The ecology of sandy beaches in Transkei

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Data from an ecological survey of three sandy beaches in Transkei and from Gulu beach on the eastern Cape coast, South Africa, are presented. Physical parameters such as beach profile, sand particle size, Eh and carbonate content, as well as abundance, composition, biomass and distribution of the macrofauna and meiofauna were investigated. Beaches in Transkei are relatively small and are usually associated with estuarine systems. Substrate at Thompson's beach in northern Transkei was relatively coarse with relatively few macrofaunal species. Further south, beaches have fine to medium substrates and are characterized by a diverse macrofaunal community. Major changes in faunal composition occurred in Transkei and this was most evident for Mpande and Cebe beaches where a subtropical east-coast fauna was replaced by species characteristic of the southern Cape coast. Molluscs also became increasingly important southwards and replaced crustaceans as the most important group. Meiofauna was dominated by nematodes and harpacticoids on all beaches and there was an increase both in numbers and biomass southwards.
S. Afr. J. Zool. 1981, 16: 210 – 218

'n Algemene ekologiese ondersoek van drie sandstrande in Transkei en een strand net suid van Oos Londen word beskryf. Fisiese faktore insluitend strandprofiel, sandpartikelgrootte, Eh en karbonaatinhoud en ook biologiese faktore soos hoeveelheid, saamstelling, biomassa en verspreiding van die makrofauna en meiofauna is ondersoek. Strande in Transkei is gewoonlik klein en met riviermondings geassosieer. By Thompson se strand in Noord-Transkei was die sand relatief grof en min makrofaunaspesies het voorgekom. Verder suid het die strande fyner sand en 'n groter verskeidenheid makrofauna kom voor. Belangrike veranderinge in makrofauna-samestelling het oor dié kusgebied plaasgevind veral in die omgewing van Mpande en Cebe waar 'n subtropiese Ooskusfauna vervang is deur spesies tipies van die Kaapse suidkus. Mollusca het suidwaarts belangriker geword en het die Crustacea vervang as die dominante groep. Die meiofauna is oorheers deur Nematoda en Harpacticoida op alle strande, en die getalle en biomassa het suidwaarts toegeneem.
S.-Afr. Tydskr. Dierk. 1981, 16: 210 – 218

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Received 4 December 1979; accepted 5 June 1981

This paper reports on the ecology of sandy beaches in southern Africa between Thompson's beach in northern Transkei and Gulu, south of East London. The survey was aimed at providing basic data on the nature and distribution of the fauna. Although this region is generally considered to be the zone of overlap between subtropical east-coast and temperate south-coast faunas, the only available data (other than taxonomic) are for rocky shores (Brown & Jarman 1978) and estuaries (Connell 1974; Blaber, Hill & Forbes 1975; Wooldridge 1976, 1977; Branch & Grindley 1979). Sandy beaches of the Natal region have been discussed in a previous publication (Dye, McLachlan & Wooldridge 1981).

Methods

Samples were taken in early summer of 1978 (December) around spring low tide. Besides three beaches examined qualitatively, quantitative surveys were carried out at Thompson's beach (30°10′48″E/31°5′30″S), Mpande beach (29°21′24″E/31°45′36″S), Cebe beach (28°35′24″E/32°31′24″S) and Gulu beach (27°40′5″E/33°10′0″S) (Figure 1). The localities are separated by approximately

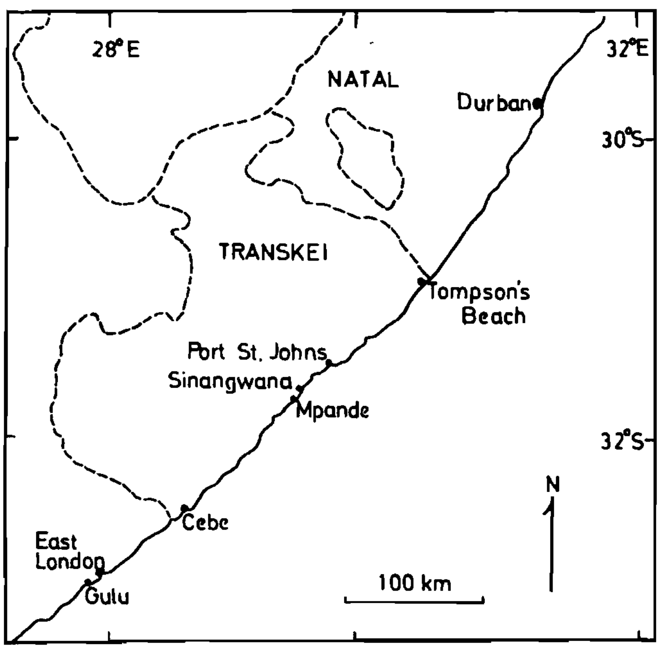

Figure 1 Map showing the locality of beaches visited.

100 km of coastline in each case. At each of the four beaches a routine procedure was followed. The parameters that were investigated as well as the field and laboratory techniques employed are given in Dye *et al.* (1981) and are only briefly summarized here.

Beach profiles were determined according to Day (1969) along transect lines chosen to represent average slope along each beach. Temperature and moisture were measured at 30-cm intervals from the sand surface to the low-tide water-table at three tidal levels (HT, MT and LT) while Eh and salinity were measured at the surface and at the water-table depth. Sand samples were collected from the top 30 cm at each tidal level for laboratory analysis of substrate particle size. A quantity of sand was acid treated (conc. HCl) to determine carbonate content.

Macrofauna samples were collected at a number of points (8 – 13) along each transect and extending into the surf out to a depth of ± 1 m. At each point a series of samples were collected and pooled. Sampling was done with a dredge (1,5-mm mesh), by digging 0,25-m^2 quadrats to a depth of 25 cm and passing the sand through a 4-mm sieve, or by using a sledge which skims off and filters the surface layer of sand (Wooldridge 1981). In the case of mysids, two quantitative series with 4 – 5 stations in each, indicated little variation and data are presented for one series only. A relatively coarse substrate precluded the use of the sledge at Thompson's beach and a small rectangular sieve (500 mm × 250 mm, aperture size 1,5 mm) was used instead. In addition supplementary data were collected in extensive qualitative surveys on all beaches visited and on other visits.

