VERTICAL DISTRIBUTION OF MEIOFAUNA AND THE EFFICIENCY OF THE VAN VEEN GRAB ON SANDY BOTTOMS IN LAKE GREVELINGEN (THE NETHERLANDS)

C. HEIP, K.A. WILLEMS and A. GOOSSENS

(Dept. of Zoology, State University of Ghent, Belgium;
Delta Instituut voor Hydrobiologisch Onderzoek, Yerseke,
The Netherlands)

Reprinted from HYDROBIOLOGICAL BULLETIN (Amsterdam)
Vol. 11, 2, p.p. 35 - 45 (1977)

"De Nieuwe Schouw" Press - Zeist, The Netherlands

VERTICAL DISTRIBUTION OF MEIOFAUNA AND THE EFFICIENCY OF THE VAN VEEN GRAB ON SANDY BOTTOMS IN LAKE GREVELINGEN (THE NETHERLANDS)*

C. HEIP, K.A. WILLEMS and A. GOOSSENS

(Dept. of Zoology, State University of Ghent, Belgium;
Delta Instituut voor Hydrobiologisch Onderzoek, Yerseke,
The Netherlands)

INTRODUCTION

It has been shown repeatedly that the use of remote sampling gear such as gravity cores and grabs to collect data on density and composition of meiofauna can result in underestimates of density and a biased picture of community composition. The use of cores obtained by SCUBA diving seems to be the only reliable method developed so far but has some serious drawbacks: diving can only be performed to a limited depth, in good weather conditions, when currents are not too strong, and it takes a lot of time. For these reasons grabs or gravity cores are still widely used when surveying large areas or deeper water. Although more sophisticated techniques are developed (e.g. manned submersibles), the budgetary problems involved are prohibitive for all but a few of the largest oceanographic institutions, and we will have to rely on data obtained in cruder ways for a long time to come.

One of the oldest grabs and one which has been used extensively in marine biology and geology is the Van Veen grab. Its use in sampling meiofauna has also been widespread, despite the recognized drawbacks, because it permits rapid sampling or because meiofauna is sampled together with macrofauna for which the grab is widely used till the present day.

An empirical investigation of the digging characteristics of the Van Veen grab has been done by LIE and PAMATMAT (1965) and GALLARDO (1965). These authors agree on the nearly rectangular profile cut by the grab into the sediment, which, if true, permits a straightforward calculation of the depth to which the grab penetrates by knowledge of the volume of sediment collected. Since 1965 several other studies appeared on the efficiency of the grab (e.g. ELMGREN, 1973; BEUKEMA, 1974) which show underestimation to be a frequently occurring consequence of its use.

The purpose of this study is to investigate the suitability of the grab on sandy bottoms for the collection of meiofauna. In order to do this the vertical distribution of the major taxa, Nematoda and Harpacticoida, and of dominant species within these taxa was studied. As this is the first report on meiofauna of the Grevelingen, some details on species and distribution are mentioned.

MATERIAL AND METHODS

Samples were taken on 1974-11-14 in the Grevelingen, a large saline lake (surface 108 km^2) which was created by damming a former estuary in

* Contribution nr. 156 of the Delta Institute of Hydrobiological Research.

the southern Netherlands. The station is called Archipel and water depth is about 3 m (see WOLFF et al.,1976, for a map and more information on the hydrography of the area).

Four series of four samples were taken. The first series was collected with a 0.1 m^2 Van Veen grab. The material in the grab was immediately collected in a bucket, without sieving, fixed with formalin to a final concentration of 4%, and transported to the laboratory. In the laboratory a subsample was taken from the bucket with a plastic core with a surface area of 10.35 cm^2.

Two further series of samples were taken by SCUBA diving with different plastic cores: one core, covering a surface area of 80.6 cm^2, was pushed into the sediment to a depth of about 26 cm; the other core covered a surface area of 10.35 cm^2 and was pushed about 17 cm into the sediment. The larger core was taken on deck, water was removed gently and collected, and the core was subsampled with a smaller one, covering a surface area of 9.62 cm^2.

Once in the laboratory, all samples or subsamples were elutriated using a standard technique in which the sample is placed in a shallow horizontal trough in which tap water is allowed to run (BARNETT, 1968). This technique has an efficiency of 100% (HEIP, 1976a). The only source of error is in counting when there is much detritus in the sediment. Staining with rose bengal is very helpful in this situation. Of importance is that the material was always collected on sieves with a mesh size of 38 μ, through which only a small fraction of the smallest nematodes will disappear (BOVÉE et al., 1974).

