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SOFT MEIOFAUNA OF SAND FROM THE DELTA REGION OF THE RHINE, MEUSE AND SCHELDT*

by

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CONTENTS

I. INTRODUCTION

This paper deals with the Cnidaria (3 species), larger Turbellaria (39), Gastrotricha (16) and Annelida (13) found during an initial survey of the soft meiofauna of sand, mainly beach, sediments in the Delta area between Hoek van Holland and the Westerschelde. Most of the species found had not previously been recorded in the Netherlands.

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II. MATERIAL AND METHODS

One hundred and twenty-nine samples were examined between 1st and 29th September 1967. Most samples consisted of about 500 ml of sand taken from the surface 5 cm of sediment. Although few specimens were found below this depth, samples were taken down to the ground water level in several beaches. A few samples were taken by grab in deeper water.

Sampling sites (Fig. 1) and samples are consecutively numbered for later reference. The approximate tidal levels (+ indicating slightly

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above this level, – slightly below, ½ midway between the specified levels and G from the ground water zone) or the approximate depth if the samples were dredged are listed below; the samples from the enclosed Veerse Meer are numbered in order of level from low to high. The arithmetical median grain size and the chlorinity of the interstitial water are added when known.

Surface samples

1. Biesbos, Buitenkooigat: 1.1 LWN; 1.2 LWN+.

2. Biesbos, Dood: 2.1 MTL½HWN, 0.30 Cl; 2.2 MTL½HWN; 2.3 MTL½HWN; 2.4 MTL½HWN, 0.29 Cl.

3. Biesbos, opposite Ganzewei: 3.1 LWN, 162 μm; 3.2 LWN; 3.3 MTL.

4. Biesbos, Groot Malta: 4.1 LWN+; 4.2 163 μm; 4.2 MTL.

5. Biesbos, opposite Groot Malta: 5.1 LWN+; 5.2 LWN+ G; 5.3 HWN–.

6. Biesbos, Kleine Koekoek: 6.1 LWN–; 6.2 LWN+; 6.3 MTL; 6.4 MTL+; 6.5 HWN–; 6.6 HWN– G.

7. Dintelsas: 7.1 MTL, 262 μm, 9.5 Cl.

8. Galathese Haven: 8.1 LWN–, 14.0 Cl; 8.2 LWN+; 8.3 MTL; 8.4 MTL½HWN; 8.5 HWN.

9. Goeree, eastside Punt: 9.1 MTL–, 17.05 Cl; 9.2 MTL+, 266 μm, 12.98 Cl; 9.3 HWN, 16.07 Cl.

10. Goeree, westside Punt: 10.1 LWN–, 207 μm, 15.87 Cl; 10.2 LWN+, 211 μm, 15.87 Cl; 10.3 LWN++, 225 μm, 16.66 Cl; 10.4 MTL, 223 μm, 14.00 Cl; 10.5 HWN, 243 μm, 15.46 Cl.

11. Grevelingendam, eastside (Krammer): 11.1 LWN–, 16.16 Cl; 11.2 LWN+, 170 μm, 11.35 Cl; 11.3 LWN++, 12.49 Cl; 11.4 MTL, 177 μm, 14.77 Cl; 11.5 MTL+, 15.42 Cl; 11.6 MTL½HWN, 16.41 Cl.

12. Grevelingendam, westside (Grevelingen): 12.1 LWN; 12.2 LWN; 12.3 MTL; 12.4 MTL+.

13. Hellegatsplein (Haringvliet): 13.1 LWN, 295 μm, 2.21 Cl; 13.2 LWN–, 135 μm, 3.83 Cl; 13.3 LWN+, 1.3 Cl; 13.4 MTL, 162 μm, 1.03 Cl; 13.5 MTL G, 1.3 Cl; 13.6 MTL½HWN, 143 μm, 2.22 Cl; 13.7 MTL½HWN G, 2.2 Cl; 13.8 HWN, 1.88 Cl; 13.9 HWN G, 1.8 Cl.

14. Krabbenkreek, Dwars in de Weg: 14.1 LWN–, 173 μm, 16.84 Cl; 14.2 LWN, 180 μm, 16.99 Cl; 14.3 LWN+, 180 μm, 16.13 Cl; 14.4 MTL 163 μm, 16.54 Cl.

15. Krammerse Slikken, south of Oude Tonge: 15.1 LWN–, 18.51 Cl; 15.2 LWN+, 236 μm, 14.5 Cl; 15.3 MTL, 14.69 Cl; 15.4 MTL+, 14.01 Cl.

