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# THE DIVERSITY OF NEMATODE COMMUNITIES IN THE SOUTHERN NORTH SEA

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(Text-fig. 1)

The diversity of nematode communities along the Belgian coast is influenced by the median grain size and the percentage of silt of the sediment, as $H = 0{\cdot}84 + 10{\cdot}96Md - 0{\cdot}013S$.

The influence of the outlet of a small stream, the IJzer, is also clearly visible in the low diversity of communities situated to the north-east of the mouth, which is the direction of the prevailing currents.

The predominating species in low-diversity communities appear to be generalists, while high specialization seems to be the rule for nematode communities as a whole.

## INTRODUCTION

Diversity is one of the most important parameters used in the description of a community; several theories relating diversity to other phenomena as predation, competition and stability have been proposed (Pianka, 1966). As a result of the increasing interest in diversity a number of studies have appeared during recent years, but the meiofauna has until recently been almost completely neglected, rather surprisingly when one considers the importance of this group of organisms in all marine benthic communities. Coull (1972) studied recently the diversity of harpacticoid copepods, with nematodes the major meiobenthic component, along the North Carolina shelf and in the deep sea. Warwick & Buchanan (1970) appear to be the only ones to have studied diversity in nematode communities, using $\alpha$ of the logarithmic series (Fisher, Corbett & Williams, 1943) as a diversity measure. The paucity of data seems primarily to be due to the taxonomic difficulties encountered in studying nematodes.

The aim of this study was to investigate the factors influencing nematode diversity in the benthos of the North Sea along the Belgian coast. The investigation covers the area of a proposed outlet of a planned collector for waste waters at Lombardsijde (Fig. 1).

## MATERIAL AND METHODS

Five points were chosen, surrounding the mouth of the IJzer, a small stream heavily loaded with organic pollution. Samples were taken three times on the five stations, on 20 April, 17 June and 5 October 1971. The samples were taken with a Van Veen grab covering a surface area of $0{\cdot}1\ m^2$. When arriving on deck, the contents of the Van Veen grab were spread out in a trough and mixed. A subsample was drawn to study the nematodes. This subsample was fixed with formalin 4 %. In the laboratory the nematodes were extracted using a simple decantation technique over sieves with a minimal mesh width of 44 $\mu$m. In the case of silt this procedure is not applicable, and here the sugar–centrifugal–flotation method (Jenkins, 1964) was used. As this procedure does not allow quantitative estimations of density, only the relative composition of the community and its diversity were studied.

The diversity index used was the Shannon–Wiener information function $H = -\Sigma p_i \log_2 p_i$, where $p_i = n_i/N$ is the proportion of individuals belonging to the $i$th species to the total number of individuals in the sample. This index is probably the most appropriate as has been shown in a computer simulation (Fager, 1972) and can be confirmed with field data (Heip & Engels, in preparation).

Evenness, being a measure of the allocation of individuals among species, was calculated as $e = H/H_{max}$ (Pielou, 1969), where $H_{max} = \log_2 S$, the logarithm of the number of species in the sample. The sediments were analysed by Dr Gullentops for the samples of 17 June.

