COASTAL AND DESERT DUNES: CONTRASTS IN PHYSICAL FEATURES, VEGETATION AND FAUNA ACROSS AN ARID GRADIENT

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Abstract

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Introduction

Coastal and desert areas have in common the presence of dunes as one of their characteristic features. However, the ecology of such dune areas differs markedly - desert dune areas are extensive, ancient and arid, supporting faunas of low diversity and high endemism, whereas coastal dunes are limited in extent, ephemeral in geological time and their faunas are diverse because of ecotonal effects, but have low endemism (McLachlan 1991). Studies done in desert dune areas suggest that macrodetritivores may be more important than microdetritivores in the breakdown and decomposition of organic material. Moist coastal conditions are expected to contain richer microfaunas. Under conditions where soil fungi and meiofauna are absent or inactive, macrodetritivores such as silverfish, crickets and tenebrionid beetles function as the major decomposers.

This study examined three small dunefields in an arid area across a gradient from the coast inland, to contrast patterns of diversity, community structure and ecological processes. The study also tested the hypothesis that the proportion of microdetritivores will decrease as macrodetritivores increase along a moisture gradient.

Study area

Three suitable dune sites were selected near Port Nolloth (**LATITUDE**) on the west coast of southern Africa. During the summer, fog moving in from the sea may provide a moisture gradient. Although not continuous, the three dune areas selected at Stilbaai (on the coast), Muisvlakte (10 km inland) and Augrabies Wes (30 km inland) comprised areas of adjacent sandflats and mobile dunes. At each site measurements were made in two habitat types: moblie, lightly vegetated dunes and semi-stable, well vegetated sandy flats between the dune ridges. The coastal site was divided into dune, flat and slack zones, giving seven habitats in total. In addition some studies were done across the beach/dune interface at the coastal site. The area has an annual rainfall of ***?*** and mean monthly temperature range **?**

Abiotic characteristics measured included soil moisture, salinity, particle size and porosity, as well as wind-borne salt spray. Biotic characteristics included subsurface micro- and macro-organic material, vegetation cover and height, soil meiofauna, invertebrate macrofauna and terrestrial vertebrate macrofauna in the form of avifauna and mammals.

Methods and Materials

Sand analysis

Sand samples collected in all habitats were wet-sieved through a 64 mm mesh sieve to determine the amount of fines. A settling tube was then used for the grain size analysis at 0.1 phi intervals. Statistical parameters were calculated according to Buller & McManus (1979). Carbonate content was determined by dissolving the carbonate with hydrochloric acid.

Soil moisture, organic content, particle size and porosity

Ten random sand cores were taken at each of the seven habitats using a 30 cm long copper (stainless steel tipped) hand corer with an internal cross-sectional area of 10 cm^2. Additional cores were taken on the beach. Cores deeper than 30 cm in the sand were taken by digging in steps to a depth of 45 cm. Sand moisture content (by weight) was measured in the field to 1% using a Speedy moisture testing kit. Subsamples were taken from each sample to determine the total organic content, particle size and porosity of the sand. All samples were fixed with a 5% formalin solution.

The organic content of the sand was determined in the laboratory by oven drying a 20 g subsample of sand for 48 hours at 60° C, weighing to 10^{-4} g, ashing for 6 hours at 500° C and reweighing. Porosity, i.e. the amount of water held by the saturated sand, was determined by placing approximately 30 g of sand in a glass pill vial and adding just enough water to cover it. The vial was then gently tapped for a minute, the excess water drained off with capillary tubes and the sample weighed to 10^{-4} g. After oven-drying at 60° C for 48 hours, the sample was reweighed.

Salt transport and sediment salt loads

Wind-borne salt spray was quantified using salt traps similar to those used by Boyce (1954), Martin (1959), Barbour (1978), Avis & Lubke (1985) and Young (1987). The traps consisted of 20 x 20 cm wooden frames attached to the top of 75 cm long stakes. Immediately prior to trap deployment, muslin cloth sections with permanently marked square decimeters in the centre were stretched over the frames and held in position with thumb tacks. Traps were positioned vertically with the frame and muslin cloth about 45 cm above ground level. After an exposure period of 24 hours the marked squares were cut out and placed in 50 ml distilled water and sealed in plastic bottles for analysis. This solution was titrated against 0.05 N silver nitrate using potassium chromate as an indicator. The amount (mg) of NaCl present in each square decimeter of cloth was then determined from a prepared standard curve. Eight salt traps were deployed at each of the three selected sites. At the two inland sites four traps were placed on the highest dune in the vicinity and four on the flat areas. At the coastal site all eight traps were positioned on the foredune ridge.

The salinity of the sediment was determined at each of the sites sampled for meiofauna and bacteria. Five grams of sediment from each depth interval were weighed out and washed in 50 ml of distilled water for 10 minutes before titration with 0.05 N silver nitrate. The amount of NaCl present was determined from a standard curve and is calculated as mg NaCl g^{-1} sediment.

Vegetation and detritus cover, biomass above and below ground

**** ASK MARY SEELY TO FILL IN****

Interstitial fauna

The meiofauna were extracted from 100 ml subsamples (of the soil collected for analysis of abiotic factors above) using decantation (McLachlan 1978, 1985a). All animals retained by a 63 um screen were preserved in a 5% formalin-rose bengal mixture. The meiofauna were counted under a stereo microscope and counts were corrected for 90% extraction efficiency (McLachlan 1978). Animals were divided into four groups - nematodes, oligochaetes, mites and other arthropods. Numbers were expressed per 100 cm^3. Average dry mass values for each group obtained from van der Merwe (1988) were used for biomass calculations. An estimated size ratio of 5:3:1 for small, medium and large nematodes was used in the above calculation. Samples for meiofauna counts were also used to determine the amount of fungi in the sand. The fungi were always associated with other plant material (detritus, roots, etc.) and could not be separated. A visual rating system was therefore used (van der Merwe 1988).

