Aspects of the ecology of meiofauna in Mngazana estuary, Transkei

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The intertidal distribution and abundance of sand and mud-flat meiofauna at the mouth and the middle reaches of Mngazana estuary were monitored over a period of 15 months from April 1977 to July 1978 and the data compared with those from other South African estuaries. The meiofauna exhibited an early winter maximum with numbers ranging ranging from 2,74 x 10^6 to 7,27 x $10^6 m^{-2}$ in sand and from 2,59 x 10^5 to 4,15 x $10^5 m^{-2}$ in mud, both to a depth of 20 cm. The fluctuations correlated with variations in Eh and temperature. Annual production in the upper 20 cm is estimated at 8,0 $gCm^{-2}h^{-1}$ and 0,6 $gCm^{-2}y^{-1}$ in sand and mud respectively.

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Die intergety-verspreiding en die rykdom aan sand- en moddermeiofauna by die mond en middelstreke van die Mngazana estuarium is gemonitor oor 'n periode van 15 maande vanaf April 1977 tot Julie 1978 en die gegewens is vergelyk met die van ander Suid-Afrikaanse estuarienes. Die meiofauna vertoon 'n vroeë winter-maksimum met getalle wat wissel van 2,74 x 10^6 to 7,27 x $10^6 m^{-2}$ in die sand en 2,59 x 10^5 tot 4,15 x 10^5 tot 4,15 x $10^5 m^{-2}$ in die modder, albei tot 'n diepte van 20 cm. Hierdie wisseling korreleer met veranderings in Eh en temperatuur. Die jaarlikse produksie in die boonste 20 cm word beraam op 8,0 $gCm^{-2}y^{-1}$ onderskeidelik in die sand en modder.

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Mngazana is one of the largest mangrove estuaries on the east coast of southern Africa. Lying at latitude 31° 42′ S this undisturbed estuary is one of the few remaining habitats of its kind on this part of the coast. Although pleas have been made for the conservation of such areas (Grindley 1970; Moll *et al.* 1971) few back-up ecological studies have been undertaken. Among these are Day (1951) on estuaries in general, Macnae (1963) on the mangroves and Wooldridge (1976, 1977) on the plankton of Msikaba and Mngazana estuaries. In addition a survey of the Mngazana estuary has been done by a habitat working group of the University of Cape Town (1975, *unpubl. rep.*). No work has been published on the meiofauna of mangrove estuaries in southern Africa and the present study was undertaken partly to fill this gap and partly as a comparative study for previous work done in the Swartkops estuary near Port Elizabeth (Dye & Furstenberg 1978; Dye *et al. 1978.*). When it was announced early in 1978 that Mngazana was to be the site of a new harbour complex the project assumed a greater importance as a base line study for assessing the impact of such a development on the estuary.

The Mngazana estuary is 5,6 km in length (Fig. 1). The river is joined by two large creeks near the mouth on the northern side. Extensive mangrove swamps occur along the length of the estuary and three species are found, *viz., Avicennia marina, Bruguieria gymnorhiza* and *Rhizophora mucronata.* The mouth is permanently open and although extensive sand banks occur in the lower reaches and mouth area, a 3- to 4- metre deep channel is kept open by the large tidal exchange. This is also responsible for the relative clarity of the water when compared to other Transkeian estuaries.

The substrate consists of clean medium to fine sand at the mouth but becomes progressively finer towards the middle and upper reaches where mud and silt predominate. At the head of the estuary the substrate consists of rock and shale.

Methods

Sampling sites

Two sampling sites were chosen, Station A on a sand flat near the mouth on the northern bank and Station B on a mud flat fringing a mangrove bed in the middle reaches.

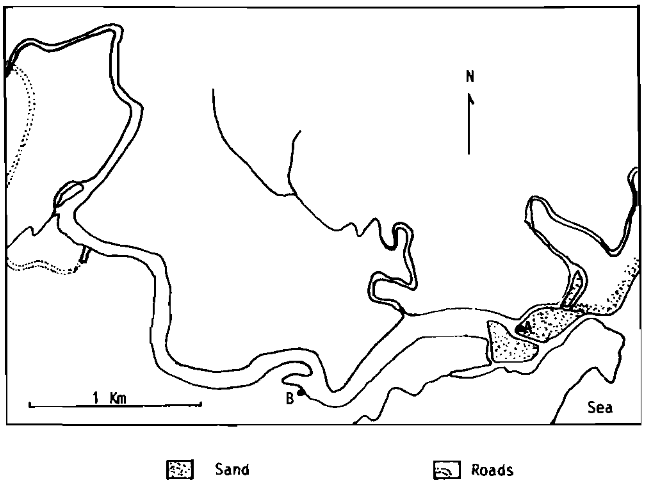

Fig. 1 Map of Mngazana estuary showing the positions of the sampling sites.

