Studies of Foraminifera associated with *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta)

Rashieda Toefy

Supervisor : Prof. Mark J. Gibbons (University of the Western Cape)

Co-supervisor: Dr Ian K. McMillan (De Beers Marine)

A thesis submitted for the degree of

Magister Scientiae

in the Zoology Department,

University of the Western Cape,

Cape Town, South Africa.

November 2002

I declare that **Studies of Foraminifera associated with *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta)** is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

....

Rashieda Toefy

This thesis is dedicated to my family, especially

my late father, Achmat Rashied and my mother, Gafsa Domingo, as well as my

husband, Seraj and my children, Rafeeq, Muneeb and Imra.

ACKNOWLEDGMENTS

I would like to thank my supervisor Prof. Mark Gibbons for his constant support, assistance and valuable criticism. He is also responsible for nurturing my development as a scientist, which I am grateful for. I would also like to thank my co-supervisor Dr Ian McMillan for assisting in the identification of foraminifera and for assistance with literature. The assistance of Mr. Basil Julies at the Electron Microscope Unit is greatly appreciated. Thank you to my funders, the National Research Foundation (South Africa) and the Royal Society of London. Thank you also to the International Foraminiferal Symposium who funded my conference fees at the Foraminiferal Conference in Perth, Australia.

I wish to thank all the staff and students in the Zoology department for supporting me during this study. Thank you to Martin Hendricks, Toufiek Samaai, Wayne Florence, Goosain Isaacs, Gordon Harkins and Lorne August for assisting in collections. Thank you also to Wayne, Martin and Toufiek for lengthy discussions and advice, and for being special friends.

I am grateful to my mother, for being supportive and for being so proud of what I have achieved, I could not have done this without her. To my brothers and sisters, thank you for your encouragement and for being role models for me. To my sisters, Adela and Badehria, a special thank you for being available for my children when I was not.

I am indebted to my husband, Seraj, without whose support, encouragement and love, I would not have been able to complete this study. To my children, Rafeeq, Muneeb and Imra for being the highlight at the end of grueling days.

Table of Contents

	Page
Declaration	ii
Acknowledgments	iv
Table of Contents	v
List of Figures	vi
List of Tables	viii
Thesis Abstract	1
Chapter One: General Introduction	4
Chapter Two: The effect of exposure on foraminifera associated with *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta)	9
Chapter Three: The biogeography of foraminifera associated with *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta)	29
Chapter Four: General Conclusions	47
Chapter Five: Appendix One	50
Species List	53
Foraminifera associated with *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta)	58
Plates 1 – 4	94
Appendix Two	98
References	113

Legends to Figures

		Page
Figure 2.1:	Map of False Bay, South Africa illustrating the position of sampling sites	12
Figures 2.2A:	Dendrogram of the percentage similarity amongst the foraminiferal assemblages found on *Gelidium pristoides* on exposed and sheltered shores in winter. Circles - sheltered shores, squares - exposed shores. FP is Froggy Pond, MP is Millers Point, DB is Dalebrook and SJ is St James.	17
Figures 2.2B:	Dendrogram of the percentage similarity amongst the foraminiferal assemblages found on *Gelidium pristoides* on exposed and sheltered shores in summer. Circles - sheltered shores, squares - exposed shores. FP is Froggy Pond, MP is Millers Point, DB is Dalebrook and SJ is St James.	18
Figure 2.3:	Relationships between the weight of *Gelidium pristoides* plants and the richness (Figure 2A), abundance (Figure 2B) and diversity (Figure 2C) of foraminifera. Relationships between the weight of sediment trapped by *Gelidium pristoides* and the richness (Figure 2D), abundance (Figure 2E) and	20

diversity (Figure 2F) of foraminifera. Circles - sheltered shores, squares - exposed shores. Shaded symbols - winter months; open symbols summer months.