16. Kwadehoek: 16.1 LWN–, 2.16 μm, 16.37 Cl; 162 LWN+,

222 μm, 12.40 Cl; 16.3 MTL, 220 μm, 10.14 Cl; 16.4 MTL, 222 μm, 10.5 Cl; 16.5 MTL+, 215 μm, 10.51 Cl.

17. Oosterscheldebrug, southside: 17.1 LWN, 160 μm, 17.34 Cl; 17.2 LWN, 165 μm; 17.3 LWN+, 16.22 Cl; 17.4 MTL, 160 μm, 17.19 Cl; 17.5 MTL G.

18. Oranjezon: 18.1 LWN, 322 μm, 17.68 Cl; 18.2 LWN+, 310 μm, 17.5 Cl; 18.3 MTL−; 18.4 MTL+.

19. Veerse Meer, near Kamperland: 19.1; 19.2, 1.87 Cl; 19.3.

20. Veerse Meer, Schotsman: 20.1, 247 μm, 10.33 Cl; 20.2; 20.3; 20.4, 335 μm, 10.0 Cl; 20.5.

21. Veerse Meer, near Arnemuiden: 21.1; 21.2, 265 μm; 21.3, 0.21 Cl; 21.4 G.

22. Voorne, Groene Punt: 22.1 LWN, 176 μm, 8.0 Cl.

23. Vrouwenpolder: 23.1 LWN−, 17.0 Cl; 23.2 LWN+, 265 μm, 17.48 Cl; 23.3 LWN+; 23.4 MTL−, 215 μm, 17.48 Cl; 23.5 MTL, 280 μm, 17.35 Cl; 23.6 MTL G; 23.7 MTL+; 23.8 MTL+ G.

24. Westnol: 24.1 LWN−, 140 μm, 17.38 Cl; 24.2 LWN+, 170 μm, 17.38 Cl; 24.3 MTL−, 132 μm, 17.32 Cl; 24.4 MTL, 175 μm, 16.21 Cl; 24.5 MTL, 180 μm, 17.0 Cl; 24.6 MTL½HWN, 215 μm, 18.29 Cl; 24.7 MTL½HWN G; 24.8 HWN, 16.24 Cl; 24.9 HWN G.

25. Yerseke: 25.1 LWN−, 205 μm, 17.31 Cl; 25.2 LWN−, 220 μm, 17.11 Cl; 25.3 LWN+, 222 μm, 17.27 Cl; 25.4 MTL−, 195 μm, 17.26 Cl; 25.5 MTL, 220 μm, 17.35 Cl; 25.6 MTL+.

Boat samples

26. Brabants Vaarwater BV20: 26.1, 2 m, 210 μm, 15.0 Cl; 26.2, 4 m, 210 μm, 15.0 Cl; 26.3, 8 m, 240 μm, 15.0 Cl.

27. Engelse Vaarwater (or Eendracht?) EK: 27.1, 1 m.

28. Grevelingen G4: 28.1, 4 m, 245 μm, 17.0 Cl.

29. Grevelingen G5: 29.1, 0 m, 230 μm, 16.0 Cl.

30. Grevelingen G7: 30.1, 2 m, 170 μm, 16.0 Cl; 30.2, 5 m, 172 μm, 16.0 Cl; 30.3, 8 m, 151 μm, 16.0 Cl.

31. Overloop van Hansweert OH5: 31.1, 3.5 m, 145 μm, 12.5 Cl; 31.2, 5 m, 12.5 Cl; 31.3, 8.5 m, 12.5 Cl.

32. Westerschelde 7: 32.1, 3 m, 263 μm, 15.0 Cl; 32.2, 6 m, 228 μm, 15.0 Cl; 32.3 11 m, 196 μm, 15.0 Cl.

The fauna was extracted by narcotizing in 7% $MgCl_2$ for 7 minutes in a large flask then shaking vigorously and decanting the supernatant just as the sand resettled. The fluid was poured through fine plankton netting; the process repeated with fresh $MgCl_2$ and then with sea water. The netting was then inverted and the trapped organisms washed into a petri dish with seawater. This process gives a semi-quantitative col-

