from near the New Varswater Quarry, Langebaanweg, has yielded a somewhat different assemblage, with *Cibicides lobatulus* (Walker & Jacob), *Pararotalia nipponica* (Asano), *Elphidium advenum* (Cushman), *Pseudo-*

nonion cf. *P. chiliensis* (Cushman & Kellett), *Nonion boueanum* (d'Orbigny), *Trifarina angulosa* (Williamson), *Oolina* sp., *Elphidium* spp., *Rosalina* cf. *R. bradyi* (Cushman), *Planorbulina mediterranensis* d'Orbigny, *?Gavelinella* spp., *Cibicides* spp., *Ammonia* spp., *?Pseudononion* sp., and *Globigerina* cf. *G. bulloides* d'Orbigny. More work is necessary on these older Pleistocene deposits but, from the abundance of *Glabratella australensis* at many localities, a correlation of the Varswater Formation with Unit IIA of the 'Bredasdorp Formation' seems likely.

It must be emphasized that the majority of the foraminifera species employed in correlation of the southern African latest Cainozoic are of local value only. *Ammonia japonica*, *Ammonia parkinsoniana*, *Elphidium crispum* and *Elphidium macellum*, for example, range back to the Early Pleistocene or Pliocene in the Mediterranean or Japan. In the case of *Ammonia* and *Elphidium*, both were late arrivals to southern Africa. *Ammonia* is first seen in the Early Miocene of Mediterranean Europe, but in South Africa it first appears in the Early Pliocene. *Elphidium* is known from the Early Eocene (Loeblich & Tappan 1964), but first appears in South Africa in the Middle Miocene.

COMPARISON WITH HOLOCENE DEPOSITS

The bedded shelly sands exposed in the Cape Town municipal trenching lie seaward of the Holocene shoreline as it was in 1693, before the construction of the modern harbour works. The location, relative to the site of the Castle, is evident on old maps. There thus exists the possibility that the sands are Holocene in age, having accumulated prior to commencement of the land reclamation schemes associated with harbour development. However, a Holocene age can be discounted on a number of points.

The latest Pleistocene Unit III sands are rich in tests of *Elphidium crispum* (Linné) s.l., and this species is absent everywhere in the Holocene, except rarely where it has been reworked. Similarly, *Quinqueloculina* cf. *Q. undulata* d'Orbigny and the other species listed on page 139 are not known from the Holocene (see Fig. 4 for interpreted stratigraphic ranges). The absence of *Elphidium magellanicum* Heron-Allen & Earland, widespread in shallow marine environments off the west coast during the later Holocene (McMillan 1987*b*), also supports a pre-Holocene age. *Elphidium magellanicum* occurs in the present-day sands washed into the canalized mouth of the Soutrivier, just a little distance north-east of the study area. Finally, nearly all the tests from the trench sands are bleached and lack their life colours, whereas tests from Holocene samples include a high proportion that retain their natural golden-brown coloration. This is probably due to the destruction of the inner tectin lining of the test by bacteria and percolating groundwater.

Since the latest Eemian–earliest Weichselian sands are overlain by a mix of rubble and soil, the fate of any Holocene deposits at the site of the trenching, laid down prior to land reclamation, is unclear.

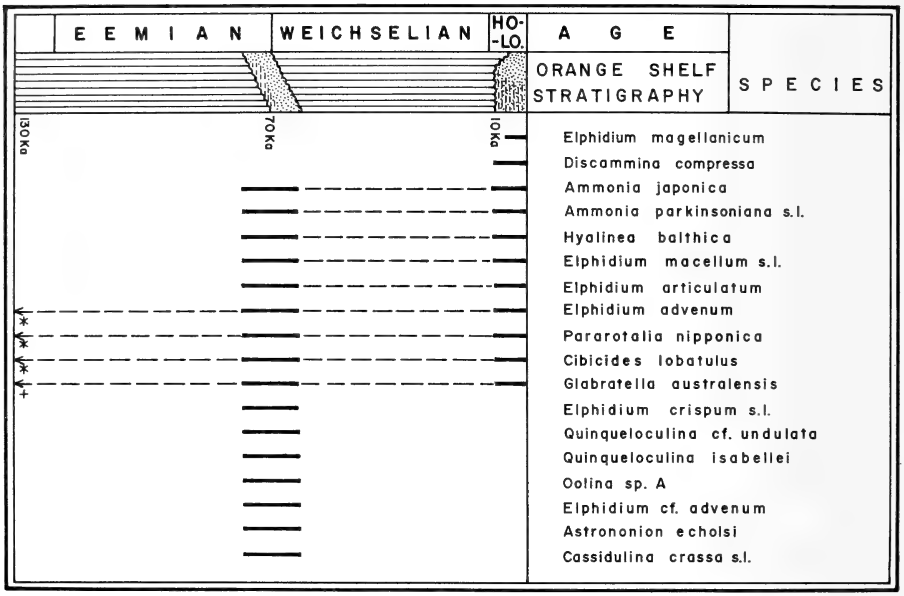

Fig. 4. Range chart of selected time-restricted benthonic foraminifera species from the latest Quaternary littoral of the west Cape and Namibia coasts. Those species marked with an asterisk range back to near the Pliocene–Pleistocene boundary (base of Unit II) in the 'Alexandria Formation'; that marked by a cross ranges back in abundance to the later Early Pleistocene (base of Unit IIA) of the 'Bredasdorp Formation'.

REWORKING

A small number of the Cape Town tests are rather more poorly preserved than the majority, and are regarded as having been reworked. One, *?Gavelinopsis* sp., appears to be derived from the local equivalent of the Varswater Formation (later Early Pleistocene) sandy limestones, as it is creamy in colour and cemented; the same species occurs in the limestones at Saldanha. Occasional angular lumps of creamy sandy limestone present in the Cape Town sands are probably also from an equivalent of the Varswater Formation.

The remaining reworked tests may prove to be from the Early Miocene, though this cannot be confirmed from the species present, which are *?Dentalina* sp., *Cibicides* spp. and *Uvigerina* sp. (Fig. 9B). All show darker infillings to the chambers (and dark test calcite) than is typical for later Neogene or Quaternary foraminifera tests. An Early Miocene age seems most likely, because of the extensive development of very fossiliferous limy clays of this age that outcrop or subcrop below the Quaternary on the continental shelf off the west coast. Intensive reworking of Early and Middle Miocene foraminifera tests into latest Pleistocene regressive sands is known from the Orange Shelf (McMillan 1987*b*) and the Uloa Formation of Zululand (McMillan 1987*a*). The species listed above are not typical of the Varswater Formation.

PROCESSING METHODS

All of the samples studied, including those described in the three appendices, consist of clean or muddy, unconsolidated sands. These were easily washed with a cold-water spray over a 240 mesh/63 micron sieve. Those samples with substantial present-day plant debris were further cleaned by standing the washed residue in a beaker of water and picking off the floating debris using a pair of tweezers.

PHOTOGRAPHY AND DEPOSITION OF MATERIAL

Scanning electron microscope work was performed using the JEOL JSM240 microscope of the University College of Wales, Aberystwyth. The line drawings were executed with a camera lucida attachment to a light microscope.

All illustrated specimens were returned to their relevant assemblage slides; they can be distinguished by their gold coating. The eleven assemblage slides have been deposited with the Ph.D. thesis material of McMillan (1987*b*) in the foraminifera collections of the Department of Geology, University College of Wales, Aberystwyth. The slides possess the following McMillan collection numbers:

CTC–1: Slide 118
CTC–2: Slide 119
CTC–3: Slide 120
CTC–4: Slide 121
BR–1: Slide 115
BR–2: Slide 116
SB–1: Slide 111
SB–LL1: Slide 112
SB–LL2: Slide 113
SB–LL3: Slide 114
H–1: Slide 117

A representative set of species slides has also been deposited in the Micropalaeontology Unit of the South African Museum.

FORAMINIFERA TAXONOMY

The taxonomic scheme followed is essentially a combination of that of Loeblich & Tappan (1964, 1974), as revised by Haynes (1981). More detailed discussions and full descriptions of many of the species listed below can be found in McMillan (1987*b*).

Family **Textulariidae** Ehrenberg, 1838
Subfamily Spiroplectammininae Cushman, 1927
Genus *Spiroplectammina* Cushman, 1927

?Spiroplectammina sp.

Fig. 5A–B

Remarks

Two badly broken tests, which seem more likely to be referable to *Spiroplectammina* than *Textularia* from their test shape. The specimens differ from *Spiroplectammina atrata* (Cushman), prevalent in the Holocene deposits of the middle and outer Orange Shelf (McMillan 1987*b*), in being less compressed and with a more rounded test periphery. The latter feature, however, is poorly preserved. The grain size of the test wall is also coarser than either *Spiroplectammina atrata* from off the west coast or *Spiroplectammina wrightii* (Silvestri), known from the Holocene of the Agulhas Bank (McMillan 1974).

Family **Milliolidae** Ehrenberg, 1839
Subfamily Quinqueloculininae Cushman, 1917
Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina contorta d'Orbigny, 1846

Fig. 6A–C

Quinqueloculina contorta d'Orbigny, 1846: 298, pl. 20 (figs 4–6). McMillan, 1974: 33, pl. 2 (fig. 1a–c); 1987*b*: 164, pl. 2 (figs 8–11).

Remarks

Some variation in the degree of indentation of the rectangular test margins is evident in southern African individuals. Those from the Agulhas Bank (McMillan 1974) display strong indentations, but examples from the west coast are flatter (McMillan 1987*b*, present study) and more in keeping with the type illustrations of the species (D'Orbigny 1846). Some of the Orange Shelf tests display distinctly inflated margins, and the rectangular feature is almost lost (McMillan 1987*b*, pl. 2 (figs 8–9)). The toothplate of the Cape Town tests is perhaps a little more bladed and more elongate than that originally figured by D'Orbigny.

The species occurs in small numbers in the more nearly littoral intervals of the latest Eemian–earliest Weichselian of the Orange Shelf (McMillan 1987*b*), and over the middle and outer shelf on the Agulhas Bank in the Holocene (McMillan 1974). This discrepancy in environments between the latest Pleistocene and the Holocene is mirrored by several other species found in the Cape Town shelly sands.

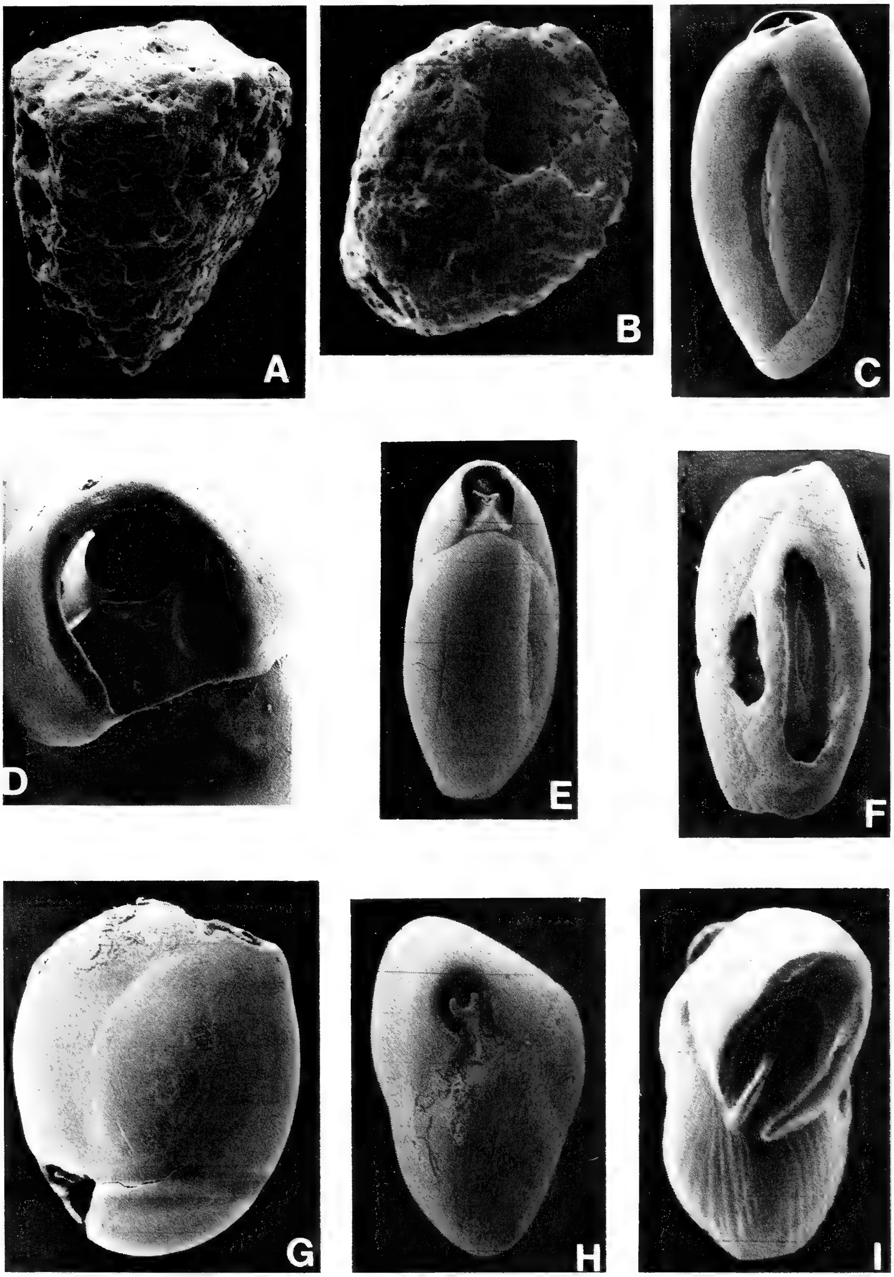

Fig. 5. A–B. *?Spiroplectammina* sp. A. Side view, CTC 4. × 130. B. Apertural view, same specimen. × 141. C–E. *Quinqueloculina isabellei* d'Orbigny. C. Side view, CTC 4. × 67. D. Apertural view, same specimen. × 520. E. Edge view, same specimen. × 60. F. *Quinqueloculina* cf. *Q. lata* Terquem. Side view, CTC 4. × 117. G–H. *Quinqueloculina triangularis* d'Orbigny. G. Side view, CTC 4. × 97. H. Apertural view, same specimen. × 113. I. *Quinqueloculina* cf. *Q. undulata* d'Orbigny. Apertural view, CTC 2. × 108.

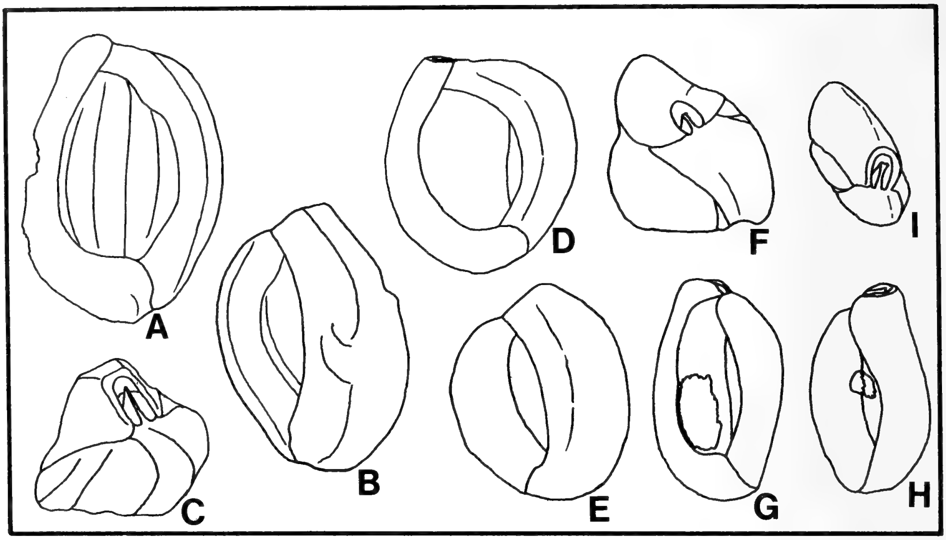

Fig. 6. A–C. *Quinqueloculina contorta* d'Orbigny. All same specimen, CTC 3. All × 67. A. Side. B. Opposing side. C. Apertural view. D–F. *Quinqueloculina dunkerquiana* (Heron-Allen & Earland). All same specimen, CTC 4. All × 67. D. Side. E. Opposing side. F. Apertural view. G–I. *Quinqueloculina seminulum* (Linné). All same specimen, CTC 3. All × 67. G. Side. H. Opposing side. I. Apertural view.

Quinqueloculina dunkerquiana (Heron-Allen & Earland, 1930)

Fig. 6D–F

Miliolina dunkerquiana Heron-Allen & Earland, 1930: 56, pl. 12 (figs 9–11).
Quinqueloculina dunkerquiana (Heron-Allen & Earland) Haynes, 1973*b*: 2, pl. 1 (fig. 8). McMillan, 1987*b*: 166, pl. 2 (figs 12–13).
Quinqueloculina cf. *Q. dunkerquiana* (Heron-Allen & Earland) McMillan, 1974: 33, pl. 2 (fig. 1a–c).

Remarks

A number of small *Quinqueloculina* specimens with test width, height and outline, and chamber shape much in keeping with the north-west European shallow marine species *Quinqueloculina dunkerquiana*. As with the shell figured by Heron-Allen & Earland (1930) from present-day sediments of the Plymouth district, south-western England, the maximum height of tests is little greater than their maximum width. The distinctive indentations on the two last-formed chambers give a slightly sigmoiline appearance to the test if seen in apertural view, but the internal arrangement is always clearly quinqueloculine.

The species has been regarded as close to *Quinqueloculina seminulum* (Linné) by British authors (Heron-Allen & Earland 1930; Haynes 1973*a*, 1973*b*), but the gradation of forms recognized by Haynes (1973*b*, pl. 1) between the two species is far less evident in southern African late Quaternary assemblages. Specimens referable to *Quinqueloculina dunkerquiana* occur widely at the present day in shallow marine, innermost shelf deposits around the entire South African coastline. The full stratigraphic range of the species remains unclear but on the Orange Shelf it extends throughout the latest Eemian to earliest Weichselian interval, while it is rare in the Holocene (McMillan 1987*b*).

Quinqueloculina isabellei d'Orbigny, 1839

Fig. 5C–E

Quinqueloculina isabellei d'Orbigny, 1839*b*: 74, pl. 4 (figs 17–19).
Quinqueloculina seminulum (*non* Linné) Boltovskoy *et al.*, 1980: 47, pl. 29 (figs 7–10, ?figs 11–13).
'*Quinqueloculina plataensis*' McMillan, 1987*b*: 169, pl. 3 (figs 1–4).

Remarks

The nearly circular aperture and strongly bifid apertural tooth, with the pronounced inflation of the final three chambers leading to a broad, evenly rounded test periphery, are distinctive features. These clearly distinguish the species from *Quinqueloculina seminulum* (Linné), with which it has been confused. *Quinqueloculina araucana*, also described by D'Orbigny (1839*b*) from present-day sediments off the west coast of South America, is clearly very similar to *Qinqueloculina isabellei*, and the two may be conspecific. The test outline of the type specimen of *Quinqueloculina isabellei* is strongly lobate, though this feature is not evident in the well-illustrated specimens of Boltovskoy *et al.* (1980), nor in the southern African tests here referred to D'Orbigny's species.

Boltovskoy *et al.* (1980: 47) considered their specimens to be part of a range of forms that they grouped under the name *Quinqueloculina seminulum*. If the neotype of *Quinqueloculina seminulum* from Rimini, Italy, illustrated by Loeblich & Tappan (1964, fig. 349 (no. la–c)), is regarded as typical for Linné's species, then the South Atlantic shells here referred to *Quinqueloculina isabellei* are clearly distinct. There is no gradation between *Quinqueloculina isabellei* and *Quinqueloculina seminulum* in either the Orange Shelf latest Eemian to earliest Weichselian shells (McMillan 1987*b*), or in those from Cape Town. See also remarks on *Quinqueloculina seminulum* (p. 138).

Quinqueloculina isabellei has yet to be found in the Holocene of southern Africa, whereas most, if not all, southern South American records are from the Holocene.

Quinqueloculina cf. *Q. lata* Terquem, 1876

Fig. 5F

see *Quinqueloculina lata* Terquem, 1876: 82, pl. 2 (fig. 8a–c). Mathieu *et al.*, 1971: 159, pl. 1 (figs 5–7).

Remarks

The few, rather damaged specimens from the Cape Town samples lack the embracing, quadrate nature of the final chambers of European littoral specimens referred to *Quinqueloculina lata*. However, they are markedly more elongate than is typical for *Quinqueloculina seminulum* (Linné). In this respect they appear similar to the tests illustrated by Haynes (1973*a*, pl. 7 (figs 10, 12), 1973*b*, pl. 1 (fig. 1)) from Cardigan Bay, Wales, although the Cape Town tests lack such an elongate aperture.

Similar forms occur in the latest Pleistocene of the Orange Shelf (McMillan 1987*b*) to those in the Cape Town samples but, as with the majority of Pleistocene littoral miliolids, almost all are badly damaged and usually only the kernel of each test has preserved. An exact comparison of the Orange Shelf and Cape Town shells is thus not easy to achieve.

Quinqueloculina seminulum (Linné, 1758)

Fig. 6G–I

Serpula seminulum Linné, 1758: 786.
Quinqueloculina seminulum (Linné) Loeblich & Tappan, 1964: C458, fig. 349 (no. 1a–c). Haynes, 1973*a*: 74, pl. 7 (figs 14, 19), pl. 8 (fig. 3), pl. 32 (figs 1–3), text-fig. 18 (nos 1–4). McMillan, 1974: 35, pl. 2 (fig. 5a–c); 1987*b*: 172, pl. 3 (figs 5–6). Martin, 1981: 26, pl. 2 (fig. 11).

Remarks

The neotype illustrated by Loeblich & Tappan (1964), from the shore sands of Rimini, Italian Adriatic, has been relied on in establishing the identity of the various smooth-walled *Quinqueloculina* tests in the Cape Town samples. The neotype displays a rounded-triangular aperture with a rather short tooth that exhibits a distinctly bifid tip (apparently slightly broken on one side). In contrast, southern African tests reveal a more elongate-ovate aperture, within which lies a long, narrow tooth that extends for about three-quarters of the aperture length. The tooth is incipiently bifid at its free end, but this feature is never as well developed as the pronounced Y-shaped tooth of *Quinqueloculina isabellei* d'Orbigny. In keeping with the neotype, southern African tests of *Quinqueloculina seminulum* display a general test outline and chamber morphology sharply different to those seen in *Quinqueloculina isabellei*, notably in the sub-rounded, rather than broadly rounded test margin. However, the Cape Town tests are not as strongly triangular in cross-section as the Rimini neotype.

Quinqueloculina triangularis d'Orbigny, 1846

Fig. 5G–H

Quinqueloculina triangularis d'Orbigny, 1846: 288, pl. 18 (figs 7–9). Mathieu *et al.*, 1971: 159, pl. 1 (figs 8–10).

Remarks

In terms of its test morphology, this species compares closely with *Quinqueloculina dunkerquiana* (Heron-Allen & Earland), differing mainly in the possession of a distinctly bifid tooth, and lacking the indentations of the final two chambers. The Cape Town tests are a little more squat than those of Mathieu *et al.* (1971), and more nearly as high as wide. The bifid tooth is particularly well developed in the figured specimen.

D'Orbigny (1946) described *Quinqueloculina triangularis* from the Miocene of the Vienna Basin; Mathieu *et al.* (1971) figured tests from the present-day beach sands of the Dunkerque coast, north France.

Quinqueloculina cf. *Q. undulata* d'Orbigny, 1852

Figs 5I, 7A

see *Quinqueloculina undulata* d'Orbigny, 1852: 195. Rosset-Moulinier, 1972: 140, pl. 6 (figs 5–7).
Quinqueloculina cf. *Q. undulata* d'Orbigny: McMillan, 1987*b*: 175, pl. 3 (figs 7–9).

Remarks

This distinctive species, with its finely grooved surface and very elongate aperture revealing a slender, tapering tooth, is at present known only from the latest Pleistocene (Unit III) off the west coast of southern Africa. D'Orbigny's (1852) species was partly distinguished by its undulating test margins, a feature that was also depicted, though not to so marked a degree, by Cushman (1945). Cushman's figured specimen is much less intensely ornamented than the original test of D'Orbigny (1852). The shells illustrated by Rosset-Moulinier (1972) are not undulate; she noted that the species was close to *Quinqueloculina bicornis* (Walker & Jacob), but more elongate in form.

None of the southern African tests, from Cape Town or the Orange Shelf, possess an undulate periphery, and they thus appear closest to those described by Rosset-Moulinier (1972) from the Brittany coast. D'Orbigny (1852) described the species from the Pliocene of Castel-Arquato and from present-day deposits near Rimini, both in Italy.

The illustrated test from Cape Town possesses a damaged apertural tooth; Orange Shelf tests display a bladed tooth, which extends for about three-quarters the length of the aperture (McMillan 1987*b*). The depressed area at either end of the aperture is also typical of the Orange Shelf examples.

Quinqueloculina spp.

Remarks

Many badly broken tests of smooth-walled, unornamented *Quinqueloculina* that probably mostly fall within the *Quinqueloculina seminulum–dunkerquiana* group.

Genus *Siphonaperta* Vella, 1957

Siphonaperta sp.

Fig. 7B–C

Quinqueloculina agglutinans (*non* d'Orbigny) Martin, 1974: 85; 1981: 25, pl. 2 (fig. 8).
Sigmoilopsis sp. McMillan, 1974: 37, pl. 2 (fig. 7a–c).
Sigmoilopsis schlumbergeri (*non* Silvestri) Martin, 1981: 27, pl. 2 (fig. 13).
Quinqueloculina horrida (*non* Cushman) Boltovskoy *et al.*, 1980: 46, pl. 27 (figs 17–20).

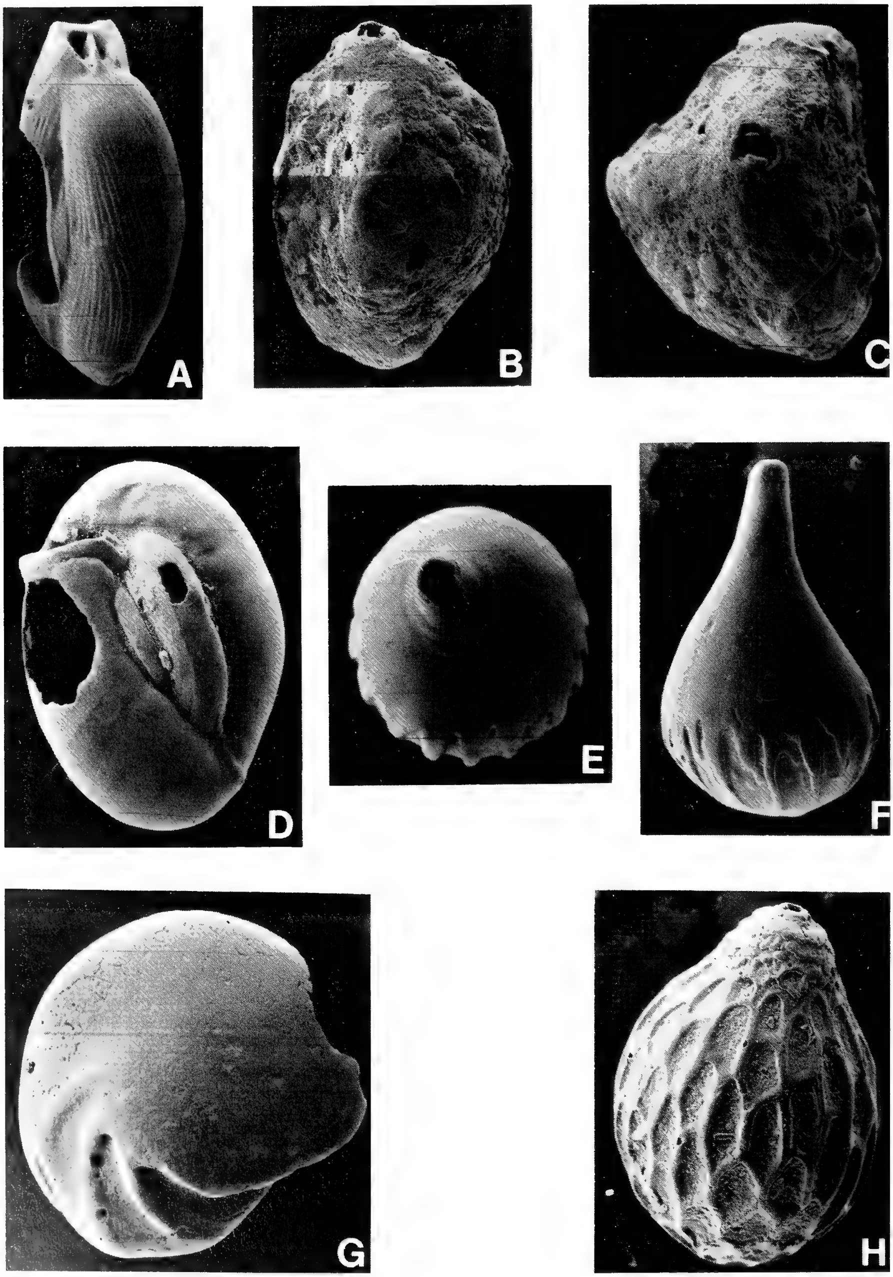

Fig. 7. A. *Quinqueloculina* cf. *Q. undulata* d'Orbigny. Oblique edge view, same specimen as Fig. 5I. × 65. B–C. *Siphonaperta* sp. B. Side view, CTC 4. × 96. C. Apertural view, same specimen. × 132. D. *Miliolinella subrotunda* (Montagu). Side view, CTC 4. × 110. E–F. *Lagena semilineata* Wright var. E. Apertural view, CTC 3. × 122. F. Side view, same specimen. × 112. G. *Lenticulina* sp. Side view, CTC 4. × 129. H. *Oolina* sp. A. Side view, CTC 4. × 168.