Figure 2.4: Dendrogram of the percentage similarity amongst the foraminiferal assemblages found on all *Gelidium pristoides* samples. Circles - sheltered shores, squares - exposed shores. Shaded symbols represent winter months and open symbols represent summer months. The algal weight classes are I - <4 g, II – 4 – 8 g, III - 8 – 12 g, IV – 12 – 16 g and V - >16 g. 22

Figure 3.1: Map of South Africa illustrating the ocean currents and the biogeographic provinces 31

Figure 3.2: Map illustrating the position of the study sites 34

Figure 3.3: Dendrogram of the percentage similarity amongst the foraminiferal assemblages on *Gelidium pristoides* on shores sampled within it distributional range. Shaded squares – West coast, shaded circles – False Bay, open circles – South-west coast and open squares- South coast 39

Figure 3.3: Dendrogram of the percentage similarity amongst the foraminiferal assemblages, using presence/absence data and assuming uniform distribution, on *Gelidium pristoides* on shores sampled within it distributional range. 42

Figure 3.4: Relationships between the sediment weight trapped by *Gelidium pristoides* plants and the abundance (4A), richness (4B) and diversity of foraminifera (4C). 42

Legends to Tables

Table 2.1: Species of foraminifera identified from samples of *Gelidium pristoides* on exposed and sheltered shores in False Bay, South Africa. 15

Table 2.2: The species of foraminifera identified by the SIMPER routine in PRIMER as being indicative of the two clusters of samples in Figure 1A and B. The average similarity between samples in each group is indicated in parentheses on the title row. The average abundance of each species in the different groups is indicated in brackets, the second value refers to the mean abundance of that species in the contrasted group. The proportion contributed by each species to the difference between the two groups is also shown. 19

Abstract

Abstract

Foraminifera of the red seaweed, *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta) were examined on intertidal rocky shores from across its distribution range in South Africa. The aim of this study was to determine the effect of wave exposure and biogeography on assemblage structure, and to compare these results with those of previous macrofaunal studies conducted in the region.

A total of 45 species of foraminifera were identified, of which 15 are potentially new. These species are described and illustrated. Although most species were rare, the common species were typically phytal and were generally ubiquitous. All species had a warm to cold temperature range.

Macrofaunal studies have shown that sheltered shores are more diverse and support a higher biomass of organisms than exposed shores. In order to determine whether foraminifera associated with *G. pristoides* exhibit the same pattern, two exposed and two sheltered shores were examined in False Bay during summer and winter. Multivariate statistics revealed that assemblages from exposed shores were distinct from those of sheltered shores. Only two species were found exclusively on exposed shores. However, the species that were dominant on exposed shores were different to those on sheltered shores; this dominance was independent of plant size. Species of foraminifera found on exposed shores were also larger, independent of season. Although there was no seasonal variation in abundance and diversity, the species composition differed. Foraminifera were more abundant and diverse on exposed shores, and this result contrasts with previous work on macrofauna and meiofauna around South Africa.

Abstract

Biogeographic studies on macrofaunal invertebrates in South Africa have revealed three main biogeographic provinces. In order to determine whether foraminifera associated with *G. pristoides* conform to these provinces, ten exposed shores from Sea Point on the west coast to Port Elizabeth on the south coast were examined. Multivariate statistics revealed that Sea Point samples were distinct from all other shores. Kommetjie, also on the west coast, clustered with the other shores. This result suggests that foraminifera conform to previously established macrofaunal biogeographic provinces. The most common species in the Sea Point samples was *Patellina corrugata* and miliolids dominated the Port Elizabeth samples. There were some species only present in Sea Point and Kommetjie. These species were, however, rare in the samples and may not be an indication of the start of a biogeographic province. Samples from the same shore and coast did not always cluster together. This may be attributed to rarity, patchiness in distribution of intertidal foraminifera as well as differences in the level of exposure on shores.

Algal and sediment weight were significantly correlated and algal weight was significantly greater on exposed than sheltered shores, irrespective of season. Although the algal weight of the groupings identified from the exposure study differed, it was found that algal and sediment weight accounted for only 20 % of the community structure.

Interestingly, in the biogeographic study, algal weight was not significantly correlated with abundance or diversity whereas sediment weight was. Species richness and diversity did not differ between the four coasts (west coast, False Bay, south-west coast and south coast). Abundance differed between False Bay and the south-west coast; this may be the result of the higher sediment weight of False Bay samples. The mean sediment weight of the groupings identified by cluster analysis did not differ significantly between the groups whereas algal weight did. As in the study on exposure, further statistics revealed that algal and sediment weight only accounted for ~3 % of the assemblage structure. Algal and sediment weight play a very small role in determining community structure of foraminiferal assemblages, but they do play an important role in determining diversity and abundance.