These sites were chosen because they represent the predominant sediment types and because the latter correspond to the type of sediments studied in other estuaries along the South African coast (Dye 1977). Sampling was done during spring low tide at three-monthly intervals from April 1977 to July 1978.

Beach surveys

Beach profiles were obtained according to the method of Day (1969). Three sampling levels were chosen along each transect, high water (HW) at HWST, mid water (MW) corresponding to half of the tidal range and low water (LW) at LWST. No vegetation occurred at Station A but the high and mid-water levels at Station B were characterized by a dense bed of *Avicennia marina* roots.

Substrate analysis

Particle size was determined on 30 g of oven-dried substrate by wet-sieving through sieves conforming to the Wentworth scale at 1 phi intervals (Morgans 1956). Permeability was determined by measuring the time taken for a 50 cm column of seawater to pass through a 10 cm column of substrate in a 1,5 cm i.d. tube (Hulings & Gray 1971). Maximum permeability was obtained by packing the substrate from below and minimum by allowing the substrate to sink through the water column (Dye 1978). The porosity of the sediment was meaured by determining the volume of water needed to saturate 100 g of oven-dried substrate. This was done in a measuring cylinder by adding the water to the substrate while tapping the cylinder to release air bubbles. The change in mass gave the volume of water used.

Substrate temperature was measured at depths of 5 and 15 cm by means of a thermistor calibrated against a mercury-in-glass thermometer.

Salinity was measured at 5 and 15 cm in the sandy area by withdrawing a few millilitres of water from the sand by syringe (Dye 1978). Readings were taken in the field by means of a refractometer accurate to $1^0/_{00}$ salt concentration. In the muddy area a different procedure had to be used because of the fineness of the sediment. Samples of sediment were taken from the 5 and 15 cm depths in centrifuge tubes and spun on a field centrifuge unit and the salinity of the supernatant was measured as described.

As a measure of the degree of reduction of the sediments Eh was measured at 5 and 15 cm depths by means of a Corning platinum electrode (No. 476060) connected to a Metrohm E 488 portable pH meter. A Corning calomel electrode (No. 476002) served as a reference.

Since 80 to 90% of the meiofauna occurs in the top 20 cm of the sediment in estuarine flats (Ott 1972; Dye & Furstenberg 1978) samples for meiofauna were taken by means of an aluminium corer 20 cm in length and 7,8 cm in diameter. Four vertical cores were taken at intervals of 30 cm in a line parallel to the water at each tidal level. Each core was cut in half to produce two 10 cm sections. The four sub-sections from each depth zone were mixed and two 200 cm³ sub-samples were taken for analysis. The samples were preserved and stained in the field by adding 100 ml of a 0,05% Rose Bengal solution in 10% formalin. The animals were extracted in the laboratory by flotation (Furstenberg *et al.* 1978). Muddy samples were further treated with sugar flotation according to the method of Heip *et al.* 1974). The animals were trapped on a 45 μm sieve and washed into beakers for subsequent counting.

Results

Beach Surveys

Figure 2 shows the beach slopes for the two stations. Although the mean slope at Station A was 1:186 a considerably greater slope occurred between HW and MW (1:58) and from a point just above LW to the edge of the water (1:35). The beach was stable until May 1978 when severe flooding changed the mouth of the estuary considerably, leaving only that area around the original high water level. For this reason no data are available for Station A in July 1978.

