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The Chironomidae (Diptera) of Lake Volkerak-Zoommeer (The Netherlands) after freshening

[Die Zuckmückenfauna (Chironomidae, Diptera) im See Volkerak-Zoommeer (Niederlande) nach seiner Aussüßung]

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With 2 figures and 2 tables

Schlagwörter: Chironomidae, Diptera, Insecta, Makrozoobenthon, Volkerak-Zoommeer, Niederlande, Aussüßung, Küstensee, See, Faunistik, Trophie, Ökologie

The chironomid population of Lake Volkerak-Zoommeer was monitored during the first seven years after embankment in 1987 and freshening. The initial occurring brackish water taxa disappeared in this period. The diversity of the chironomids increased. In 1993 at least 21 chironomid taxa were present. From 1989 on, the chironomid population was dominated by *Cladotanytarsus* sp. The chironomid population after embankment of Lake Volkerak-Zoommeer now is very similar to that of Fjord Hjarbæk.

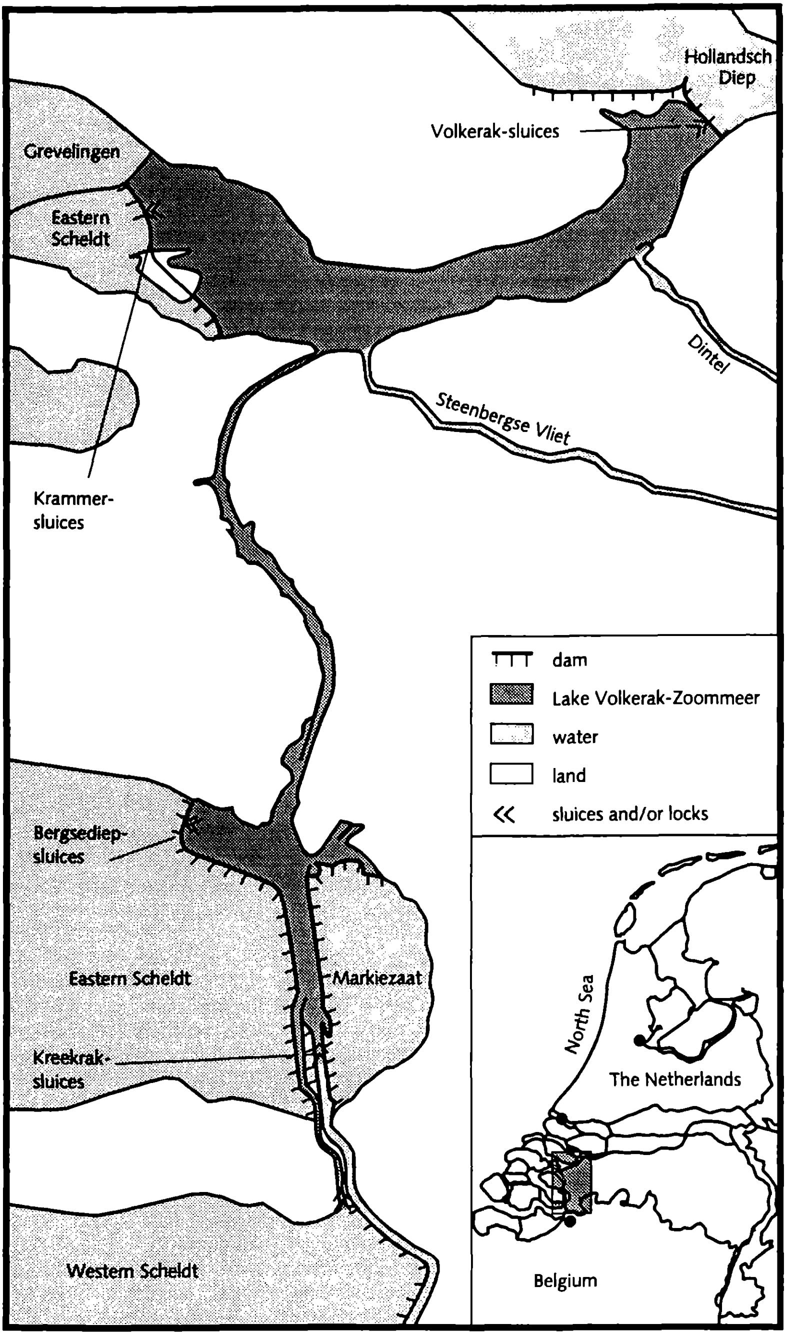
1 Introduction

In april 1987 a part of the salt and tidal Rhine-Scheldt estuary in the Netherlands was embanked, creating a new lake system: Lake Volkerak-Zoommeer (Fig. 1). The lake system actually consists of 2 lakes, Lake Volkerak (48 km²) and Lake Zoommeer (6 km²) which are connected by the Rhine-Scheldt canal (7 km²). Immediately after embankment the lake system was flushed with freshwater from the lower Rhine-Meuse. Freshening took place in a period of 9 months. Details on the embankment and the freshening are given by HOOGHART& POSTHUMUS (1992). The changes in flora and fauna after embankment were monitored. This paper presents the changes of the chironomid population.

2 Materials and methods