Chapter One

General Introduction

Our understanding of the macrofauna of hard intertidal substrata around South Africa is fairly comprehensive, and we have a good understanding of the environmental factors responsible for structuring macrofaunal communities (McQuaid & Branch, 1985; Bustamante *et al.,* 1996; Emanuel *et al.,* 1992). The same cannot be said for meiofaunal communities of rocky shores, which despite their neglect are known to play an important role in the functioning of many intertidal systems (Gibbons & Griffiths, 1986). While macrofauna may dominate rocky shores in terms of biomass, meiofauna are generally more abundant, and because they have faster turnover rates they make an important contribution to secondary production (Gibbons & Griffiths, 1986).

Meiofauna on rocky shores can be found occupying rock crevices and living upon algae and sessile animals (Gibbons & Griffiths, 1986). They can attain high abundances on algae; abundance being dependent on algal morphology, condition and size (Gunnill, 1982; Kangas, 1978). Meiofaunal abundance and diversity among algae reflects the availability of micro-habitats, the amount of sediment trapped and the elevation on rocky shores (Gibbons, 1988a).

Foraminifera form part of the meiofauna (63 μm– 100 μm), although large living Tertiary (up to 5 cm) and Cretaceous (up to 10 cm) species have been reported (Boltovskoy & Wright, 1976). Foraminifera are protozoans, which belong to the sub-phylum Sarcodina (presence of pseudopodia), and are assigned to the class Granuloreticulosea (delicate filiform, granular pseudopodia) (Gooday, 1992). They are primarily marine and hyposaline organisms, although some freshwater forms have been reported (Phleger, 1973). Foraminifera have been reported as part of the plankton (Cifelli, 1982; Cifelli & Smith, 1970; Bé *et al.,* 1971) and the benthos (Buzas & Culver, 1991; Golik & Phleger, 1977). They are specific in their depth ranges and some species can be found exclusively in the intertidal zone (Cooper, 1961; Boltovskoy, 1963; Kitazato, 1988), nearshore (Culver & Buzas, 1999; Lankford & Phleger, 1973) and in deep-sea environments (Bernstein *et al.,* 1978; Gooday, 1999).

Foraminifera have either chitinous, agglutinated, siliceous or calcareous tests (Cushman, 1959). The test preserves well, providing an extensive fossil record, which extends from the Cambrian to the Recent (Buzas & Culver, 1991). It has been found that many foraminifera have definite geological and geographic distribution ranges, which makes them suitable for determining the age of sediments, and thereby of value to mining and geological exploration companies (Cushman, 1959). The accumulation of tests on the sea floor has provided a record of environmental conditions in both the ocean and the sediment at the time of death (Phleger, 1973).

Globally, studies on foraminifera have concentrated on the examination of fossilized material (Boltovskoy & Wright, 1976), though ecological studies on foraminifera have increased since the 1950's (Murray, 1991). Foraminifera are ideal organisms in both geological and ecological studies because of their small size, and their presence in statistically viable numbers, even in small sediment samples (Buzas & Culver, 1991). They are also easily sampled (Culver & Buzas, 1999).

Foraminiferal distribution is influenced by depth, temperature, salinity, pH, oxygen concentration, trace elements and biological interactions (Pielou, 1979). The aforementioned factors affect growth and reproduction; any changes in the levels of these factors would affect whether a species would be present in that environment. Their response to changes in environmental factors make them suitable as indicators of environmental health (Bernhard, 1997; Pielou, 1979; Samir, 2000; Yanko *et al.,* 1994). Assemblages change in abundance and community structure around sewage outfalls (Stott *et al.,* 1996). Morphological test abnormalities have also been reported in areas where there are high levels of trace metal pollutants (Yanko *et al.,* 1994). Therefore, test abnormalities or changes in community structure of foraminifera would be an indication of changed environmental health.

Most research into extant foraminifera in South Africa has been conducted on deep-sea and pelagic forms (e.g. Rogers & Bremner, 1991, Giraudeau, 1993). Fossil material has also been well documented from oil and mineralogical surveys (Dale & McMillan, 1998). The study of intertidal foraminifera, however, has been neglected, this is in spite of the fact that foraminifera have been shown to form a conspicuous component of the meiofauna.

Foraminifera have been retrieved in both intertidal sediments (Boltovskoy, 1963; Boltovskoy & Lena, 1966; Smith, 1968; Boltovskoy & Lena, 1970; Boltovskoy, 1970), and upon intertidal algae (Hedley *et al.*, 1967; Atkinson, 1969; Boltovskoy & Wright, 1976). Phytal assemblages of foraminifera are generally richer in species than those of sediments (Boltovskoy & Wright, 1976; Atkinson, 1969).

