Taxonomy, Systematics and Biogeography of South African Cirripedia (Thoracica)

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A thesis submitted in fulfilment of the degree of Master of Science in the Department of Zoology, Faculty of Science, University of Cape Town

Supervisor

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ZOOLOGY
UCT
Marine Biology Research Centre

“and whatever the man called every living creature, that was its name.”

- Genesis 2:19

Plagiarism declaration

This dissertation documents the results of original research carried out at the Marine Biology Research Centre, Zoology Department, University of Cape Town. This work has not been submitted for a degree at any other university and any assistance I received is fully acknowledged.

The following paper is included in Appendix B for consideration by the examiner. As a supervisor of the project undertaken by T. O. Whitehead, I participated in all of the field work and laboratory work involved for the identification of specimens and played a role in the conceptualisation of the project. Figure 1 was compiled by me.

Whitehead, T. O., Biccard, A. and Griffiths, C. L., 2011. South African pelagic goose barnacles (Cirripedia, Thoracica): substratum preferences and influences of plastic debris on abundance and distribution. *Crustaceana*, 84(5-6): 635-649.

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Contents

Abstract

The South African Cirripedia (Thoracica) are reviewed for the first time in 88 years, since that of Barnard (1924). Data collection consisted of records from the South African Museum, previously published literature, and specimens collected in the field. The current state of knowledge of the taxon in South Africa has been considerably raised. Thirteen new records are added to the fauna, of which 84.6% are cosmopolitan and 15.4% introduced species. This raises the total number of South African Cirripedia (Thoracica) to 86, of which 64.06% are cosmopolitan, 11.24% introduced and 24.7% endemic. Excluded from this, are three unknown species, which are likely to be new to science. Descriptions of these species will be undertaken outside of this thesis and published; however, they were classified as endemic and included in the analyses presented in Chapter three. Eleven of the new fauna can be described as "offshore benthic" and represent well known deep-water taxa. The remaining five are "coastal inshore" species. The Agulhas bioregion displays the highest species richness, with a total of 53 species recorded. It also contains the highest number of endemic species, 15 in total, out of all nine bioregions in South Africa. Lowest species richness was observed in the deep water, offshore bioregions (apart from the South-west Indian offshore) as a result of a lack in samples from these areas. High endemicity rates in the Agulhas and the South-west Indian offshore bioregion are most likely attributable to inadequate sampling of the surrounding deep water habitat. High discovery rates of new species to the region are indicative of many years without the work of fulltime taxonomic experts. Additional expertise and work is required in order to improve on the current state of knowledge of marine biodiversity in South Africa.

Acknowledgements

A great deal of value was added to this project by the following people who contributed material or data is some form or another: Clova Jurk, Dr. Ken Hutchings, Debbie Robertson-Andersson, Dr. Kerry Sink, Dr. Peter Ryan, Dr. Lara Atkinson, Megan Clair Laird, Matthew Melidonis, Otto Whitehead, Katharine James, Oscar Kathide, Rebecca Milne, Jennifer Olbers, Laura Tang, Dane-Lee Marx and Lousie Lange – thank you to all of you.

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Last and certainly not least, thank you to my supervisor, Prof. Charles L. Griffiths, for offering this project to me and believing that I could succeed. Thank you for all the ideas borne out of the many thought-provoking conversations over a cup of tea.

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General Introduction

The Cirripedia (Thoracica) represents a highly diverse taxon within the marine Crustacea with species living on a wide range of substrata from the intertidal zone down to the deepest parts of the ocean. We are most familiar with those frequently encountered in the intertidal and coastal inshore zones, however, these represent only a fraction of the existing diversity, the majority of which is located in pelagic and deeper water offshore. South African Cirripedia were first mentioned in the literature by Christian Ferdinand Friedrich Krauss in 1848. The two species he described can be found in his volume on molluscs, as they were considered to be members of this phylum at the time. They were *Asemusporosus* and *Coniarosea* – now known as *Tetraclita serrata* (Darwin, 1854) and *Tetraclita rufotincta* (Pilsbry, 1916) respectively. It was J. V. Thompson (1823) who established that the Cirripedia were in fact not molluscs but crustaceans. Darwin (1852, 1854) later produced an extensive work on the subject, which included several type specimens from South Africa and Cape Town. He recorded eleven species in total, of which five types were classified as endemic, these included *Balanus capensis* (*Austromegabalanus cylindricus*), *Tetraclita serrata*, *Cthamalus dentatus*, *Octomeris angulosa* and *Scalpellum ornatum* (*Ornatoscalpellum ornatum*).

The first major contribution to the crustacean fauna of South Africa was that of Stebbing (1910) who documented 26 species of barnacles. This was later increased to 67 species of Cirripedia (Thoracica) by K. H. Barnard who wrote a detailed guide to the fauna in 1924. Since then only several other publications have reported additional species and no updated version of Barnard's 88 year old guide to the Cirripedia exists. The sole purpose of this thesis is to provide such a guide to the scientific community in South Africa. This will be achieved in the following three chapters:

Additions to the South African Cirripedia (Thoracica) which accounts for all the species recorded for the first time within our political borders. A diagnosis and abbreviated description is provided for each of the new species to aid in their identification. Furthermore, they are classified as being either cosmopolitan, endemic or introduced based on known global

distribution ranges and invasive tendencies as defined in the literature (Mead *et al*., 2010; Carlton *et al*., 2011).

A guide to the South African Cirripedia (Thoracica) provides an illustrated account of every species presently recorded in South Africa, and is structured to be used as a much needed tool for the accurate identification of species by the scientific community. It includes updated synonymies and classification of species based on their current inferred phylogenetic relationships using alpha-taxonomy. Distribution ranges for each species are also established and are provided as a series of maps together with a photographic account of the fauna all in the interest of assisting the user in narrowing down an identification of a species. All data, apart from the pelagic taxa, are displayed as points rather than ranges as these are more informative and avoid any margin of error. The predicted distribution range of each pelagic species has been indicated by shading the relevant parts of oceanic water on their respective maps. Locality records and shading on the maps within the plates relate to South African waters only and do not imply absence of a species from Namibia or Mozambique. Many species are represented by very few samples and their distribution ranges are poorly defined. This is largely due to a combination of inadequate sampling and lack of expertise in South Africa (Gibbons *et al.*, 1999; Griffiths 1999; Griffths *et al*., 2010). This is a cause for concern and is further dealt with in Chapter 3.

Biogeographic patterns in species richness and endemicity within South African Cirripedia (Thoracica) provides an indication of how species are distributed around the coast of South Africa and which proportion of these are considered endemic. Further analyses are conducted to bring to light the current issue regarding the lack of taxonomic expertise and inadequate sampling of our deep water bioregions.

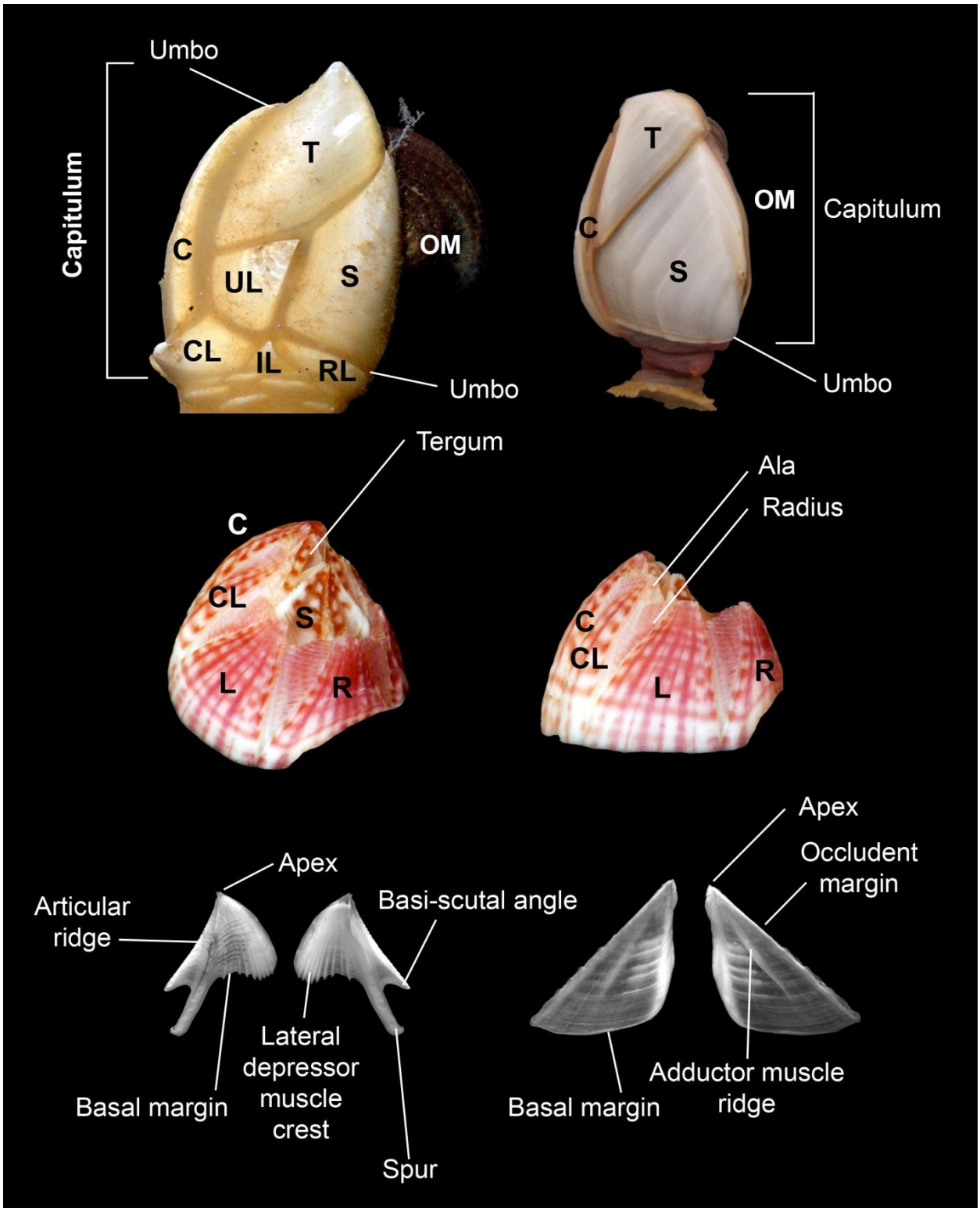

Figure 1: Morphological terms for typical scalpellid (top left), lepadid (top right), balanomorph (middle) and balanomorph opercular plates (terga – bottom left, scuta – bottom right). T = tergum, S = sctum, C = carina, CL = carinal latus, UL = upper latus, IL = inframedian latus, RL = rostral latus, OM = occludent margin, L = latus, R = rostrum.

Chapter 1

Additions to the South African Cirripedia (Thoracica)

Introduction

The following account lists the additions to the South African Cirripedia (Thoracica) and is the first work of its kind in more than 80 years. From 1924 to 1955, Barnard listed 67 species of Cirripedia (Thoracica) from South Africa. Since then, one additional species has been recorded in South African waters, although the exact date of collection is unclear (see under *Tetraclita rufotincta*), another three were inadvertently omitted from earlier lists published by Barnard (see *Amphibalanus* and *Perforatus perforatus*), and two have subsequently been added to the fauna by Sandison (1950) and Simon-Blecher *et al.* (2008). This brings the total to 73 previously known species, spread across 37 genera, 10 families and three suborders. The current study reports an additional 13 known species, raising the total to 86 – an increase of 15%. These include eight genera, three families and two suborders recorded in South Africa for the first time. Excluded from this total are three apparently undescribed species. These will be formally described outside of this dissertation for inclusion in any subsequent publication. The methods regarding the collection and analysis of material are outlined in Chapter 3.

Taxa are systematically arranged in sequence, according to inferred phylogenetic relationships. The sequence is based mainly upon that given by Zevina (1981), Jones *et al.* (2000) and Pitombo (2004). Each species is entered under the current binomen. This is followed by the original author's name, year of publication and subsequent synonyms in historical order. The latest taxonomic reference and any additional in-date references considered useful appear at the end of the reference list for each species. A full list of synonyms is provided only for those species which are here recorded in South African waters for the first time.

Where possible a diagnosis and abbreviated description is provided for each species in note-form. However, in cases where a combination of characters (present or absent) define a particular species, the diagnosis and description have been combined into a single entry. A series

of plates with photographs of various soft and hard tissue body parts, e.g. mouthparts, cirrus I and opercular plates have been included in this chapter to supplement the descriptions of each species. Chapter 2 places each of the new additions among the known fauna and photographs of the specimens and a distribution map are included here in a separate plate series. An indication of maximum size is provided from either personal observation or from the literature cited within the entry. A global and South African distribution are provided for cosmopolitan and introduced species. The South African distribution of species represented in this work conforms to the five inshore and four offshore bioregions (Fig. 15, Chapter 3) established by Lombard *et al.* (2004) in the South African Exclusive Economic Zone (EEZ). A full analysis of the patterns of distribution and endemicity within the regional fauna is provided separately in Chapter 3. Information relating to substrate preference, biology and distribution is provided under the remarks entry.

CLASS MAXILLOPODA Dahl, 1956
SUBCLASS CIRRIPEDIA Burmeister, 1834 (= Cirrhipèdes Lamarck, 1806)
SUPERORDER THORACICA Darwin, 1854
ORDER LEPADIFORMES Buckeridge & Newman, 2006

Suborder Heteralepadomorpha Newman, 1987
Family Heteralepadidae Nilsson-Cantell, 1921
Genus *Paralepas* Pilsbry, 1907

Paralepas minuta (Phillipi, 1836)

Plate 1, figs A, B

Alepas minuta Phillipi, 1836: pl. 12 fig. 23. – Darwin 1852: 160, pl.3 fig. 5.

Alepas (Paralepas) minuta. – Weltner 1897: 239.

Heteralepas (Paralepas) minuta. – Broch 1927: 18, fig. 4, pl. 1 figs 1, 2. – Hiro 1933: 51, fig. 15, pl. 2 fig. 4.

Paralepas minuta. – Stubbings 1965: 881, figs 1, 2. – 1967: 240. – Chan 2009a: 58, figs 1I, 11.

Diagnosis

Capitulum globular, yellow, without valves.

Description

Capitulum: small in size, surface slightly wrinkled; orifice crenulated. *Peduncle*: very short and strongly contracted towards the basal part of the capitulum. Base usually divided into two finger-like projections around the spine of a sea-urchin (Hiro, 1933). *Mouthparts*: maxilla I globular; mandibles with 3 major teeth and a tooth-like pointed lower angle, second and third tooth with large denticles; labrum concave with small sharp denticles (mouthparts lost). *Size*: capitular length 5 mm; capitular width 3.8 mm; peduncle length 1 mm.

Global distribution

Mediterranean, West Africa, Japan, Philippines and Australia (Jones *et al.* 1990) depth 110 – 414 m.

South African distribution

One sample collected in the Agulhas bioregion at a depth of 171 m.

Remarks

The only representative of this suborder in South Africa – found attached to the spine of a deep-water species of sea-urchin.

Suborder Lepadomorpha Pilsbry, 1916

Family Poecilasmatidae Annandale, 1909

Genus *Glyptelasma* Pilsbry, 1907

***Glyptelasma hamatum* Calman, 1919**

Plate 2, figs E, F

Megalasma (Glyptelasma) hamatum Calman, 1919: 370, Figs 5-7. – Nilsson-Cantell 1927: 770, fig. 12; 1928: 23, fig. 11; 1931: 10; 1934: 49; 1955: 219, pl. 5 fig. 1, 2, pl. 14 fig. 3. – Weisbord 1979: 48, pl. 5 figs 1, 2, pl. 14 fig. 3. – Zevina 1982: 93, fig. 83. – Liu and Ren 1985: 262, fig. 49, pl. 12 fig. 10-13. – Jones *et al*. 1990: 9.

Megalasma carinatum – Foster 1978: 26, fig. 12, pl. 3b.

Glyptelasma hamatum – Young 2001: 720, figs 10 A-B, 11. – Liu and Ren 2007: 157, fig. 7. – Chan 2009a: 61, figs 1H, 14, 15.

Diagnosis

Base of carina wide and expanded horizontally. Prosoma with two short dorsal hooks.

Description

Capitulum with 5 white valves. Basal margin of carina and scutum continuous or in line, forming an even curve as seen in lateral view. Carina with wide sides, umbo not produced below basal margin of scutum. Rami of Cirrus 1 subequal, each with 6 segments (Fig. 2 C). *Mouthparts*: mandible with 4 main teeth, last tooth minutely bifid (Fig. 2 A), maxilla I deeply notched with 2 strong spines at upper angle (Fig. 2 B). *Size*: capitular length 24 mm; capitular width 12.5 mm; peduncle length 5 mm.

Global distribution

Cosmopolitan, depth 366 - 3660 m.

South African distribution

South-west Indian offshore and West Indian offshore bioregions, depth 450 - 1200 m.

Remarks

Fairly common, attaches to a variety of substrata, mostly hydroid stems in South Africa. Replaces *G. carinatum* in the deep warmer waters of South Africa with an overlap in the South-west Indian offshore bioregion, where both species are encountered.

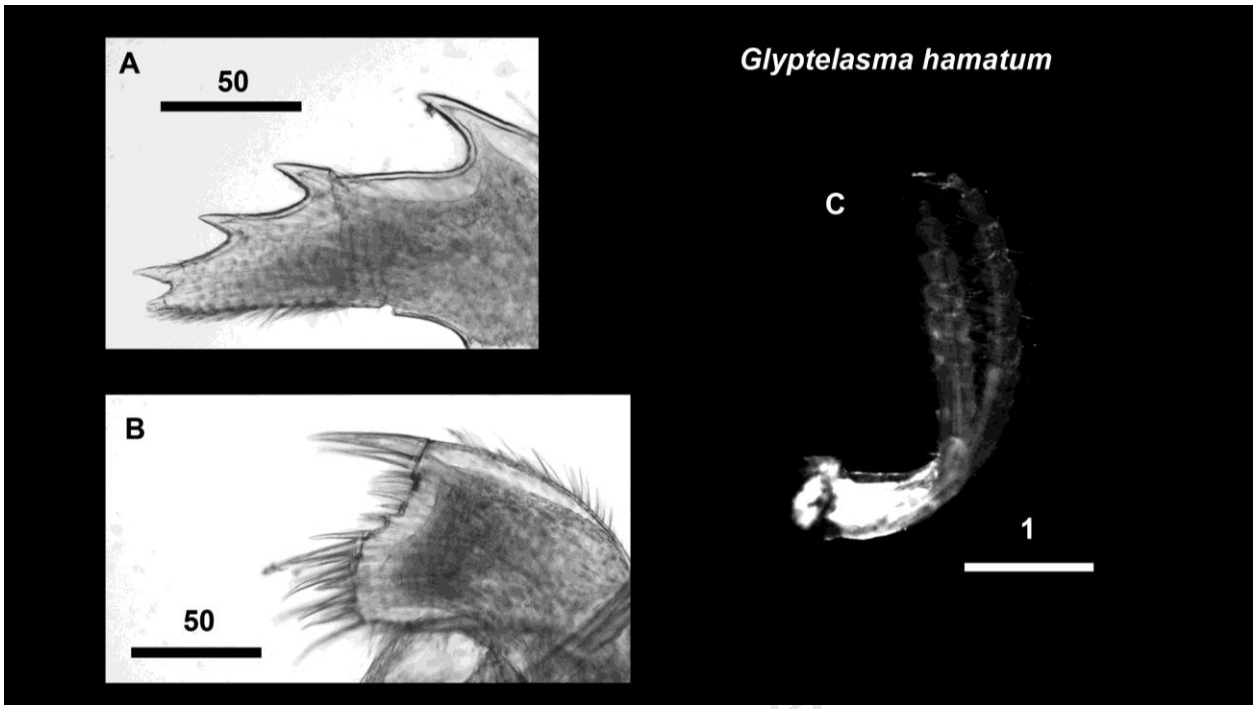

Figure 2: *Glyptelasma hamatum* – soft parts: A, mandible; B, maxilla I; C, cirrus I. Scale bars for A and B in μm, C in mm.

***Temnaspis amygdalum* (Aurivillius, 1894)**

Plate 3, figs C, D

Poecilasma amygdalum Aurivillius, 1894: 10, pl. 1 figs 4-6, pl. 8 fig. 14. – Gruvel 1905. – Annandale 1905. – Nilsson-Cantell 1921: 262, fig. 48a-c.

Poecilasma fissa – Darwin 1852: 109, pl. 2 fig. 4.

Poecilasma fissum – Hoek (non Darwin) 1907: 8, pl. 10 figs 2-5. – Annandale (non Darwin) 1909; 1910.

Poecilasma amygdalum madagascariense – Nilsson-Cantell 1921: 262, figs 48 d-g.

Trilasmis (Temnaspis) amygdalum – Hiro 1937: 412, fig. 10, 11. – Nilsson-Cantell 1938: 28.

Temnaspis amygdalum – Jones et al. 2000: 240.

Diagnosis

Scutum divided into two segments, terga without notch, apex of occludent segment of scuta not extending beyond basal margin of terga.

Description

Capitulum with 5 valves; scutum divided into a narrow occludent segment and a wide lateral segment by means of a fissure extending from umbo to apex – where, as Darwin (1852) notes, in most species a ridge extends. Two scutal segments united at the umbo. Upper end of narrow occludent segment projecting only slightly beyond apex of the lateral segment. Edges of valves tinged with red in the specimens examined. *Peduncle*: shorter and darker in colour than Darwin (1852) describes; one-quarter length of capitulum, narrow and dark yellow-brown in colour. *Mouthparts*: agree well with literature and in particular with those figured by Hiro (1937). Mandible with 4 teeth (Fig. 3 A), the fourth close to inferior angle, and surrounded by minor teeth (Fig. 3 C). Maxilla I very deeply notched with two stout teeth above notch and about 10 below notch (Fig. 3 B). Tooth described by Hoek (1907) on edge of inferior angle not visible. *Size*: capitular length 4 mm; capitular width 3 mm; peduncle length 1 mm.

Additional notes

Distinguished from *Temnaspis tridens tridens* in that the terga are not notched and apices of the occludent segment of the scuta do not extend beyond the basal margin of the terga. Although it may appear as though the capitulum consists of 7 valves, as described by Darwin (1852), it only consists of 5 – Darwin having overlooked the fact that the scutal segments are united at the umbo and represent a single valve, not 2.

Global distribution

Indian Ocean, Indo-west Pacific, South China Sea and central Pacific, intertidal to subtidal.

South African distribution

Natal bioregion, intertidal to subtidal.

Remarks

Known in South Africa from a single sample collected in 2011 by Prof. C. L. Griffiths at Umhloti Beach, KwaZulu-Natal. The sample was washed up on the beach attached to the antennae of a *Panulirus* carapace – a known specific substratum for this species. Therefore, one could expect *T. amygdalum* to follow the same distribution as *Panulirus* in South Africa.

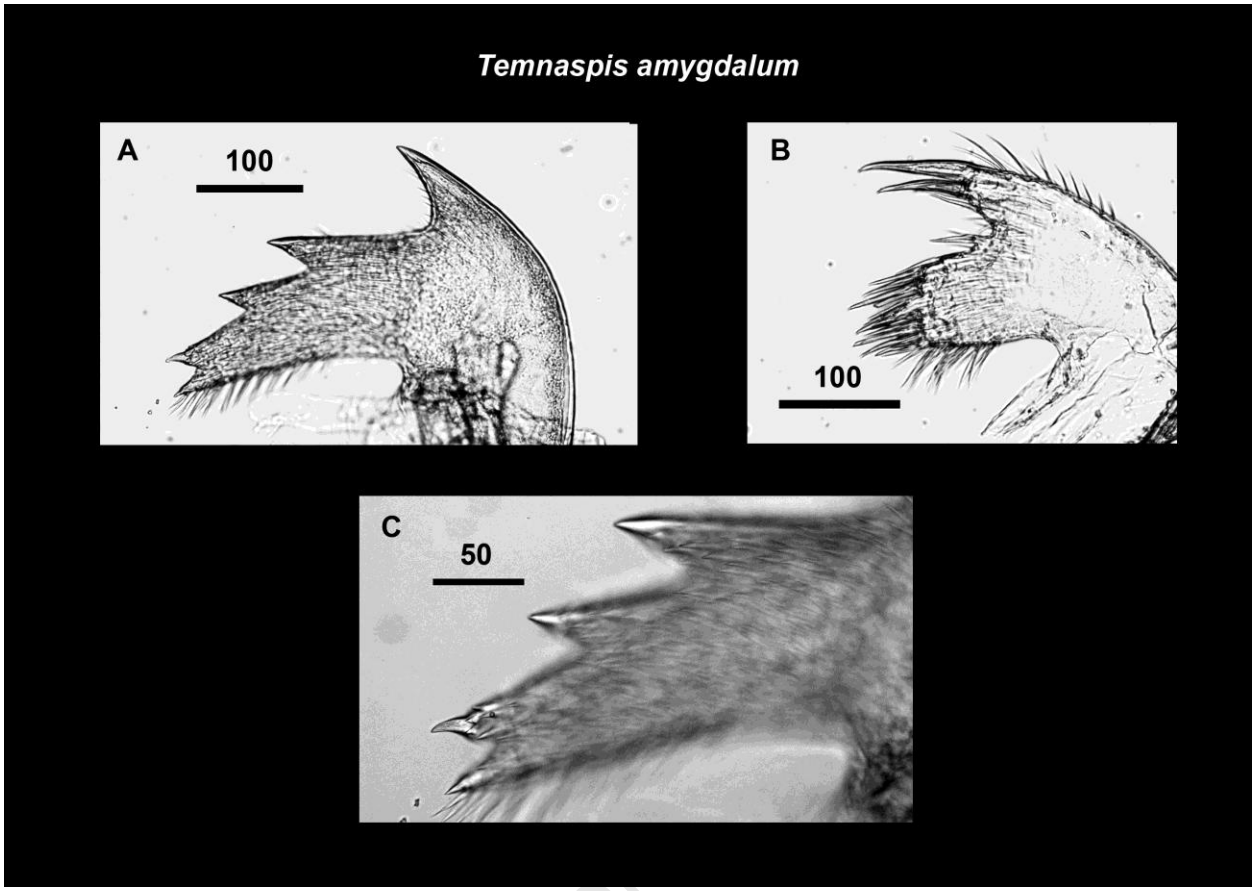

Figure 3: *Temnaspis amygdalum* – soft parts: A, mandible; B, maxilla; C major and minor teeth on mandible. Scale bars in μm.

Genus *Lepas* Linnaeus, 1758

Subgenus *Anatifa* Bruguière, 1789

***Lepas (Anatifa) anatifera striata* de Graaf, 1952**

Plate 6, figs C, D

Lepas anatifera var. s*triata* de Graaf, 1952: 3.

Lepas anatifera striata – Newman 1972: 34, fig. 2 A-G.

Diagnosis

Internal umbonal tooth on right scutum only, markings on the scuta consist of normally 1, but up to 3 (Newman, 1972), rows of dark square pits radiating from umbo and coinciding with intersections of concentric growth lines and radial striations.

Description

Identical to *L. anatifera*. Peduncle striking red in colour from collected specimens in South Africa. *Size*: capitular length 20 mm; capitular width 10 mm; peduncle length 30 mm.

Global distribution

Tropical and sub-tropical seas, pelagic.

South African distribution

Extends eastward from False Bay into the Delagoa bioregion.

Remarks

Easily distinguished by general appearance alone. Frequently encountered in the warm sub-tropical waters of Durban. It is likely that remnants of bright red peduncles attached to various objects washed up in the Sodwana Bay area were those of *L. anatifera striata*, however these records were excluded from the study for reasons of uncertain identification. In one rare case, specimens were found washed up in the cooler temperate waters of False Bay, the western limit of its distribution in South Africa.

ORDER SCALPELLIFORMES Buckeridge & Newman, 2006

Suborder Scalpellomorpha Newman, 1987

Family Scalpellidae Pilsbry, 1907

Subfamily Arcoscalpellinae Zevina, 1978

Genus *Verum* Zevina, 1978

Verum novaezelandiae (Hoek, 1883)

Plate 14, figs C, D

Scalpellum novae-zelandiae Hoek, 1883: 124, pl. 5 figs 7, 8. – 1913: 231. – Weltner 1922: 71.

Scalpellum poculum – Hoek 1907: 100, pl. 8 figs 4, 4a.

Scalpellum (Scalpellum) novae-zelandiae – Calman 1918a: 123.

Arcoscalpellum novaezelandiae – Foster 1978: 65, fig. 39, pl. 8D.

Verum novaezelandiae – Chan *et al.* 2010: 17, figs 1I, 12, 13.