From 1987 on, the macrozoobenthos was sampled every year in fivefold using a hand corer (0.008 m²) or a van Veen grab (0.023 m²). The samples were taken around October on 19 locations scattered all over Lake Volkerak-Zoommeer. The macrozoobenthos was collected after sieving the samples on a 0.5 mm meshed sieve. All organisms were preserved in ethanol until identification. The chironomids were identified using KLINK (1981), MOLLER PILLOT (1984a,b), WEBB & SCHOLL (1985) and MOLLER PILLOT & al. (1995). *Chironomus balatonicus* was identified using KIKNADZE & al. (1991). Besides data on chironomids, some additional abiotic (chloride, transparency and total phosphate) and biotic (chlorophyll-a, submerged macrophytes, fish stock and other macrozoobenthic groups) data were collected.

An area based weighted mean density of the macrozoobenthos taxa in Lake Volkerak-Zoommeer was calculated as described below. Lake Volkerak-Zoommeer was partitioned into seven areas: three areas consisted of depth-classes of Lake Volkerak; three areas consisted of depth-classes of Lake Zoommeer; and one area consisted of the whole Rhine-Scheldt canal. The depth-classes of Lake Volkerak and Lake Zoommeer were: less than 1 m; between 1 and 5 m and deeper than 5 m. The extent of these areas of Lake Volkerak was 12 km² (<1 m), 17 km² (1-5 m) and 19 km²



Hollandsch Diep
Volkerak-sluices
Grevelingen
Eastern Scheldt
Dintel
Steenbergse Vliet
Krammer-sluices
dam
Lake Volkerak-Zoommeer
water
land
sluices and/or locks
Bergsediep-sluices
Eastern Scheldt
Markiezaat
Kreekrak-sluices
North Sea
The Netherlands
Western Scheldt
Belgium

Fig. 1: Map of Lake Volkerak-Zoommeer

(>5 m), of Lake Zoommeer 1 km² (<1 m), 2½ km² (1-5 m) and 2½ km² (>5 m) and of the Rhine-Scheldt canal 7 km². All locations were assigned to one of the seven areas. The mean of each taxon per area was calculated in individuals per m² and multiplied with the extent of that area. Finally, for each taxon, the sum of the total number of individuals of all areas was divided by the total area of Lake Volkerak-Zoommeer and was rounded off to integers.