Phytal foraminifera have been found attached to algal fronds, but are mostly present in the sediment at the base (Atkinson, 1969). Algae that retain more sediment seem to provide more shelter and have richer assemblages than those with less sediment (Boltovskoy & Wright, 1976). Algae and sediment in the intertidal zone also retain water during low tide, which might allow foraminifera to avoid desiccation (Kitazato, 1988). In addition, diatoms and microalgae, which are trapped as water moves amongst the thalli and sediment, provide a source of food for foraminifera (Kitazato, 1988).

This project focuses on the foraminifera of one species of intertidal alga, *Gelidium pristoides*, and attempts to a) explore the environmental factors responsible for structuring communities, and b) document the species present. The specific questions that will be addressed include: (Chapter 1) Are foraminifera more abundant and diverse on sheltered than exposed shores, as has been found in previous studies in South Africa? (Chapter 2) Do foraminifera conform to the biogeographic provinces around South Africa, established by macrofaunal studies?

The structure of *Gelidium pristoides* is suitable as a habitat for foraminifera. It is tuft-like and consists of many fronds, and each plant is approximately 30 mm in height (Carter & Anderson, 1986). *G. pristoides* provides a microenvironment for intertidal fauna; it provides a source of food, shelter from heat build-up and desiccation (Beckley, 1977), as well as protection against wave exposure and predation (Gibbons, 1988c). *G. pristoides* is found in the mid to low intertidal zone, and on exposed and sheltered, warm and cold-water shores as well as on different rock types (McQuaid & Branch, 1984). It is a commercially important mid-shore alga, which is harvested for its agar content (Carter & Anderson, 1986). It is endemic to South Africa and is found from Sea Point in the Western Cape to Port Edward on the East coast (Day, 1969). By confining the study to one algal species, many variables can be eliminated which allows for comparison between the foraminifera of the different shore types (see Gibbons, 1988c).

The thesis is divided into the following sections:

Chapter 2: Gibbons (1988b) studied the effect of wave exposure on meiofaunal communities of *G. pristoides*. This chapter investigates the effect of exposure on the foraminiferal communities of *G. pristoides*. It also compares the findings of Gibbons (1988b) on meiofauna taxa with those of foraminiferal communities.

Chapter 3: Studies on intertidal biogeography in South Africa have concentrated on invertebrate macrofauna, algae and some intertidal fish. The biogeography of intertidal meiofauna has been neglected. Meiofauna and more specifically foraminifera may react in a different way to the generally accepted provinces established in macrofaunal studies. This chapter investigates the biogeographic patterns of foraminifera associated with *G. pristoides* and compares this with the findings of macrofaunal studies.

Appendix: The appendix provides an inventory and a brief description of the species that were recovered from *G. pristoides*. The species are documented here because this is the first study to be conducted explicitly on intertidal foraminifera from the western Cape, South Africa, and as such it acts as a base-line reference for future work. The appendix should not be regarded as a taxonomic treatise of the fauna, as only a few specimens of each species were examined and no examination of type material was undertaken. Furthermore, full taxonomic literature is difficult to obtain in South African libraries. Some errors in identification may have occurred because of either morphological variation attributable to environmental conditions or reproductive states.

Chapter Two

The effect of wave exposure on the foraminifera of the intertidal agarophyte *Gelidium pristoides.*

Abstract

The foraminifera of the red seaweed, *Gelidium pristoides* (Turner) Keutzing (Gelidiales: Rhodophyta) were examined on exposed and sheltered shores around False Bay, South Africa, during summer and winter 1998/1999. Twenty-five species were recognised, seven of which are potentially new. Multivariate statistics indicated that the assemblages on plants from exposed shores were distinct from those on sheltered shores, and two species of foraminifera were confined to exposed shores. Plant size and the quantity of trapped sediment were positively correlated, and plants on exposed shores were significantly bigger than those on sheltered shores. Plant size and sediment weight were linked to assemblage diversity and abundance; assemblages on exposed shores were generally more diverse and abundant than those of sheltered shores. Different species dominated on the two shore types, and larger foraminifera tended to be more common on exposed shores. The response of foraminifera to exposure differs from that of other meiofauna on *G. pristoides* and this is likely a reflection of their more sessile habit.