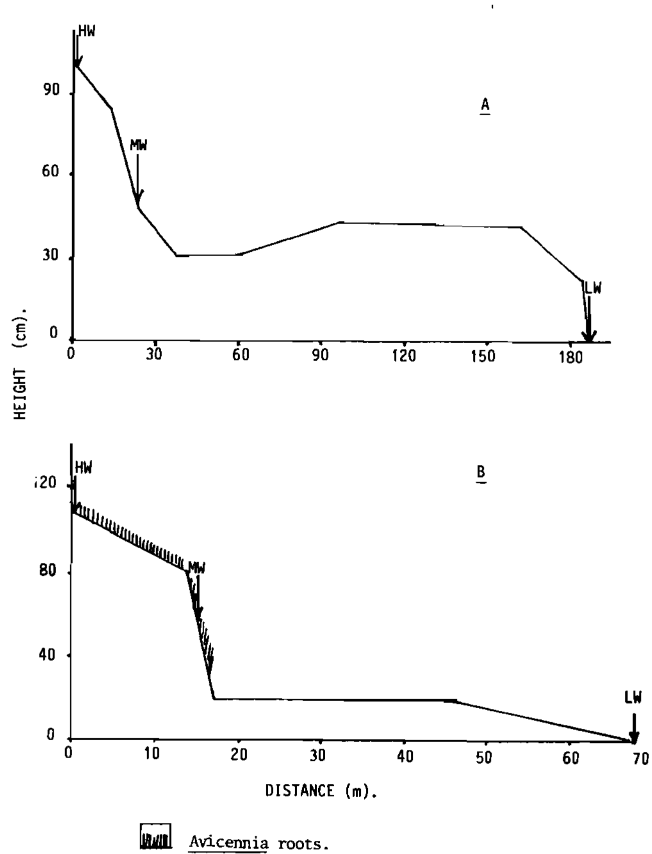

Fig. 2 Results of beach surveys showing slopes and sampling levels.

Table 1 Results of substrate analyses, porosity and permeability determinations at Stations A and B. Permeability times are in minutes and are the means of maximum and minimum measurements

Parameter	Station and sampling level					
	A			B		
	HW	MW	LW	HW	MW	LW
Md_ϕ	178	178	179	55	57	64
Qd_ϕ	0,29	0,29	0,27	not determined		
Skq_ϕ	-0,01	-0,01	-0,04	not determined		
Mud percentage	0,63	2,50	1,90	50,00	56,25	56,88
Porosity percentage	28,40	28,30	27,90	38,20	37,80	37,80
Permeability	42,00	42,00	41,00	greater than 720		

The greatest slope at Station B was between HW and MW (1:19) although the mean was 1:255. Between HW and MW the substrate had a dense bed of *Avicennia marina* roots and a large number of fiddler crabs *(Uca pugilator)*. The beach was stable throughout the study and did not seem affected by floods.

Substrate analysis

Table 1 gives the results of the substrate analysis at both stations. The substrate at Station A had a median particle size of 178 μm while that at Station B was 59 μm. The percentage of particles smaller than 63 um (silt and clay) was on average 1,67% and 54,4% at stations A and B respectively. Low quartile deviations and skewness values at Station A indicate good sorting with a high percentage of particles falling around the median. These values are difficult to obtain for sediments in which the percentage of mud is higher than 50% but such areas are characterized by poor sorting and a wide scatter of particles around the median (Morgans 1956).

These differences in substrate composition are reflected in the porosity values, a mean of 28,2% at A and 37,9% at B. The finer particles tend to clog the interstices and reduce water movements as is reflected in the long permeability times for Station B.

Figures 3 and 4 show the seasonal fluctuations in temperature at the two stations. Temperature ranges from 19,2 to 23,0° C at A and from 19,7 to 24,1° C at B, in July and January respectively. Greatest temperature stability was found in the deeper layers of the substrate as well as near the mouth of the estuary.

Figures 5 and 6 show the fluctuations in salinity. Salinity was fairly constant at 35‰ at Station A with the exception of January 1978 when the salinity decreased slightly to 32 and 30‰ at MW and LW respectively. The salinity at Station B was more variable and the mean was 28‰. Salinity decreased to 24 and 20‰ at HW and MW respectively in January 1978 and to 15‰ at LW in July 1978 as a result of flooding.