Dry mass was determined in the laboratory by drying at 90 °C for 24 h. In the case of molluscs the shells were first removed. Mysid dry mass was determined from length/mass regression equations. For this purpose 50 – 60 individuals of known length (anterior tip of carapace to posterior tip of telson, excluding spines) were oven-tried at 60 °C to constant mass and weighed on a Sartorius electronic microbalance. Biomass was then determined for seven breeding classes (Wooldridge 1981) and summed for the sample.

Meiofauna sampling was done by means of a copper corer of 30 cm length and 10 cm^3 internal cross-sectional area at each of the three tidal levels where physical and chemical parameters were monitored. Four replicate samples were taken every 30 cm and down to about 30 cm below the low-tide water-table. A sample was halved and each 15-cm core stored in a glass bottle together with the corresponding section from the other samples taken at the same level. $MgSO_4$ was added to relax the animals and a solution of Rose Bengal in buffered formaldehyde added to preserve them. Extraction was done by decantation and sieving through a 45-μm sieve and repeated four times for each sample. Dry mass was determined by drying a number of specimens on pre-weighed cover-slips at 60 °C for 24 h and weighing to the nearest 1 μg on a microbalance.

Results

Beach profiles and spring low-tide water-table depths are given in Figures 2 – 5. Thompson's beach (Figure 2) is 400 m in length and is flanked by a shallow lagoon and a rocky shore on the east and west sides respectively. Behind the beach steep, forested dunes rise to about 30 m while the low fore-dunes are vegetated with *Ipomoea* sp. The high-water swash line was 2,5 m above LW and the intertidal gradient was 1 : 10. A berm was present near the HW swash line.

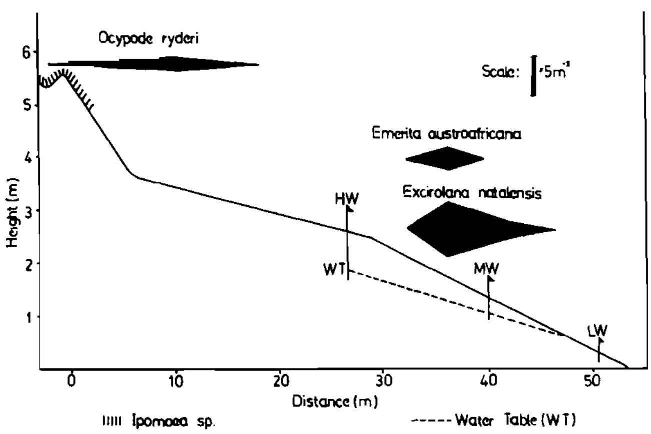

Figure 2 Beach profile at Thompson's beach sampling area showing meiofaunal sampling sites and distribution of the macrofauna.

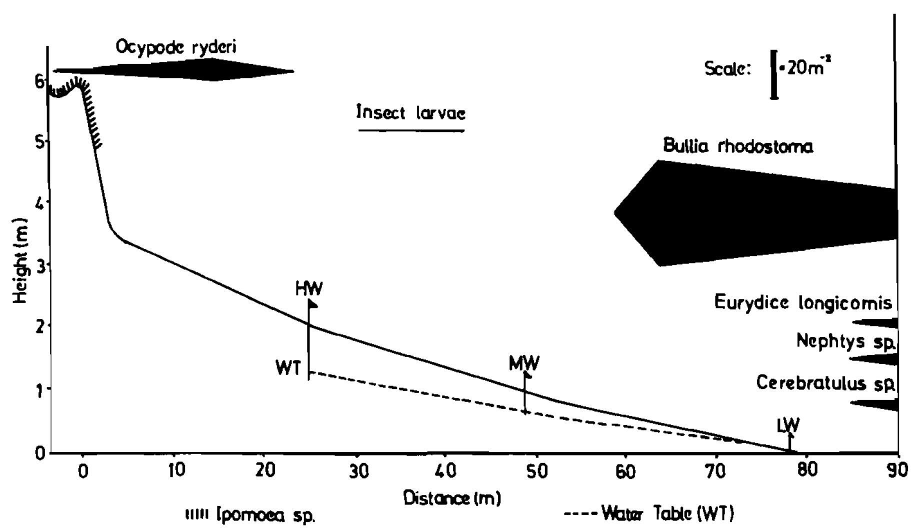

Figure 3 Beach profile at Mpande beach sampling area showing meiofaunal sampling sites and distribution of the macrofauna.

Mpande beach, to the south, stretches for about 500 m between two rocky headlands (Figure 3). A small estuary is present behind the beach and opens to the sea over a shallow channel on the western side. The beach was slightly concave with an intertidal slope of 1 : 26. The high-tide swash line was approximately 2,1 m above LW. Low foredunes were covered with *Ipomoea* sp. while a narrow belt of coastal forest separated the beach from the estuary.

Cebe beach in southern Transkei is approximately 1 km in length and is located between rocky stretches of coastline. The profile is slightly concave and the beach is intercepted by a small outcrop of rock and two shallow streams (< 0,5 m depth) a few metres wide. The intertidal gradient was 1 : 33 and the high-tide swash line was 1,8 m above LW. At the time of sampling, spring tides were almost at their peak. A wide shallow platform with a gradient of 1 : 150 was present below LW and was occasionally exposed as the swash receded. Low foredunes (≃4 m) were covered by *Ipomoea* sp. and *Scaevola thunbergii*. Behind the beach the low hills were covered with patches of coastal bush.

Gulu beach, (Figure 5), south of East London, is 500 m in length and is located between a small estuary mouth and rocky headland. The mouth channel was < 0,5 m in depth and approximately 5 m wide. The beach was concave with an intertidal gradient of 1 : 36. High-tide swash line was 2,3 m above LWST. The foredunes were covered with *Ipomoea* sp. and *Scaevola thunbergii* while further inland a range of former sand dunes was vegetated with coastal bush.