Remarks

The above, rather disparate references appear to be to the same species. The presence of an apertural neck and the rough, agglutinated test surface, as well as a quinqueloculine chamber arrangement, are indicative of the genus *Siphonaperta*, rather than *Quinqueloculina* or *Sigmoilopsis*. Sectioning of tests from the Orange Shelf Holocene (see McMillan 1987*b*, pl. 3 (fig. 11), text-fig. 2) shows the chamber arrangement to be quinqueloculine rather than sigmoiline.

These tests can be distinguished from *Quinqueloculina horrida*, described by Cushman (1947) from off Charleston, South Carolina, in being substantially more triangular in cross-section and somewhat more squat, and lacking the elongate neck and slender bifid apertural tooth of the United States species. *Quinqueloculina agglutinans*, in contrast, possesses subangular chamber margins, and a large, circular aperture with a phialine lip, but not developed on a neck (see Le Calvez & Le Calvez 1958: 166, pl. 9 (figs 103–104)).

Analysis of wall composition of one test dissolved in dilute hydrochloric acid (McMillan 1987*b*) revealed the presence of small lengths of broken sponge spicules in the wall, a feature that is not evident in external view. The species ranges throughout the latest Eemian to earliest Weichselian and Holocene sequences studied by McMillan (1987*b*), though it is substantially more abundant in the Holocene. The species does not occur in the older Pleistocene rocks of South Africa. Most of the Cape Town specimens are damaged, but the distinctive arrangement of coarse- and fine-grained quartz particles over the test wall easily distinguishes even badly fragmented tests.

Subfamily Miliolinellinae Vella, 1957

Genus *Miliolinella* Wiesner, 1931

Miliolinella subrotunda (Montagu, 1803)

Fig. 7D

Serpula subrotunda dorso elevato Walker & Boys, 1784: 2, pl. 1 (fig. 4).

Vermiculum subrotundum Montagu, 1803: 521.

Miliolinella subrotunda (Montagu) Haynes, 1973*a*: 56, pl. 5 (figs 5–6, 12–13), pl. 31 (figs 8–9), text-fig. 11 (nos 1–4), text-fig. 12 (nos 1–11). Ponder, 1974: 201, pl. 1 (figs 1–2), pl. 2 (figs 6–11).

Remarks

British researchers have considered the wide variety of forms encountered to be referable to one species: ‘It would seem altogether inappropriate to separate some as *Miliolinella*, some as *Scutuloris* and to dispatch the irregular, wild-growing, hauerinid forms into a separate genus and even subfamily’ (Haynes 1973*a*: 57). This concept is followed here. South African specimens also show much variation, from tight triloculine tests to ones that are loosely and irregularly triloculine, but the wild forms are by and large missing from the cool waters of the west coast.

Miliolinella subrotunda occurs widely in the South African littoral at the present day, from cold-water west coast to warm-water east coast. The species ranges back to the latest Eemian to earliest Weichselian on the Orange Shelf (McMillan 1987*b*), but its earlier record in southern Africa is as yet unclear.

Family **Nodosariidae** Ehrenberg, 1838
Genus *Lagena* Walker & Jacob, 1798

Lagena semilineata Wright, 1886 var.

Fig. 7E–F

see *Lagena semilineata* Wright, 1886: 320, pl. 26 (fig. 7).
Lagena semilineata (*non* Wright) Earland, 1934: 161, pl. 7 (figs 19–20).
Lagena semilineata Wright var. McMillan, 1987*b*: 204, pl. 5 (figs 9–11).

Remarks

The single specimen is not particularly well formed, and the ornamentation is not quite typical of the tests described by McMillan (1987*b*) from the Orange Shelf. The group of short apical spines of this specimen are poorly developed, lost perhaps through abrasion of the test. The flat-topped, tapering ribs that occupy much of the lower half of the globular part of the test are rather more irregularly formed, particularly in their varying width and length, than is usual. There also are occasional tubercular or rugose developments in the depressed areas between the ribs. However, the style of the ornamentation is so distinctive that there can be no doubt that the Cape Town specimen and those from the Orange Shelf are the same variety.

Genus *Lenticulina* Lamarck, 1804

Lenticulina sp.

Fig. 7G

Remarks

One broken specimen that appears to be *in situ*, may be referable to one of the rather conservative, unornamented species typified by *Lenticulina gibba* (d'Orbigny). Little can be made of the single specimen.

Family **Glandulinidae** Reuss, 1860
Subfamily Oolininae Loeblich & Tappan, 1961
Genus *Oolina* d'Orbigny, 1839

Oolina sp. A McMillan, 1987

Figs 7H, 8A–B

Oolina sp. A McMillan, 1987*b*: 220, pl. 6 (figs 13–14).

Remarks

This graceful, pyriform *Oolina* occurs rarely in the sandier, littoral deposits of the latest Eemian to earliest Weichselian of the Orange Shelf (McMillan

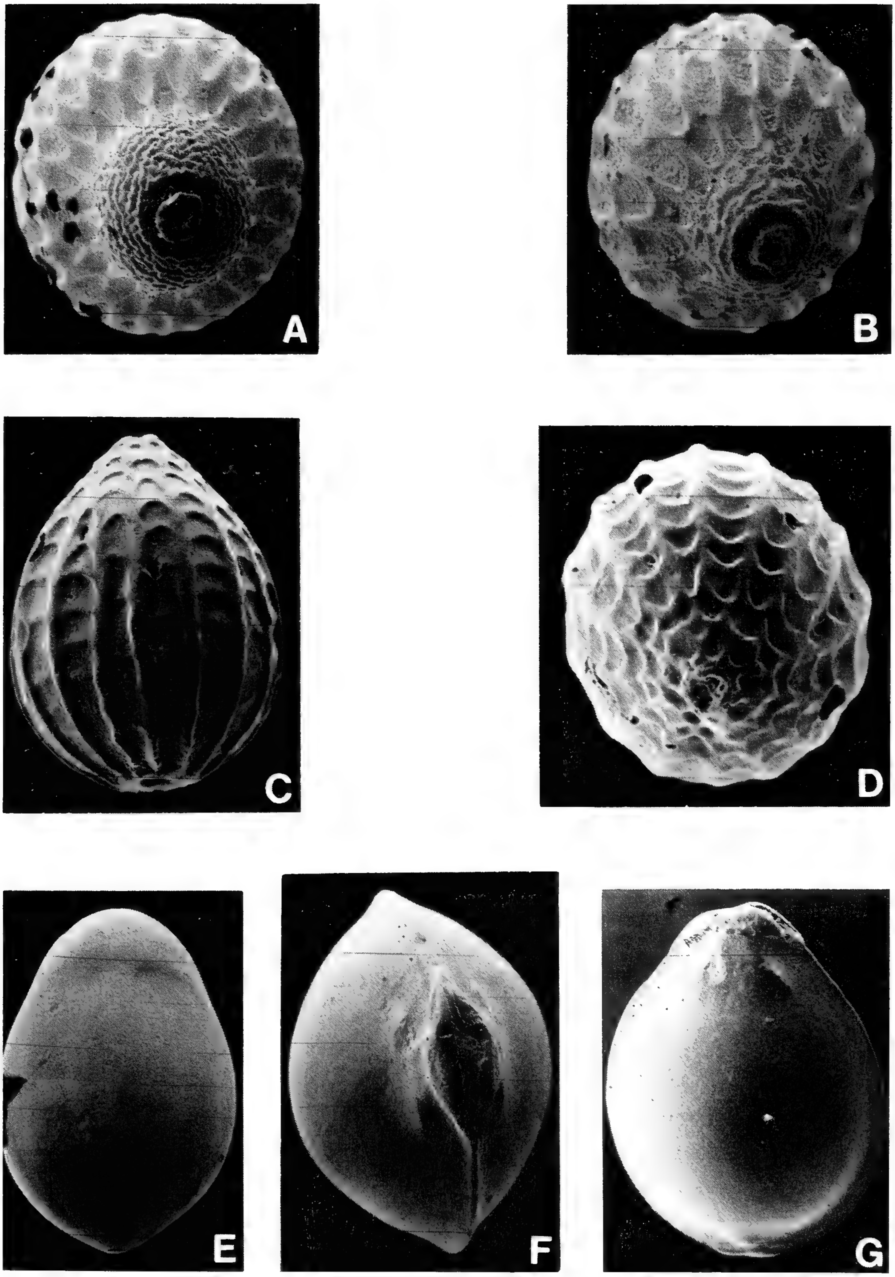

Fig. 8. A–B. *Oolina* sp. A. A. Apertural view, CTC 4. × 156. B. Apertural view, same specimen as Figure 7H. × 173. C–D. *Oolina squamososulcata* (Heron-Allen & Earland). C. Side view, CTC 4. × 206. D. Apertural view, same specimen. × 246. E. *Fissurina lucida* (Williamson). Side view, CTC 3. × 327. F–G. *Fissurina* cf. *F. marginata* (Walker & Boys). F. Apertural view, CTC 3. × 204 G. Side view, same specimen. × 161.

1987*b*). The species is distinguished by a vertically elongated hexagonal ribbing pattern ornamenting the test surface. Some variation is evident in the height of the elongated hexagons at the maximum width of the test; those from Cape Town exhibit more nearly regular hexagons than those from further north.

The narrower part of the test adjacent to the aperture is marked with small depressions and protrusions that give the surface a rather scaly, reptilian appearance. The subcircular aperture is developed on a short neck, which in well-preserved examples is almost phialine and ornamented with many short, vertically aligned grooves.

Oolina squamososulcata (Heron-Allen & Earland, 1922)

Fig. 8C–D

Lagena squamoso-sulcata Heron-Allen & Earland, 1922: 151, pl. 5 (figs 15, 19).

Oolina squamoso-sulcata (Heron-Allen & Earland) Loeblich & Tappan, 1953: 74, pl. 12 (figs 6–7).

Remarks

The single test compares closely with *Oolina squamososulcata* except that the horizontally aligned ribs ornamenting the test are more arched, and they fade away only slowly toward the apical end of the test, rather than disappearing abruptly about midway down. The holotype figured by Heron-Allen & Earland (1922) displays 13 vertical ribs; Loeblich & Tappan (1953) reported that their tests exhibit about 12 to 20; the present example possesses 15.

Genus *Fissurina* Reuss, 1850

Fissurina lucida (Williamson, 1848)

Fig. 8E

Entosolenia marginata (Montagu) var. *lucida* Williamson, 1848: 17, pl. 2 (fig. 17).

Fissurina lucida (Williamson) Murray, 1971: 97, pl. 39 (figs 1–3). Boltovskoy *et al.*, 1980: 32, pl. 15 (figs 17–20).

Remarks

One specimen, rather damaged, but closely comparable to Orange Shelf examples of this species. As with *Fissurina marginata* (Walker & Boys), it would seem to be confined to cool, shallow marine environments, off the west coast of southern Africa only, in both the latest Pleistocene and the Holocene (McMillan 1987*b*).

Fissurina cf. *F. marginata* (Walker & Boys, 1784)

Fig. 8F–G

see *Serpula (Lagena) marginata* Walker & Boys, 1784: 2, table 1, fig. 7.

see *Fissurina marginata* (Walker & Boys) Feyling-Hanssen, 1964: 315, pl. 15 (fig. 22). Haynes, 1973*a*: 97, fig. 20 (nos 7–8). McMillan, 1987*b*: 225, pl. 7 (figs 2–3).

Remarks

This single example displays several slight differences from the tests seen in the latest Pleistocene and Holocene of the Orange Shelf (McMillan 1987*b*). The peripheral ornamentation is more nearly carinate rather than a rounded thickening; the lips on each side of the slit aperture are thicker but less elongate; and there are two raised areas on each side of the test, a little below the aperture. The raised features are low elongate protrusions, aligned roughly parallel to the test periphery. The degree of inflation and the general outline of the Cape Town test is about the same as seen in the Orange Shelf specimens.

A rounded peripheral ornamentation would seem to be closer to *Fissurina marginata* in British waters (Haynes 1973*a*: 98), so that this Cape Town example rather falls outside the confines of the north-west European interpretation of the species.

Family **Buliminidae** Jones, 1875
Genus *Bulimina* d'Orbigny, 1826
Bulimina marginata d'Orbigny, 1826

Fig. 9A

Bulimina marginata d'Orbigny, 1826: 269, pl. 12 (figs 10–12). Murray, 1971: 119, pl. 49 (figs 1–7). Knudsen, 1973: 181, pl. 2 (figs 10–11). Martin, 1981: 41, pl. 4 (figs 8–9).

Remarks

One specimen, showing rather poorly incised steps into the bases of the later chambers, but with a distinct fringe of blunt spines near the lower margins of some chambers. The test is abraded and has been subject to boring, but is clearly comparable to the more distinctive tests detailed by Martin (1981) and McMillan (1987*b*) from further north. *Bulimina marginata* ranges throughout the latest Eemian–earliest Weichselian and the Holocene sequences of the Orange Shelf (McMillan 1987*b*).

Family **Uvigerinidae** Haeckel, 1894
Genus *Trifarina* Cushman, 1923
Trifarina angulosa (Williamson, 1858)

Fig. 10A–B

Uvigerina angulosa Williamson, 1858: 67, pl. 5 (fig. 140).
Trifarina angulosa (Williamson) Knudsen, 1971: 241, pl. 18 (figs 8–9). Haynes, 1973*a*: 126, pl. 10 (figs 12–13, 16–17), pl. 11 (fig. 11).

Remarks

One example, with the terminal part rather broken. However, it clearly shows the triserial chamber arrangement, the tricarinate test periphery, the nearly triangular cross-section to the test, and irregular, vertically aligned ribs on the test surface. The species occurs throughout the latest Eemian to earliest Weichselian and the Holocene of the Orange Shelf (McMillan 1987*b*), where it shows a considerable range in its surface ornamentation of vertically aligned ribs. Tests range from being almost smooth, with only the three peripheral keels, to densely

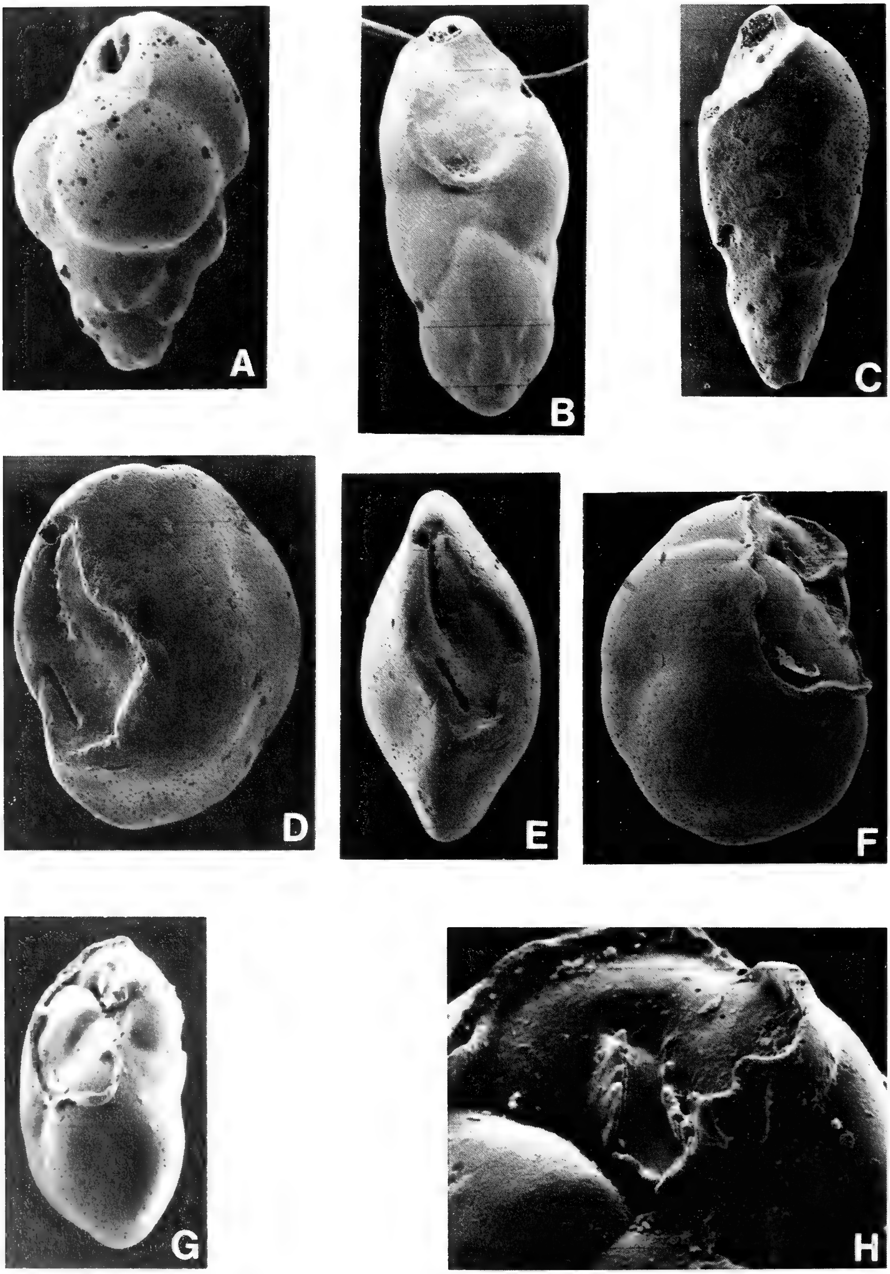

Fig. 9. A. *Bulimina marginata* d'Orbigny. Side view, CTC 4. × 123. B. *Uvigerina* sp. (reworked). Side view, CTC 3. × 133. C. *Brizalina spathulata* (Williamson). Side view, CTC 3. × 153. D–E. *Cassidulina laevigata* d'Orbigny. D. Side view, CTC 4. × 136. E. Apertural view, same specimen. × 129. F–H. *Cassidulina crassa* d'Orbigny s.l. F. Side view, CTC 3. × 187. G. Apertural view, same specimen. × 177. H. Close up of foramen, showing serrate margins, same specimen. × 646.

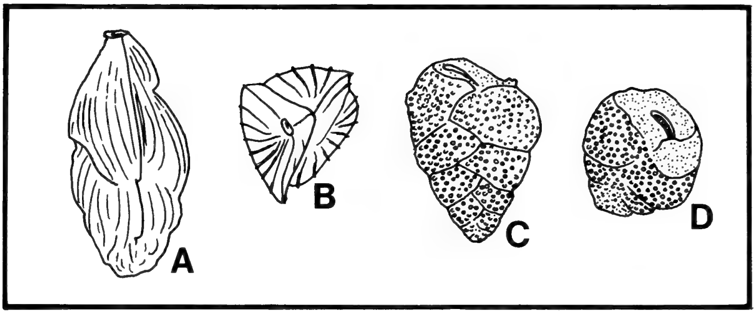

Fig. 10. A–B. *Trifarina angulosa* (Williamson), same specimen, CTC 4. Both × 67. A. Side view. B. Apertural view. C–D. *Bolivina* sp., same specimen, CTC 3. Both × 135. C. Side view. D. Apertural view.

ribbed over almost the entire exterior. Variation also occurs in the intensity of the ribs, some shells displaying few strongly developed ones, whereas others reveal many closely spaced fine ribs.

Family **Bolivinitidae** Cushman, 1927

Genus *Bolivina* d'Orbigny, 1839

Bolivina sp.

Fig. 10C–D

Remarks

One small test, ornamented with fine, dense pitting over the surface. The specimen shows some resemblance to *Bolivina variabilis* (Williamson), but is too juvenile a shell to make a reliable identification.

Genus *Brizalina* Costa, 1856

Brizalina spathulata (Williamson, 1858)

Fig. 9C

Textularia variabilis Williamson var. *spathulata* Williamson, 1858: 76, pl. 6 (figs 164–165).
Brizalina spathulata (Williamson) Hedley *et al.*, 1965: 21, pl. 6 (fig. 23a–b), text-fig. 6A–G. Haynes, 1973*a*: 135, fig. 25 (nos 10–13).

Remarks

One example, rather damaged. A narrow test when compared to examples from off the Orange River, but the arrangement and coarseness of the test perforations, the sub-rounded acute margin to the test, and the angle at which the sutures decline to the margin are closely comparable. The central zig-zag suture of the Cape Town test is particularly limbate and prominent.

Brizalina spathulata ranges throughout the latest Eemian and earliest Weichselian, and the Holocene of the Orange Shelf (McMillan 1987*b*). However, in the latest Pleistocene, the species is widespread through the sandier, more nearly littoral parts of the sequence; these tests lack any substantial carination of the periphery (see McMillan 1987*b*, pl. 11 (figs 10–11)). The shell from the Cape Town samples is of this type. In contrast, in the Holocene, the species appears commonest in more offshore, shelf environments; these tests usually possess a rather bladed carina (see Martin 1981, pl. 3 (figs 12–13); McMillan 1987*b*, pl. 11 (fig. 12)). There is thus the possibility that two varieties are represented off the west coast in the Late Quaternary.

Family **Cassidulinidae** d'Orbigny, 1839

Genus *Cassidulina* d'Orbigny, 1826

Cassidulina laevigata d'Orbigny, 1826

Fig. 9D–E

Cassidulina laevigata d'Orbigny, 1826: 282, pl. 15 (figs 4–5). Knudsen, 1971: 246, pl. 7 (figs 20–21), pl. 18 (fig. 12). Boltovskoy *et al.*, 1980: 22, pl. 7 (figs 4–6).

Remarks

Few specimens, all distinguished from the similar species *Cassidulina carinata* Silvestri by a rounded, non-carinate margin, coarser test perforations and thicker walled test. The precise relationship between the two species is not clear. On the Orange Shelf, *Cassidulina laevigata* occurs in abundance in the littoral and sublittoral deposits of the latest Eemian–earliest Weichselian, but is present only rarely in the nearshore Holocene. *Cassidulina carinata*, in contrast, is rare in the latest Pleistocene, but common in the offshore (middle to outer shelf) Holocene. It remains possible that the two species are two facies-controlled *formae* of one species.

Cassidulina crassa d'Orbigny, 1839 s.l.

Fig. 9F–H

see *Cassidulina crassa* d'Orbigny, 1839*b*: 56, pl. 7 (figs 18–20).
Cassidulina crassa d'Orbigny 'intermediate form' Heron-Allen & Earland, 1932: 358.
Cassidulina crassa d'Orbigny forma *media* Lena, 1966: 316, pl. 2 (fig. 7).

Remarks

One test, which like those present in the latest Pleistocene of the Orange Shelf, is not *Cassidulina crassa* sensu stricto but a smaller form, first recognized by Heron-Allen & Earland (1932) from the seas around the Falkland Islands. This form, termed 'intermediate', was believed by Heron-Allen & Earland to be a juvenile or pauperate stage of *Cassidulina crassa*, as first described by D'Orbigny (1839*b*).

Tests possess a rather short aperture, extending from the interio-marginal suture, up toward, but not reaching, the test periphery. There is no extension of the aperture along the interio-marginal suture, as is seen in *Cassidulina crassa* 'small type' of Heron-Allen & Earland (1932, pl. 9 (figs 29–31)). Some subsequent listings of the 'intermediate form' have been made by Boltovskoy (1959, 1961) and Lena (1966) from the coast of Argentina.

Cassidulina crassa s.s. would seem to be absent in southern African waters, both in the Pleistocene and the Holocene. The 'intermediate form' appears to be confined to deposits of the latest Eemian–earliest Weichselian, and to the cold waters off the west coast.

Family **Discorbidae** Ehrenberg, 1838

Genus *Planulinoides* Parr, 1941

Planulinoides biconcavus (Jones & Parker, 1862)

Fig. 11A–C

Discorbina bi-concava Jones & Parker, *in* Carpenter, 1862: 201, fig. 32G.
Discorbina biconcava Parker & Jones (*sic*) Parker & Jones, 1865: 385, 422, pl. 19 (fig. 10a–c). Brady, 1884: 653, pl. 91 (fig. 2a–c).
Planulinoides biconcavus (Jones & Parker) Parr, 1941: 305, fig. a–c. Loeblich & Tappan, 1964: C584, fig. 458 (nos 4a–c, 5–6). Lowry, 1987: 269, pl. 17 (fig. 1a, c, ?1b).
Planulinoides biconcava (Jones & Parker) (*sic*) McMillan, 1974: 58, pl. 5 (fig. 5a–c).
Discorbinella biconcava (Jones & Parker) Carter, 1978: 19, pl. 1 (figs 2–3).

Remarks

This very distinctive species, widespread in shallow marine environments around south-east Australia at the present day (Carpenter 1862; Parker & Jones 1865; Brady 1884; Chapman 1909; Parr 1941, 1945; Collins 1974), also occurs sporadically around southernmost Africa. Specimens from the middle shelf of the Agulhas Bank (McMillan 1974) are always abraded and scoured, and clean tests would seem to be lacking. Whether this indicates that *Planulinoides biconcavus* is restricted to latest Pleistocene (latest Eemian–earliest Weichselian), Unit III deposits on the Agulhas Bank, rather than the Holocene as well, and has been reworked into the Holocene, is not fully clear at present.

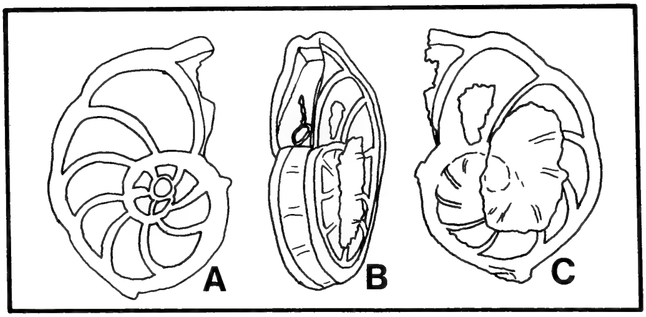

Fig. 11. *Planulinoides biconcavus* (Jones & Parker). All same specimen, CTC 3. All × 68. A. Dorsal view. B. Apertural view. C. Ventral view.

Planulinoides biconcavus occurs in small numbers on the Agulhas Bank (McMillan 1974; Lowry 1987), and Lowry recorded it between 107 m and 890 m water depth. The species appears to be absent off the west coast in the Holocene and Pleistocene, except for the single specimen from the present study. However, in the Early Miocene of the Orange Shelf, a similar, perhaps identical species occurs (McMillan 1975). A full comparison of the Miocene and Late Quaternary specimens has not yet been attempted. In Australia, the species is known from the Early Miocene (Heron-Allen & Earland 1924), the Middle Miocene (Mitchellian) (Carter 1978), and the Early and Middle Pliocene (Cheltenhamian and Kalimnan) (Parr 1939, 1941) of Victoria.

The Cape Town test is typical in its shell morphology, but as is often the case with the Agulhas Bank specimens examined by McMillan (1974), the thinner-walled, less-ornamented ventral side, with the small rounded flaps over the spiral suture, is very badly broken. The elongate-ovate, oblique primary aperture is distinct, though rather damaged. Despite showing some morphological similarities to *Planulina ariminensis* d'Orbigny, even very badly broken tests of *Planulinoides biconcavus* are easily distinguished, since they entirely lack the coarse test perforations of D'Orbigny's species.

Some differences in size of the flaps on the ventral side, over the spiral suture, can be seen. Tests such as that illustrated by Carter (1978) display large triangular flaps, whereas southern African Quaternary examples reveal only small, rounded flaps.

Genus *Rosalina* d'Orbigny, 1826

Rosalina bradyi (Cushman, 1915)

Fig. 12A–C

Discorbina globularis (*non* d'Orbigny) Brady, 1884: 643, pl. 86 (fig. 8a–c).
Discorbis globularis (d'Orbigny) var. *bradyi* Cushman, 1915: 12, pl. 8 (fig. 1a–c).
Rosalina bradyi (Cushman) Hedley *et al.*, 1967: 42, pl. 1 (fig. 3), pl. 11 (fig. 2a–c), text-figs 50–55.

Remarks

This essentially Indo-Pacific species appears to reside preferentially in patches of *Corallina* alga in the littoral (Hedley *et al.* 1967). It occurs in association with *Corallina* debris in vibracore 620/40 on the nearshore Orange Shelf, in sandy sediments of earliest Weichselian age (McMillan 1987*b*). The illustrated test from Cape Town is closely comparable to those from the Orange Shelf, although, being a rather juvenile shell, the limbation of the dorsal sutures is not well developed. The 'milled edge' of *Rosalina bradyi* (Cushman, 1915) is caused by the peripheral coarse perforations when viewed from the ventral side, which are visible at right angles through the glassy shell. This feature, obviously, is obscured in the scanning electron microscope photographs.