All nematodes and copepods in the samples or subsamples were counted and identified to species as far as possible. In total 10 species of harpacticoid copepods and 59 species of nematodes were identified (GOOSSENS, unpublished). As most species occur in insufficient numbers to permit statistical analysis on this level, they are not treated here further.

To compare the densities as obtained with the different sampling methods, all values were converted to a common unity of number per cm^2. When this is done, the significance of the observed difference can be tested with

$$t = \frac{(\bar{x}_1 - \bar{x}_2)\sqrt{\frac{n_1 n_2}{n_1+n_2}}}{\sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 1}}}$$

with degrees of freedom n_1+n_2-1.

In this formula $\bar{x}$ = mean, s^2 = variance and n = number of samples. An equivalent test, taking the conversion factors used into account, was used in a similar study by ELMGREN (1973). It is slightly more laborious and not more efficient.

When large departures of normality of the original data are expected it might be necessary to transform the data x_i to $\ln(x_i+1)$ in order to meet the requirements of the t-test. This transformation was performed in all cases but as we never observed a difference in the outcome of the test whether raw or transformed data were used, these tests are not reproduced in the text.

The sediment at Archipel is medium sand according to the Wentworth scale with a medium diameter of 0.272 mm (range 0.229 - 0.293 mm, irregularly varying with depth). This sediment has a yellow (aerobic) layer to a considerable depth, between 10 and 20 cm, in spite of the fact that it is permanently submerged. This situation may be the consequence of wind action in these shallow waters, or the absence of large amounts of organic matter.

RESULTS

Mean numbers of harpacticoid copepods and nematodes in each 2 cm layer of the large cores are shown in Fig. 1. From this figure it is clear that there is a fundamental difference between the vertical distribution of these two groups: although both have their largest density at the surface, nematodes penetrate much deeper into the sediment. This fact is well known and is a general feature of meiobenthic communities but it is stressed here again as it has profound consequences on the efficiency of the different sampling methods.

Two species make up for the bulk of the harpacticoid copepods: *Asellopsis hispida* (Brady and Robertson, 1873) and *Canuella perplexa* T. & A. Scott, 1893 (Fig. 2). These species are typical surface dwellers, although *A.hispida* occurs in very small numbers throughout the whole sediment column. The interstitial Cylindropsyllidae are represented by