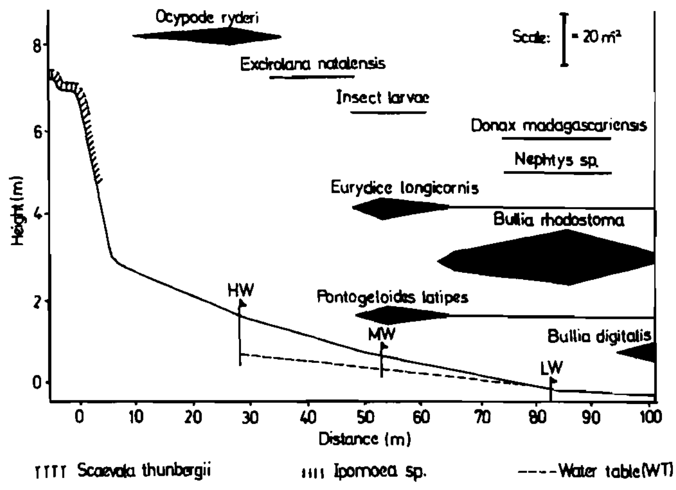

Figure 4 Beach profile at Cebe beach sampling area showing meiofaunal sampling sites and distribution of the macrofauna.

Intertidal distances of 25 m, 55 m, 55 m and 82 m were recorded at Thompson's, Mpande, Cebe and Gulu beaches respectively. McLachlan (1980a) has proposed a simple scale for rating the degree of exposure of beaches. On this scale the four beaches may be defined as 'exposed' with values of 13,5; 12,5; 12,0 and 13,5 respectively.

Results of substrate analysis are given in Table 1. Median particle diameters increased towards LW on Thompson's beach but particle size fell within the range of medium sand at all tidal levels (Morgans 1956). The sand was fairly well sorted with no skewness towards preferen-

Table 1 Substrate analysis of sand from high water (HW), mid-water (MW) and low water (LW) on four east-coast beaches. Data in phi-units except where otherwise indicated. Mdϕ: Median value; Qdϕ: Quartile deviation; Skqϕ: skewness; Mz: graphic mean; σI: inclusive graphic deviation; Sk: inclusive graphic skewness

Beach and tidal level		Mdϕ	Qdϕ	Skqϕ	Mz	σI	Sk
Thompson's beach	HW	1,67	0,34	−0,04	1,62	0,53	−0,14
	MW	1,65	0,34	−0,07	1,58	0,51	−0,16
	LW	1,30	0,45	−0,05	1,23	0,34	−0,44
Mean particle size at three levels (μm)		346			362		
Mpande beach	HW	2,40	0,27	0,02	2,40	0,34	−0,05
	MW	2,10	0,21	−0,01	2,09	0,34	0,10
	LW	2,10	0,33	−0,08	2,04	0,46	−0,22
Mean particle size at three levels (μm)		221			225		
Cebe beach	HW	2,35	0,25	0,00	2,36	0,32	0,01
	MW	2,40	0,21	−0,01	2,39	0,29	−0,11
	LW	1,90	0,35	0,05	1,95	0,47	0,12
Mean particle size at three levels (μm)		218			215		
Gulu beach	HW	2,18	0,33	−0,01	2,18	0,39	0,01
	MW	2,10	0,33	−0,18	2,12	0,39	0,12
	LW	1,80	0,33	0,03	1,86	0,52	0,15
Mean particle size at three levels (μm)		247			242		

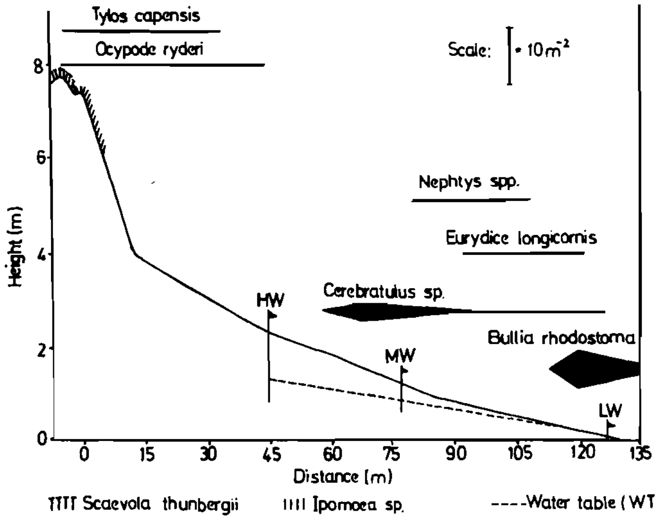

Figure 5 Beach profile at Gulu beach sampling area showing meiofaunal sampling sites and distribution of the macrofauna.

tial sorting of sizes. At Mpande particle size was only slightly less at HW than at lower tidal levels. The beach was composed of well-sorted fine sand with no preferential sorting. At Cebe and at Gulu the sand above MW was fine, tending towards medium at lower tidal levels. Sand was well-sorted and low skewness values indicate no preferential sorting of sizes. Carbonate contents were all low and varied between 15% at Thompson's beach and 1% at Mpande.

Temperatures just below the surface of the sand varied between 36 °C and 26 °C at HW, between 30 °C and 22 °C at MW, and between 20 °C and 17,5 °C at LW in the four beaches. Temperatures decreased progressively nearer the water table and were generally around 20 – 22 °C. High Eh values sampled throughout the beaches indicated good oxygenation. The lowest recorded value was + 250 mV at Thompson's beach (70 cm depth at HW) and at Cebe (33 cm depth at MW) which is comparable to the profiles obtained by McLachlan, Dye & van der Ryst (1979). Salinities were all above 30‰ and indicate little seepage of ground water from the backshores or dunes except at Cebe where 20‰ was recorded at 40 cm depth around HW.