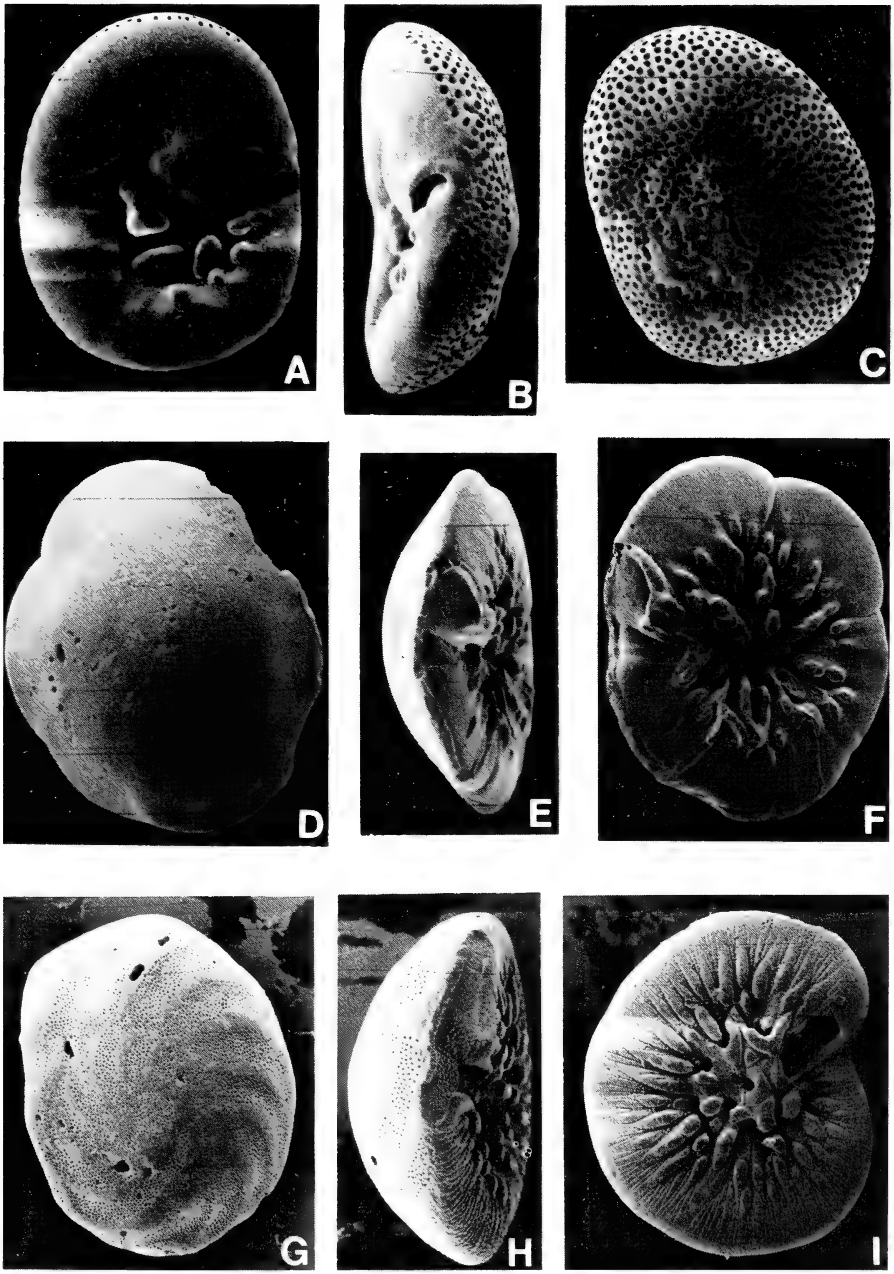

Fig. 12. A–C. *Rosalina bradyi* (Cushman). A. Ventral view, CTC 4. × 139. B. Side view, same specimen. × 144. C. Dorsal view, same specimen. × 135. D–F. *Rosalina* sp. D. Dorsal view, CTC 3. × 125. E. Side view, same specimen. × 115. F. Ventral view, same specimen. × 120. G–I. *Glabratella australensis* (Heron-Allen & Earland). G. Dorsal view, CTC 4. × 81. H. Side view, CTC 4. × 130. I. Ventral view, CTC 4. × 107.

Rosalina sp.

Fig. 12D–F

Remarks

One specimen, closely comparable in its test morphology to *Rosalina williamsoni* (Chapman & Parr), but differing in a pronounced umbilical ornament. A similar form, less ornate, occurs on the Orange Shelf (McMillan 1987*b*—described as *Rosalina williamsoni*). The Orange Shelf shells display a variable, tuberculate ornamentation in and around the umbilicus, but the Cape Town test exhibits a stronger ornament of radiating, elongate-ovate flat-topped pillars and bosses.

North-west European examples of *Rosalina williamsoni* (see Rosset-Moulinier 1972, pl. 9 (fig. 32); Haynes 1973*a*, pl. 17 (fig. 13), text-fig. 31 (no. 3)) feature a relatively unornamented umbilicus, with just occasional bosses or tubercles on the umbilical terminations of the chambers in the final whorl, and within the umbilicus itself. In contrast, the tests figured by Boltovskoy *et al.* (1980, pl. 12 (figs 5–12)) from the coast of Argentina as *Discorbis williamsoni* appear in fact more closely allied to *Gavelinopsis praegeri* (Heron-Allen & Earland), since the umbilicus is infilled with a distinct plug. It seems probable that the *Discorbis* cf. *D. valvulatus* (d'Orbigny) of Boltovskoy *et al.* (1980, pl. 12 (figs 1–4)) is conspecific with *Rosalina williamsoni* sensu McMillan (1987*b*). Some similarity, in terms of style of ornamentation, exists between the Orange Shelf tests and *Rosalina malovensis* (Heron-Allen & Earland) from the seas around the Falkland Islands. However, none of the southern African shells feature such elongate, crescentic chambers, evident on both dorsal and ventral sides of the test, as exist in *Rosalina malovensis*.

The radiating ornament around the umbilicus of both the Cape Town and Orange Shelf forms perhaps shows some similarity to *Rosalina parri* Collins (1974, pl. 3 (fig. 36a–c)). However, this Australian species is only slightly bedecked with pillars around the umbilicus; more evident are the radiating grooves and ridges that cover nearly all the ventral side of the illustrated test. Radiating ornament around the umbilicus has been one of the characteristics of the family Glabratellidae of Loeblich & Tappan (1964: C587), but the last chamber of many of the southern African tests of this group clearly extends a small triangular flap into the umbilical area, a feature that is rather more typical of *Rosalina* than *Glabratella*.

Family **Bagginidae** Cushman, 1927

Genus *Glabratella* Dorreen, 1948

Glabratella australensis (Heron-Allen & Earland, 1932)

Fig. 12G–I

Discorbina pileolus (*non* d'Orbigny) Brady, 1884: 469, pl. 89 (figs 2–4).

Discorbis australensis Heron-Allen & Earland, 1932: 416. Parr, 1939: 68.

Glabratella australensis (Heron-Allen & Earland) McMillan, 1987*b*: 363, pl. 14 (figs 14–18), pl. 15 (figs 1–2).

Remarks

A common littoral species along most of the South African coastline at the present day (Brady 1884), extending at least from Cape Town to Mzamba, Transkei (unpubl. studies). It has also been widely recorded along the south, south-east and south-west coasts of Australia (Brady 1884; Chapman 1909; Parr 1945; McKenzie 1962; Albani 1968*a*, 1968*b*; Johnson & Albani 1973; Collins 1974; Albani & Johnson 1975) and off New Zealand (Mestayer 1916; Cushman 1919). Its fossil range in Australia appears to be Middle Pliocene (Kalimnan) (Parr 1939), Pleistocene (Collins 1953), and present day. In contrast, in South Africa, it is confined to the Pleistocene, being extremely rare or absent in the earliest Pleistocene (Unit II) of the 'Alexandria Formation', and only coming into prominence in the later Early Pleistocene (Unit IIA) of the 'Bredasdorp Formation'. *Glabratella australensis* occurs in considerable numbers at some localities of the Varswater Formation (probably Unit IIA), particularly at Hoedjiespunt, Saldanha.

The species is distinguished from the South American *Glabratella pileolus* (d'Orbigny) in its larger number of chambers per whorl ('eight or more' rather than 'four or five'—Heron-Allen & Earland 1932: 416), its shallower umbilicus, and its somewhat compressed, low-spired test. Living specimens of *Glabratella australensis* from intertidal pools at Camps Bay and elsewhere on the north-west Cape Peninsula are a strong greenish brown in colour; perfect, unabraded tests are spectacular when viewed under the scanning electron microscope (see McMillan 1987*b*, pl. 14 (figs 14–18)). Tests from the Cape Town city centre samples are rather abraded, and much of the detail of the ventral ornamentation of radiating ridges and tubercles has been smoothed.

Family **Anomalinidae** Cushman, 1927
Subfamily Cibicidinae Cushman, 1927
Genus *Cibicides* De Montfort, 1808

Cibicides fletcheri Galloway & Wissler, 1927 s.l.

Fig. 13A–C

Cibicides fletcheri Galloway & Wissler, 1927: 64, pl. 10 (figs 8a–c, 9a–c). Lankford & Phleger, 1973: 117, pl. 6 (figs 11a–c).

Cibicides cf. *C. fletcheri* Galloway & Wissler. Boltovskoy *et al.*, 1980: 24, pl. 8 (figs 17–21).

Remarks

Three rather damaged tests, compressed, and characterized by a small, rounded, domed umbilical infilling on the ventral side, and a flat and wide boss, flush with the test surface, in the dorsal umbilicus. These tests are similar to those detailed by McMillan (1987*b*) from the latest Eemian–earliest Weichselian and Holocene of the Orange Shelf.

The correct taxonomic name for this form is difficult to determine; so many similar, though distinctly different morphotypes have been assigned to Galloway

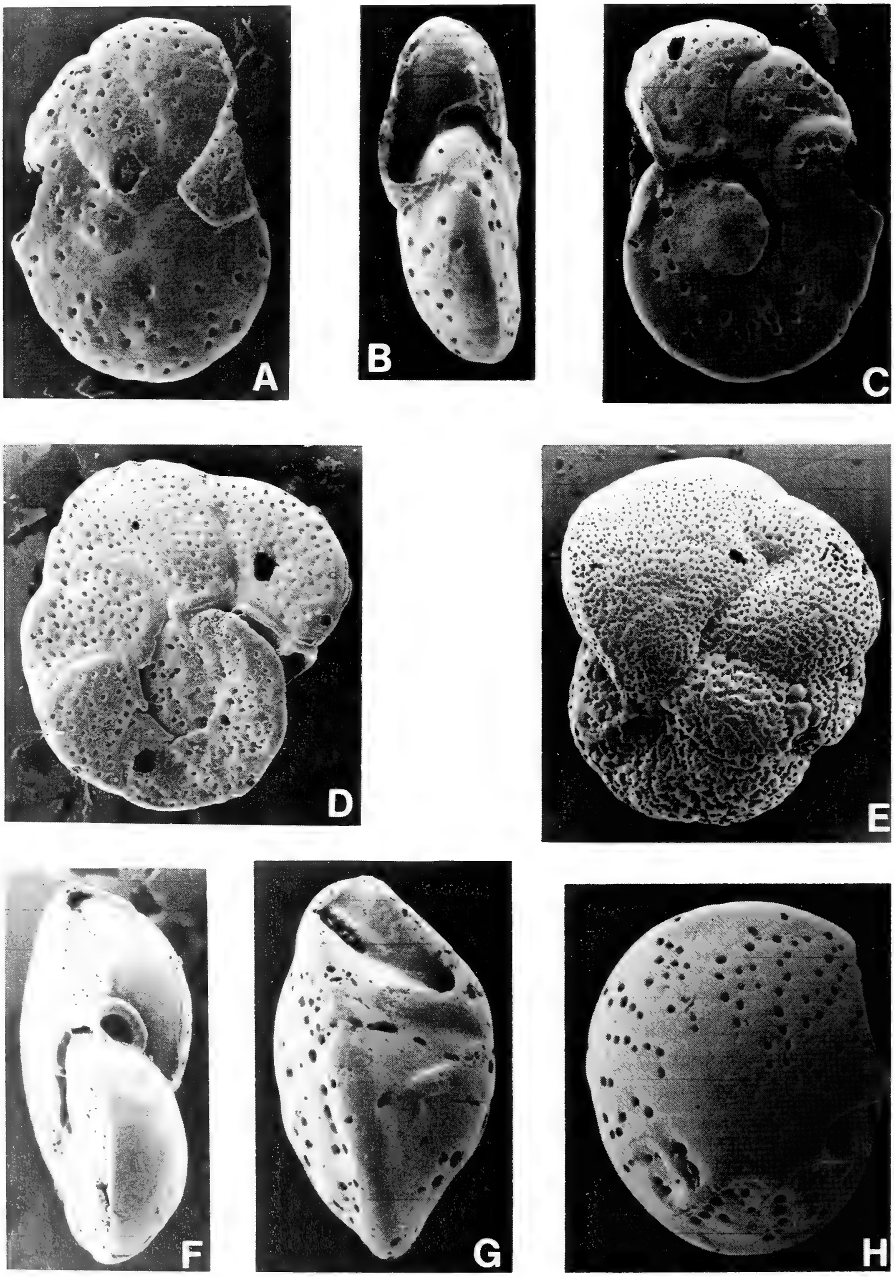

Fig. 13. A–C. *Cibicides fletcheri* Galloway & Wissler s.l. A. Ventral view, CTC 3. × 174. B. Side view, same specimen. × 168. C. Dorsal view, same specimen. × 174. D–F. *Cibicides lobatulus* (Walker & Jacob). D. Dorsal view, CTC 4. × 88. E. Ventral view, CTC 4. × 82. F. Side view, CTC 4. × 146. G–H. *Cibicidoides* sp. G. Side view, CTC 3. × 84. H. Ventral view, CTC 2. × 129.

& Wissler's (1927) species that it is unclear what the limits of the species should be. A comparable species is *Anomalina schmitti*, described by Cushman & Wickenden (1929) from present-day sediments off Juan Fernandez Islands, off the west coast of South America. It is not clear how distinct are these two species. *Cibicides fletcheri* was first described by Galloway & Wissler (1927) from the Pleistocene of the Palos Verdes Hills of California.

Cibicides lobatulus (Walker & Jacob, 1798)

Fig. 13D–F

Nautilus lobatulus Walker & Jacob, *in* Kanmacher, 1798: 642, pl. 14 (fig. 36).

Cibicides lobatulus (Walker & Jacob) Murray, 1971: 175, pl. 73 (figs 1–7). Haynes, 1973*a*: 173, pl. 20 (figs 1–2), pl. 21 (figs 3, 5–6), pl. 33 (figs 1–7), text-fig. 35 (nos 4–10). Boltovskoy *et al.*, 1980: 24, pl. 9 (figs 1, 3–4, ?2). Martin, 1981: 52, pl. 5 (figs 4–6).

Remarks

All tests possess narrow, elongate chamber flaps over the spiral suture, from under which the secondary apertures are developed on the dorsal sides of the final whorl of chambers. The shape of the flaps along the spiral suture is in keeping with those seen on tests from the latest Pleistocene and Holocene of the Orange Shelf (McMillan 1987*b*), off the west coast of southern Africa (Martin 1981), on the Agulhas Bank (McMillan 1974—though not well drawn on pl. 8 (fig. 1c)), and off the coast of Argentina (Boltovskoy *et al.* 1980). However, north-west European tests (the type locality is Whitstable in Kent) tend to possess rather more lobate chamber flaps (Feyling-Hanssen 1964; Knudsen 1971; Murray 1971; Rosset-Moulinier 1972; Haynes 1973*a*). The difference is slight but it may prove to be consistent between the two regions.

As with the latest Pleistocene and Holocene tests of *Cibicides lobatulus* from the Orange Shelf (McMillan 1987*b*), there are substantial differences in the density of test perforations and in the overall test morphology of the Cape Town shells. Spreading, more rounded-conical forms, often with a distinct peripheral thickening, are usually densely perforate over the entire ventral side. The higher, button-shaped, more biconvex tests, with a more rounded periphery and little thickening, are generally only sporadically perforate on the ventral side, more so over the surface of the earlier chambers.

Genus *Cibicidoides* Thalmann, emend. Loeblich & Tappan, 1955

Cibicidoides sp.

Figs 13G–H, 14A–B

Remarks

All tests of this species are rather broken. All are coarsely perforate on both sides of the test, and exhibit ventral sutures that are more radiate and

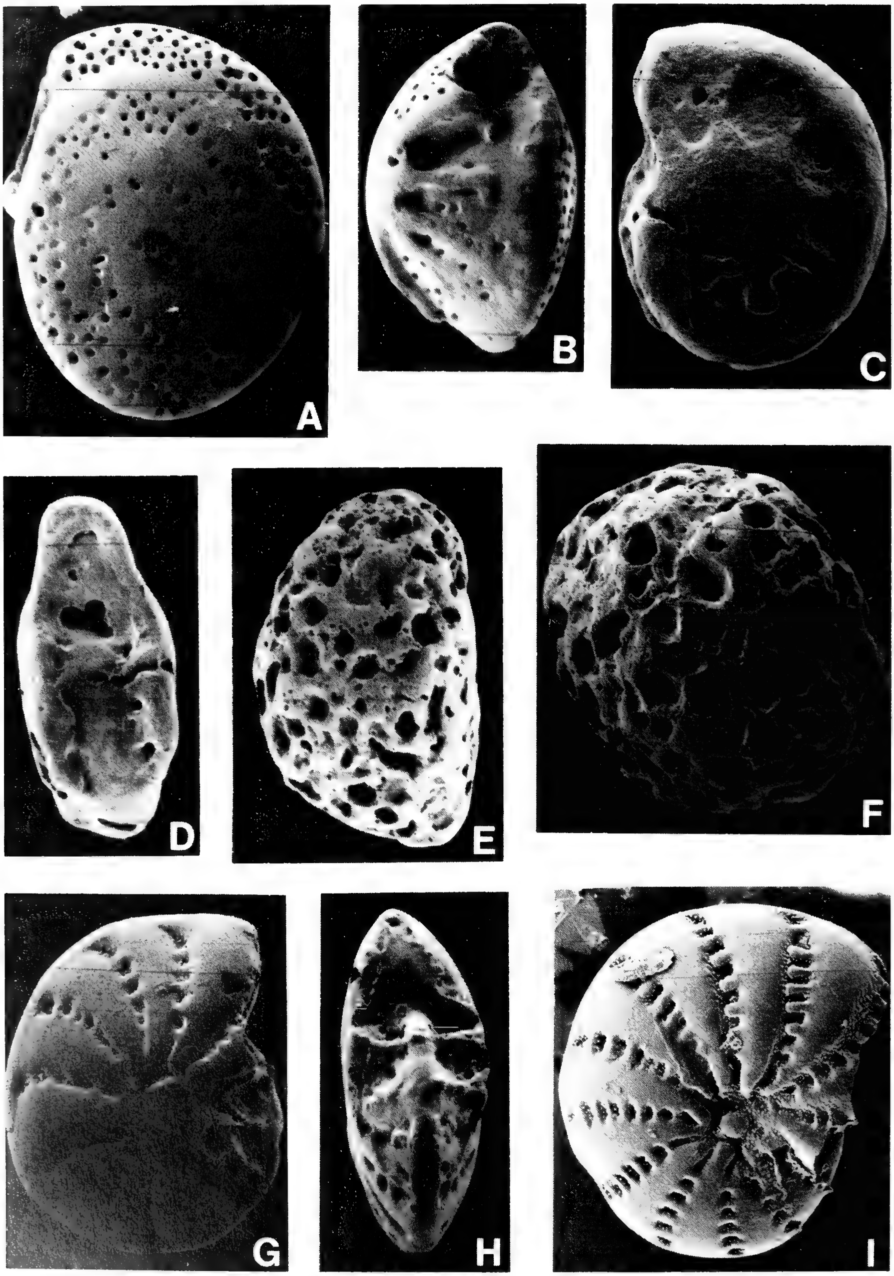

Fig. 14. A–B. *Cibicidoides* sp. A. Dorsal view, CTC 2. × 112. B. Side view, same specimen as Figure 13H. × 120. C–D. *Hyalinea balthica* (Schröter). Side view, CTC 3. × 205. D. Apertural view, same specimen. × 205. E–F. *Sphaerogypsina globulus* (Reuss). Different views of the same specimen, CTC 3. E. × 137. F. × 144. G–H. *Elphidium advenum* (Cushman). G. Side view, CTC 3. × 144. H. Apertural view, same specimen. × 146. I. *Elphidium* sp. A. Side view, CTC 4. × 120.

straight or weakly curved than is typical of the type species, *Cibicidoides mundulus* (Brady, Parker & Jones), which is coarsely perforate only on the dorsal side. This type of *Cibicidoides* is not known from the Orange Shelf (McMillan 1987*b*), and would seem closer to the *Cibicides* cf. *C. praecinctus* (Karrer) of McMillan (1974) from the Agulhas Bank and Martin (1981) from scattered western offshore localities. These tests are distinctly more biconvex than is typical for *Cibicidoides pseudo-ungerianus* (Cushman), widely found off both the south and west coasts of southern Africa (McMillan 1974; Martin 1974, 1981).

Subfamily Planulininae Bermúdez, 1952
Genus *Hyalinea* Hofker, 1951

Hyalinea balthica (Schröter, 1783)

Fig. 14C–D

Nautilus balthicus Schröter, 1783: 20, pl. 1 (fig. 2).
Hyalinea balthica (Schröter) Murray, 1971: 173, pl. 72 (figs 5–8).
Hyalinea balthica (Gmelin) Bremer *et al.*, 1980: 23, pl. 3 (fig. 8).

Remarks

One specimen, rather broken and with tubular borings. The specimen is typical for the species, which occurs widely over the western continental margin of southern Africa at the present day (Pinto 1955; Martin 1974, 1981), as far south as the westernmost Agulhas Bank (McMillan 1974). *Hyalinea balthica* ranges throughout the latest Eemian–earliest Weichselian and Holocene deposits of the Orange Shelf (McMillan 1987*b*). It is known from the latest Eemian–earliest Weichselian sediments of the Agulhas Bank (borehole F–A 13) (McMillan 1986), and at that time ranged as far east as Algoa Bay, where it is seen in the coastal Unit III of the 'Alexandria Formation' (Rümke *in* Engelbrecht *et al.* 1962; Salmon 1981; McMillan in press).

In the latest Eemian–earliest Weichselian Unit III, *Hyalinea balthica* occurs in littoral sands but, in the Holocene and at the present day, the species is more typical of middle to outer shelf environments and deeper; Martin (1981) gave its depth range as 92 m to 995 m off the west coast. As is the case with the Cape Town test, latest Pleistocene shells would appear to be slightly thicker walled than those from the Holocene, but there seems to be no distinct morphological difference.

Hyalinea balthica has not been found in earlier Pleistocene deposits in South Africa, though this may be due to the depositional facies of the rocks. Certainly, though, the species cannot be considered as a marker for the Pliocene–Pleistocene boundary on the continental shelf of southern Africa, as has been done elsewhere (see Bayliss 1969).

Family **Acervulinidae** Schultze, 1854
Genus *Sphaerogypsina* Galloway, 1933
Sphaerogypsina globulus (Reuss, 1848)
Fig. 14E–F

Ceriopora globulus Reuss, 1848: 33, pl. 5 (fig. 7a–c).
Sphaerogypsina globulus (Reuss) Loeblich & Tappan, 1964: C698, fig. 569 (nos 1–2).

Remarks

Several subspherical tests, although damaged, some with a flattened surface that may have attached to a substrate, are referable to this species. One or two examples were seen in the latest Pleistocene deposits of the Orange Shelf (McMillan 1987*b*), but the species is more numerous in the Cape Town samples. In most of the studied tests, the thin perforated walls over each chamberlet are usually damaged or entirely worn away, and only the thicker intercameral walls remain visible, as in the illustrated test. Similar forms, though larger and more nearly spherical, occur in the Early Miocene (Burdigalian) shelly, white lime-muds at a number of localities on the South African continental margin.

Family **Elphidiidae** Galloway, 1933
Subfamily Elphidiinae Galloway, 1933
Genus *Elphidium* De Montfort, 1808
Elphidium advenum (Cushman, 1922)
Fig. 14G–H

Polystomella subnodosa (*non* Münster) Brady, 1884: 734, pl. 110 (fig. 1a–b).
Polystomella advena Cushman, 1922: 56, pl. 9 (figs 11–12).
Elphidium advenum (Cushman) Albani, 1968*a*: 111, pl. 10 (fig. 6).
see *Elphidium advena* (Cushman) Apthorpe, 1980: 211, pl. 26 (figs 10–11).

Remarks

Most later authors studying Indo-Pacific material appear to have followed the illustrations of Brady (1884) rather than those given by Cushman (1922) for their identification of *Elphidium advenum*. The septal pits of Indo-Pacific tests of the species are short and never as elongate as those of the holotype, which is from the Tortugas region of the West Indies. It may be, as suggested by Cushman (1922), that the Indo-Pacific shells assigned to this species are of a slightly different form than the tropical Atlantic *Elphidium advenum* s.s.

From studies of the 'Alexandria Formation' of the eastern Cape (McMillan in press), it is clear that *Elphidium advenum*, as here understood, ranges from the present day to near the base of the Pleistocene (and includes Unit II). It can thus be considered as a useful marker species for the South African Quaternary, in company with *Pararotalia nipponica* (Asano) and *Cibicides lobatulus* (Walker & Jacob). The species is extensively distributed off the west, south and east coasts of southern Africa at the present day, and tends to predominate in shallow marine environments (Albani 1965; Martin 1981; unpubl. studies), although off the west coast it ranges into waters as deep as 418 m (Martin 1981), and small numbers of specimens occur as deep as 127 m on the Agulhas Bank (McMillan 1974). It was also widely distributed in latest Eemian–earliest Weichselian times in shallow marine environments around southern Africa, from the Orange Shelf (McMillan 1987*b*) to the Uloa Formation.

Elphidium sp. A

Fig. 14I, 15A

Elphidium advenum (*non* Cushman) McMillan, 1987*b*, pl. 17 (figs 1–2).

Remarks

A small proportion of the tests, initially assigned to *Elphidium advenum* by McMillan (1987*b*), lack the distinctive peripheral carina and wide, flat-topped and flush umbilical boss of that species. Instead, the umbilical boss is small, almost like a pinhead, and sited in a narrow umbilicus that is not entirely occupied by the boss. The later chambers are slightly inflated, the test size is somewhat greater, and the septal pits are more sharply defined, rather deeper, and more elongate than true *Elphidium advenum*.

Elphidium sp. A is apparently confined to the latest Pleistocene of the west coast, and is absent in the Holocene. The differences from true *Elphidium advenum* are sufficient for this form to be considered a separate, possibly new species but insufficient specimens occur in the Cape Town samples for a formal taxon to be erected here.

Elphidium articulatum (d'Orbigny, 1839)

Fig. 15B–C

Polystomella articulata d'Orbigny, 1839*b*: 30, pl. 3 (figs 9–10).
Elphidium articulatum (d'Orbigny) Boltovskoy, 1963: 61, pl. 6 (fig. 15). Boltovskoy *et al.*, 1980: 29, pl. 13 (figs 1–4).