Invertebrate macrofauna of the dune-beach interface

Macrofauna was sampled in the dunes as well as at the dune/beach interface by means of pit traps. Macrofaunal community structure at the dune/beach interface was examined along two pit trap transects, the first at a position on the beach with high kelp wrack concentrations and the second with little wrack. Pit traps (14.6 cm diameter) were placed at 5 m intervals along each transect from the high water mark to the top of the foredune. Soapy water to a depth of 1 to 2 cm was placed at the bottom of each pit trap to prevent animals from climbing or jumping out once caught. Pit traps were set just before dusk (18h00) and were collected 12 hours later.

Invertebrate macrofauna of the dunes

***ASK MARY SEELY TO FILL IN METHODS, I.E. HOW MANY TRANSECTS, LENGTHS, ETC.**

Avifauna

At each site an area of approximately 1 ha was selected and all the bird species present in that area were recorded. Each site was surveyed in the morning between 8 am and 12 am. The two inland sites were divided into two areas - a low vegetated area and a higher region consisting of shifting dunes. The fore-dunes of the coastal site were surveyed as an area separate from the rest of the coastal dunes. Numbers of each species were not recorded.

Dune small mammals

Small mammals were trapped using Sherman live traps baited with peanut butter and oats. At each site 70 traps were set 15 m apart on a 7 x 10 grid (effective area = 1.5 ha), for three nights and two days (totalling 350 trap nights). Traps were checked as close to dawn and dusk as possible, and captured individuals were identified to species, weighed, sexed, individually toe-clipped and released. The grid at the beach site extended from behind the storm drift line into the dunes. At the central site (Muisvlakte) the grid was evenly divided between "dune" and "slack" habitats. No trapping was conducted at the inland site, although bush rats' nests and mole burrows were observed there.

Results

Sand analysis

Coastal dune sands were finer than those from the other sites and they were negatively skewed and well sorted (Table 1). Carbonate content at this site was about 5 %, representing biogenic input of shelly sand. The remainder of the sand was fairly angular quartz and no fines were present. The size parameters were typical of beach sands (Blatt, Middleton & Murray 1972), reflecting their source. Aeolian processes had not yet had time to imprint the size parameters typical of dune sands. The white colour is typical of coastal quartz sands.

The dune and flat sands at the central site (2) had similar medium grain sizes, but the flat had a fine tail (Table 1). The sorting and skewness of these sands were on the verges of other published data on dune sands (Blatt *et al.* 1972, Ahlbrandt 1979); these parameters are more typical of beach sands and thus indicate that this site represents fossil coastal dune sands. The coarser size compared to present-day coastal dunes (Site 1) could be partly due to winnowing, and partly due to the addition of locally derived coarse sand, probably from the weathering of surrounding and underlying rocks. The low carbonate content is possibly due to some marine-derived shell fragments which have survived dissolution by weathering processes. Only the surface samples had slight positive skewness, indicating that dune sedimentary processes were beginning to have an effect on the size distributions. A brown colour was partly due to some iron oxide staining and partly due to traces of clay minerals.

The dune and flat sands at the inland site (3) had similar medium grain sizes, but the dune sands were much better sorted. The flat sand had a fine tail, reflected in the large positive skewness; this also reduced the mean grain size slightly. There was 5 - 6 % fines (< 64 microns) in flats samples. Carbonate content was nil and quartz was the main mineral. The size, sorting and skewness of the dune sand was typical of other published data on dune sands (Blatt *et al.* 1972, Ahlbrandt 1979). The dune sand was very well sorted (as classified by Blatt *et al.* 1972) and is a good example of dune sand, indicating that aeolian processes have operated at this site for a long time. The sand in the flats was probably derived from the dune sand, the size distributions being very similar, apart from the fine tail in the flats. This fine tail was probably derived from the dust particles (which would be winnowed out of the dunes) and soil formation processes. The position of site 3 (landward of a rocky range) probably means that the sands were terrestrially derived and are not fossil coastal dunes. The red colour is due to iron oxide staining of the sand grains, typical of older dune sands (Walker 1979).

Soil moisture, organic content, particle size and porosity

The sand moisture content was similar across the coast-inland gradient at depths of 0 - 30 cm (Table 2). A moisture gradient could only be discerned at depths greater than 30 cm, where the coastal dune slack contained the highest percentage sand moisture (6%). The central and inland dunes contained very similar percentages of sand moisture at this depth.

The sand organic content was low, with a mean value of 0.39% (s.d. = 0.47; n = 174). It generally decreased with an increase in sand depth for all sites combined (Figure 1), with the surface 15 cm significantly higher (ANOVA, P = 0.001) than the deeper sands. The organic contents of the sand from the flat habitats at sites 2 and 3 were considerably higher than those from the other habitats (Figure 2). Although ANOVA indicated a significant difference in organic sand content between the seven habitats, no significant differences were found between the dunes of sites 2 and 3, sites 1 and 2 and slack and dune/flat of site 1 when comparing the habitats individually.

Sand porosities varied between 2.8% and 41.4% with a mean of 24.4% (s.d. = 2.98; n = 174). The porosity of the inland sites was slightly lower than the site adjacent to the beach. There were no significant differences in sand porosity at different sand depths. Fungi occurred in 70% of the samples but quantities were too low to obtain accurate estimates of abundance.

Salt transport and sediment salt loads

Wind-borne salt loads were highest at the coastal station (Table 3) with mean values of 6.87 ± 2.06 mg NaCl dm^{-2} recorded. The salt loads recorded at the central and inland sites were low (0.51 ± 0.22 and 0.81 ± 0.31 mg dm^{-2} respectively) with no significant differences (ANOVA, $P > 0.05$) found between dune and flat areas at either station. Statistical comparison of the salt loads at the three sites was not attempted as the stations were sampled on different days and therefore under different environmental conditions.

Salinity levels of the sand from the two inland sites were low (Table 4) with no significant differences (ANOVA, $P > 0.05$) in salt content between the dune and flat area at each site. No clear increase or decrease in sediment salinity was noted with depth in both the flat and dune areas of both sites. The sediment salt content of the foredune area at the coastal site was significantly higher (ANOVA, $P < 0.05$) than that measured at the coastal dune flat and slack zones. The sediment salt content of the coastal sites (all three areas) was significantly higher (ANOVA, $P < 0.05$) than that of the two inland sites.