Macrofauna

The intertidal distribution of macrofauna collected quantitatively on four beaches is shown in Figures 2 – 5. The ghost crab, *Ocypode ryderi*, was present on all beaches and was most abundant above high water and into the vegetated foredunes. At Thompson's beach (Figure 2) only the mole crab *Emerita austroafricana* and the isopod *Excirolana natalensis* were present in addition to *O. ryderi*. This beach shelved off steeply below LW, which resulted in some waves breaking directly onto the exposed lower beach. These relatively harsh physical conditions probably excluded most macrofauna from lower tidal levels.

Seven species were recorded at Mpande (Figure 3), including the mysid shrimps, *Gastrosaccus longifissura* and *G. bispinosa*. Nemerteans *Cerebratulus* sp., polychaetes of the genus *Nephtys* and the isopod *Eurydice longicornis* were also recorded subtidally, while the gastropod, *Bullia rhodostoma* was present around the mid-tide level. Insect larvae were present around HW.

All species present at Mpande were recorded at Cebe (Figure 4) with the exception of the nemertean, *Cerebratulus* sp. Five further species were quantitatively collected and include the mysid, *Gastrosaccus psammodytes*, the isopods *Pontogeloides latipes* and *Excirolana natalensis*, and the molluscs *Bullia digitalis* and *Donax madagascariensis*.

Seven macrofaunal species were recorded at Gulu (Figure 5); *Gastrosaccus bispinosa, G. psammodytes, Eurydice longicornis, Glycera* sp. (Polycheata), *Cerebratulus* sp., *Tylos capensis* (Isopoda) and *Ocypode ryderi*.

A number of species not taken in quantitative samples were also collected. These, together with data from other localities, are included in Table 2 which illustrates faunal changes between the more tropical east coast and the temperate south coast. The additional data were collected within six months of the present survey. Sinangwana beach is located 1 km east of Mpande while data from the

Table 2 Distribution of sandy beach macrofauna between Sodwana Bay in northern Natal and Maitland beach near Port Elizabeth on the south coast. Data compiled from Dye *et al.* 1981, McLachlan (1977), the present survey and additional collections made by the first author and Mrs C.M. Watters at Cebe beach

	Natal					Transkei					Cape Province
	Sodwana Bay	St Lucia	Blythedale	Kelso	Palm beach	Thompson's	Sinangwana	Mpande	Cebe	Gulu	Algoa and St Francis Bays
Glycera sp.		×									
Hippa adactyla	×										
Charibarbitus celetus	×	×									
Bullia natalensis	×	×			×						
Emerita austroafricana	×	×				×	×				×
Ocypode ceratophthalma	×	×						×			
Donax madagascariensis	×	×							×		
Tivela polita	×	×							×		
Excirolana natalensis		×				×			×		
Gastrosaccus longifissura	×						×	×	×		
Gastrosaccus bispinosa	×	×			×		×	×	×	×	
Ocypode ryderi	×	×	×	×	×	×	×	×	×	×	×
Bullia rhodostoma					×		×	×	×	×	
Cerebratulus sp.								×		×	×
Nephtys sp.								×	×	×	×
Eurydice longicornis								×	×	×	×
Gastrosaccus psammodytes									×	×	×
Bullia digitalis									×	×	×
Bullia pura									×		×
Donax serra									×		×
Ovalipes punctatus									×	×	×
Pontogeloides latipes									×		×
Donax sordidus										×	×
Tylos capensis										×	×

Natal region are taken from Dye *et al.* (1981). These data include new distribution records for a number of species which are summarized in Table 3. The distributions of *Ocypode* spp. are dealt with by McLachlan (1980b) while Branch & Grindley (1979) record *Donax serra* from the mouth of the Mgazana estuary.

Abundance and biomass of the macrofauna species are given in Table 4 and were calculated for a metre-wide and metre-deep strip of shore extending from the sea to the foredunes (Figures 2 – 5). Biomass was highest at Mpande (99 g dry mass/m-strip) and at Cebe (56 g dry mass/m-strip), largely due to the presence of *O. ryderi* and *B. rhodostoma*. Values of 19 and 9 g dry mass/m-strip were recorded at Gulu and Thompson's beach respectively. Crustaceans were the only component recorded on Thompson's beach while in the central region (Mpande and Cebe) crustaceans were only slightly more important than molluscs. At Gulu crustaceans contributed only 22% and molluscs 57%. Of the Crustacea, *O. ryderi* was the most important organism on the three northern beaches, while at Gulu, mysids were the dominant component. *B. rhodostoma* was the principal mollusc on all beaches sampled.

Table 3 New distribution records of sandy beach macrofauna. The original reference given in brackets (living specimens only)

Species	New distribution	Previous distribution
	Southward extension of east-coast fauna	
Donax madagascariensis	Cebe beach	Durban (Barnard 1964; Day 1969)
Tivela polita	Cebe beach	Natal-Mozambique (Barnard 1964)
Emerita austroafricana	Sinangwana beach	Scotsburgh, south of Durban (Day 1969)
Gastrosaccus bispinosa	Gulu beach	Kei Mouth (Wooldridge 1978)
	Northward extension of south-coast fauna	
Bullia digitalis	Cebe beach	Port Elizabeth (Brown 1971)
Bullia pura	Cebe beach	False Bay (Brown 1971)
Donax sordidus	Gulu beach	Algoa Bay (McLachlan 1977)
Tylos capensis	Gulu beach	Port Elizabeth (Kensley 1978)
Gastrosaccus psammodytes	Cebe beach	Kei Mouth (Wooldridge 1978)

Meiofauna

Figures 6 – 9 show the intertidal and depth distribution of meiofauna on the four beaches and the meiofauna biomass and numbers per metre-strip of beach are given for the four localities in Table 5.

Although biomass was relatively high at Thompson's beach (110,7 g/m-strip, meiofauna density was greater at Mpande (Figure 7) averaging 600 animals per 100 cm^3. On both these beaches nematodes and harpacticoids dominated the community and were most abundant in a band from 20 to 60 cm depth at high water extending to the surface just below mid-water. Turbellarians were also well represented in this zone. Since the intertidal distance was less than at Thompson's beach, the total numbers and dry mass were less despite the higher animal density (Table 5). The meiofauna on Cebe beach was distributed around mid-water in densities of 500 – 600/100 cm^3 (Figure 8). The community was dominated by nematodes, while harpacticoids, turbellarians and others were present in low numbers (< 50/100 cm^3).

