SEASONAL FLUCTUATIONS IN THE VERTICAL DISTRIBUTION OF MEIOFAUNA IN ESTUARINE SEDIMENTS

A H DYE
Zoology Department, University of Port Elizabeth
Accepted: March 1978

ABSTRACT

The vertical distribution of meiofauna in estuarine sand and mud sediments was investigated over a period of fourteen months. Statistically significant differences were found between fluctuations of meiofauna inhabiting different depth zones in the top 20 cm of the sediment. The shallow populations are affected more drastically during times of adverse conditions but they have the ability to respond rapidly to favourable conditions. It is concluded that a combination of physiological adaptation and changes in species composition, rather than seasonal vertical migrations, are responsible for the observed patterns.

INTRODUCTION

Seasonal changes in the vertical distribution of meiofauna in sediments may be caused by a number of factors. These are: (i) migrations in response to seasonal fluctuations in environmental parameters such as oxygen and salinity, (ii) physiological adaptation such as changes in growth rate and fecundity in response to environmental pressures and (iii) differences in species composition either seasonally or between populations inhabiting different depth zones. Seasonal migrations of meiofauna have been reported by Renaud-Debyser (1963) who found that meiofauna tended to congregate near the surface in summer and deeper down in winter. The influence of environmental factors such as temperature and oxygen on meiofauna is well documented (Cooper *et al.* 1970; Tietjen *et al.* 1970; Tietjen & Lee 1972; Atkinson 1973*a*, *b*; Dye *et al.* 1978). The preference of certain species for particular depth zones has also been noted (Wieser *et al.* 1974). During a study of the meiofauna in the Swartkops Estuary near Port Elizabeth it became apparent that considerable differences existed between the environmental response of meiofauna populations inhabiting different depths in the substrate. As with diurnal vertical migrations (Dye 1978*b*) seasonal differences in vertical distribution must be taken into account when interpreting distribution patterns. This paper gives an analysis of the variations and gives an indication of the degree to which they may be expected to occur in estuarine sediments.

METHODS

From May 1975 to June 1976 monthly samples for meiofauna were taken during spring low tide from two stations in the Swartkops Estuary, Station A near the mouth (sand) and

Station B in the middle reaches (muddy sand). A full description is given in Dye (1978*a*). Samples were taken from the 0–6,5 cm; 6,5–13,0 cm and 13,0–20,0 cm depth zones from four tidal levels, *viz.* HWST, MW, LWST and UW, the last ("under water") being a point permanently covered by at least 0,30 m of water. The animals were extracted by Oostenbrink flotation (Dye & Furstenberg 1978).

RESULTS

Figure 1 shows the seasonal distribution of meiofauna with depth at Station A. It can be seen that a summer and winter minimum occurs in all levels of the substrate, but the monthly changes are greater in the surface layer. Although the population is much smaller at Station B the same general trend is evident (Figure 2). In order to illustrate this more clearly the total number of organisms in each depth zone was plotted against the lower limit of that zone and the regression line for each month calculated. Thus, if for example there were 100 animals in the 0–6,5 cm zone; 50 animals in the 6,5–13 cm zone and 10 animals in the 13–20 cm zone,