Vegetation, detritus and macrofauna biomass above and below ground

The vegetated sub-plots (flats) examined at each site contained more above-ground vegetation than the plots in mobile dune sands, except at the coastal site, where most of the above-ground vegetation was in the mobile and beach sections (Table 5). Although the vegetated inland dune had almost twice as much above-ground vegetation biomass as the central site, the proportions of above-ground vegetation on the mobile parts of these sites were very similar (3.88 $g.m^{-2}$ and 3.83 $g.m^{-2}$, respectively). Below-ground vegetation and detritus biomass was high in the vegetated regions of all the sites, with a marked increase from the coast (556 $g.m^{-2}$) inland (714 $g.m^{-2}$). Above-ground detritus was also highest in the vegetated regions of all sites, the highest being on the beach (102 $g.m^{-2}$). Below-ground detrital biomass was higher at all sites than above-ground detritus.

Above-ground faunal biomass was highest at the vegetated inland dune site (3.85 $g.m^{-2}$), followed by the mobile coastal dune (1.01 $g.m^{-2}$). Below-ground faunal biomass was generally higher than its above-ground counterpart, being highest at the vegetated inland dune and coastal slack sites.

Interstitial fauna

Meiofaunal numbers were generally highest in the flat habitats, with the exception of the dunes of site 2 (Figure 3a). Nematodes accounted for 90.2%, oligochaetes 4.6%, mites 1.3% and other arthropods 3.9% of the interstitial fauna counted (Figure 3b). The proportion of nematodes decreased slightly in the dune habitats and increased on the flat areas from the sea landwards. The dunes of the inland site had the highest percentage of arthropods (21.2%), while the slack area adjacent to the beach had the highest relative oligochaete numbers (16.2%).

There were no significant differences in meiofauna numbers between the dunes at sites 2 and 3, 1 and 2, as well as the flats at sites 1 and 2 and the dune and flat at site 3. Total meiofauna numbers decreased significantly (ANOVA, P = 0.013) with an increase in sand depth. Nematode numbers as a whole decreased significantly (ANOVA, P = 0.049) with an increase in sand depth. The mites generally decreased in number with an increase in sand depth, while oligochaetes increased, although these trends were not statistically significant.

The other taxa occurred in very low numbers and generally decreased in number with an increase in sand depth in the dunes but increased with depth in the other habitats (Figure 3c). There were no significant correlations (Spearmans rank correlation) between the meiofaunal taxa examined and the sand organic content, porosity or mean particle size. Interstitial faunal biomass values were generally low, with the highest values occurring in the soil of the flat areas of all three sites and the dunes of the central site.

Invertebrate macrofauna of the dune-beach interface

The beach could be divided into two regions, a high wrack zone and a low wrack zone based on the amount of wrack present. The wrack consisted primarily of the kelp *Ecklonia maxima*; several other species were also present at the high wrack site. A total of 12 and 39 species of invertebrates were collected in the pitfall transects at the high and low wrack sites respectively. Coleopterans were the most diverse group collected in the pit traps (14 species), followed by spiders (8 species) and Diptera (6 species). Species with 2 or less individuals present at the high wrack site and 5 or less at the low wrack site were omitted from further analyses. At the high wrack site the 9 remaining species comprised 98.1%.

Talorchestia quardrispinosa made up 63.7% of total individuals at the high wrack site. Along with *Fucella capensis* it dominated the wrack zone and extended to the Spring High Water mark (Figure 4). Five additional species, dominated by *Pachyphalaria capensis*, occurred between the wrack band and SHW. The predatory beetle *Platychila pallida* occurred from the top of the wrack to the top of the unconsolidated dune and the spider, Spider A, was found on the dune face. The species distribution diagram (Figure 4) shows 2 zones with an intermediate transition zone. Cluster analysis using the Bray-Curtis dissimilarity measure and average linkage on ln(x+1) transformed data revealed a similar pattern. A supratidal group of 7 species, dominated by *P. capensis* and *T. quadrispinosa*, is present from a distance of 10 m below the Spring High Water mark with some species extending 10 m above the Spring High Water mark. At the other extreme, there is a dune group composed of 3 to 4 species and dominated by the isopod *Tylos granulatus*. Two species present on the storm platform were responsible for the transition zone ranging from 5 m to 20 m above SHW.

Invertebrate macrofauna of the dunes - FIGURE 4

* ALL WE HAVE FOR THIS IS THE FAX IDENTIFYING THE INVERTEBRATES - NO DATA ON WHERE THEY WERE FOUND, NUMBERS, ETC.

* THE ONLY STUFF ON THE POSTER TO DO WITH THIS HAS BIOMASS, FEEDING GUILDS AND DIVERSITY

* MARY, COULD YOU PLEASE FILL IN THE NECESSARY DETAILS

A dendrogram of faunal affinities of the invertebrate macrofauna resolved into two groups - the coastal sites and the non-coastal sites (Figure 5). Thus, in terms of its fauna, the central site may be classified as desert and not coastal dunes.

Avifauna

The coastal sites exhibited greater avifaunal species richness (9, 12 and 10, respectively) than the central and inland sites (6, 10, 8 and 2, respectively). Although the coastal site was distinguished by the presence of seabirds, such as Whitefronted Plover *Charadrius marginatus*, Grey Plover *Pluvialis squatarola*, Turnstone *Arenaria interpres,* Curlew Sandpiper *Calidris ferruginea*, Sanderling *Calidris alba,* Kelp Gull *Larus dominicanus* and Hartlaubs Gull *Larus hartlaubii,* it also shared several typically terrestrial species with the central and inland sites (Table 6). With increasing distance from the sea the differences in species composition between sites became less distinct.