Remarks

Distinct, though slight differences exist in the style of the umbilical ornamentation of Cape Town tests compared with those illustrated by McMillan (1987*b*) from the Orange Shelf. The Orange Shelf examples reveal a rather depressed umbilicus ornamented with 20 or more thin calcite pillars. In the illustrated Cape Town shell, there are no more than ten pillars, and these are often merged together, or with the umbilical terminations of the chambers; they also tend to be larger in size than the pillars of the Orange Shelf tests. The septal pits, both in their numbers and outline, the style of the aperture, the number of chambers in the final whorl, the chamber morphology and the overall test morphology of the Orange Shelf and Cape Town tests are all closely comparable. Those from Cape Town show an umbilical arrangement somewhat closer to the

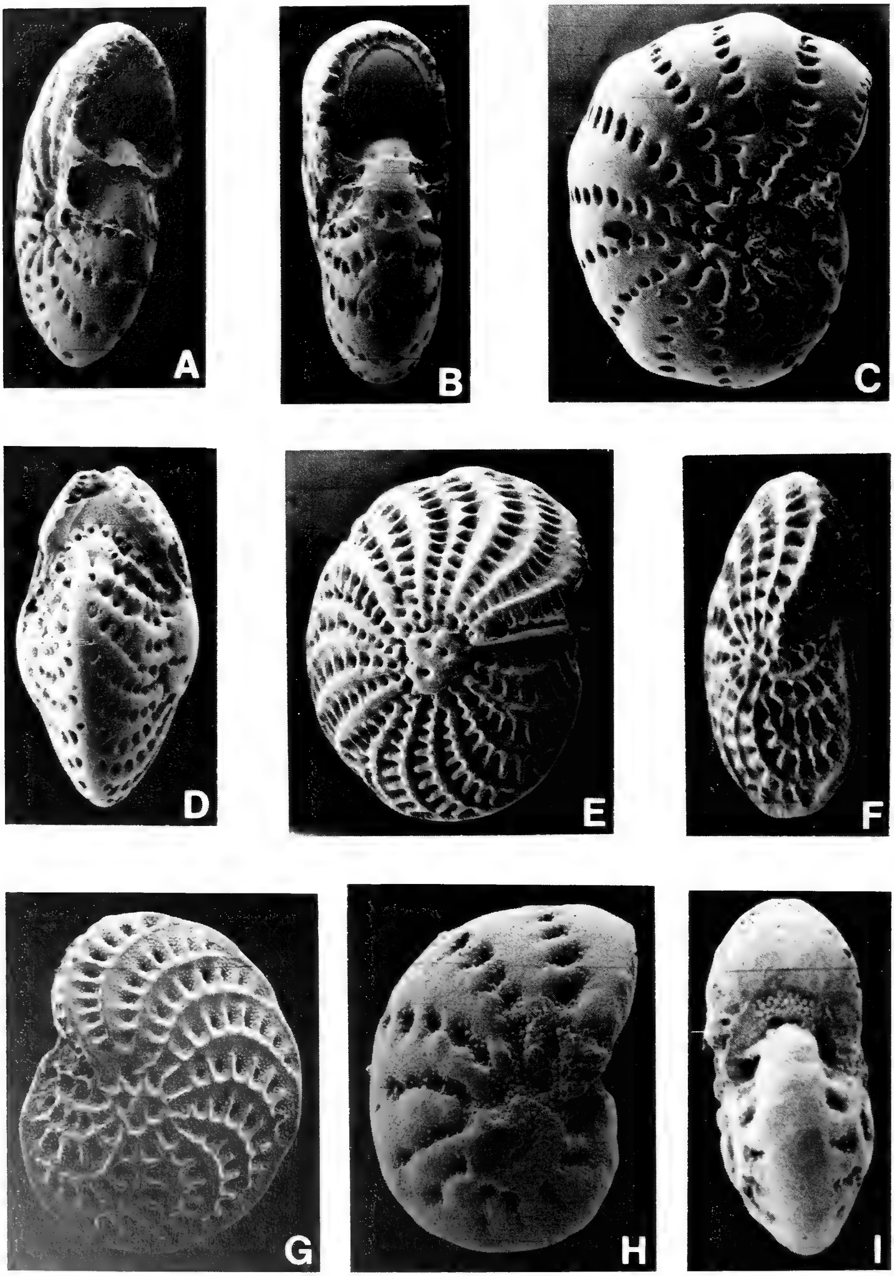

Fig. 15. A. *Elphidium* sp. A. Oblique apertural view, same specimen as Figure 14I. × 113. B–C. *Elphidium articulatum* (d'Orbigny). B. Apertural view, CTC 4. × 84. C. Side view, same specimen. × 86. D–E. *Elphidium crispum* (Linné) s.l. D. Apertural view, CTC 4. × 79. E. Side view, CTC 4. × 83. F–G. *Elphidium macellum* (Fichtel & Moll) s.l. F. Oblique apertural view, CTC 4. × 95. G. Side view, same specimen. × 95. H–I. *Elphidium* sp. B. H. Side view, CTC 3. × 178. I. Apertural view, same specimen. × 178.

individuals illustrated by Boltovskoy *et al.* (1980) from the coast of Argentina. However, the Argentinian tests are more strongly biconvex than those from southern Africa, if the apertural view (Boltovskoy *et al.* 1980, pl. 13 (fig. 3)) can be regarded as typical.

D'Orbigny (1839*b*) figured a specimen that is substantially more lobate around the test periphery than is the case in more recently illustrated South Atlantic tests; his specimens were from the Río Negro coast of Patagonia and from off the Falkland Islands. *Elphidium articulatum* appears to range from the latest Eemian–earliest Weichselian to the present day in southern Africa. It is typical of innermost shelf, cold-water locations on the west coast, and occurs in the present-day sands washed into the canalized mouth of the Soutrivier, just north-east of Cape Town city centre.

Elphidium crispum (Linné, 1758) s.l.

Fig. 15D–E

Nautilus crispus Linné, 1758: 709 (figured by Plancus, 1739, pl. 1 (fig. 2d–f)).
Elphidium crispum (Linné) Cushman & Leavitt, 1929: 20, pl. 4 (figs 3a–b, 4a–b). Hageman, 1979: 94, pl. 5 (fig. 6a–b).

Remarks

Preliminary details of the taxonomic complexity surrounding this species and *Elphidium macellum* (Fichtel & Moll), and the relationship of these two Mediterranean species to comparable southern African forms, were given by McMillan (1987*b*). The following are supplementary notes.

Examination of authors' illustrations of *Elphidium crispum* from the Mediterranean Sea shows a wide range of forms. All the original figures are somewhat stylized drawings (Plancus 1739; Gualtieri 1742), and it is upon these that Linné based his concept of this species. The tests detailed by Gualtieri appear to display an immense number of chambers in the final whorl, whereas those figured by Plancus seem to contain about 20 chambers.

Cushman & Leavitt (1929), in an attempt to distinguish clearly between *Elphidium macellum* and *Elphidium crispum*, re-examined the illustrations of both species as figured by Fichtel & Moll (1798), and compared these with specimens 'from as near the type locality as possible'. In the case of *Elphidium crispum*, it is worth including here Cushman & Leavitt's full description:

'Test of large size for the genus, about 2½ times longer than wide in peripheral view, lenticular, completely involute, the umbilical regions with a medium sized, slightly projecting, rounded boss of clear shell material, the surface of which is set with 10–12 small, shallow, rounded pits, periphery sharply angular but not sharply keeled, sometimes becoming slightly lobulate and blunter in the last portion of the adult coil; chambers very numerous, 20–40 in number, long, narrow, the last few often inflated, forward part slightly raised, giving a radially ribbed appearance; sutures somewhat sigmoid, the middle portion of each nearly radial, partially obscured by the retral processes, set with pores, those of the earlier ones indistinct but later ones with large and deep pores; wall finely perforate with about 12 relatively long retral processes extending well up onto the side of the next added chamber, appearing as fairly widely spaced, low elevations of the wall in the earlier chambers, but as thicker and more rod-like structures in the later chambers; aperture, a row of small openings between the retral processes at the base of the apertural face, which is low, sagittate, the sides often slightly concave, the ends pointed. Diameter up to 3 mm.'

Such large-sized tests of *Elphidium* occur nowhere in South Africa, living or fossil. South African tests assigned to this species possess only from 17 to 22 chambers in the final whorl of adult specimens, whereas juvenile examples reveal rarely more than 12. The South African individuals tend to be more biconvex rather than lenticular, normally with a small, sharply defined, well-raised umbilical boss that exhibits a maximum of seven pits on its surface, rather than the 10–12 described by Cushman & Leavitt (1929). Closer similarity would seem to exist between the style and numbers of the septal pits and bridges, though perhaps the tests figured by Cushman & Leavitt (1929) are a little stylized in this respect.

South African shells feature a rounded to weakly sub-rounded, never acute, test margin that reveals a hint of thickening along the earlier part of the final whorl, whereas the periphery of the Italian form is sharply angular. However, some latest Pleistocene tests of *Elphidium crispum* clearly show abrasion along the periphery, which in severe cases may wear through to the chamber cavities. It thus seems likely that the test periphery has been substantially amended on occasion by post-mortem transport, probably through rotating and cartwheeling of these shells in the littoral sands before final deposition. Nevertheless, despite the probability of some post-mortem changes to these *Elphidium crispum* shells, there are clearly distinct differences between southern African and Mediterranean tests. Although the differences are not great, and the southern African examples clearly fall within *Elphidium crispum* s.l., nevertheless they can be confidently regarded as a local, distinctive form, which is easily distinguished from *Elphidium crispum* s.s.

Unfortunately, this fairly simple picture is complicated by authors' changing attitudes to species through the twentieth century. Cushman & Leavitt (1929) evidently based their descriptions on adult specimens only, for they noted that a considerable difference exists between the test morphologies of microspheric and megalospheric, and juvenile and adult tests of both *Elphidium crispum* and *Elphidium macellum*; these changes mostly remain to be documented. Thus, for Cushman & Leavitt (1929), the two species are easily distinguishable, but later authors have tended to see the two as end-members with substantial variation between them. In addition, later authors' illustrations are of smaller-sized (?juvenile) tests, e.g. Kruit (1955, pl. 2 (fig. 10)) from the Rhône delta, Hageman (1979, pl. 5 (fig. 6a–b)) from the Plio–Pleistocene of the western Peloponnesus of Greece, and Jonkers (1984, pl. 12 (fig. 4)) from the Pliocene of Crete. Hageman (1979) reported on a continuous gradation from lenticular tests with a large umbilical boss (typical *Elphidium crispum*) to compressed tests lacking or possessing a small umbilical boss (closely resembling typical *Elphidium macellum*), and Jonkers (1984) followed similar methods of interpretation. Despite this rather confusing picture of Mediterranean *Elphidium crispum*, the South African tests appear to remain distinct from the species in a strict sense. However, to avoid increasing the range of names available for this group of *Elphidium*, the southern African tests are here referred to *Elphidium crispum* s.l.

Elphidium crispum s.l. occurs in large numbers in the Cape Town samples and elsewhere around the south-western Cape coast in deposits of the same age (see Appendices A to C). The species is not found in deposits older than latest Eemian–earliest Weichselian in the South African Pleistocene, though similar species, of the *Elphidium crispum–macellum* group, occur in both the Varswater Formation and in the older 'Bredasdorp Formation' (both Unit IIA). *Elphidium crispum* s.l. became extinct during the Weichselian or at the end of the Pleistocene, and it is not found *in situ* in any Holocene deposits in South Africa.

This species occurs in smaller numbers in the latest Eemian–earliest Weichselian of the Orange Shelf (McMillan 1987*b*) than at Cape Town. It is also present close to the coast in the youngest parts (Unit III) of the 'Bredasdorp Formation' and the 'Alexandria Formation', at Plettenberg Bay, and on the Agulhas Bank (McMillan 1974); on the inner shelf it may occur in considerable numbers, reworked into the Holocene. The species is also known from the Aliwal Shoal (Carter 1966) and the Uloa Formation of Zululand (pers. obs.), but there are slight morphological differences evident in these warmer-water tests that have yet to be defined. *Elphidium crispum* s.l. thus seems to be an ideal zone fossil for all the littoral or sublittoral deposits of the latest Eemian–earliest Weichselian regression. It is restricted to the same time interval over which *Ammonia* sp. B (Alexandria) and *Ammonia* sp. C (Alexandria) range (McMillan 1987*a*), but is better developed in the colder waters of the west coast, where the two *Ammonia* species are absent (see Fig. 3).

Elphidium crispum s.l. tests from studied localities are invariably broken or abraded, and often the entire outer whorl of chambers is missing, leading to strongly raised umbilical bosses, which tend to better survive the abrasion processes. McMillan (1987*b*: 565) considered the possibility of *Elphidium crispum* s.l. and *Elphidium macellum* s.l. being abraded and clean tests, respectively, of the same species. On the Orange Shelf, the former is most common in the sandier, littoral parts of studied sections; the latter, always well preserved, is most frequent in the clayier intervals that presumably accumulated in quieter water conditions. There thus appears to be rather different facies controls on the two species. However, examination of the test outlines of the two, particularly their cross-sections, reveal distinct differences. Sectioned tests of *Elphidium macellum* s.l. are far too slender and lenticuline throughout their course of growth to accommodate a kernel in their interior of the more strongly biconvex *Elphidium crispum* s.l. (or *vice versa*).

Elphidium macellum (Fichtel & Moll, 1798) s.l.

Fig. 15F–G

Nautilus macellus Fichtel & Moll, 1798: 66, var. β, pl. 10 (fig. h–k).
Elphidium macellum (Fichtel & Moll) Cushman & Leavitt, 1929: 18, pl. 4 (figs 1a–b, 2a–b). Rögl & Hansen, 1984: 50, pl. 14 (figs 2, 5–6), pl. 15 (figs 1–2), text-fig. 18B.

Remarks

As with *Elphidium crispum* (Linné), local, southern African populations of *Elphidium macellum*, though closely similar to those from the type area of the Mediterranean Sea, nevertheless show some distinct and consistent differences. Cushman & Leavitt (1929), in their examination of *Elphidium macellum* from Rimini on the Adriatic coast of Italy, gave the following description:

'Test of medium size for the genus, about 3½ times longer than wide in peripheral view, lenticular, planispiral, completely involute, umbilical regions flat, periphery angular, slightly more rounded in the last-formed chambers, slightly keeled, somewhat lobulate; chambers numerous, averaging 17 in adults in the last-formed coil, slightly arched giving a ribbed appearance to the test; sutures slightly depressed, those of the last-formed chambers slightly more so, partially obscured by the retral processes, curved backward strongly toward the periphery, the proximal half nearly radial, set with indistinct pores; wall thin, finely perforate, usually with less than 12 relatively long retral processes, more widely spread than in *E. crispum* and extending from well up on the side of the chamber to the front of the preceding and appearing as narrow, fairly widely spaced, low elevations of the wall; aperture, a row of small openings between the retral processes at the base of the apertural face which is convex, sagittate, with the sides slightly convex, the lobes sharply angled, saddling the preceding coil. Diameter typically less than 1 mm; thickness 0,25 mm.'

Cushman & Leavitt (1929) concluded by distinguishing *Elphidium macellum* from *Elphidium crispum* and *Elphidium striatopunctatum* (Fichtel & Moll) by its keeled periphery that is often lobate, the fewer chambers in the final whorl, and the flattened or depressed umbilicus.

More recently, the Fichtel & Moll collections have been rediscovered in Vienna (Hansen & Rögl 1980), and a full re-appraisal of their species of 1798, including *Elphidium macellum*, has been achieved (Rögl & Hansen 1984). In the case of *Elphidium macellum* itself, Rögl & Hansen (1984: 51) described and illustrated a lectotype from the Fichtel & Moll collection, which thus must be regarded as the nomenclatural type. This specimen possesses a circular, non-lobate outline, a sharply angled and keeled periphery, 16 and a half chambers in the final whorl, curved sutures with 8 to 15 septal bridges per suture, slightly depressed umbilicus, lacking ornamentation or plug, apertural face low, sagittate, with fine tubercles, and interio-marginally an equatorially placed aperture composed of multiple openings with small protruding lips; maximum diameter 0,79 mm; maximum thickness 0,32 mm.

On comparing the South African tests with the illustrations and descriptions of Rögl & Hansen (1984), it can be seen that the local tests differ in a number of skeletal features. These shells are more compressed, more slender than either the lectotype of Rögl & Hansen (1984) or the comparative Rimini tests illustrated by Cushman & Leavitt (1929). They contain from 13 to 19 chambers in the final whorl, with an apparent increase in numbers with increasing test size (McMillan 1987*b*). Most significantly, the umbilical area of the southern African tests is infilled with a low, irregular plug of varying size that is ornamented over its surface with one to seven pits, which in well-preserved examples can be seen to be spinose or tuberculate interiorly. The plug is never as large or as prominent as that seen in *Elphidium crispum* s.l. tests from the latest Pleistocene of south-western Africa, but it clearly shows variation in size and height (McMillan 1987*b*, pl. 18 (figs 1–6)). The southern African shells are also not quite as acutely carinate on the periphery of the test as the lectotype of Rögl & Hansen (1984). Because these differences in test morphology appear to be consistent distinctions between the Mediterranean and southern African tests, the latter are here termed *Elphidium macellum* s.l., for the same reasons as expressed for *Elphidium crispum* s.l.

It should be added that the southern African shells of *Elphidium macellum* s.l. compare closely, especially in their umbilical ornament, with some figured from the coast of Patagonia (Thomson 1978, pl. 2 (fig. 1)). The test illustrated by Brady (1884, pl. 110 (fig. 11a–b)) is of the same group, though the arrangement of pits over the surface of the umbilical infilling has not been found in so symmetrical a pattern in any of the southern African examples examined by the present author, and is perhaps a little stylized. Tests of this group have also been illustrated by Martin (1981, pl. 6 (fig. 12, and probably also fig. 10)) and McMillan (1974, pl. 9 (fig. 7a–b)).

Elphidium macellum s.l. ranges from the latest Eemian–earliest Weichselian (Unit III) deposits through to the present day around South Africa, and shows a slight preference for cooler water conditions. The species is also one of the group that occurs on the shelf during the Holocene (Martin (1981) gave its single occurrence in her samples as at 118 m water depth, and it was recognized by McMillan (1987*b*) between 137 m and 183 m on the Orange Shelf), but it is more typical of sublittoral, fairly quiet water conditions in the latest Pleistocene. Spinose juveniles, such as are typical of north-west European waters (see Haynes 1973*a*: 202, pl. 24 (figs 2–3)) do not occur in South Africa, either fossil or extant.

Elphidium sp. B

Fig. 15H–I

Remarks

One specimen, slightly reminiscent of *Elphidium gunteri* Cole, as described by McMillan (1987*b*) from the Orange Shelf but differing on several points. There are 12 chambers in the final whorl, intersected by deeply incised, curved to straight, radiate sutures that are crossed by up to five septal bridges per side, the bridges appearing only on the later sutures. The umbilical chamber terminations are rounded and slightly nodose, and the umbilicus is fairly wide and shallow, being ornamented with a granular, almost sugary surface. The test wall is finely and densely perforate; the test periphery is broadly and uniformly rounded, the margin being sub-circular and continuous. The foramen, possibly composed of two arched interio-marginal openings at the base of the terminal face, is overlain by a zone of tuberculate ornamentation. *Elphidium gunteri* tests display a more lobate test periphery, coarser test wall perforations, less incised sutures, and an umbilical ornamentation of small numbers of irregularly shaped calcite pillars.

Genus *Astrononion* Cushman & Edwards, 1937

Astrononion echolsi Kennett, 1967

Fig. 16A–B

Astrononion echolsi Kennett, 1967: 134, pl. 11 (figs 7a–b, 8). Fillon, 1974: 139, pl. 6 (figs 1–3).
Astrononion stelligerum (*non* d'Orbigny) McMillan, 1987*b*: 422, pl. 19 (figs 1–3).

Remarks

A reconsideration of the *Astrononion* specimens described and illustrated by McMillan (1987*b*) from the latest Eemian–earliest Weichselian of the Orange Shelf suggests that they should rather be referred to the Antarctic species *Astrononion echolsi*.

Le Calvez (1974) has examined the type specimen of *Nonionina stelligera* d'Orbigny, found it to be unusable, and has proposed a neotype (Le Calvez 1974: 37, pl. 9 (figs 1–4)) from D'Orbigny's Canary Island (Teneriffe) specimens. The neotype is strongly compressed, with ten chambers in the last-formed whorl, deeply incised sutural slits outside of the umbilical cover plate(s), and a broad, shallow umbilicus almost entirely covered, except centrally, by the cover plate(s).

In contrast, the present specimen and those from the Orange Shelf possess only seven or eight chambers in the final whorl, rather more inflated chambers and a lobate test periphery, wider, more open and shorter incisions of the sutures, and a less extensive cover plate revealing more of the central umbilicus. The Cape Town specimen is a little more strongly biconvex than is typical for the Orange Shelf shells. This species would seem to be confined to the cold-water influenced latest Eemian and earliest Weichselian deposits of the west coast of South Africa.

Family **Rotaliidae** Ehrenberg, 1839

Genus *Ammonia* Brünnich, 1772

Ammonia japonica (Hada, 1931)

Fig. 16C–E

Rotalia japonica Hada, 1931: 137, fig. 93a–c.
Ammonia japonica (Hada) Matoba, 1970: 48, pl. 5 (fig. 14a–c), pl. 6 (fig. 1a–c). McMillan, 1987*a*: 37, text-fig. 7a–d.
Ammonia beccarii (*non* Linné) Martin, 1974: 84, fig. 14–1 (*part.*). Salmon, 1979: 77, fig. 3p. Martin, 1981: 48, pl. 3 (figs 2–3).
Ammonia beccarii (Linné) var. *inflata* (*non* Seguenza) McMillan, 1974: 62, pl. 6 (fig. 2a–c).

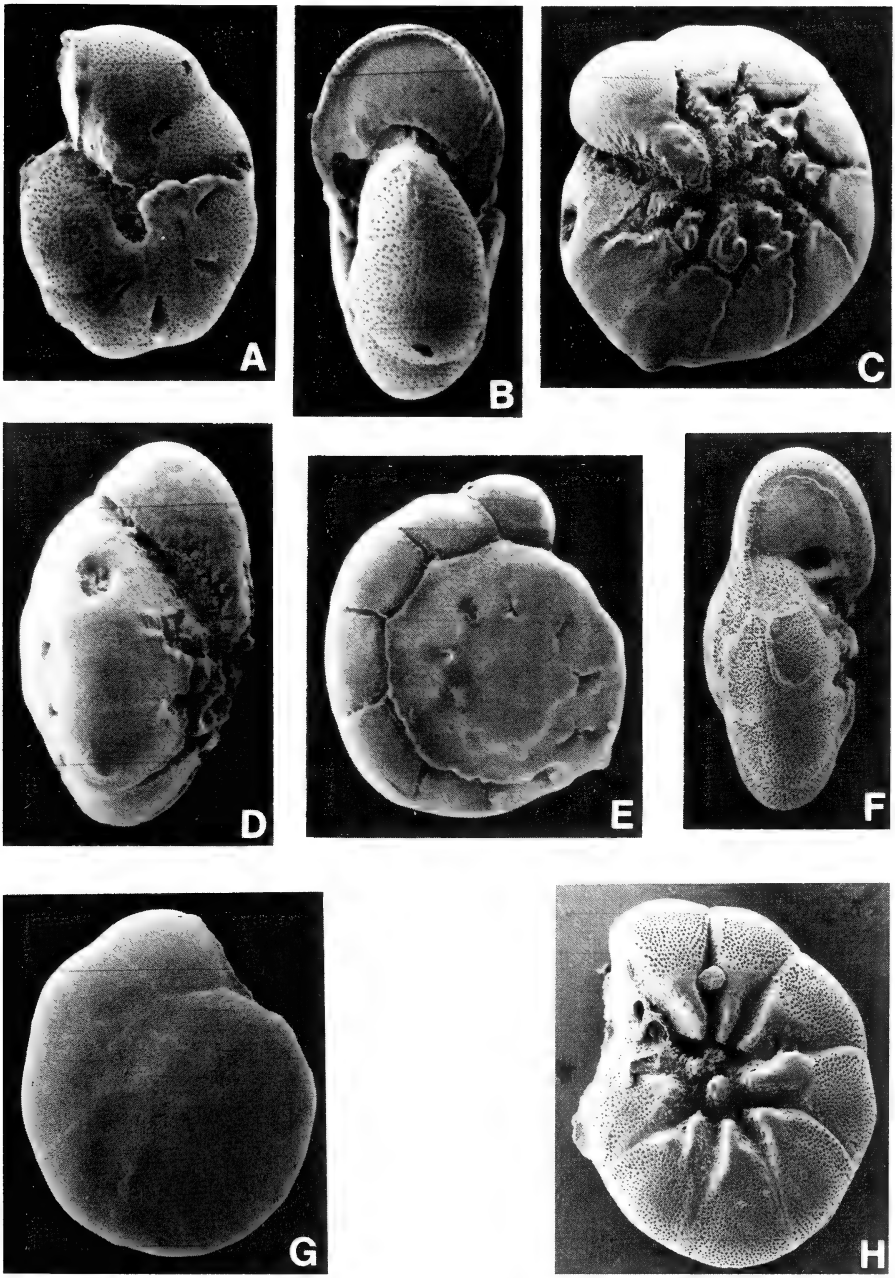

Fig. 16. A–B. *Astrononion echolsi* Kennett. A. Side view, CTC 4. × 139. B. Apertural view, same specimen. × 157. C–E. *Ammonia japonica* (Hada). C. Ventral view, CTC 4. × 111. D. Side view, same specimen. × 124. E. Dorsal view, same specimen. × 110. F–H. *Ammonia parkinsoniana* (d'Orbigny) s.l. F. Side view, CTC 4. × 135. G. Dorsal view, CTC 4. × 111. H. Ventral view, same specimen as F. × 142.

Remarks

Subsequent to the comments on *Ammonia japonica* by McMillan (1987*a*, 1987*b*), additional studies have been made of the Pleistocene littoral deposits of the Saldanha–Langebaan region, the 'Bredasdorp Formation' and the 'Alexandria Formation' of the southern Cape coast, and the Uloa Formation and Bluff Sandstone Formation of Zululand/Natal. As was mentioned by McMillan (1987*a*), *Ammonia japonica* is best developed in the Holocene off the south and west coasts of South Africa, and is similarly distributed in the latest Eemian–earliest Weichselian (Unit III) deposits. The species is absent in older Pleistocene and Pliocene marine rocks of this region, although a similar form does occur in the Varswater Formation (Unit IIA) of the Langebaan–Saldanha area, that is of the same *Ammonia*-group as *Ammonia japonica*.

Holocene tests tend to possess numerous, rather granular calcite pillars in the umbilicus (Martin 1981, pl. 3 (fig. 2); McMillan 1987*b*, pl. 19 (figs 12, 15–16)), but latest Pleistocene shells are usually characterized by more robust umbilical pillars, which may often merge into sinuous, irregular structures (McMillan 1987*b*, pl. 20 (figs 1–2)). It is probable that the difference is due to abrasion of the Pleistocene tests but not the Holocene ones. However, variation in test morphology through time is also a possible cause.

Rouvillois (1974) described *Pseudoeponides falsobeccarii* from the continental shelf (60–120 m water depth) off the west of France, and it is clear that southern African *Ammonia japonica* is closely related to this North Atlantic species. Neither show much similarity to the genotype, *Pseudoeponides japonicus* Uchio (*in* Kawai *et al.* 1950). Rouvillois (1974) identified both ventral and dorsal openings in her species, but these are so unlike those of *Pseudoeponides japonicus* that, together with major differences in test and chamber morphology, it seems best for the moment to regard the French species as referable to *Ammonia*. The 'secondary openings' of the ventral side of *Ammonia falsobeccarii* occur in various forms in all species of *Ammonia*, but the dorsal openings, present also in southern African *Ammonia japonica*, clearly separate these two species from *Ammonia beccarii* (Linné) s.s., *Ammonia parkinsoniana* (d'Orbigny) s.l., and other species typical of more littoral environments. It may be that the deeper-water, shelf species of *Ammonia* warrant a distinct genus.

A comparison of southern African *Ammonia japonica* with *Ammonia falsobeccarii* evinces the following similarities and differences. Rouvillois' species possesses usually eight chambers, southern African tests display eight or nine, more rarely seven or ten, chambers in the final whorl. Both species possess very strongly convex ventral sides but the dorsal side of the southern African shells is always markedly convex, whereas that of the French species is weakly convex, almost flat. Variation in the arrangement and the style of the umbilical filling is similar, with well-preserved tests exhibiting a granular or tubercular ornament over the dense array of thin calcite pillars that occupy the umbilicus. The arrangement of incisions, bordered with granules and small nodes along the spiral and septal sutures, is much the same in both groups of specimens.

The detail of the secondary openings at the inner junctions of the septal and spiral sutures cannot be seen in the illustrations of *Ammonia japonica* given by Hada (1931) and Matoba (1967, 1970). Their figures appear to be derived from light microscope photography and drawings, and the depressions on the dorsal side may thus either be obscured by reflection effects within the shell, or they are absent in the Japanese tests. For the present, Hada's name has been retained for these southern African tests.

McMillan (1974) employed the name *Ammonia beccarii* (Linné) var. *inflata* (Seguenza) for this species on the Agulhas Bank. The dorsal sides of Agulhas Bank tests are generally less convex than those of tests from off the west coast (McMillan 1987*a*). *Rosalina inflata* was originally described by Seguenza (1862) from the 'Pleistocene abbastanza recente' clays of Catania, Sicily. Again, the ventral side of the test is strongly convex, the dorsal side less so. Some variation can be seen in the tests illustrated by Seguenza (1862, pl. 1 (figs 6, 6a–c)) but, although the umbilical ornamentation and the test outline are similar to southern African *Ammonia japonica*, the beaded bordered incisions of the sutures (in fig. 6b) may extend to the test periphery, and the ventral surfaces of the chambers may be strongly ornamented with irregular rugosities (figs 6a, 6c). Billman *et al.* (1980: 86, pl. 5 (figs 1–14)) have illustrated tests referred to *Ammonia inflata* (Seguenza) from northern Morocco, but noted that the species should be revised using topotypic material. The Moroccan tests possess incised sutures with beading over the entire ventral side; over the dorsal side the same ornamentation occurs, but it is less well developed along both septal and spiral sutures of the early part of the test. The umbilical infilling again consists of numerous calcite pillars. It is felt by the present author that *Ammonia inflata*, as understood by Seguenza (1862) or as differently interpreted by Billman *et al.* (1980), does not occur in southern Africa. The Agulhas Bank tests are hence regarded as *Ammonia japonica*, with a local variation being the less high trochospire of the tests compared to those seen off the west coast.