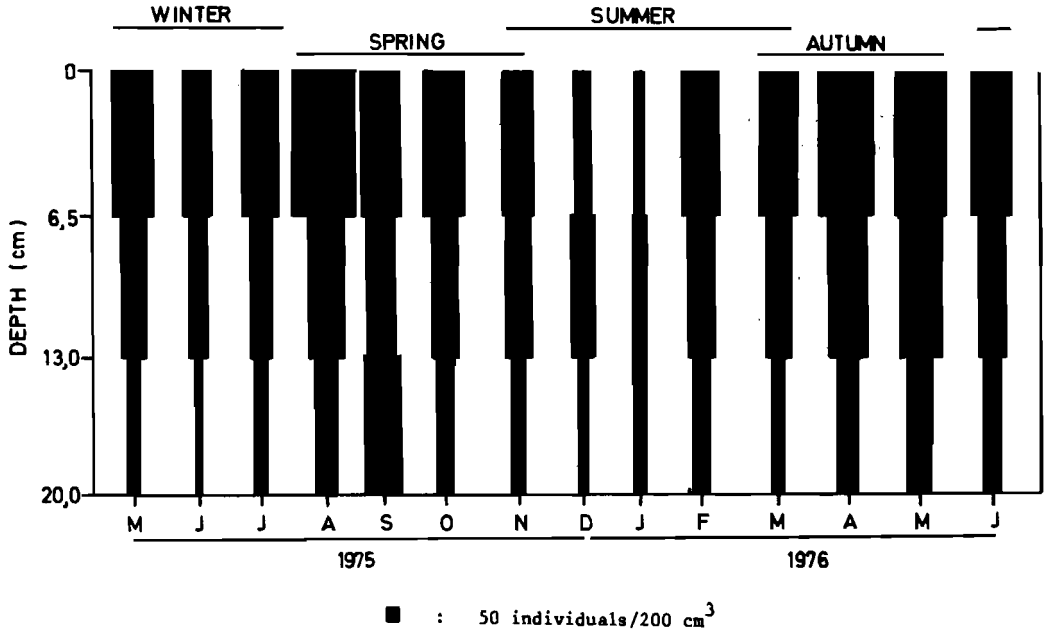

FIGURE 1.

Seasonal variations in vertical distribution of meiofauna at Station A. Each histogram is the mean of four sampling levels.

then 100 is plotted against 6,5; 50 against 13,0 and 10 against 20,0. The slope of the resulting line (assuming it to be straight (Dye & Furstenberg 1978)) gives an indication of the rate of change in animal numbers with depth. The slope may be either positive or negative depending on whether the animals increase or decrease in number with depth. If these rates are plotted against time the graph in Figure 3 is produced. The data were divided into a winter period from April to September and a summer period, October to March, on the basis of the meiofauna population fluctuations which exhibited peaks in April and September (Dye & Furstenberg 1978).

Previous work had shown that meiofauna fluctuations are controlled mainly by temperature and oxygen in such a way that in summer the lower the oxygen the lower the number of animals, while in winter the lower the temperature the lower the number of animals. There are thus two peaks of meiofauna, one in autumn and one in spring when both temperature and oxygen are most favourable (Dye 1978*a*; Dye & Furstenberg 1978). When these findings were applied to the present case it was found that during summer and winter the meiofauna is evenly distributed with depth. This is shown in Figure 3 (Station A) by the