Diagnosis and description

Capitulum elongated and flattened with 14 fully calcified white valves. Inframedian latus narrow. Carinal latus with basicarinal angle not projecting beyond carina. *Capitulum*: tall and narrow, valves smooth, closely fitting. Covered in fine cuticle with fine, sparse pile, longest on carina (in contradiction with the literature). *Scutum*: about twice as long as wide, occludent margin slightly convex, apex slightly produced and overlapping tergum. *Tergum*: larger than scutum, occludent margin slightly convex intersecting with scutal margin at a right angle. *Carina*: bowed, umbo at apex, roof flat, bordered by distinct ridges. *Inframedian latus*: wine glass-shaped, widest at apex, narrowest at sub-basal umbo then widening slightly towards basal margin. *Upper latus*: pentagonal, tergal and scutal margins longest, apical umbo produced, margin abutting with inframedian latus short. *Carinal latus*: taller than wide, carinal margin slightly concave and longer than convex lateral margin, umbo at basi-carinal angle. *Rostral latus*: wider than high, umbo at angle of rostral and scutal margins. *Rostrum*: present, narrow. *Peduncle*: about a third length of occludent margin, not completely covered in scales *Mouthparts*: maxilla I notched, 4 spines above notch, notch naked, more than 6 teeth below notch, mandible with 3 large teeth, first separated from second and third, inferior angle pectinated by more than 3 large cuspidate setae. Cirrus I separated from other cirri, rami unequal, inner ramus short with 6 segments, outer ramus long and slender, nine-segmented. *Size*: capitular length 9 mm; capitular width 4.5 mm; peduncle length 3 mm.

Additional notes

Similar to *Catherinum sinuatum,* yet easily distinguished by the more slender capitulum, sub-basal umbo of inframedian latus and apex of carina extending only two-thirds along the tergal margin. The South African material differs slightly from that described in the literature; by

presence of a thin pilose cuticle and peduncle not completely covered in scales – characters I consider variable. Apart from these inconsistencies, the specimens match closely to the descriptions of Hoek (1907) and Chan *et al.* (2010).

Global distribution

Cosmopolitan but scarce – Pacific, Atlantic and Indian Oceans, depth 918 – 2194 m.

South African distribution

South-west Indian offshore, West Indian offshore and Delagoa bioregions, depth 630 – 1200 m.

Remarks

Specimens collected during the South African Museum's Meiring Naudè cruises during the late 1970's.

Genus *Amigdoscalpellum* Zevina, 1978

Amigdoscalpellum vitreum (Hoek, 1883)

Plate 15, figs C, D

Scalpellum vitreum Hoek, 1883: 155, pl. 5 fig. 14. – Weltner 1897: 251. – Gruvel 1902: 54. – 1905: 84, fig. 94. – Nilsson-Cantell 1955: 219. – Zevina 1973: 137. – 1979: 272, figs 14, 18.

Scalpellum talismani – Gruvel 1902: 86, pl. 2 figs 3D, 6, 7. – 1905: 86, fig. 96. – 1920: 23. – Nilsson-Cantell 1955: 219. – Broch 1953: 8, fig. 4.

Scalpellum formosum – Hoek 1907: 110, pl. 8 fig. 2, 2a. – Stubbings 1936: 55 (part.). – Nilsson-Cantell 1938: 21. – 1955: 219. – Tarasov and Zevina 1957: 140, pl. 1 fig. 1, fig. 44.

Scalpellum bellum – Pilsbry 1908: 111 (replacement name for *S. formosum* Pilsbry 1907a).

Arcoscalpellum formosum – Newman & Ross 1971: 60, fig. 26, pl. 8 fig. G.

Arcoscalpellum vitreum – Newman & Ross 1971: 87, figs 44-47, pl. 8 figs E, F. – Foster 1978: 58, pl. 7D fig. 34.

Amigdoscalpellum vitreum – Zevina 1981: 276, fig. 208.

Diagnosis

Sides of carina strongly sculptured with irregular, non-continuous, oblique ribs. Inframedian latus small, not projecting above carinal and rostral latus.

Description

Capitulum elongated with 14 distinctly striate valves. Inframedian latus triangular, umbo apical, never making contact with upper latus. Sides of carina strongly sculptured. Carinal margins of carinal latera interdigitating below carina. Tergum triangular, umbo apical, basal margin longest, scutum quadrangular, about twice as high as wide, umbo apical, slightly produced, projecting over corner formed by basal and occludent margin. Carina bowed, roof flat, sides moderately broad, strongly sculptured with irregular, non-continuous oblique ribs. Upper latus different to that figured by Newman & Ross (1971) – subtriangular but with 4 sides, carinal and basal margin forming less of an obtuse angle, meeting rostral latus at a point with no margin shared between the two plates. Carinal latus, largest of the latera, irregularly pentagonal, umbo elevated above plate on carinal margin, about a quarter way up from inferior margin, latera extending behind and below carina, interdigitating. Inframedian latus, triangular, height greater than width, umbo apical, extending upward always falling well short of upper margins of adjacent latera. Rostral latera, differs to that figured by Newman & Ross (1971) – subtriangular, basal margin very short, not contiguous with occludent margin of scutum, apical third of lateral margin abutting with carinal latus, forming an acute angle with scutal margin. Rostrum present, narrow, covered by rostral latera. *Mouthparts*: maxilla I with shallow notch (Fig. 4 A), mandible with 3 major teeth, minor teeth absent (Fig. 4 B). Cirrus I with unequal rami, inner ramus flattened and short, seven-segmented, outer ramus slender, ten-segmented (Fig. 4 C). *Size:* capitular length 30 mm; capitular width 17 mm; peduncle length 8 mm.

Additional notes

There are a number of characters which, according to Chan (2009), separate *A. elegans* from this species: the tergum in *A. elegans* is shaped like a right-angled triangle, whereas the tergum in *A. vitreum* is shaped more like an equilateral triangle; the basal margin of the scutum is slightly convex in *A. elegans*, whereas in *A. vitreum* it is concave; there are fine striations on the sides of the carina in *A. elegans*, however in *A. vitreum* the sides of the carina are strongly sculptured with irregular, non-continuous, oblique ribs.

With regard to South African specimens, the latter character proved to be the most consistent and reliable. The shape of the terga and scuta are too variable to be considered reliable characters. In most cases the basal margins of the scuta in *A. vitreum* were either straight or slightly convex and rarely concave; I suggest that these characters be used with caution.

Easily confused with *Amigdoscalpellum elegans* and *Arcoscalpellum botellinae.* The inframedian latus is the most reliable character to distinguish *A. vitreum* from *A. botellinae.* In *A. vitreum* the inframedian latus is small and does not project above the carinal and rostral latus. The opposite is true in *A. botellinae*.

Global distribution

Cosmopolitan, depth 2280 – 4531 m.

South African distribution

South-west Indian offshore bioregion, 440 – 1420 m.

Remarks

The South African material extends the known depth range to a new shallow limit. One specimen attached to a worm tube.

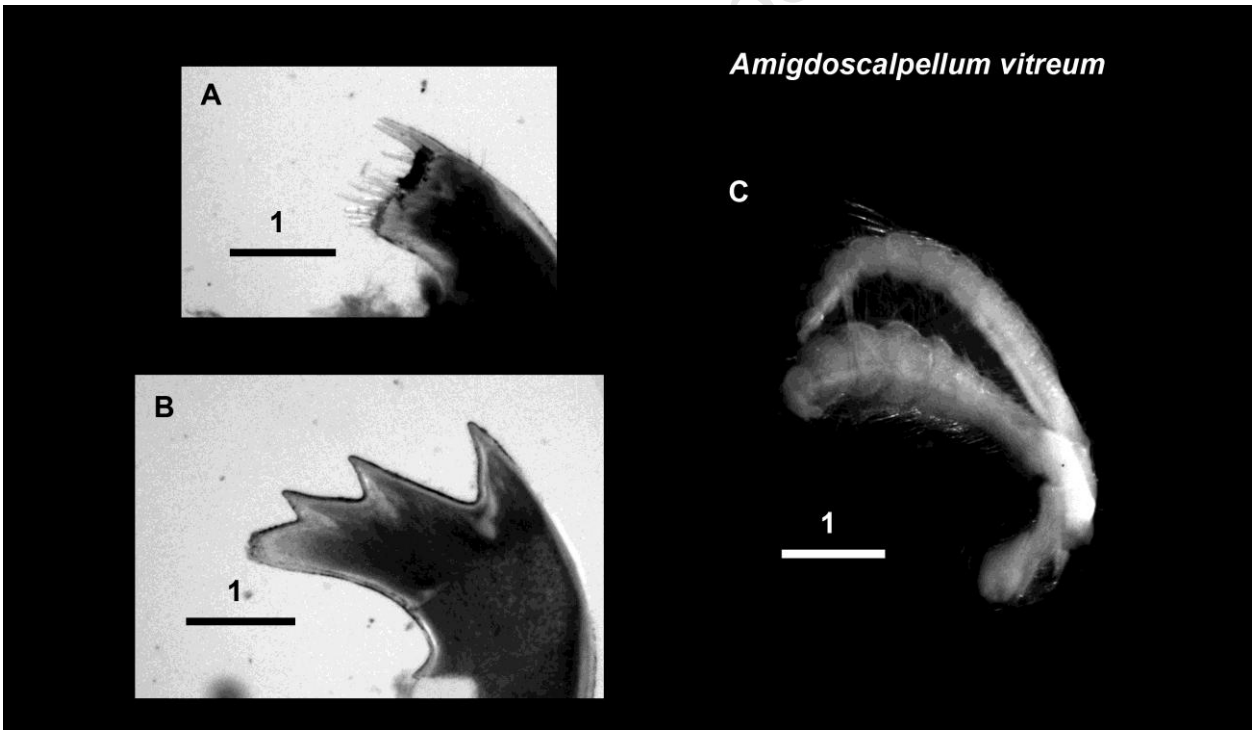

Figure 4: *Amigdoscalpellum vitreum* – soft parts: A, maxilla I; B, mandible; C, Cirrus I. Scale bars in μm.

ORDER SESSILIA Lamark, 1818

Suborder VERRUCOMORPHA Pilsbry, 1916

Family Verrucidae Darwin, 1854

Species within this family are classified according to characters outlined by Buckeridge (1997), i.e. sessile cirripedes with asymmetrical shell wall consisting of a fixed scutum, tergum, rostrum and carina; operculum consisting of a movable tergum and scutum; latera absent.

Genus *Altiverruca* Pilsbry, 1916

Verrucids with an erect form, bases of plates not inflected, operculum almost vertical to base, myophore absent.

Altiverruca nitida (Hoek, 1883)

Plate 16, figs A, B

Verruca nitida Hoek, 1883: 138, figs 6-7. – Gruvel 1905: 177, fig. 194. – Hoek 1913: 150. – Nilsson-Cantell 1927: 778.

Gibbosaverruca nitida – Young 2002.

Altiverruca nitida – Buckeridge 1994: 101, fig. 6a-g. – 1997: 135, fig. 8a-b.

Diagnosis

Only known representative of the genus in South Africa – see diagnosis for genus above.

Description

As in *Altiverruca*, base calcareous, carina and rostrum interdigitating with 2 ribs, movable scutum with two ribs articulating with 1 strong diagonal rib of movable tergum, caudal appendages long. *Mouthparts*: Maxilla I straight or with lower margin projecting (Fig. 5 A), mandible with 3 major teeth, distance between first and second than that between second and

third (Fig. 5 B), inferior angle denticulated (Fig. 5 C). Cirrus I with rami equal in length, each with 10 segments (Fig. 5 D). *Size*: rostro-carinal width, 5 mm; height 6 mm.

Global distribution

Tropical western Pacific and South African waters 650 – 2040 m.

South African distribution

South-west Indian offshore bioregion, depth 775 – 1660 m.

Remarks

A deep water cosmopolitan species. Barnard (1924) found it remarkable that representatives of this family were yet to be found in South Africa. The specimens examined in this study were collected in the late 70's as part of the South African Museum Meiring Naudè Cruises. The specimens were presumably overlooked in the past as they were found within group of scalpellid samples at the Iziko South African Museum in Cape Town. With a severe lack in abyssal samples in our offshore bioregions (see Chapter 3) it is not surprising that species of this taxon remained undetected in South Africa.

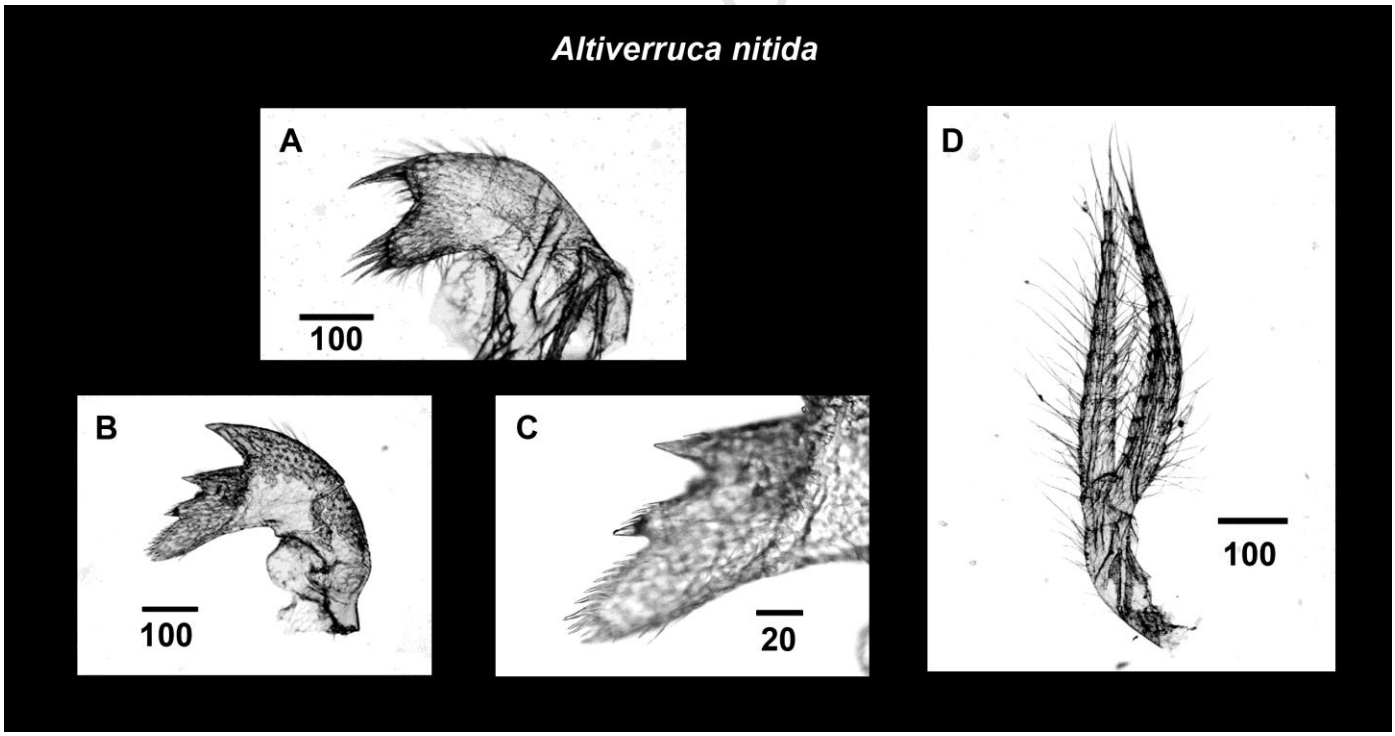

Figure 5: *Altiverruca nitida* – soft parts: A, maxilla I; B, mandible; C, inferior angle of mandible; D, Cirrus I. Scale bars in μm.

Genus *Metaverruca* Pilsbry, 1916

Verrucids with a box-like shell; apices of carina and rostrum marginal, fixed scutum with myophore; operculum parallel to base, with straight basal margin; aperture D-shaped, base of shell wall inflected internally, thickened.

Metaverruca plicata Buckeridge, 1994

Plate 16, figs C, D

Metaverruca plicata Buckeridge, 1994: 114, fig. 12 a-i.

Diagnosis

Only known representative of the genus in South Africa – see diagnosis for genus above.

Description

Medium to large in size, shell distinctly box-shaped, strong external ribbing, D-shaped operculum parallel to base, movable tergum and scutum each with 3 articular ribs (Fig. 6 B), movable scutum somewhat narrow, caudal appendages long. Fixed scutum with myophore (Fig. 6 A) *Mouthparts*: Maxilla I straight with lower margin projecting (Fig. 6 C), mandible with 3 teeth (Fig. 6 D), lower angle denticulated with 8 denticles (Fig. 6 E). *Size*: rostro-carinal width 8 mm; height 4 mm.

Global distribution

South west Pacific and South African waters depth 520 – 1220 m.

South Africa

South-west Indian offshore bioregion, depth 670 – 680 m.

Remarks

A well known deep water species which, like *Altiverruca nitida*, were presumably overlooked in the past as they were found within group of scalpellid samples at the Iziko South African Museum in Cape Town.

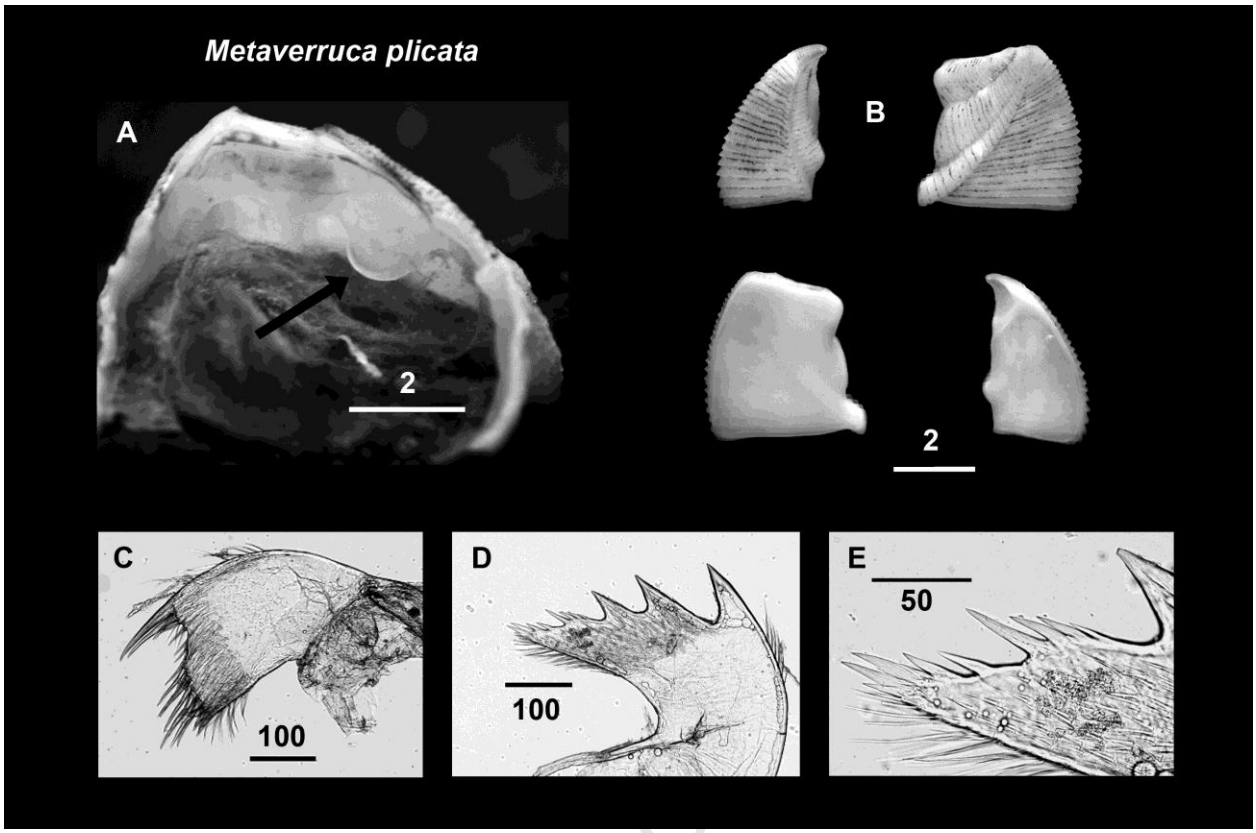

Figure 6: *Metaverruca plicata*: A, myophore; B, opercular plates; C, maxilla I; D, mandible; E, denticulate inferior angle of mandible. Scale bars for A and B in mm, scale bars for C – E in µm.

Suborder BALANOMORPHA Pilsbry, 1916

Superfamily Balanoidea Leach, 1817

Family Archaeobalanidae Newman & Ross, 1976

Subfamily Archaeobalaninae Newman & Ross, 1976

Genus *Solidobalanus* Hoek, 1913

***Solidobalanus auricoma* (Hoek, 1913)**

Plate 21, figs A, B

Balanus (Solidobalanus) auricoma Hoek, 1913: 198, pl. 18, figs 20-22, pl. 19, figs 1-7. – Nilsson-Cantell 1938: 49, fig. 14. – Rosell 1981: 303.

Solidobalanus (Solidobalanus) auricoma – Newman & Ross 1976: 50. – Jones et al. 2000: 266. – Achituv 2002: 34, fig. 3A-D, 4A-F, 6A-D.

Diagnosis and description

Shell conical and truncated, consisting of 6 compartments, parietes solid (Fig. 7 B), inner lamina with short, basal longitudinal ribs. Orifice diamond-shaped. Parietes and radii ranging from completely white to covered in irregular lateral and longitudinal pink stripes resulting in a "speckled" appearance. Radii developed with distinct parallel growth lines, exposed part of alae similar, summits oblique. Calcareous basis solid, radially grooved. Apices of opercular plates setose. Scutum triangular, occludent margin longest, long, inconspicuous adductor ridge (Fig. 7 A). Tergum with shallow external groove, spur short, as wide as long, half its width from basiscutal angle (Fig. 7 A). *Mouthparts*: Labrum almost straight, with 3 to 4 stout teeth either side of cleft (Fig. 7 D), maxilla I with small shallow notch below 2 upper spines, lower margin with about 10 smaller spines (Fig. 7 C), mandible with 4 teeth, first one biggest, second located in middle of superior angle with 1 or 2 denticles on inferior angle (Fig. 7 E). *Size*: diameter 2 – 14 mm.

Global distribution

West Atlantic, Mediterranean Sea, Persian Gulf, Indo-west Pacific and Indian Ocean, depth 27 – 376 m.

South African distribution

Agulhas, Natal and South-west Indian offshore bioregion, depth 18 – 200 m.

Remarks

Attaches to hydroids, soft coral, *Chaetopterus* tubes and stones – often sharing the substratum with various scalpellid species occurring in the same depth range. The South African material extends the known shallow limit for the depth range of this species.

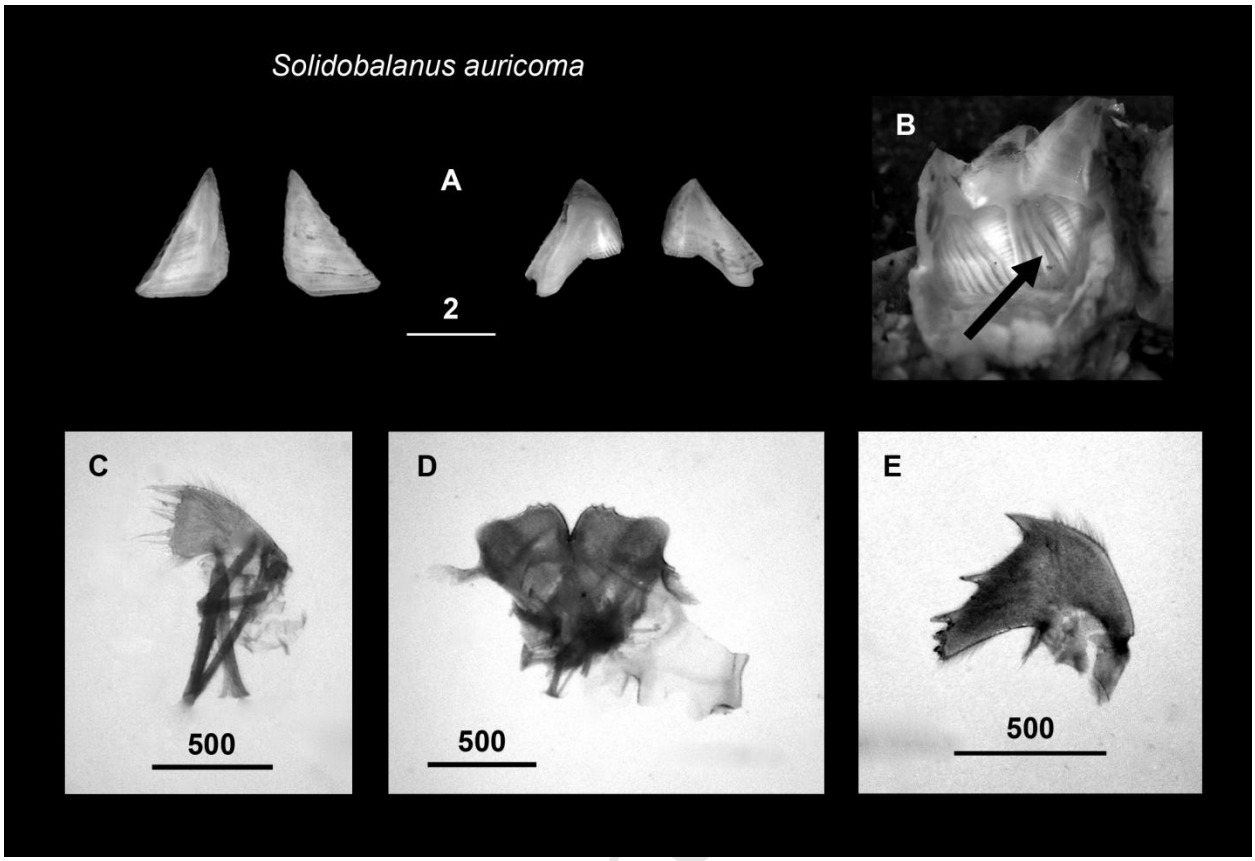

Figure 7: *Solidobalanus auricoma*: A, opercular plates; B, solid parietes; C, maxilla I; D, labrum; E, mandible. Scale bars for A in mm, scale bars for C – E in μm.

***Solidobalanus fallax* Broch, 1927**

Plate 21, figs E, F

Balanus (Hesperibalanus) fallax Broch, 1927: 26, figs 7-9, pl. 2 figs 12-17, pl. 3 figs 18-19. – Utinomi 1959: 402, fig. 1.

Balanus occidentalis – Stubbings 1961a: 34, figs 8-11. – 1961b: 189.

Balanus fallax – Stubbings 1963: 30, figs 10, 11. – 1967: 287, figs 19, 20.

Solidobalanus fallax – Young 1998: 45, fig. 31. – 2001: 748.

Diagnosis and description

Shell conical and truncated, consisting of 6 solid, externally smooth parietes, variable in colour – mottled pink to white with regular lines of pigment, margins with blotches of deep pink.

Radii developed, summits oblique. Scuta triangular, occludent margin longest, no adductor ridge, upper end of articular ridge "scroll-like". Terga with strongly developed crests, sometimes with small crests near base of spur, apices and growth ridges covered with thin setose epidermis. Basidorsal point with spine. *Mouthparts*: Mandible with 4 teeth, third and fourth bifid, inferior angle with 3 complex teeth - pointed in some specimens, blunt in others (Fig. 8 A), maxilla I with 2 large upper spines, small barely distinguishable notch, 7 smaller spines on lower margin (Fig. 8 B). *Size*: diameter 4 mm.

Global distribution

West African coast extending north to England, depth 7 – 220 m.

South African distribution

Agulhas bioregion, depth 49 – 58 m.

Remarks

The South African material constitutes the southern-most record for the species.

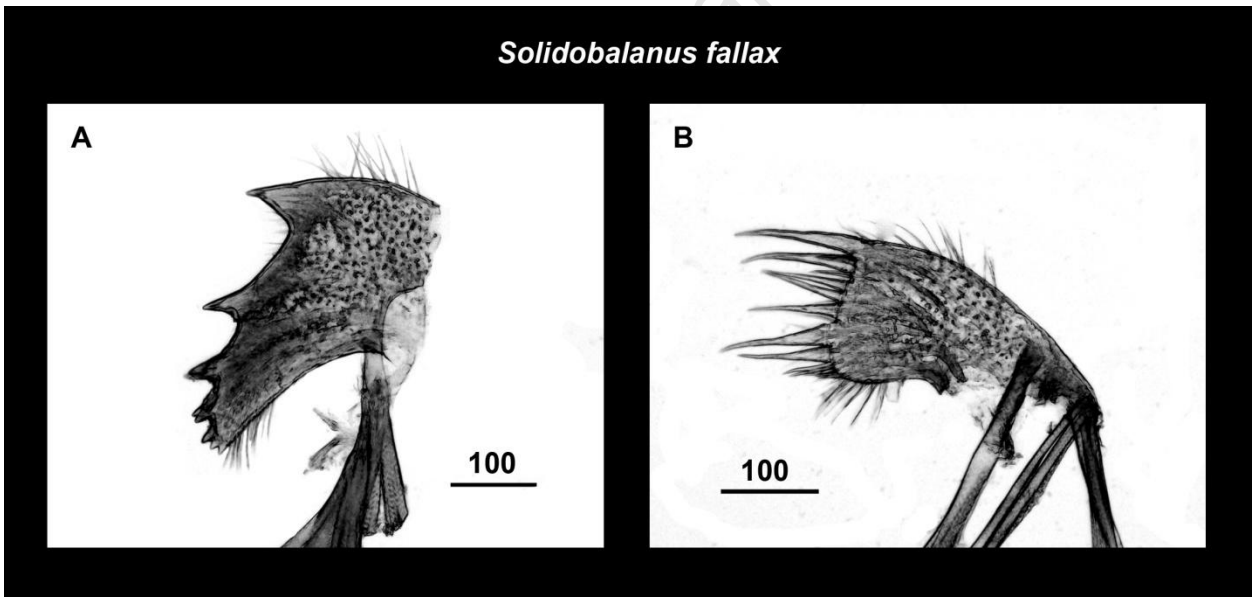

Figure 8: *Solidobalanus fallax*: A, mandible; B, maxilla I. Scale bars in μm.

