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ON A NEW BOTTOM-SAMPLER FOR INVESTIGATION OF THE MICRO FAUNA OF THE SEA BOTTOM

WITH REMARKS ON THE QUANTITY AND SIGNIFICANCE OF THE BENTHONIC MICRO FAUNA

BY

AUGUST KROGH AND R. SPÄRCK



KØBENHAVN

LEVIN & MUNKSGAARD

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While the benthonic macro fauna of the sea has in the last decades been subject to a series of investigations, especially by C. G. JOH. PETERSEN and his collaborators, we have until now only very little knowledge of the quantitative composition of the micro fauna of the sea bottom. This deficiency has certainly been caused by the lack of a suitable apparatus for taking samples for this purpose. Some years ago TH. MORTENSEN<sup>1</sup> (1925) described an apparatus for catching the micro fauna of the sea bottom; this apparatus has turned out to be very useful for collecting animals of several groups, as for instance free living *Nematoda*, *Ostracoda*, bottom *Copepoda*, *Cumacea* etc., as it is obvious from the investigations of REMANE<sup>2</sup> (1933) in the Bay of Kiel, but it does not give any information regarding the quantity of the said micro fauna. As it may be of importance to our conception of the production and metabolism of the sea to know the rôle of the micro fauna in these processes we have been anxious to elaborate an apparatus for this purpose.

After several trials we have arrived at the construction shown in fig. 1 and 2. It consists of a brass frame which can be loaded with lead weights. Six arms carrying brass

<sup>1</sup> TH. MORTENSEN: An apparatus for catching the micro fauna of the sea bottom. (Vid. Medd. **80**, 1925).

<sup>2</sup> A. REMANE: Verteilung und Organisation der Benthonischen Microfauna der Kielerbucht. (Wiss. Meeresunters. N. F. **21**, Abt. Kiel 1933).

tubes of 40 cm. length and 35 mm. inside diameter are provided. These arms are interchangeable and the apparatus can work with 2, 3, 4 or 6 according to the character of the bottom. Each metal tube carries a rubber valve allowing water to pass out. The bottom samples are taken into celluloid tubes of 50 cm. length, 28 mm. inside and 33 mm. outside diameter securely fastened in the metal tubes by means of rubber tubing. The right dimensions for these tubes have

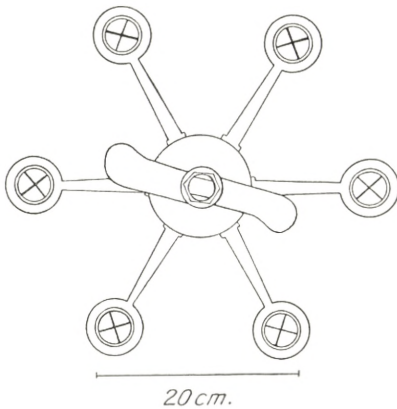


Fig. 1.

been adjusted by trial to conditions in Danish waters. Narrower tubes will give smaller samples and from wider tubes the bottom material is likely to drop out, especially when the sampler is lifted out of the water.

When the apparatus strikes the bottom the tubes penetrate to a certain depth. The load and the number

of tubes should be so adjusted that this depth is at least 10—15 cm.

When the sampler gets on board the celluloid tubes are immediately stoppered and removed (the valves must be kept open during this process) and when fresh tubes are inserted the sampler is again ready for use.

Each sampling tube now contains a column of undisturbed bottom material. The upper ends are also closed and the tubes which must be kept in a vertical position can be brought to the laboratory. The bottom animals will keep alive for several hours at room temperature, but whenever possible they should be kept in a refrigerator at 2°—4°.

The sorting out of the micro fauna has been made in the following way. The water column has first been drawn from the tube by means of a siphon into flat dishes where it can be investigated with a binocular microscope. Then the column of bottom material is forced by means of a rubber piston to the upper end of the tube, and when it reaches about 1 cm. over the upper edge of the tube a slice of bottom material 1 cm. thick is cut off. In some cases it may perhaps be more practical to drive the material the other way out, which can be effected by applying air pressure to the column by means of a bicycle pump.