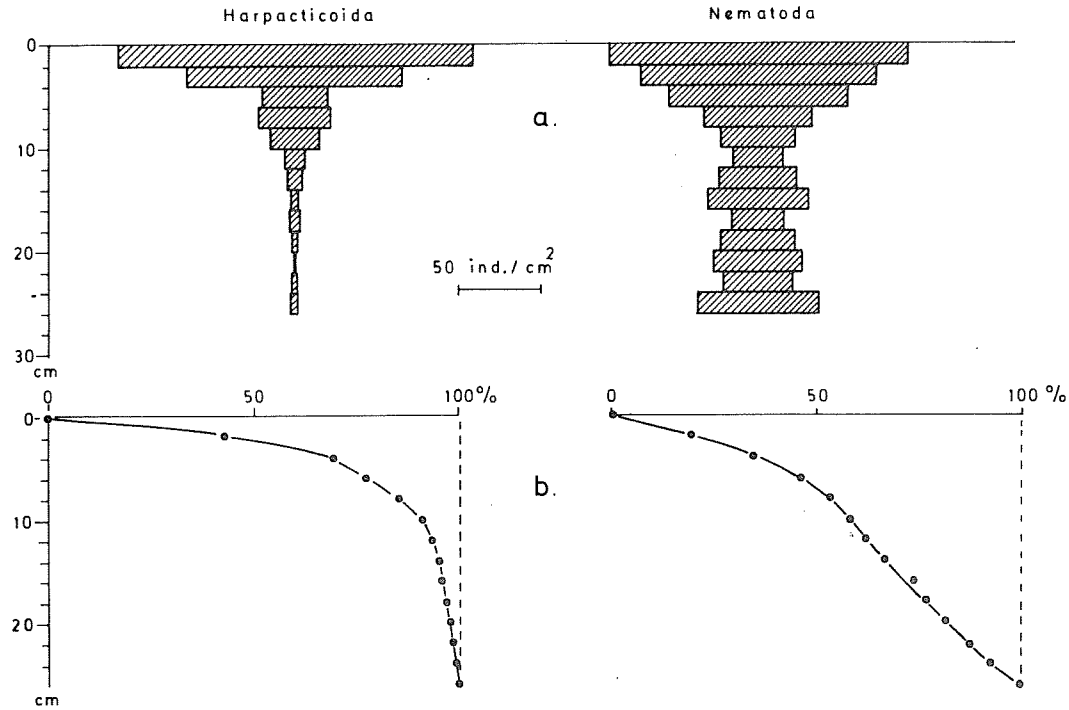

Fig. 1a: Vertical distribution of Nematoda and Harpacticoida. Mean of four cores.

Fig. 1b: Cumulative percentage of mean number in each layer.

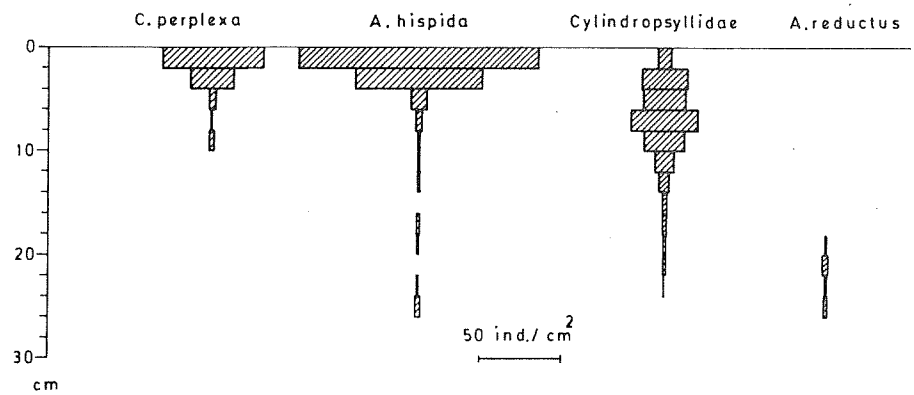

Fig. 2: Vertical distribution of the dominant copepod taxa. Mean of four coures.