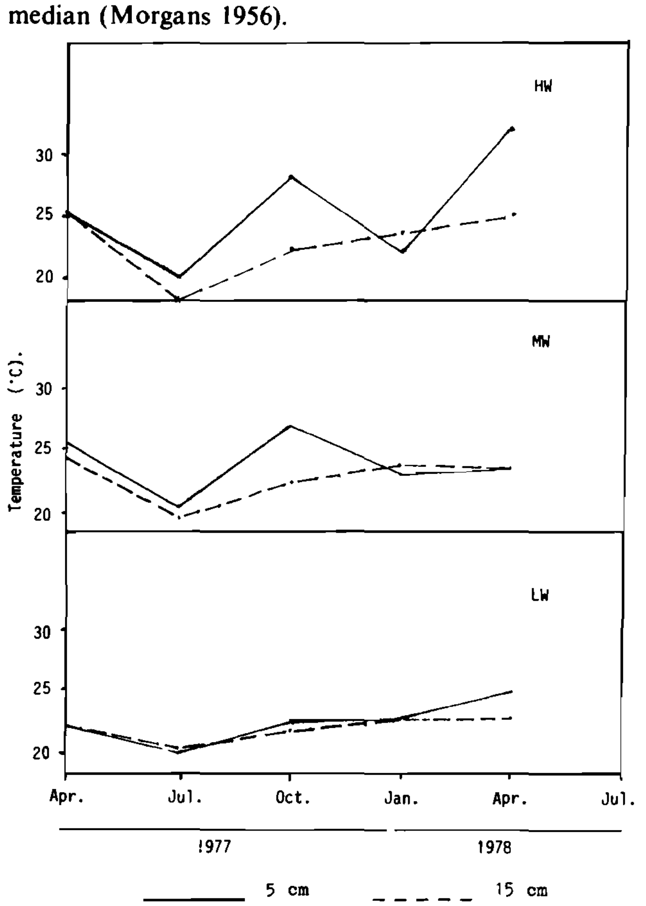

Fig. 3 Seasonal fluctuations in temperature in the substrate of Station A.

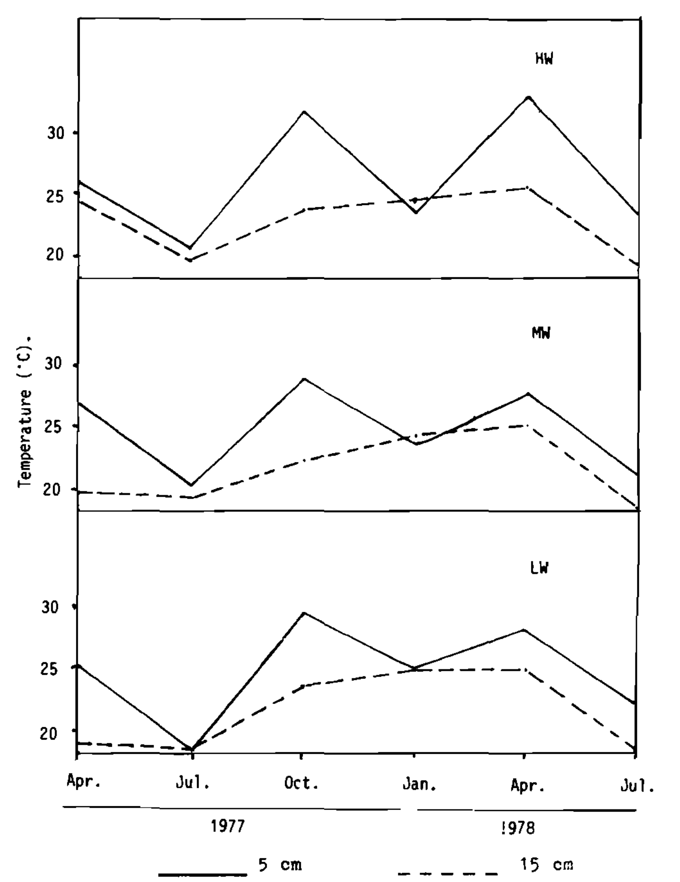

Fig. 4 Seasonal fluctuations in temperature in the substrate of Station B.