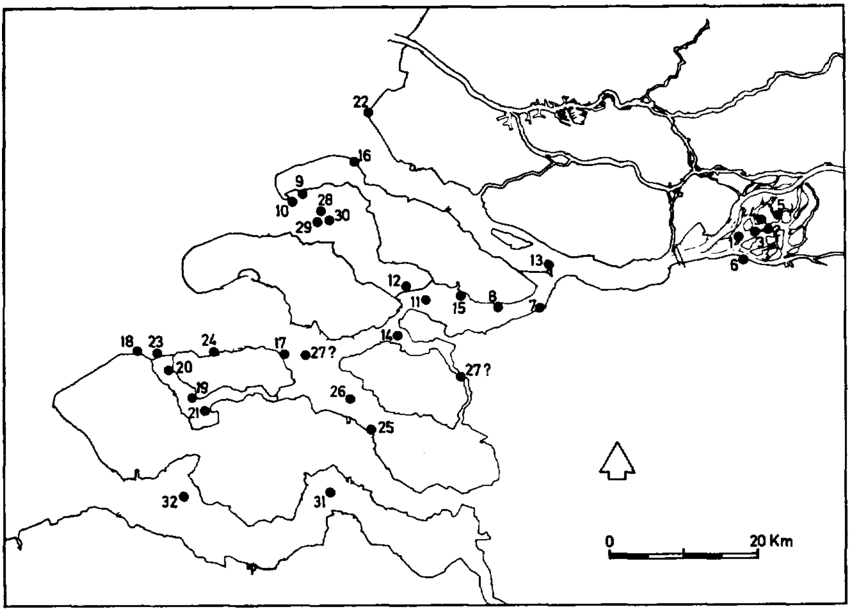

Fig. 1. Map of Delta region indicating sampling sites.

lection of soft metazoan taxa. The fauna was sorted under a stereomicroscope, transferred to slides and identified under a research binocular microscope.

Chlorinity determinations were by titration, and granulometric analyses by % weight from dry sieving. These determinations were made by Mr J. Nieuwenhuize.

III. FAUNA

The name and authority of each species is given followed by the sample number (see foregoing chapter) and the approximate abundance (R rare, L occasional, C common, A abundant and S superabundant; y denotes that only young specimens were found, ? a doubtful identification).

Cnidaria

Halammohydra octopodides Remane: 25.1L, 28.1?Ry, 32.1C. Three of the smaller specimens (< 400 μm) which bore whorls of 4 and 8 tentacles had only 3 statocysts.

Halammohydra vermiformis Swedmark & Teissier: 25.1R. This species has previously been reported from the Netherlands by WOLFF, SANDEE & STEGENGA (1974).

Protohydra leukartii Greef: 25.1R.

Gnathostomulida

Gnathostomula paradoxa Ax: 25.5R.

Turbellaria

Carcharodorhynchus subterraneus Meixner: 11.6A, 12.3R, 9.1R, 25.3?R, 25.4R.

Cheliplana boadeni Schilke: 10.3R, 23.4R.

Cheliplana stylifera Karling: 14.1L, 14.2R.

Cheliplanilla caudata Meixner: 11.4R, 14.1C, 14.2C, 14.3L, 16.1C, 16.2L, 17.4R, 24.6R.

Cicerina brevicirrus Meixner: 11.2C, 11.3R, 11.4L, 11.5R, 12.2R, 12.3L, 12.4C, 14.3C, 16.1C, 16.2L, 24.2R, 24.4R, 24.5L, 24.6L.

Cicerina remanei Karling: 9.1R, 9.2R, 10.2L, 10.3R, 18.1R, 25.1R, 25.2R, 25.5L, 30.2?Ry, 32.1R.

Cicerina tetradactyla, Giard: 10.1R, 10.2L, 10.3L, 14.1R, 14.2R, 14.3L, 16.1R, 16.2C, 16.4L, 23.4Ry, 28.1L, 29.1L.

Coelogynopora aculeata Ax: 32.2R, 32.3R.

Coelogynopora biarmata Steinbock: 7.1A.

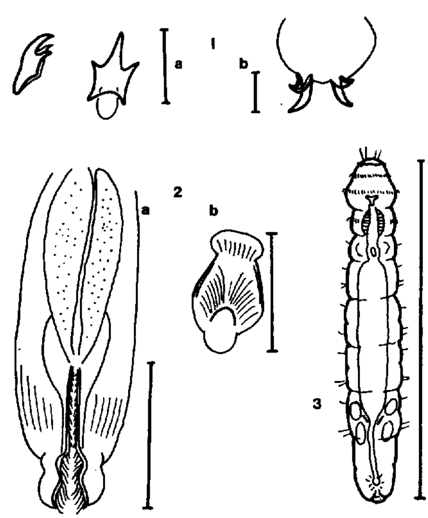

Fig. 2. 1. Gnathorhynchid, proboscis teeth, 8.5 μm (a) and male armament, 22 μm (b). 2. *Thylacorhynchus* sp., penis with cirrus, 70 μm (a) and vesicle of vagina externa, 52 μm (b). 3. *Trilobodrilus axi,* male showing two pairs of testes and a pair of protonephridia, 830 μm.