Dune small mammals

Only two small mammal species (*Rhabdomys pumilio* and *Macroscelides proboscides*) were trapped, although the bush Karoo rat *Otomys unisulcatus* was common at both the coastal and central sites, with numerous, prominent stick-nests and tracks observed. Whistling rats *Parotomys* sp. were observed at the central "slack" habitat, but not on the actual study site. Most captures (85%, n = 13) at this site were in the "slack" habitat. A single shrew (unidentified, but probably *Suncus varilla*) was caught in the pit traps at the central site, and subsurface burrows of an insectivorous mole (*Cryptochoris wintoni*, *C. zyli*, *Chrysocloris asiatica*, or *Eremitalpa granti*) were observed at both sites. This site appeared to be heavily impacted by domestic ungulates.

Discussion

Sand analysis

The mean total organic content of the sands at the Port Nolloth stations falls within the same range as that of coastal dune sands in the Eastern Cape (van der Merwe & McLachlan 1991). There is, however, a much sharper decrease in values with an increase in sand depth at Port Nolloth. Coleman & Elliott (1986) noted that roots are a major contributor of organic matter. As the plants in the coastal dune slacks in the Eastern Cape obtain most of their water directly from the water table, their roots extend well over a metre below the sand surface. The plants on the West Coast, on the other hand, obtain their moisture via shallow roots from mist-drenched surface sands. The differences in sand organic values are thus possibly due to different types of root systems. The slightly higher porosity of the sand at **the coastal site is probably due to smaller mean grain size of the sand in this area.

Wind-borne salt loads measured in the foredune area of the coastal site (6 $mg.dm^{-2}.d^{-1}$) were low, but similar to levels recorded by Boyce (1954) and Young (1987) in foredune areas during low onshore wind speeds. As salt spray is primarily produced by bursting bubbles in the surf zone (Boyce 1954), the airborne salt load reaching land is a function of surf-zone energy state and wind speed and direction. Oostings and Billings (1942) reported that salt spray intensity decreased rapidly with distance from the beach, the greatest decrease occuring immediately behind the foredune. Young (1987) found an exponential relationship between salt load and distance from the surf zone with most of the wind-borne salt deposited within the first 200 m from the shore. The extremely low air-borne salt loads recorded at the two inland sites support the findings of Oostings and Billings (1942), Boyce (1954) and Young (1987).

Sediment salt loads reflected the pattern of wind-borne salt loads. The foredune sediment salt content was significantly higher than values recorded in the dune slack and flat areas and the two inland sites. The sediment salt values measured at the coastal site were similar to levels recorded in the foredune areas of the Eastern Cape dunes after rain (Young 1987), and similar to levels found in the dunes of the New Jersey coast (Boyce 1954). The sediment salt content in foredune areas varies greatly between periods of prevailing onshore and offshore winds and moist and dry conditions. The relatively low salt content of the foredune sediments measured in this study could thus be a function of offshore winds and leaching due to rain or fog.

Vegetation and detritus cover, biomass above and below ground

COULD YOU FILL THIS IN PLEASE, MARY

Interstitial fauna

Although relatively high microarthropod numbers are mentioned in most literature on arid interstitial fauna (Wallwork 1972; Santos *et al.* 1981; Elkins & Whitford 1982), the extraction technique used during the present study could possibly account for the low numbers recovered and a bias towards nematodes. As is to be expected in most soils, nematodes at all the sites on the West coast were the most abundant meiofaunal taxon. The higher oligochaete numbers encountered in the slack adjacent to the beach were probably due to the relatively high soil moisture content in this area.

Although no significant correlations between the meiofauna and sand organic content, porosity or mean particle sizes could be established, there appeared to be a relationship between the vertical distribution of the interstitial fauna and the presence of moisture in the sand. Van der Merwe (1988) noted that sand moisture governs the vertical distribution of interstitial fauna in the dune slacks on the East Coast of South Africa. Although meiofaunal numbers normally decrease with an increase in sand depth (van der Merwe & McLachlan 1991), the sites at Port Nolloth contained moisture even in the deeper sand. The meiofauna thus appeared to have moved away from the drier surface sand to deeper moist sand. This has important implications in planning a sampling strategy, as most samples are taken only from the top few centimeters of the soil. Although the interstitial fauna numbers and biomass values were relatively low, they nevertheless fall within the ranges tabulated by Van der Merwe (1988) for East Cape dunes.

Invertebrate macrofauna of the dune-beach interface

There were two distinct macrofaunal communities across the dune-beach interface. The beach community, dominated by the amphipod *T. quadrispinosa* and the beetle *P. capensis*, is found in association with the kelp wrack upon which it feeds, and is located around the spring high tide line. The dune community and areas where vegetation is dominated by the semi-terrestrial isopod *T. granulatus* provides a detrital source of leaf and flower litter. Few species and individuals were found between the berm and the hummock dunes at the base of the foredune.

This region had little fresh detritus and was littered with refractory detritus of terrestrial origin. The gradient of exposure to wave action along the bay resulted in the wrack being distributed unevenly. At the protected southern end of the bay the very low wave energy resulted in the wrack being deposited in a dense narrow band at the high tide line. In the more exposed region, the swash had sufficient energy to continually redistribute the wrack, resulting in a wider, more dispersed band.

Invertebrate macrofauna of the dunes

MARY, COULD YOU PLEASE FILL IN THIS SECTION

Avifauna

Although no clear trend in avifaunal species richness could be observed along the landward gradient, the species composition of the site closest to the sea (Stilbaai) was distinct because of the presence of seabirds. With increasing distance from the sea, differences in avifaunal species composition between sites became less distinct than for the other fauna examined. Because of their mobility, birds are not forced to adapt to specific substrates, and are generally able to use a large number of habitats (van Teylingen *et al.* 1993). The relatively low species richness at the coastal dune site has been attributed to lower rainfall and less vegetation complexity along the west coast, resulting in fewer microhabitats that can be utilised (van Teylingen *et al.* 1993).

Dune small mammals

The lack of gerbils *Gerbillurus paeba* at the coastal and central sites may be a sampling artefact due to insufficient trapping effort. In other respects these communities are similar to Karoo small mammal communities (Kerley 1990). Vegetation influences desert small mammal diversity, both in terms of higher structural complexity, increasing habitat availability and therefore species diversity (Rosenzweig & Winakur 1969, Price 1986), as well as in terms of resource availability (Brown 1973, Hafner 1977, Abramsky 1988). The variation in small mammal community structure between the two sites sampled, with higher diversity and biomass at the central (Muisvlakte) site, is therefore probably a function of the differences in vegetation between the two sites, with higher plant cover of taller vegetation at Muisvlakte, suggesting increased precipitation (fog and rain) at this site. The two sites also differed in terms of the relative importance of the different trophic guilds, with more herbivores and insectivores at Muisvlakte, suggesting higher productivity at this site.