The richest meiofauna in terms of both numbers and biomass occurred at Gulu beach in the eastern Cape Province (Figure 9). Greatest concentration of animals (1100/100 cm^3) was again present from mid- to high-

Table 4 Macrofauna abundance and dry biomass on four east-coast beaches given for 1 m transects from about 1 m depth to the foredunes. Species not collected in quantitative samples are excluded

	Beach							
	Thompson's		Mpande		Cebe		Gulu	
Species	Abundance no./m-strip	Biomass g/m-strip	Abundance no./m-strip	Biomass g/m-strip	Abundance no./m-strip	Biomass g/m-strip	Abundance no./m-strip	Biomass g/m-strip
Cerebratulus sp.			8	1,04			51	2,38
Nephtys sp.			8	0,29	17	1,10	20	1,69
Gastrosaccus bispinosa			814	1,39	496	0,77	584	0,35
Gastrosaccus longifissura			776	0,32	74	0,08		
Gastrosaccus psammodytes					856	1,63	2 184	2,93
Eurydice longicornis			8	0,06	100	0,69	40	0,34
Excirolana natalensis	77	0,54			9	0,07		
Pontogeloides latipes					104	1,84		
Tylos capensis							0,2	0,05
Emerita austroafricana	27	0,29						
Ocypode ryderi	1	7,80	7	47,93	4	25,99	0,1	0,68
Insect larvae			5	0,13	13	0,19		
Bullia digitalis					27	0,48		
Bullia rhodostoma			1 164	48,12	489	21,92	162	11,00
Donax madagascariensis					17	1,37		
Total	105	8,63	2 790	99,28	2 206	56,13	3 041	19,42

water and from the surface to a depth of 60 cm. Nematodes and harpacticoids dominated the community

Table 5 Total numbers and dry mass of meiofauna on each beach sampled

Beach	Numbers/m-strip	Biomass g/m-strip
Thompson's	$1,0 \times 10^8$	110,7
Mpande	$1,7 \times 10^8$	90,7
Cebe	$1,0 \times 10^8$	64,8
Gulu	$2,0 \times 10^8$	156,0

although considerable numbers of turbellarians were found. The other meiofauna taxa were also centered around mid-water in low numbers (Figure 9).

Discussion

Beaches in Transkei may be described as isolated pocket beaches usually associated with estuarine systems. Sand particle size falls within the range of medium to fine sand, which is in contrast to beaches immediately north of Transkei which are steep, with coarse to very coarse substrates (Dye *et al.* 1981). Changes again occur further north in Natal where particle size varies between medium

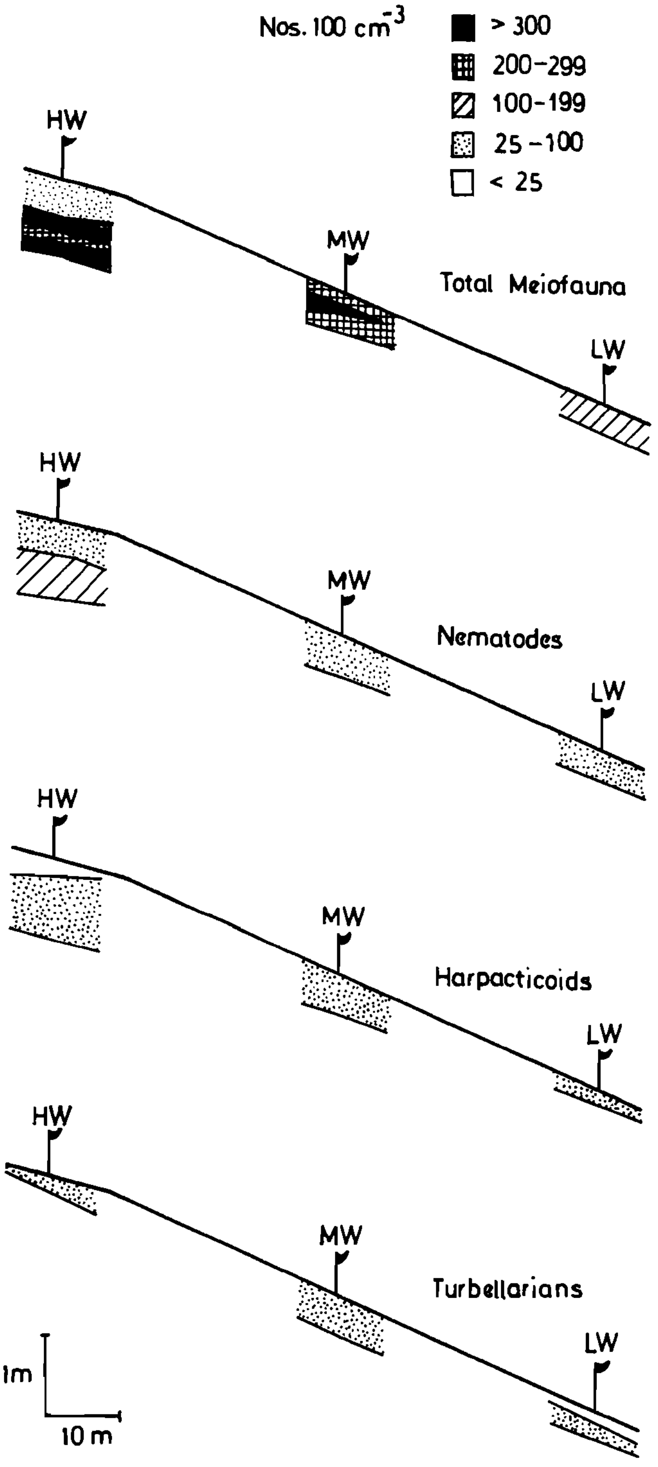

Figure 6 Density (per 100 cm^3) and intertidal distribution of meiofauna at Thompson's beach.