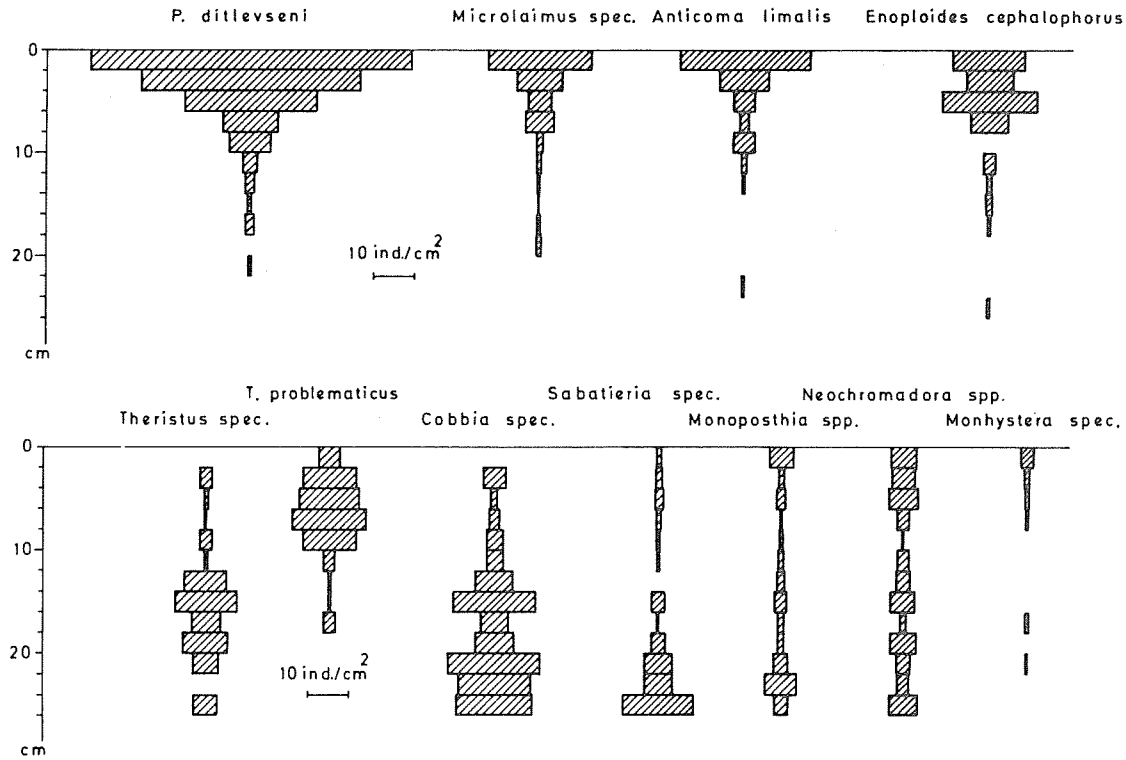

Fig. 3: Vertical distribution of the dominant nematode taxa. Mean of four cores.

Paraleptastacus espinulatus Nicholls, 1953 and *Stenocaris minuta* Nicholls, 1935. They show their maximum occurrence deeper in the sediment, although they remain in the oxidized zone. Of particular interest is the occurrence of *Apodopsyllus africanus listensis* Mielke, 1975, a species belonging to the Paramesochridae, in the anaerobic layers of the sediment.

Predominant among the nematodes is *Prochromadorella ditlevseni* (De Man, 1922) (Fig. 3), which is a typical surface dweller; other species occurring mainly in the surface layers are *Theristus problematicus* (Allgen, 1928), *Microlaimus spec.*, *Anticoma limalis* Bastian, 1865 , *Enoploides cephalophorus* (Ditlevsen, 1918) and probably *Monhystera spec.* The genus *Neochromadora* is represented by *N.poecilosoma* (De Man, 1893) and *N.poecilosomoides* (Filipjev, 1918); the genus as a whole does not seem to have any preference for a particular depth, although there might be differences between the species. The same may hold for the genus *Monoposthia*, mainly represented by *M.mirabilis* Schulz, 1932. Other species are typical for the deeper layers of the sediment: *Sabatieria spec.*, *Cobbia spec.* and *Theristus spec.* We hope to be able to determine these species more accurately in near future.

		LC	SC	VV	VVss
Nematoda + Harpacticoida					
	$\bar{x}$	135.27	113.31	98.32	95.23
	s^2	1312.43	701.86	135.94	773.86
	$s/\bar{x}$	0.27	0.23	0.12	0.29
Nematoda					
Total	$\bar{x}$	85.31	47.82	35.54	27.79
	s^2	437.88	183.06	82.26	37.73
	$s/\bar{x}$	0.52	0.28	0.26	0.22
P.ditlevseni					
P.ditlevseni	$\bar{x}$	20.30	15.14	21.45	13.42
	s^2	113.42	59.02	37.84	16.92
	$s/\bar{x}$	0.52	0.51	0.29	0.31
Harpacticoida					
Total	$\bar{x}$	49.95	65.48	62.76	66.64
	s^2	261.43	180.09	68.17	741.44
	$s/\bar{x}$	0.32	0.20	0.13	0.41
C.perplexa	$\bar{x}$	9.32	14.47	11.58	13.14
	s^2	49.91	13.63	0.56	26.37
	$s/\bar{x}$	0.76	0.26	0.06	0.39
A.hispida	$\bar{x}$	24.47	41.56	43.03	46.43
	s^2	59.76	78.34	89.37	311.94
	$s/\bar{x}$	0.32	0.21	0.22	0.38
Cylindropsyllidae	$\bar{x}$	15.45	8.74	7.58	6.35
	s^2	36.82	8.90	4.10	28.44
	$s/\bar{x}$	0.39	0.34	0.27	0.84

Table I. Mean $\bar{x}$, variance s^2 and variability $s/\bar{x}$ of the number per cm^2 of different meiobenthic taxa in four replicates of four sampling methods. LC = Large core, SC = small core VV = Van Veen, VVss = Van Veen subsample.