We have found that by far the greater part of the micro fauna is present in this upper layer of the bottom. This slice is

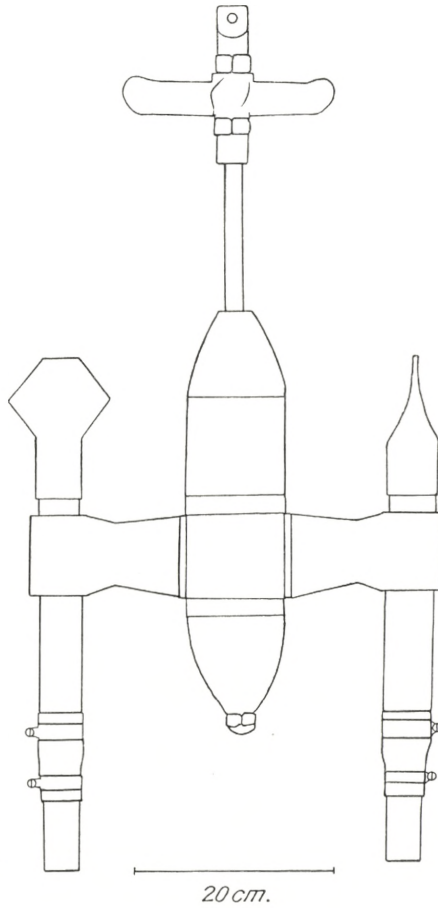


Fig. 2.

washed into sea water and is then sifted through a sieve with a size of meshes of about 0.5 mm. By this process the larger specimens of the micro fauna are kept back. The water and bottom material going through this sieve are then examined in small glass dishes with a binocular microscope at a mag-

Table 1. Numbers and weights in grammes per sq. m. of  
of the harbour

Dates of collecting . . . . .	26. VIII. 1935		2. IX. 1935		25. IX. 1935	
	Number per sq. m.	Weight per sq. m.	Number per sq. m.	Weight per sq. m.	Number per sq. m.	Weight per sq. m.
Names of groups						
Prosobranchiata (Hydrobia) . . . . .	10600	6 g.	37000	22 g.	30000	18 g.
Opisthobranchiata . . . . .	...	...	...	...	200	0.3 g.
Small Lamellibranchiata . . . . .	800	0.8 g.	800	0.8 g.	800	0.8 g.
Isopoda . . . . .	...	...	...	...	200	0.4 g.
Amphipoda . . . . .	800	1.4 g.	600	1 g.	1000	1.7 g.
Copepoda . . . . .	1600	0.2 g.	2600	0.3 g.	2200	0.3 g.
Polychæta . . . . .	1800	2 g.	1200	1.2 g.	200	0.2 g.
Oligochæta . . . . .	5800	5.8 g.	1200	12 g.	3600	3.5 g.
Nematoda . . . . .	37000	3.7 g.	47000	4.7 g.	25000	2.5 g.
Turbellaria . . . . .	...	...	1000	0.7 g.	1600	1 g.
Infusoria . . . . .	600	0.6 g.	400	0.3 g.	200	0.1 g.
Foraminifera . . . . .	...	...	...	...	...	...
Total . . . . .	59000	20.5 g.	91800	43.0 g.	65000	28.8 g.

nification of about 20. Deeper than 1 cm. only *Polychæta*, *Oligochæta* and *Nematoda* are found in larger quantities. Therefore it is sufficient to strain the rest of the column through a sieve which will retain these forms. Before this sifting the bottom material is washed into fresh water; by this process the Nematodes uncoil so that they can be kept back in the sieve together with the larger animals.

In the last few years we have used this apparatus in a number of cases and in different parts of Danish waters. In most cases we have succeeded in getting suitable samples in localities where the bottom consisted of clay or mud; and in the autumn and winter 1935—36 we have made a more regular investigation at some localities in the Sound. In the following we shall give some main results of this investi-



the micro-fauna at a depth of 5.5 m. in the outer basin of Copenhagen.

10. XII. 1935		18. XII. 1935		23. I. 1936		27. I. 1936	
Number per sq. m.	Weight per sq. m.	Number per sq. m.	Weight per sq. m.	Number per sq. m.	Weight per sq. m.	Number per sq. m.	Weight per sq. m.
22600	13.5 g.	16000	11.6 g.	52000	31.0 g.	29000	18.0 g.
...	...	...	...	...	...	...	...
200	0.2 g.	200	0.2 g.	800	0.8 g.	1200	1.2 g.
...	...	...	...	400	0.5 g.	1600	2.0 g.
200	0.2 g.	800	1.0 g.	...	...	400	0.4 g.
1000	0.1 g.	3600	0.4 g.	2800	0.3 g.	7800	0.8 g.
200	0.5 g.	2200	6.0 g.	1400	2.8 g.	1000	1.7 g.
12600	13.0 g.	14000	14.0 g.	17000	17.0 g.	26000	26.0 g.
43000	4.3 g.	53600	5.4 g.	71000	7.0 g.	66000	6.6 g.
400	0.4 g.	1000	1.0 g.	400	0.4 g.	1000	1.0 g.
200	0.1 g.	...	...	...	...	200	0.1 g.
...	...	200	0.1 g.	1400	0.7 g.	200	0.1 g.
80400	32.3 g.	91600	39.7 g.	147200	60.5 g.	134400	57.9 g.

gation to show the applicability of the apparatus. The sorting out of the material from this investigation has been made by Mag. sc. HOLGER MADSEN, and the technique of sorting out described above is due to him.