Diascorhynchus rubrus Boaden: 10.1C, 25.3R, 30.1L, 30.2L, 30.2R, 32.1R.

Gnathorhynchid: 16.1R, 16.3R. Only one of the specimens was mature. The species has a pair of eyes, two distinct testes and vitellaria and a single ovary. A rough sketch of the proboscis teeth and the male armament is given (Fig. 2).

Gyratrix hermaphrodita Ehrenberg: 24.2R, 30.2R.

Limirhynchus danicus? Schilke: 14.1C, 14.2R, 16.1L, 16.2L, 17.2R, 22.1R, 25.4C, 28.1R. The species seems to agree fairly well with the description by SCHILKE (1970) except for a transverse body septum posterior to the brain which is more characteristic of the genus *Schizorhynchoides*. The proboscis reaches 112 μm but the stylet is shorter than in SCHILKE's description (60 μm compared with 90 μm).

Nematorhynchus parvoacumine Schilke: 14.3R.

Neoschizorhynchus longipharynggus Schilke: 14.1R, 14.3R.

Opisthocystis goettei Bresslau: 12.1R, 12.2R, 12.4C.

Paracicerina maristoi Karling: 14.3R, 16.1L, 25.3L, 25.4R, 26.3R.

Placorhynchus octoaculeatus Karling: 8.1R, 8.2R, 16.2R, 16.3L.

Promonotus schultzei Meixner: 20.4A, 20.5L, 32.2L.

Proschizorhynchus oculatus Meixner: 12.3C, 16.1L, 16.4?Ry, 20.1R, 20.4L, 21.1A.

Proschizorhynchus pectinatus l'Hardy: 24.2R, 25.4R, 25.5R.

Proschizorhynchus triductibus Schilke: 18.1R, 23.4R, 25.1R, 25.2L, 25.3R, 26.1?C, 26.2?L.

Psammorhynchus tubulipenis Meixner: 12.3R, 10.1R, 18.2R, 25.5L, 25.6R, 32.1R.

Rhinepera remanei Meixner: 12.3R, 9.2L, 10.4L, 14.3R, 18.1R, 23.4L, 23.5L, 25.3R, 25.4C, 32.2?Ry.

Schizochilus choriurus Boaden: 23.6R, 25.1R, 25.3R.

Schizochilus marcusi Boaden: 18.1R.

Schizorhynchoides aculeatus l'Hardy: 23.6L.

Schizorhynchoides coronostylus Boaden: 18.1R.

Schizorhynchoides meixneri Boaden: 10.1A, 10.4R, 17.2C, 17.3L, 17.4R, 25.1L, 26.3L, 28.1L, 32.1R, 32.2R, 32.3R.

Thylacorhynchus arcassonensis Beauchamp: 9.2C, 16.2L, 16.3L, 16.4C. The specimens accord well with the redescription by SCHILKE (1970).

Thylacorhynchus conglobatus Meixner: 14.1R, 14.2L, 18.2R, 25.4L, 28.1C.

Thylacorhynchus sp.: 10.1Ry, 10.2R, 10.3R, 18.2R, 29.1L. This species is very close to *T. ambronensis* Schilke but the male cirrus is always shaped more like a thistle-funnel than a straight cylinder and the vagina externa is relatively narrower (Fig. 2). The species is therefore either a distinct form or a closely related sister-species, but this question cannot be resolved without further material and detailed examination of the internal anatomy.

Trigonostomum neocomense? (Fuhrmann): 2.2R, 2.3R, 5.3R.

Uncinorhynchus flavidus Karling: 15.2R.

Utelga scotica Karling: 11.4R, 11.5L.

Vejdovskya ignava Ax: 20.4R, 20.5C.

Zonorhynchus salinus Karling: 24.4L.

Gastrotricha

Aspidiophorus marinus Remane: 25.5R. Previously reported from the Netherlands by ZANEVELD (1938).

Cephalodasys turbanelloides (Boaden): 10.3R, 26.1L, 26.2L, 26.3Cy, 29.1R, 32.1L, 32.2R.

Cephalodasys littoralis Renaud-Debyser: 23.2R.