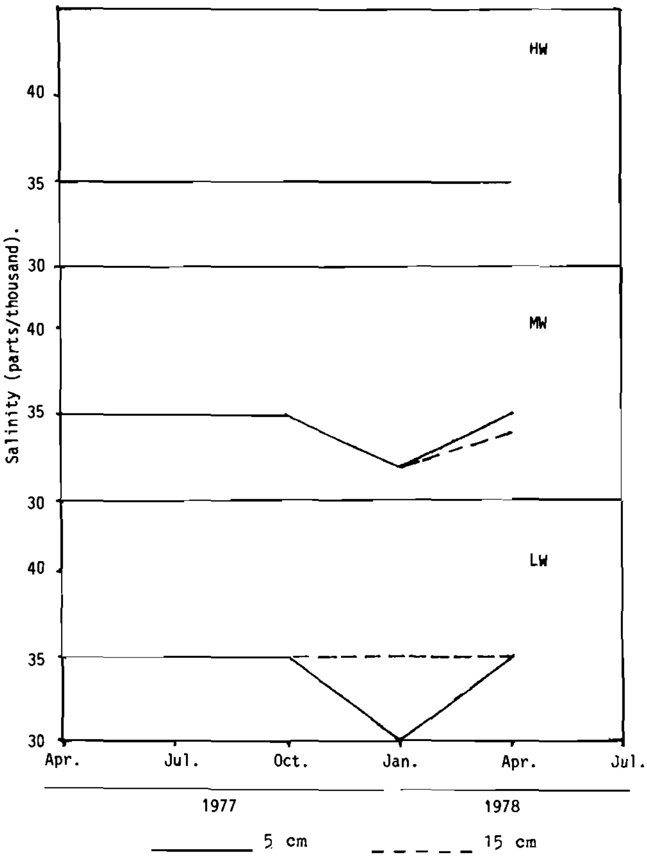

Fig. 5 Seasonal fluctuations in salinity in the substrate of Station A.

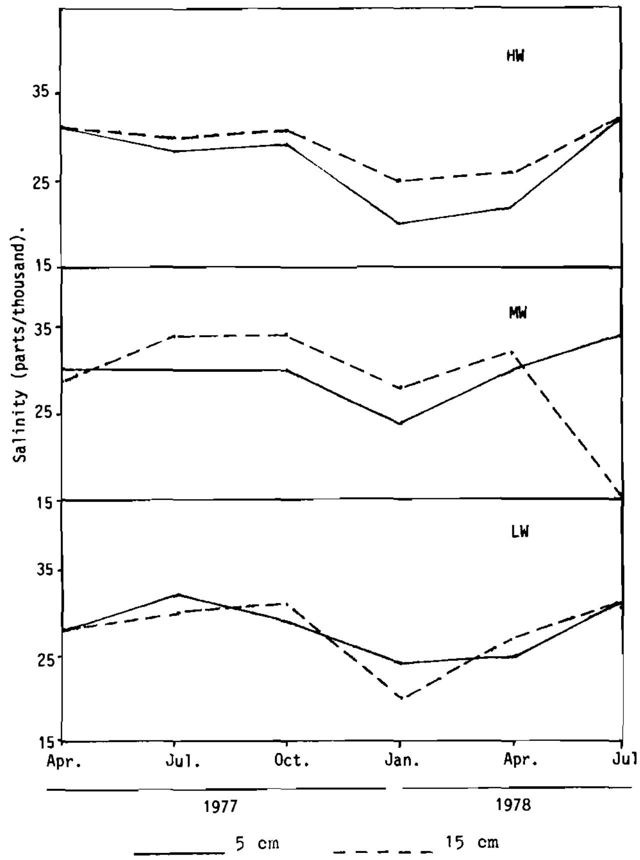

Fig. 6 Seasonal fluctuations in salinity in the substrate of Station B.

Figures 7 and 8 show the seasonal fluctuations in Eh at the two stations. Since the necessary equipment was not available at the start of the project no data are available for April 1977. Eh was always high at Station A (+250 to +480 mV) and the substrate was not reduced. At Station B the mean Eh level was only +2 mV as opposed to a mean of +265 mV at A. Eh usually decreased with depth and values of -200 mV were common. A smell of H_2S was always present and the substrate was black to the surface.

Figures 9 and 10 show the seasonal fluctuations of the meiofauna. A clear autumn/winter peak of numbers was evident at both stations. Numbers ranged from 2,74 x 10^6 to 7,27 x $10^6 m^{-2}$ in summer and winter respectively at A and from 2,59 x 10^5 to 4,15 x $10^5 m^{-2}$ at Station B during these seasons. Unlike Station A, where the depth distribution was variable, meiofauna decreased with depth at Station B.

The community was at all times dominated by nematodes. At Station A they accounted for 83,6% of the total, harpacticoid copepods for 3,4%, turbellarians for 6,3% and the remainder of 6,7% was accounted for by low and variable numbers of macrofauna larvae, polychaetes and oligochaetes. The copepods were concentrated in the deeper layers at MW and LW while the turbellarians were randomly distributed.

At Station B the meiofauna was even more homogeneous with nematodes acounting for 92% of the total, burrowing harpacticoids for 1,2%, turbellarians for 4% and the remainder, mainly polychaetes and oligochaetes, for 2,8%.