Although the species is known only as far back as the latest Eemian–earliest Weichselian in southern Africa, *Ammonia japonica* ranges back to the Early Pleistocene in Japan (Matoba 1967).

Ammonia parkinsoniana (d'Orbigny, 1839) s.l.

Fig. 16F–H

Rosalina parkinsoniana d'Orbigny, 1839*a*: 99, pl. 4 (figs 25–27).
Ammonia parkinsoniana (d'Orbigny) forma *tepida* Poag, 1978: 397, pl. 1 (figs 1–4, 10–12, 17–18).
Ammonia parkinsoniana (d'Orbigny) forma *typica* Poag, 1978: 397, pl. 1 (figs 5–9, 13–16, 19–21).
Ammonia beccarii (*non* Linné) Martin, 1981: 48 (*part.*).
Ammonia parkinsoniana (d'Orbigny) s.l. McMillan, 1987*a*: 35, figs 3a–r, 4–5.

Remarks

Extensively distributed around southern Africa in shallow marine environments in the Holocene and the latest Eemian–earliest Weichselian. The major morphological variations of the species in the southern African Holocene have been detailed by McMillan (1987*a*). *Ammonia parkinsoniana* s.l. occurs in the quieter water, clayier and siltier intervals, as well as the more active, sandier parts of the latest Pleistocene sections studied by McMillan (1987*b*) on the Orange Shelf.

Genus *Pararotalia* Le Calvez, 1949

Pararotalia nipponica (Asano, 1936)

Fig. 17A–C

Calcarina rotula (*non* Egger) Chapman, 1923: 3, pl. 1 (fig. 1).
Rotalia nipponica Asano, 1936: 614, pl. 31 (fig. 2a–c).
Rotalia ozawai Asano, 1951: 15, figs 115–117.
Pararotalia taiwanica (*non* Nakamura) Huang, 1964: 56, pl. 2 (fig. 2a–c).
Pararotalia sp. A Martin, 1974: 84, fig. 14–1 (*part.*).
Pararotalia cf. *P. inermis* (*non* Terquem emend. Le Calvez) McMillan, 1974: 63, pl. 6 (fig. 3a–c).
Pararotalia cf. *P. nipponica* (Asano) Martin, 1981: 48, pl. 9 (fig. 6).
Pararotalia nipponica (Asano) McMillan, 1987*b*: 443, pl. 20 (figs 13–17), pl. 21 (figs 1–3), text-fig. 9.

Remarks

Studies of the 'Alexandria Formation' (McMillan in press) indicate that *Pararotalia nipponica* ranges from the earliest Pleistocene (Unit II) to the present day; it is absent from the oldest, most inland part of the sequence (Early Pliocene, Unit I). In this respect it has a stratigraphic range comparable to *Cibicides lobatulus* (Walker & Jacob) and *Elphidium advenum* (Cushman).

Chapman's (1923) record of *Pararotalia nipponica* in the Late Cretaceous Mzamba Formation is clearly a contaminant from the overlying latest Pleistocene sands; similar tests, markedly different in their preservation to the *in situ* microfauna, were recognized by Makrides (1979). Neither *Calcarina* nor *Pararotalia*, nor any morphologically similar genera with peripheral blunt spines, are known anywhere in the South African Late Cretaceous.

The reference to *Rotalia dentata* Parker & Jones by Chapman (1907) from the ?latest Pleistocene of the Buffalo River, East London, almost certainly is referable here too. Siesser & Salmon (1979) reported '*Pararotalia inermis*', supposedly from the Late Eocene Langental Beds of southern Namibia, but samples from pits dug in these outcrops yielded no trace of Eocene *Pararotalia* species (unpubl. studies). The illustrations given (Siesser & Salmon 1979, fig. 15c–d) are certainly of *Pararotalia nipponica*. It is evident that these *Pararotalia* tests, in keeping with those of *Elphidium* and *Ammonia*, were introduced into the Langental region with windblown sand derived from the littoral. The presence of *Elphidium* cf. *E. crispum* (Linné) at Langental (Siesser

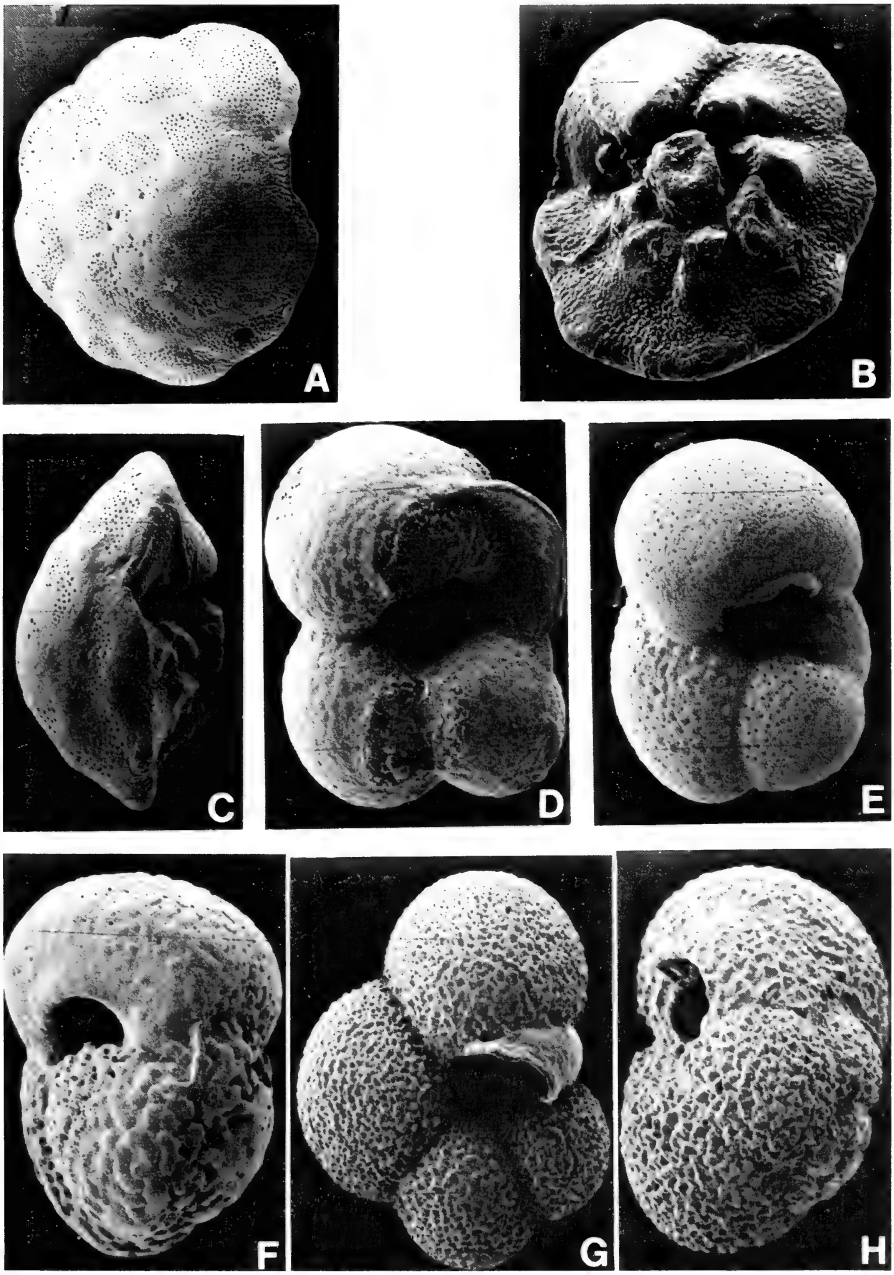

Fig. 17. A–C. *Pararotalia nipponica* (Asano). A. Dorsal view, CTC 4. × 98. B. Ventral view, CTC 4. × 122. C. Side view, same specimen as B. × 122. D. *Globigerina (Globigerina) bulloides* d'Orbigny. Ventral view, CTC 3. × 172. E–F. *Globorotalia (Globoconella) inflata* (d'Orbigny). E. Ventral view, CTC 3. × 181. F. Side view, CTC 3. × 235. G–H. *Neogloboquadrina* cf. *N. pachyderma* (Ehrenberg). G. Ventral view, CTC 3. × 200. H. Side view, CTC 3. × 275.

& Salmon 1979) perhaps suggests a latest Eemian–earliest Weichselian age for the windblown contaminants.

Pararotalia nipponica occurs in the Varswater Formation (McMillan 1987*b*, Appendix A) of the Langebaan area. It has also been reported as '*Rotalia*-like foraminifers' and '*Rotalia*' in the Saldanha area (Visser & Schoch 1973). The species is widespread throughout the 'Bredasdorp Formation' (unpubl. studies), and was noted by Rümke (*in* Spies *et al.* 1963) under the name *Rotalia audouini* d'Orbigny, though it is distinctly different from D'Orbigny's European Eocene and Oligocene species. In the 'Alexandria Formation' the species is widespread and abundant in the Early Pleistocene Unit II and latest Pleistocene Unit III—again previously recognized by Rümke (*in* Engelbrecht *et al.* 1962) as *Rotalia audouini*.

Specimens of '*Rotalia* sp.' from the Bluff Sandstone Formation at Durban, described by Parr (1958), are certainly referable to *Pararotalia nipponica*. Some of this material was stored on grid slides at the Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, and, through the courtesy of Professor M. Raath, were examined by the present author. *Pararotalia nipponica* also occurs, presumably *in situ*, in the latest Pleistocene (Unit III) *Pecten* bed in the lower half of the Uloa exposure, Zululand. As *Streblus taiwanica* (Nakamura), this species was encountered in Quaternary sands along the Inharrime to Vilanculos coast of Moçambique (Rocha 1965).

The *Pararotalia nipponica*-group exhibits wide morphological variation, particularly in the height of the trochospire, size of the umbilical boss, and in the spinose, lobate or circular test outline. Attempts to divide the latest Pleistocene tests into discrete morphological *formae* proved to be impossible for the Orange Shelf material (McMillan 1987*b*). However, there does seem to be one tendency toward tests with a high trochospire, circular or weakly lobate periphery, and large umbilical boss (*Pararotalia nipponica* form), and one tendency to low trochospire, spinose periphery, and small or divided umbilical boss (*Pararotalia ozawai* form). These two trends resemble the distinctions made by Ujiié (1966) within the group. Bhalla (1972) considered sexual dimorphism to be partly responsible for the wide range of morphologies included within *Pararotalia nipponica*.

Pararotalia nipponica is closely comparable to *Pararotalia serrata*, described by Ten Dam & Reinhold (1941) from the Pliocene of the Netherlands, and also known from similarly aged Crag deposits of eastern England (Funnell 1981). The precise differences between the two species remain to be determined.

Family **Globigerinidae** Carpenter, Parker & Jones, 1862

Genus *Globigerina* d'Orbigny, 1826

Globigerina (Globigerina) bulloides d'Orbigny, 1826

Fig. 17D

Globigerina bulloides d'Orbigny, 1826: 277, modèles no. 17 (1 ère livraison), no. 76 (4 ème livraison).

Remarks

Only brief notes are given for this and the following planktonic species. One test, with the last-formed chamber broken away. Compared with examples encountered in the Holocene of the Orange Shelf (McMillan 1987*b*), this test displays a rather low-arched aperture but is otherwise typical. The species is characteristic of subpolar and transitional waters in the world oceans (Bé & Tolderlund 1971). Kennett & Srinivasan (1983) regarded *Globigerina bulloides* to range from the Middle Miocene to the present day.

Family **Globorotaliidae** Cushman, 1927

Genus *Globorotalia* Cushman, 1927

Globorotalia (Globoconella) inflata (d'Orbigny, 1839)

Fig. 17E–F

Globigerina inflata d'Orbigny, 1839*c*: 134, pl. 2 (figs 7–9).

Remarks

Two specimens, one rather more lobate than is typical. Both are sinistrally coiled, as are almost all examples encountered by McMillan (1987*b*) through the Holocene of the Orange Shelf. The species is most typical of temperate water masses (Bé & Tolderlund 1971; Stainforth *et al.* 1975). Its stratigraphic range is Late Pliocene to present day (Kennett & Srinivasan 1983).

Genus *Neogloboquadrina* Bandy, Frerichs & Vincent, 1967

Neogloboquadrina cf. *N. pachyderma* (Ehrenberg, 1861)

Fig. 17G–H

see *Aristerosira pachyderma* Ehrenberg, 1861: 303; 1873: 386, pl. 1 (fig. 4).

Remarks

Two specimens of the shelf *forma* (non pachyderm), both sinistrally coiled and both exhibiting a kummerform final chamber. These tests show similarities to the shelf *forma* tests illustrated by McMillan (1987*b*, pl. 22, figs 14–16) from a water depth of 46,5 m, close to the Namaqualand coast. However, the presence of the kummerform final chambers result in distinctly unusual apertures, and the unique apertural arrangement of *Neogloboquadrina pachyderma* is not seen. For this reason, the two tests are placed in the status of confer *N. pachyderma*.

Sinistrally coiled *Neogloboquadrina pachyderma* appears to be associated with upwelling waters of the Benguela Current close to the west coast of southern Africa (Bé & Tolderlund 1971). The species ranges from the Late Miocene to the present day (Kennett & Srinivasan 1983).

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APPENDIX A

THE LLANDUDNO–SANDY BAY COAST, CAPE PENINSULA

Deposits of the same age as those described in the main body of this article occur intermittently around the Cape Peninsula. Along the Llandudno to Sandy Bay part of the coastline, 'raised beach' deposits occur about 10 m above present

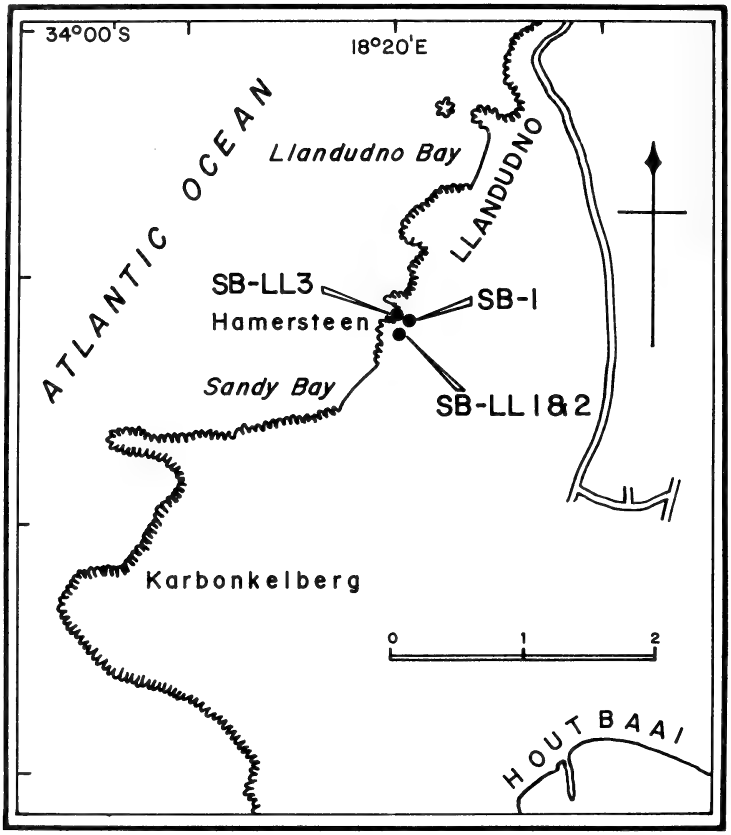

Fig. 18. Locality map of sampling sides along the Llandudno to Sandy Bay coast, Cape Peninsula.

mean sea-level as unconsolidated, white shelly sands at 34°01′05″S 18°20′00″E, just north of the Hamersteen (Fig. 18).

Because of their loose nature, they are poorly exposed and tend to wash down slope, but occasional clear faces may be seen or excavated on either sides of paths leading inland from, and parallel to the beach. Large shells, particularly gastropods, are common and often well preserved. Three samples were collected from the best available exposures late in 1986, and revealed the presence of abundant, though rather poorly preserved, often leached, and abraded foraminifera tests (sample SB–LL 3).

In addition, cemented shelly sandstone was noticed occasionally adhering to the large granite slabs and boulders in the present-day surf zone. One sample of sandstone revealed a microfauna very similar in composition to that of the 'raised beach' deposits, but severely affected by calcite leaching and precipitation, and somewhat less diverse.

The foraminiferal faunas of the four samples are closely comparable, both in species and composition, to those from Cape Town city centre. It is clear that these deposits near Llandudno are derived from the same regressional episode during the latest Eemian–earliest Weichselian. The faunas are distinguished by the predominance of *Elphidium crispum* (Linné) s.l., *Pararotalia nipponica* (Asano) and *Cibicides lobatulus* (Walker & Jacob), the first-named confirming the Unit III, latest Pleistocene age. Table 2 details the foraminifera recovered from the four samples.

The absence of *Ammonia parkinsoniana* (d'Orbigny) s.l. in the Llandudno samples is of note, and probably reflects the minute rainfall catchment area of this part of the coast, with a corresponding lack of dilution of littoral sea-water. In contrast, numbers of *Cibicides lobatulus* are substantially greater than at Cape Town, probably indicating a more turbulent environment: a rocky shore rather than a beach. Again, a littoral to sublittoral environment is indicated by the foraminifera species present, though in such a wave-influenced shallow marine environment, considerable post-mortem transport of tests must have occurred. Macrofaunal debris is composed mainly of mollusc shell, some of which retains its life colours. In addition, barnacle plates, echinoid spines and sponge spicules occur.

TABLE 2

Distribution of foraminifera in studied samples from the latest Eemian–earliest Weichselian deposits of the Llandudno to Sandy Bay coast, Cape Peninsula.

Sample number				Sp. no.	Species
SB-LL3	SB-LL2	SB-LL1	SB-1		
			1	1	*Spiroplectammina* cf. *S. wrightii*
		1		2	*Quinqueloculina contorta*
3	2	2	5	3	*Quinqueloculina dunkerquiana*
1	1			4	*Quinqueloculina seminulum*
3	4	5	7	5	*Quinqueloculina* spp. (broken)
	2			6	*Siphonaperta* sp.
			1	7	*Lagena perlucida*
		1	3	8	*Lenticulina* spp.
	1			9	*Bulimina gibba*
	1		2	10	*Cassidulina laevigata*
			1	11	*Rosalina bradyi*
	1		1	12	*Rosalina* cf. *R. williamsoni*
			1	13	*Rosalina* sp.
	3	1	3	14	*Glabratella australensis*
17	55	27	71	15	*Cibicides lobatulus*
1	2	4	4	16	*Cibicides* spp. (broken)
1	1	3	2	17	*Cibicidoides* sp.
	1			18	*Hyalinea balthica*
	1			19	*Elphidium advenum*
	1		2	20	*Elphidium* sp. A
33	39	36	96	21	*Elphidium crispum* s.l.
	1	1		22	*Elphidium macellum* s.l.
	1			23	*Elphidium* sp. (broken)
21	56	24	149	24	*Pararotalia nipponica*
80	173	105	349		Total number of tests

Many of the species present are confined to the west-coast littoral at the present day, and indicate that, as with the Cape Town fauna, water temperatures were closely comparable to those experienced today along this coast. It seems likely that the very close similarity of the foraminifera species in the latest Eemian–earliest Weichselian of the south-western Cape and the Orange Shelf (McMillan 1987*b*) can be taken to indicate little difference in coastal sea-water temperatures between the two areas in the latest Pleistocene.

APPENDIX B

LATEST PLEISTOCENE FORAMINIFERA FROM BERG RIVER MOUTH

Further north along the west Cape coast, near the mouth of the Berg River, deposits of the same age (latest Eemian–earliest Weichselian, Unit III) as those of Cape Town city centre are preserved beneath the Holocene estuarine sediments. Recent dredging and channelling operations for a new marina at Port Owen, just inside the estuary mouth, have excavated muddy and shelly sands that have been used as fill over the adjacent area.

Two samples were collected in late 1986: one from a brown, clayey and lignitic sand, apparently *in situ*, near the base of a telephone pole next to the dredged marina channel (BR–2), and the other of muddy shelly sand dredged from the bed of the channel (BR–1). The localities of the samples are shown in Figure 19, and a list of the recovered foraminifera in Table 3. The two samples were from closely adjacent sites at 32°47′25″S 18°09′05″E.

TABLE 3

Distribution of foraminifera in two studied samples from the latest Eemian–earliest Weichselian deposits of the Berg River mouth, west Cape coast.

Sample number BR-2	BR-1	Sp. no.	Species
	2	1	*Bulimina elongata*
	3	2	*Bulimina gibba*
	1	3	*Trifarina angulosa*
	1	4	*Cassidulina laevigata*
	1	5	*Rosalina* cf. *R. globularis*
	1	6	*Glabratella australensis*
8	6	7	*Cibicides lobatulus*
	1	8	*Cibicides* sp. (broken)
11	49	9	*Elphidium advenum*
1	21	10	*Elphidium* sp. A
18	3	11	*Elphidium* cf. *E. alvarezianum*
62	87	12	*Elphidium crispum* s.l.
10		13	*Elphidium macellum* s.l.
58	68	14	*Ammonia japonica*
1	1	15	*Ammonia parkinsoniana* s.l.
13	48	16	*Pararotalia nipponica*
182	293		Total number of tests

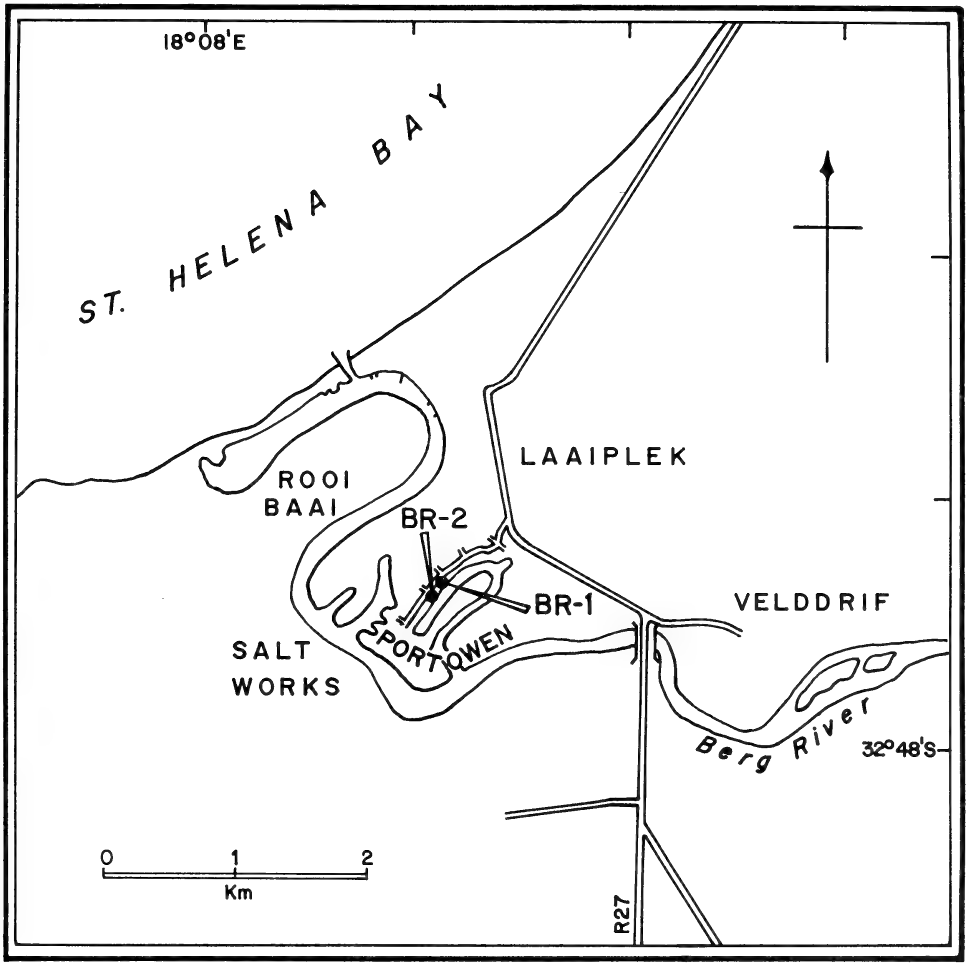

Fig. 19. Locality map of sampling sites at Berg River mouth, west Cape coast.

Both samples are rather gypsiferous, though this would seem to be a secondary feature derived from the overlying Holocene estuary. Present-day environments in the estuary are markedly hypersaline, and some areas are utilized for salt production. However, the foraminifera of the latest Pleistocene Unit III reveal a much more normal marine environment. *Cibicides lobatulus* (Walker & Jacob) occurs in fairly small numbers—as at Cape Town but unlike Llandudno–and is suggestive of a sandy beach environment rather than a rocky shore. *Ammonia japonica* (Hada) in such numbers clearly illustrates a good connection to the open sea, whereas the lack of *Ammonia parkinsoniana* (d'Orbigny) s.l. perhaps implies little fresh water entering the Berg estuary during the latest Eemian–earliest Weichselian. Very rare fragments of mollusc shell retain their life colours, whereas all of the foraminifera tests are bleached. Occasional tests of *Ammonia parkinsoniana* s.l. with their natural brown colour are substantially better preserved than the rest of the assemblage, and are considered to be contamination from the Holocene estuarine deposits.

The brown sand contains much lignite and clay, and it yielded rather more corroded foraminifera tests than the channel sample. It seems likely that the clayey sand accumulated in a non-marine or estuarine mud-flat environment, as plant fragments, seeds and non-marine gastropods also occur. The marine foraminifera shells were probably carried off the adjacent beach and into the estuary by onshore winds. However, the absence of Holocene foraminifera in the clay clearly identifies it as having accumulated before the Holocene transgression. The abundance of *Elphidium crispum* (Fichtel & Moll) s.l. in both samples clearly shows these deposits to have been laid down at the time of the latest Eemian–earliest Weichselian regression.

APPENDIX C

LATEST PLEISTOCENE FORAMINIFERA OF HOEDJIESPUNT PENINSULA, SALDANHA

Although the main body of the white, shelly and sandy limestones that cap the Palaeozoic and older rocks of the Hoedjiespunt Peninsula are the most obvious latest Cainozoic deposits of this region, there nevertheless are small residues of an even later unit. Foraminifera from shelly parts of the main limestones (the Varswater Formation, and including the 'Saldanha Formation')

TABLE 4

Foraminifera species of one studied sample from the latest Eemian–earliest Weichselian sands of Hoedjiespunt Peninsula, Saldanha, west Cape coast.

Sample no. H-1	Sp. no.	Species
3	1	*Quinqueloculina dunkerquiana*
2	2	*Quinqueloculina seminulum*
11	3	*Quinqueloculina* spp. (broken)
1	4	*Siphonaperta* sp.
1	5	*Cassidulina laevigata*
24	6	*Glabratella australensis*
9	7	*Glabratella australensis* (reworked)
5	8	*Cibicides lobatulus*
12	9	*Cibicidoides* sp.
4	10	*Elphidium advenum*
3	11	*Elphidium crispum* s.l.
6	12	*Elphidium* sp. (reworked)
1	13	*?Haynesina* sp.
3	14	*Ammonia* spp. (reworked)
112	15	*Pararotalia nipponica*
21	16	*Pararotalia nipponica* (reworked)
238		Total number of tests

indicate a later Early Pleistocene age (see p. 132), regarded as equivalent in age to Unit IIA of the 'Bredasdorp Formation'.

However, bleached white, unconsolidated, shelly sands were recognized by Mr V. H. Valicenti about 8 m above high tide mark, below the Control Tower, on the north side of the Hoedjiespunt Peninsula, unconformably overlying the Varswater Formation limestones. Though severely affected by rainwash downslope, and rather obscured by small plants and humus, as well as being contaminated with weathered debris from the adjacent limestones, one relatively clean sample was obtained. The locality is at 33°01′36″S 17°57′44″E, on Figure 20, and the foraminifera assemblage is listed in Table 4.