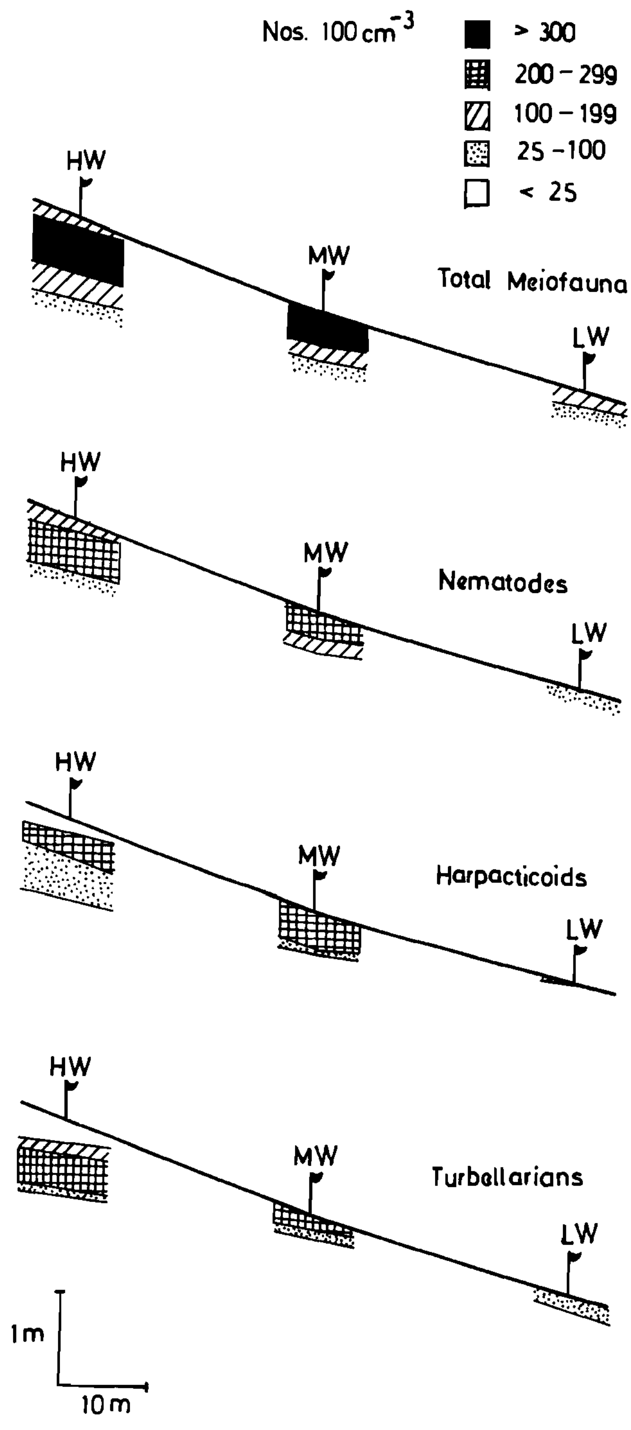

Figure 7 Density (per 100 cm^3) and intertidal distribution of meiofauna at Mpande beach.

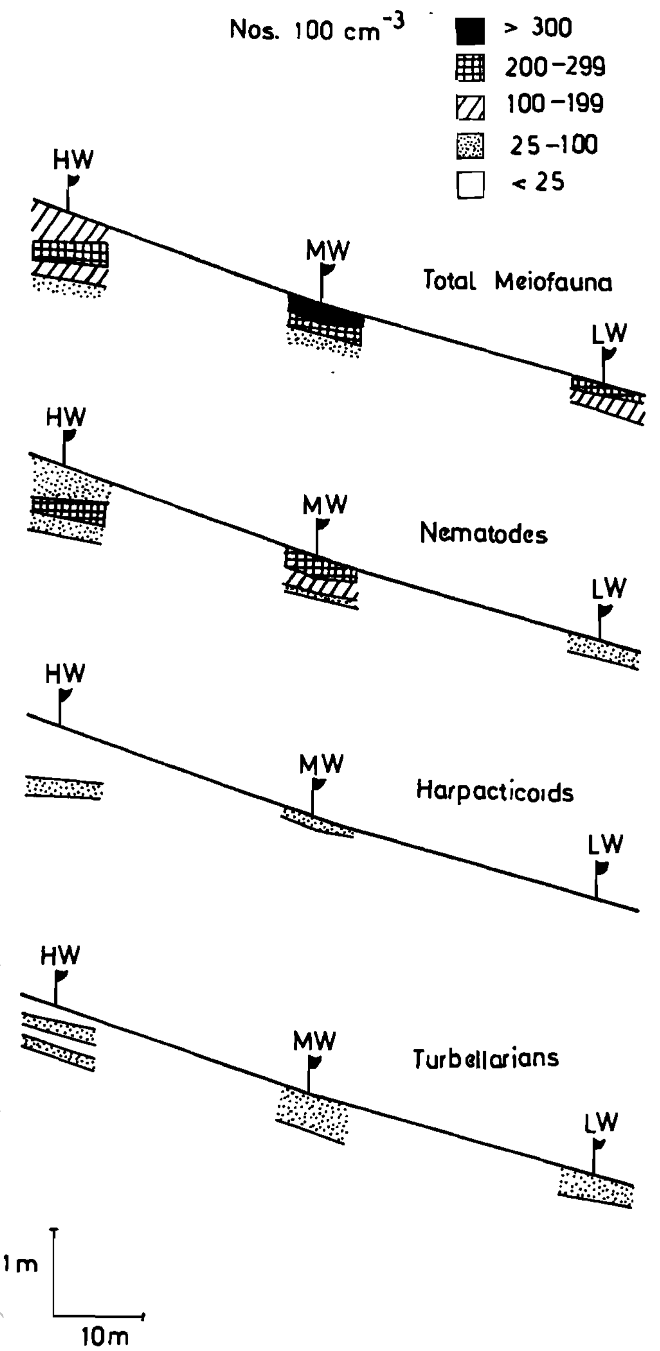

Figure 8 Density (per 100 cm^3) and intertidal distribution of meiofauna at Cebe beach.