Family Pyrgomatidae Gray, 1825

Subfamily Pyrgomatinae Gray, 1825

Genus *Cantellius* Ross and Newman, 1973

***Cantellius gregarius* (Sowerby, 1823)**

Plate 25, figs A – C

Creusia gregaria Sowerby, 1823: no pagination.

Creusia spinulosa var. 3 – Darwin 1854: 378, pl. 13 fig. 6h.

Creusia spinulosa forma g*regaria* – Broch 1931: 118. – Nilsson-Cantell 1938: 60, fig. 21, pl. 2 fig. 6.

Cantellius gregarius – Anderson 1992: 297, figs 12 I, 13.

Diagnosis

The only known species from South African waters which burrows into plate corals – easily recognisable.

Description

Four-plated, low-conical wall with pentagonal orifice and a deep basis. Opercular plates fragile, carinal ends of scuta expanded and tergum reduced (Fig. 9 A). Cirrus I outer ramus long with 11 segments, inner ramus significantly shorter with 6 segments. *Mouthparts*: mandible with 4 teeth (Fig. 9 B), labrum with 3 minute teeth either side of moderately deep notch (Fig. 9 C), maxilla I with 2 large upper spines, barely distinguishable notch, 7 smaller spines on lower margin (Fig. 9 D). *Size*: diameter 15 mm.

Global distribution

Indian Ocean, Australia (Jones et al., 1990) and China (Ren, 1986).

South African distribution

Delagoa bioregion, depth 10 – 30 m.

Remarks

Embedded in *Acropora* coral species in moderate to high densities. These specimens were collected on SCUBA from a piece of *Acropora* plate coral in the Sodwana Bay area as part of the African Coelacanth Ecosystem Programme (ACEP) field work. This work represents the first known description of the mouthparts.

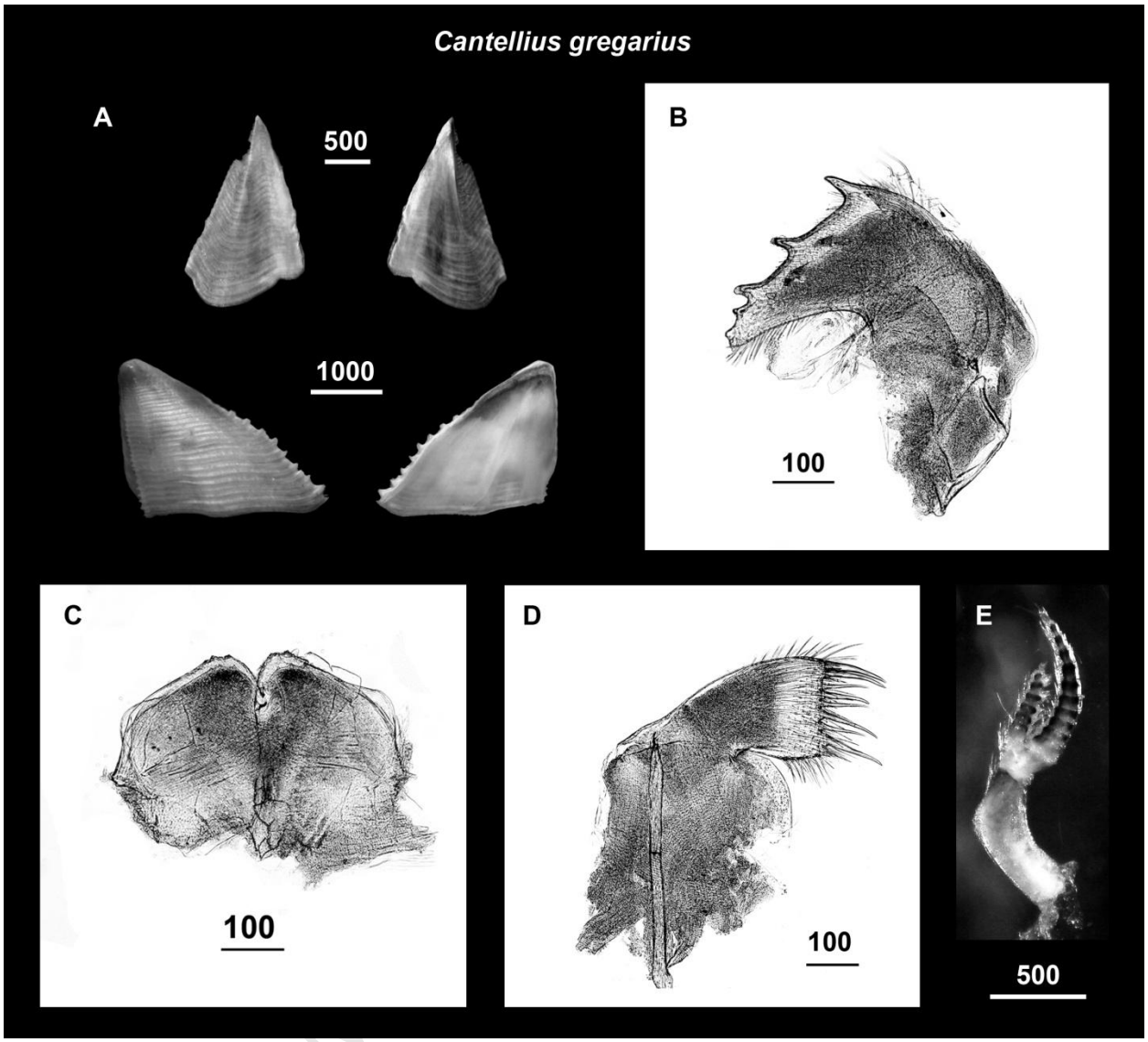

Figure 9: *Cantellius gregarius*: A, opercular plates; B, mandible; C, labrum; D, maxilla I; E, cirrus I. Scale bars in μm.

Family Balanidae Leach, 1817

Subfamily Amphibalaninae Pitombo, 2004

Genus *Amphibalanus* Pitombo, 2004

***Amphibalanus eburneus* (Gould, 1841)**

Plate 26, figs E, F

Balanus eburneus Gould, 1841: 15, pl. 1 fig. 6. – Henry & McLaughlin 1975: 60, fig. 15, pl. 4, pl. 5 fig. g, (lower row right) incl. syn.

B. [*alanus*] *democraticus* – DeKay 1843: 252.

Balanus amphitrite var. *niveus* – Oliveira 1941: 19, pl. 3 figs 3-6, pl. 4 figs 2, 7 (in part; not *Balanus amphitrite* var. *niveus* – Darwin 1854: 240).

Amphibalanus eburneus – Pitombo 2004: 263.

Diagnosis and description

Wall of 6 plates, parietes usually smooth and white, parietal tubes in single row with transverse septa, orifice toothed. Radii narrow and rough, thickened near summits, occasionally crenulated. Scutum with growth ridges, strongly crenulated, articular ridge two-thirds length of tergal margin, adductor ridge short, almost confluent with articular ridge, tergum with carinal margin protuberant in upper third, spur length greater than width, three-quarters width from basiscutal angle (Fig. 10 A). *Mouthparts*: labrum multidenticulate, mandible with 4 teeth, fourth bifid (Fig. 10 B), maxilla I with 2 large upper spines, barely distinguishable notch, 10 smaller spines on lower margin (Fig. 10 C). *Size*: diameter 10 mm.

Global distribution

Endemic to western Atlantic, introduced to Europe, Indian and Pacific Ocean, littoral.

South African distribution

South-western Cape Bioregion, littoral.

Remarks

A fouling species introduced to Cape Town docks.

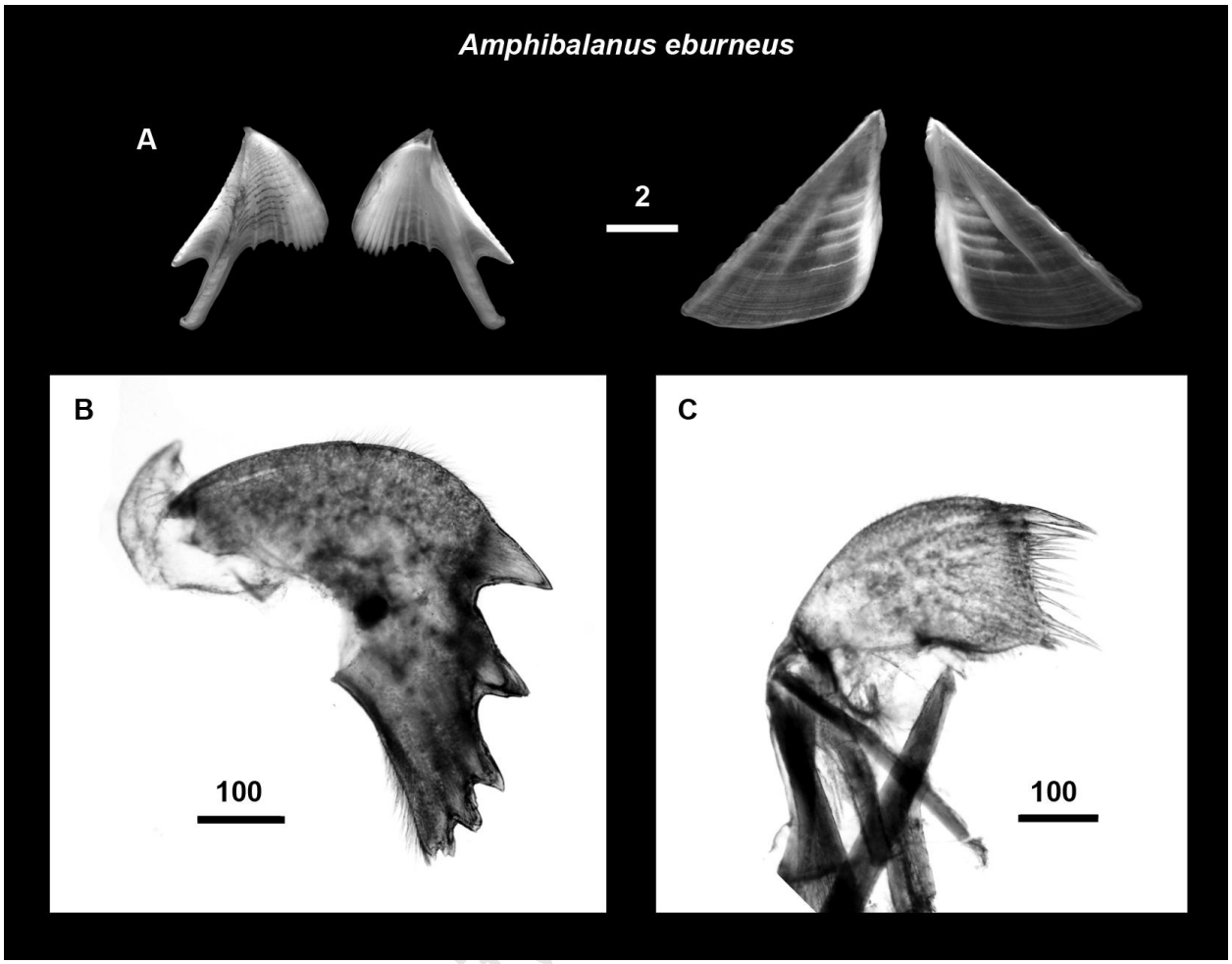

Figure 10: *Amphibalanus eburneus*: A, opercular plates; B, mandible; C, maxilla I. Scale bars in μm.

Subfamily Megabalaninae Newman, 1979

Genus *Megabalanus* Hoek, 1913

***Megabalanus coccopoma* (Darwin, 1854)**

Plate 28, figs C, D

Balanus tintinnabulum var. *coccopoma* Darwin, 1854: (in part) 196, pl. 1 fig. d, pl. 2 figs 1f, 11, lo.

Balanus tintinnabulum coccopoma – Pilsbry 1916: 68, pl. 16 figs 1, la, 2, 2a. – Henry 1942: 120, figs 3a, b. – Davadie 1963: 26, pl. 2 fig. 1. – Lacombe & Monteiro 1975: 633, figs 2, 3.

Megabalanus coccopoma – Newman & Ross 1976: 67. – Henry & McLaughlin 1986: 25, figs 3h, 7a-f.

Diagnosis

Shell large and bright pink, scutum with broad, obtusely inflected tergal segment and strongly toothed occludent margin.

Description

Shell globuloconic with 6 smooth parietes, rugose, sometimes finely ribbed, intense rose colour with occasional fine, light pink longitudinal lines. Radii tinged with purple, moderately wide with horizontal summits, orifice half width of basal diameter. Scutum with broad, obtusely inflected tergal segment and strongly toothed occludent margin, sometimes with faint longitudinal striae, articular ridge about four-fifths length of tergal margin, adductor ridge well developed and separated from articular ridge, tergum with spur furrow infolded, almost closed, apex beaked, spur long and narrow occupying about one-sixth of the basal margin, separated by one and a half times its width from basiscutal angle, basal margin usually sloping to spur on both sides, occasionally straight on one or both sides, protuberant near carinal margin (Fig. 11 A). Cirrus I, outer ramus longer with 15 segments, inner ramus significantly shorter with 14 segments (Fig. 11 B). *Mouthparts*: mandible with 4 teeth (Fig. 11 C), labrum straight with 3 fine teeth either side of notch (Fig. 11 D), maxilla I with 3 large upper spines separated from 9 spines on lower margin by distinct shallow notch (Fig. 11 E). *Size*: basal diameter 30 mm.

Additional notes

Diagnosis largely in accordance with Henry & McLaughlin (1986), apart from the terga which vary somewhat and are more similar to those described by Yamaguchi *et al.* (2009).

Global distribution

Native to the tropical east Pacific coasts of Central and South America, introduced to Europe, Japan, Brazil, Belgium, Australia, Great Britain, the African tropics and now South Africa, littoral.

South African distribution

Restricted to the warm waters of the Natal bioregion, littoral.

Remarks

An introduced species recorded in South Africa for the first time. A well-known fouling species which prefers clean, man-made substrata (Kerckhof & Cattrijsse, 2001). Specimens were found on a buoy off Richard's Bay and on two barges shortly after they were scuttled in 35 m

just south of the Delagoa bioregion. Both mature and juvenile specimens were found, indicating that a breeding population has been established. Although the species remains to be found north of the Natal bioregion, it is highly likely that they already occur there and simply remain to be found.

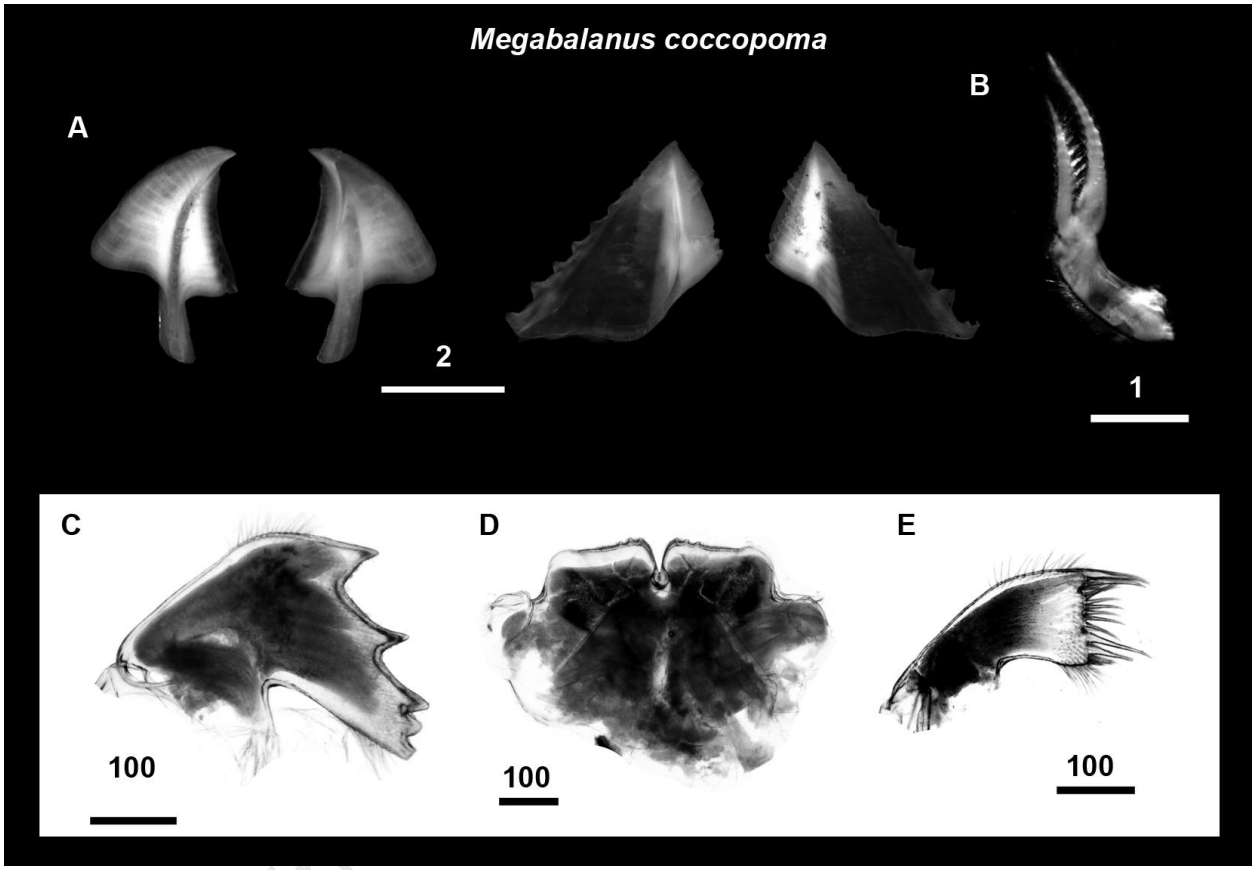

Figure 11: *Megabalanus coccopoma*: A, opercular plates; B, cirrus I; C, mandible; D, labrum; E, maxilla I. Scale bars for A, B in mm, scale bars for C-E in μm.

Chapter 2

A Guide to the South African Cirripedia (Thoracica)

Introduction

The following account provides a fully-illustrated guide to the known South African Cirripedia (Thoracica), based both on previously published literature, plus new records and species reported from South Africa for the first time during this study (Chapter 1). To date, no such guide exists and the sole objective of this chapter is to provide a means to identify the known South African Cirripedia (Thoracica). The only existing work on this scale is that of Barnard (1924), which is out of date and poorly illustrated. Many of the types described in his work have since been reclassified and synonymised – the only publication listing these changes is Zevina (1981), which is written in Russian and is difficult to use for most South African taxonomists. A series of plates with a distribution map and a photograph of each species is provided at the end of the chapter with many of the species having never been photographed before.

The layout is similar to that of Chapter 1 with taxa systematically arranged in sequence, according to inferred phylogenetic relationships. Each species is entered under the current binomen. This is followed by the original author's name, year of publication and original reference. The latest taxonomic reference is then included and serves as a source for synonyms. A full list of synonyms is provided only for those species which are here recorded in South African waters for the first time (i.e. Chapter 1). Any changes in synonymy subsequent to work on taxa described by Barnard (1924) have been included, with remarks regarding their reclassification added.

Where possible a diagnosis and abbreviated description is provided for each species in note-form. However, in cases where a combination of characters (present or absent) define a particular species, the diagnosis and description have been combined into a single entry. An indication of maximum size is provided from either personal observation or from the literature

cited within the entry. See Chapter 1 for the definition of information included under the "distribution" and "remarks" entries.

SYSTEMATIC PART

CLASS MAXILLOPODA Dahl, 1956
SUBCLASS CIRRIPEDIA Burmeister, 1834 (= Cirrhipèdes Lamarck, 1806)
SUPERORDER THORACICA Darwin, 1854
ORDER LEPADIFORMES Buckeridge & Newman, 2006

Suborder Heteralepadomorpha Newman, 1987
Family Heteralepadidae Nilsson-Cantell, 1921
Genus *Paralepas* Pilsbry, 1907

Maxilla I without strong notch, filamentary appendages well-developed, posterior and anterior rami of cirrus V and VI similar in length, segments in cirri V and VI square-shaped.

Paralepas minuta (Darwin, 1852) – new record

Plate 1, figs A, B

An addition to the South African fauna – see chapter 1.

Suborder Lepadomorpha Pilsbry, 1916
Family Poecilasmatidae Annandale, 1909
Genus *Poecilasma* Darwin, 1852

Hermaphroditic, capitulum with 5 calcified plates. Umbo of scuta and carina basal; carina narrow not extending beyond terga. Filamentary appendages absent; caudal appendages short, one-segmented. Peduncles naked.

Poecilasma crassa (Gray, 1848)

Plate 1, figs C, D

Anatifa crassa Gray, 1848: 44, pl. 3, figs 5, 6. *Poecilasma crassa* – Young 2001: 715, figs 6-9 – syn. incl.

Diagnosis and description

Capitulum bullate or strongly globose, with 5 white valves. Scuta with prominent apico-basal ridge, sometimes with a narrow "fissure-like" line or groove running along the carinal side – somewhat more distinct in mature individuals according to Barnard (1924), but apparently not according to Young (2001). Insufficient material was available to provide clarity on this. Apical portion of carina nearly flat, becoming keeled towards the lower end, terminating in a small embedded tooth. *Size*: capitular length 20 mm; capitular width 17 mm; width 12 mm; peduncle length 10-13 mm.

Global distribution

Central Atlantic, Indian Ocean, Indo-west Pacific and east Pacific, depth 22 – 866 m.

South African distribution

South-western Cape bioregion and Atlantic offshore bioregion, depth 549 – 581 m.

Remarks

Attaches to deep sea decapod Crustacea – recorded in South Africa on the carapace and legs of *Geryon quinquedens* together with *Poecilasma kaempferi*. Species within the genus *Poecilasma* often have asymmetrical scuta, one slightly larger and more convex than the other (Hiro 1938). This asymmetry is dependent on the position of attachment of each specimen (Darwin 1852). Generally, the smaller, flat scutum is always on the side closest to the host and, when stimulated, the barnacle always bends towards the flat side of the capitulum. Furthermore, the umbo-apical fissure is believed to show how the divided scuta have evolved in *Temnaspis* (Darwin 1852).

Poecilasma kaempferi Darwin, 1852

Plate 1, figs E, F

Poecilasma kaempferi Darwin, 1852: 102, pl. 2 fig. 1. – Jones et al. 2000: 238 – incl. syn.

Diagnosis and description

Capitulum oval, compressed and narrow, consisting of 5 smooth, white valves with faint striations and sometimes with a light yellow margin. Radial striations never more pronounced than the growth lines. Scutum oval, higher than wide, occludent margin not strongly projecting. Carina very narrow, straight, basally truncate. Peduncle fairly short, ranging in colour from pale yellow to light brown. *Size*: capitular length 14 mm; capitular width 9 mm; peduncle length 4 mm.

Distribution

Cosmopolitan in tropical and warm temperate waters, depth 19 – 1885 m.

Remarks

Attaches to deep sea decapod Crustacea – frequently recorded in South Africa on the carapace and legs of *Geryon quinquedens* together with *Poecilasma crassa*. Other hosts in South Africa include *Jasus parkeri, Chaceon granulates, Chaecon chuni,* and *Neolithodes asperrimus*. Similarly, *P. kaempferi* often has asymmetrical scuta, one slightly larger and more convex than the other (Hiro 1938). This asymmetry is dependent on the position of attachment of each specimen (Darwin 1852). Generally, the smaller, flat scutum is always on the side closest to the host and, when stimulated, the barnacle always bends towards the flat side of the capitulum. Furthermore, the umbo-apical fissure is believed to show how the divided scuta have evolved in *Temnaspis* (Darwin 1852).

Genus *Glyptelasma* Pilsbry, 1907

Umbo at basal angle of scutum. Basal margin of scutum forming a distinct right angle with the occludent margin. Valves finely striate.

Glyptelasma annandalei Pilsbry, 1907

Plate 2, figs A, B

Megalasma annandalei Pilsbry, 1907: 89, pl. 5 fig. 14, pl. 7 figs 15-19.

Glyptelasma annandalei – Jones et al. 2000: 238 - incl. syn.

Diagnosis

Sides of carina widened in lower third, umbo beak-like, projecting internally well below base of scutum.

Description

Capitulum with 5 white valves, twice as long as wide, compressed in its upper half. Basal margin of carina shorter than that of scutum, meeting at an angle as seen from the side. Peduncle about a quarter length of capitulum. *Size*: capitular length 19 mm; capitular width 9 mm; peduncle length 5 mm.

Global distribution

Indo-west Pacific, Southern Africa, depth 1115 – 1557 m.

South African distribution

Atlantic offshore bioregion, depth 1120 m.

Remarks

Known in South Africa from a single deep water sample – specimens attached to *Arcoscalpellum michelottianum*.

***Glyptelasma carinatum* (Hoek, 1883)**

Plate 2, figs C, D

Poecilasma carinatum Hoek, 1883: 44, pl. 1, figs 8-10, pl. 2, fig. 1, pl. 7, figs 6-7.

Glyptelasma carinatum – Young 2001: 720, figs 10C-D, 12 – incl. syn.

Diagnosis

Carina with wide sides, umbo not produced below basal margin of scutum. Dorsal margin of prosoma with 2 rows of numerous, fine and long filamentary appendages.

Description

Capitulum narrow with 5 white valves. Basal margin of carina and scutum continuous or in line, forming an even curve – as seen from side. *Size*: capitular length 15 mm; capitular width 8 mm; peduncle length 1 mm.

Global distribution

Cosmopolitan, depth 60 – 2865 m.

South African distribution

Atlantic offshore, South-west Indian offshore and Agulhas bioregions, depth 137 – 1768 m.

Remarks

Specimens found attached to gorgonian stems and *Octolasmis orthogonia*. Seems to be restricted to deep cooler, temperate waters of South Africa.

***Glyptelasma hamatum* Calman, 1919 – new record**

Plate 2, figs E, F

An addition to the South African fauna – see chapter 1.

Subgenus *Megalasma* Hoek, 1883

***Megalasma minus* Annandale, 1906**

Plate 3, figs A, B

Megalasma striatum minus Annandale, 1906: 399.

Megalasma minus – Jones et al. 2000: 239 – incl. syn.

Diagnosis

Basal margin of scutum continuous with occludent margin and basal margin of carina (all in line).

Description

Capitulum lancelet-shaped with 5 white valves, strongly striate. Scutum triangular with umbo above basal angle, tergum triangular, occludent and scutal margins almost forming a right angle, carina short, spoon-shaped, basal region expanded horizontally. Lateral margins of peduncular orifice arched forward. Peduncle very short, hardly visible. *Size*: capitular length 15 mm; capitular width 5.5 mm; peduncle length 1 mm.

Global distribution

Indo-Pacific, depth 290 – 2050 m.

South African distribution

Uncertain, label with exact locality lost (Barnard, 1924).

Remarks

Known in South Africa from a single sample collected by the S. S. Pieter Faure – specimens were attached to the spines of a *Porocidaris* urchin.

Genus *Temnaspis* Fischer, 1884

Scutum with fissure extending from umbo to tergal margin dividing valve into 2 segments, segments united at umbo.

Temnaspis amygdalum (Aurivillius, 1894) – new record

Plate 3, figs C, D

An addition to the South African fauna – see chapter 1.

Temnaspis tridens tridens (Aurivillius, 1894)

Plate 3, figs E, F

Poecilasma tridens Aurivillius, 1894: 14, pl. 1 fig. 3, pl. 6 fig. 12, pl. 8 fig. 13, 29.

Temnaspis tridens tridens – Jones et al. 2000: 241 – incl. syn.

Diagnosis

Scutum divided into a narrow and wide segment by means of a fissure extending from umbo to tergal margin – running more or less parallel to occludent margin. The 2 segments are united at umbo (see Nilsson-Cantell, 1934).

Description

Basal margin of tergum notched for reception of apex of narrow segment of scutum. Peduncle narrowing to about half its diameter just before capitulum. Mouthparts: agree well with literature. Mandible with 4 teeth and a pointed inner angle which is divided in 2 smaller secondary teeth. Maxilla I of South African specimens with a distinct notch, as figured by Rosell (1981). This character seems to be variable, as Nilsson-Cantell (1934) illustrates a specimen with an indistinct notch and goes on to mention that it is sometimes absent. *Size*: capitular length 5 mm; capitular width 3.5 mm; peduncle length 2mm.

Global distribution

South Atlantic, Indian Ocean and Indo-west Pacific, depth 16 – 296 m.

South African distribution

Natal bioregion from the intertidal zone to 118 m depth.

Remarks

Previously identified by Barnard (1924) as *Octolasmis tridens*, and believed to be the transitional form from the genus *Poecilasma* to *Octolasmis*. However, the capitulum is virtually fully covered by well developed valves and I have to agree with the placement of this species in the genus *Temnaspis*. Museum specimens correspond well with specimens figured by Rosell (1981) - attached to *Scylla serrata* in Durban Bay and *Carcinoplax longimana* in deeper water of the Natal bioregion. Recorded from a variety of Decapod Crustacea elsewhere.