3 Results

Within 9 months after the embankment, the water of Lake Volkerak-Zoommeer can be characterised as freshwater. Initially the transparency (Fig. 2a) increased from ± 1 m in 1987 to more than 3 m in 1990. Later on it decreased to ± 1.5 m in 1993. Total phosphate decreased in the first years from ± 0.3 mg/l to ± 0.1 mg/l. From 1989 on, the total phosphate concentration was more or less stable at ± 0,1 mg/l. In fig. 2 quantitative data on chlorophyll-a, submerged macrophytes and fish are given also. Chlorophyll-a initially decreased from ± 55 μg/l in 1987 to ± 5 μg/l in 1990 and since 1990 increased to ± 20μg/l in 1993. During the seven years after embankment, the area of submerged macrophytes increased to more than 15 % of the total area of Lake Volkerak-Zoommeer. The total fish stock increased to ± 100 kg/ha in 1993. In tab. 1 the total number of chironomids and other macrozoobenthic groups are given. The Crustacea and Mollusca show an initial decrease followed by a slow increase. The Oligochaeta show a steady increase and the Polychaeta a rapid decrease to zero.

In tab. 2 the composition of the chironomids in Lake Volkerak-Zoommeer is given. About half a year after embankment, the chironomids were dominated by *Chironomus balatonicus*. Ten taxa were found including six of the genus *Chironomus*. The weighted mean density of chironomids was ± 1000 per m². In 1988 five new taxa were found, including *Cladotanytarsus* sp., *Polypedilum nubeculosum* agg. and *Lipiniella arenicola*. *Chironomus balatonicus* remained the dominant taxon. The weighted mean density of chironomids in 1988 was ± 1500 per m². In 1989 four new taxa were found including *Stictochironomus* sp. and *Einfeldia* gr. *insolita* f. l. *reducta*. *Cladotanytarsus* sp. became the dominant taxon and the weighted mean density increased to ± 5000 per m². In the period 1990-1992 *Cladotanytarsus* sp. remained the dominant chironomid and the weighted mean density remained about 5000 per m². In this period six new taxa were found of which *Polypedilum* gr. *bicrenatum* was the most abundant. In 1993 another three new taxa were recorded. The weighted mean density increased to ± 9000 per m². *Cladotanytarsus* sp. remained the most dominant taxon with ± 4000 per m². *Stictochironomus* sp., *Polypedilum* gr. *bicrenatum* and *Glyptotendipes paripes* were also found in high abundance.