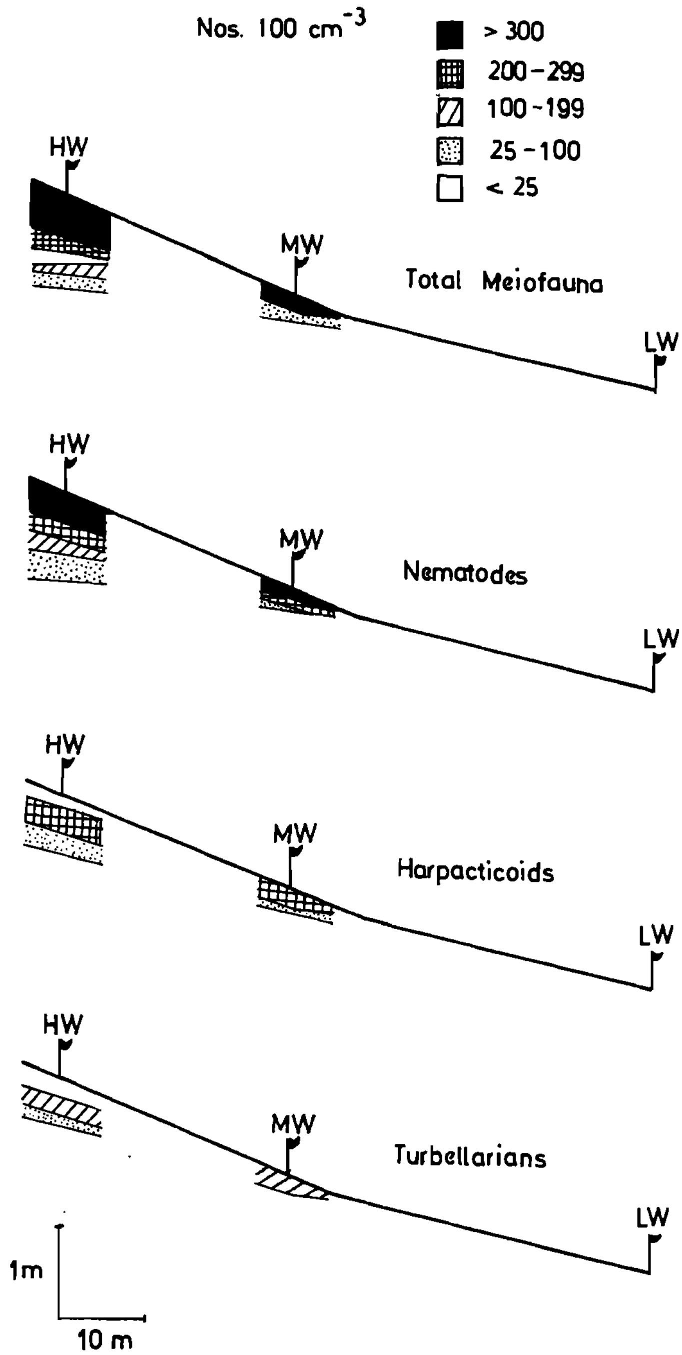

Figure 9 Density (per 100 cm^3) and intertidal distribution of meiofauna at Gulu beach.

to fine sand at higher tidal levels and coarse sand around LW (Dye *et al.* 1981). In these northern regions beaches may also extend for long distances without interruption.

The changes in the physical nature and degree of exposure of beaches from north to south are reflected in changes in the macrofauna. Although largely based on one survey, some general conclusions can be made with regard to these changes. On northern Natal beaches macrofauna species were well represented and crustaceans were the most important in terms of biomass (Dye *et al.* 1981). In southern Natal macrofauna were poorly represented and this is also shown for Thompson's beach. Fine sandy beaches are again characteristic south of Thompson's beach and this is reflected in a more diverse macrofauna community (see Table 2). Molluscs also became progressively more important on these southern beaches.

Analysis of the beach macrofauna at Mpande and Cebe also shows that species characteristic of the Natal region were present together with species characteristic of the southern Cape coast. That the region encompassing these beaches exhibits major changes in faunal composition is well documented and was recognized by workers as early as 1914 (Brown & Jarman 1978). Stephenson, Stephenson & du Toit (1937) published the first of a series of papers on eight rocky-shore localities situated at intervals round the coast of southern Africa. In a paper relating to the Port Elizabeth district (Stephenson, Stephenson & Bright 1938) it was suggested that three principal 'populations' were present on the South

African coast and that tropical species, which are strongly represented around Durban, disappeared (apart from isolated species), between Durban and East London. Eyre, Broekhuysen & Crichton (1938) also suggested a transition from a sub-tropical south-coast biota between Durban and East London and stated 'We have reason to suppose that the tropical element is still fairly strong at Port St Johns but this needs confirmation'. It was left to Stephenson (1944) and Stephenson & Stephenson (1972) to demonstrate that the reduction in the number of tropical-subtropical rocky-shore species and the increase in the other components was most rapid along the stretch of coast between Port St Johns and Qolora. This relatively short stretch of coast is also regarded by other workers to represent the boundary between the two faunistic provinces (Brown & Jarman 1978). This also appears true for the sandy beach macrofauna in the present work, since Mpande and Cebe are situated between Port St Johns and Qolora. Variations in the distribution of some species within the zone of transition probably occur, since the beaches are relatively small and therefore influenced by strong flooding of the estuaries or severe scouring due to storm conditions. The relative isolation and presence of some species in low numbers may result in a slow recolonization of a species on a particular beach.

Warm-temperate and subtropical estuarine fauna also overlap in Transkei (Day 1974) and this is well illustrated for the Mgazana estuary, 10 km north-east of Mpande (Branch & Grindley 1979). Branch & Grindley's (1979) records of *Hippa adactyla* and *Donax serra* at Mgazana were new. These species are normally associated with exposed open beaches, but were present on the sand-bank inside the mouth of the estuary. Both *Gastrosaccus bispinosa* and *G. longifissura* were also recorded from this sheltered sand-bank (Wooldridge 1978).