Chaetonotus linguaeformis? Voigt: 2.2R.

Chaetonotus maximus Ehrenberg: 4.2R.

Heterolepidoderma armatum Schrom: 13.6L.

Heterolepidoderma marinum Remane: 30.2R.

Macrodasys buddenbrocki Remane: 12.3R, 9.1?Ry, 25.5L, 25.6L.

Macrodasys remanei Boaden: 18.1R, 25.2R, 25.3L.

Neodasys chaetonotoides Remane: 10.3R, 14.1L, 14.2R, 14.3R, 24.2R, 24.4R, 25.1R, 25.3R, 26.1A, 26.3R.

Paraturbanella teisseri Swedmark: 26.3L, 32.1R.

Pleurodasys megasoma Boaden: 26.3R.

Turbanella ambronensis Remane: 10.4L.

Turbanella cornuta Remane: 25.2C, 25.3R, 25.5L, 26.1R, 32.1L.

Turbanella hyalina Schultze: 10.2A, 14.1C, 14.2C, 14.2L, 14.3L, 14.4R, 17.2C, 20.1C, 24.5A, 24.6A, 29.1L, 30.1R. This was the commonest gastrotrich encountered during the survey being even more abundant than *Neodasys*. It has been previously reported from Scheveningen by ZANEVELD (1938).

Turbanella mustela Wieser: 10.4L. This species was originally described by WIESER (1957) from Puget sound on the Pacific Coast of the United States, however the specimens found agree well with the original description.

Annelida

Aelosoma sp.: 1.2R, 2.2R, 2.3R, 3.1R, 3.2L, 4.1L, 4.2R, 4.3R, 5.2R, 6.1C, 6.2L, 6.3L, 6.4C. The species apparently occurs in coarse to medium sediments throughout the Biesbos, and was more frequent than *Rheomorpha*, the only other oligochaete recorded during the survey.

Ctenodrilus serratus (O. Schmidt): 11.2R, 26.3R, 30.3R.

Diurodrilus minimus Remane: 9.2A, 10.4?L, 14.2R, 16.1R, 16.2R, 17.2R, 26.3R, 29.1R, 32.1R.

Hesionides sp.: 23.5R.

Microphthalmus aberrans Webster & Benedict: 18.1R, 23.2R, 23.4R, 23.5L, 23.6R, 26.3L.

Nerilla antennata Schmidt: 26.2R.

Protodriloides chaetifer (Remane): 23.2C, 23.6R, 23.8C.

Protodriloides symbioticus (Giard): 10.1R, 10.2L, 10.3R, 14.1R, 14.2R, 14.3R, 17.3L, 17.4R, 23.1R, 25.1A, 25.2C, 25.3S, 25.4L, 25.5R, 25.6R, 29.1C. This species is the commonest intertidal archiannelid in sandy european shores.

Protodrilus ciliatus Jagersten: 23.5R, 23.6A, 26.2R, 26.3L, 32.1R.

Psammodrilus balanoglossoides Swedmark: 12.2C, 14.1R, 14.3L, 25.6R, 29.1C.

Rheomorpha sp.: 1.1R, 1.2L, 2.4A, 3.1A, 3.2C, 4.3R, 5.1R. The species is probably *R. niezvestnovi* Ruttner-Kolisko but it was not studied in detail. Adults attain 950 μm length.

Streptosyllis sp.: 25.1R, 25.2R, 25.3C, 25.4R.

Trilobodrilus axi Westheide: 10.3R, 10.4C, 18.1R, 18.2R, 18.4L, 23.2R, 23.5C, 25.4R. The specimens were rather smaller than the original description by WESTHEIDE (1967) adults only reaching 850 μm. There is a transverse ciliated groove across the pygidium. Protonephridia were observed in one male specimen (Fig. 2) but in general the specimens accord well with the original description.

IV. DISCUSSION

Rather little is known of the response of meiofauna to changes in environmental factors likely to affect their distribution. On a small scale it is known that factors such as oxygen, temperature, light and mechanical disturbance will cause vertical or horizontal migrations within beach sands. On a larger scale there is limited information about granulometry and salinity. The general ecology and behaviour of sediment meiofauna has been reviewed by McINTYRE (1969). Since water movement affects granulometry, other environmental factors and the behaviour of interstitial species (BOADEN, 1968), it is obvious that changes in tidal and fluvial currents arising from the Delta Works will affect the sediment meiofauna.