The localities which have been specially investigated are the outer deep basin of the harbour of Copenhagen, where the samples have been taken at a depth of 5.5 m., and a locality in the Sound a little northwest of Middelgrunden, where the samples were taken at 17 m. At these two localities samples have been taken at intervals from the end of August 1935 to the end of January 1936, besides samples have been taken also from greater depths in the Sound, maximum 56 m. The results of this investigation are shown in tables 1—3.

Table 2. Numbers and weights in grammes per sq. m. of the micro-fauna at a depth of 17 m. in the Sound.

Dates of collecting . . . . .	1. X. 1935		3. XII. 1935		5. I. 1936	
Names of groups	Number per sq. m.	Weight per sq. m.	Number per sq. m.	Weight per sq. m.	Number per sq. m.	Weight per sq. m.
Prosobranchiata . . . . .	800	0.5 g.	...	...	1200	0.7 g.
Opisthobranchiata . . . . .	800	0.8 g.	...	...	200	0.2 g.
Small Lamellibranchiata..	200	0.2 g.	...	...	...	...
Small Echinocardium cor- datum . . . . .	200	0.2 g.	...	...	...	...
Holothurioidea . . . . .	...	...	...	...	200	0.2 g.
Halacaridæ . . . . .	200	0.1 g.	400	0.2 g.	2600	0.3 g.
Cumacea . . . . .	200	0.3 g.	400	0.6 g.	...	...
Ostracoda . . . . .	1400	1.5 g.	600	0.6 g.	1600	1.5 g.
Copepoda . . . . .	14500	1.5 g.	13000	1.3 g.	13000	1.3 g.
Polychæta . . . . .	1800	4.0 g.	1600	3.6 g.	6200	11.0 g.
Oligochæta . . . . .	1000	1.0 g.	...	...	11000	11.0 g.
Nematoda . . . . .	87000	8.7 g.	39000	3.9 g.	46000	4.6 g.
Kinorhyncha . . . . .	400	0.1 g.	...	...	...	...
Turbellaria . . . . .	1000	0.7 g.	1000	0.7 g.	3400	2.2 g.
Infusoria . . . . .	...	...	800	0.6 g.	...	...
Foraminifera . . . . .	...	...	200	0.1 g.	7000	3.5 g.
Total . . . . .	109500	19.6 g.	57000	11.6 g.	52400	36.5 g.

The weighings have been made in the following way: A number (5, 10 or 20) of the different size categories in each group has been weighed and "average weight" of the group has been determined in this way. The animals have been weighed in alcohol preserved condition: they have been taken out of the alcohol, superficially dried on filter paper and then weighed. To the weights found have been added 10 per cent. and the weight thus found is to be regarded as the weight of the living animal. According to the experience of the Danish Biological Station the alcohol weight augmented by 10 per cent. is equal to the weights of the living animal.

Table 3. Numbers and weights in grammes per sq. m. of the micro-fauna at depths of 26 and 54 m. in the Sound.

Date of collecting.....	7. X. 1935 depth 26 m.		7. X. 1935 depth 54 m.	
	Number per sq.m.	Weight per sq.m.	Number per sq.m.	Weight per sq.m.
Names of groups				
Small Lamellibranchiata..	2200	2.2 g.	2800	2.8 g.
Ostracoda.....	1400	1.5 g.	...	...
Copepoda.....	2200	0.3 g.	...	...
Polychæta.....	1400	3.0 g.	2800	6.0 g.
Oligochæta.....	2200	2.2 g.	...	...
Nematoda.....	47000	5.0 g.	70000	7.0 g.
Turbellaria.....	400	0.3 g.	...	...
Infusoria.....	2200	1.0 g.	...	...
Foraminifera.....	177000	75.0 g.	2800	1.6 g.
Total...	236000	90.5 g.	78400	18.4 g.

In the weights of the molluscs and Foraminifera are included the weight of the shells.

Regarding the distribution of the animals in the different tubes of the apparatus we can refer to table 4. It will be seen from this table that the variations from tube to tube are not greater than each tube will show which of the groups are really common. When we have chosen 6 tubes it is because in this way we can obtain a fairly large material of the rarer groups represented by one or two specimens in each tube.

In spite of the rather few samples of this preliminary investigation it is evident from the tables that the micro fauna on the sea bottom is composed of 50000 to about 200000 individuals per sq. m. Numerically it is consequently far greater than the macro fauna, as was to be expected.