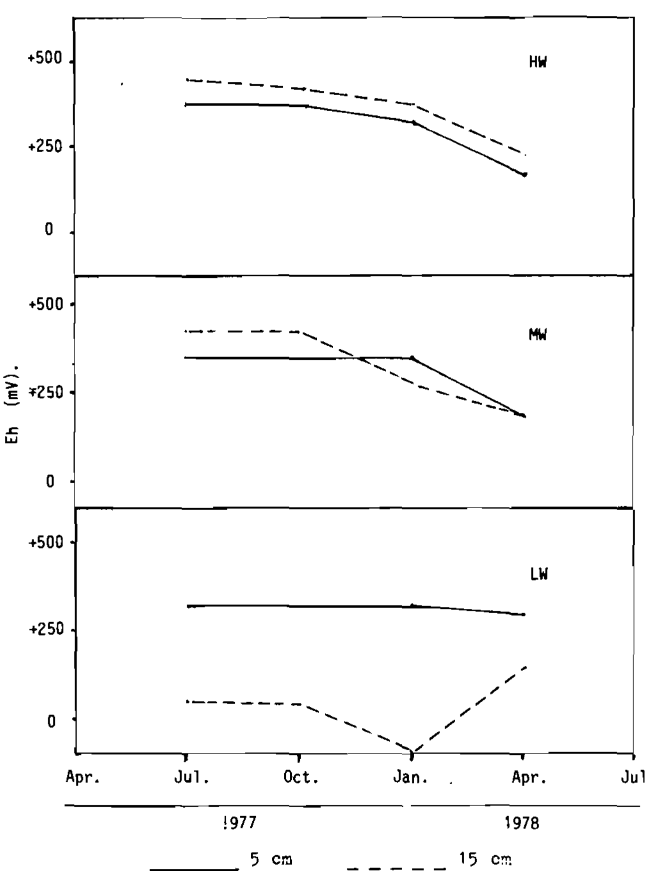

Fig. 7 Seasonal fluctuations in Eh in the substrate of Station A.

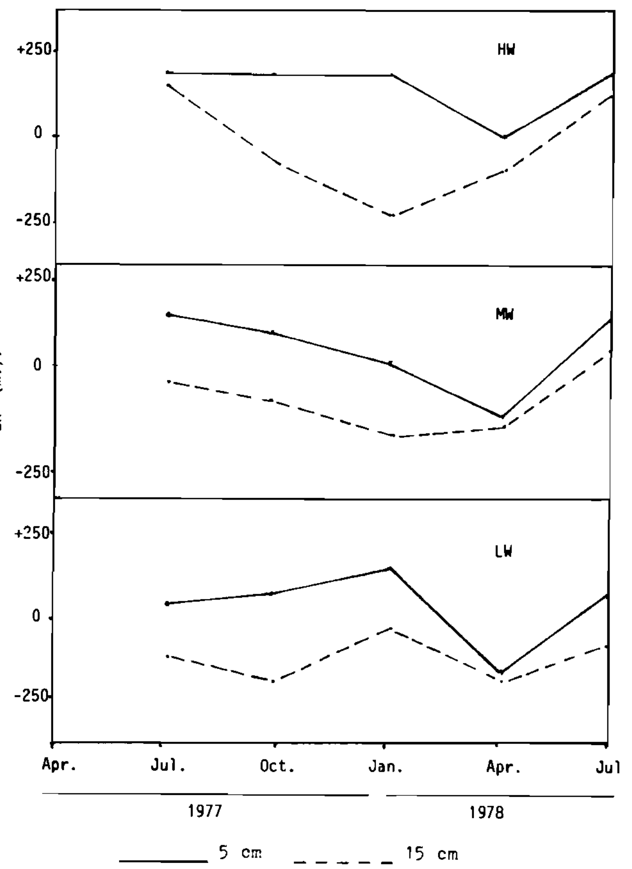

Fig. 8 Seasonal fluctuations in Eh in the substrate of Station B.

