REVUE SUISSE DE ZOOLOGIE 112 (2): 543-558; juin 2005

# Ten years trends in the oligochaete and chironomid fauna of Lake Neuchâtel (Switzerland)

Avec mes mes leurs meserges Projeto 44

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Ten years trends in the oligochaete and chironomid fauna of Lake Neuchâtel (Switzerland). - Quantitative surveys of benthic macroinvertebrates (oligochaetes and chironomids) were conducted during 1992, 1997, 2000 and 2002 at a depth of 40 m to monitor the biological quality of sediments in Lake Neuchâtel. Recent declines in frequency of occurrence and abundance of oligochaete species characteristic of oligotrophic conditions (Stylodrilus heringianus, Embolocephalus velutinus) contrasted with the improvement of water quality metrics. Total phosphorus concentrations in lake waters decreased from 63 mg m<sup>-3</sup> in 1980 to 10 mg m<sup>-3</sup> in 2002. Since 1992, significant reductions of total zoobenthic biomass have been recorded and the chironomid community structure reflects typical oligomesotrophic conditions in the upper sediment layer. The population of the oligochaete species Potamothrix vejdovskyi is in clear expansion and indicates that this new species for the lake (1986) has found good conditions for a successful colonization. These divergent responses within the zoobenthic community are discussed according to three main hypotheses: implications of toxic pollutants like heavy metals and organic micropollutants in the sediment, impact of algae on oxygen conditions on the bottom layer and different biological responses of oligochaetes to competition for food and space.

**Keywords**: Zoobenthos - biomonitoring - profundal zone - sediment contamination - organic deposition - micropollutant.

## INTRODUCTION

In marine and lacustrine ecosystems, it is generally accepted that pelagic phytodetrital organic material, derived from autochtonous and allochthonous inputs, drives profundal zoobenthos production (Brinkhurst, 1974; Graf, 1989). The major part of autochtonous input arises from phytoplankton primary production which is controlled largely by nutrient elements (mainly P and N) coming in the system (Håkanson & Jansson, 1983). Thus, profundal macroinvertebrate growth is supported directly by nutrients in fresh or decaying algae or indirectly via microbial production (Johnson & Wiederholm, 1992).

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Fig. 4

Mean zoobenthic biomass (oligochaete worms and chironomid larvae) (FW, g  $m^{-2}$ ) between 1992 and 2002 and between zones. The median, percentiles (25<sup>th</sup> and 75<sup>th</sup>) and 1.5 interquartile range are indicated.

TABLE 4. Summary of the analysis of variance (one-way ANOVA) inter-zones for two variables.

Variable		ANOVA inter-zone	
		F	Р
Black reduced layer	1997	7.99	< 0.001
	2000	38.24	< 0.001
	2002	30.80	< 0.001
Zoobenthic mean biomass	1992	5.33	0.006
	1997	10.52	< 0.001
	2000	15.49	< 0.001
	2002	4.46	0.013

the presence and the settlement of *Paracladopelma nigritula* gr., a species group characteristic of oligotrophic lakes (Saether, 1979). This taxon was also present in Lake Geneva at a depth of 40 m in 1995 (Lods-Crozet, unpubl. data) and in Lake Annecy (Verneaux & Verneaux, 2002). Chironomid composition and richness (11 taxa) during the last ten years is analogous to that of other lakes of the Alpine region, for the same depth: Lake Constance (Reiss, 1968), Lake Geneva (Lods-Crozet & Lachavanne, 1994) and Lake Starnberger (Gerstmeier, 1989). Furthermore, the inter-annual up and down pattern (Fig. 5) could be explained by the fact that, if profundal communities are food limited, then year-to-year fluctuations in autochtonous algal production may ulti-

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FIG. 5

Total abundance (No.  $m^{-2}$ ) of oligochaete worms (circles) and chironomid larvae (triangles) (± CL) between 1992 and 2002.

mately affect profundal zoobenthos communities resulting in time-delayed population responses (Johnson & Wiederholm, 1992).

In addition, two species of molluscs (*Pisidium conventus*, *P. personatum*), typical of deep lakes were found. These two species were also present in the deep zone of the oligotrophic Lake Annecy, France (Mouthon, 2002) and were rare or absent in meso-eutrophic Swiss lakes (P. Stucki, pers. comm.)

## THE EFFECTS OF ABIOTIC AND BIOTIC FACTORS

Chemical and phytoplanktonic metrics in the pelagic waters of lake Neuchâtel indicate that mean total phosphorus concentrations in the water column have markedly decreased from 38 mg m<sup>-3</sup> in 1984 to 18 mg m<sup>-3</sup> in 1992 and 10.0 mg m<sup>-3</sup> in 2002. Consequently, mean algal biomass has also decreased (Pokorni-Aebi, 1997, 2002). In

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contrast, during a similar phase of recovery from eutrophication in Lake Geneva, good relationships were found between pelagic chemical parameters and zoobenthic communities, with a significant increase of oligochaete species bioindicators of oligotrophic conditions (Lang, 1998).