Genus *Octolasmis* Gray, 1825

Octolasmis cor (Aurivillius, 1892)

Plate 4, figs A, B

Dichelaspis cor Aurivillius, 1892: 124.

Octolasmis cor – Jones et al. 2000: 242 – incl. syn.

Diagnosis and description

Capitulum oval with 3 valves – 2 scuta and T-shaped carina (terga absent). Form of valves variable. Scuta forked into a basal and occludent arm, basal arm becoming

proportionately heavier and unequally bifid with age. *Size*: capitular length 5 mm; capitular width 4 mm; peduncle length 12 mm.

Additional notes

Easily recognisable. The only member of the genus with 3 valves.

Global distribution

Indo-west Pacific, shallow water.

South African distribution

Natal and Agulhas bioregions, intertidal.

Remarks

Only known from gills of *Scylla serrata* in South Africa, but recorded from a variety of decapod Crustacea elsewhere (Jones *et al.*, 2000).

***Octolasmis neptuni* (MacDonald, 1869)**

Plate 4, figs C, D

Paradolepas neptuni MacDonald, 1869: 440, fig. 1, pl. 33, 34.

Octolasmis neptuni – Jones et al. 2000: 243 – incl. syn.

Diagnosis and description

Capitulum oval with 5 reduced plates. Scutum L-shaped, basal arm narrow and tapering distally, terga small and semicircular, carina curved with forked basal area. *Size*: capitular length 2 mm; capitular width 1.5 mm; peduncle length 4 mm.

Global distribution

Indo-west Pacific, depth 12 – 300 m.

South African distribution

Durban, Natal bioregion, intertidal.

Remarks

Found attached to gills of *Scylla serrata* in Durban Bay. Also known from other decapod Crustacea in other parts of the world.

Octolasmis orthogonia (Darwin, 1852)

Plate 4, figs E, F

Dichelaspis orthogonia Darwin, 1852: 130, pl. 2, fig. 10.
Octolasmis orthogonia – Chan 2009a: 68, figs 2B, 17.

Diagnosis

Scutal margin of tergum tridentate.

Description

Capitulum with 5 valves, scutum L-shaped, tergum triangular with 3 prominent ridges at scutal margin, third ridge (closest to carina) longest. *Size*: capitular length 15 mm; capitular width 9 mm; peduncle 8 mm.

Global distribution

Indo-west Pacific, depth 14 – 818 m.

South African distribution

Agulhas, Delagoa, and West Indian offshore bioregion, depth 27.5 – 450 m.

Remarks

Found attached to hydroids and stems of corals, sometimes fouling. Yet to be recorded in the Natal bioregion, but likely to occur there too.

Octolasmis warwickii (Gray, 1825)

Plate 5, figs A, B

Octolasmis warwickii Gray, 1825: 100. – Jones et al., 2000: 244 incl. syn.

Diagnosis

Scutal margin of tergum with 2 prominent ridges or teeth.

Description

Capitulum with 5 valves, apex produced, scutum divided into 2 branches at rostral angle, branch alongside occludent margin narrow and triangular, basal branch L-shaped and large, tergum notched at basal margin and divided into 2 ridges - carinal ridge wider and heavier than occludent ridge. *Size*: capitular length 9 mm; capitular width 6 mm; peduncle length 6 mm.

Global distribution

Indo-West Pacific, depth 14 – 100 m.

South African distribution

Natal and Delagoa bioregion, intertidal to 46 m depth.

Remarks

Barnard (1924) notes that this species is widely distributed over the Indian Ocean. It is known to occur in both benthic and pelagic habitats; attaching to a variety of decapod Crustacea, molluscs, antipatharians, fish, and sea-snakes. Yet to be recorded south of Durban, however its distribution (shaded blue in Pl. 5 C) is likely to extend to the southern limit of Natal bioregion.

Family Lepadidae Darwin, 1852

Genus *Lepas* Linnaeus, 1758

Subgenus *Anatifa* Bruguière, 1789

Apart from his key, Barnard (1924) does not go into any detailed description for any of the species within this genus. I have thus included a brief description of the most obvious diagnostic characters for each species in the genus, as per Darwin (1852) and in the case of *L. testudinata*, Aurivillius (1894). In most cases, specimens identified agree well with the literature, yet some of the characters are quite variable and several dissections may be required to yield a positive identification.

Lepas (Anatifa) anatifera Linnaeus, 1758

Plate 5, figs C, D

Lepas anatifera Linnaeus, 1758: 668. – Chan 2009a: 68, figs 2C, 18 – incl. syn.

Diagnosis

Internal umbonal tooth on right scutum only; 2 filamentary appendages; apex of terga broad and flat; caudal appendages slender and rounded.

Description

Capitulum with 5 thick valves, white in colour sometimes with bright orange/yellow margins, usually with concentric growth lines, radiating up from umbo of scutum, otherwise valves largely smooth and sometimes faintly striate, carina forked below umbo. Peduncle dark brown/black to lighter khaki. Two filamentary appendages on either side, 1 shorter appendage attached to coxa of cirrus I and a longer appendage attached to side of prosoma. *Size*: capitular length 50 mm; peduncle length 80 mm.

Additional notes

External appearance very similar to other species in the genus, particularly *L. australis*. Distinguishable by internal umbonal tooth present on the right scutum only, whereas *L. australis* has internal umbonal teeth present on both scuta. Further factors distinguishing it from *L. australis* include distinct bifurcation at the base of the carina and a somewhat more pronounced, longer filamentary appendage attached to the prosoma (Hinojosa, 2006).

Global distribution

Cosmopolitan in tropical, sub-tropical and temperate seas, pelagic.

South African distribution

Found around entire coastline throughout all bioregions.

Remarks

A pelagic species which attaches to floating substrata in dense colonies. Data collected in South Africa (Whitehead *et al.* 2011) suggest a preference for unnatural substrata, particularly plastics but has also been recorded on glass, rope, rubber and polystyrene. Natural substrata consist of kelp *Ecklonia maxima* (where present), wood, bamboo and even the loggerhead turtle *Caretta caretta*. The introduction of plastics into the environment as a preferred substrate for this species has implications on its abundance and distribution. It is difficult to quantify such implications, as no baseline data predating the advent of plastics exists. It is likely that a few "stray" specimens may occur northward into the Namaqua bioregion, where the cold Benguela current flows northward, but such "strays" are yet to be found.

***Lepas (Anatifa) anatifera striata* de Graaf, 1952 – new record**

Plate 5, figs E, F

An addition to the South African fauna – see chapter 1.

Lepas (Anatifa) anserifera Linnaeus, 1767

Plate 6, figs A, B

Lepas anserifera Linnaeus, 1767: 1109. – Young, 1990: 642, fig. 1d-f – incl. syn.

Diagnosis

Only member of genus with 4 to 6 filamentary appendages (usually 5). Distinct quadrangular terga.

Description

Capitulum with 5 valves, white in colour and sometimes edged in dull yellow, strongly striate – terga in particular. Occludent margin of scutum convex and protuberant, terga quadrangular. Barbs sometimes present on roof of carina, particularly in younger specimens, but usually eroded away in older specimens - their former presence indicated by small round bumps. Peduncle dark to light brown in colour and fairly short in comparison to other species in genus, yet still easily discernable. Four, usually 5, rarely 6 filamentary appendages (Newman, 1972) present. One attached to side of prosoma, remainder attached to coxa of cirrus I. *Size*: capitular length 45 mm; capitular width 29.5 mm; peduncle length 26 mm.

Additional notes

Externally very similar in appearance to *L. pectinata* yet is distinguishable by quadrangular terga and a protruding convex occludent margin. The number of filamentary appendages is the most reliable taxonomic character for this species.

Global distribution

Cosmopolitan in tropical, subtropical and temperate seas, pelagic.

South African distribution

Found around entire coastline throughout all bioregions.

Remarks

A pelagic species attaching to floating substrata in dense colonies, with similar synthetic substrate preferences to *L. anatifera*. The vast majority of collected material was attached to plastics and rubber sandals, but also recorded on glass and rope. Far fewer found attached to natural substrata, which consisted of *Ecklonia maxima*, wood, bamboo, reeds (*Typha capensis*), coconut shells, gas-filled *Spirula spirula* shells and even an apple. Abundant in warmer waters

on south and eastern coastline of South Africa, becoming rare northward of Saldanha Bay. Specimens yet to be recorded north of this point, however, it is possible that the Benguela Current carries this species further north into the Namaqua bioregion.

***Lepas (Anatifa) australis* Darwin, 1852**

Plate 6, figs C, D

Lepas australis Darwin, 1852: 89, pl. 1 fig. 5. – Newman & Ross 1971: 31, figs 8, 9 – incl. syn.

Diagnosis

Internal umbonal teeth on both scuta, valves relatively thin and brittle; caudal appendages broad and blunt.

Description

Capitulum with 5 valves, white to grey in colour, usually smooth. Basal fork of carina broadly rounded. Carina wider than *L. anatifera* and often proportionately shorter, contributing to the broad, robust shape of capitulum, apex of terga narrow and rounded. Internal umbonal teeth on both scuta, tooth on right scutum generally larger. Peduncle ranging in colour from brown to a more common light khaki brown to almost white/transparent. Filamentary appendages 2 on each side, 1 shorter appendage attached to coxa of cirrus I and a very fine, long appendage attached to side of prosoma – thicker and more obvious in *L. anatifera*. *Size*: capitular length 45 mm; capitular width 35; peduncle length 30 mm.

Additional notes

Easily confused with *L. anatifera* but can usually be identified by presence of umbonal teeth on both scuta.

Global distribution

Southern Ocean, extending into parts of southern Atlantic and Pacific, pelagic.

South African distribution

West coast of South Africa, extending eastward to False Bay.

Remarks

Predominantly a Southern Ocean species carried northward by the Benguela Current and occasionally encountered on our west coast after winter storm swell. Rarely found east of Cape

Point – only one sample collected at Danger Beach in False Bay. Prefers a variety of natural and synthetic substrata: mostly plastics, followed by *Ecklonia maxima* (where it is often associated with *Lepas testudinata*). Known to attach to seals, penguins and fish.

***Lepas (Anatifa) hilli* (Leach, 1818)**

Plate 6, figs E, F

Pentalasmis hilli Leach, 1818.

Lepas hilli – Newman 1972: 36, figs 2H-I incl. syn.

Diagnosis

Scuta without internal umbonal teeth, 3 filamentary appendages on each side.

Description

Capitulum laterally compressed, with 5 smooth, white valves. Tergum narrow and wedge-shaped, carina widely separated from scuta and terga in mature individuals (Cornwall, 1925). Peduncle brown, can attain more than twice length of capitulum in mature individuals (Cornwall, 1925). Filamentary appendages 3 on each side, 2 shorter appendages attached to coxa of cirrus I and a longer appendage attached to flank of prosoma. *Size*: capitular length 12 mm; capitular width 10 mm; peduncle length 8 mm.

Additional notes

External appearance closely resembles *L. anatifera* and *L. australis*, yet unlike these species *L. hilli* has 3 filamentary appendages and is easily recognisable by absence of internal umbonal teeth on the scuta.

Global distribution

Cosmopolitan, pelagic.

South African distribution

Found around entire coastline throughout all bioregions.

Remarks

A well-known hull-fouling species, hence the probable country-wide distribution. Not yet found attached to other substrata in South Africa. The only representative was taken off the hull of a yacht at the Royal Cape Yacht Club in Table Bay, Cape Town. Otherwise extremely rare.

Lepas (Anatifa) pectinata Spengler, 1793

Plate 7, figs A, B

Lepas pectinata Spengler, 1793. – Young 1990: 644, figs 2a-b – incl. syn.

Diagnosis

Occludent margin a continuous arch from umbo to apex, terga narrow and triangular, scutum apex projected inside a fold of tergum border, 1 short, obtuse filamentary appendage – sometimes absent.

Description

Capitulum with 5 calcified valves, thin and strongly striate/furrowed. Scutum with prominent ridge extending from umbo to apex, close to occludent margin. Internal umbonal teeth on each of scuta (tooth of right scutum generally larger). Tergum with distinct notch to receive apex of scutum. Peduncle narrow and short (less than length on capitulum), scarcely visible in most specimens. One, short, obtuse filamentary appendage projecting either side from posterior of coxa of cirrus I, sometimes absent. *Size:* capitular length 8 mm; capitular width 6 mm; length peduncle 2 mm.

Global distribution

Cosmopolitan in tropical and temperate seas, pelagic.

South African distribution

Found around entire coastline throughout all bioregions.

Remarks

Frequently found washed up on west and south coast of South Africa after winter storm swell. Increasingly rare as one moves eastward towards Mozambique border. Only one sample recorded from Durban. Has a distinct preference for attachment to gas-filled *Spirula spirula* shells and feathers, also found attached to plastics, wood and glass.

Lepas (Anatifa) testudinata Aurivillius, 1892

Plate 7, figs C – E

Lepas testudinata Aurivillius, 1892: 123. – Jones *et al.* 2000: 246 – incl. syn.

Diagnosis

Occludent margin straight, internal umbonal teeth on both scuta, 2 filamentary appendages, terga projecting ventrally, valves relatively thin.

Description

Capitulum with 5 valves, white to grey in colour with growth lines evident, wide interspaces between valves. Peduncle long, brown to yellow-brown covered in soft spiny projections. Two filamentary appendages on each side, 1 shorter appendage attached to coxa of cirrus I and a longer appendage attached to flank of prosoma. *Size*: capitular length 30 mm; capitular width 20 mm; peduncle length 60 mm.

Aberration

Many specimens collected in the Cape had long peduncles which were smooth and often transparent in colour, some exceeding 300 mm in length (Pl. 7 E). These are morphologically distinct in comparison to the typical form, which has a much shorter peduncle with many soft spiny projections (Pl. 7 D).

Global distribution

Cosmopolitan in southern seas, pelagic.

South African distribution

Restricted to the cooler waters of the Atlantic offshore, Namaqua, South-western Cape and Agulhas bioregions – not found washed up east of Jeffrey's Bay.

Remarks

Attached most frequently to the kelp, *Ecklonia maxima*, frequently in the order of kilograms with individuals numbering in their thousands (Whitehead *et al*., 2011).

Genus *Dosima* Gray, 1825

Dosima fascicularis (Ellis and Solander, 1786)

Plate 7, figs F, G

Lepas fascicularis Ellis and Solander, 1786: 197, pl. 15, fig. 6.
Dosima fascicularis – Young 1990: 644, figs 2c, d – incl. syn.

Diagnosis

Carina angularly bent at umbo, terminating in a flat disc, thin paper-like valves, 4 to 5 short filamentary appendages.

Description

Capitulum inflated and laterally compressed with 5 thin white valves which transmit colour of animal inside (ranges from grey to bright blue). Basal margin of scutum flared forming a "collar". Basal and carinal margins of tergum meet forming a point. Peduncle fairly short, thick and light in colour. Modified glands at base of peduncle secrete flotation cement which aid buoyancy. Four short filamentary appendages attached to coxa of cirrus I (2 of which are minute), a fifth attached to flank of prosoma. *Size*: capitular length 49 mm; capitular width 38 mm; peduncle length 35 mm; diameter of float 50 mm (Ryan and Branch, 2012).

Global distribution

Cosmopolitan, pelagic.

South African distribution

Found around the entire coastline throughout all bioregions.

Remarks

The only known pelagic species to secrete a float of its own. Smaller individuals often found attached to floating substrata with a preference for bird feathers and plastic, yet individuals are also found attached to wood, bamboo and glass.

According to Newman & Ross (1971), the cyprid larvae select small objects for attachment and before the mass of the animal exceeds the buoyancy of the object, a buoyant secretion is deposited around the area of attachment. Other individuals then attach forming a buoyant self-sustained, free-floating colony.

It is possible that populations of pelagic goose barnacles are limited by the availability of suitable substrata (Newman & Ross, 1971; Whitehead et al., 2011). *Dosima fascicularis* has avoided this problem by selecting objects which are too small for the attachment of other species. The success of this strategy was witnessed during a phenomenal event in November 2011 when thousands of *D. fascicularis* colonies appeared in coastal waters off the Western Cape and washed ashore over hundreds of kilometres of coastline - the majority making use of their own floats. The event was well documented by Ryan and Branch (2012).

Genus *Conchoderma* Olfers, 1814

Conchoderma auritum (Linnaeus, 1767)

Plate 8, figs A, B

Lepas aurita Linnaeus, 1767: 1110.

Conchoderma auritum – Newman & Ross 1971: 36, pl. 3 – incl. syn.

Diagnosis

Two distinct fleshy ear-like siphons projecting backward from top of capitulum.

Description

Capitulum covered in cuticle – usually grey to purplish-brown, sometimes with indistinct cream stripes (purple in younger specimens). Smaller individuals with up to 5 rudimentary plates present anterior to fleshy siphons. Scuta bi-lobed – usually present in mature specimens only. *Size:* capitular length 35 mm; capitular width 30 mm; peduncle length up to 70 mm.

Global distribution

Cosmopolitan in all seas, pelagic.

South African distribution

Found around entire coastline throughout all bioregions.

Remarks

A pelagic species usually found attached to mobile "hosts" such as turtles, cetaceans and ships. Often described as an "energy parasite" relying on the current generated by the host to

filter food particles passively from the water column with filtered water exiting through the fleshy siphons (Branch *et al*. 2010).

***Conchoderma hunteri* (Owen, 1830)**

Plate 8, figs C, D

Cineras hunteri Owen, 1830: 71.

Conchoderma hunteri – Chan 2009a: 71, figs 2D, 19 – incl. syn.

Diagnosis

Capitulum covered in thin cuticle - deep purple to grey in colour with 5 white, reduced, narrow valves.

Description

Scutum tri-lobed, Y-shaped, lateral lobe not wider than lower lobe. Terga and carina narrow and bent. Single filamentary appendage attached to base of cirri I-IV. Peduncle cylindrical and smooth. *Size*: capitular length 27 mm; capitular width 23 mm; peduncle length 8 mm.

Global distribution

Indo-Pacific Ocean, pelagic.

South African distribution

Found around entire coastline throughout all bioregions.

Remarks

It is uncertain whether *C. hunteri* and *C. virgatum* should be considered separate species. Chan (2009) states that data from his unpublished work revealed considerable genetic divergence in the COI gene between *C. virgatum* and *C. hunteri* – he therefore recognises them as separate species.

The probable distribution of this species in South Africa is deduced from the distributions of the various animals it attaches to. Most commonly encountered attached to sea snakes and turtles – although also recorded from a jelly fish (Barnard 1955), the back of a crab and a flying fish.

Conchoderma virgatum (Spengler, 1790)

Plate 8, figs E, F

Lepas virgata Spengler, 1790: 207, tab. 6, fig. 9.

Conchoderma virgatum – Newman & Ross 1971: 35, fig. 11, pl. 5 E – incl. syn.

Diagnosis

Tergum narrow and thin, elevated at both apices with a fleshy outgrowth between the terga and carina.

Description

Capitulum rectangular, carinal and tergal margin perpendicular to each other, covered in a thin cuticle, usually blue-grey with 6 black or purple-brown longitudinal stripes extending down the length and onto peduncle. Five white, reduced valves: scutum tri-lobed or Y-shaped – lateral lobe wider than lower lobe. Peduncle smooth and tapering off from capitulum. *Size*: capitular length 34 mm; capitular width 29 mm; peduncle length 28 mm.

Global distribution

Cosmopolitan in tropical and temperate seas worldwide.

South African distribution

Found around entire coastline throughout all bioregions.

Remarks

A pelagic species more commonly found attached to turtles, sea snakes, fish, cetaceans, crustaceans – also known to foul ships. Never attached directly to the skin of "host" - apart from one record (Barnard 1924) where a small group was found attached to the tail of a large eel (*Gymnothorax favagnieus*). Rarely found attached to flotsam.

ORDER SCALPELLIFORMES Buckeridge & Newman, 2006

Suborder Scalpellomorpha Newman, 1987

Family Calanticidae Newman, 1996

Formerly a subfamily, Calanticinae (Zevina, 1978) was elevated to family level by Newman (1996). Members of this family are distinguished from all other scalpellids by presence of a sub-carina in the female or hermaphrodite and, unlike the Scalpellidae; the males are distinctly divided into a capitulum and peduncle. In a revision of the taxon, Young (2003) suggests that the scalpellids are in fact a sister clade of the calanticids, which have lost the subcarina and have a reduced rostrum. He goes on to say that it is likely the calanticids are paraphyletic with several unrelated groups of species.

Calantica and *Smilium* are the two genera represented in South Africa and are solely defined by the degree of elevation in the upper latus – a somewhat variable character which has caused much confusion with regard to the correct placement of species (Pilsbry, 1908; Hiro, 1932, 1933; Nilsson-Cantell, 1938). I have followed Zevina (1981) with regard to the placement of species between these two genera.

To date only two species of calanticids are known from South Africa, *Calantica pollicipedoides* and *Smilium hypocrites*. Fortunately, *S. hypocrites* is the only known aberration of its kind within the calanticids and can be easily distinguished from *C. pollicipedoides*.

Genus *Calantica* Gray, 1825

Calantica pollicipedoides (Hoek, 1907)

Plate 9, figs A, B

Scalpellum pollicipedoides Hoek, 1907: 60, pl. 5, fig. 9-11.
Calantica pollicipedoides – Zevina 1981: 57, fig. 31 – incl. syn.

Diagnosis

Upper latus not elevated, forming part of basal whorl of plates.

Description

Fifteen valves covered by thin and transparent membrane. Scutum triangular, tergum rhomboid, carina nearly straight, sometimes with apex projecting. Valves of basal whorl consisting of a rostrum, 4 pairs of latera and a subcarina – all, apart from the larger upper latus, triangular and small. *Size*: capitular length 10 mm; capitular width 8 mm; peduncle length 5 mm.

Additional notes

As noted by Barnard (1924), the upper latus in the South African specimens have 2 divergent ridges, varying in distinctness, running from the umbo to the basal margin.

Global distribution

Indo-west Pacific.

South African distribution

Natal and Delagoa bioregions depth 36 – 165 m.

Remarks

The only representative of the genus in South Africa, rare.

Genus *Smilium* Gray, 1825

Smilium hypocrites Barnard, 1924

Plate 9, figs C, D

Smilium hypocrites Barnard, 1924: 14, pl. 1 (figs 1, 2).

Diagnosis

Upper latus elevated above basal whorl of plates.

Description

Capitulum with 9 valves; upper latus narrow and greatly reduced, sickle-shaped, elevated above basal whorl of plates. Scutum with occludent margin slightly concave, umbo at acute apex. Tergum narrow and triangular, occludent margin short, umbo at subacute apex. Reduction in number of plates in basal whorl. Peduncle half length of capitulum with incomplete and irregularly developed rings of minute granules at upper end. *Size*: capitular length 4 mm; capitular width 3 mm; peduncle length 4 mm.

Distribution

Endemic to South Africa, Natal bioregion, 165 m depth.

Remarks

Known from a single record collected off the KwaZulu-Natal coast. Completely overgrown and covered by the coenenchyme and polyps of the Cnidarian, *Villogorgia mauritiensis* (Barnard, 1924).

Family Scalpellidae Pilsbry, 1907

Female or hermaphrodite with not more than 14 valves, subcarina absent. Never more than two unpaired plates. Male reduced to a sack-like form without a mouth or peduncle.

Subfamily Scalpellinae Pilsbry, 1907

Penis absent, carina angularly bent, umbo at bend.

Genus *Compressoscalpellum* Zevina, 1978

Zevina (1981) has since placed one endemic species described by Barnard (1924) within the genus, which is diagnosed by the presence of a narrow inframedian latus with basal umbo and capitulum with perfectly calcified plates.

Compressoscalpellum faurei (Barnard, 1924)

Plate 9, figs E, F

Scalpellum faurei Barnard, 1924: 22, pl. 1 fig. 4.
Compressoscalpellum faurei – Zevina 1981: 106.

Diagnosis

Angular bend in carina with umbo removed from apex.

Description

Capitulum subquadrangular with 13 or 14 closely fitting valves, carina angularly bent with umbo situated at bend. Inframedian latus with umbo basal, narrow, curved and widening

slightly upwards, apex acute and making contact with upper latus. Occludent and carinal margins slightly convex, subparallel. Valves all finely striate radiately, covered with very fine cuticle and sparsely clad with short, fine hairs. *Mouthparts*: labrum obtusely produced, mandible with 3 teeth, outer margin of second and third tooth denticulate, maxilla I with notch between upper 4 spines and lower 6. *Size*: capitular length 4 mm; capitular width 3 mm; peduncle length 1 mm.

Additional notes

The angular bend in the carina with the umbo removed from the apex is a very important character to consider when identifying *C. faurei*. The only other genus in South Africa with this character is *Ornatoscalpellum* and this can be easily distinguished by the morphology of the inframedian latus.

Distribution

Endemic to South Africa – recorded in South-west Indian offshore, West Indian offshore and Natal bioregions, depth 90 – 775 m.

Remarks

Found in warmer waters of South Africa attached to gorgonians, *Villogorgia mauritiensis*, and *Allopora nobilis.*

Genus *Ornatoscalpellum* Zevina, 1978

Ornatoscalpellum was erected by Zevina (1978) and *O. ornatum* subsequently placed therein (Zevina, 1981). Specimens identified agree well with Darwin (1852), however, no detailed description is provided by Barnard (1924). I have thus included a brief description below largely according to Darwin (1852), but modified with personal observations.

Ornatoscalpellum ornatum (Gray, 1848)

Plate 10, figs A – C

Thaliella ornata Gray, 1848: 44.

Ornatoscalpellum ornatum – Zevina 1981: 109, fig. 76 – incl. syn.

Diagnosis and description

Capitulum with 14 valves; upper latus quadrilateral with lower margin deeply notched. *Capitulum*: oblong, valves close-fitting with faint striations radiating from umbones. Growth lines sometimes evident. *Scuta*: trapezoidal, occludent margin convex, umbo apical lateral margin slightly concave. *Terga*: subtriangular, large and roughly equal in surface area to scuta. Occludent margin convex. Scutal margin not quite straight, slightly convex and about one-third longer than occludent margin. *Carina*: angularly bent, laterally broad and widening from apex to base, umbo located on the bend. *Rostrum*: minute, wedged between umbones of rostral latera, hardly projecting beyond their upper margins. *Upper latus*: quadrilateral, lower margin concave with a deep square notch for reception of upper part of carinal latus. Shallow depression or groove visible on surface of valve – formed by 2 ridges radiating and widening from umbo to either side of the notch. *Rostral latera*: small, widening from umbo to opposite end. Not reaching upper latus. In most specimens the umbones project slightly beyond profile of rostrum, however, like Barnard (1924) I have examined False Bay material where this is not observed. *Carinal latera*: consists of a lower and upper part (as if formed of 2 valves united together – Darwin, 1852), upper part widening and curving upward, inserting into notch of upper latus, lower shorter part with a square, truncate margin abutting against inframedian latus. In most specimens umbones project beyond profile of carina, however, again like Barnard (1924) I have observed specimens from False Bay where this is not the case. *Inframedian latera*: somewhat curved towards occludent margin (convex on the carinal side) with apex being spear-shaped and widening towards basal margin. The entire valve does not appear to be diamond-shaped as described by Darwin (1852), owing to the overall curvature which I have observed. Size: capitular length 6.5 mm; capitular width 4 mm; peduncle 2.5 mm.

Distribution

Endemic to South Africa. Recorded in Agulhas, Natal and South-west Indian offshore bioregions, depth range extended to 200 m.

Remarks

Barnard (1924) documented an aberration of this species which I have also encountered. This form (Pl. 10 C) can be readily distinguished from the typical form (Pl. 10 B) by the long, slender, sickle-shaped inframedian latera. These have been modified in this way to accommodate the much larger rostral latera, which extend inward such that the upper angle touches the upper latus, thereby completely isolating the inframedian latera from the scuta. Based on these

findings, and pending the collection of further aberrant specimens, I suggest that further work be carried out to test whether these forms are a separate species.

Most frequently found attached to hydroids and small stones, often together with *T.natalense, T. valvulifer,T. eumitos* and *S. auricoma*.

Subfamily Meroscalpellinae Zevina, 1978

Includes species with imperfectly calcified valves.

Genus *Litoscalpellum* Newman & Ross, 1971

The genus was erected by Newman & Ross (1971) for specimens "with relatively unspecialised capitular armour, holding a superficial resemblance to *Arcoscalpellum*". In their key on page 37 of their work "Antarctic Cirripedia", the diagnostic character for this genus reads: "Capitular plates of adult **reduced**". However, on page 108, under the description for "*Litoscalpellum* gen. nov." the first sentence reads: "female armed with 14 **mostly unreduced** calcareous plates". This contradiction has caused considerable difficulty in keying out specimens. Quite clearly, reduction in capitular plates is an unreliable diagnostic character for specimens within this genus.

Newman & Ross (1971), list *Arcoscalpellum regina* (Pilsbry, 1907a) on page 60 as a member of the *Arcoscalpellum michelottianum* group. According to Zevina (1981), the current accepted nomenclature is *Litoscalpellum regina* (Pilsbry, 1907a), with no mention of *A. regina* as a synonym. Therefore, Zevina (1981) has either inadvertently placed *A. regina* within *Litoscalpellum* by virtue of poor diagnostics for the genus defined by Newman & Ross (1971), or it has been overlooked as a synonym. This issue needs resolving. For now, I have maintained Zevina's placement of the species and included *A. regina* as a synonym.