Introduction

Wave action has long been considered an important factor influencing the community structure of intertidal communities (Lewis, 1964). The coast of the western Cape is generally subject to high wave energy, owing to its essentially linear nature, the absence of protected embayments and to the prevailing winds (Bustamante & Branch, 1996). The effects of wave exposure on macrofaunal communities of rocky intertidal shores have been well-documented (McQuaid & Branch, 1984; McQuaid *et al.,* 1985; Emanuel *et al.,* 1992, Bustamante & Branch, 1996). Exposure appears to influence the biomass, diversity and trophic structure of the community (McQuaid *et al.,* 1985); biomass tends to increase with increased exposure (McQuaid & Branch, 1984). Exposed shores tend to be dominated by filter-feeders, whereas sheltered shores are dominated by grazers and macroalgae (McQuaid & Branch, 1984; McQuaid *et al.,* 1985). More mobile organisms also tend to be less abundant than sessile organisms on wave-beaten shores (Bustamante & Branch, 1996).

Gibbons (1988b), in the only comparable study conducted on meiofauna in South Africa, demonstrated that the meiofauna of *G. pristoides* varied with shore exposure, and that small meiofauna were generally more abundant and diverse on sheltered shores. These observations were based on studies of broad taxic groups (e.g. copepods, nematodes), and lacked the detail inherent in studies of individual species or taxa.

Studies on the effects of exposure on foraminifera have been conducted in Argentina by Thompson (1978 in Murray, 1991). Although Thompson noted that assemblages appeared to differ slightly with exposure, clear differences in structure or composition of assemblages could not be observed as the study was not quantitative.

Thompson also found that the strength of foraminiferal tests from exposed shores was much greater than that on sheltered shores; this is thought to be a result of the higher energy environment of exposed shores (Murray, 1991).

This study aims to investigate the effects of wave exposure on foraminifera associated with *Gelidium pristoides*. It tests whether foraminiferal assemblages follow the same patterns revealed by previous macro- and meiofaunal studies around South Africa, that is, whether the abundance and diversity is higher on sheltered than exposed shores.

Materials and Methods

Sampling site

Sampling took place on the 10/11 August 1998 (austral winter) and 1/2 February 1999 (austral summer) at low tide, ~0.8 m above chart datum. Five of the largest *G. pristoides* plants were collected from two exposed shores [St. James (18.45°E, -34.11°S) and Dalebrook (18.45°E, -34.12°S)] and from two sheltered shores [Froggy Pond (18.45°E, -34.19°S) and Miller's Point (18.45°E, -34.22°S)] around False Bay (Figure 1.1). To investigate the effect of algal size on foraminiferal assemblages, an additional five plants of variable size were collected from each shore in February 1999. All plants were collected on limpets to minimise the disturbance and loss of phytal fauna (as Gibbons, 1988b), and samples were immediately preserved in 70% ethanol.

Laboratory analysis

The alga was scraped off the limpet and agitated in water to remove sediment. The alga was weighed (wet weight) and oven dried at 60 °C to constant mass. The