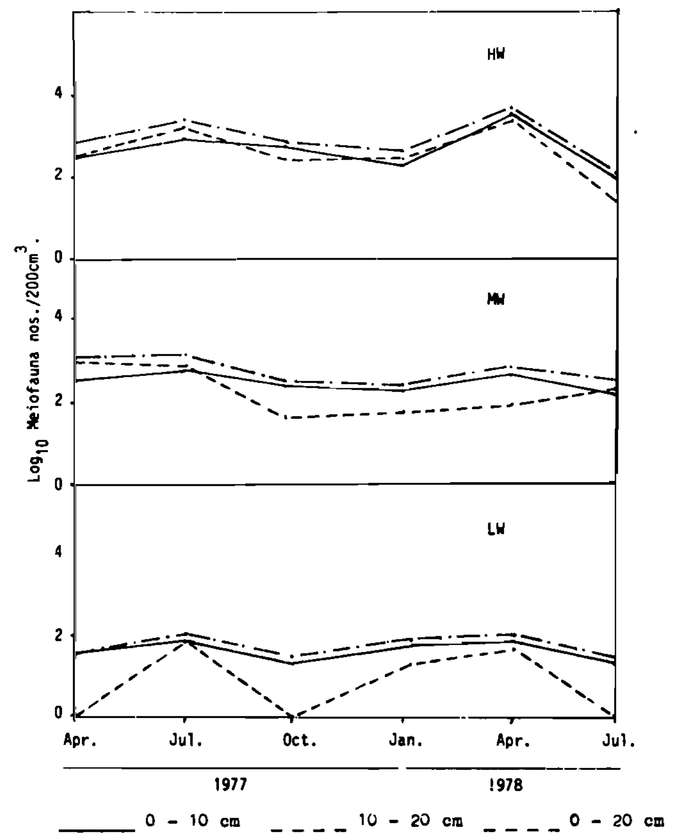

Fig. 10 Seasonal fluctuations in total meiofauna numbers/200 cm^{-3} (Log_{10}) at Station B.

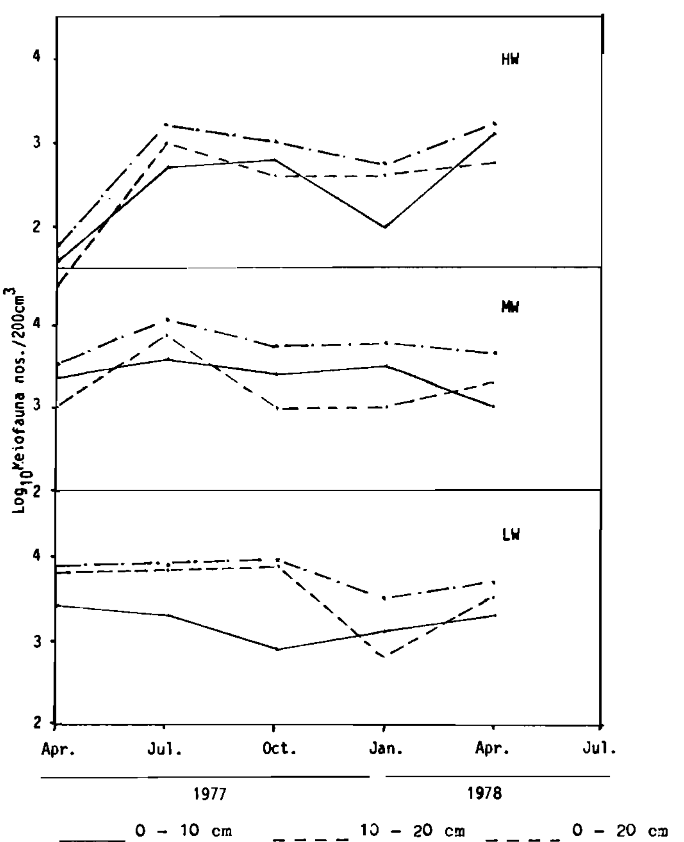

Fig. 9 Seasonal fluctuations in total meiofauna numbers/200 cm^{-3} (Log_{10}) at Station A.

Discussion

The gradients of both stations are characteristic of areas experiencing little or no wave action. The steep slope at LW of Station A is probably due to scouring during in- and outgoing tides. The steep slope between HW and MW at Station B is due to the deposition of silt and its stabilization by mangroves and is a feature of such estuaries.

Silt deposition reduces permeability and increases porosity. It also traps detritus and encourages bacterial growth. This in turn leads to reducing conditions and to the great differences between the two stations.