Table 4. Number of specimens in each of the 6 tubes in a single sample (taken in the sound 27. XI. 1935 at a depth of 12 m.).

Name of groups	Tube	Tube	Tube	Tube	Tube	Tube	Total
	1	2	3	4	5	6	
Opisthobranchiata .....	..	..	1	..	..	..	1
Small Lamellibranchiata..	..	1?	..	..	..	1	2
Halacaridæ .....	..	..	2	1	..	..	3
Ostracoda .....	..	1	..	1	..	..	2
Harpacticoidæ.....	} 5	8	3	4	5	5	30
Cyclopoidæ .....							
Polychaeta .....	..	1	1	2	3	1	8
Oligochaeta .....	..	1	1	2	..	..	4
Nematoda .....	47	40	9	41	19	24	180
Turbellaria .....	1	..	2	3	2	..	8
Infusoria .....	..	..	1	2	1	1	5
Foraminifera .....	..	20	20	1	..	5	46

Also regarding the weights the micro fauna proves to be of some importance. The weights vary from 11 to 90 gr./sqm. It seems that the weights are generally a little higher in the samples taken at 5.5 m. compared to those taken at greater depths. However a sample from 26 m. shows the highest value, but this is only due to the very great number of *Foraminifera*. In the papers of PETERSEN (1913) and BLEGVAD (1932)<sup>1</sup> we can find information concerning the macro fauna of the same regions. It appears from these papers that the quantity of the macro fauna at depths of about 5 to 10 m. off the Harbour of Copenhagen is 4—500 g., the number of specimens 7—800 on an average. At 5.5 m. the quantity of the micro fauna is 40 g. and 80000 individuals per sq. m. on an average. It seems thus that the micro fauna represents about 10 per cent. of the macro fauna in the said locality.

<sup>1</sup> In Rep. Dan. Biol. Stat. 21 & 37.

At greater depths in the Sound the macro fauna according to the investigations of PETERSEN seems to show quantities of about 200 g. per sq. m. The 3 samples from 17 m. show a micro fauna of 25 g per sq. m. on an average. Also in this case the micro fauna seems to represent about 10 per cent. of the macro fauna. It is likely that the oxygen consumption of the species making up the micro fauna is at least 3 to 4 times larger per g. than that of the macro fauna, and the importance of the micro fauna to the metabolism of the sea bottom must therefore be considered much larger than 10 per cent., probably about 40 per cent.

From the investigations of the fauna of the forest soil by BORNEBUSCH (1930)<sup>1</sup> it appears that in the soil rather big species, as f. inst. earthworms, constitute the greater part of the weight of living animals and consequently they also play the greatest rôle to the metabolism even if they occur in rather small numbers per sq. m. Also in the sea bottom it seems to be animals of the medium size as *Polychæta* and *Lamellibranchiata* whose individual weights are a few grammes, which are responsible for most of the metabolism, even if the rôle of the micro fauna is not quite unimportant. If we regard the micro fauna it is obvious from the tables that not the *Nematoda*, which in nearly all the samples are numerically by far the most predominant, but the *Oligochæta*, *Polychæta* and *Prosobranchiata* are the most important from a metabolism point of view.

Even if we do not intend at the present time to discuss more in detail the qualitative differences between the samples from the different depths we shall point out some conspicuous features.

In the samples from 5.5 m. small *Prosobranchiata* play a

<sup>1</sup> The Fauna of Forest Soil. Diss. Copenhagen.

very important rôle, further the occurrence of *Amphipoda*, *Isopoda* and many *Oligochæta* is characteristic of this depth. At medium depths (17 m.) the *Amphipoda* and *Isopoda* disappear, the *Prosobranchiata* are quite insignificant and *Oligochæta* are of smaller consequence. At this medium depth *Copepoda* and *Polychæta* play a greater part and also *Halacaridæ*, *Cumacea* and *Ostracoda* are of a certain importance. At still greater depths the *Foraminifera* seem to be important, whereas the rôle of the other groups seems to be decreasing. The greatest number of species is found at a depth of 17 m. Even if we have not yet made any exact determination it can however be said at the present time that it is in part different species of *Nematoda* which occur at different depths.

From the above mentioned we have arrived at the conclusion that by means of the described apparatus it will be possible to make thorough investigations of the micro fauna on soft bottom and to make out communities on a quantitative basis similar to the communities of the macro fauna described by PETERSEN. Further we believe that by means of this apparatus it will be possible to determine the importance of the micro fauna to the metabolism at different depths and in different localities in the waters.

(From the Laboratory of Zoophysiology, Copenhagen University).

# BIOLOGISKE MEDDELELSER

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