Litoscalpellum regina (Pilsbry, 1907)

Plate 10, figs D, E

Scalpellum regina Pilsbry, 1907a: 31, pl. 2, figs. 4 – 6.

Arcoscalpellum regina – Newman & Ross 1971: 60.

Litoscalpellum regina – Zevina 1981: 136, fig. 95 – incl. syn.

Diagnosis

Exceptionally large, capitular plates reduced, peduncle long.

Description

Capitulum with 14 valves, moderately compressed and covered in a thin cuticle with a short, dense pile. Adults with capitular plates separated by wide chitinous sutures – in young specimens they are in contact. Carina arcuate, umbo apical. Rostral latera wider than high, basal and scutal margins parallel. Carinal latera irregular in shape. Posterior margin convex and projecting beyond carina with plates meeting below. Umbo elevated, acute and curved upward. Peduncle length in agreement with Barnard (1925), usually exceeding that of capitulum, sometimes by more than half – considerably longer than Pilsbry's specimens. *Size:* capitular length 45 mm; capitular width 33 mm; peduncle length 50 mm.

Additional notes

One of the largest scalpellids in South African waters. Easily confused with the other large species *Arcoscalpellum michelottianum,* but distinguished by a reduction in capitular plates in the adult and longer peduncle.

Global distribution

Widely distributed throughout the Atlantic and Southern Ocean, depth 91 – 1500 m.

South African distribution

Namaqua and Atlantic offshore bioregion, depth 900 – 1200m.

Remarks

Restricted to cold deep water bioregions of South Africa – yet to be recorded east of Cape Point. Frequently found with species of Poecilasmatidae attached to the capitulum amongst juveniles.

Subfamily Arcoscalpellinae Zevina, 1978

Carina not angularly bent, umbo apical/subapical. Valves perfectly calcified, 13 -14.

Genus *Tarasovium* Zevina, 1978

Zevina (1981) has since placed several endemic species described by Barnard (1924) within the genus *Tarasovium*, based on the following characters: umbo of upper latus apical; inframedian latus wide, umbo basal; umbo of carinal latus protruding past carina.

Tarasovium brevicaulis (Barnard, 1924)

Plate 10, figs F – H

Scalpellum brevicaulis Barnard, 1924: 32, pl. 1 fig. 11.
Tarasovium brevicaulis – Zevina 1981: 198.

Diagnosis

Carinal latus irregular, V-shaped with umbo at apex of V and extending out beyond carina. Outer arm of the V forming a normally shaped valve, inner arm extending diagonally upward into excavate base of carina meeting its fellow. When viewed dorsally 2 carinal latera are shaped like a W (Pl. 10 H).

Description

Capitulum ovate with 14 closely fitting valves. Capitulum and peduncle smooth. Scutum trapezoidal, occludent margin slightly convex, occludent margin of tergum also slightly convex but shorter than scutal margin, apex acute. Roof of carina bordered by more or less prominent ribs. *Mouthparts*: labrum obtusely produced, mandible with 3 teeth, first largest with outer margins of second and third minutely denticulate, maxilla I with scarcely defined notch on inner angle. *Size*: capitular length 4 mm; capitular width 2 mm; peduncle length < 1 mm.

Additional notes

Easily distinguished from other members of the genus by the "W configuration" of the carinal latera.

Distribution

Endemic to South Africa, restricted to the Agulhas bioregion, depth 66 – 88 m.

Remarks

Rare, only known from two records in South Africa – specimens attached to calcareous Polyzoan. Barnard (1924) draws similarity between this species and *Pilsbryiscalpellum parallelogramma* with respect to the V-shaped carinal latera.

Tarasovium eumitos **(Barnard, 1924)**

Plate 11, figs A, B

Scalpellum eumitos Barnard, 1924: 34, pl. 1 fig. 12.
Tarasovium eumitos – Zevina 1981: 194.

Diagnosis

Upper latus pentagonal, lower margin biconcave. Carinal latus triangular with upper part somewhat feebly inserting into concavity on carinal side of upper latus.

Description

Capitulum with 14 closely fitting valves, covered with pale yellow cuticle with a short, thick pile becoming longer on carina. Occludent margin nearly straight. Carina strongly arched, sides moderately wide, roof convex – bordered by 2 prominent ribs. All valves radiately striate, striations variable between specimens. Scutum pentagonal, basal and lateral margins slightly concave, margin abutting against inframedian latus always short. Tergum with apex acute. Rostral latus is more often higher than wide, contrary to Barnard (1924). Peduncle setose. *Mouthparts*: labrum obtusely produced, mandible with 3 teeth, first largest with outer margins of second and third minutely denticulate, inner angle subacute, maxilla I inner edge with barely distinguishable notch. *Size*: capitular length 10 mm; capitular width 5 mm; peduncle 4 mm.

Distribution

Endemic to South Africa. Recorded in the South-western Cape, Agulhas and Natal bioregions. Previously known depth range of 104 – 421 m, now extended to 42 – 421 m.

Remarks

Attached to hard corals and stones. Barnard (1924) notes it is a variable species and describes two aberrant forms.

Tarasovium natalense (Barnard, 1924)

Plate 11, figs C – E

Scalpellum natalense Barnard, 1924: 39, pl. 1 fig. 14.

Scalpellum uncinatum – Barnard 1924: 38, pl. 1 fig. 13.

Tarasovium natalense – Zevina 1981: 197.

Zevina (1981) has since included *Scalpellum uncinatum* Barnard, 1924 as a synonym. I agree with this notion as it appears that *S. uncinatum* is merely a mature version of *T. natalense.* Barnard (1924) bases the diagnosis of this species on height of the rostral latus. In lieu of my findings regarding this character in *T. eumitos*, it is no longer helpful to use this as a diagnostic feature of *T. natalense*. I have therefore modified the diagnosis and description of the capitular plates quite extensively.

Diagnosis

Inframedian latus at least twice as high as wide, never narrowing towards apex which is never lower than that of carinal latus.

Description

Capitulum with 14 valves, not always closely fitting, growth lines distinct. Carina narrow. Umbo of inframedian latus at basi-rostral angle with a prominent ridge extending to upper carinal angle. Rostral latus variable in height, basal margin short, sometimes non-existent. Peduncle never setose, sparse to densely imbricated with scales. *Mouthparts*: labrum obtusely produced, mandible with 3 equidistant teeth, first slightly larger than second, outer margin of third tooth minutely denticulate, maxilla I inner edge without notch but a gap present between the outer 4 unequal spines and the inner ones. *Size*: capitular length 6 mm; capitular width 4 mm; peduncle length 4.5 mm.

Additional notes

The height of the inframedian latus is the most reliable character in distinguishing this species from others in the genus, apart from *Tarasovium valvulifer* (in the absence of accessory valves), which differs in morphology of the carina.

Distribution

Endemic to South Africa. Recorded in the Agulhas, Natal, South-west Indian offshore and West-Indian offshore bioregions. Previously known depth range of 66 – 168 m, now extended to 27 – 650 m.

Tarasovium valvulifer (Annandale, 1910)

Plate 11, figs F – H

Scalpellum valvulifer Annandale, 1910: 214, figs 1-2.
Tarasovium valvulifer – Zevina 1981: 195, fig. 136 – incl. syn.

Diagnosis

Capitulum with accessory valves in adult. Carina with umbo remote from apex, resulting in an angularly bent shape.

Description

Umbo of carinal latera protruding past carina. Upper latus quadrangular. *Mouthparts*: labrum obtusely produced, mandible usually with 3 teeth, sometimes with only 2 besides the inner angle which varies from being merely bifid to bearing several minute denticles, maxilla I with inner edge straight and hardly any trace of a notch. *Size*: capitular length 6 mm; capitular width 3 mm; peduncle length 4 mm.

Global distribution

South Indian Ocean and China Sea, depth 22 – 159 m.

South African distribution

South-western Cape, Agulhas and South-west Indian offshore bioregions. Previously known depth range of 40 – 159 m, now extended to 36 – 200 m.

Remarks

Accessory valves formed from centres of calcification midway between major valves. There is no evidence to suggest their formation by splitting off from the major valves (Barnard, 1924). Found attached to gorgonians, ascidians and molluscs.

Genus *Pilsbryiscalpellum* Zevina, 1978

Two species described by Barnard (1924) have been assigned to this new genus by Zevina (1981) with the following characters in common: inframedian latus narrow, triangular or vase shaped, umbo basal or sub-basal; umbo of carinal latera extending past edge of carina.

Pilsbryiscalpellum capense (Barnard, 1924)

Plate 12, figs A, B

Scalpellum capense Barnard, 1924: 26, pl. I (fig. 7).

Diagnosis

Capitulum oval with 14 closely fitting valves with strong radial striations. Carinal margin of carinal latus ridge-like, thickened, not reflexed. Upper latus incised.

Description

Upper latus quadrant shaped, incised. Inframedian latus narrow, height more than twice width of the upper part, narrowing towards the basal umbo and curving forward under rostral latus, not projecting. Peduncle short with closely imbricated scales. *Mouthparts*: labrum obtusely produced, mandible with 3 teeth, decreasing in size, inferior angle blunt, denticulate, maxilla I with 4 upper unequal spines separated by a gap (no notch) from the lower spines. *Size*: capitular length 5 mm; capitular width 3 mm; peduncle 1.5 mm.

Distribution

Endemic to South Africa, known from only two samples collected off Lion's Head in the South-western Cape bioregion, depth 250 m.

Remarks

Rarely encountered, specimens found attached to a polyzoan.

Pilsbryiscalpellum subalatum (Barnard, 1924)

Plate 12, figs C, D

Scalpellum subalatum Barnard, 1924: 25, pl. 1 fig. 6.

Diagnosis

Carinal margin of carinal latus reflexed outwards.

Description

Capitulum lanceolate, robust at base, with 14 closely fitting valves. Scutum trapezoidal, occludent margin convex, tergum with occludent margin straight, shorter than scutal margin, apex acute. Upper latus quadrant shaped and incised but to a lesser degree than *P. capense*. Inframedian latus hour-glass shaped – moderately wide at base, then strongly restricted and then gradually widening to a quadrate apex. Umbo basal, projecting laterally downward and outward over peduncle, separated from rostral latus by a wing-like process. Peduncle short with closely imbricated scales. *Mouthparts*: labrum obtusely produced, mandible with 3 teeth, decreasing in size, inferior angle subacute, denticulate, maxilla I with small distinct notch separating 3 upper spines from lower 7 spines. *Size*: capitular length 5 mm; capitular width 3 mm; peduncle length 1.5 mm.

Distribution

Endemic to South Africa, restricted to warmer waters east of Cape Point – originally located in Agulhas and South-west Indian offshore bioregions, now extended to the West Indian offshore and Delagoa bioregions. Previously known depth range of 104 – 366 m, now extended to 65 – 720 m.

Remarks

Frequently encountered in deep water trawl and dredge samples, attached to calcareous polyzoans.

Genus *Verum* Zevina, 1978

Three species described by Barnard have been moved by Zevina (1981) into the genus *Verum* based on the following characters: narrow inframedian latera with umbo basal or sub-basal; basicarinal angle not extending beyond carina.

Verum agulhense (Barnard, 1924)

Plate 12, figs E, F

Scalpellum agulhense Barnard, 1924: 28, pl. 1 fig. 8.

Verum agulhense – Zevina 1981: 240.

Diagnosis

Inframedian latus high yet narrow at basal umbo, widening slightly towards apex, not extending beyond that of carinal latus. Upper latus moderately incised.

Description

Capitulum slender with 14 close-fitting, smooth valves. Carinal margin of carinal latus not thickened. Carina arcuate, roof convex, widening rapidly towards base and entering in a V-like fashion between carinal latera. Intraparietes narrow. Upper latus sub-triangular with angle between carinal and carinolateral margins obtuse. Rostrum present, variable in length. *Mouthparts*: labrum subacutely produced, mandible with 3 teeth, outer margin of second and third minutely denticulate, inferior angle denticulate, maxilla I with notch separating upper 4 unequal spines from 6-7 spines on lower margin. *Size*: capitular length 5.5 mm; capitular width 3 mm; peduncle length 2 mm.

Additional notes

Specimen figured by Barnard appears to be covered in a cuticle with a short, thick pile. No such specimens were encountered during this study. Closely allied to *Verum hendersoni* (Pilsbry, 1911) but distinguished by presence of a rostrum and morphology of the upper latus.

Distribution

Endemic to South Africa. Recorded in Agulhas and South-west Indian offshore bioregions. Previously known depth range of 457 – 468 m, now extended to 720 m depth.

Remarks

Rarely encountered. Attached to worm tube with *Verum cancellatum*.

Verum branchiumcancri (Weltner, 1922)

Plate 13, figs A, B

Scalpellum brachium-cancri Weltner, 1922: 65, pl. 2, fig. 2.

Verum branchiumcancri – Zevina 1981: 220, fig. 157.

Diagnosis

Inframedian latus curved and expanding upward into fan-like shape from an acute, basal umbo, rostral margin concave.

Description

Capitulum ovoid with 14 slightly separated valves – far less than figured by Barnard. Valves with strong radial striations, scutum pentagonal, occludent margin slightly convex, lateral margin straight, apex acute, slightly recurved, tergum with occludent margin strongly convex, apex subacute, strongly recurved, projecting only slightly above apex of carina. Peduncle stout. *Mouthparts*: labrum subacutely produced, mandible with 3 teeth, first far removed from and much larger than second and third, inferior angle subacute, denticulate. *Size*: capitular length 10 mm; capitular width 6.5 mm; peduncle length 4 mm.

Distribution

Endemic to South Africa. Recorded in Agulhas and South-west Indian Offshore bioregions, depth 192 – 457 m.

Remarks

A rare species. Weltner (1922) recorded specimens attached to the back of the crab, *Scyramathia hertwigi*, which according to Barnard (1924) is typically a cold-water west coast species.

Verum cancellatum **(Barnard, 1924)**

Plate 13, figs C, D

Scalpellum cancellatum Barnard, 1924: 24, pl. 1 fig. 5.

Verum cancellatum – Zevina 1981: 221.

Diagnosis

Upper latus triangular, not incised, valves cancellate.

Description

Capitulum ovate with 14 closely fitting valves, strong radial striations set very close to each other and more widely separated concentric striations resulting in a cancellate appearance.

Upper latus triangular, not incised. Carina simply arched, extending to middle of tergum, umbo apical. Inframedian latus very narrow, linear and curved, rostral margin concave with basal umbo almost extending under basal margin of rostral latus. Carinal latus with carinal margin slightly thickened, but not reflexed. Peduncle wide at capitulum, narrowing distally. *Mouthparts*: labrum obtusely produced, mandible with 3 teeth, decreasing in size, inferior angle subacute, denticulate, maxilla I with notch on inner margin barely distinguishable. *Size*: capitular length 6.5 mm; capitular width 3.75 mm; peduncle length 2 mm.

Distribution

Endemic to South Africa. Recorded in Agulhas and South-west Indian offshore bioregions. Previously known depth range of 366 – 457 m, now extended to 366 – 650 m depth.

Remarks

Attaches to worm tubes and calcareous polyzoans, associated with *Verum agulhense* and *Pilsbryiscalpellum subalatum*.

***Verum novaezelandiae* (Hoek, 1883) – new record**

Plate 13, figs E, F

An addition to the South African fauna – see chapter 1.

***Verum porcellanum* (Barnard, 1924)**

Plate 14, figs A, B

Scalpellum porcellanum Barnard, 1924: 31, pl. 1 fig. 9.

Verum porcellanum – Zevina 1981: 239.

Diagnosis

Roof of carina flat, terga strongly projecting, inframedian latus wide, distinctly hour-glass shaped.

Description

Capitulum broadly ovate, with 14 close fitting valves, valves with obvious radial striations, cuticle present but hardly noticeable. Carina with narrow sides, roof flat and square in

section, bordered by 2 faint acute ridges, faint median ridge present. Inframedian latus wide, distinctly hour-glass shaped and leaning towards carinal side, constricted above basal umbo and widest at apex, scutal angle bevelled off. Peduncle broad at capitulum and narrowing distally, not completely covered in scales. *Mouthparts*: labrum subacutely produced, mandible with 3 teeth, decreasing in size, first farther from second than second from third, second and third teeth with outer margin minutely denticulate, inferior angle subacute with 5-6 denticles, maxilla I with distinct notch separating upper 4 unequal spines from lower ones. *Size*: capitular length 8 mm; capitular width 6 mm; peduncle length 5 mm.

Additional notes

Barnard (1924) was correct in suspecting his material consisting of only immature individuals and his figure of the type, with an underdeveloped inframedian latus and spaces between the valves, is misleading. Specimens examined in this study were at least twice the size with no spaces between the valves.

Distribution

Endemic to South Africa. Extended from South-western Cape into Namaqua and Atlantic offshore bioregions – a cold water west coast species. Previously recorded at a depth of 247 m, range now established at 184 – 448 m.

Remarks

Attached in great numbers to the dorsal surface of the carapace and chelae of the deep water crab *Exodromidia*.

Genus *Catherinum* Zevina, 1978

Catherinum sinuatum (Pilsbry, 1907)

Plate 14, figs C, D

Scalpellum sinuatum Pilsbry, 1907a: 50, fig. 16.

Catherinum sinuatum – Zevina 1981: 242, fig. 179.

Diagnosis

Inframedian latus narrow and variable in shape, umbo at or near middle.

Description

Capitulum ovate with 14 close fitting valves. Inframedian latus narrow and variable in shape – narrowing from base upward, ending in a blunt apex sometimes in contact with upper latus, superficially appearing to be subtriangular but on closer inspection always hour-glass shaped with a medial umbo. Tergum with apex slightly produced past carina. Upper latus subtriangular. Carinal latus large, quadrangular. Peduncle sparsely covered in fine scales. *Mouthparts*: labrum bluntly produced, mandible with 3 teeth, minute secondary tooth between first and second, variable in size on both mandibles, inferior angle acute, denticulate, maxilla I inner margin with gap, notch absent. *Size*: capitular length 7 mm; capitular width 3 mm; peduncle 2.5 mm.

Additional notes

Easily confused with *V. novaezelandiae* but distinguished by medial umbo of inframedian latus and the carina, which extends almost all the way to the apex of the tergum.

Global distribution

East coast of North America, 3165 m.

South African distribution

Atlantic offshore, South-west Indian offshore and Delagoa bioregions. Previously known depth range of 1463 – 1828 m, now extended to 620 – 1828 m depth.

Remarks

A cryptic deep-water species more frequently encountered offshore. Attached to stones and worm tubes. The material agrees well with the various forms described by Barnard (1924) and closely resembles the young form figured by Pilsbry in both morphology and size. However, Barnard observed several inconsistencies with his material and Pilsbry's type, notably the absence of the sinus in the upper latus. The same can be said for the specimens examined in this study and I ask the same question of Pilsbry's type as did Barnard, that is whether the sinus in the upper latus is normal or not. More North Atlantic material is required to answer this.

Genus *Amigdoscalpellum* Zevina, 1978

Amigdoscalpellum vitreum (Hoek, 1907)

Plate 14, figs E, F

An addition to the South African fauna – see chapter 2.

Genus *Arcoscalpellum* Hoek, 1907

Zevina (1981) has relocated *Scalpellum botellinae* (Barnard, 1924) to this genus. It includes species with fully calcified valves; carinal latera with umbones elevated above basal margin; triangular inframedian latera with apical umbones extending up to and sometimes beyond upper margins of carinal and rostral latera.

Arcoscalpellum botellinae (Barnard, 1924)

Plate 15, figs A, B

Scalpellum botellinae Barnard, 1924: 44, pl. 1 fig. 15.
Arcoscalpellum botellinae – Zevina 1981: 335.

Diagnosis

Umbo of inframedian latus at acute apex, rostral latus situated low on capitulum. Inner extension of carinal latus joining that of other side under base of carina.

Description

Capitulum ovate with 14 striate valves, both margins convex. Scutum trapezoidal with apical umbo somewhat recurved, projecting over corner of tergum formed by occludent and basal margin. Tergum triangular, carinal margin excavate just below apical umbo. Carinal latus quadrangular, with umbo projecting beyond carina, not meeting its fellow, inner extension of valve joining that of other side under base of carina – as in *Tarasovium brevicaulis*. Peduncle very short with closely imbricated scales. *Mouthparts*: labrum obtusely produced, mandible with 4 teeth, first largest with inferior angle acute (sometimes with a fifth well developed tooth between the first and second), maxilla I with narrow gap separating 4 unequal upper spines from lower ones. *Size*: capitular length 4 mm; capitular width 2.5 mm; peduncle length 0.75 mm.

Distribution

Endemic to South Africa. Natal bioregion, depth 86 – 99 m.

Remarks

Rare. Known from only two samples within two nautical miles of each other. Attached to the Rhizopod *Botellina pinnata*.

Arcoscalpellum michelottianum **(Seguenza, 1876)**

Plate 15, figs C, D

Scalpellum michelottianum Seguenza, 1876: 381, pl. 6, figs 15-25, 464, pl. 10, fig. 26.
Arcoscalpellum michelottianum – Newman & Ross 1971: 71, fig. 34, pl. 9b – incl. syn.

Formerly identified by Barnard (1925) as *Scalpellum velutinum* Hoek, 1883 but subsequently synonymised as *A. michelottianum* by Newman & Ross (1971).

Diagnosis

Inframedian latus triangular, higher than adjacent latera, umbo apical. Carinal latera horn-shaped, wider than high, not interdigitating below carina, umbo apical.

Description

Large. Capitulum oval with 14 fully calcified, closely fitting valves, covered in a cuticle with fairly long bristles. Roof of carina broad, gently convex, basal margin evenly rounded. Rostrum large, elongate. Male unique, ovoid with a wing-like process projecting out on each side, no antennae. Peduncle about a quarter to a third length of capitulum, covered in widely interspaced scales. *Mouthparts*: labrum slightly concave, mandible with 3 teeth besides inferior angle (denticulate), maxilla I without notch. *Size*: capitular length 50 mm.

Distribution

Cosmopolitan, depth 1550 – 3422 m.

Remarks

The largest known scalpellid in South Africa. Several specimens with *Glyptelasma* and *Poecilasma* attached to the capitulum.

Arcoscalpellum micrum (Pilsbry, 1907)

Plate 15, figs E, F

Scalpellum micrum Pilsbry 1907a: 57, fig. 21.

Arcoscalpellum micrum – Zevina 1981: 356, fig. 275 – incl. syn.

Diagnosis

Carinal latus pentagonal, umbo elevated, situated medially on carinal margin. Umbo of inframedian latus at acute apex, rostral latus situated high on capitulum. Mandible with only 2 teeth.

Description

Capitulum elongate, inframedian latus large, triangular, height double basal width, umbo apical, extending beyond margins of adjoining latera and making contact with upper latus and scutum. Carina short, simply arched with umbo apical, roof rounded, sides narrow, base rounded. Rostral latus high. Rostrum well-developed, equal in height to adjacent latera. Peduncle imbricated with large scales, spaces between scales moderately wide. *Mouthparts*: labrum strongly and subacutely produced, mandible with 2 teeth, second tooth bifid sometimes trifid, maxilla I with deep notch on inner edge separating upper 3-4 spines from 7-8 lower ones. *Size*: capitular length 9 mm; capitular width 4.5 mm; peduncle length 4.5 mm.

Additional notes

Similar in appearance to *A. vitreum*, but distinguished by height and large size of inframedian latus.

Global distribution

North Atlantic, 538 m.

South African distribution

South-west Indian offshore bioregion. Previously known from a single record at 823 m, depth range now established at 650 – 823 m.

Remarks

A rare species known from only three records all in close proximity to each other.

ORDER SESSILIA Lamark, 1818

Suborder VERRUCOMORPHA Pilsbry, 1916

Family Verrucidae Darwin, 1854

Genus *Altiverruca* Pilsbry, 1916

***Altiverruca nitida* (Hoek, 1883) – new record**

Plate 16, figs A, B

An addition to the South African fauna – see chapter 1.

Genus *Metaverruca* Pilsbry, 1916

***Metaverruca plicata* Buckeridge, 1994 – new record**

Plate 16, figs C, D

An addition to the South African fauna – see chapter 1.

Suborder BALANOMORPHA Pilsbry, 1916

Superfamily Chthamaloidea Darwin, 1854

Family Chthamalidae Darwin, 1854

Subfamily Euraphiinae Newman & Ross, 1976

Genus *Octomeris* Sowerby, 1825

***Octomeris angulosa* Sowerby, 1825**

Plate 16, figs E, F

Octomeris angulosa Sowerby, 1825: 244, pl. 12, figs 1-11. – Barnard 1924: 98 – incl. syn.

Diagnosis and description

Eight compartments, parietes with prominent longitudinal ribs. *Size*: carino-rostral diameter 10 – 25 mm.

Distribution

Endemic to South Africa. Found in the Namaqua, South-western Cape, Agulhas and Natal bioregions, low to mid intertidal zone.

Remarks

The only representative of the subfamily in South Africa. Common, forming extensive beds on wave-exposed rocks. Barnard (1924) refers to an Australian specimen in the collection, which he erroneously includes as part of the geographic distribution of this species. In a comprehensive checklist of the Australian Cirripedia compiled by Jones et al. (1990) no mention of *O. angulosa* is made.

Subfamily Chthamalinae Darwin, 1854

Genus *Chthamalus* Ranzani, 1818

Chthamalus dentatus Krauss, 1848

Plate 17, figs A, B

Chthamalus dentatus Krauss, 1848: 135, pl. 6, fig. 27. – Stubbings 1967: 252, fig. 8a-d, fig. 9a-g – incl. syn.

Diagnosis and description

Six compartments, parietes longitudinally ribbed, base membranous. Rostrum with alae overlapped by radii of adjacent rostrolateral plates, distinguishing it from all intertidal balanid species in South Africa. *Size*: diameter 5 – 10 mm.

Global distribution

Isolated populations along the west and east coast of Africa – extending to Madagascar and the Gulf of Aden. *Size*: carino-rostral diameter 5 – 10 mm.

South African distribution

South-western Cape, Agulhas, Natal and Delagoa bioregions, upper intertidal. Replaced by the invasive species, *B. glandula*, in the Namaqua bioregion (Laird and Griffiths, 2008).

Remarks

Easily confused with *B. glandula* in the Cape, where the two species coincide. Previously, thought to extend around the entire coast of South Africa into the Namaqua bioregion until it was discovered that *B. glandula* had been overlooked for some time and incorrectly identified as *C. dentatus* (Simon- Blecher *et al*., 2008; Laird and Griffiths, 2008). In the past, rarely encountered in the Namaqua bioregion, now appearing to be completely absent, out-competed by *B. glandula*.

Superfamily Coronuloidea Leach, 1817

Family Chelonibiidae Pilsbry, 1916

Genus *Chelonibia* Leach, 1817

***Chelonibia caretta* (Spengler, 1790)**

Plate 17, figs C, D

Lepas caretta Spengler, 1790: 185, pl. 6, fig. 4.

Chelonibia caretta – Barnard 1924: 93 – incl. syn.

Diagnosis

Shell wall with 6 compartments, radii narrow and not well developed, cavities in parietes between basal septa filled up almost to the base, shell thick and heavy. *Size*: carino-rostral diameter 30 mm.

Distribution

Tropical and Indo-west Pacific, pelagic.

Remarks

Epizoic on turtles, usually the loggerhead turtle, *Caretta caretta*, however Barnard (1924) reports two specimens from a vagrant green turtle, *Chelonia mydas*, in Table Bay. Also known to attach to *Eretmochelys squamosa*. Predicted distribution range based on that of turtle species in South Africa.

Chelonibia testudinaria (Linnaeus, 1758)

Plate 17, figs E, F

Lepa testudinaria Linnaeus, 1758: 668.

Chelonibia testudinaria – Hiro 1937: 470, fig. 41, – incl. syn.

Diagnosis

Radii well developed and usually notched on sides, cavities in parietes between basal septa deep, parietes not ribbed or longitudinally folded –peripheral edge evenly curved without lobes or incisions.

Description

Shell flattened, oval, white and smooth, wall consisting of 6 compartments, each side of plates denticulated. Scutum triangular and smooth, tergum rectangular and flattened. *Mouthparts*: labrum cleft, multidenticulate, mandible with 5 teeth, inferior angle short, maxilla I without notch, cutting edge straight. *Size*: carino-rostral diameter 41 mm.

Distribution

Widely distributed in all tropical and warm temperate seas, pelagic.

Remarks

Epizoic on turtles, in South Africa mostly *C. caretta*. Predicted distribution range based on that of turtle species in South Africa.

Family Coronulidae Leach, 1817

Subfamily Coronulinae, Leach 1817

Genus *Coronula* Lamarck, 1802

Coronula diadema (Linnaeus, 1767)

Plate 18, figs A, B

Lepas diadema Linnaeus, 1767: 1109.

Coronula diadema – Darwin 1854: 417, pl. 15, figs 3-3b, pl. 16, figs 1, 2, 7. – Young 2000: 98 – incl. syn.

Diagnosis and description

Crown-shaped, body contained within 6 compartments, hexagonal, parietes thick with external convex crenulated ribs, radii broad. Parietes inner surface folded forming 4 tubes at each pariete. Opercular valves present, terga absent or rudimentary. *Size*: carino-rostral diameter 86 mm; height 67 mm.

Distribution

Cosmopolitan, pelagic.