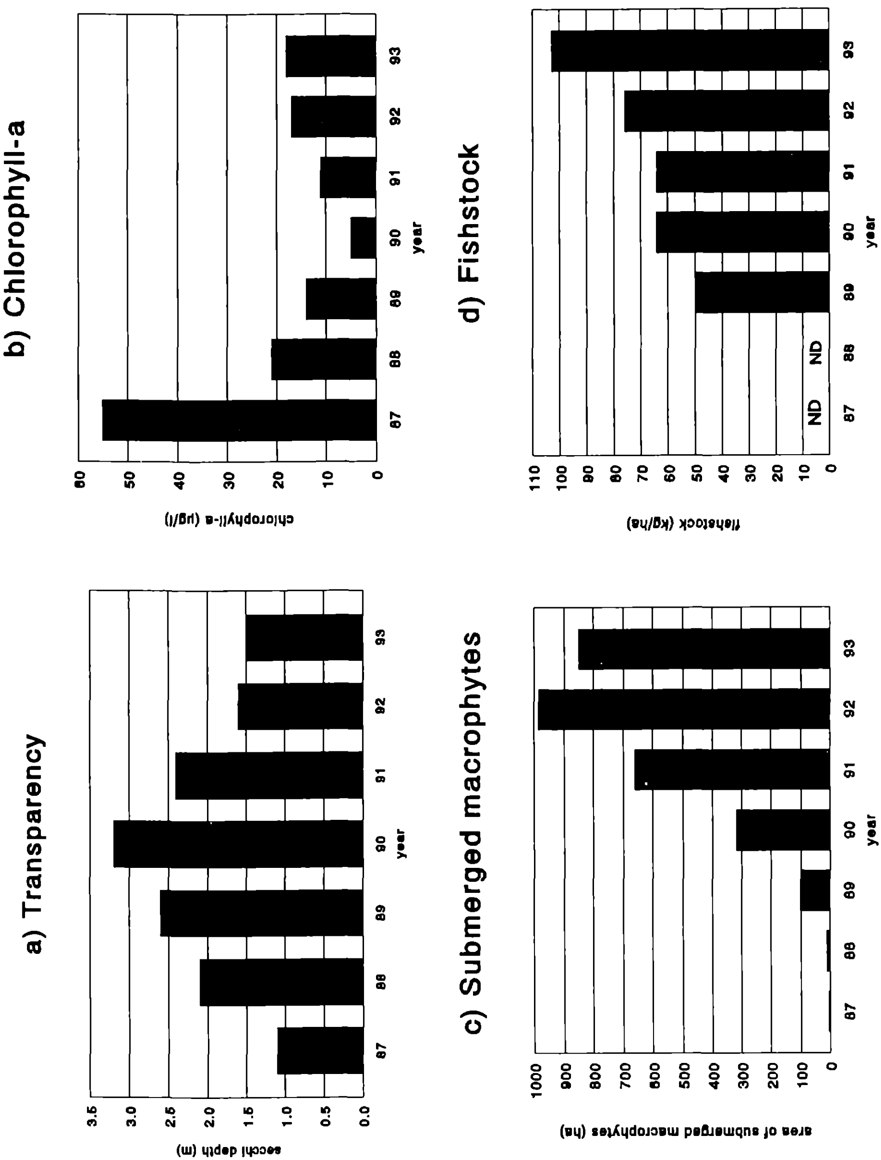


Fig. 2: Mean summer transparency in Lake Volkerak (a), mean summer chlorophyll-a in Lake Volkerak (b), total area covered with submerged macrophytes in Lake Volkerak-Zoommeer (c), total density of fish stock in November in Lake Volkerak-Zoommeer (d); data Ministry of Transport, Public Works and Water Management. ND stands for not determined

Tab. 1: A weighted mean density of macrozoobenthic groups (ind./m²) in Lake Volkerak-Zoommeer 1987-1993

	1987	1988	1989	1990	1991	1992	1993
Chironomidae	857	1504	5320	5304	4374	5420	8882
Crustacea	4672	320	2546	1664	750	517	2130
Mollusca	1208	510	1160	872	1061	2373	4087
Oligochaeta	0	22	250	839	1457	1277	6275
Polychaeta	1288	230	24	1	1	0	0
Other groups	0	12	72	97	110	94	232

Tab. 2: Composition and a weighted mean density of the Chironomidae (ind./m²) in Lake Volkerak-Zoommeer 1987-1993

	1987	1988	1989	1990	1991	1992	1993
Ablabesmyia monilis (LINNAEUS)					1		
Chironomus acutiventris WÜLKER, RYSER & SCHOLL	3	1					
Chironomus aprilinus MEIGEN	148						
Chironomus balatonicus DÉVAI, WÜLKER & SCHOLL	348	517	628	51	97	35	130
Chironomus nudiventris RYSER, SCHOLL & WÜLKER	14	14	4			1	1
Chironomus plumosus (LINNAEUS)	1	1		18	11	1	0
Chironomus salinarius KIEFFER	93		1				
Chironomus sp. MEIGEN	192	10	1		20	21	6
Cladotanytarsus sp. KIEFFER		287	301	4063	2969	3043	4210
Cryptochironomus sp. KIEFFER	1	68	251	146	133	38	208
Cricotopus sylvestris agg.					1		
Dicrotendipes nervosus (STAEGER)		8	1				8
Einfeldia gr. insolita f. l. reducta	10	239	15	22	71		
Endochironomus albipennis (MEIGEN)						4	7
Glyptotendipes pallens (MEIGEN)							1
Glyptotendipes paripes EDWARDS							712
Glyptotendipes sp. KIEFFER	51	81	1492	341	109	821	
Harnischia sp. KIEFFER			1		6	4	10
Lipiniella arenicola SHILOVA		4				0	3
Microchironomus deribae (FREEMAN)			5		17		
Microchironomus tener (KIEFFER)					1	1	
Microtendipes chloris agg.							1
Parachironomus gr. vitiosus					4	2	7
Polypedilum breviantennatum TSHERNOVSKIJ							0
Polypedilum gr. bicrenatum					290	611	1323
Polypedilum nubeculosum agg.		16	95	85	250	100	434
Procladius sp. SKUSE	5	301	315	147	263	86	243
Psectrocladius gr. sord./limb.*		5	17	57	5		32
Rheotanytarsus sp. BAUSE							0
Stictochironomus sp. KIEFFER			32	152	146	536	1367
Tanytarsus sp. VAN DER WULP	2	192	168	5	35	49	106