Conclusions

* changes in biota occur close to the sea, coastal site different to other 2 sites and switch probably occurs within 1km of coast

* no clear change in macro/microdetritivores **CALCULATE RATIOS OF BIOMASS MEIOFAUNA/MACROFAUNA ONCE WE HAVE MARY SEELY'S DATA

*thus, coastal dunes = small, ephemeral, whereas desert dunes = large, ancient thus more unique, endemics

The three sites investigated represented a coast/land gradient and not a moisture gradient, all three being relatively arid. The biomass of macrodetritivores was highest at the coastal site where moisture levels were marginally higher, but sub-surface organisms were less abundant than at the other sites. Meiofaunal biomass corresponded with the distribution of sub-surface macro- and microdetritivores. The biomass of macrodetritivores was at least an order of magnitude higher than that of the meiofauna at all sites. Faunal analysis emphasised a sharp transition between the invertebrate faunas of the beach and dune at the coast, as well as a marked difference between the coastal and the two inland sites. The central site represents old coastal dunes, but has lost its faunal affinities with the coast and has characteristics of inland dunes.

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List of tables and figures:

Table 1

SITE	% $CaCO_3$	% < 62um	Mean diameter		Sorting	Skewness	DESCRIPTION
			phi	um			
Coastal slack	5	0	2.3	200	0.31	-0.24	Fairly well sorted, fine sand
Coastal flat	4	0	2.3	200	0.28	-0.26	Well sorted, fine sand
Coastal dune	4	0	2.4	190	0.26	-0.21	Well sorted, fine sand
Central flat	0	12	1.7	290	0.66	0.04	Moderately sorted, medium sand
Central dune	1	0	2.1	230	0.43	-0.03	Fairly well sorted, fine sand
Inland flat	0	6	1.9	260	0.3	0.52	Fairly well sorted, medium sand, fine skewed
Inland dune	0	0	1.8	280	0.13	0.22	Well sorted, medium sand

Table 2

			SAND DEPTH (%)		
HABITAT			00 - 15	15 - 30	30 - 45
Coast	Site 1	Dune	0	0	2
		Flat	0	0	1.5
		Slack	0	0	6
Central	Site 2	Dune	0	0	0
		Flat	0	0	0
Inland	Site 3	Dune	0	0	1 - 2
		Flat	0	0	0

Table 3

SITE	N	SALT LOAD
Site 1 (Coastal)	8	6.78 ± 2.06
Site 2 (Cental)	8	0.51 ± 0.22
Site 3 (Inland)	8	0.81 ± 0.31

Table 4

	SITE	DEPTH	N	SALT CONTENT (mg NaCl.g^{-1})
COASTAL	1D	0 - 15	3	1.40 ± 0.56
		15 - 30	3	1.30 ± 0.72
		30 - 45	3	0.50 ± 0.43
	1F	0 - 15	3	0.32 ± 0.09
		15 - 30	3	0.30 ± 0.15
		30 - 45	3	0.28 ± 0.06
	1S	0 - 15	3	0.70 ± 0.11
		15 - 30	3	0.20 ± 0.15
		30 - 45	3	0.46 ± 0.21
CENTRAL	2D	0 - 15	3	0.30 ± 0.01
		15 - 30	3	0.41 ± 0.20
		30 - 45	3	0.23 ± 0.01
	2F	0 - 15	3	0.38 ± 0.10
		15 - 30	3	0.24 ± 0.14
		30 - 45	3	0.24 ± 0.09
INLAND	3D	0 - 15	3	0.01 ± 0.004
		15 - 30	3	0.01 ± 0.003
		30 - 45	3	0.05 ± 0.1
	3F	0 - 15	3	0.02 ± 0.10
		15 - 30	3	0.01 ± 0.04
		30 - 45	3	0.01 ± 0.004

Table 5

		ABOVE			BELOW	
	Habitat	Vegetation	Detritus	Animals	Vegetation & Detritus	Animals
Site 1	MOBILE	27.82	3.39	1.01	60.55	0.17
(Coastal)	SLACK	12.74	0.95	0	165.35	2.37
	BEACH	28.22	102.91	0	556.04	0.15
Site 2	MOBILE	3.88	6.19	0	80.06	0.08
(Central)	VEGETATED	44.92	79.73	0	683.16	0.45
Site 3	MOBILE	3.83	3	0	16.55	1
(Inland)	VEGETATED	85.48	25.49	3.85	714.17	2.84

Table 6

R.#	COMMON NAME	SCIENTIFIC NAME	1a	1b	1c	2a	2b	3a	3b
62	Grey Heron	*Ardea cinerea*	X	X				X	
162	Pale Chanting Goshawk	*Melierax canorus*		X		X	X		X
246	Whitefronted Plover	*Charadrius marginatus*	X	X					
254	Grey Plover	*Pluvialis squatarola*	X						
262	Turnstone	*Arenaria interpres*	X						
272	Curlew Sandpiper	*Calidris ferruginea*	X						
281	Sanderling	*Calidris alba*	X						
312	Kelp Gull	*Larus dominicanus*	X						
316	Hartlaubs Gull	*Larus hartlaubii*	X						
500	Longbilled Lark	*Mirafra curvirostris*			X		X		
502	Karoo Lark	*Mirafra albescens*		X		X	X	X	X
518	European Swallow	*Hirundo rustica*		X	X	X	X		
529	Rock Martin	*Hirundo fuligula*			X	X	X	X	
557	Cape Penduline Tit	*Anthoscopus minutus*		X				X	
590	Tractrac Chat	*Cercomela tractrac*		X	X			X	
592	Karoo Chat	*Cercomela schlegelii*		X			X		
596	Stonechat	*Saxicola torquata*		X	X	X		X	
614	Karoo Robin	*Erythropygia coryphaeus*			X	X	X	X	
669	Greybacked Cisticola	*Cisticola subruficapilla*		X				X	
686	Spotted Prinia	*Prinia maculosa*			X		X		
688	Rufous-eared Warbler	*Malcorus pectoralis*			X		X		
713	Cape Wagtail	*Motacilla capensis*	X	X	X				
783	Lesser D-collared Sunbird	*Nectarinia chalybea*			X		X		
878	Yellow Canary	*Serinus flaviventris*		X					
	TOTAL # SPECIES		9	12	10	6	10	8	2