Nematoda + Harpacticoida

	LC	SC	VV	VVss
LC	-	0.98	1.94	1.75
SC	n.s.	-	1.04	0.94
VV	n.s.	n.s.	-	0.20
VVss	n.s.	n.s.	n.s.	-

Nematoda

	LC	SC	VV	VVss
LC	-	3.01	4.36	5.16
SC	+	-	1.51	2.54
VV	++	n.s.	-	1.23
VVss	++	+	n.s.	-

Prochromadorella ditlevseni

	LC	SC	VV	VVss
LC	-	0.75	0.16	1.21
SC	n.s.	-	1.16	0.39
VV	n.s.	n.s.	-	2.09
VVss	n.s.	n.s.	n.s.	-

Table II. Significance of difference between mean numbers as estimated by four different sampling methods. Value of t, d.f. = 6. LC = large core, SC = small core, VV = Van Veen, VVss = Van Veen subsample. n.s. = not significant, + = significant at 95% level, ++ = significant at 99% level.

Harpacticoida

	LC	SC	VV	VVss
LC	-	1.48	1.42	1.05
SC	n.s.	-	0.34	0.08
VV	n.s.	n.s.	-	0.27
VVss	n.s.	n.s.	n.s.	-

Canuella perplexa

	LC	SC	VV	VVss
LC	-	1.29	0.64	0.87
SC	n.s.	-	1.53	0.42
VV	n.s.	n.s.	-	0.60
VVss	n.s.	n.s.	n.s.	-

Asellopsis hispida

	LC	SC	VV	VVss
LC	-	2.91	3.04	2.28
SC	+	-	0.23	0.49
VV	+	n.s.	-	0.34
VVss	n.s.	n.s.	n.s.	-

Cylindropsyllidae

	LC	SC	VV	VVss
LC	-	1.98	2.46	2.25
SC	n.s.	-	0.64	0.78
VV	+	n.s.	-	0.43
VVss	n.s.	n.s.	n.s.	-

The number of animals in the large core was taken as reference to judge the accuracy of other sampling methods for two reasons: the large cores were taken to a greater depth, and their larger diameter should prevent the generation of shock waves when the diver approaches the bottom with the core.

In Table I the mean number of nematodes, copepods and the dominant species within these groups is given, together with the variance and variability obtained from the four replicates. The total number of nematodes is about 850.000 per m^2, which seems to be rather low when compared with recent literature values; the total number of copepods is about 500.000 per m^2, which is rather high. However, these are single estimates and it is outside the scope of this paper to comment further on them.

Comparisons of these density values using a t-test as described above are given in Table II. These comparisons lead to the following results: estimates of the total number of nematodes plus harpacticoid copepods are not significantly different, with all methods. However, the number of nematodes as obtained from the large core, is significantly larger than the numbers obtained by all other mehtods and numbers in the small core are also significantly larger than those obtained with the Van Veen grab directly or subsampled. It follows that the number of harpacticoids must be smaller in the large core and this is indeed the case but the difference is not significant. From this we may conclude that the Van Veen grab is as efficient to sample harpacticoids as are the other methods. When species are examined the situation does not remain quite the same as there is a difference between estimates obtained by the large core and estimates obtained by the small core and the Van Veen samples for the surface form *Asellopsis hispida* and between the large core and the Van Veen samples for the interstitial Cylindropsyllidae.

Another aspect that we investigated is the composition of the community. In Table III the relative abundance of representative species is given as obtained with the four different sampling methods. It is

	LC	SC	VV	VVss
Nematoda				
P.ditlevseni	23.8	31.7	60.4	48.3
Cobbia spec.	10.5	14.8	0.4	
Theristus spec.	7.2	0.7	0.0	
Sabatieria spec.	5.0	0.0	0.3	
Harpacticoida				
C.perplexa	16.0	21.1	18.6	19.9
A.hispida	49.4	63.7	68.1	70.7
Cylindropsyllidae	31.3	13.3	12.3	6.9

Table III. Relative abundance of selected meiofauna species from different sampling methods. LC = large core SC = small core, VV = Van Veen, VVss = Van Veen subsample.