The distribution of the three mysid shrimps showed clear patterns of interspecific zonation. *G. bispinosa* was always the most abundant species closest inshore on the three beaches where it was recorded. Further offshore it was replaced by *G. longifissura* or *G. psammodytes*, except at Cebe where all three species occurred. Here *G. psammodytes* occupied a zone closer inshore than *G. longifissura*. The same pattern was observed for *G. bispinosa* and *G. longifissura* on Mgazana beach (Wooldridge 1978). Intraspecific zonation, already described for *G. psammodytes* (Wooldridge 1981), was also evident in the three species, but this pattern was not as precise as shown for *G. psammodytes* on Maitland beach.

Meiofauna

The composition of the meiofauna on Transkei beaches is similar to that of the northern Natal beaches. Nematodes and harpacticoids are usually dominant as is common in such substrates (McIntyre 1969). The finer sand characteristic of these beaches probably accounts for the increase in numbers from southern Natal to the Transkei. This increase continues towards the eastern Cape so that Gulu has approximately 20 times more meiofauna than St Lucia and 16 times greater biomass (Dye *et al.* 1981). The intertidal distribution is similar to both Natal and eastern Cape beaches with the bulk of the meiofauna concentrated around mid-water in the upper layers of the substrate and in the deeper layers at high water. In most cases the meiofauna is relatively sparse at the lower tidal levels.

Acknowledgements

The authors wish to thank the Department of Environmental Planning and Energy and the University of Port Elizabeth for financial support. The Department of Nature Conservation in Transkei is also acknowledged for permission to work on Transkei beaches.

References

BARNARD, K.H. 1964. Contributions to the knowledge of South African marine Mollusca. Part V. Lamellibranchiata. *Ann. S. Afr. Mus.* 47: 361 – 593.

BLABER, S.J.M., HILL, B.J. & FORBES, A.T. 1975. Infratidal zonation in a deep South African estuary. *Mar. Biol.* 28: 333 – 337.

BRANCH, G.M. & GRINDLEY, J.R. 1979. Ecology of southern African estuaries. Part II. Mgazana: a mangrove estuary in Transkei. *S. Afr. J. Zool.* 14: 149 – 170.

BROWN, A.C. 1971. The ecology of the sandy beaches of the Cape Peninsula, South Africa. Part 2: The mode of life of *Bullia* (Gastropoda: Prosobranchiata). *Trans. R. Soc. S. Afr.* 39: 281 – 319.

BROWN, A.C. & JARMAN, N.J. 1978. Coastal marine habitats. In Biogeography and ecology of southern Africa. 1239 – 1277. ed. Werger, M.J.A., Junk, The Hague.

CONNELL, A.D. 1974. Mysidacea of the Mtentu river estuary, Transkei, South Africa. *Zool. afr.* 9: 147 – 159.

DAY, J.H. 1969. A guide to marine life on South African shores. A.A. Balkema, Cape Town.

DAY, J.H. 1974. The ecology of Morrumbene Estuary, Mozambique. *Trans. R. Soc. S. Afr.* 41: 43 – 97.

DYE, A.H., McLACHLAN, A. & WOOLDRIDGE, T. 1981. The ecology of sandy beaches in Natal. *S. Afr. J. Zool.* 16: 200 – 209.

EYRE, J., BROEKHUYSEN, G.J. & CRICHTON, M.I. 1938. The South African intertidal zone and its relation to ocean currents. 6. The East London district. *Ann. Natal Mus.* 11: 7 – 111.

KENSLEY, B. 1978. Guide to the marine isopods of southern Africa. Cape Town: South African Museum.

McINTYRE, A.D. 1969. Ecology of marine meiobenthos. *Biol. Rev.* 44: 245 – 290.

McLACHLAN, A. 1977. Composition, distribution, abundance and biomass of the macrofauna and meiofauna of four sandy beaches. *Zool. afr.* 12: 279 – 306.

McLACHLAN, A. 1980a. The definition of sand beaches in relation to exposure: a simple rating system. *S. Afr. J. Sci.* 76: 137 – 138.

McLACHLAN, A. 1980b. Occurrence of ghost crabs, *Ocypode* spp., on East Cape beaches. *S. Afr. J. Zool.* 15: 57 – 58.

McLACHLAN, A., DYE, A.H. & VAN DER RYST, P. 1979. Vertical gradients in the fauna and oxidation of two exposed sandy beaches. *S. Afr. J. Zool.* 14: 43 – 47.

MORGANS, J.F.C. 1956. Notes on the analysis of shallow water soft substrates. *J. anim. Ecol.* 25: 367 – 387.

STEPHENSON, T.A. 1944. The constitution of the intertidal fauna and flora of South Africa. *Ann. Natal Mus.* 10: 18 – 357.

STEPHENSON, T.A. & STEPHENSON, A. 1972. Life between tidemarks on rocky shores. Freeman & Co., San Francisco.

STEPHENSON, T.A., STEPHENSON, A. & BRIGHT, K.M.F. 1938. The South African intertidal zone and its relation to ocean currents. 4. The Port Elizabeth district. *Ann. Natal Mus.* 9: 1 – 19.

STEPHENSON, T.A., STEPHENSON, A. & DU TOIT, C.A. 1937. The South African intertidal zone and its relation to ocean currents. 1. A temperate Indian Ocean shore. *Trans. R. Soc. S. Afr.* 24: 341 – 382.

WOOLDRIDGE, T. 1976. The zooplankton of Msikaba estuary. *Zool. afr.* 11: 23 – 44.

WOOLDRIDGE, T. 1977. The zooplankton of Mgazana, a mangrove estuary in Transkei, southern Africa. *Zool. afr.* 12: 307 – 322.

WOOLDRIDGE, T. 1978. Two new species of *Gastrosaccus* (Crustacea, Mysidacea) from sandy beaches in Transkei. *Ann. S. Afr. Mus.* 76: 309 – 327.

WOOLDRIDGE, T. 1981. Zonation and distribution of the beach mysid, *Gastrosaccus psammodytes*. *J. Zool., Lond.* 193: 183 – 189.