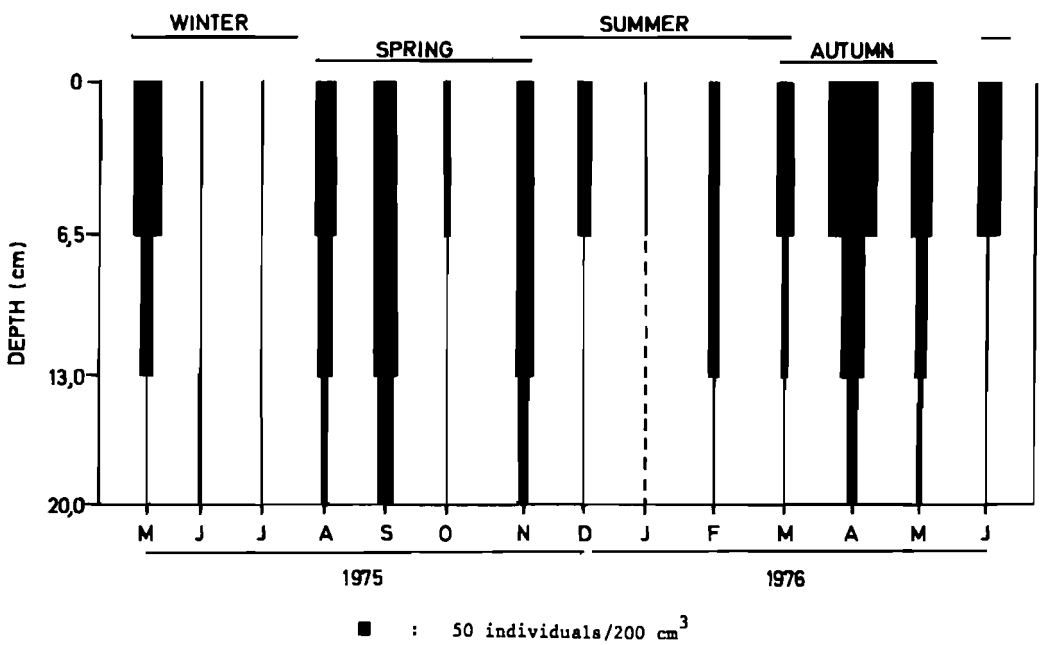

FIGURE 2.

Seasonal variations in vertical distribution of meiofauna at Station B. Each histogram is the mean of four sampling levels.

fact that the decrease rates approach zero at these times. Only at times during Spring and Autumn do the rates become very negative showing that animal numbers decrease drastically with depth. This also indicates that the main population fluctuations occur in the upper layers of the sediment. At Station B the situation is different due to the presence of a large population of the sand prawn *Callianassa kraussi* and the relationships are obscure. The role of the prawns will be discussed below.

DISCUSSION

Figures 1 and 2 clearly indicate differences in seasonal fluctuation between populations inhabiting different layers in the substrate. When a statistical comparison was made (linear regression and t-tests) between the sesonal fluctuations of the meiofauna in these layers a significant difference ($p \leqslant 0{,}05$) between the surface and the two deeper layers was found at Station A. Since the surface population is exposed to more severe conditions (Dye 1978*a*), i.e. low oxygen during summer and low temperatures during winter, it fluctuates to a much greater extent than the population deeper down. Migration can be eliminated as a significant

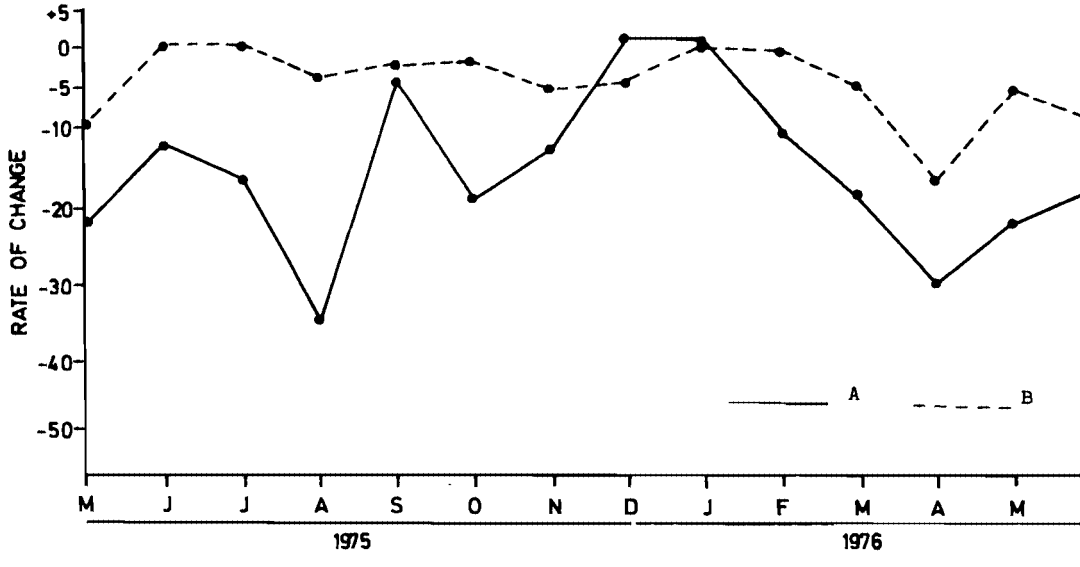

FIGURE 3.