P.ditlevseni (t-value; d.f. = 4 to 6)				
	LC	SC	VV	VVss
LC	-	1.23	8.34	6.34
SC	n.s.	-	4.39	2.97
VV	++	++	-	5.97
VVss	++	+	++	-
C.perplexa (t-value; d.f. = 6)				
	LC	SC	VV	VVss
LC	-	0.94	0.51	0.73
SC	n.s.	-	1.33	0.49
VV	n.s.	n.s.	-	0.66
VVss	n.s.	n.s.	n.s.	-
A.hispida (t-value; d.f. = 6)				
	LC	SC	VV	VVss
LC	-	3.15	3.59	5.19
SC	+	-	1.00	2.25
VV	+	n.s.	-	0.67
VVss	++	n.s.	n.s.	-
Cylindropsillidae (t-value; d.f. = 6)				
	LC	SC	VV	VVss
LC	-	3.73	3.70	4.09
SC	++	-	0.31	1.57
VV	+	n.s.	-	1.28
VVss	++	n.s.	n.s.	-

Table IV. Significance test of difference of relative abundance of selected meiofauna species. Mean of transformed values. LC = large core, SC = small core, VV = Van Veen, VVss = Van Veen subsample, n.s. = not significant, + = significant at 95% level, ++ = significant at 99% level.

clear that there is a large underrepresentation of all deep-layer nematodes in the Van Veen samples (which were lumped to calculate the values of Table III). In the large core the surface forms *Canuella perplexa* and *Asellopsis hispida* are relatively less abundant than in the other sampling methods, the Cylindropsyllidae are relatively more abundant in the large core. The significance of these differences was tested after transformation to arc $\sin\sqrt{x}$ using the t-test described above (Table IV). It follows that the surface form *Prochromadorella ditlevseni* is relatively overestimated by the Van Veen samples, but that there is no difference whether the small or the large core is used; the differences between the large core and the other sampling methods when *Asellopsis hispida* and the Cylindropsyllidae are concerned are significant.

DISCUSSION

In the sandy bottom at Archipel, the oxidized layer extends unusually deep into the sediment and this is reflected in the considerable depth to which copepods and nematodes penetrate; the number of nematodes in particular does not drop off significantly even at 23 m depth, although there is a distinct maximum in the surface layers.

Normally, nematodes do not often penetrate as deep in subtidal sediments as we found in lake Grevelingen. TEAL and WIESER (1966) found nematodes limited mainly to the upper 8 cm of subtidal substrates; BOUCHER (1972) and BOVÉE and SOYER (1974) also found nematodes almost exclusively in the upper 8 to 10 cm of terrigeneous muds in the Mediterranean. The same holds for subtidal sands. COULL (1974) found more than 90% of the total meiofauna in the upper 5 cm of the calcium carbonate sediments in Bermuda, nearly irrespective of the grain size. ARLT (1973) found only 8% of the total meiofauna in the deepest of the five 1 cm layers he investigated from a shallow sandy bottom in the Baltic.

Our quantitative results demonstrate that in the sediment studied the Van Veen grab is a suitable tool to sample harpacticoid copepod populations but that its use is not justified to sample nematode populations. In view of the unusual extension of these populations into the sediment, we may be fairly confident that this statement holds for the majority of substrates which can be sampled with the grab. This can be explained entirely by the depth to which the grab penetrates and this is demonstrated by the fact that there is no difference between figures from different sampling methods when surface forms are compared (*Canuella perplexa* and *Prochromadorella ditlevseni*) or when numbers of nematodes in the first four centimeter in the larger core are compared to other techniques (Table V), neither when numbers of nematodes in the first seventeen centimeter in the large core are compared to numbers in the small core. This also demonstrates that there is no effect of a possible shock wave.

Although more than 95% of all harpacticoids occur in the upper 17 cm of the large core, there appears to be a significant difference between results from this core and the small core when numbers of the surface species *Asellopsis hispida* are compared. The large core also has relatively more Cylindropsillidae and less surface forms than all other sampling methods. This is not readily explained but as there is no difference between the small core and the Van Veen samples, it does not invalidate the view that the Van Veen samples yield unbiased estimates of harpacticoid density and composition.

	LC 4	VV	VVss
LC 4	-	0.64	0.97
VV	n.s.	-	1.23
VVss	n.s.	n.s.	-

Table V. Significance of difference of mean numbers of nematodes in first 4 cm of large core and Van Veen samples. LC 4 = large core, VV = Van Veen, VVss = Van Veen subsamples. n.s. = not significant.