Despite the apparent cleanness of the sample, reworked foraminifera from the Varswater Formation do occur, but they can be easily identified by being cemented, creamy in colour and well preserved. *In situ* tests, in contrast, are

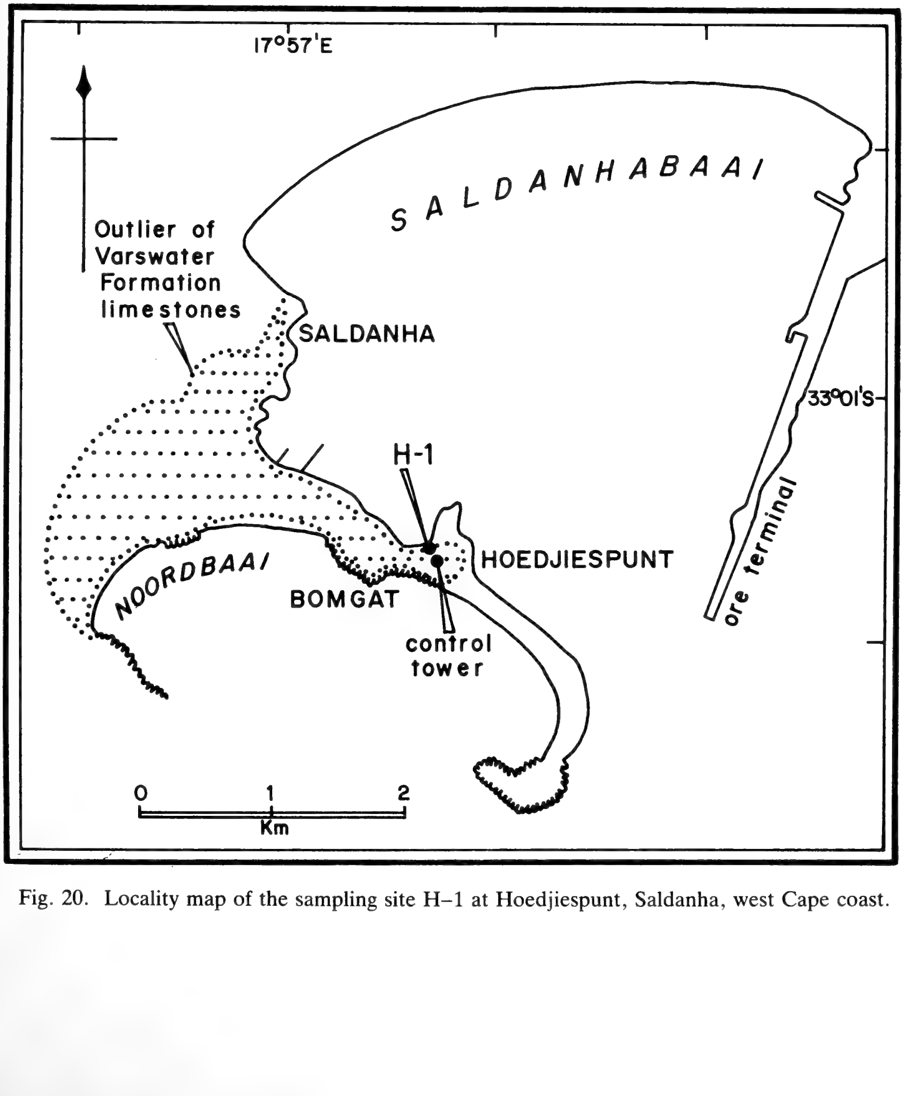

Fig. 20. Locality map of the sampling site H–1 at Hoedjiespunt, Saldanha, west Cape coast.

bleached white, rather damaged, often displaying borings, poorly preserved, and often appear rather 'leached'.

Again, the age of the shelly sands is regarded as being latest Eemian–earliest Weichselian, based on the presence of *Elphidium crispum* (Linné) s.l. The absence of *Ammonia parkinsoniana* (d'Orbigny) s.l. would seem to duplicate the situation along the Llandudno–Sandy Bay coast, with little coastal dilution of seawater. As with the previous deposits studied, the mollusc shell often retains its life colours, but unlike elsewhere, tests of foraminifera are relatively rare.

6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers.

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach, Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

7. SPECIAL HOUSE RULES

Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text
e.g. '. . . the Figure depicting *C. namacolus* . . .': '. . . in *C. namacolus* (Fig. 10) . . .'

(b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene

(c) Scientific names, but not their vernacular derivatives
e.g.Therocephalia, but therocephalian

Punctuation should be loose, omitting all not strictly necessary

Reference to the author should preferably be expressed in the third person

Roman numerals should be converted to arabic, except when forming part of the title of a book or article, such as
'Revision of the Crustacea. Part VIII. The Amphipoda.'

Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively. The generic name should not be abbreviated at the beginning of a sentence or paragraph.

Name of new genus or species is not to be included in the title; it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

I. K. McMILLAN

FORAMINIFERA FROM THE LATE PLEISTOCENE (LATEST EEMIAN TO EARLIEST WEICHSELIAN) SHELLY SANDS OF CAPE TOWN CITY CENTRE, SOUTH AFRICA

99 PART 6 MAY 1990 ISSN 0303-2515

ANNALS OF THE SOUTH AFRICAN MUSEUM

CAPE TOWN

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INSTRUCTIONS TO AUTHORS

1. MATERIAL should be original and not published elsewhere, in whole or in part.

2. LAYOUT should be as follows:

(a) *Centred masthead to consist of*
  Title: informative but concise, without abbreviations and not including the names of new genera or species
  Author's(s') name(s)
  Address(es) of author(s) (institution where work was carried out)
  Number of illustrations (figures, enumerated maps and tables, in this order)
(b) *Abstract* of not more than 200 words, intelligible to the reader without reference to the text
(c) *Table of contents* giving hierarchy of headings and subheadings
(d) *Introduction*
(e) *Subject-matter* of the paper, divided into sections to correspond with those given in table of contents
(f) *Summary*, if paper is lengthy
(g) *Acknowledgements*
(h) *References*
(i) *Abbreviations*, where these are numerous.

3. MANUSCRIPT, to be submitted in triplicate, should be typewritten and neat, double spaced with 3 cm margins all round. First lines of paragraphs should be indented. Tables and a list of captions for illustrations should be typed separately, their positions indicated in the text. All pages should be numbered consecutively.

Major headings of the paper are centred capitals; first subheadings are shouldered small capitals; second subheadings are shouldered italics; third subheadings are indented, shouldered italics. Further subdivisions should be avoided, as also enumeration (never roman numerals) of headings and abbreviations.

Footnotes should be avoided unless they are short and essential.

Only generic and specific names should be underlined to indicate italics; all other marking up should be left to editor and publisher.

4. ILLUSTRATIONS should be reducible to a size not exceeding 12 × 18 cm (19 cm including caption); the reduction or enlargement required should be indicated (and preferably uniform); originals larger than 35 × 47 cm should not be submitted; photographs should be rectangular in shape and final size. A metric scale should appear with all illustrations, otherwise magnification or reduction should be given in the caption; if the latter, then the final reduction or enlargement should be taken into consideration.

All illustrations, whether line drawings or photographs, should be termed figures (plates are not printed; half-tones will appear in their proper place in the text) and numbered in a single series. Items of composite figures should be designated by capital letters; lettering of figures is not set in type and should be in lower-case letters. If Letraset is used authors are requested to use Helvetica-style lettering, if possible.

The number of the figure should be lightly marked in pencil on the back of each illustration.

5. REFERENCES cited in text and synonymies should all be included in the list at the end of the paper, using the Harvard System (*ibid., idem, loc. cit., op. cit.* are not acceptable):

(a) Author's name and year of publication given in text, e.g.:

'Smith (1969) describes . . .'
'Smith (1969: 36, fig. 16) describes . . .'
'As described (Smith 1969*a*, 1969*b*; Jones 1971)'
'As described (Haughton & Broom 1927) . . .'
'As described (Haughton *et al.* 1927) . . .'

Note: no comma separating name and year
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names of joint authors connected by ampersand
et al. in text for more than two joint authors, but names of all authors given in list of references.

(b) Full references at the end of the paper, arranged alphabetically by names, chronologically within each name, with suffixes *a*, *b*, etc., to the year for more than one paper by the same author in that year, e.g. Smith (1969*a*, 1969*b*) and not Smith (1969, 1969*a*).

For books give title in italics, edition, volume number, place of publication, publisher.
For journal article give title of article, title of journal in italics (according to the *World list of scientific periodicals*. 4th ed. London: Butterworths, 1963), series in parentheses, volume number, part number in parentheses, pagination (first and last pages of article).

Examples (note capitalization and punctuation)

BULLOUGH, W. S. 1960. *Practical invertebrate anatomy*. 2nd ed. London: Macmillan.

FISCHER, P. H. 1948. Données sur la résistance et de la vitalité des mollusques. *Journal de conchyliologie* **88** (3): 100–140.

FISCHER, P. H., DUVAL, M. & RAFFY, A. 1933. Études sur les échanges respiratoires des littorines. *Archives de zoologie expérimentale et générale* **74** (33): 627–634.

KOHN, A. J. 1960*a*. Ecological notes on *Conus* (Mollusca: Gastropoda) in the Trincomalee region of Ceylon. *Annals and Magazine of Natural History* (13) **2** (17): 309–320.

KOHN, A. J. 1960*b*. Spawning behaviour, egg masses and larval development in *Conus* from the Indian Ocean. *Bulletin of the Bingham Oceanographic Collection, Yale University* **17** (4): 1–51.

THIELE, J. 1910. Mollusca. B. Polyplacophora, Gastropoda marina, Bivalvia. *In:* SCHULTZE, L. *Zoologische und anthropologische Ergebnisse einer Forschungsreise im westlichen und zentralen Süd-Afrika ausgeführt in den Jahren 1903–1905* **4** (15). *Denkschriften der medizinisch-naturwissenschaftlichen Gesellschaft zu Jena* **16**: 269–270.

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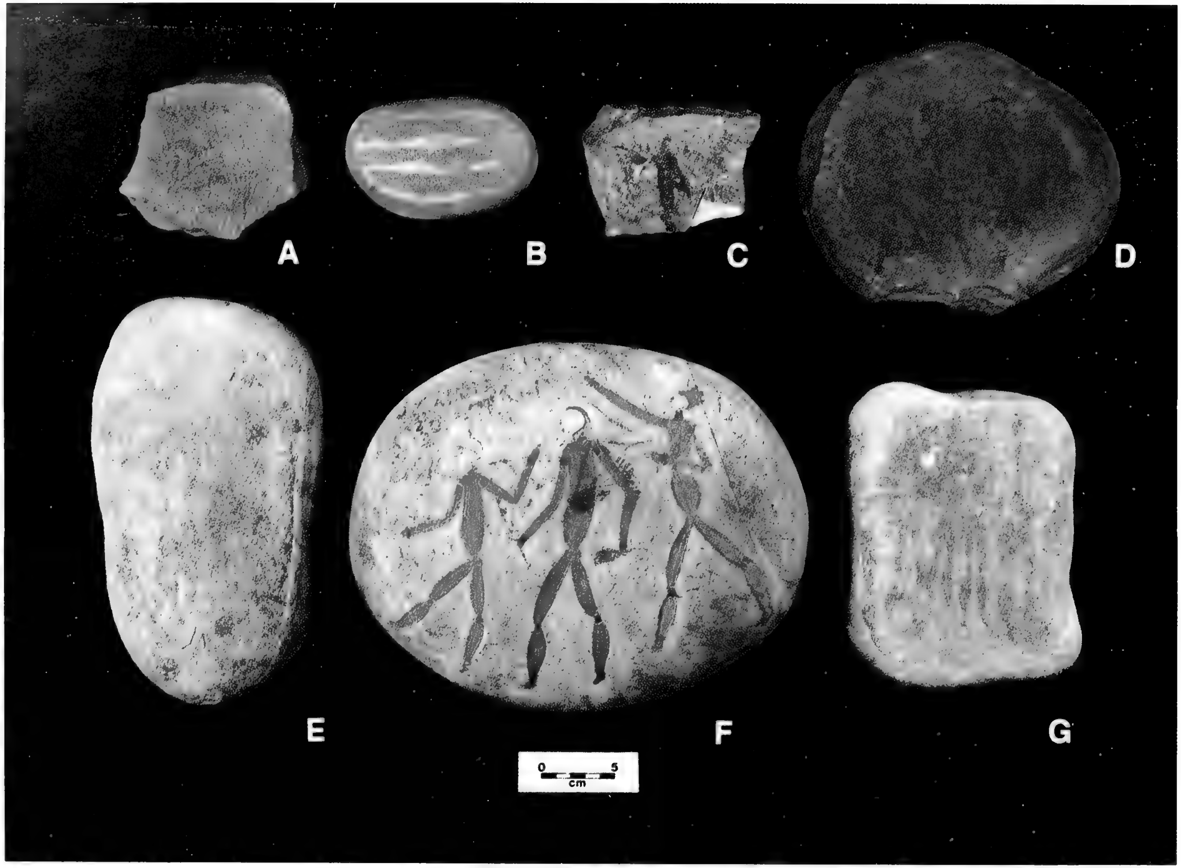

Fig. 1. Painted stones in the South African Museum's collections. A. SAM–AA8386, from the Eastern Head, Knysna. B. SAM–AA8778, from Klasies River Mouth Cave 5. C–D. SAM–AA8387, both from the Coldstream shelter. E. SAM–AA8778, from Klasies River Mouth Cave 5. F. SAM–AA6008, the 'Coldstream Stone'. G. SAM–AA6654, from Danielskraal, Calitzdorp district. (Photograph by W. J. J. van Rijssen).

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By

M. L. WILSON, W. J. J. van RIJSSEN
&
D. A. GERNEKE

Cape Town Kaapstad

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(With 10 figures)

[*MS accepted 23 July 1989*]

ABSTRACT

The South African Museum has in its collections an unusually well-preserved, polychrome painted stone recovered from archaeological deposits in the southern Cape Province.

Doubts have been expressed as to the authenticity of this artefact. Documentary research and micro-analysis of the paints indicate that, while there are a number of points that cannot be resolved, there is no evidence to refute the authenticity of the painting on the stone.

CONTENTS

INTRODUCTION

In 1911 a remarkable painted stone (Fig. 1F) was reported to have been found in association with a human burial during excavations in a rock-shelter near the mouth of the Lottering River on the southern coast of the Cape Province of South Africa, in what is now the Tsitsikama Coastal National Park (Fig. 2). To this day this artefact remains unique because of the unusual state of

Ann. S. Afr. Mus. **99** (6), 1990: **187–213**, 10 figs.

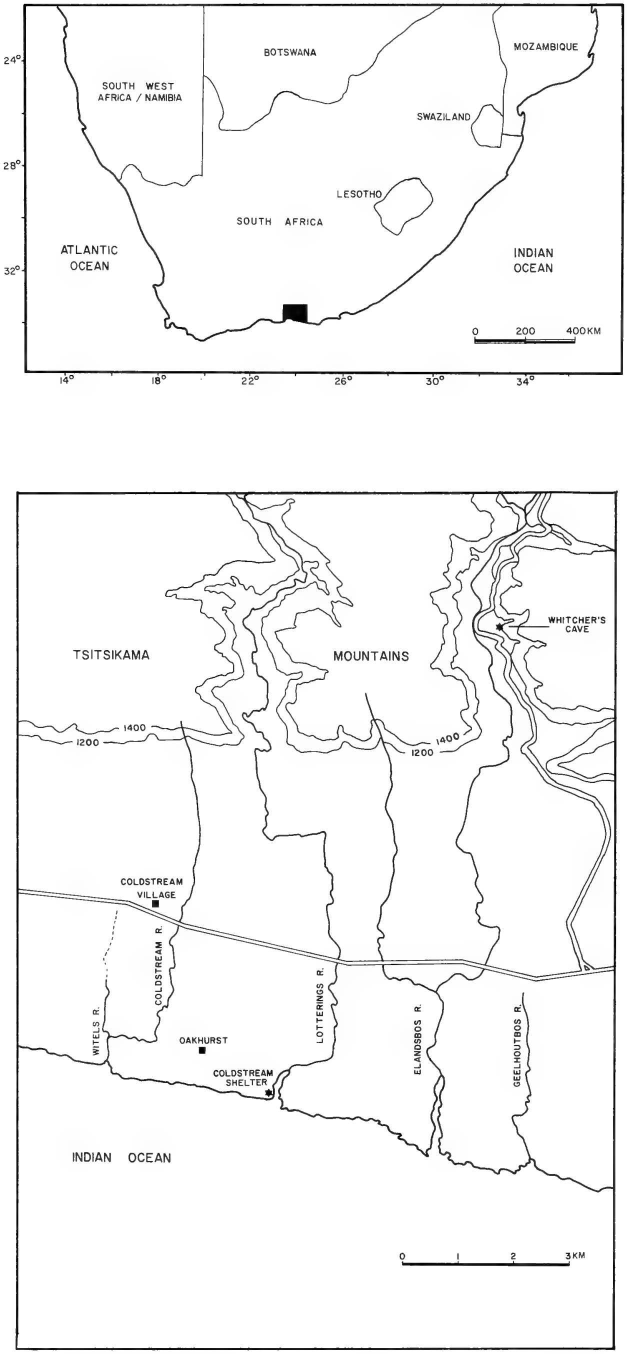


Fig. 2. Maps showing the location of the Coldstream shelter and Whitcher's Cave.

preservation of the painting and because it is the only known polychrome painted stone to have come from archaeological deposits in South Africa.

This stone, together with the associated skeleton, was on display in the South African Museum for a number of years. When the display was changed the stone was put for safe-keeping in the Museum's strong-room, stored in the wooden box made for its transport from Coldstream, and was seen by very few people, although a copy was later put on display in the Museum. The skeleton was integrated into the Museum's physical anthropology collections with the others excavated from the shelter but, unfortunately, can now not be identified.

In 1980, pending the removal of most of the Museum's staff and collections to temporary premises during building operations, the 'Coldstream Stone', as it has become known, was returned to the Archaeology Department's artefact collections, where it has since been seen more frequently by researchers. Sight of the stone itself and comparison of it with other painted stones in the Museum's collections, such as those shown in Figure 1, have raised doubts that anything so fragile as a painting could have survived in so remarkable a state of preservation, given that it was said to have been found in the damp deposits of a coastal rock-shelter.

Since it is clearly in the Museum's interest, as well as that of other researchers, to know whether or not this unique artefact is genuine, various lines of enquiry were followed. These included documentary research, micro-analysis of the paints and comparison with paints and pigments from other sources, and the opinion was sought of those who knew the excavator. These points are discussed below.

THE DOCUMENTARY EVIDENCE

The first record of the finding in South Africa of painted stones associated with human burials appears to have been a report by J. S. Henkel, Conservator of Forests at Knysna, to the then Director of the South African Museum, L. Péringuey. Henkel's correspondence cannot now be traced, but Péringuey wrote to him on 12 April 1909 'I never heard of painted stones or slabs placed above the head. I'll go further and say that nothing of this kind is known and your announcement took my breath away' (S.A. Museum Letter Book 1908–1910: 184).

Péringuey was obviously intrigued by Henkel's report and possibly stimulated by another letter from him, for he wrote to Henkel again on 7 July 'I have a group of, perhaps dancers, perhaps dead bodies judging from their attitude, painted on a small stone, found in one of the Knysna grottoes or caverns' (SAM Letter Book 1908–1910: 376). Again, on 18 December, he wrote to Henkel 'Hitherto painting or carving on stone could not be traced to these primitive people—I mean the Strand Looper—except however a small painting which is alleged, and I am sure rightly so, to have been found in a cave' (SAM Letter

Book 1908–1910: 835). The stone referred to is one found in 1872 by the son of a Mr Chevalier in a cave in the Eastern Head at Knysna, about two feet (0,6 m) below the surface (J. Rudner 1971: 54; see also Péringuey 1911: 162–163) and which is in the Museum's collections (SAM–AA8386—Fig. 1A).

Péringuey twice again referred to this stone in letters to Henkel the following year. On 12 May 1910 he wrote 'I have had a good deal of information regarding the contents of some of these caves in the Knysna–Plettenberg Bay coastal region and I thought we had the only painting, a monochrome, found there, until you told me of Witcher's [*sic*] discovery' (SAM Letter Book 1910–1911: 136). On 11 October he wrote 'The painting has been carefully preserved—it is a small fragment and had the painted stones of Coldstream not been found, I would have been left in doubt as to it having been detached from the sides or roof of the cave' (SAM Letter Book 1910–1911: 527).

C. J. Whitcher was the owner of a sawmill near the little village of Coldstream (Fig. 2) and of extensive tracts of indigenous forest in the surrounding area. He excavated in the shelter at the mouth of the Lottering River, one of several shelters on his property, possibly in 1908 but certainly early in 1909, making the discoveries referred to in Henkel's correspondence with Péringuey.

Péringuey (1911: 154–158) published excerpts from Henkel's correspondence in his seminal monograph on the Stone Ages of South Africa, in which Whitcher's excavations are described. Initially, Henkel emphasized 'You will observe from my account that there was no direct evidence to connect the stones decorated with drawings with skeletons, although in the first instance I was led to believe that this was so' (Péringuey 1911: 158). However, later in the same extract, Henkel confirmed from personal observation on 14 July 1909 that from one to three stones, none of them painted, were found overlying skeletons excavated during his visit.

Péringuey was extremely anxious to obtain for the Museum the artefacts and skeletons excavated by Whitcher, as well as to ensure that any future excavations were carried out systematically. Henkel negotiated with Whitcher on Péringuey's behalf for the purchase of the material and on 7 July 1910 Péringuey wrote to Henkel, acknowledging receipt of it and commenting 'The ostrich eggshell beads are interesting because found on the child, and the cockle necklace is next to the painted stone—the larger one—the interesting part of the collection' (SAM Letter Book 1910–1911: 271).

Péringuey's reference to 'the larger one' of the painted stones, implying as it does that two were received, calls for comment. In a paper on painted 'burial stones' from the Cape, J. Rudner (1971: 56) described four painted stones from the Coldstream shelter. Rudner's C1–3 are said to have been found by Whitcher and to have the accession number SAM–[AA]8387, whereas his C4, accession number SAM–[AA]6008, is the painted stone that is the subject of this paper. According to Rudner, 'C1 is a lower grinding stone with four human figures painted on a red background . . . C2 consists of a rough rock fragment with a black painting on the upper part carrying a long, probably cylindrical quiver and a bow . . . C3 originally contained four black figures of animals, but these have now disappeared'.

The Archaeology Department's accession register lists under SAM–AA8387 only two painted stones that, from Rudner's descriptions, are his C1 and C2. According to Péringuey (1911: 163), 'Mr Henkel reports that the third one became obliterated as soon as exposed to light'. It is thus possible that Péringuey actually received three stones, but omitted to mention the third, Rudner's C3, from which the painting had vanished and which was accordingly not accessioned as a painted stone.

The matter of the acquisition of Rudner's C1 (Fig. 1D) also calls for comment. On 12 April 1912 Péringuey wrote to Whitcher 'I should very much like you to loan me the tracing taken by Fourcade of the dancing women, on the stone found in the cave. Our copy has greatly faded and I want to re-touch it' (SAM file M–18–d). This seems a strange request if the Museum had acquired the stone itself in 1910. Moreover, Péringuey (1911, fig. 199) had published an artist's impression of the stone, coloured lithographs of which are still in the Museum's possession. However, Péringuey (1911: 163) observed of the painted stones from Coldstream 'They are fading so rapidly that we had a great difficulty in reproducing them'. He may therefore have considered that Fourcade's copy would provide a more accurate representation than could be obtained from the stone itself.

Whatever the case, it is evident from the foregoing that, up to the beginning of 1911, the only painted stones known to exist in South Africa were considered to be either monochrome: the Knysna Heads stone (Fig. 1A), or bichrome: the 'dancing women' stone (Fig. 1D) and the smallest of the three stones from the Coldstream shelter (Fig. 1C). It should be pointed out that, although—as mentioned above—Péringuey considered the Knysna Heads stone to be a monochrome, the black figures are painted on a red ochre background, as are the 'dancing women'.

Where Rudner's C2, the smallest of the Coldstream stones, is concerned, microscopic examination of what Rudner (1971: 56) described as 'a white mark . . . that . . . may be part of the picture' has shown that it is in fact white pigment, evidently depicting a bag, or possibly two, slung over the figure's shoulder. Samples of the pigments on this stone were included in the analyses discussed below.

Péringuey (1911: 163) did not at first consider that the 'hook-heads' of the figures in the 'dancing women' painting resulted from the loss of the white pigment used to depict the faces, a phenomenon now well known to occur in paintings on rock-shelter walls (Yates *et al.* 1985: 70; W.J.J.v.R. pers. obs.). He suggested that it might be a totem, but thought there was no doubt that it was 'a distinctive badge'. However, in the final chapter of his monograph, which deals with the Coldstream shelter and appears to have been written after the main body of his text, Péringuey (1911: 209), in describing the 'Coldstream Stone', commented 'The face is painted white and the crescent-shaped process . . .

which I took at first to be possibly the mark of a clan—stands for the hair and is black'. The conclusion is, therefore, that on the basis of the information then available, there was no reason to suppose that anything other than monochrome or bichrome painted stones would be found.

DRURY'S EXCAVATION

On 16 February 1911, on Péringuey's instructions, James Drury, the Museum's taxidermist (Fig. 3), started excavations in the shelter in which Whitcher had made his finds. The following are excerpts from Drury's field notes (SAM file M–18–d). In the interests of authenticity, the only alterations that have been made to Drury's text are the omission of certain passages that are not directly relevant and the separation of the daily information into paragraphs. The days of the week, written in the margin of Drury's notes, have been incorporated into the text.

'Mr Whitcher had dug out a part of the cave marked in sketch, he had got to a depth of 10 feet, so I dug another 2 feet found remains of Baby skeleton very badly preserved, and as I don't think skeletons or paintings can be of any use at that depth I gave up working and made a fresh start, at the back centre of cave as in sketch. I found the top layers sandy for a few inches then shells stones and refuse to a depth of just on 3 feet, then a layer of limy ground varying from an inch to 3 inches thick and so on in alternating layers of ashes earth lime and shells to a depth of about 4 feet 6 in. then the ground is brownish earthy and rather damp. . . .

Thursday. I started a section next to where Mr Whitcher had worked and am now working down to the same level as first section about 11 feet deep. . . . At a depth of 4 feet I found my first skeleton, no. 2 . . . their was no flat stones on top or side of him . . . this skeleton is very rotten (as I find all are) and I don't think it will be any good to go too deep. Next skeleton was a baby but as before too far gone, this was close to the above skeleton, then I found another just a little deeper . . . lying on right side with a stone on top this time but their was no trace of Paintings. All through we found lots of colouring substances but no trace of painting. I got charcoal, Red Ochre also Yellow Ochre but so far no white.

Friday. I started another section down and when nearly the end of the layer I found the second full skeleton and the most interesting find so far. I was having layers carefully removed when I saw back part of skull protruding out of ground so started to carefully work earth away all round with trowels and hands and in so doing found a large flat stone lying on shoulder, so with great care removed the earth from on top, and thus exposed was the finest Painting I have so far seen anywhere, and with great care got it cleaned of all dirt adhering and so removed to Mr Whitcher's house where I finished cleaning, their is three figures in colours and realy marvellous it is. The position of stone was flat on shoulder with feet end of figures next to the jaw of skeleton on painting side

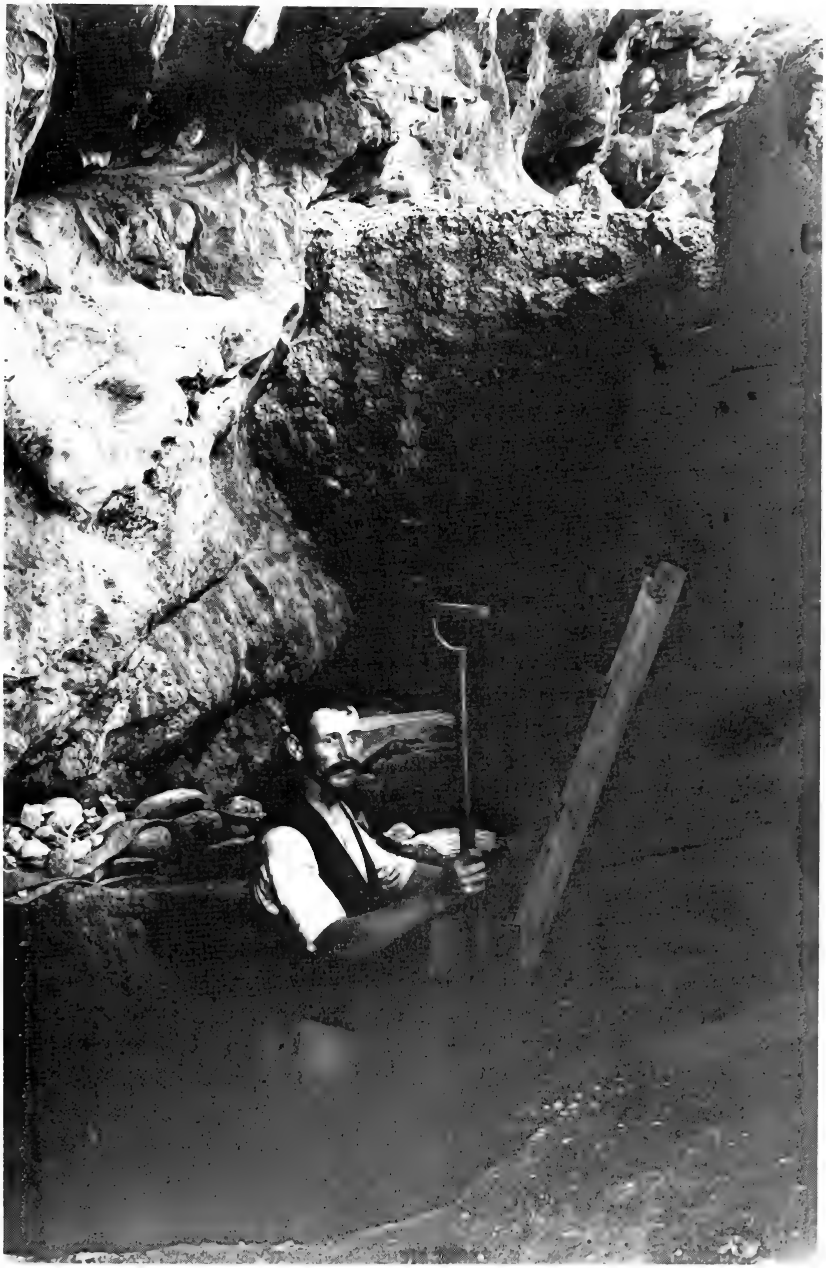


Fig. 3. James Drury excavating in the Coldstream shelter, February 1911.
(Photograph: S.A. Museum archives.)

up . . . there was a flat stone lying on hips of skeleton also but there were no tracings of Paintings . . . close by him I found for the first time two pieces of white clay which now gives all the colours found on painting, this clay was in a hole in rock just at back of where the painting was found. . . .'