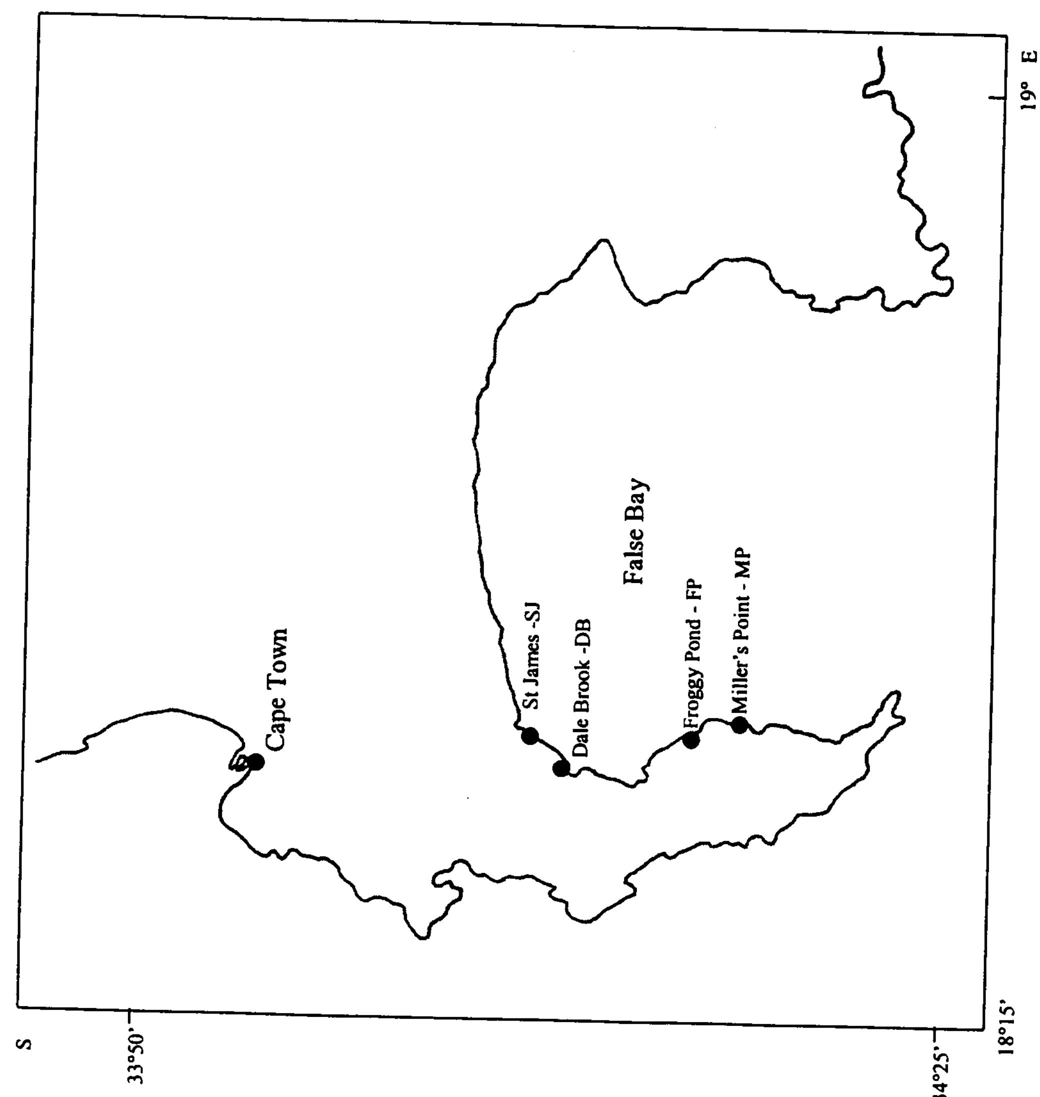

Figure 2.1: Map of False Bay, South Africa illustrating the position of sampling sites

sediment and meiofauna were sieved through a 63 μm mesh and then stained with Rose Bengal for at least 24 h. The carbon tetrachloride flotation method was used for isolating foraminifera from the sediments (Cushman, 1959), but this method is only about 85% efficient and thus the sediments were also visually inspected (as Boltovskoy & Wright, 1976). All live foraminifera were identified and counted using a stereoscopic dissecting microscope at 80x magnification. A representative of each species was measured using scanning electron microscopy. While the use of one representative may bias data, it is useful as an indication of the size structure of assemblages on the two shore types. The mean individual size of foraminifera per plant was calculated by multiplying the number of individuals of a species by the size of the measured representative of that species, the measurements were totalled for the plant and divided by the total number of individuals in the whole sample. The sediment from each sample was then oven dried at 60 °C to constant mass and weighed.

Statistical analysis

Analysis of variance (ANOVA) was used to determine if algal or sediment weight and the abundance and diversity of foraminifera varied with season or shore type. Species diversity was calculated using the Shannon-Wiener Index (H') (Krebs, 1999). Linear relationships between the physical environment and the abundance and diversity of foraminifera were determined using correlation analyses. ANOVA was used to compare the individual size of foraminifera on the two shore types during summer and winter. A significance level of $p < 0.05$ was used in all tests, unless stated otherwise.

The structure of the foraminifera communities on the different shores was investigated using descriptive multivariate statistics. The numerical composition of samples was root-root transformed and a similarity matrix was constructed using the Bray-Curtis Similarity Index (Field *et al.*, 1982). All species from all samples were included in the analysis. Cluster analysis of the samples was undertaken using PRIMER software using group average sorting (Clarke & Warwick, 1997).

The species most responsible for determining similarities between and within the groups identified by the cluster analysis were determined using the SIMPER routine in PRIMER. The BIOENV procedure in PRIMER was used to determine which of the investigated environmental parameters (algal weight and sediment weight) could best explain the structure of the identified foraminiferal assemblages (Clarke & Warwick, 1997).