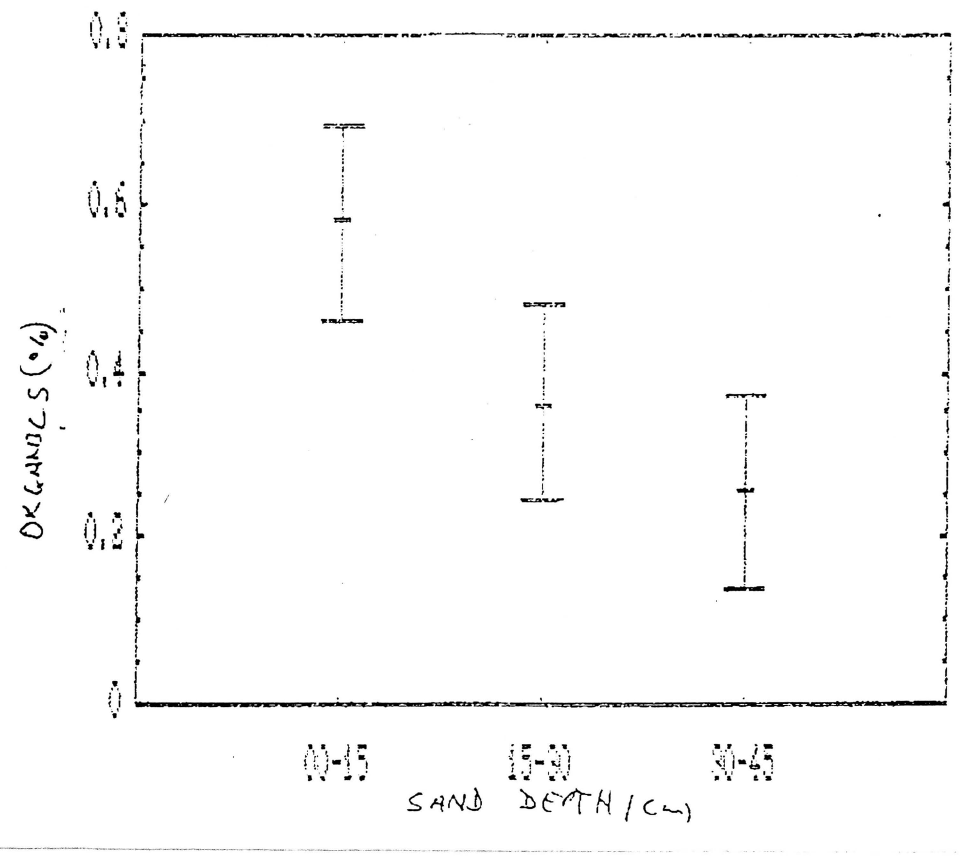


Figure 1

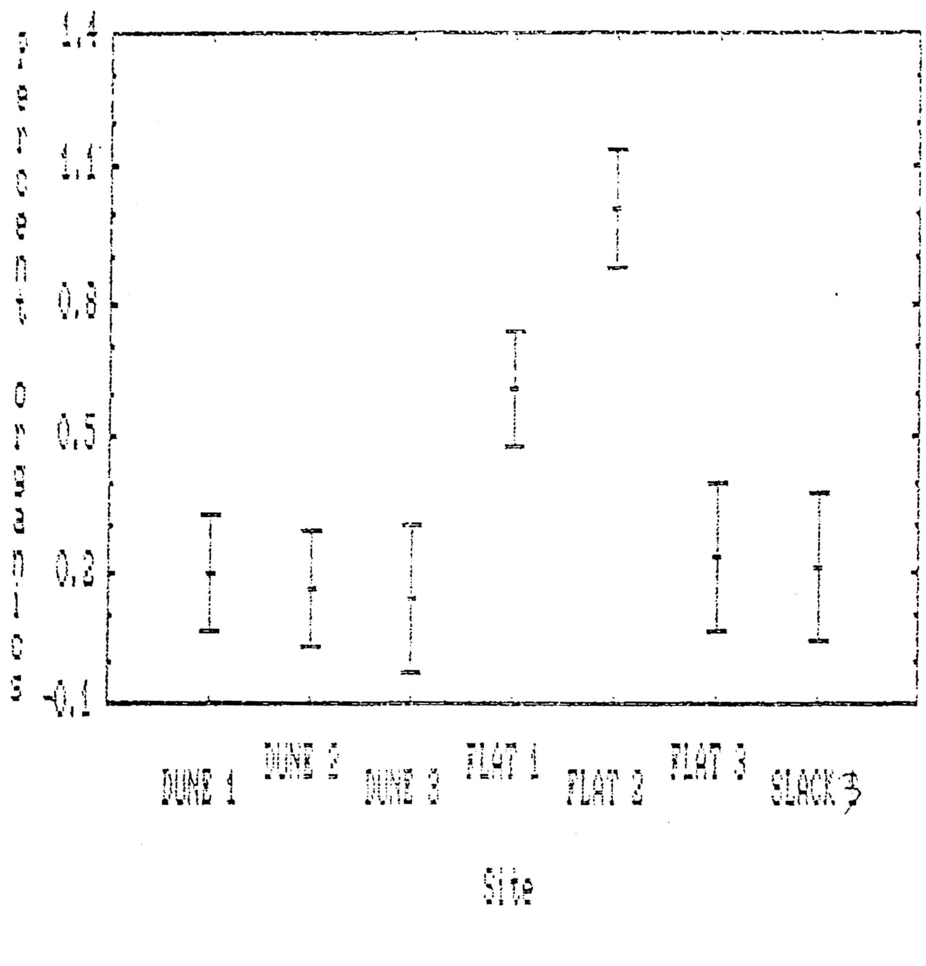
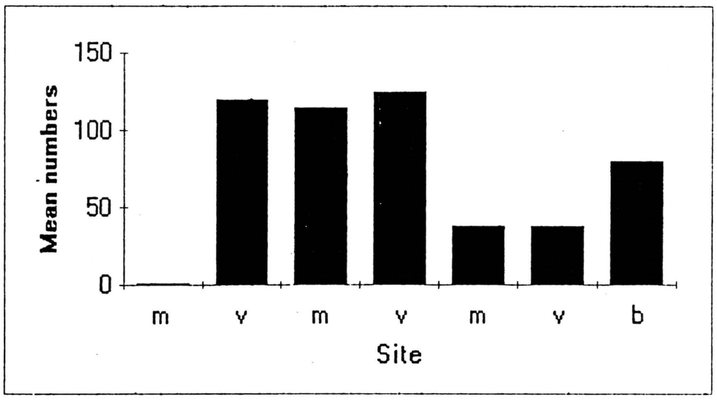
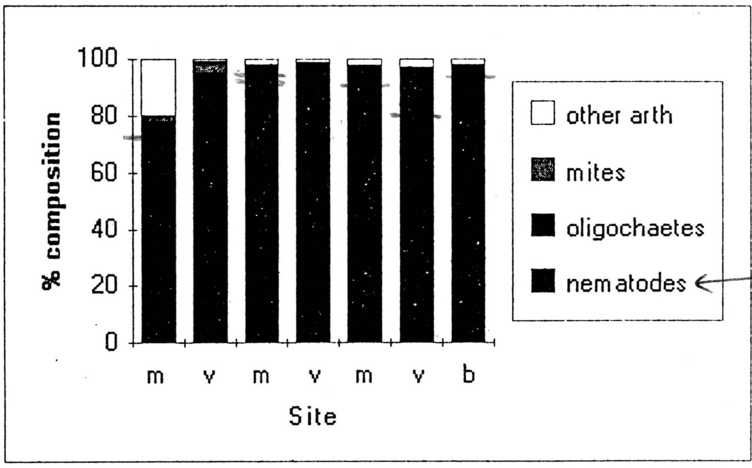