Drury continued excavating until 28 February, removing the bulk of the deposits and finding a total of 28 skeletons. Some of the burials had stones associated with them, but none of them was painted.

According to J. Rudner (1971: 56) the skeleton with the painted stone was found at a depth of 6 feet (approx. 1,8 m). This is not stated in Drury's notes but the three sketches of burials that accompany his notes are, according to the captions, of the first three skeletons, that noted as having been found at a depth of 6 feet being identified as '2nd skeleton' and 'no. 10'. It will be seen above that on the Friday, Drury mentioned finding 'the second full skeleton' and Rudner's identification may thus be correct. None of the three sketches contains information about the placement of stones apart from a note that the first skeleton had 'no big stones on top' (SAM file M–18–d).

SUBSEQUENT HISTORY

As already mentioned, Péringuey (1911: 209, pl. 27) described the 'Coldstream Stone' in his monograph but illustrated only the other two painted stones from the site and the Knysna Heads stone. This tends to confirm that his chapter on the Coldstream shelter was a late addition to his manuscript and that he did not have time to have a plate prepared from an artist's impression, as was the case with the 'dancing women' stone. One was prepared at some stage and sent to Germany for the preparation of coloured lithographs, but due to the exigencies of the First World War these did not reach South Africa until after 1920 (R. Summers pers. comm. 1985). It was left to Haughton (1926) to publish the first illustration of the 'Coldstream Stone', after Péringuey's death in 1924.

Burkitt (1928, fig. 20) illustrated only the 'dancing women'. Goodwin (1929: 209, pl. 42), in discussing painted stones, merely remarked that 'Coldstream shows three female figures and a child' and illustrated a monochrome from the collections of the Port Elizabeth Museum (PEM 603). In a later monograph Goodwin (1946: 115–16) mentioned the coastal caves of the southern Cape and the 'amazing efflorescence of culture' of the area, which included painted 'gravestones'; and elsewhere in the same work (Goodwin 1946: 127) he discussed Péringuey's (1911) monograph. As mentioned above, the latter publication contains a description of the 'Coldstream Stone' though not an illustration of it. Goodwin must therefore have known of the stone's existence; and, as he was at that time honorary curator of the Museum's archaeological collections, he could accordingly be expected to have known of the stone's presence in the Museum's collections. Moreover, he sent a copy of the coloured lithograph to J. D. Clark (Clark pers. comm. to J. Deacon 1986). It seems, however, that Goodwin never published a reference to this unique artefact in the years remaining before his death in 1959. Goodwin's apparent failure to refer to the 'Coldstream Stone' in any of his prolific writings is a puzzling aspect of this case for which there is now no ready explanation. On the other hand, E. M. Shaw, until recently Head of the Ethnography Department, who started at the Museum in 1933, and in whose charge the archaeological collections were until the appointment of an archaeologist to the Museum's staff in 1967, has said (pers. comm. 1986) that it was many years before she became aware of the existence of the 'Coldstream Stone'; and it may be that it lay forgotten in the Museum's strong-room. (It was only accessioned in 1956.)

The 'Coldstream Stone', remarkable though it is, appears to have been ignored for more than thirty years after Haughton's publication, until Clark (1959: 214, pl. 15b) mentioned 'the magnificent painted stones of Coldstream' and included an illustration of the stone under discussion. Since then it has been described and/or illustrated by Woodhouse (1968, 1969, 1987, 1988 *in* Coertze *ed*. 1988 (unpaginated)), Lee & Woodhouse (1970), Rudner & Rudner (1970), J. Rudner (1971), Summers (1975), I. Rudner (1982), Lewis-Williams (1984) and Willcox (1984). None of these authors commented on the fact that this is the only known polychrome in the category of painted stones, and only J. Rudner (1971: 56) and Lewis-Williams (1984: 241) commented on the remarkable state of preservation of the painting.

PHYSICAL ANALYSES OF THE PIGMENTS

INTRODUCTION

The rarity and consequent importance of the painted stones impose severe restrictions on the size of the sample available for analysis. The sampling technique must be as little destructive as possible, which means that only small quantities of the paint may be removed. The paint is nowhere thick, with an estimated maximum of 100 μ; and this further affects the available size of the sample. Energy-dispersive X-ray (EDX) micro-analysis is thus the only technique available for this purpose.

Samples were obtained by placing a 5 × 5 mm piece of silver mylar tape (Scotch 3M 850 PAU333310) with the adhesive face down on to the painted area and rubbing the back of the tape with a small, blunt object. The effect of this sampling technique was minimal and the places from which the samples were removed cannot be detected with the naked eye. The pieces of tape were then glued to Cambridge 100 stubs and carbon coated, to an interference colour blue, in a Balzer's high-vacuum evaporator.

The paint and raw pigment samples were analysed using a KEVEX 7000 EDX system, interfaced with a Cambridge S180 scanning electron microscope. Standardized operating conditions were used for all the analyses. Conditions included a calibrated 15 keV probe, 38° take-off angle and a 20 per cent amplifier dead time. The electron optic parameters gave a probe current of $1{,}2 \times 10^{-9}$ amps. All the analyses were carried out using the same electron optic parameters so that spectra would be comparable, even though absolute values were not obtained.

EDX micro-analysis is capable of detecting any element having an atomic number greater than 11 (Na) and in practice the detection limit is about 0,1 weight per cent (wt %) in the analysed volume. The volume analysed depends on sample density, but is in the order of 0,08 mm^3 for a sample of density 8 g/mm^3 and using a 15 keV probe and a scanning electron microscope magnification of 1 000 × on the visual screen.

By measuring the intensity of X-ray emission for each element and comparing the experimental with the theoretical X-ray yield, the concentration of constituent elements can be determined. Unfortunately, the relative errors in this method of analysis can be high, particularly if the sample contains undetectable elements such as oxygen and carbon, and is not homogeneous and flat. The more satisfactory strategy involves direct comparisons of X-ray yield with similar accurate standards. The difficulties in this method are obtaining suitable standards, polishing the samples, and particle selection based on morphology.

For each sample the secondary electron image was observed and analyses carried out, initially using area mode (the probe scanned in a raster over an area of about 30 × 30 μ) on visually selected differences. Nine additional spot or area acquisitions (the probe stationary in one position) were undertaken on selected, morphologically similar particles or areas in order to establish the nature of the sample and to determine the average concentration of detectable elements. In selecting the area or spot for acquisition, the probe was carefully positioned to assist in minimizing topographical, refluorescence and interaction volume errors. In this connection, it must be pointed out that, although the samples analysed were small, because they were almost without exception not homogeneous, probes that, for example, included a grain of sand would yield results very different from that of pure ochre. The raw pigments may have been ground on a quartzite grindstone, using a muller of the same material, which would introduce foreign material. The pigment was mixed with some sort of binder and probably liquefied with additional fluid, both of which would introduce more foreign elements.

Incontrovertible factual information regarding the nature of the binders used in rock paintings is not available, although much has been written about these, and a number of experiments carried out by various researchers. I. Rudner carried out extensive documentary research and fieldwork in regard to Khoisan paints and pigments and their relationship to rock paintings, and concluded (I. Rudner 1982: 264) that there is virtually no primary information regarding the nature of the binders used, and that very little of what is available can be considered as reliable. She was particularly sceptical of the claim by Denninger (1971) that a number of binders had been identified by means of paper chromatographic analysis of the constituent amino-acids (I. Rudner 1982: 33–34).

The results of the five analyses of each sample that were most similar were averaged and are presented in graphic form in Figures 4–10 as weight per cent (wt %) of the elements detected in the analysed volume, normalized to 100 per cent. Since the samples are not homogeneous and averages were used, the results *characterize* the samples rather than provide precise, absolute determinations of their constituents.

When studying the results of the EDX analyses given below, it must be borne in mind that none of the samples can be considered as chemically pure. They have all been subjected to various taphonomic processes: adsorption, absorption, and leaching of material, in addition to the other forms of contamination mentioned above. It should also be remembered that silicon (Si) and aluminium (Al) are the two most common elements in the earth's upper crust (hence its name, sial). For the purposes of these analyses, the presence of these elements should be considered as 'noise' and, for the most part, irrelevant.

Included in the small collection of non-skeletal material Drury retained from his excavation (SAM–AA1378, AA1379) are a few pieces of ochre as well as one of the pieces of 'white clay' that he recorded (see above) as having found in the deposits. It was therefore decided to analyse samples of these as well as of the paint on the 'Coldstream Stone' and, where necessary, to compare the results with those of other paints and pigments. Because of a lack of concordance between the results of the analyses of the various white and black pigments in the earlier series of analyses, samples of marine shell and burnt animal bone were also analysed.

There is too little black paint left on the 'dancing women' stone (Fig. 1D) to allow for analysis, and the red ochre background is also a complicating factor. Samples of the black and white paints from the smallest of the three stones from the site (Fig. 1C) were, however, included in the analyses.

RED PAINTS AND PIGMENTS

Four samples of red paint from the 'Coldstream Stone' were analysed, and two of unprocessed ochre from the excavation that visually matched the light red and dark red paints most closely. The results are shown in histogram form in Figures 4–6.

The light red paint from the front (left) figure (Fig. 4A) has less iron (Fe) and lower frequencies of the minor elements (S–Ti) than the dark red paint from the central figure (Fig. 4B); otherwise these two samples are broadly similar.

Both the light red ochre from the excavation (Fig. 5A) and the dark red (Fig. 5B) have very little iron by comparison with the frequencies in the paints (Figs 4A–B) and are generally dissimilar to the paints in most respects. The light red ochre lacks five of the minor elements present in the dark red. These minor elements in the latter may be the cause of its darker colour.

Figure 6A is the analysis of the light red paint from the front leg of the last (right) figure and Figure 6B that from the back leg. It is immediately evident

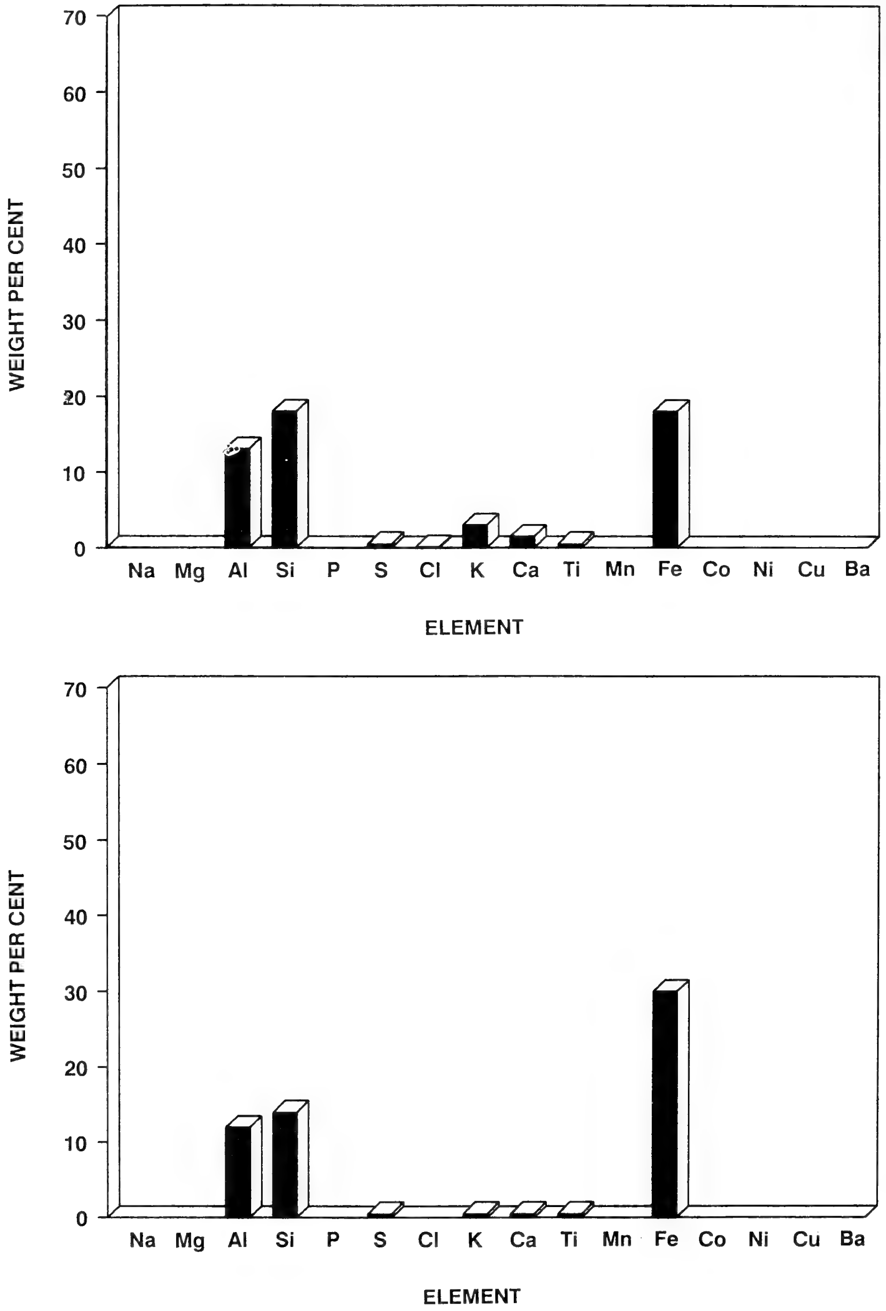


Fig. 4. Histograms of amounts (wt%, normalized to 100%) of elements detected in paint samples. A. Light red paint from the 'Coldstream Stone'. B. Dark red paint from the 'Coldstream Stone'.

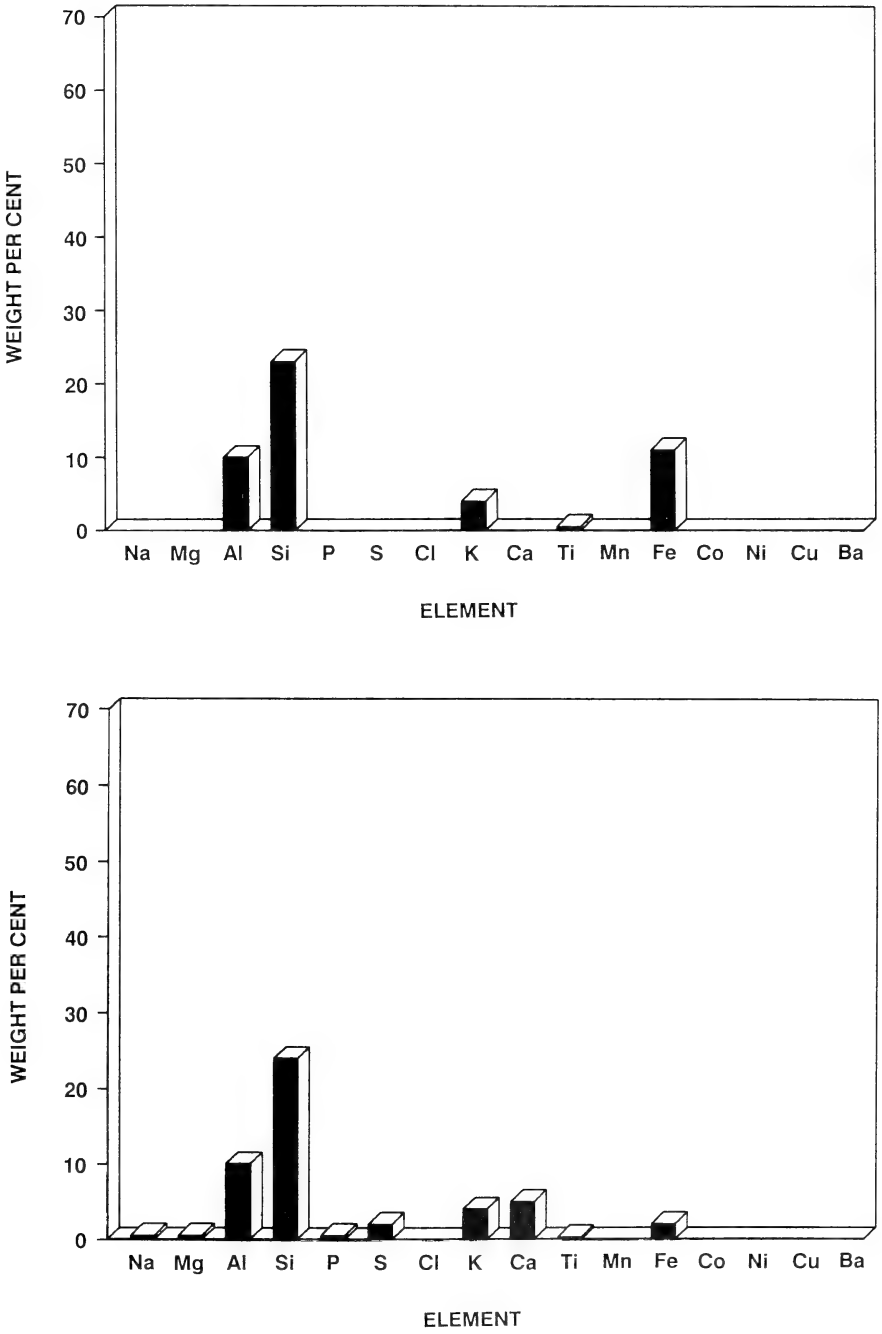


Fig. 5. Histograms of amounts (wt%, normalized to 100%) of elements detected in pigment samples. A. Dark red ochre from the excavation. B. Light red ochre from the excavation.

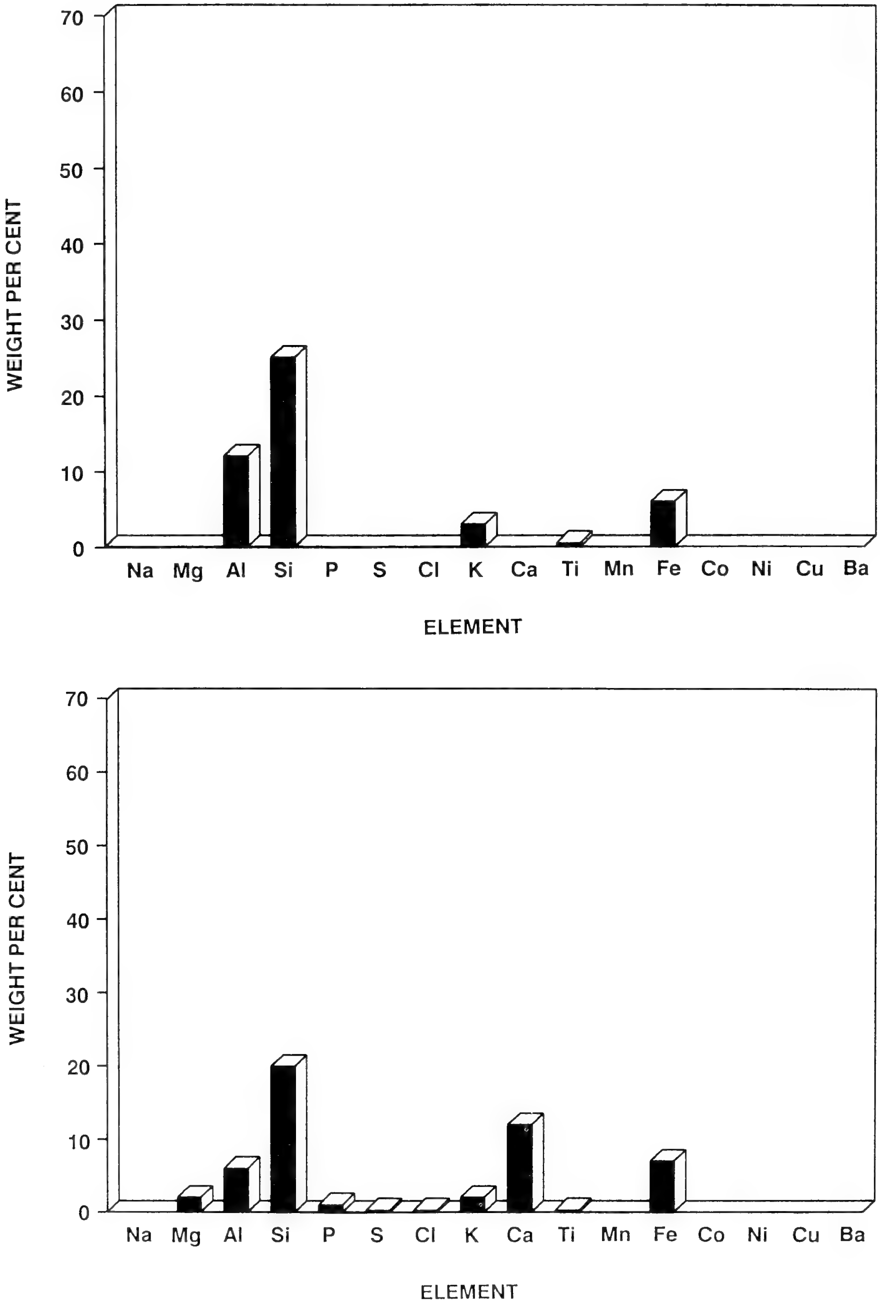


Fig. 6. Histograms of amounts (wt%, normalized to 100%) of elements detected in paint samples. A. Light red paint from the front leg of the last (right) figure on the 'Coldstream Stone'. B. Light red paint from the back leg of the same figure.

that the two samples differ considerably from each other and from those of the other two figures. The paint from the front leg is similar to that of the light red ochre from the excavation (Fig. 5A), although this contains only about half as much iron. The presence of a relatively high frequency of calcium (Ca) in the sample from the back leg is not easy to explain. Unlike the front leg, there is no white paint on the back leg, which is, however, outlined in black on its front (Fig. 1). A possible source of the black paint used on the 'Coldstream Stone', and thus of the calcium in this sample, is given below.

WHITE PAINTS AND PIGMENTS

Samples of white paint from the face of the central figure on the 'Coldstream Stone' and the white bag(?) carried by the figure on the smallest painted stone from the site were analysed, as was a sample of the white 'clay' Drury reported as having found in the excavation. The presence of a high frequency of calcium in the samples could not be explained, particularly as one of the samples analysed for comparative purposes (but not included here), from a mural painting in the Transkei, only contained a minimal amount of calcium (approx. 6%). A sample of calcined marine shell from an excavation in the southern Cape was therefore also analysed. The results of these analyses are shown in Figures 7–8.

The paint from the 'Coldstream Stone' (Fig. 7A) and that from the smallest stone (Fig. 7B) differ only in the amount of calcium present and in the presence or absence of various minor elements. The white 'clay' (Fig. 8A) has considerably less calcium than the paint samples, partly because of the increased presence of other elements. Examination of this material under a standard binocular microscope indicated that it is not clay but an agglomerate of calcined material that includes marine shell, sand and other unidentified material.

Because of uncertainty as to the precise nature of the white paint, a sample of calcined marine shell, brown mussel *Perna perna*, without its periostracum, was also analysed (Fig. 8B). Despite differences caused by the presence or absence of small amounts of minor elements in the two paint samples, the result of the shell analysis strongly suggests that shell was the pigment used for the white paint on both stones. It also tends to confirm that the white 'clay' is probably a lump of calcined shell with other admixtures. Another possibility, eggshell, which is also rich in calcium, was considered later but not tested.

BLACK PAINTS AND PIGMENT

Samples of black paint from the quiver or bag held by the central figure on the 'Coldstream Stone' and from the figure on the smallest of the stones from the site were analysed. The results of these were compared with that of black paint from a mural rock painting in the Cedarberg Mountains of the western Cape. As will be seen below, this bore no resemblance to the paint on the two stones. On the basis of the discovery that the white paint on these stones had probably been made from calcined shell, it was decided to analyse a fragment of

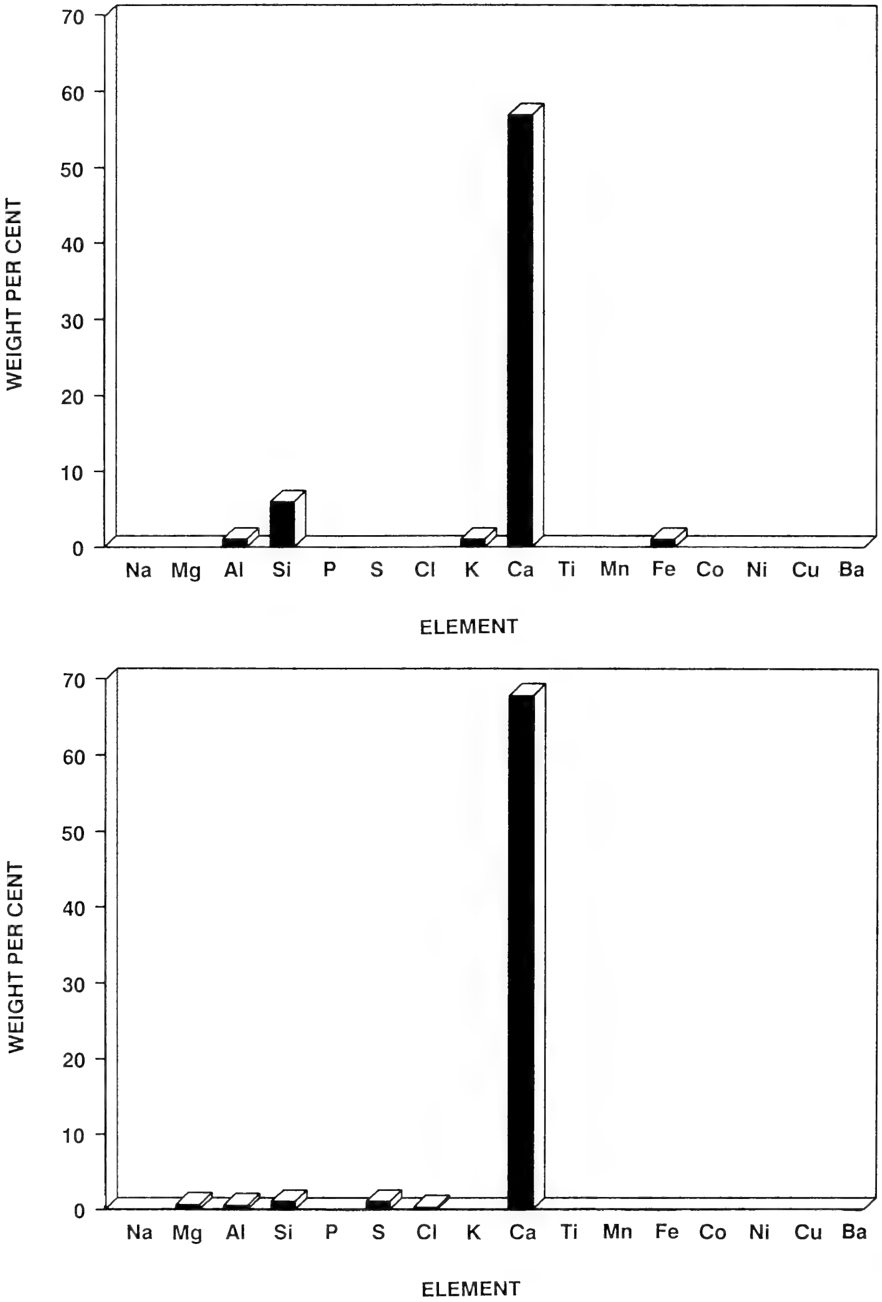
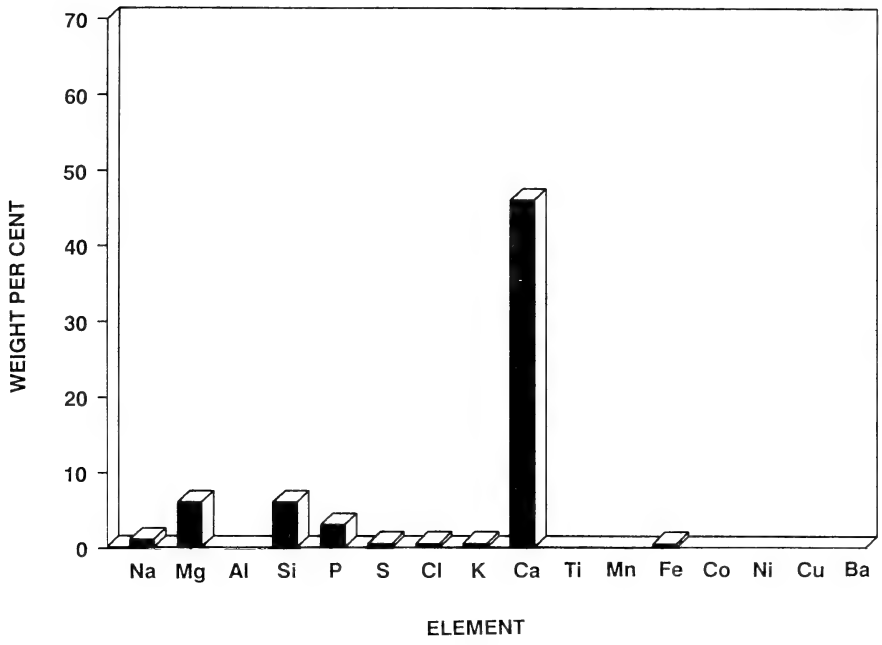


Fig. 7. A. Histograms of amounts (wt%, normalized to 100%) of elements detected in paint samples. White paint from the 'Coldstream Stone'. B. White paint from the smallest of the painted stones from the Coldstream shelter.