Results

Two sub-orders, six superfamilies and 25 species of foraminifera were present in the samples. Of these, some were difficult to separate consistently to species level and further analyses were confined to 20 species (Table 2.1 and Appendix 1). The identification of seven of the species was uncertain. These included *Glabratella* sp. A, *Cibicides* sp. A, *Glandulina* sp. A, *Lagenosolenia* sp. A, *Lagena* sp. A, *Oolina* sp. A and *Fissurina* sp. A, which were only identifiable to genus level.

Only two species of foraminifera (*Lagena semilineata* Wright and *Planorbulina mediterranensis* d'Orbigny) were confined to one shore type (exposed) and most were recovered from both shores. Having said that, the species that dominated on exposed

Sub-order	Super-family	Genus	Species
Miliolina	Miliolacea	*Quinqueloculina*	*Quinqueloculina* cf *Q. undulata* d'Orbigny
			Quinqueloculina vulgaris d'Orbigny
			Quinqueloculina dunkerquiana (Heron-Allen & Earland)
			Quinqueloculina isabellei d'Orbigny
			Quinqueloculina seminula (Linné)
		Miliolinella	*Miliolinella subrotundata* (Montagu)
Rotalina	Nodosariacea	*Lagena*	*Lagena semilineata* Wright
			Lagenosolenia sp. *A*
			Lagena sp. *A*
		Oolina	*Oolina* sp. *A*
			Oolina cf *O. melo* d'Orbigny
		Fissurina	*Fissurina* sp. *A*
		Glandulina	*Glandulina* sp. *A*
	Buliminacea	*Bolivina*	*Bolivina "fossa"* McMillan, 1987
			Bolivina pseudoplicata Heron-Allen & Earland
		Brizalina	*Brizalina "rocklandsensis"* McMillan, 1987
	Rotaliacea	*Elphidium*	*Elphidium macellum* (Fichtel & Moll)
			Elphidium cf *E. advenum* (Cushman)
	Discorbacea	*Rosalina*	*Rosalina* cf *R. globularis* (Heron-Allen & Earland
		Glabratella	*Glabratella australensis* (Heron-Allen & Earland)
			Glabratella sp. *A*
	Orbitoidacea	*Cibicides*	*Cibicides* sp. *A*
		Planorbulina	*Planorbulina mediterranensis* d'Orbigny
		Cibicides	*Cibicides lobatulus* (Walker & Jacob)
	Spirillinacea	*Patellina*	*Patellina corrugata* Williamson

Table 2.1: Species of foraminifera identified from samples of *Gelidium pristoides* on exposed and sheltered shores in False Bay, South Africa (Refer Appendix 1).

shores were different to those that dominated on sheltered shores. *Glabratella australensis* (Heron-Allen & Earland), *Rosalina* cf. *R. globularis* d'Orbigny and *Cibicides lobatulus* (Walker & Jacob) were dominant on *G. pristoides* from exposed shores. *Patellina corrugata* Williamson, *Miliolinella subrotundata* (Montagu) and *Bolivina pseudoplicata* Heron-Allen & Earland were dominant on *G. pristoides* from sheltered shores. Patterns of dominance appeared independent of plant size. Foraminifera on exposed shores were significantly larger than those on sheltered shores during both summer (292.18 ± 4.25 μm vs. 213.98 ± 10.94 μm) and winter (308.59 ± 3.55 μm vs. 254.69 ± 8.31 μm).

The results of the cluster analysis revealed that samples from exposed shores were distinct from those on sheltered shores, irrespective of season (Figure 2.2 A and B). Although no seasonal variation in abundance or diversity was observed overall ($p > 0.05$), the specific composition of foraminifera on algae from exposed and sheltered shores did change (Table 2.2). For example, *Fissurina* sp. A was responsible for ~13% of the difference between algae on exposed and sheltered shores during winter, whereas, *Elphidium* cf. *E. advenum* (Cushman) was responsible for ~11% of the difference between assemblages during summer.

Seasonality had no effect on the weight of algae ($p= 0.096$) or sediments ($p= 0.822$) per shore. However, algae were significantly larger on exposed (8.02 ± 0.86 g), than on sheltered shores (4.54 ± 0.37 g), and also trapped more sediment (2.41 ± 0.35 g vs.1.32 ± 0.29 g, respectively), irrespective of season. There was a significant, positive correlation between algal weight and sediment weight ($p < 0.05$).