Mngazana has a good fresh water inflow resulting in lower salinities in the upper and middle reaches than near the mouth. Both salinity and temperature tend to be more stable near the mouth than higher up the estuary due to the buffering effect of the sea. The inverse relationship between temperature and Eh was found, is not unexpected since high temperatures will reduce oxygen saturation levels and stimulate bacterial activity resulting in a decrease in Eh.

Work done on the Swartkops estuary (Dye & Furstenberg 1978) showed that a combination of oxygen and temperature was responsible for the observed fluctuations in meiofauna numbers. It was postulated that in tropical and sub-tropical estuaries, where oxygen becomes limiting, a winter peak of meiofauna would occur while in temperate estuaries, where temperature is the dominating factor, a summer peak would be found. It can be seen that in Mngazana an autumn/winter peak occurs at both stations. Multiple linear regression analysis of Eh, temperature and meiofauna numbers revealed relationships between these parameters at both stations ($p < 0{,}10$) while no relationships could be found between either substrate properties or salinity and numbers. It therefore appears that as temperatures rise, Eh drops and animal numbers decrease, accounting for the summer minimum. Conversely as temperatures decrease, Eh increases and so do the meiofauna populations. Although the precise mechanism is obscure the effect of temperature and oxygen on meiofauna is well documented (Cooper *et al.* 1970; Tietjen & Lee 1972) while Eh is known to affect both the species composition and distribution of nematodes (Wieser *et al.* 1974).

The interactions mentioned above, although present at both stations, are less clear at Station B than at A. This may in part be due to the presence of *Avicennia* roots which may provide a habitat for plant parasitic nematodes controlled by different environmental parameters to those measured in the present study. The presence of large numbers of burrowing macrofauna (fiddler crabs) may also alter the interstitial environment by allowing oxygenated water to penetrate more rapidly than would otherwise have been the cause. This would reduce the effect of oxygen in the system and obscure the pattern. A similar situation was found in the Swartkops estuary (Dye & Furstenberg 1978).

The community composition in Mngazana compares with Swartkops estuary (Dye & Furstenberg 1978) and with other major estuaries such as Kromme, Knysna and Berg Rivers (Dye, *unpubl.*) while similar meiofauna communities have been reported from elsewhere (Wieser 1959; Jansson 1968; McLachlan & Furstenberg 1977).

Table 2 gives a comparison of standing crops and production estimates for Berg River, Knysna estuary, Kromme River and Swartkops estuary as well as for Mngazana. The data for Knysna, Kromme and Berg Rivers were obtained from surveys done in November 1975, January 1976 and May 1976 respectively (Dye 1977).

Production is estimated using a turnover of $8{,}0\text{y}^{-1}$ for the meiofauna (Dye *et al.* 1978), a dry biomass of 0,44 ug per individual (Dye & Furstenberg 1978), and a carbon equivalent of dry mass of 50% (Hargrave 1969).

In all of the estuaries surveyed the sand flats ($\pm$ 180 μm median particle size) supported larger standing crops than the mud flats (60 - 130 μm median particle size). The difference is, on average, an order of magnitude. The highest annual production of meiofauna in sandy areas (8 $\text{gCm}^{-2}\text{y}^{-1}$) occurs in Mngazana. This is followed by Kromme, then Swartkops, Knysna and Berg Rivers. The highest annual mud flat production of 0,9 $\text{gCm}^{-2}\text{y}^{-1}$ occurs at Knysna and this is followed by Mngazana Swartkops, Kromme and Berg Rivers.

Standing crops and productions of Berg, Knysna and Swartkops Rivers compare well with data from northern hemisphere estuaries (Coull 1973) but those of Kromme and Mngazana are considerably higher and are more productive per unit area in this respect. An interesting feature is the increase in meiofauna production as one moves from the cold west coast to the warm east coast, particularly if the three south coast estuaries (Knysna, Kromme and Swartkops) are combined. The exception is the mud flat areas at Knysna which showed the highest production for that type of substrate.

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Table 2 Meiofauna standing crops (nos. 200 cm^{-3}) and production estimates ($\text{gCm}^{-2}\text{y}^{-1}$) for five southern African estuaries

Estuary	Substrate type			
	Sand		Mud	
	no. 200 cm^{-3}	Production	no. 200 cm^{-3}	Production
Berg River	125	0,2	58	0,1
Knysna	737	1,3	530	0,9
Kromme River	2 193	3,9	72	0,1
Swartkops	960	1,7	138	0,2
Mngazana	5 000	8,0	337	0,6

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