percent organics
1.4
1.1
0.8
0.5
0.2
-0.1
DUNE 1
DUNE 2
DUNE 3
FLAT 1
FLAT 2
FLAT 3
SLACK 3
Site

Figure 2

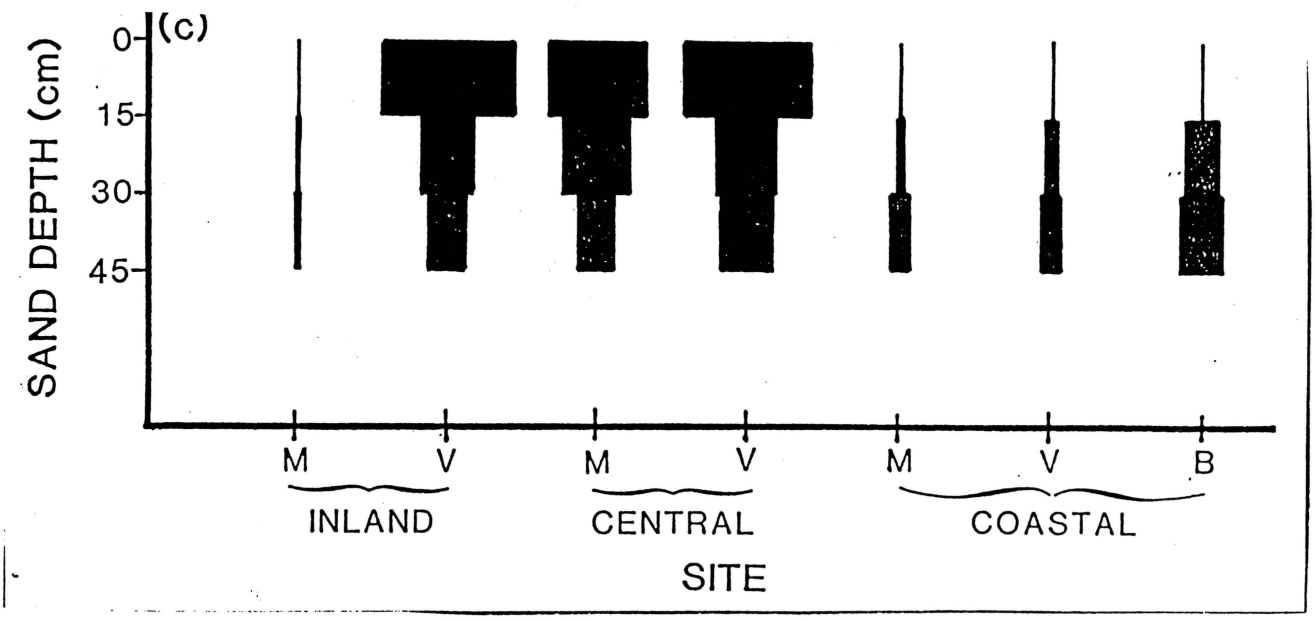


a



← bottom of bar each time

b



c

Figures 3 a, b : c

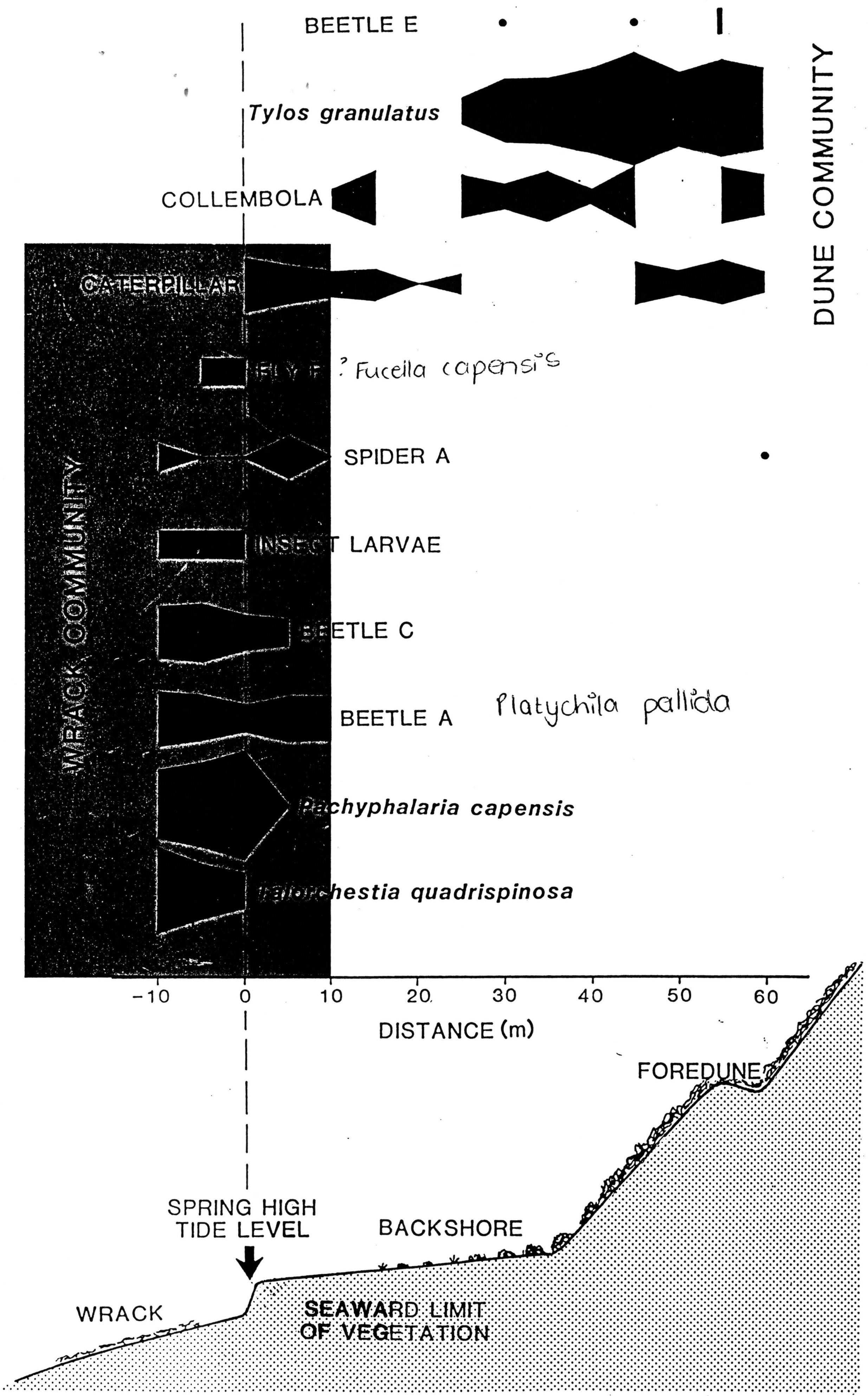
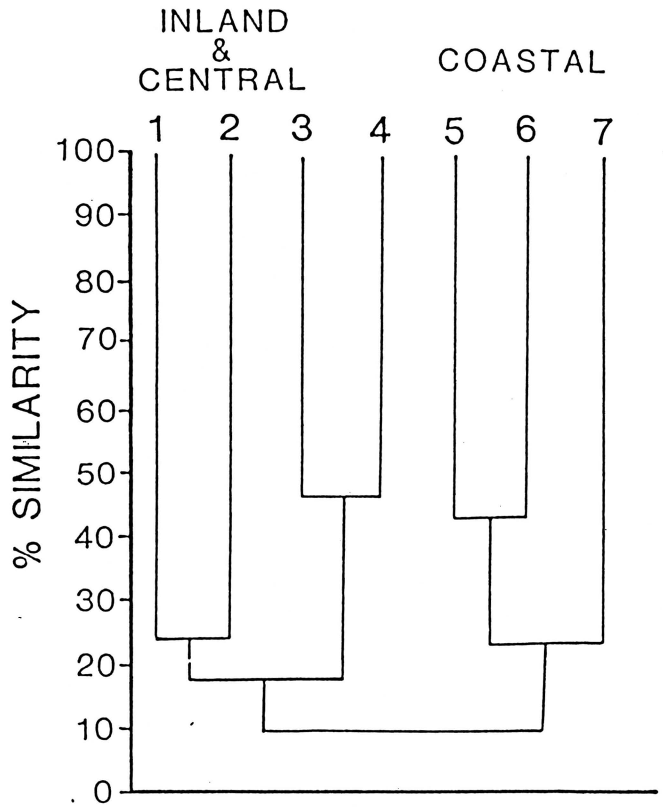

BEETLE E
Tylos granulatus
COLLEMBOLA
CATERPILLAR
FLY F
? Fucella capensis
SPIDER A
INSECT LARVAE
BEETLE C
BEETLE A
Platychila pallida
Pachyphalaria capensis
Talorchestia quadrispinosa
WRACK COMMUNITY
DUNE COMMUNITY
-10
0
10
20
30
40
50
60
DISTANCE (m)
FOREDUNE
SPRING HIGH
TIDE LEVEL
BACKSHORE
WRACK
SEAWARD LIMIT
OF VEGETATION

Figure 4



DENDROGRAM SHOWING FAUNAL AFFINITIES BETWEEN DIFFERENT SITES BASED ON PIT TRAP RESULTS AND GROUP AVERAGE CLUSTERING. THIS RESOLVES INTO TWO GROUPS - THE COASTAL SITES AND THE NON-COASTAL SITES.

1 - INLAND MOBILE DUNES
2 - INLAND VEGETATED FLATS
3 - CENTRAL MOBILE DUNES
4 - CENTRAL VEGETATED FLATS
5 - COASTAL MOBILE DUNE
6 - COASTAL BACKSHORE VEGETATED
7 - COASTAL SLACK FLAT

Figure 5