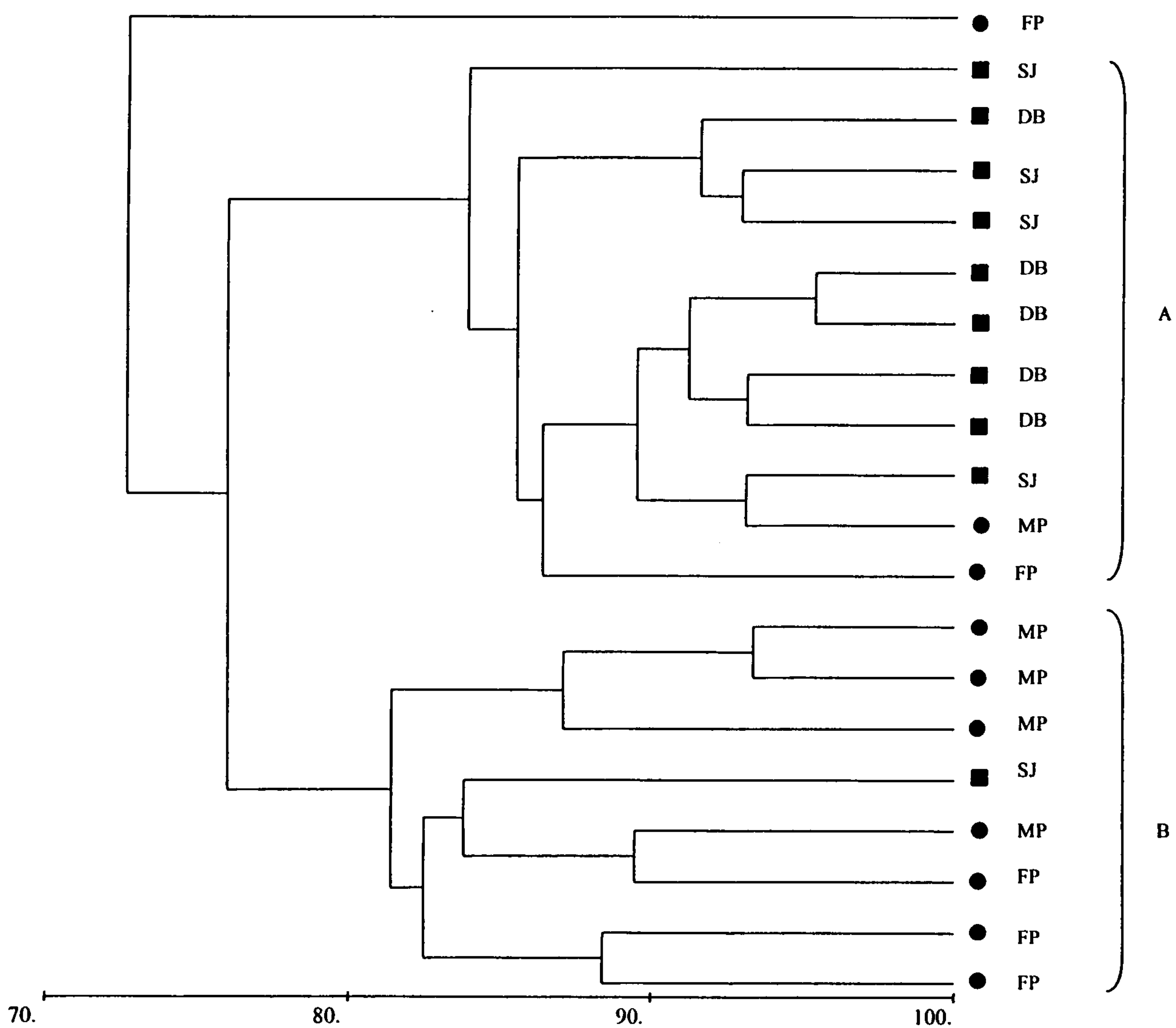

Figure 2.2.A: Dendrogram of the percentage similarity amongst the foraminiferal assemblages found on *Gelidium pristoides* on exposed and sheltered shores in winter. Circles - sheltered shores, squares - exposed shores. Shaded symbols - winter months. FP is Froggy Pond, MP is Millers Point, DB is Dalebrook and SJ is St James.