* Psectrocladius gr. sordidellus/limbatellus

4 Discussion

4.1 Faunal development

The chironomids showed an increasing diversity during the first seven years after embankment and freshening. From the initially occurring taxa only *Chironomus salinarius*, *C. aprilinus* and *C. acutiventris* disappeared. This was expected for the brackish water species *Chironomus salinarius* and *C. aprilinus*; however not for the freshwater species *Chironomus acutiventris*. All other chironomid taxa found in 1987 or 1988 were still present in 1993.

The freshening also caused changes in the number of the other macrozoobenthic groups. Due to freshening the Polychaeta (mainly *Nereis diversicolor*) disappeared from Lake Volkerak-Zoommeer. Until 1992, the number of Oligochaeta slowly increased. In 1993 a rapid increase is shown. Possibly this is caused by the increasing effects of eutrophication as shown by the transparency and chlorophyll-a concentration (Fig. 2a,b). The density of Crustacea and Mollusca decreased in 1988 due to the freshening and resulting in a disappearance of brackish or marine species (such as *Corophium volutator* and *Mya arenaria*). Later on the density increased due to the appearance of freshwater species. The increase of Mollusca (such as *Valvata piscinalis*) is also caused by the increase of the area of submerged macrophytes (Fig. 2c).

The colonisation of chironomids in Lake Volkerak-Zoommeer can be compared with the colonisation of the enclosed Fjord Hjarbæk in Denmark (LINDEGAARD & JÓNSSON 1983). Two years after embankment of this fjord, the chironomid fauna consisted of *Cryptochironomus redekei*, *Cladotanytarsus* sp., *Tanytarsus* sp., *Procladius* sp., *Chironomus plumosus* f. *semireductus* and *Glyptotendipes* sp. Furthermore some unidentified chironomids were found. LINDEGAARD & JÓNSSON (1987) already indicated that the morphology of the *Chironomus plumosus* f. *semireductus* larvae from Fjord Hjarbæk does not differ from that of *Chironomus muratensis* as described by WEBB & SCHOLL (1985). Initially the *Chironomus balatonicus* larvae of Lake Volkerak-Zoommeer were identified as *Chironomus muratensis*, using WEBB & SCHOLL (1985). However, new insights into this genus point to *Chironomus balatonicus* (VAN DER VELDEN & al., 1995). Assuming that the reported *Chironomus plumosus* f. *semireductus* and *Chironomus balatonicus* are identical, all identified chironomids found two years after embankment of Fjord Hjarbæk were also found in Lake Volkerak-Zoommeer two years after embankment.

Five to seven years after embankment of Fjord Hjarbæk, the list of existing chironomids had increased by *Polypedilum bicrenatum*, *Psectrocladius* sp., *Polypedilum nubeculosum* and *Fleuria lacustris*. In Lake Volkerak-Zoommeer five to seven years after embankment *Polypedilum* (gr.) *bicrenatum*, *Psectrocladius* sp. and *Polypedilum nubeculosum* (agg.) were also found. The missing of one taxon in the list may again be caused by difficulties in the nomenclature, namely of the genera of *Fleuria* and *Einfeldia* (MOLLER PILLOT 1986). Assuming that the reported *Fleuria lacustris* and *Einfeldia* gr. *insolita* f.l. *reducta* are identical, all species found five to seven years after embankment in Fjord Hjarbæk were also found in Lake Volkerak-Zoommeer. In both lakes, five to seven years after embankment, *Cladotanytarsus* sp. was the dominant chironomid.