Remarks

Epizoic on the humpback whale, *Megaptera novaeangliae*. Barnard (1924) reports specimens in the South African Museum labelled as from the Southern Right Whale, *Eubalaena australis*. Predicted distribution range based on that of *M. novaeangliae*.

***Coronula reginae* Darwin, 1854**

Plate 18, figs C, D

Coronula reginae Darwin, 1854: 419, pl. 15 fig. 5, pl. 16 fig. 4. – Barnard 1924: 94.

Diagnosis

Depressed, rarely exceeding 20 mm in height, body contained within 6 compartments, parietes with flat beaded ribs. Opercular valves present, terga absent. *Size*: carino-rostral diameter 65 mm; height 19 mm.

Distribution

Cosmopolitan, pelagic.

Remarks

Epizoic on the humpback whale, *Megaptera novaeangliae*. Predicted distribution range based on that of *M. novaeangliae*.

Genus *Cetopirus* Ranzani, 1817

Cetopirus complanatus Mörch, 1852

Plate 18, figs E, F

Cetopirus complanatus Mörch, 1852: 67. – Newman & Ross 1976: 45 – incl. syn.

Diagnosis and description

Composed of 6 compartments, branches of sutural ribs symmetrical – peripheral margin with evenly spaced parietal buttresses. *Size*: carino-rostral diameter 30 mm.

Distribution

According to Darwin (1854), restricted to the southern hemisphere with specimens recorded from Chile, Cape of Good Hope, Australia and Tasmania. However, it is reported that a sample from Norway exists.

Remarks

Epizoic on whale species from the Southern Ocean. Poorly represented in the collection by only two samples from the Cape Peninsula. Predicted distribution range based on that of whale species in South Africa.

Subfamily Xenobalaninae Gruvel, 1903

Wider at top and narrowing towards base, opercular membrane extending almost all of the way down to base, upper end of shell continually scaling off.

Genus *Tubicinella* Lamarck, 1802

Tubicinella major Lamarck, 1802

Plate 19, figs A, B

Tubicinella (major), (minor), striata, Lamarck, 1802: 463, pl. 30, fig. 1.

Tubicinella major – Newman & Ross, 1976: 45 – incl. syn.

Diagnosis and description

Shell composed of 6 compartments, sub-cylindrical in shape, wider at the top than at the bottom surrounded by 2 to 10 annular blunt ridges or belts, radii narrow. Body contained within shell walls. Opercular valves present. *Size:* carino-rostral diameter 30 mm; height 60 mm.

Distribution

Southern Atlantic and Pacific Oceans, pelagic.

Remarks

Epizoic on the Southern Right Whale, *E. australis*.

Genus *Xenobalanus* Steenstrup, 1851

Xenobalanus globicipitis Steenstrup, 1851

Plate 19, figs C, D

Xenobalanus globicipitis Steenstrup, 1851: pl. 3, figs 11-15. – Newman & Ross 1971: 180, pl. 48.

Diagnosis

Shell drastically reduced and irregularly star-shaped, body not contained within shell walls, sub-cylindrical, narrow at base becoming wider at top, emanating from star-shaped shell, embedded in skin of cetaceans.

Description

Shell with 6 compartments, body terminating in a "pseudo-capitulum" – formed by a membranous reflexed collar with 2 fleshy horn-like projections on carinal side. Opercular plates absent. *Mouthparts*: mandible with 5 teeth, fifth minute, hardly visible. *Size*: length of body: 51 mm; shell diameter: 6.4 mm.

Additional notes

The only balanomorph of its kind. Easily mistaken for *Conchoderma auritum*, yet unlike the Lepadidae, *X. globicipitis* is directly attached to the skin of its host.

Distribution

Cosmopolitan, pelagic.

Remarks

A truly unique balanomorph species having reverted back to ancestral, pedunculate form. Attaches to dolphins and whales in South African waters (specimens examined were collected from the false killer whale – *Pseudorca crassidens*). A list of hosts is provided by Nilsson-Cantell (1930).

Superfamily Tetraclitoidea Gruvel, 1903, stat. nov. Newman, 1993

Family Austrobalanidae Newman & Ross, 1976

Subfamily Elminiinae Foster, 1982

Genus *Austrominius* Buckeridge, 1983

***Austrominius modestus* (Darwin, 1854)**

Plate 19, figs E, F

Elminius modestus Darwin, 1854: 350, pl. 12 fig. 1a-e.

Austrominius modestus – Buckeridge and Newman 2010: 39-54 – incl. syn.

Diagnosis and description

Shell conical, composed of 4 compartments, parietes solid, never porose, sometimes filled with chitinous material.

Distribution

New Zealand, Australia, Europe, Cape of Good Hope, littoral.

Remarks

A single specimen representing this invasive species was recorded on an experimental plate submerged at a depth of two feet for three months in the Cape Town Docks (Sandison, 1950). Not subsequently recorded in South Africa, but has been introduced to Europe by means of shipping vectors (O'Riordan et al., 2009; Carlton et al., 2011). Utinomi (1968) mentions that *A. modestus* immigrated to England "by way of South Africa", perhaps assuming that a population had established itself in the Cape, which has never been the case. In fact, Bishop (1947) has determined the correct route of passage, which is from New Zealand via the Panama

Canal. It remains to be seen whether *A. modestus* becomes a significant introduction to South African waters.

Family Tetraclitidae Gruvel, 1903
Subfamily Tetraclitinae Gruvel, 1903
Genus *Tetraclita* Schumacher, 1817

Tetraclita serrata Darwin, 1854

Plate 20, figs A, B

Tetraclita serrata Darwin, 1854: 334, pl. 10, fig. 2a-d. – Newman & Ross 1976: 47.

Diagnosis and description

Tall, "volcano-shaped" species composed of 4 compartments, surface covered with numerous narrow, serrated longitudinal ridges, parietes with multiple rows of pores, dark greenish-grey. Terga strongly beaked. *Size*: carino-rostral diameter 30 mm.

Additional notes

Barnard mentions that this species should be considered a variety of *Tetraclita rufotincta* Pilsbry, 1916 in light of transitional forms reported by Weltner (1897) and Krüger (1911). I have been assured that this is not the case and that *T. serrata* in South Africa should be maintained as a valid species (Dr. Y. Achituv and Dr. B. Chan, pers. comm.).

Global distribution

Southern Namibia, South Africa, Madagascar, Ceylon and Philipines – intertidal.

Distribution

Namaqua, South-western Cape, Agulhas and Natal bioregions, mid-intertidal.

Remarks

Grows extensively along the mid-intertidal zone on moderately sheltered shores. Gradually replaced by *T. rufotincta* from the south coast of Durban northward, completely absent north of Cape Vidal. Utinomi (1968) collected specimens from Simonstown Harbour and Hermanus which he identified as *Tetraclita squamosa stalactifera* – an American relative of the

genus. Both of these areas receive a fair amount of shipping traffic and it is plausible that the species could have been introduced via a shipping vector. However, I was unable to locate the material to confirm these findings and to date, have not encountered this introduced species. Perhaps Utinomi was correct in his findings as colleagues abroad are currently using molecular techniques to detect what is believed to be a second cryptic species or "evolutionary significant unit" (ESU) which is disguised among the *T. serrata* population.

***Tetraclita rufotincta*, Pilsbry 1916**

Plate 20, figs C, D

Tetraclita squamosa rufotincta Pilsbry, 1916: 253, pl. 58, figs 5-6a.
Tetraclita rufotincta – Astachov et al. 2011: 311 – incl. syn.

Diagnosis and description

Shell wall composed of 4 pink shell plates with fine, short longitudinal ridges, wall very thick with many rows of small pores, sutures hardly visible. Scutum with articular and adductor ridges united. Size: carino-rostral diameter 20 mm.

Global distribution

Gulf of Suez to Zanzibar, now extended to Durban, South Africa, upper-intertidal.

South African distribution

Previously only known from the Delagoa bioregion, now extended to the Natal bioregion.

Remarks

An abundant upper intertidal species, forming dense sheets on the rocky shore. It is unclear as to when it was first recorded as part of the South African fauna.

Superfamily Balanoidea Leach, 1817

Family Archaeobalanidae Newman & Ross, 1976

Several species originally described by Barnard (1924) have subsequently been placed within this family.

Subfamily Archaeobalaninae Newman & Ross, 1976

Genus *Striatobalanus* Hoek, 1913

Striatobalanus tenuis (Hoek, 1883)

Plate 20, figs E, F

Balanus tenuis Hoek, 1883: 154, pl. 13, figs 29-33.

Striatobalanus tenuis – Chan 2009a: 74, figs 2H, 23 – incl. syn.

Diagnosis

Parietes solid, tergum with external furrow.

Description

Shell wall consisting of 6 white, solid parietes, radii narrow with oblique summits, orifice oval, deeply toothed, base calcareous, solid. Scutum with longitudinal striations. Occludent margin of scutum with teeth. Tergum with external furrow, spur about twice as long as wide, distance from basiscutal angle equal to width of spur. *Mouthparts*: labrum bullate with 2-3 teeth either side of cleft, mandible with 5 teeth besides inferior angle, maxilla I slightly notched. *Size*: carino-rostral diameter 34.6 mm.

Global distribution

China Sea, Philippines, Japan, Indonesia and the Indian Ocean, depth 163 – 597m.

South African distribution

Natal and Agulhas bioregion, depth 86 – 125 m.

Remarks

Frequently found attached to mollusc shells. The South African material extends the known shallow limit for this species.

Genus *Solidobalanus* Hoek, 1913

The species *Balanus elizabethae* Barnard has been reassigned to this genus as it has solid parietes.

Solidobalanus auricoma (Hoek, 1913) – new record

Plate 21, figs A, B

An addition to the South African fauna – see chapter 1.

Solidobalanus elizabethae (Barnard, 1924)

Plate 21, figs C, D

Balanus elizabethae Barnard, 1924: 72. – Millard 1950: 267, fig. 1, pl. 11, figs A-D.
Balanus emkweniensis – Nilsson Cantell 1932. – 1938: 12.
Balanus (Solidobalanus) elizabethae – Henry and McLaughlin 1967: 47.
Solidobalanus (Hesperibalanus) elizabethae – Newman and Ross 1976: 51.

Barnard (1924) describes the species with solid parietes and is has therefore been reassigned to this genus.

Diagnosis

Strictly estuarine, parietes solid.

Description

Shell, conical and truncated, composed of 6 solid parietes, externally smooth, white with no markings, sometimes transparent, covered in a very thin, colourless epidermis, internally with regular strong ribs. Orifice diamond-shaped to pentagonal, slightly notched. Basis calcareous, sparsely porous. Scutum with very prominent articular ridge, projecting over the articular furrow. Tergum externally flat with a shallow groove running towards the spur. *Mouthparts*: labrum with 3 teeth on either of notch, third tooth minute, mandible with 5 teeth, maxilla 1 with inner edge straight. *Size*: carino-rostral 19 mm; orifice diameter 10 mm; height 12 mm.

Additional notes

Contrary to Barnard (1924), an additional minute tooth was observed on the inner angle of the labrum on either side of the notch in accordance with Millard (1950).

Distribution

Endemic to South Africa, restricted to estuaries in the Agulhas and Natal bioregions, intertidal.

Remarks

A unique, unmistakable estuarine species – all other members of the genus in South Africa are strictly marine. Millard (1950) provides evidence to show that the species can tolerate a wide range of salinity from sea water to as low as 1.4 ‰. Records from catalogues of the University of Cape Town Ecological Survey in the South African Museum show that the species has been recorded as much as 22 km upstream from the mouth of the estuary.

***Solidobalanus fallax* Broch, 1927 – new record**

Plate 21, figs E, F

An addition to the South African fauna – see chapter 1.

Genus *Membranobalanus* Hoek, 1913

Elevated to genus level by Rosell (1973) – previously a subgenus of *Balanus*

***Membranobalanus orcutti* (Pilsbry, 1907)**

Plate 22, figs A, B

Balanus orcutti Pilsbry, 1907: 361, pl. 29, figs 1-7.
Membranobalanus orcutti – Jones et al. 2000: 268 – incl. syn.

Diagnosis

Rostrum tongue-shaped, almost twice as long as carina, terminating in a rounded blunt end, sometimes with an external longitudinal depression, sheath of rostrum about one third of whole length.

Description

Shell conical, composed of 6 white loosely articulated plates, inner surface with distinct ribs. Basis membranous, carina slightly longer than lateral plates. Radii extremely narrow or absent. Scutum without longitudinal depression, adductor ridge well-developed. Tergum with spur occupying more than half of basal margin. *Mouthparts*: labrum wide with shallow notch, 2 teeth on either side, mandible with 3 conspicuous teeth, fourth rudimentary, fifth obsolete,

maxilla I with straight inner margin. *Size*: carino-rostral basal diameter 13 mm; rostrum length 13 mm; carina length 8 mm.

Additional notes

Specimens examined agree well characters outlined by Hiro (1936), in particular the morphology of the opercular plates. However, the depression or groove running from the apex to the basal margin of the scutum as described by Rosell (1973) is absent and I believe this to be quite variable. Furthermore the radii are somewhat narrower than those figured by Rosell (1973).

Global distribution

Pacific, Indian and Indo-west Pacific Ocean, depth littoral – 52 m.

South African distribution

Agulhas bioregion, depth 17 – 48 m.

Remarks

Always embedded in the tissue of sponges – according to the label, the specimens examined were extracted from a "horny sponge".

Genus *Conopea* Say, 1822

Conopea scandens Pilsbry, 1916

Plate 22, figs C, D

Balanus scandens Pilsbry, 1916: 93, pl. 57, pl. 56, figs. 2-2d, text fig. 76.

Conopea scandens – Newman and Ross 1976: 55 – incl. syn.

Diagnosis

Parietes solid. Carina and rostrum strongly elongate, not making contact with substratum.

Description

Shell covered by coenenchyma and polyps of gorgonian to which it is attached, rostrocarinal axis strongly elongate, composed of 6 solid parietes, light pinky-white, externally smooth, internally ribbed at the base, sheath long. Length of carinal laterals one-fifth that of laterals. Radii well developed, horizontally striated, summits parallel to base. Base compressed,

conical, no basal furrow, solid, not meeting closely with basal margins of parietes – a narrow space between, cut into small square pores by internal ribs joining walls to base. Scutum with articular ridge prominent. Tergum with short spur occupying half basal margin. *Mouthparts*: labrum with 3 minute teeth either side of notch, mandible with 5 distinct teeth, second, third and fourth bifid, maxilla I with straight inner edge and 5 spines between 2 outer and inner enlarged ones. *Size*: carino-rostral diameter 17mm; height 5 mm; orifice 3 mm.

Additional notes

This is the only species of the genus presently recorded from South Africa.

Global distribution

Japan and South Africa, depth 110 – 250 m.

South African distribution

Natal bioregion, depth 101 m.

Remarks

Attached to *Villogorgia mauritiensis*, associated with *Amphibalanus poecilotheca*. Known from a single record in South Africa.

Subfamily Acastinae Kolbasov, 1993

Genus *Acasta* Leach, 1817

***Acasta alba* Barnard, 1924**

Plate 22, figs E, F

Acasta alba Barnard, 1924: 83. – Kolbasov 1993: 411.

Diagnosis

Tergum without groove from apex to spur, gaps present at base of parietes.

Description

Shell conical, with 6 compartments, white to pink in colour. Parietes, solid, internally ribbed with small gaps at base, hollowed out on one side and in crenulated edge of basal cup. Base calcareous, cup-shaped although not deep. Summits of radii, scutum and tergum oblique,

tergum without groove. Fourth cirrus with subequal rami, 17 segments. Armed, second segment of peduncle with 2 recurved teeth and 2 minute denticles on anterior apical angle, anterior ramus with 2-3 unequal recurved teeth on joints 1-7, 1 tooth on joint 8. *Size*: carino-rostral diameter 4 mm; height 4 mm; height of basal cup 1.5 mm.

Additional notes

Displays a combination of characters found in *A. fenestrata* and *A. purpurata* (Barnard, 1924).

Distribution

Endemic to the Agulhas and Natal bioregions of South Africa, depth 86 – 168 m.

Remarks

Embedded in sponges. No specimens found since Barnard (1924), rare.

***Acasta cyathus* Darwin, 1854**

Plate 23, figs A, B

Acasta cyathus Darwin, 1854: 312, pl. 9 figs 3 a-c. – Young 2000: 98 – incl. syn.

Diagnosis

No gaps at base of parietes, base flattened, radii wider than parietes.

Description

Shell composed of 6, solid, internally ribbed parietes with some external projections. Radii well developed, wider than parietes, parietes with some long spiniform projections. Base flat. Opercular plates with growth lines only. *Mouthparts*: Maxilla I with inner edge straight, 2 large outer spines followed by 7 smaller ones. *Size*: carino-rostral diameter 8 mm.

Additional notes

The only *Acasta* species of its kind in South Africa – easily distinguishable by the exceptionally wide radii and flat base.

Global distribution

Cosmopolitan, depth 15 – 180 m.

South African distribution

Natal bioregion, 36 – 165 m.

Remarks

Embedded in an "open horny sponge".

Acasta spongites (Poli, 1791)

Plate 23, figs C, D

Lepas spongites Poli, 1791: 25, pl. 6, figs 3-6.

Acasta spongites – Kolbasov 1993: 411 – incl. syn.

Diagnosis

No gaps at base of parietes, base cup-shaped, radii not as wide as parietes.

Description

Shell composed of 6, solid, feebly internally ribbed parietes with short, rigid external projections, basal gaps absent, deep red-brown. Carinolateral parietes one sixth of width of lateral parietes. Base always cup-shaped, porous, white. Radii not as wide as parietes. Scutum with articular ridge abruptly truncated. Tergum with rounded spur occupying about one-third of basal margin. *Size*: carino-rostral diameter 4 mm.

Global distribution

Atlantic, Mediterranean, Red Sea, Indian Ocean and Indo-west Pacific, depth 15 – 188 m.

South African distribution

South-western Cape, South-west Indian offshore, Indo-Pacific offshore and Natal bioregions, depth 27 – 165 m.

Remarks

Embedded in sponges.

Acasta sulcata Lamarck, 1818

Plate 23, figs E, F

Acasta sulcata Lamarck, 1818. – Newman & Ross 1976: 54 – incl. syn.

Acasta sulcata anchoris – Barnard 1924: 81, pl. 1, fig. 16.

Diagnosis

Basal gaps in parietes absent, base cup-shaped, outer surface with long flexible projections.

Description

Subglobular, 6 externally smooth parietes with strong internal ribs, apices incurved, sheath occupying more than half as long, no slits at base. Carinolaterals one-sixth as wide as lateral parietes. Alae and radii equal in width, summits very oblique, slightly wider than parietes. Scutum flat with well developed articular ridge. Tergum long and thin, slightly beaked, spur occupying a third to half the basal margin. Penis longer than posterior cirri, setulose. *Mouthparts*: labrum with 3 denticles on inner apex, mandible with 3 distinct teeth, fourth and fifth rudimentary, inferior angle with 2 minute denticles, setose, maxilla I with straight inner edge, 9-10 spines present. *Size*: carino-rostral diameter 6.3 mm; height 8 mm.

Additional notes

The diagnosis takes into the consideration the high variability within this species and constitutes an interpretation of Hiro (1937) and Barnard (1924). Both authors agree on most characters, but differ in opinion on cirral counts and the width of the tergal spur – Barnard describing this as occupying only a third and Hiro half of the basal margin of the tergum. Furthermore, Barnard (1924) notes long flexible filamentous projections from the external walls of the parietes, where Hiro (1937) does not.

Global distribution

Red Sea, Persian Gulf, Indian Ocean, Indo-west Pacific, depth 5 – 25 m.

South African distribution

Natal bioregion, depth 26 m.

Remarks

Embedded in sponges.

Genus *Archiacasta* Kolbasov, 1993

Archiacasta membranacea (Barnard, 1924)

Plate 24, figs A, B

Acasta membranacea Barnard, 1924: 88.

Archiacasta membranacea – Kolbasov 1993: 404. – Newman & Ross 1976: 54 – incl. syn.

Kolbasov (1993) erected the genus with *Archiacasta membranacea* (Barnard, 1924) as the type. With it being the only member of the genus in South Africa, it is easily distinguished.

Diagnosis

Base, flat, membranous, partly calcified around the periphery in older specimens.

Description

Shell conical with 6 solid, thin parietes, orifice large, deeply notched, externally with growth-lines and numerous irregular short calcareous projections. Scutum higher than wide with strong growth ridges, tergum strongly beaked, scutal margin concave, basal margin shortest, groove from apex to spur. *Mouthparts*: mandible with 4 distinct teeth, fifth hardly distinct from inferior angle, second bifid, maxilla I inner margin straight, sometimes with a very small notch, 8-10 spines between the outer and inner 2 large spines. *Size*: carino-rostral diameter 10 mm; carinal length 14 mm.

Distribution

Endemic to South Africa. Agulhas and Natal and South-west Indian offshore bioregions, depth 18 – 180 m.

Remarks

Embedded in sponges.

Genus *Neoacasta* Kolbasov, 1993

Kolbasov (1993) reassigns *Acasta fossata* Barnard, the only South African representative, to *Neoacasta*.

Neoacasta fossata (Barnard, 1924)

Plate 24, figs C, D

Acasta fossata Barnard, 1924: 84. – Newman and Ross 1976: 53.

Neoacasta fossata – Kolbasov 1993: 404.

Diagnosis

Base calcareous and flat, tergum with distinct and well marked groove, not cancellate, basal parietal gaps absent.

Description

Shell conical with 6 solid parietes, internally with 6 radiating ridges, each thickened to a tooth at periphery, not bifid. Base saucer shaped. Scuta and terga covered with short, thick pile. Scutum thick, high and narrow with short basal margin, tergum short, slightly thinner than scutum with prominent groove. *Mouthparts*: mandible with 5 teeth, fifth scarcely distinct from blunt inner angle, second and third obscurely double, maxilla I with 3-4 spinules present in shallow notch, followed by 8 spines of which 2 on lower margin are equal in size to 2 on upper margin. *Size*: carino-rostral diameter 8 mm; height 8 mm.

Distribution

Endemic to South Africa. Agulhas bioregion, depth 22 – 47.5 m.

Remarks

Embedded in sponges.

Genus *Pectinoacasta* Kolbasov, 1993

Pectinoacasta pectinipes (Pilsbry, 1912)

Plate 24, figs E, F

Acasta pectinipes Pilsbry, 1912: 294.

Pectinoacasta pectinipes – Kolbasov 1993: 404, fig. 14 – incl. syn.

Diagnosis

Base calcareous and cup-shaped, tergum cancellate with distinct and well marked groove, small gaps at base of parietes.

Description

Wall of 6 solid parietes with small gaps or slits at base, internally grooved, corresponding with external ridges, apices strongly incurved. Carinolateral parietes about one-seventh (or less)

width of lateral parietes. Calcareous base, large, cup-shaped. Orifice not very large nor deeply notched. Opercular plates with growth ridges and longitudinal ribs. *Size*: carino-rostral diameter 10 mm; height 16 mm.

Additional notes

Readily identified by the presence of slits/gaps at the base of the parietes – presently, the only species with this character in South Africa.

Global distribution

Indian Ocean, Indo-west Pacific, 35 – 170 m.

South African distribution

Agulhas, Natal and South-west Indian offshore bioregions, depth 31 – 155 m.

Remarks

Embedded in sponges.

Family Pyrgomatidae Gray, 1825

Subfamily Pyrgomatinae Gray, 1825

Genus *Cantellius* Ross and Newman, 1973

Cantellius gregarius (Sowerby, 1823) – new record

Plate 25, figs A – C

An addition to the South African fauna – see chapter 1.

Family Balanidae Leach, 1817

The latest accepted systematic review is that of Pitombo (2004).

Subfamily Balaninae Leach, 1817

Represented by one genus in South Africa.

Genus *Balanus* da Costa, 1778

Balanus balanus group

**Balanus crenatus* Bruguière, 1789

Balanus crenatus Bruguière, 1789: 168.

Barnard (1924) mentions this species as being widely distributed in the Northern Hemisphere and not represented in the South African collection. However, Darwin and Gruvel have recorded it from within and south of the Tropics - the former reports to have collected a single specimen in Algoa Bay. Pilsbry writes that he is unwilling to accept these extensions in distribution until confirmed by further material.

Subsequently, I have not yet encountered such material and can only suggest that the specimen collected by Darwin may have been introduced on the hull of a ship under favourable seasonal conditions. Given today's increased shipping through Algoa Bay, it is possible that a small introduced population exists in the immediate vicinity, but this is not confirmed. The species should thus be regarded as unconfirmed in the region.

Balanus glandula Darwin, 1854

Plate 25, figs D – F

Balanus glandula Darwin, 1854: 265, pl. 7, figs 1a, b. – Newman & Ross 1976: 60 – incl. syn.

Diagnosis and description

Wall of 6 plates, parietes longitudinally ribbed, each with a row of small tubes with transverse septa, radii narrow, alae wide, basis calcareous. Scutum with short adductor ridge, tergum with a short, broad spur – shape of opercular valves vary with degree of erosion (Simon-Blecher *et al*., 2008). *Size*: carino-rostral diameter 5-10 mm.

Global distribution

Native to west coast of North America. Introduced to Argentina, Japan and South Africa, intertidal.

South African distribution

Namaqua and South-western Cape bioregion. Not found east of Cape Point.

Remarks

Now the most common intertidal barnacle along the south-west coast. Remained undetected until 2008 as it was mistaken for *Chthamalus dentatus* – the external appearance of the two species being very similar (see *C. dentatus* for distinguishing characters).

***Balanus trigonus* group**

***Balanus spongicola* Brown, 1827**

Plate 25, figs G, H

Balanus spongicula Brown, 1827: pl. 7, fig. 6.

Balanus spongicola – Young 2000: 98 – incl. syn.

Diagnosis and description

Shell conical, uniform dark red to pink, composed of 6 smooth parietes, sometimes longitudinally folded, rostrum much paler, sometimes white to uniform white. Scuta lacking pits, but with distinct longitudinal striations. Terga strongly beaked, furrow absent, spur truncated, one-third of basal margin. *Size*: carino-rostral diameter 10 mm.

Global distribution

Cosmopolitan, unknown depth range.

South African distribution

South-western Cape, Agulhas, Natal and South-west Indian offshore bioregion, depth range established at 4.5 – 212 m.

Remarks

Attached to a variety of substrata – shells, coral and often embed in sponges.

***Balanus trigonus*, Darwin 1854**

Plate 26, figs A, B

Balanus trigonus Darwin, 1854: 223, pl. 3, figs 7a-f. – Chan 2009b: 230, fig. 196 - 199 – incl. syn.

Diagnosis

Scuta thick with 1 to 6 rows of longitudinal pits.

Description

Shell with 6 ribbed, parietes, mottled pink-purple, operculum triangular. External surface of scutum with holes arranged in longitudinal patterns, terga wide, triangular, without longitudinal furrow, spur occupying a third of the basal margin. *Mouthparts*: labrum with 2 teeth on either side of deep notch, mandible with 3 teeth excluding inferior angle, maxilla I slightly notched with 2 large spines above and 10 below. *Size*: carino-rostral diameter 20 mm.

Additional notes

This species can be identified by the rows of longitudinal pits on the scuta. The scuta vary in colour from white to dark red or purple, sometimes making the pits harder to distinguish.

Global distribution

Cosmopolitan, native to the Pacific, having been introduced to other parts of the world (Zullo, 1992; Carlton *et al.*, 2011), littoral to 450 m depth.

South African distribution

Namaqua, South-western Cape, Agulhas, Natal and Delagoa bioregions, depth 2 – 67 m.

Remarks

A common fouling species which attaches to just about any substratum. Introduced from the Pacific via shipping vectors and now well established around the entire coastline of South Africa. Prolific in warmer waters especially harbours and estuaries, where it is able to tolerate reduced levels of salinity (Millard, 1950). The depth record of 3000 m reported by Gruvel (1905) is somewhat dubious.

Subfamily Amphibalaninae Pitombo, 2004

Newly established using taxonomic characters to infer phylogenetic relationships within the Balanidae by Pitombo (2004). It is represented by one genus, (*Amphibalanus*) in South Africa.

Genus *Amphibalanus* Pitombo, 2004

Encompasses the species of *Balanus* under the *B. amphitrite* complex/group (Henry & McLaughlin, 1975; Newman & Ross 1976). Species within the genus meet the following criteria: parietes smooth with a single row of tubes with or without transverse septa; radii solid

Barnard (1924) failed to include *Balanus amphitrite* var. *venustus* Darwin, from Durban Harbour – now *Amphibalanus venustus*. He includes Darwin's *Balanus amphitrite* var. *communis* (in part) also from Durban Harbour, which is later synonymised under *Balanus reticulatus* Utinomi based on new type material from Japan. Both species are now known as *Amphibalanus reticulatus and Amphibalanus amphitrite amphitrite*.

***Amphibalanus amphitrite amphitrite* (Darwin, 1854)**

Plate 26, figs C, D

Balanus amphitrite var. *communis* Darwin, 1854: 240 [in part; not pl. 5 fig. 2e, h, l (= *Balanus reticulatus* Utinomi); type locality of subsequent designation by Harding, 1962: 274; Natal, Republic of South Africa].
Balanus amphitrite amphitrite – Henry and Mclaughlin 1975: 30, figs 10, 11, 13, pl. 1, pl. 5 (fig. g, upper row right), pl. 9 (figs b, c) – incl. syn.
Amphibalanus amphitrite amphitrite – Pitombo 2004: 263.