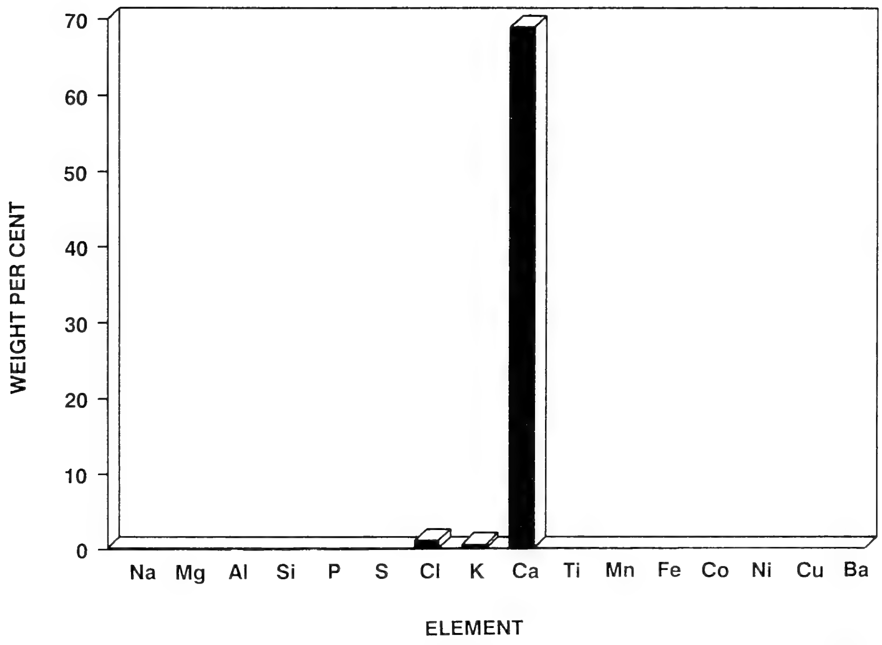


Fig. 8. Histograms of amounts (wt%, normalized to 100%) of elements detected in pigment samples. A. White 'clay' from the excavation. B. Calcined marine shell.

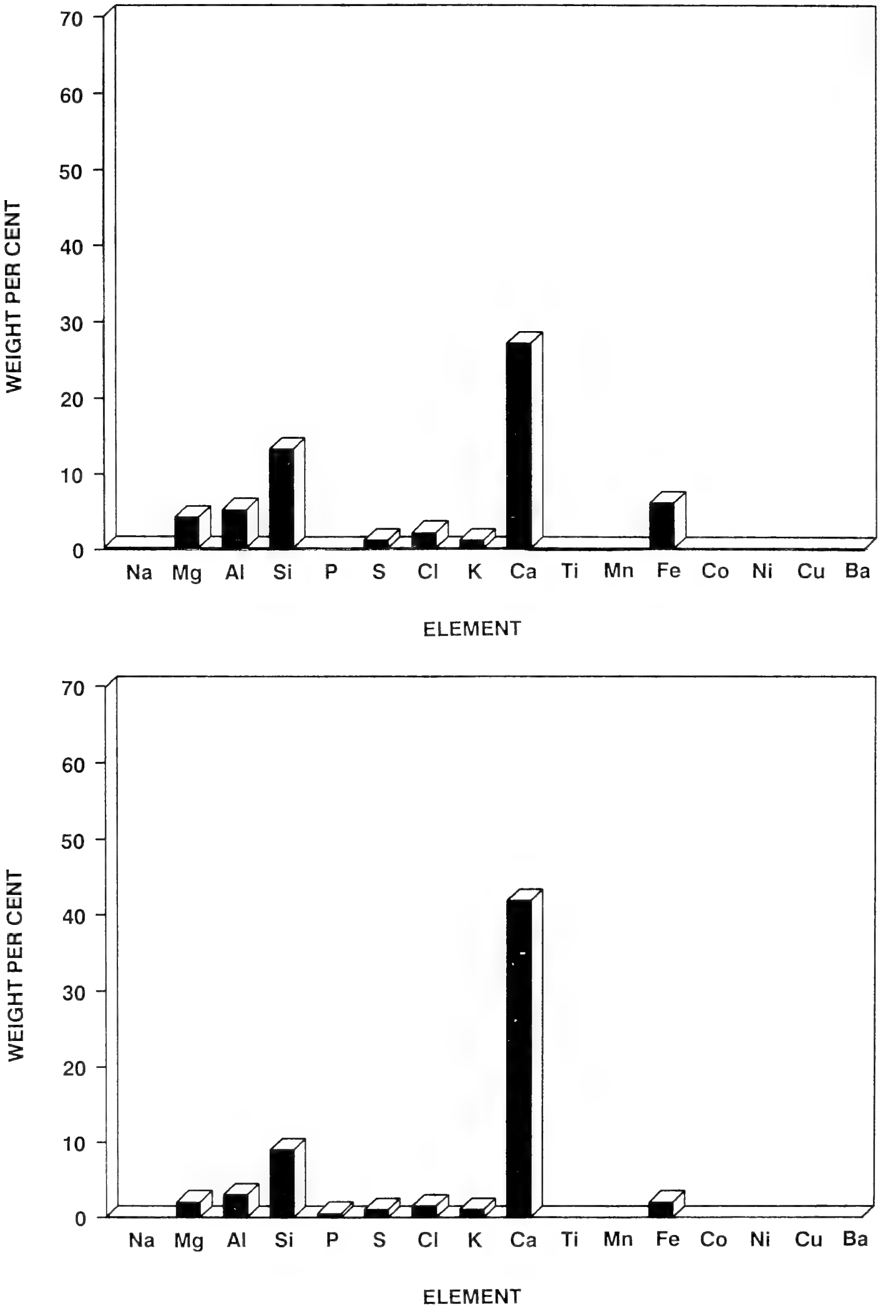


Fig. 9. Histograms of amounts (wt%, normalized to 100%) of elements detected in paint samples. A. Black paint from the 'quiver' of the central figure on the 'Coldstream Stone'. B. Black paint from the smallest of the painted stones from the Coldstream shelter.

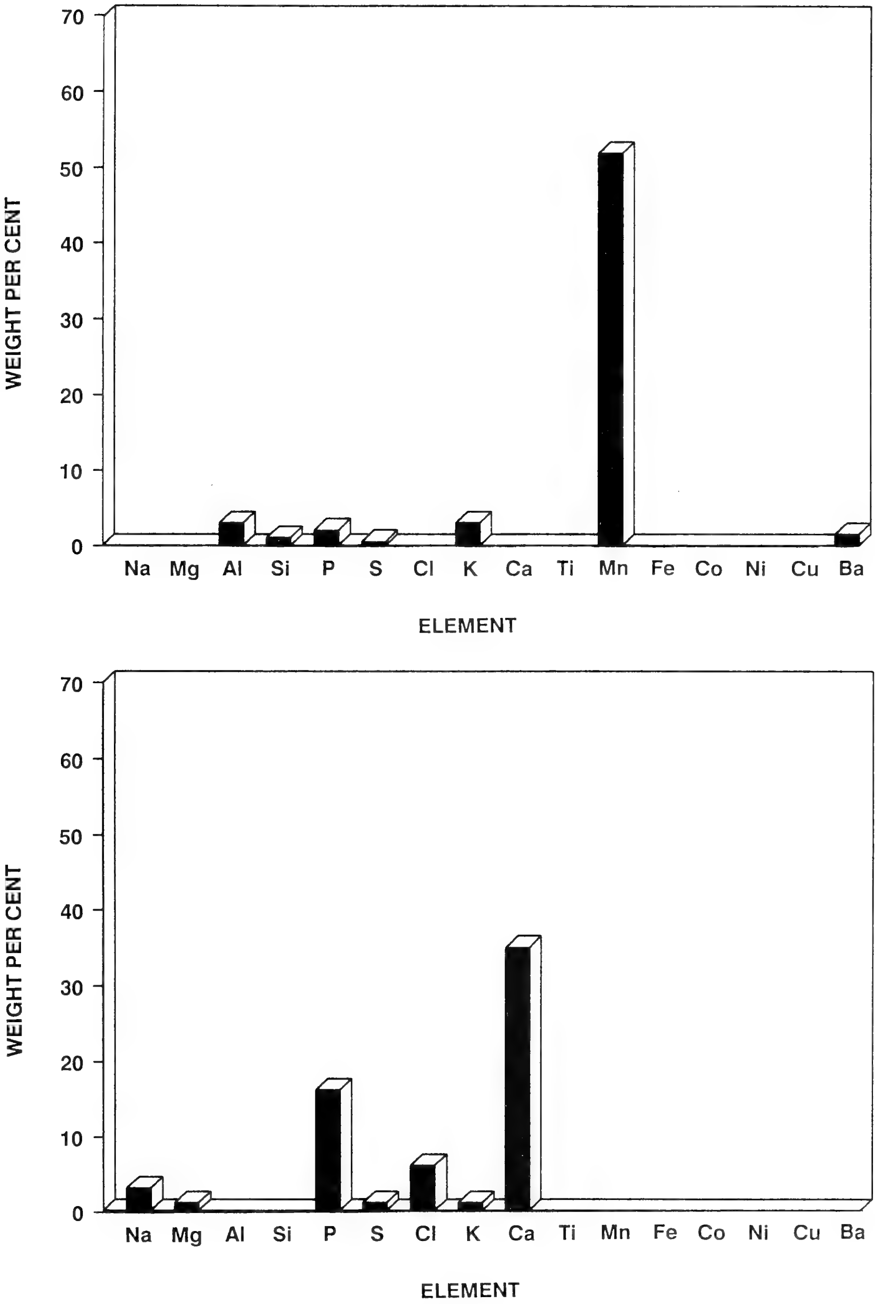


Fig. 10. Histograms of amounts (wt %, normalized to 100 %) of elements detected in paint and pigment samples. A. Black paint from a rock painting in the Cedarberg. B. Burnt mammal bone.

burnt mammal bone, also from an excavated site in the southern Cape. The results of these analyses are given in Figures 9–10.

The large amount of calcium in the paint from the 'Coldstream Stone' (Fig. 9A) and from the smallest of the painted stones (Fig. 9B) was surprising, especially when these were compared with the paint from the Cedarberg rock painting (Fig. 10A), which consists mostly of manganese (Mn), a substance often found in nodular form in archaeological deposits, and common in the sandstones of the Table Mountain Group. Since it was known that carbon, an organic element that is used to prepare samples for electron microscopy, would not register in the EDX analyses another source of the black pigment was sought: burnt bone. Although the result of this analysis (Fig. 10D) shows differences from the paint on the two stones from the Coldstream shelter in the presence or absence of a number of minor elements, and differences in the frequency of others, the burnt bone sample is more like the two Coldstream paint samples than any of the three are like the Cedarberg paint sample. Although these analyses have not demonstrated conclusively that the black paint was made from burnt bone, they do show that the pigment used was not derived from a manganese-based compound.

DISCUSSION

As mentioned in the introduction to this section, EDX analysis is at present the only feasible method of analysing very small samples of paint from rock paintings. The method has its limitations in that it cannot identify all the constituents of the paints and, because of their lack of homogeneity, cannot identify them precisely.

However, given these limitations, the analyses have shown that it is possible to characterize paints and raw pigments to a degree that enables it to be determined whether any two samples are alike or not. Moreover, as was shown in the cases of the white and black paints, it is possible to identify possible, even probable, sources of the pigments from which the paints were made. The analyses have therefore proved useful in the investigation of the 'Coldstream Stone'.

THE STYLE OF THE PAINTINGS

The figures on the 'dancing women' stone (Fig. 1D) are now only barely visible, but examination of the coloured lithograph in the Museum's possession (see Péringuey 1911, fig. 199; Burkitt 1928, fig. 20, etc.) shows that, in general, they differ from the figure on the smallest stone only in having 'hook-heads' and in being more robust. This latter aspect may be a consequence of the different sizes of the paintings, though this is not true of the larger 'Coldstream Stone'. In general, however, figures of women in rock paintings are more amply proportioned than those of men (W.J.J.v.R. pers. obs.).

The 'hook-heads' of the 'dancing women' provide a stylistic link with the figures on the 'Coldstream Stone': were the men's white faces to disappear, they would be left with 'hook-heads'. That apart, the stylistic differences between the paintings on the three stones from the Coldstream shelter are marked. The 'Coldstream Stone' appears to have the most elaborate style of the three, but it should be borne in mind that the painting of the 'dancing women' is now only a faint vestige of what it was originally.

The style of the painting on the two smaller stones is closer to that of the figures in the mural paintings in Whitcher's Cave and the small shelter above it (Woodhouse 1966) than to that of the 'Coldstream Stone'. However, the Whitcher's Cave paintings are in red only and do not have 'hook-heads' indicative of the loss of the white paint used for the faces on the 'Coldstream Stone' and, probably, the 'dancing women' stone. Whitcher's Cave is in the southern foothills of the Tsitsikamma Mountains, some 10 km north-east of the Coldstream shelter (Fig. 2), and is the closest known site with mural rock paintings.

Relatively little has been published about the rock art of the southern Cape, but L. Abel, who has studied the art of the area and has seen an illustration of the 'Coldstream Stone', is of the opinion (pers. comm. 1985) that the style of the painting on the stone is similar to that of mural rock paintings in the Langkloof and in the Willowmore district, which are to the north of the Tsitsikamma range. Rudner & Rudner (1970: 126) found the figures on the stone reminiscent of some of those in the mural paintings on Kriedouwkrantz Hill, which is in the Clanwilliam district of the western Cape Province.

Since there is no information as to the stratigraphic provenance of the painted stones from the Coldstream shelter, even their relative chronology cannot be established. The most that can be said, then, is that their styles fall within the range of painting styles of the rock art of the area.

The last figure on the 'Coldstream Stone' differs from the other two figures in some respects. In these, the body and limbs were sketched in white before the red paint was applied, and the lower part of the bodies as well as the front of the legs were outlined in black. In the last figure, only the front leg and the lower part of the body were first sketched in white and the black outlining was extended to the back of the trunk and to the back of the rear leg. Parts of this figure, and particularly the rear leg, have the appearance of having been retouched, a suggestion that is reinforced by the differences indicated above in the element composition of the paint on the two legs.

DISCUSSION AND CONCLUSIONS

Discussing the 'Coldstream Stone', Lewis-Williams (1984: 241) commented 'The extraordinarily good preservation of the painting on this stone, coming as it does from a rather damp cave deposit, has led some workers to question its authenticity. Two possibilities exist: Either the stone is a complete forgery, or it has been considerably touched up. The second of these possibilities may be correct because it seems unlikely a forger in 1911, when the stone was found, would have known about some of the details in the painting and because, if it had been touched up, the workers of that time may not have considered it necessary to record their restoration'. The details Lewis-Williams referred to are those such as the red lines across the faces, which he interpreted as stylized depictions of nasal haemorrhage induced during trance performance, rather than the purely technical details such as the style and manner in which the painting was executed.

The possibility that the painting was touched up subsequent to its discovery seems unlikely. The present condition of the paint is not uniform, most of the black, in particular, having all but disappeared. If any touching up was done, it seems most likely to have been of the rear leg and lower part of the body of the last figure; but if this was so, it was a clumsy attempt at restoration to have outlined the back of the trunk and leg in black when the back of the front leg is outlined in white, as are the legs of the other figures. Moreover, had it been the practice to restore such paintings, this would surely have been done to the 'dancing women' stone which, as mentioned above, was in a very poor condition as early as 1912. At some time, attempts were made to preserve some of the Museum's other painted stones, notably those from the caves on the Robberg Peninsula at Plettenberg Bay (SAM–AA2822 to AA2828), by covering them with clear varnish. This has now discoloured to the extent that some of the paintings are almost obliterated, and it is fortunate that the painted stones from Coldstream, whatever their present condition, were not subjected to this treatment.

Discussing the painted 'gravestones' of the southern Cape, Battiss (1948: 93) commented 'It is difficult to examine the paintings on these gravestones for so many are in a very poor state of preservation. In a letter to me Mr A. J. H. Goodwin writes: "The many gravestones from Robberg have almost been destroyed. This was owing to the way in which the paint was forced out of the stone by the efflorescence of salt crystals and so formed a fine impalpable powder—just like a pastel"'. The Robberg Peninsula is some 35 km west of the Coldstream shelter and in the same general environment, although the Coldstream shelter is higher above sea-level than some of the Robberg caves from which the painted stones were recovered, and better protected by vegetation from wind-blown salt spray. The shielding vegetation does, however, enhance the dampness of the shelter's deposits (M.L.W. pers. obs.).

There is no indication on any of the three painted stones from Coldstream of any crystalline efflorescence, nor any indication of the paint having been forced out of the stone by such action. On the contrary, most of the paint is retained in the pores and other surface irregularities on the stones. The same is true of the painted stones from Klasies River Mouth Cave 5 (Fig. 1B, E; Singer & Wymer 1982, figs 48–49) as well as the other painted stones in the Museum's collections. The painted stone from a rock-shelter in the Caledon River Kloof, on the farm Danielskraal in the Calitzdorp district (Fig. 1G), has a calcareous accretion on its sides and base, but it is the only one of the painted stones in the

Museum's collections that shows any such damage, perhaps excluding those from Robberg already mentioned, which were subjected to preservative treatment. The Danielskraal painted stone was one of two found on the floor of the shelter, the deposits having been washed away (J. Rudner 1971: 57).

The differential preservation of the painting on the three painted stones from the Coldstream shelter may be explained partly by differences in the nature of the pigments and/or binders used, partly by the nature of the rock surface on to which they were painted, and partly by differences in the way in which the artefacts were handled during and after excavation.

The nature of the binders clearly has some bearing on the way in which the paint adheres to its stone base. In the absence of any clear information in this regard, however, and particularly with regard to the painted stones from the Coldstream shelter, it is not possible to enter into any discussion on this subject.

It will be seen that, in the examples illustrated in Figure 1, red is the colour that is generally best preserved, followed by white, and with black least well preserved, although in the case of the 'dancing women' stone the white has completely disappeared, leaving only 'hook-heads'. In the case of mural rock paintings, the order in which paints are best preserved is generally red, yellow, black and white (W.J.J.v.R. pers. obs.; see also Yates *et al.* 1985: 70). This makes it the more surprising that white is better preserved than black on the 'Coldstream Stone'. This may have to do with the use of different types of pigments in different areas.

The 'dancing women' are painted on a lower grindstone, the surface of which is accordingly smoother than that of the 'Coldstream Stone', although this is a small water-worn boulder. The smallest of the three stones is an irregular piece of cave rock, quartzite like the others, but with a more uneven surface. The different surface textures almost certainly play a part in the retention of the paint on its base.

From the information Henkel gave Péringuey, the 'dancing women' stone may have been the first found by Whitcher who, being unaware of the existence of such artefacts, may not have handled it as carefully as he did the other two painted stones, although the third was left exposed to the weather. Drury began his excavation in the knowledge that painted stones might be found, and he would accordingly have treated any stones he found very carefully, as his field notes in fact reveal he did when the 'Coldstream Stone' was found. Figure 3 shows that the stones and other material from his excavation were laid on sacking.

One of the aspects of Drury's field notes that seemed suspicious was his mention, the day before making his great discovery, of finding red, yellow and black pigments in the deposits 'but so far no white'. In this, he seems almost to have anticipated the discovery of a polychrome painted stone. It must be stated again, however, that the smallest of the three painted stones obtained from Whitcher is a black and white bichrome, and was already in the Museum's possession. As discussed earlier, Drury had no reason to suspect the existence of polychrome painted stones, the only three painted stones known before his discovery being monochromes or bichromes. Moreover, yellow ochre, one of the pigments he mentioned, appears not to have been used in the painting. He would, on the other hand, have known that polychrome mural paintings existed, as indicated by the comment in his field notes given above, that this was 'the finest Painting I have so far seen anywhere'. The Museum's earliest other acquisition of polychrome paintings, two pieces of a large slab from a mural painting in a cave on the farm Zamenkomst in the Maclear district of the eastern Cape (SAM–AA1617), was only obtained in 1912 (SAM Antiquities Register: 93).

If Drury were the perpetrator of a forgery, the logistics of this act, though not insuperable, would have been considerable. The stone on which the painting was done measures 300 × 240 × 90 mm and weighs 8,5 kg. Had Drury prepared the stone in Cape Town, he would have had to take it with him on the train journey to Assegaibosch, and thence by cart on the close on 70 km journey to Coldstream. He stayed with Whitcher at the latter's home, 'Oakhurst', which is about 5 km from the shelter (Fig. 2), and even though Whitcher gave him the use of a cart, its closest access to the shelter was about a mile (1,6 km) from the site (SAM file M–18–D). Drury would thus have had to transport the stone to Coldstream, get it into and out of Whitcher's house and then to the site, all unnoticed by Whitcher, who probably accompanied him to the shelter on at least the first day.

An alternative possibility is that Drury painted the stone at the site. He could have obtained the stone from the site: as mentioned above, he found a number of unpainted stones in the deposit (see Fig. 3, behind Drury); or he could have brought it up from the beach, some 20 m below. He could have used some of the pigments he recorded as having found in the deposit, although this is somewhat negated by his record that it was only *after* he had found the painted stone that he found two pieces of 'white clay' in a niche in the shelter wall behind the burial. In this case, Drury would almost certainly have had to bring a drawing, or drawings, with him, that he could use to copy on to the stone. He employed four labourers, who would have been witnesses to this action, as well as to his 'salting' of the deposit, or to his pretence that he had found the stone on the shoulder of the skeleton, as he reported.

While neither of these scenarios is beyond the bounds of possibility, both tend to seem far-fetched, and to credit Drury with remarkable deviousness. The strongest argument that can be advanced against Drury's having done the paintings is the evidence provided by the analyses of the paints and pigments. These indicate, with a high degree of probability, that the white paint was made from ground shell and the black from burnt bone. Drury thought that the white material he found at the back of the cave after he had found the painting was clay; and he said in his field notes that charcoal was the black colouring material. It seems highly unlikely that he would have considered that shell or bone could or would have been used as pigments. That there is a close match between the light red ochre from the site and the paint on the front leg of the last figure but not on the back leg, which is the one that might appear to have been retouched, seems to provide further support for the argument that Drury was not involved in either the painting or the retouching. Since the red colour of the first and last figures is visually similar, and different from that of the central figure, it seems more logical to have used the same pigment for both. The retouching could well have been done before the stone was buried.

Apart from the fact that Drury made numerous plaster casts of rock engravings, some from as far afield as Namibia, nothing is known of his interest in, or knowledge of, rock art. He joined the Museum in 1902 but, although Péringuey is known to have had a high regard for Drury's craftsmanship in the fields of taxidermy and life-casting (Summers 1975: 103), the touching-up of the photographic negatives Péringuey used in his monograph was done by A. R. Walker, one of the Museum assistants (Péringuey 1911: 163); and he commissioned a local artist, G. M. Winkles, to prepare the copies of the 'Coldstream Stone' and the 'dancing women' stone from which the coloured lithographs were later prepared (Summers 1975: 107). It may be that Péringuey did not consider Drury's artistic abilities, even as a copyist, to be adequate for such a task. There is, too, no evidence that Drury spent any time in the southern Cape, although it is possible that he may have done so during the Anglo-Boer War, which brought him to South Africa from Scotland (Summers 1975: 103).

Although Drury had a reputation for eccentricity and secretiveness (Summers 1975: 128), E. M. Shaw (pers. comm. 1985) and R. H. N. Smithers (1985 *in litt.*), both of whom knew him for many years, stressed that he was a man of the highest integrity. Smithers also mentioned that Drury was a meticulous worker who would probably have taken greater care in the execution of the painting had he done it; and here the anomalous treatment of part of the last figure may be mentioned again.

Presumably, the reason for anyone wanting to perpetrate such a forgery would be to acquire, or share in, the prestige attaching to such a spectacular 'discovery'. In the event, the 'Coldstream Stone' did not arouse international interest, and appears to have been ignored, even locally, for nearly 50 years, apart from Haughton's (1926) publication. Although Péringuey was an entomologist by profession, rather than an archaeologist, there can be no doubt that he would not have allowed the stone to be exhibited if he had had even the slightest suspicion about its authenticity. There is, moreover, no indication that, until recently, the genuineness of this artefact has been doubted by any of those who have seen it, and then only on the grounds of the remarkable state of preservation of the painting.

The conclusion to be drawn is that, although this investigation has shown some lacunae, if not enigmas, in the documentary evidence, the pigment analyses strongly suggest that Drury was not the author of the painting, nor responsible for the retouching. The remarkable state of preservation of the paint on the stone must be considered a taphonomic problem for which there is at present no ready answer. Ultimately, however, the evidence yielded by this investigation suggests that there are no grounds for doubting the authenticity of the painting on the 'Coldstream Stone'.

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6. SYSTEMATIC papers must conform to the *International code of zoological nomenclature* (particularly Articles 22 and 51).

Names of new taxa, combinations, synonyms, etc., when used for the first time, must be followed by the appropriate Latin (not English) abbreviation, e.g. gen. nov., sp. nov., comb. nov., syn. nov., etc.

An author's name when cited must follow the name of the taxon without intervening punctuation and not be abbreviated; if the year is added, a comma must separate author's name and year. The author's name (and date, if cited) must be placed in parentheses if a species or subspecies is transferred from its original genus. The name of a subsequent user of a scientific name must be separated from the scientific name by a colon.

Synonymy arrangement should be according to chronology of names, i.e. all published scientific names by which the species previously has been designated are listed in chronological order, with all references to that name following in chronological order, e.g.:

Family **Nuculanidae**

Nuculana (Lembulus) bicuspidata (Gould, 1845)

Figs 14–15A

Nucula (Leda) bicuspidata Gould, 1845: 37.
Leda plicifera A. Adams, 1856: 50.
Laeda bicuspidata Hanley, 1859: 118, pl. 228 (fig. 73). Sowerby, 1871: pl. 2 (fig. 8a–b).
Nucula largillierti Philippi, 1861: 87.
Leda bicuspidata: Nicklès, 1950: 163, fig. 301; 1955: 110. Barnard, 1964: 234, figs 8–9.

Note punctuation in the above example:
comma separates author's name and year
semicolon separates more than one reference by the same author
full stop separates references by different authors
figures of plates are enclosed in parentheses to distinguish them from text-figures
dash, not comma, separates consecutive numbers.

Synonymy arrangement according to chronology of bibliographic references, whereby the year is placed in front of each entry, and the synonym repeated in full for each entry, is not acceptable.

In describing new species, one specimen must be designated as the holotype; other specimens mentioned in the original description are to be designated paratypes; additional material not regarded as paratypes should be listed separately. The complete data (registration number, depository, description of specimen, locality, collector, date) of the holotype and paratypes must be recorded, e.g.:

Holotype

SAM–A13535 in the South African Museum, Cape Town. Adult female from mid-tide region, King's Beach, Port Elizabeth (33°51′S 25°39′E), collected by A. Smith, 15 January 1973.

Note standard form of writing South African Museum registration numbers and date.

7. SPECIAL HOUSE RULES

Capital initial letters

(a) The Figures, Maps and Tables of the paper when referred to in the text
e.g. '. . . the Figure depicting *C. namacolus* . . .': '. . . in *C. namacolus* (Fig. 10) . . .'
(b) The prefixes of prefixed surnames in all languages, when used in the text, if not preceded by initials or full names
e.g. Du Toit but A. L. du Toit; Von Huene but F. von Huene
(c) Scientific names, but not their vernacular derivatives
e.g.Therocephalia, but therocephalian

Punctuation should be loose, omitting all not strictly necessary

Reference to the author should preferably be expressed in the third person

Roman numerals should be converted to arabic, except when forming part of the title of a book or article, such as
'Revision of the Crustacea. Part VIII. The Amphipoda.'

Specific name must not stand alone, but be preceded by the generic name or its abbreviation to initial capital letter, provided the same generic name is used consecutively. The generic name should not be abbreviated at the beginning of a sentence or paragraph.

Name of new genus or species is not to be included in the title; it should be included in the abstract, counter to Recommendation 23 of the Code, to meet the requirements of Biological Abstracts.

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&
D. A. GERNEKE

AN INVESTIGATION OF THE 'COLDSTREAM STONE'