From above comparison, it may be concluded that the composition of chironomids in estuaries which are embanked and freshened, is highly similar. Although the composition of chironomids in the first seven years after embankment of Lake Volkerak-Zoommeer were highly similar to those of Fjord Hjarbæk, the later data of Fjord Hjarbæk can not regardlessly be used to predict the further composition of chironomids in Lake Volkerak-Zoommeer. In the near future, the impact of management, eutrophication, fish stock, vegetation etc. will probably have a larger influence on the chironomid fauna than the embankment.

4.2 Environmental factors

The high transparency (fig. 2a) resulted in a high biomass of microphytobenthos. *Lipiniella arenicola* and *Einfeldia* sp., both supposed to be selective microphytobenthos grazers (BIJKERK 1994) in the littoral zone, may have taken advantage of this high biomass.

The chlorophyll-a concentration (fig. 2b) in the water may explain the changes of the populations of *Tanytarsus* sp., *Glyptotendipes* sp. and possibly *Chironomus balatonicus*. These three taxa show a dip around 1990/1991, just like the chlorophyll-a concentration. As these taxa probably have a more opportunistic feeding behaviour to algae (BIJKERK 1994) the low concentration of algae may be a limitation.

The colonisation by some taxa, such as *Endochironomus albipennis* and *Parachironomus* gr. *vitiosus* (MOLLER PILLOT & BUSKENS 1990), can be explained by the increased area covered by submerged macrophytes as shown in figure 2c.

The shift from relatively large chironomids (such as *Chironomus* sp. and *Glyptotendipes* sp.) in the first years after embankment to smaller chironomids (such as *Cladotanytarsus* sp. and *Polypedilum* sp.) in the later years can possibly be explained by the increased fish stock (fig. 2d). In the first years after embankment the fish stock was low and thus the predation on chironomids was low. During the following years the fish stock increased, mainly by fish like roach which forage on larger macroinvertebrates. This predation possibly favoured medium and small sized chironomids.

4.3 Eutrophication

Many of the chironomid taxa found in Lake Volkerak-Zoommeer are characteristic for eutrophic waters, such as *Glyptotendipes paripes*, *Polypedilum nubeculosum* agg. and *Cricotopus sylvestris* (SAETHER 1979). According to the correlation given by SAETHER (1979) of total phosphorus/mean lake depth (for Lake Volkerak-Zoommeer: 5 m) with the trophy-level, Lake Volkerak-Zoommeer is extreme eutrophic. However at this moment not all eutrophication characteristics are fully present. For instance, compared with other eutrophic water systems the transparency (fig. 2a) and the area of submerged macrophytes (fig. 2c) are relatively high and the chlorophyll-a concentration is relatively low.

Further manifestation of eutrophication characteristics will affect the chironomid composition. A decrease in the microphytobenthos biomass may result in a decrease or disappearance of for instance *Lipiniella arenicola* and *Einfeldia* sp.; an increase in the chlorophyll-a concentration may result in an increase of for instance *Chironomus balatonicus* and *Glyptotendipes* sp.; a decrease of the area of submerged macrophytes may result in a decrease or disappearance of for instance *Endochironomus albipennis*. Further manifestation of eutrophication characteristics will also affect other fauna such as Oligochaeta and fish. The density of Oligochaeta will probably increase and changes in the fish population may take place, such as an increase of bream. An increased number of Oligochaeta may result in foodcompetition with chironomids and therefore in a different chironomid composition. An increase of bream may, as a result of its feeding behaviour, influence the chironomid composition indirectly by a decrease of the transparency and an increase of chlorophyll-a concentration and total phosphorus (BREUKELAAR & al., 1994) and directly by the disappearance of the advantage of medium sized chironomids (such as *Stictochironomus* sp.) to large sized chironomids. The domination of *Cladotanytarsus* sp. will not directly be influenced by bream, as bream is not able to feed on this species due to its small size and protecting sandtube (BUND & GROENEDIJK 1994).

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