Diagnosis

Parietal tubes in single row, without transverse septa, exterior of shell with longitudinal striations.

Description

Shell conical, white and distinctly marked with thick, sparse purple longitudinal stripes, composed of 6 parietes. Tergum with carinal margin protuberant in upper half to third, spur length a tenth shorter than width, distance from basiscutal angle less than own width. Labrum multidenticulate. *Size*: carino-rostral diameter 40 mm.

Additional notes

Easily confused to the untrained eye with other "purple-pink striped" species, requires dissection to confirm identity. The only representative of the genus in South Africa with a multidenticulate labrum.

Global distribution

Cosmopolitan, littoral and subtidal.

South African distribution

South-western Cape, Agulhas and Natal bioregions, depth low intertidal to 49 m.

Remarks

A prolific fouling species introduced to many parts of the world, cryptogenic.

Amphibalanus eburneus (Gould, 1841) – new record

Plate 26, figs E, F

An addition to the South African fauna – see chapter 1.

Amphibalanus poecilotheca (Krüger, 1911)

Plate 27, figs A, B

Balanus poecilotheca Krüger, 1911: 48, pl. 1, figs 2c-e, pl. 3, fig. 32, text figs 95-97. Barnard, 1924: 71. *Amphibalanus poecilotheca* – Chan 2009b: 242, fig. 209 – incl. syn.

Diagnosis

Parietal tubes in single row, with transverse septa, exterior of shell with longitudinal and horizontal striations.

Description

Shell tubulo-conical when attached to other individuals, depressed conical and laterally compressed when not, 6 parietes streaked and mottled with bright red-pink, sometimes uniform white. Orifice more than half carinorostral diameter. Radii wide, summits oblique. Scutum with weak adductor ridge, sometimes absent. Basis porous. *Size*: carino-rostral diameter 8 mm; height 6 mm.

Global distribution

Indian Ocean and Indo-west Pacific, depth 44 – 294 m.

South African distribution

South-western Cape, Agulhas, Natal and South-west Indian offshore bioregions, depth range established at 2 – 155 m.

Remarks

Fouling species, attached to a variety of substrata. The South African material extends the shallow limit of the known depth range for the species.

***Amphibalanus reticulatus* (Utinomi, 1967)**

Plate 27, figs C, D

Balanus reticulatus Utinomi, 1967: 216, figs 9a, b, 10a, b, 11a-e, pl. 6, figs 7, 8.
Amphibalanus reticulatus – Chan 2009b: 234, figs 200 – 203 – incl. syn.

Diagnosis

Parietal tubes in single row usually with transverse septa, radii narrow to moderately wide, summits distinctly bevelled.

Description

Wall of 6 plates, parietes with characteristic purple-pink stripes of the genus, parietal tubes in single row usually with transverse septa. Scutum with articular ridge about two-thirds length of tergal margin, adductor ridge short, well separated from articular ridge. Tergum usually with spur fasciole, occasionally with open furrow, spur length greater than width, distance from basiscutal angle equal to spur width. Labrum simple. *Size*: carino-rostral diameter 6 mm.

Global distribution

Circumtropical, littoral.

South African distribution

Natal and South-western Cape bioregions, littoral.

Remarks

Fouling form, encountered in harbours and estuaries attached to a variety of synthetic and natural substrata.

***Amphibalanus venustus* (Darwin, 1854)**

Plate 27, figs E, F

Balanus amphitrite var. *venustus* Darwin, 1854: 240 (in part, pl. V, fig. 2a)
Balanus venustus – Henry and Mclaughlin 1975: 164, fig. 30, pl. 21, figs a-f – incl. syn.

Amphibalanus venustus – Pitombo 2004: 263.

Diagnosis

Parietal tubes in single row without transverse septa, labrum simple.

and description

Wall of 6 plates, parietes rarely ribbed, covered in fine, longitudinal red-pink stripes, parietal tubes in single row without transverse septa. Radii moderate to wide, summits thick and rough. Scutum with longitudinal striae sometimes absent, adductor ridge long, well separated from articular ridge. Tergum with spur fasciole, spur length one-fifth shorter than width, distance from basiscutal angle half spur width. *Size*: diameter 8 mm.

Global distribution

Native to tropical and subtropical western North Atlantic, introduced to Mediterranean, Africa, Persian Gulf and Indian Ocean, littoral.

South African distribution

South-western Cape, Agulhas and Natal bioregions, depth range established at low intertidal to 66 m. Scarce west of Cape Point.

Remarks

A fouling species most likely introduced via shipping vectors, now well established on the south and east coast, frequently found on the low-shore under boulders(Mead *et al*., 2011). Previously not recorded west of Hermanus, but has been found at Cape Town Harbour.

Subfamily Concavinae Zullo, 1992

Genus *Perforatus* Pitombo, 2004

Perforatus perforatus (Bruguière, 1789)

Plate 28, figs A, B

Balanus perforatus – Bruguière, 1789: 167. – Newman & Ross 1976: 66 – incl. syn.

Perforatus perforatus – Pitombo 2004: 265.

Diagnosis and description

Wall of 6 plates, parietes smooth, pale purple with darker longitudinal stripes, 1 row of tubes without transverse septa, usually filled at apices and often corroded appearing to be ribbed, sheath purple. Radii narrow, solid, orifice small. Alae with cleft, lateral margin of sheath extending over adjacent ala, longitudinal abutment on inner face of radii near the margin of sheath. Basis tubiferous. Scutum smooth, with adductor and lateral depressor ridges. Tergum with beaked apex, spur furrow margin infolded causing abrupt change in direction of growth lines, spur long and narrow, generally more than twice its own width from the basiscutal angle. *Size*: basal diameter of South African specimen 6 mm.

Global distribution

East and West Atlantic, introduced to the Mediterranean, East Coast of North America and South Africa, littoral.

South African distribution

Agulhas bioregion, intertidal.

Remarks

The only representative of the Concavinae in South Africa. Gruvel (1907) reports the species from the rocks at Simonstown on the Cape Peninsula, but it is not documented by Barnard (1924). I am yet to "rediscover" this species on the Cape Peninsula and agree with Stubbings (1967) in that previous records "may represent brief shipborne introductions which have failed to maintain themselves". However, Miss T. Reynolds from the University of Stellenbosch kindly provided me with fresh material collected from Mossel Bay which reaffirms the presence of this species in South Africa. The South African material extends the known distribution of this species further south.

Subfamily Megabalaninae Newman, 1979

Genus *Megabalanus* Hoek, 1913

Distinguished from other megabalanids by the presence of evenly distributed denticles on the upper and lower side of the transverse septa of the radii (Pitombo, 2004).

Megabalanus coccopoma (Darwin, 1854) – new record

Plate 28, figs C, D

An addition to the South African fauna – see chapter 1.

Megabalanus tintinnabulum (Linnaeus, 1758)

Plate 28, figs E, F

Lepas tintinnabulum Linnaeus, 1758: 668.

Megabalanus tintinnabulum – Henry & McLaughlin 1986: 17, figs 1e, 2a, g, h, 3a-c, 5a-l – incl. syn.

Diagnosis

Parietes purple, smooth, spur wide and short.

Description

Shell tall and cylindrical varying to conical, parietes without spines or projections, smooth, sometimes roughened, reddish purple/purplish pink/blackish purple often with darker or lighter longitudinal striae. Radii wide, horizontally striate, summits horizontal, summits of alae oblique. Orifice one to two-thirds of basal diameter. Scutum with narrow to broad tergal segment, ranging from obtusely inflicted in conical specimens to not obtusely inflicted in cylindrical specimens, growth ridges not scalloped by longitudinal striae, basal margin straight, occludent margin toothed, articular ridge one-half to two-thirds length of tergal margin. Tergum with spur furrow closed, spur moderately long occupying slightly less than a quarter of the basal margin, separated from basiscutal angle by one and a half times its own width, scutal margin denticulate, articular ridge about two-thirds of scutal margin, crests for depressor muscles weak to moderately developed – more prominent in younger specimens. *Mouthparts*: labrum with 3 teeth either side of deep cleft, mandible with 5 teeth excluding inferior angle, maxilla I slightly notched. *Size*: carino-rostral diameter 50 mm; height 50 mm.

Global distribution

Cosmopolitan, depth range uncertain.

South African distribution

South-western Cape, Agulhas and Natal bioregions, depth range established at intertidal – 37 m.

Remarks

Well known fouling species, occurring in almost every port in the world (Kerckhof & Cattrijsse, 2001). Specimens collected during this study represent the first autochthonous records for South Africa, Barnard (1924) having collected his material from a ship returning from Cameroon. The specimens were from the same barges as *M. coccopoma*, a species with which it is frequently associated and known to out-number *M. tintinnabulum* (Kerckhof *et al.*, 2010).

Genus *Austromegabalanus* Newman, 1979

Distinguished from other megabalanids by the presence of denticles mostly on the lower side of the transverse septa of the radii (Pitombo, 2004).

Austromegabalanus cylindricus (Gmelin, 1791)

Plate 29, figs A, B

Lepas cylindrical Gmelin, 1791: 3213.

Austromegabalanus cylindricus Henry and McLaughlin, 1986: 7, 56 – incl. syn.

Diagnosis

Denticles present mostly on the lower side of the transverse septa of the radii, apex of tergum produced, beak-like.

Description

Six tall shell plates ranging from pink to white with a calcareous base. Scutum triangular, basal margin turning sharply upward to meet the tergal margin, lower two-thirds of occludent margin toothed, articular ridge occupying about three-quarters of the tergal margin. Terga with closed spur furrow, spur twice as long as wide, distance from basiscutal angle less than width, basal margin straight, turning sharply upward to meet scutal margin, apices of terga strongly beaked and needle-like resembling "fangs". *Size*: carino-rostral diameter 40 mm; height typically 30 – 40 mm attaining 150 mm in mature individuals.

Global distribution

Native to South Africa, introduced to New Zealand (Carlton et al. 2011) low intertidal and littoral.

South African distribution

Restricted to the temperate waters of the Namaqua, South-western Cape, Agulhas and Natal bioregions, depth range established at lower intertidal to 27 m.

Remarks

One of the only large megabalanids to occur naturally in the lowermost intertidal zone of rocky shores in South Africa. More frequently encountered subtidally and also known to foul floating substrata, particularly ship's hulls, where it is deemed a pest. Currently establishing a foothold as an invasive species in other temperate waters of the world with shipping serving as the primary vector.

Genus *Notomegabalanus* Newman, 1979

Notomegabalanus algicola Pilsbry, 1916

Plate 29, figs C – E

Balanus algicola Pilsbry, 1916: 72, pl. 12, figs. 3, 3g, text figs. 12, 13.

Notomegabalanus algicola – Jones et al. 1990: - incl. syn.

I do not consider this a subspecies of *Austromegabalanus* as it is clearly distinct from other megabalanid genera – with denticles only on the lower side of the septa of the radii, as figured by Pilsbry (1916). Furthermore, I include *Balanus algicola* var. *costatus* (Barnard, 1924) as a synonym of the species, as it is merely described as a colour morph of the typical form without any morphological differences. Transitional forms are frequently encountered on the Cape Peninsula.

Diagnosis

Radii with well developed horizontal tubes, denticles present only on the lower side of the septa of the radii.

Description

Small, strongly depressed to conical when crowded. Shell plates ranging from uniform white to darker ash-colour with purple-pink longitudinal striations mainly on radii. Parietes strongly ribbed in depressed form becoming smooth in conical form. Radii wide with level summits, horizontal tubes well developed. Basal margin of scutum greater than height. Tergum with longitudinal furrow more or less open, spur short with rounded end, distance from basiscutal angle to spur about equal to spur width. Basis thin, radially porous. First 3 pairs of cirri short. *Size*: rostrocarinal diameter 4 mm; height 6 mm.

Additional notes

Frequently mistaken for several "non-megabalanid" species. Almost always requiring a cross-section of the radii to check for the presence of pores.

Global distribution

Native to southern Africa, elsewhere on ship hulls, introduced to New Zealand and Australia, intertidal, depth range uncertain.

South African distribution

Namaqua, South-western Cape, Agulhas, Natal, depth range established at lower intertidal to 36 m.

Remarks

Attaches to a variety of substrata, also known to be fouling. Most frequently encountered in the lower intertidal zone of rocky shores attached in tight groups on the shells of *Mytilus*.

Plates

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Chapter 3

Biogeographic patterns in species richness and endemicity within South African Cirripedia (Thoracica)

Introduction

The marine invertebrate fauna of South Africa can be regarded as diverse, consisting of over 12900 described species, 18% of which is comprised of crustaceans (Griffiths *et al.*, 2010). This considerably high species richness can be attributed to the high variability in habitats within the nine bioregions as defined by Lombard *et al*. (2004). This is largely a result of the warm Agulhas Current on our east coast, the cold Benguela Current on our west coast and the confluence of these on our south coast, giving rise to a coastline which varies in temperature as one moves from the west to east. Therefore one would expect to observe distinct patterns in the biogeographic distribution of species around the coast of South Africa.

Much research has been undertaken in order to investigate such biogeographical patterns in the distribution of various marine invertebrates for both offshore (Gibbons *et al*., 1995; Gibbons and Hutchings, 1996; Turpie *et al*. 2000) and coastal inshore taxa (Barnard, 1950; Day, 1967a,b; Griffiths, 1976; Clark and Courtman-Stock, 1976; Kensley, 1978; Kilburn and Ripley, 1982; Goslinger, 1987; Thander, 1989; Williams, 1992; Monniot *et al*., 2001; Acuña and Griffiths, 2004; Primo and Vásquez, 2004; Franschetti *et al*., 2005; Laird and Griffiths, 2008). These are summarised by Awad *et al.* (2002), the main trend being an increase in species richness around the coast from west to east with diversity peaking in the Western Cape. Furthermore, rates of endemicity peak on the south coast which is largely attributable to it being located furthest from the political borders of South Africa, "i.e. for species of any given distribution of ranges, a declining proportion of those ranges will cross the border as one moved further from it" (Awad *et al*., 2002; Acuña and Griffiths, 2004). On a broader scale, the deep-sea environment displays several general worldwide biogeographic trends in species richness and endemicity which will be investigated here with respect to the South African Cirripedia

(Thoracica). The deep-sea is considerably cool and deficient of light energy with mean temperatures at around 4° C resulting in low levels of productivity and habitat variation (Costello *et al*., 2011). For this reason, deep-sea species display greater distribution ranges than shallow-water species (Eschmeyer *et al*., 2010), i.e. species depth ranges increase with depth and few abyssal endemic species are observed (Rex *et al*., 2005; Vanreusel *et al*. 2010).

The Cirripedia (Thoracica) is a highly diverse taxon within the marine Crustacea, occupying a wide range of substrata from the intertidal zone down to the deepest parts of the ocean. This constitutes the first comprehensive work of its kind on the biogeography of the Superorder Thoracica, in South Africa. The biogeography of the common intertidal species have in themselves received limited attention, and apart from the work of Laird and Griffiths (2008), which documents the distribution of the invasive *Balanus glandula* in the Cape among other species, nothing noteworthy has been undertaken in recent years. This chapter sets out to examine biogeographic trends in species richness and endemicity within each of the bioregions, across the entire taxon – including the pelagic and deep offshore benthic species. The results are compared to establish whether barnacles conform to the generally accepted biogeographic provinces as proposed by Lombard *et al.* (2004).

Methods

Synonymy for South African Cirripedia (Thoracica) in Barnard (1924) was first resolved with the aid of online biogeography and cybertaxonomy databases such as the World Register of Marine Species (WoRMS), Ocean Biogeographic Information System (OBIS), Integrated Taxonomic Information System (ITIS) and the Global Biodiversity Information Facility (GBIF). Reference to the literature was required to resolve synonymy for various species which could not be found online. A list of South African Cirripedia with updated synonymies was then compiled (see Chapter 1). Both identified and unidentified material from the collection at the Iziko South African Museum in Cape Town was examined (this included inspection of the crab, lobster, coral, gorgonian and sponge collections for epifaunal cirripedes). A representative of each species was photographed and locality data for every sample recorded. New records were added to the list.

Field work consisted of intertidal rocky shore collections by hand; beachcombing and the use of SCUBA gear to collect subtidal specimens to a maximum depth of 30 m. Specimens were also donated from the Natal Sharks Board and colleagues from all over the country. All fresh samples were fixed and preserved in 96% ethanol to allow for possible future DNA extraction. The point locality, substrate, and where possible, depth were recorded for each sample. In total, 1024 samples were analysed. The majority of these samples were obtained from the collection at the South African Museum in Cape Town and were supplemented with fresh material which was collected on an opportunistic basis from all over the country throughout the study period.

These locality data were extracted and digitised from all the South African samples in the museum collection and from the catalogues of the University of Cape Town Ecological Survey – depth and substratum were noted where possible. Additional historic data used from the literature included those of Barnard (1924; 1925; 1955), Sandison (1950), and Laird and Griffiths (2008). Datasets from previous rocky shore intertidal surveys around South Africa were kindly provided by Dr. K. Sink and Dr. A. Mead and relevant locality data for intertidal thoracic Cirripedia extracted. Where possible, depths were included for all samples. Intertidal and pelagic records were assigned as 0 m depth for the purposes of this study, as most of the pelagic records were specimens washed up on the beach and were species known to be neustonic at sea. It must be mentioned however, that several pelagic taxa, notably species of the Chelonibiidae, Coronulidae, Octolasmatidae and Lepadidae, are epizoic on various cetaceans, turtles, fish and other animals, as detailed in Chapter 1. Exact depth ranges for these taxa are variable and depend entirely on the distribution pattern of the host organism. Hence for matters of simplicity, these species were assigned to the 0 m depth category. Samples collected from the hulls of ships and weather buoys were designated a depth of 1 m. Biogeographic distribution ranges were determined for each species and plotted in ArcGIS 9.3 indicating the exact location of where the sample was found in relation to the nine bioregions established by Lombard *et al*. (2004) and depicted in Figure 15.

In order to ascertain whether barnacles conform to the generally accepted biogeographic provinces, as proposed by Lombard *et al.* (2004), the coastline was divided into 100 km long segments and ArcGIS 9.3 used to assign all benthic nearshore (i.e. < 30 m depth) taxa to each segment. Each segment was then assigned to the biogeographic region within which it was situated. In cases where a segment was divided among two or more biogeographic regions, it was assigned to the region which occupied the majority of that segment. Species presence was then

recorded within each segment and a presence/absence matrix compiled across all the 100 km segments. The data were then entered into Primer 6, and a resemblance matrix was created using a Bray Curtis similarity measure (no transformation was applied). A cluster analysis and SIMPROF test were then conducted to determine which sample segments were similar based on the presence/absence of various barnacle species. Biogeographic regions were added as a factor. A multi-dimensional scaling (MDS) plot (with the biogeographic regions added as a factor) was produced to establish whether segments clustered by bioregion. An ANOSIM was then conducted to test the statistical significance of the clustering. Furthermore, each significant cluster was assigned a cluster name and mapped in ArcGIS to aid in the comparison of the clustering with the biogeographic regions as defined by Lombard *et al*. (2004). The analysis could only be applied to the nearshore benthic (pelagic species omitted) taxa as the offshore data points were too sparse.

Each record was further classified as being either endemic, cosmopolitan or introduced. Endemic species were defined as those found only within the political borders of South Africa or known to be native to South Africa, despite having been introduced elsewhere (e.g. *Austromegabalanus cylindricus*). Cosmopolitan and introduced species were defined according to Carlton *et al*. (2011) and Mead *et al*. (2011). Graphs were compiled using SigmaPlot version 10.0 (Systat Software, 2006) and Microsoft Excel (2007).

Results

Significant clusters between the sample segments are indicated by means of red lines (Figure 12). With biogeographic regions added as a factor, no grouping of the sample segments can be observed. This is further confirmed by the results displayed in the MDS plot (Figure 13). It is evident that there is no clear clustering of the segments by bioregion.

Results from the SIMPER analysis indicate that the Namaqua and South-western Cape Bioregion share a dissimilarity of 53% with *Amphibalanus amphitrite amphitrite* and *Chthamalus dentatus* each contributing 14.12%. The highest dissimilarity was shared between the Namaqua and Delagoa Bioregion (96%) with *Cantellius gregarious, Tetraclita rufotincta* and *Chthamalus dentatus* each contributing 15%.

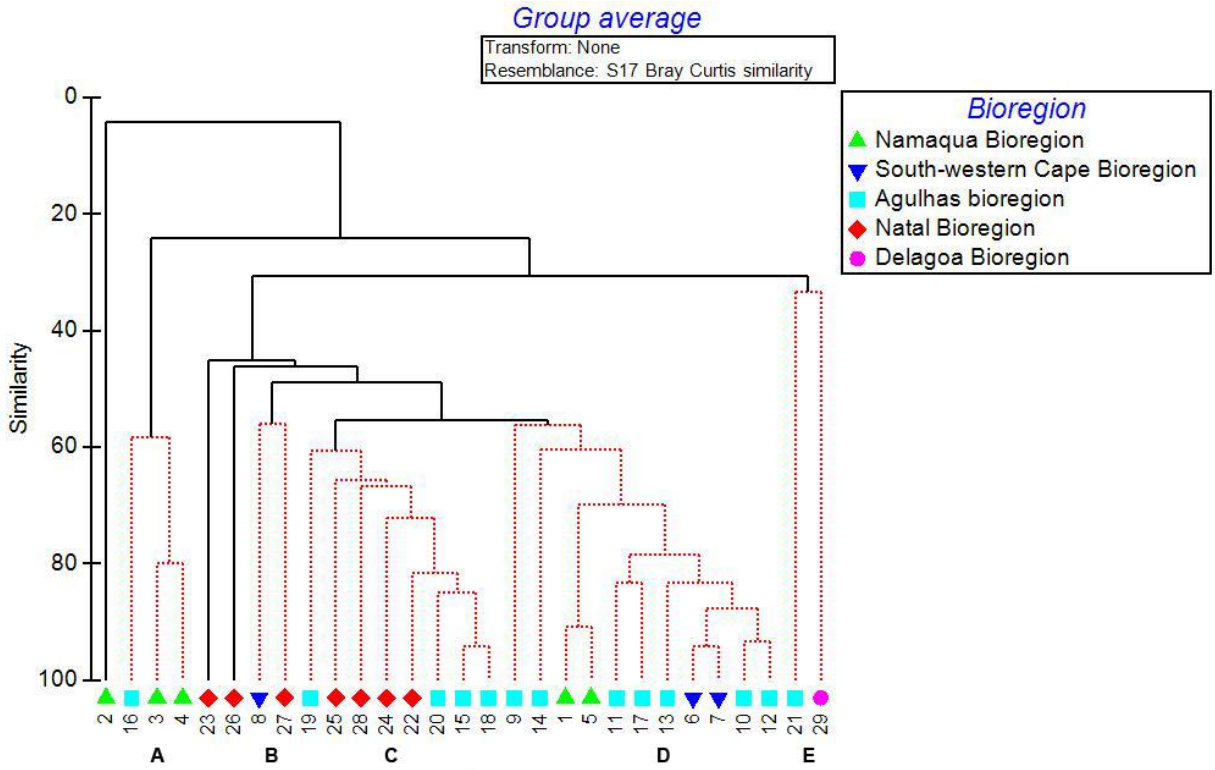

Figure 12: Cluster analysis with biogeographic regions added as a factor. Significant clusters indicated by red lines. The analysis was performed using a Bray-Curtis similarity measure on untransformed data. Significant clusters were assigned names (letters) and then mapped in GIS – see Figure 14.

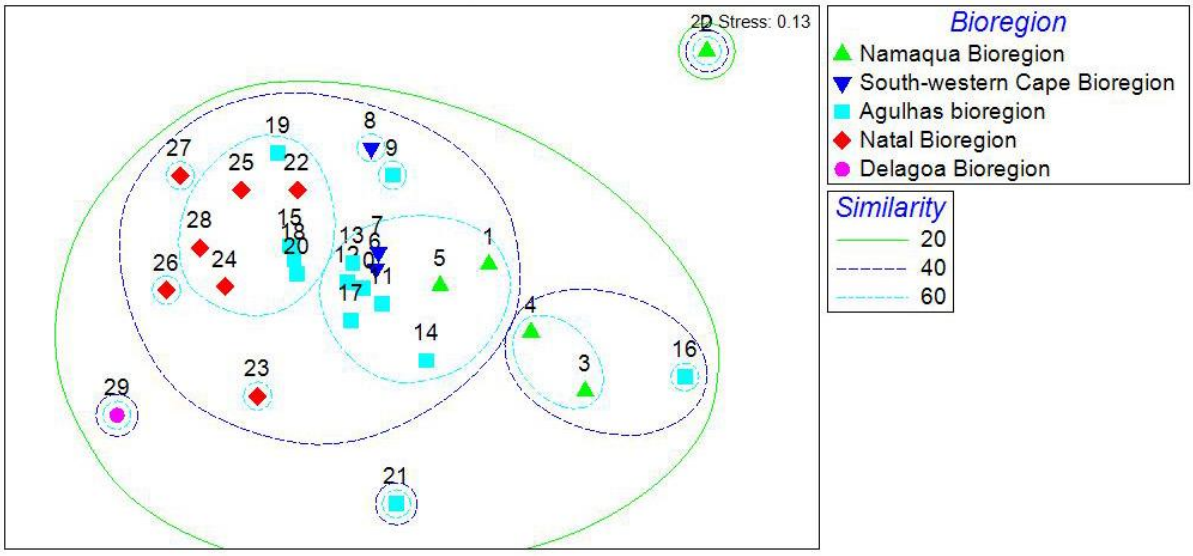

Figure 13: Multi-dimensional Scaling (MDS) plot with bioregions added as a factor and similarity levels indicated by the circles. The analysis was performed using a Bray-Curtis similarity measure on untransformed data.

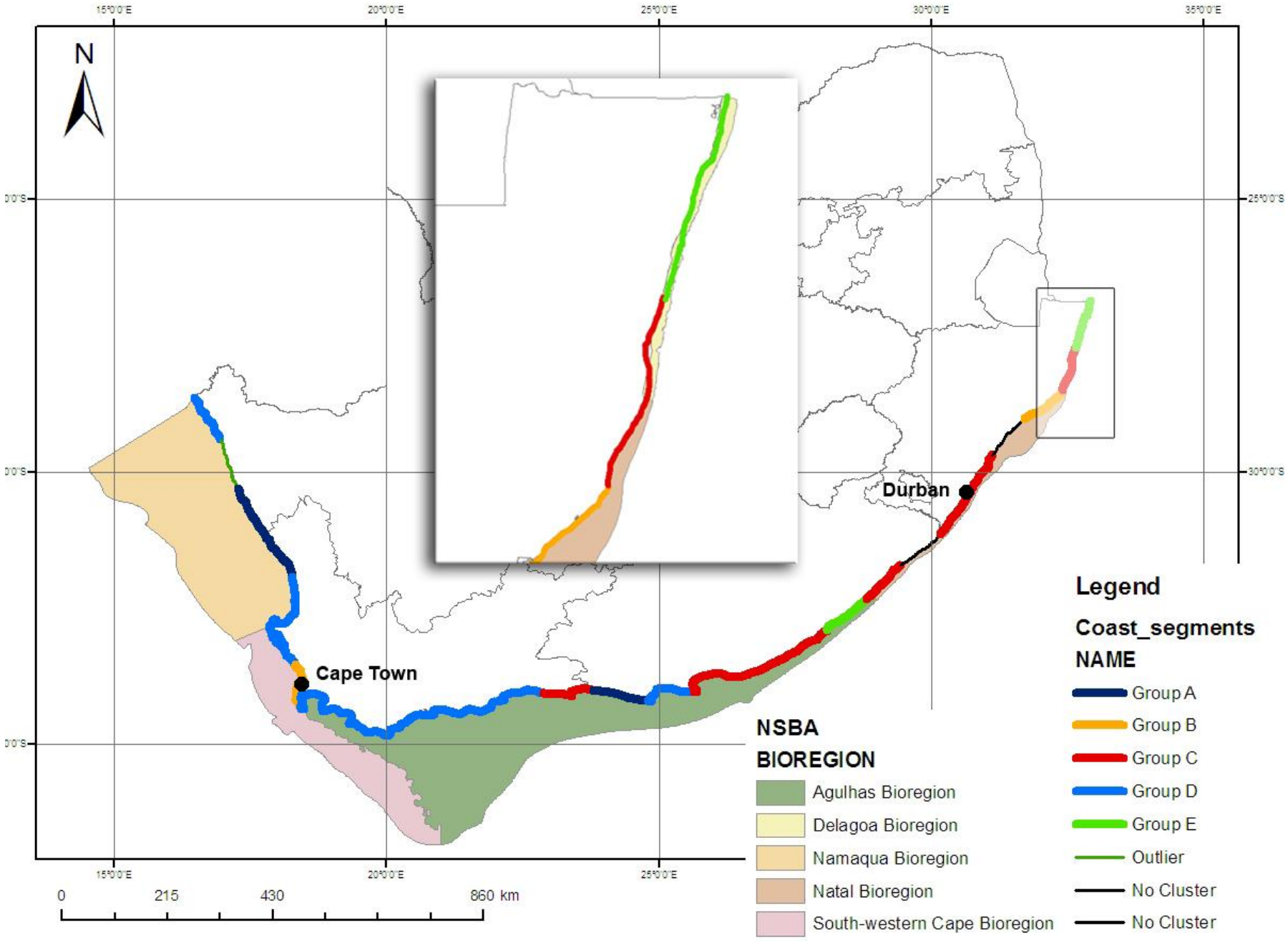

Figure 14: Significant clusters (from Figure 12) mapped in ArcGIS to in comparison to the nearshore biogeographic regions as defined by Lombard *et al.* (2004). Inset: magnification to show the Delagoa bioregion.