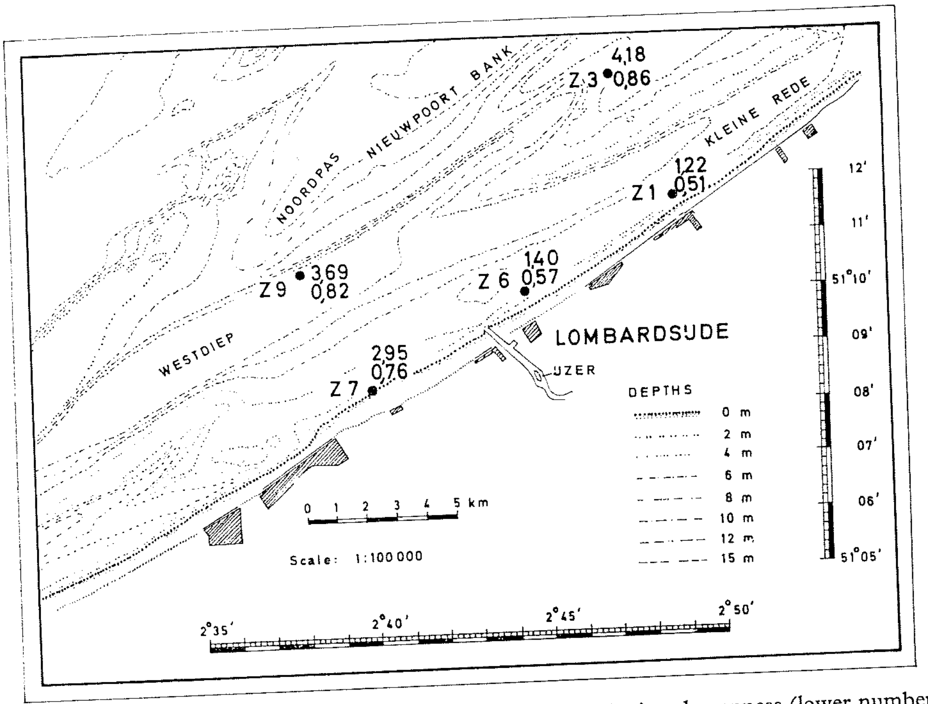


Fig. 1. Location of sites studied showing diversity (upper number) and evenness (lower number).

## RESULTS

The five stations yielded 140 species of nematodes, which will be described in more detail elsewhere (Decraemer, in preparation). This is an extremely high number considering only a few samples have been taken, but the same feature has been observed by other authors studying nematode communities (Hopper & Meyers, 1967; Warwick & Buchanan, 1970; Moore, 1971; Warwick, 1971; McIntyre & Murison, 1973). The off-shore stations Z3 and Z9 (Fig. 1) yield most species (74 and 62 respectively); Z7, situated to the south-west of the mouth of the IJzer, has an intermediate number of species (38), while the two stations to the north-east of the mouth have a low number of species (13 at Z6 and 14 at Z1).

While in Z3 and Z9 respectively eight and nine species account for 50% of the individuals, there are three species in Z7 and only one in both Z6 and Z1. This clearly shows that dominance is much higher in those last two stations.

The species composition is totally different for the species-rich stations Z3 and Z9. On a total of 129 species for both stations, only 15 are in common. The poor stations Z6 and Z1 show a high resemblance, nearly half of the species on one station is also present on the other. The dominant species are the same for the poor stations and different for the rich stations. At Z1 and Z6 *Sabatieria* sp. and *Theristus* sp. 1 are dominant, at Z7 it is *Richtersia inaequalis* Riemann, 1966. At Z3 *Hypodontolaimus* sp. 1 and *Rhips* sp. predominate, while at Z9 it is *Theristus* sp. 1 and *Paracanthonchus* sp.

Only two species occur at all five stations: *Sabatieria* sp. and *Richtersia inaequalis*. Six species occur at four stations: *Axonolaimus* sp. 1 (not Z9), *Paramonhystera elliptica* Filipjev, 1918 (not Z1), *Paramonhystera* sp. 1 (not Z9), *Odontophora armata* Ditlevsen, 1919 (not Z3), *Desmolaimus* sp. 1 (not Z7) and *Theristus* sp. 1 (not Z3). All other 132 species occur at only three stations or less. This illustrates the high level of specialization occurring in nematodes.

TABLE 1. DIVERSITY AND EVENNESS, MEDIAN GRAIN SIZE AND PERCENTAGE OF SILT AT THE FIVE STATIONS

| Station | Diversity H (bits per individual) | Evenness *e* | Median grain size of sand fraction *Md* (in *mm*) | Percentage of silt *S* |
|---|---|---|---|---|
| Z1 (−4·0 m) | 1·22 | 0·51 | 0·120 | 83·8 |
| Z6 (−4·2 m) | 1·40 | 0·57 | 0·134 | 31·0 |
| Z7 (−2·0 m) | 2·95 | 0·76 | 0·163 | 3·0 |
| Z9 (−15·0 m) | 3·69 | 0·82 | 0·257 | 0·5 |
| Z3 (−7·2 m) | 4·18 | 0·86 | 0·312 | 0·7 |

The diversity and evenness of the nematode communities at the five stations was calculated and the mean over the three data is compared with the characteristics of the sediments in terms of median grain size of the sand fraction and the percentage of silt (particles smaller than 62 $\mu$m) (Table 1). Diversity (higher number) and evenness (lower number) are shown in Fig. 1. It is immediately clear that there is a strong correlation between these parameters:

Between diversity $H$ and/median grain size $Md$

Linear regression $H = -0{\cdot}261 + 14{\cdot}96 Md$ $(r = 0{\cdot}936)$

Power regression $H = 20{\cdot}39 Md^{1{\cdot}27}$ $(r = 0{\cdot}927)$

Between evenness $e$ and median grain size $Md$

Linear regression $e = 0{\cdot}376 + 1{\cdot}66 Md$ $(r = 0{\cdot}894)$

Power regression $e = 1{\cdot}64 Md^{0{\cdot}51}$ $(r = 0{\cdot}914)$

Between diversity $H$ and evenness $e$

Linear regression $H = -3{\cdot}30 + 8{\cdot}50 e$ $(r = 0{\cdot}991)$

As diversity and evenness show a strong linear correlation, it is not possible to decide whether diversity and evenness are both influenced by the median grain size or whether high diversity is necessarily accompanied by high evenness (as present theory suggests).