One of the most important effects will be *via* the increased deposition of fine particles of sediment and organic matter. Field work and laboratory studies show that local distribution is closely linked to the sediment particle-size spectrum. Since sand on marine beaches is usually well sorted it has generally proved possible to correlate species distribution with mean grain size. In experiments offering choice of particle size to animals it has nearly always been found that there is preferential colonization of sand closest to that of their normal habitat, although the grain size preferendum is usually fairly wide and species on a beach will migrate into somewhat finer or coarser grades of sand (BOADEN, 1962). A complete account of such work may be found in reviews by GRAY (1974) and MEADOWS & CAMPBELL (1972).

It might be assumed from this that it will take a considerable time for a changing sediment to become uninhabitable by its original fauna. However, accumulation of fine material may cause fairly rapid changes since, as shown by BRAFIELD (1964) oxygenation is closely correlated with the percentage of fine particles in the sediment.

For the interstitial mode of life grain sizes in the region of 200 μm are particularly critical (WIESER, 1959). However in well sorted sediments an interstitial fauna including *Turbanella hyalina, Neodasys chaetonotoideus, Cicerina brevicirrus* and *Cheliplanilla caudata* may extend into sands as fine as 145 μm (BOADEN, 1966). Where restriction of water flow has occurred following the Delta Works the interstitial fauna may move towards such a community.

There will also be changes in the salinity regime at many of the sampling sites. WOLFF (1973) in an excellent paper on the macrofauna of the Delta Area gives details of the "original regimes". Predictions have also been made of the situation into the 1980's (PEELEN, 1967). Unfortunately little is known of the salinity tolerances of intertidal meiofauna although in general it seems fairly euryhaline.

AX (1957) and RIEMANN (1966) give some details of the distribution of meiofauna in the Elbe Estuary. According to the latter the gastrotrich *Turbanella* aff. *cornuta* extends well into the β oligohaline zone living in salinities which drop to less than 3‰ S. HUMMON (1972) studied salinity tolerance of *T. cornuta* from a marine beach in North America but it was unable to survive salinities of less than 8‰ S and showed no evidence of acclimation. It is quite probable however that meiofaunal species will prove to have physiological races and there is already some evidence of considerable morphological variation between quite close populations (for example see MAGUIRE, 1976). RIEMANN (1966) also cites *Macrodasys* sp. (probably *M. buddenbrocki*) from polyhaline water of approximately 25‰ S on flood tide from near Cuxhaven. According to D'HONDT (1971) the lower limit of salinity resistance in *Neodasys chaetonotoides* "may be" at 15 to 20‰ S.

The turbellarian *Coelogynopora biarmata* was also found by RIEMANN (1966) in association with *Turbanella* aff. *cornuta. C. biarmata* is also known to be euryhaline and according to AX (1951) is a very specific inhabitant of the otoplanid-zone and areas of strong surf. Its occurrence at Dintelsas indicated a rather unstable sediment. The distribution in the Elbe indicates it could survive a lowering of salinity of more than 10‰ S without strong adverse effects. *Vejdovskya ignava* penetrates into fresh water (Ax & Ax, 1970). It occurs at salinities of 5‰ S in the Baltic at Tvarminne as does *Cicerina brevicirrus* (Karling, 1974). Fifteen of the turbellarians listed are known to occur in the Baltic; the most eurytopic of these are *Gyratrix hermaphroditus*, *Placorhynchus octoaculeatus*, *Promonotus schultzei* and *Uncinorhynchus flavidus* (Karling, 1974).

It therefore seems, from the limited information available, that the soft meiofauna of many formerly marine sands in the Delta Area will be moving towards a euryhaline fine sand community. Some of the existing members can be expected to prosper. These will include *Turbanella hyalina*, *T. cornuta*, *Neodasys chaetonotoides*, *Cicerina brevicirrus*, *Gyratrix hermaphroditus*, *Placorhynchus octoaculeatus*, *Promonotus schultzei*, *Thylacorhynchus arcassonensis* and *Vejdovskya ignava*. However, where the median grain size drops below the 200 to 150 μm range and the salinity below about 10‰ S there will be further selective loss and replacement by brackish water forms such as *Protohydra* or limnic species such as *Rheomorpha* and *Aelosoma*.

V. SUMMARY

A brief survey of sands in the Rhine Delta Area was undertaken in September 1967 and revealed a fairly diverse meiofauna. A list of the distribution of the Cnidaria, larger Turbellaria, Gastrotricha and Annelida is given and details of the sampling localities presented. The probable effect of changes in sediment and salinity on this fauna is discussed.

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