In order to understand these divergent trends between zoobenthic groups we have explored three main hypotheses. One of them is contamination of sediment by micropollutants (heavy metals, PCBs and PAHs) and their potential impact on zoobenthic communities. Anthropogenic contaminants were detected along the 15 kilometreslong transect, but no spatial differences were noted. Heavy metals concentrations were relatively low compared to those measured in Lake Geneva in 1983 (Mondain-Monval et al., 1983) and in 2003 at 70 m-depth in the same lake (Lods-Crozet, unpublished data). Compared to background concentrations observed prior to industrialisation (Vernet & Viel, 1984) mean values were close and even lower than background levels (Table 4). PCBs in Lake Neuchâtel have similar values as at 70 m-depth in Lake Geneva (Lods-Crozet, 2003, unpublished data). Their long-term persistence in the upper layer of bottom sediments, despite their banning in industrial processes since 1986, could explain the residual contamination. PAHs levels are higher than those measured at 70 m depth in Lake Geneva: 0.193 mg Kg<sup>-1</sup> (Lods-Crozet, 2003, unpublished data). The Swiss reference is a zero value for these synthetic and persistant contaminants (PCBs and PAHs) but reasonable limits could be chosen on the basis of threshold values determined for agricultural valorisation of wastewater sludges (Osol, 1998) (Table 2).

Similar levels of sediment contamination by heavy metals and PAHs were found in Lake St-François, Canada (Pinel-Alloul et al., 1996) and attempts to correlate contaminants and macroinvertebrate metrics were unsuccessful. It should be stressed that sediment toxicity assessment is not an easy task (Luoma & Carter, 1993) and sediment quality criteria essentially take into account the capacity of benthic organisms to tolerate the different contaminant concentrations. Substantial doubt exists about pollutants concentrations that pose significant ecological dangers because the bioavailable fraction of toxicants in sediments is rarely measured (Pardos et al., 2004). The use of sediment quality assessment metrics, developped by Smith et al. (1996) permitted the following considerations. The Probable Effect Level (PEL) on benthic organisms, showed that the concentrations of metallic and organic (PAHs) contaminants detected were well below those estimated by the PEL (Smith et al., 1996). On the other hand, in laboratory experiments, Nalepa (1991) pointed out that sublethal effects were apparent at lower concentrations than those reported from Lake Ontario sediments. For instance, Stylodrilus heringianus ceased feeding after 58 days at PCB concentrations over 0.05 mg Kg<sup>-1</sup> (PCB congeners not known). Concentrations at this level were found in Lake Neuchâtel in 2003. In addition, tubicifids feed continuously in a conveyor-belt fashion by ingesting particles in bulk at depth and defecating on the sediment surface. Such bioturbation has been reported to significantly increase the flux of metals and organic contaminants from sediment into the water column (Reynoldson, 1987; Reible et al., 1996). While results of laboratory experiments may not be applicable to the field situation, these results do demonstrate the possibility of low-level, long-term chronic impacts of pollutants on oligochaete populations (Nalepa, 1991).

Another hypothesis, proposed by Lang (1999) was the changes in the phytoplankton composition between 1993 and 1996, with the dominance of large diatoms (Butty *et al.*, 2003). These have a high sinking rate and as a result, sedimented intact on the bottom surface. Algal signatures at the sediment level were also observed by Steinmann *et al.* (2003) using the analysis of suspended material from the lake epilimnion. Settlement of these algae is known to increase oxygen uptake at the watersediment interface (Johnson *et al.*, 1989; Lang, 1999). Consequently, some oligochaete species, sensitive to oxygen depletion, were able to be disturbed in their growth and reproductive behavior.

The last hypothesis concerned competition mechanisms. Few studies have actually demonstrated increases or decreases in population growth rate by interaction between oligochaete species (Milbrink, 1993; Timm, 1996). The rapid expansion of Ponto-Caspian *Potamothrix vejdovskyi*, which may compete for habitat and food with other oligochaete species like *Stylodrilus heringianus* and *Embolocephalus velutinus*, should not to be neglected. Furthermore, increase of lake water temperature during the last fifteen decades (Lazzarotto *et al.*, 2002; Pokorni-Aebi, 2002) may have enhance growth and reproduction of this opportunistic species and strengthened up its expansion over more stenothermic native species.

Our study confirms the potential multiple controls of the macroinvertebrate community in anthropogenically stressed ecosystems by both simple and combined effects of chemical, toxicological, biological and ecological factors. Further improvement of lake biomonitoring programs must address assessment of the structure of predominant and profundal zoobenthic community (oligochaetes, chironomids and bivalves molluscs). We consider that Lake Neuchâtel, in terms of biological quality of sediments is in phase of recovery from eutrophication, by using zoobenthic biomass, chironomid community structure and *Pisidium* assemblages as descriptors. The decline of characteristic oligochaete species indicators of oligotrophic conditions from 1992 should be monitored further in order to better understand the causes of this apparent degradation.

### ACKNOWLEDGEMENTS

We thank Raymond Ducret for his technical assistance in the field, Claude Lang for providing data and helpful comments and Pascal Stucki for the *Pisidium* identifications. The authors are grateful to Sandra Knispel and Emmanuel Castella for valuable comments on an early draft of the manuscript and to two anonymous reviewers for their constructive remarks. The authors also thank John E. Brittain for correcting the English in a subsequent version of the manuscript.

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