Seasonal variations in the rate of change of animal numbers with depth at Stations A and B. Each curve is the mean of four sampling levels.

factor since, if this were operative, the upper layers of the substrate would gain animals at the expense of the lower layers during times of favourable conditions and *vice versa* during adverse conditions. That this does not happen can be seen in Figures 1 and 2. When a population increase occurs near the surface it is usually accompanied by an increase of lesser magnitude deeper down. It is clear that the surface populations are able to respond rapidly to favourable conditions but are easily reduced by adverse conditions. The deeper populations do not respond readily to such changes. The most logical explanation is a combination of physiological adaptation and changes in species composition with depth.

Turning to Station B where no significant statistical relationships could be found, one would be at a loss to explain the lack of controlling factors if it were not for the fact that this area supports a large population of the sand prawn *Callianassa kraussi* (250/m^2). These organisms pump oxygenated water into the substrate throughout the year and thus remove one of the most important controlling factors in meiofauna fluctuation, namely oxygen. The population fluctuations are thus not so clear as at Station A (Dye & Furstenberg 1978).

In conclusion it may be said that the meiofauna either appears to consist of more than one population or has a continuously changing species composition with depth.

ACKNOWLEDGEMENTS

The University of Port Elizabeth and the Department of Planning and the Environment are thanked for the financial assistance which made this work possible, and the University of Port Elizabeth for financial aid in publication.

REFERENCES

ATKINSON, H J 1973*a*. The respiratory physiology of the marine nematodes *Enoplus brevis* (Bastian) and *E. communis* (Bastian). I. The influence of oxygen and body size. *J. exp. Biol.* 59: 247–254.

ATKINSON, H J 1973*b*. The respiratory physiology of the marine nematodes *Enoplus brevis* (Bastian) and *E. communis* (Bastian). II. The effect of changes in the imposed oxygen regime. *J. exp. Biol.* 59: 255–260.

COOPER, A F, VAN GUNDY, S D & STOLZY, L H 1970. Nematode reproduction in environments of fluctuating aeration. *J. Nematol.* 2: 182–188.

DYE, A H 1978*a*. An ecophysiological study of the meiofauna of the Swartkops estuary. I. The sampling sites: Physical and chemical features. *Zool afr.* 13: 1–18.

DYE, A H 1978*b*. Diurnal vertical migrations of meiofauna in an estuarine sand flat. *Zool. afr.* 13: 201–205.

DYE, A H & FURSTENBERG, J P 1978. An ecophysiological study of the meiofauna of the Swartkops estuary. II. The meiofauna: composition, distribution, seasonal fluctuation and biomass. *Zool. afr.* 13: 19–32.

DYE, A H, ERASMUS, T & FURSTENBERG, J P 1978. An ecophysiological study of the meiofauna of the Swartkops estuary. III. Partition of benthic oxygen consumption and the relative importance of the meiofauna. *Zool. afr.* 13: 187–199.

OTT, J A, FUCHS, B, FUCHS, R & MALASEK, A 1976. Observations on the biology of *Callianassa kraussi* Borrodaille and *Upogebia litoralis* Risso and their effect upon the sediment. *Senckenberg. marit.* 8: 61–79.

RENAUD-DEBYSER, J 1963. Reserches ecologiques sur la faune interstitielle des sable Basin d' Arcachon ile de Bimini, Bahamas. *Vie Milieu Suppl.* 15: 1–157.

TIETJEN, J H, LEE, J J, RULLMAN, J, GREENGART, A & TROMPETER, J 1970. Influence of temperature and salinity on the development of *Monhystera denticulata* Timm. *Oecologia* 10: 543–575.

TIETJEN, J H & LEE, J J 1972. Life cycles of marine nematodes. Influence of temperature and salinity on the development of *Monhystera denticulata* Timm. *Oecologia* 10: 167–176.

WIESER, W, OTT, J, SCHIEMER, F & GNAIGER, E 1974. An ecophysiological study of some meiofauna species inhabiting a sandy beach at Bermuda. *Mar. Biol. Wash.* 26: 235–248.