Figure 14 shows the significant clusters mapped in GIS compared to the bioregions defined by Lombard *et al.* (2004). It is apparent that there is no clear grouping of the significant clusters within any of the already established bioregions. Results from the ANOSIM indicate insignificant dissimilarities ($P < 0.05$) between the Namaqua and Agulhas Bioregion, the Namaqua and Natal Bioregion, and the Agulhas and Natal Bioregion. All other comparisons were deemed significant in terms of dissimilarity (i.e. they were different) notable examples include the Namaqua and Delagoa Bioregion, the South-western Cape and Natal Bioregion, and the South-western Cape and Delagoa Bioregion.

Of the 86 species recorded in South Africa, 64.06% are of cosmopolitan distribution, 11.24% are introduced and 24.7% endemic. Included in this are the 13 current additions to the known fauna, 84.6% of which are cosmopolitan and 15.4% introduced. Three species, *Oxynaspis* sp., Scalpellid 1, and Scalpellid 2, which have yet to be identified, were found. It is likely that they are new to science and were classified as endemic for the analyses of this study, thus raising the total of added species to 16. Eleven of these can be described as "offshore benthic" (Sink *et al*. 2011) and represent well known deep-water taxa. The remaining five are "coastal inshore" species (Sink *et al*. 2011).

The locality data , colour coded according to depth, for each sample used in this study are shown in Figure 6 with the nine bioregions, defined by Lombard *et al.*(2004), superimposed. The vast majority of the samples used were collected at depths less than 300 m (red, pink and blue points). Very few samples deeper than 300 m were collected (green, yellow and orange points). The two insets of the Cape Town and Durban coastline show that most samples were collected inshore at less than 30 m depth with many collected in the intertidal zone, including pelagic species which had been washed up (brown points). Most striking is the absence of samples collected in the Indo-Pacific offshore bioregion.

Localities for benthic pedunculate and sessile taxa are shown in Figure 18 (pelagic species excluded). A distinct difference in their respective distribution can be observed – most benthic Sessilia (blue points) are located closer inshore, in comparison to the benthic Pedunculata (red points) which are located offshore in deeper water, primarily consisting of scalpellid and poecilasmatid taxa (Fig. 16 and 18). The outline of the Agulhas Bank is discernable from the offshore collections of the benthic Pedunculata. The lone offshore blue point is a record of Acasta spongites.

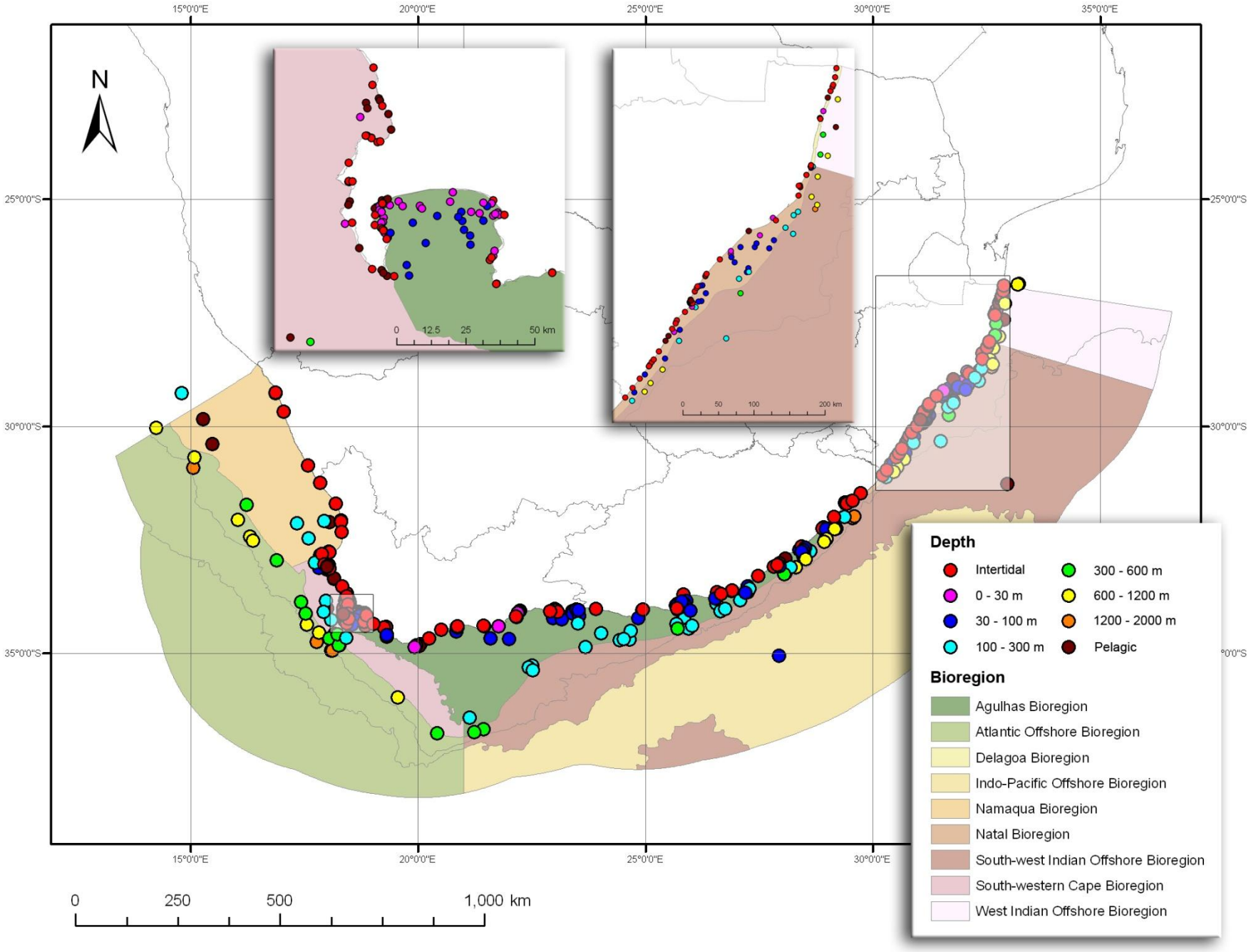

Figure 15: Plot of each sample used in this study, colour coded according to depth, with the nine bioregions, defined by Lombard *et al.*, (2004).Left inset – Cape Peninsula and False Bay (Cape Town). Right inset – north KwaZulu-Natal coast (Durban).

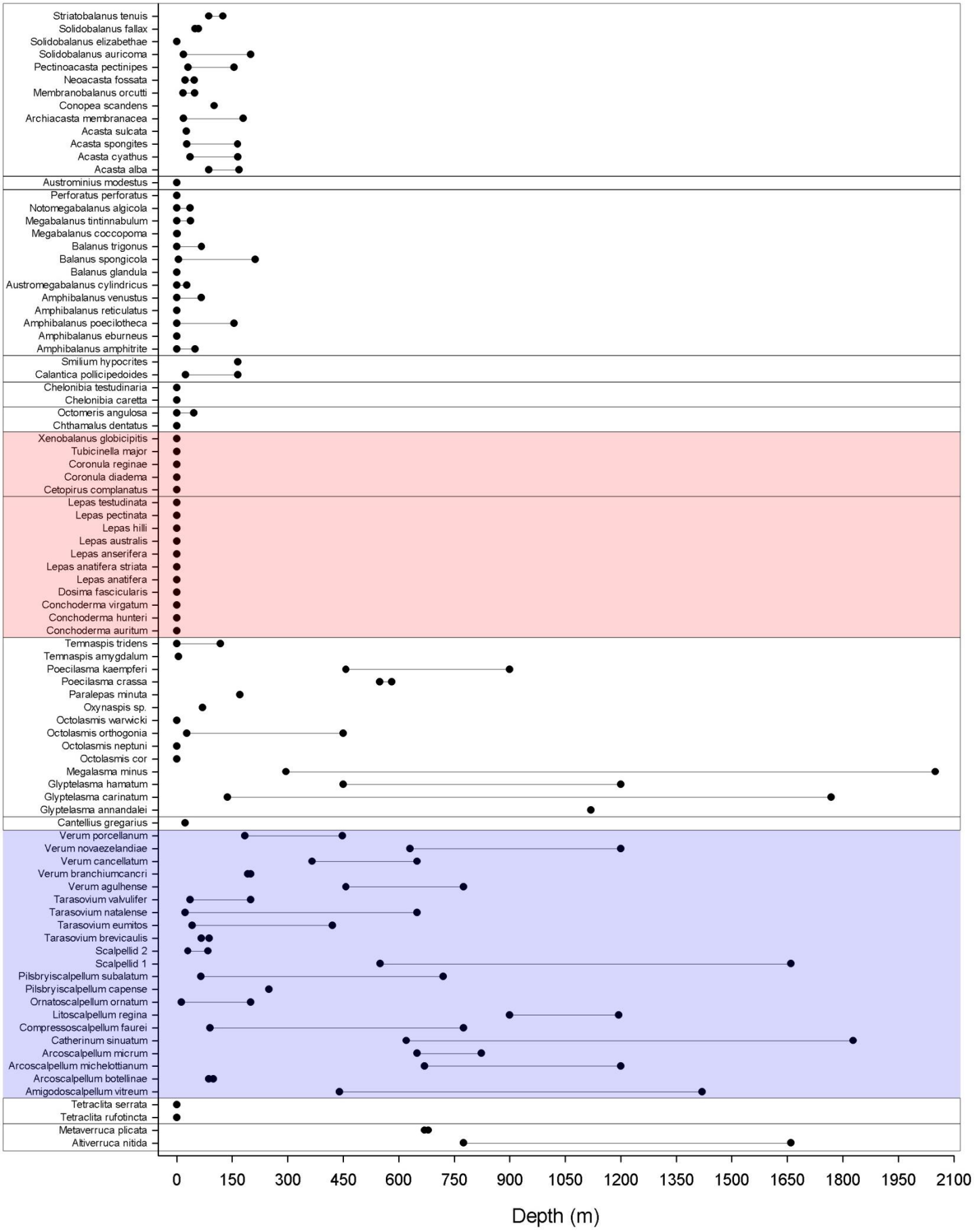

Figure 16: Depth ranges for the South African Cirripedia (Thoracica). Species on the y-axis have been divided into families. The Lepadidae and Coronulidae (pelagic) are shaded red. The deep water Scalpellidae are shaded blue.

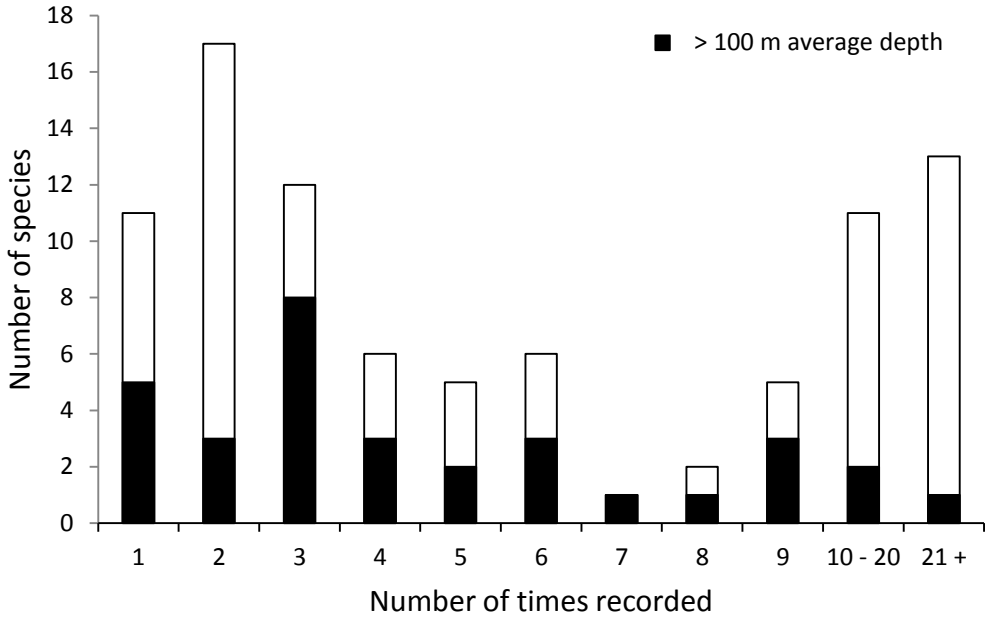

Figure 17: The number of species recorded χ number of times. The portion filled with black represents those species recorded over more than 100 m average depth.

Species richness, broken down into the number of constituent cosmopolitan, endemic and introduced species within each bioregion, is shown in Figure 19. The Agulhas bioregion displays the highest species richness, with a total of 53 species recorded. It also contains the highest number of endemic species, 15 in total, out of all nine bioregions in South Africa. In addition, five introduced species have been recorded there. This is followed by the Natal bioregion with a total of 50 species, subdivided into 34 cosmopolitan, ten endemic and six introduced. Next is the South-west Indian offshore bioregion with 43 species, followed by the South-western Cape bioregion with 39. Twenty-six cosmopolitan species are found in the South-western Cape, 5 endemic and the most introduced species in South Africa – eight in total. This is followed by the

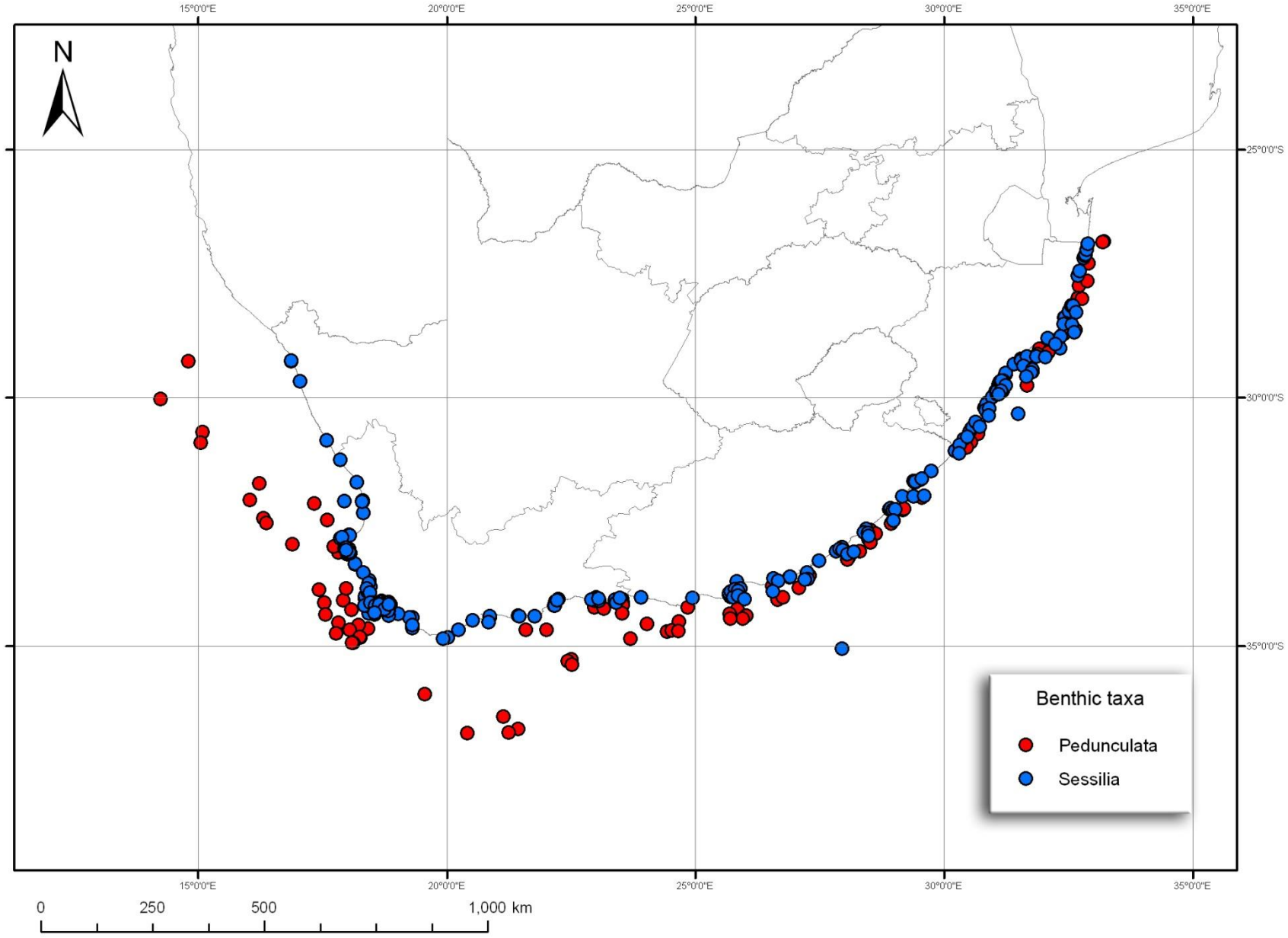

Figure 18: Distribution of benthic taxa (pelagic excluded) separated by Order. Pedunculata red, Sessilia blue. Note the two taxa are well separated where the continental shelf is broad (Agulhas Bank) and the deep water is located far offshore. The separation decreases where the continental shelf is narrow and the deep water is located closer inshore.

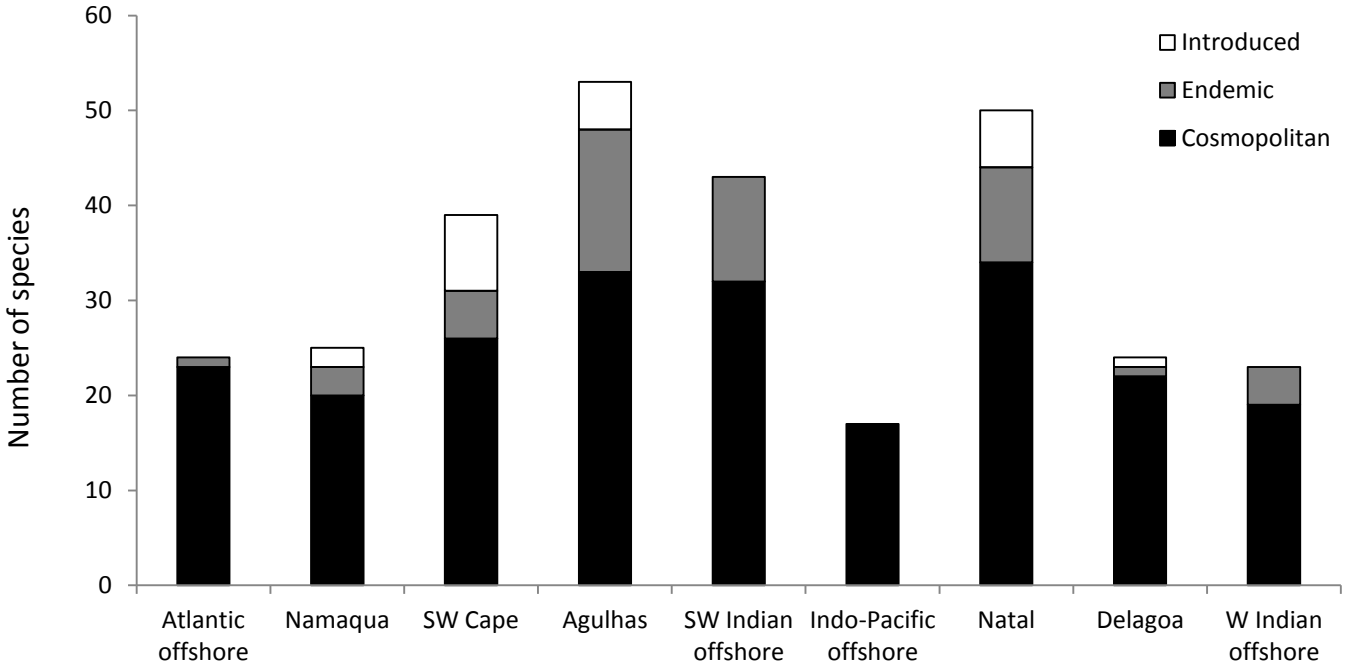

Figure 19: Species richness in each of the bioregions, as per Lombard *et al*., (2004), broken down into their constituent classifications: cosmopolitan (black); endemic (grey); introduced (white). SW = south west, W = west.

Namaqua and Delagoa bioregions each containing 25 and 24 species respectively. The 25 species recorded in the Namaqua bioregion are composed of 20 cosmopolitan, three endemic and two introduced species, whilst the Delagoa has 22 cosmopolitan only one endemic and one introduced species. No introduced species are found in any of the offshore bioregions, the fauna of which consist of mostly cosmopolitan taxa. The South West Indian and West Indian offshore bioregions display the highest levels of endemicity in comparison to the other offshore bioregions. In general species richness appears to be lower on the west coast, increasing towards the south coast and then decreasing again eastward towards the Mozambican border.

Discussion

Results from the various Primer analyses indicate that barnacles do not conform to the generally accepted biogeographic regions proposed by Lombard *et al.* (2004). As expected, the Delagoa and Namaqua biogeographic regions show the greatest dissimilarity, which can be explained by

the presence of unique taxa within each of these regions. Similarly, the same can be said for the South-western Cape and the Delagoa Bioregions amongst others. Interestingly, there were some bioregions which shared the presence of various species thus rendering them insignificantly dissimilar when one would expect otherwise given the distance between them. Upon closer inspection it was found that the species shared between these bioregions are in fact fouling taxa e.g. *Amphibalanus venustus*, *Amphibalanus reticulatus*, *Amphibalanus amphitrite amphitrite* and *Balanus trigonus*. The vast majority of these samples were collected from synthetic substrata such as yacht hulls and buoys within ports (Durban, Cape Town, Port Elizabeth and Saldanha Bay) each of which are situated within a different biogeographic region. Thus the sharing and dispersal of these fouling taxa across the different biogeographic regions of South Africa is resulting in unexpected similarities of these biogeographic provinces which would otherwise be different if analysed using other groups of animals or plants. Because of their fouling tendencies and ease at which they disperse, barnacles cannot be considered a reliable proxy for predicting biogeographic provinces in South Africa (and any other part of the world). Perhaps an analysis using non-fouling taxa would provide better results.

The Cirripedia (Thoracica) of South Africa are diverse and well represented. Most of the new records consist of well known deep water cosmopolitan species. It is likely that their late discovery can be attributed both the lack of experts with the available skills to identify new species and the severe lack of deep water invertebrate samples in South Africa waters, as can be seen in Figure 15. Griffiths (1999) mentions that there is not one full-time professional crustacean taxonomist in South Africa and that the discipline is maintained by a small group of part-time researchers assisted by overseas specialists. The current situation is no different and for this reason, many crustacean species (especially deep water taxa) will remain undescribed until such experts become available in South Africa.

Depth ranges for each species were established and it is clear that the deep water species, notably the Scalpellidae, occupy a much greater depth range than the shallow species. This is in accordance with global trends in the distribution ranges of species across depth strata, as shown by Rex *et al*., (2005) and Vanreusel *et al*., (2010). Most striking are the results illustrated in Figure 17, which show that the majority of South African Cirripedia are known from less than ten records. Even more striking is that 46.51% of the known species of barnacles in South Africa are known from three or less records. Again, this is most likely attributable to the lack of available expertise and sampling of deep waters and not due to any actual rarity of species.

Twenty-eight percent of species are known from more than ten records and it is clear that most of these are shallow water or intertidal species (Fig. 17) which are frequently encountered.

Benthic species of the Orders Sessilia, Lepadiformes and Scalpelliformes occupy different distinct habitats, with the former occurring almost exclusively offshore in deeper water and the latter inshore in shallower water. The two are well separated where the continental shelf is broad (Agulhas Bank) and deep water is thus located far offshore. The separation of the two taxa decreases where the continental shelf is narrow, as occurs along the east coast up to the Mozambique border. The success of the benthic stalked barnacles in deep water habitats is curious and, at present, one can only speculate as to why this is the case.

Species richness and endemicity increased around the coast from west to east, with the greatest species richness and endemicity recorded in the Agulhas bioregion, followed by the Natal bioregion, the South West Indian offshore bioregion and the South-western Cape bioregion. This was expected as these bioregions are isolated from our political borders and, as indicated by Awad *et al*. (2002), since fewer species are likely to have ranges extend across borders of other bioregions (and countries) as distance from those borders increases. This is similar to the patterns shown by other invertebrate taxa in South Africa, which display peaks in species richness and endemicity on the south coast of South Africa (Bustamante and Branch, 1996; Acuña and Griffiths, 2004; Griffiths *et al*., 2010). The greatest number of introduced species were located in the South Western Cape, Agulhas and Natal bioregions. This is directly related to the presence of a major shipping port in each of these bioregions at the coastal cities of Cape Town, Port Elizabeth and Durban, where many alien species are introduced via shipping vectors (Robinson *et al*., 2005, Simon-Blecher *et al.* 2008, Mead *et al*. 2011, Griffiths et al. 2011).

Species richness and endemicity were lowest in the Indo-Pacific offshore, West-Indian offshore, Namaqua and Delagoa bioregions. In the former two, this is most likely an underestimate, as a result of poor sampling effort in these areas. Their true species richness remains to be established for South African Cirripedia (Thoracica), and the future collection of samples is urgently required from these bioregions. However, the latter two share borders with neighbouring countries, this being the likely cause of low endemicity in these areas. The low overall species richness in the Namaqua bioregion is congruent with other invertebrate taxa (Griffiths *et al*., 2010), however the species richness observed in the Delagoa bioregion is

uncharacteristically low in comparison that of other invertebrate taxa (Griffiths *et al*., 2010). Apart from the South-west Indian offshore bioregion, low levels of species richness were observed in the offshore bioregions of South Africa. This is in line with the general global trend of few abyssal endemics (Rex *et al*., 2005; Vanreusal *et al*., 2010), but is more likely due to the marked inadequate number of samples from these areas. By comparison, the South-west Indian offshore bioregion is moderately well sampled, thus explaining the greater observed species richness.

In conclusion, the biogeography and species richness of the South African Cirripedia (Thoracica) follows similar trends to other invertebrates in South Africa. However, the group cannot be considered a reliable predictor of the established biogeographic provinces in South Africa due to the overriding presence and dispersal of fouling taxa. The trends observed with respect to depth range are also congruent with those from other parts of the world. The overall endemicity of 24.7% is slightly lower than that of the Crustacea which stands at 30% (Griffiths, 1999). It likely that the level of endemicity may be artificially elevated by virtue of the poor state of taxonomic knowledge in adjoining countries (Griffiths *et al*., 1999). However, undersampling and lack of taxonomic expertise are some of the main reasons for the results observed and it goes without saying that more work in field is required both in South Africa and in other parts of the world. In the words of Costello (2010): "Evidently, a global review of gaps in marine biodiversity knowledge and resources is overdue".

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Synthesis

The thesis has attempted to provide an account of the Cirripedia (Thoracica) in South Africa incorporating new additions and presenting these and the current known taxa in the form of a usable guide. The distribution of these species throughout our bioregions (after Lombard *et al*., 2004) was analysed and levels of species richness for each bioregion established.

In Chapter 1, 13 species were added to the list of South African Cirripedia (Thoracica), raising the total number of species to 86. Most of these represent species from deep water habitats which are known from other parts of the world and have therefore remained undetected for a long period of time. It was deduced that this has occurred for two main reasons: the first is that there are not enough full-time experts working on taxa for which the state of knowledge is comparatively poor; the second is the severe lack in samples from our deep water bioregions. A good example of the latter is the discovery of the Verrucomorpha, one of two entirely new suborders added from the result of this work from specimens collected in the 1970's. The fact that is has taken 40 years for the samples to be correctly identified, catalogued and formally added to the list of South African fauna validates the views expressed by Griffiths *et al*., (2010) - in that more experts are required to work on the subject of taxonomy in order to establish an adequate state of knowledge of our marine biodiversity. From the difference in publication dates of the aforementioned papers, it is clear that this issue has existed for some time and, on a global scale, is also long overdue (Costello, 2011).

The second theme portrayed throughout the chapters is the severe lack in sampling effort in our deep water bioregions. The result of this is poorly established distribution ranges of the South African Thoracica, which feeds directly into a greater perceived level of endemicity. This is demonstrated quite clearly in Chapter 3 and is also evident in the distribution maps of the species described by Barnard (1924) in Chapter 2 the majority of which are represented by only one or two points on the map.

The situation will remained unchanged unless we either increase our output of experts in the field of taxonomy from the South African universities whilst simultaneously increasing sampling effort in areas where it is needed. Unfortunately funding agencies no longer appear to prioritise such challenges for various reasons outlined by Costello *et al*., (2010) – perhaps the

most concerning of which is that "doing so is out of fashion, except when new technologies are involved". But it is important to remember that although modern molecular techniques are useful in complementing traditional taxonomic methods, they should not replace them altogether. After all how would it be possible to run informative analyses on organisms without knowing which taxonomic features make them more closely related than others? Hopefully future research is directed towards understanding marine biodiversity. I consider this dissertation as a step in the right direction.

Appendix A

List of species

Appendix B