Next, there is a strong negative correlation between diversity and evenness and the percentage of silt in the sediment:

Between diversity $H$ and percentage of silt $S$

| | | |
|---|---|---|
| Linear regression | $H = 3{\cdot}43 - 0{\cdot}031S$ | $(r = -0{\cdot}838)$ |
| Power regression | $H = 3{\cdot}52S^{-0{\cdot}23}$ | $(r = -0{\cdot}985)$ |

Between evenness, '$e$' and the percentage of silt $S$

| | | |
|---|---|---|
| Linear regression | $e = 0{\cdot}80 - 0{\cdot}0039S$ | $(r = -0{\cdot}900)$ |
| Power regression | $e = 0{\cdot}808S^{-0{\cdot}10}$ | $(r = -0{\cdot}985)$ |

As a last calculation, the regression between median grain size and percentage of silt shows a negative correlation:

| | | |
|---|---|---|
| Linear regression | $S = 83{\cdot}4 - 302Md$ | $(r = -0{\cdot}493)$ |
| Power regression | $S = 8{\cdot}3 \times 10^{-4}\, Md^{-5{\cdot}13}$ | $(r = -0{\cdot}935)$ |

Only the power regression shows a significant correlation coefficient. As a lower median grain size corresponds with a high percentage of silt, it can not be decided which factor is responsible for changes in nematode diversity.

## DISCUSSION

The diversity of the investigated nematode communities shows a clear pattern: diversity is lowest at the near-shore stations Z6 and Z1, which are directly influenced by the outflow of the IJzer going to the north-east with the current along the Belgian coast. Z3, lying as near the coast as Z6 and Z1, is however on the south of this mouth and not influenced by its outflow. The slight difference between Z6 and Z1 in terms of both diversity and evenness indicates that the influence of diversity-lowering factors is highest at Z1, but as nothing is known about the small-scale pattern of the currents there and as the percentage of silt is much higher at Z1, this is not necessarily contradictory with the situation relative to the IJzer.

Low diversity is associated with a sediment with a low median grain size and a high percentage of silt. The regression equation between the three parameters is

$$H = 0{\cdot}84 + 10{\cdot}96Md - 0{\cdot}013S \quad (r = 0{\cdot}970).$$

A similar relationship between diversity and median grain size was observed by Warwick & Buchanan (1970) using William's Index of diversity $\alpha$: they found highest diversity at the sandiest of three stations, lowest diversity at the siltiest station. As the siltiest environment will show the lowest spatial heterogeneity, it may be suspected to contain fewer niches than the sandier environment, and thus will support fewer species. The number of nematode species seems to be very much higher than the number of species of other taxa in the same biotope indicating a high degree of specialization in the group. The influence of grain size and silt content on nematode diversity needs to be borne in mind in any study of the effects of other factors. In particular when studying the consequences of the disposal of effluents, only areas of similar substrate should be compared.

In the off-shore stations Z3 and Z9 diversity is high and increases through the year: from 3·72 to 4·73 at Z3 and from 2·19 to 4·31 at Z9. At Z7 diversity is nearly constant (from 2·93 in April to 3·07 in June and 2·84 in October). At Z6 and Z1, however, diversity is far lower in June than in the other months (0·34 in June and 2·25 in October at Z1, 0·19 in June and 2·00 in October at Z6) resulting in greater variability of the diversity index at Z6 (75 %) and Z1 (79 %) than at the other stations (Z7; 4 %; Z3, 12 %; Z9, 35 %). This may be a consequence of an increased output of organic material in June.

It is interesting to note that the dominant species at the low diversity stations Z1 and Z6 is one of the only two species occurring at all stations (*Sabatieria* sp.), while the second dominant occurs at four out of five stations (*Theristus* sp. 1). This indicates that the dominant species in those environments are generalists, with adaptations to a wide array of possible environmental conditions. The communities at the various high-diversity stations show marked differences, nevertheless their diversity seems to be controlled by the same set of factors, as if fits in one general equation. This confirms the validity of the diversity concept.

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