There is another point of interest in these comparisons. The mean coefficient of variation is much smaller in the Van Veen samples than in all other methods when copepods or total hard bodied meiofauna are compared (Table I). This has important consequences on the confidence interval of the estimates which will be much narrower when the latter are based on Van Veen samples. It seems that the crude method used causes the very desirable side-effect that the material is uniformised thereby lowering the variability of the populations due to natural occurring patchiness. Indeed, HEIP (1975, 1976b) has shown that many populations have a variability of around 0.27, and this is nearly the value found in three of the four sampling methods when the total hard-bodied meiofauna is considered. In most other cases, variability in the Van Veen samples is lowest.

In conclusion, estimates of copepod density obtained with a Van Veen grab are reliable and have a low coefficient of variation; for nematodes, densities should be multiplied by a conversion factor which in the case of the sandy sediment of lake Grevelingen can be estimated as 85.31 (density in large core): 35.54 (density in Van Veen) = 2.6.

ACKNOWLEDGEMENTS

For help in the field we would like to thank the crew of the Jan Verwey. Dr. P. Lippens (Diepenbeek, Belgium) has been of great help in the determination of the nematodes. Technical assistance was provided by A. Van Bost. The first author acknowledges a grant from the Belgian National Foundation of Scientific Research, the second author a grant from the Beyerinck-Popping fund. We are grateful to Drs. E.K. Duursma and P.H. Nienhuis for comments.

SUMMARY

Comparison of density estimates of Nematoda and Harpacticoida obtained by a Van Veen grab and SCUBA diving from a sandy sediment in shallow water shows that Harpacticoida are sampled efficiently with the grab but Nematoda are not. For the Nematoda, total density is underestimated and the relative abundance of surface-dwellers is overestimated.

Samples obtained with a Van Veen grab from which the material is collected in a bucket and subsampled afterwards have a much smaller statistical variability than samples obtained with other methods.

REFERENCES

ARLT, G., 1973. Vertical and horizontal microdistribution of the meiofauna in the Greifswalder Bodden. Oikos, suppl., 15: 105-11.

BARNETT, P.R.O., 1968. Distribution and ecology of harpacticoid copepods of an intertidal mudflat. Int.Rev.ges.Hydrobiol.Hydrogr. 53: 177-209.

BEUKEMA, J.J., 1974. The efficiency of the Van Veen grab compared with the Reineck box sampler. J.cons.int.Explor.Mer., 35: 319-27.

BOUCHER, G., 1972. Distribution quantitative et qualitative des Nématodes d'une station de vase terrigène côtière de Banyuls-sur-Mer. Cah.Biol.Mar., 13: 45-74.

BOVEE, F. de and J. SOYER, 1974. Cycle annuel quantitatif du meiobenthos des vases terrigènes côtières. Distribution verticale. Vie Milieu, série B, 24: 141-57.

BOVEE, F. de, J. SOYER and P. ALBERT, 1974. The importance of the mesh size for the extraction of the muddy bottom meiofauna. Limnol.Oceanogr., 19: 350-54.

COULL, B.C., 1970. Shallow water meiobenthos of the Bermuda platform. Oecologia, 19: 350-57.

ELMGREN, R., 1973. Methods of sampling sublittoral soft bottom meiofauna. Oikos, suppl., 15: 112-20.

GALLARDO, V.A., 1965. Observations on the biting profiles of three 0.1 m^2 bottom samplers. Ophelia, 2: 319-22.

HEIP, C., 1975. On the significance of aggregation in some benthic marine invertebrates. In: Proceedings of the 9th European Marine Biology Symposium, ed. H. Barnes, 527-38. Aberdeen University Press.

HEIP, C., 1976a. The life-cycle of *Cyprideis torosa* (Crustacea, Ostracoda). Oecologia, 24: 229-45.

HEIP, C., 1976b. On the relative abundance of natural populations. Biol.Jaarb., 44: 210-216.

LIE, U. and M. PAMATMAT, 1965. Digging characteristics and sampling efficiency of the 0,1 m^2 Van Veen grab. Limnol.Oceanogr., 10: 379-84.

TEAL, J.M. and W.W. WIESER, 1966. The distribution and ecology of nematodes in a Georgia salt marsh. Limnol.Oceanogr., 11: 217-22.

WOLFF, W.J., F. VEGTER, H.G. MUDER and T. MEYS, 1976. The production of benthic animals in relation to the phytoplankton production. Observations in the saline Lake Grevelingen. The Netherlands. In: Proceedings of the 10th European Marine Biology Symposium, ed. G. Persoone & E. Jaspers, 653-72. Universa Press, Wetteren, Belgium.