Zooplankton response to long term liming of 13 Swedish acid lakes

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Objectives: Ecosystem development in lime-treated waters in Sweden has been studied since 1985, in a program for integrated studies of the effects of liming in acidified waters (ISELAW). Liming effects on zooplankton communities are discussed in terms of trophic status in community composition and in standing crop.

Approach: Nutrient and biotic conditions were assessed in 13 long-term (15-28 yr) limed Swedish lakes to study the effects of liming (Fig. 1). Parallel studies of 10 unaltered circumneutral lakes (pH 6.0-7.0) and 5 acid lakes were used to reveal differences between the three studied lake groups. Older records obtained during a pre-acidification period as well as during the acid period preceding the initial liming were compared to records from the limed period when available.

Material & Methods: Samples for species identification were taken by vertical tows with plankton nets (33 and 25 micron mesh size, formatin preservation) during the years 1990-1992. Older data from the acid period preceding the liming were gathered from various sources, most notably from C. Elekstro, who also analysed the sample from the early 1990s. Quantitative zooplankton samples were taken with a Limnos sampler (4.3 l) at 2 m intervals down to 8 m depth, pooled and preserved in acid Lugols solution before species identification and enumeration under the inverted microscope. The most shallow lakes had to be sampled in 4 or 2 m strata. The lakes were sampled in June, July, August and September. Median values for a 3-yr period (2000-2002) are given. Vertically integrated phytoplankton samples were taken with a rake sampler (total volume 0.4 m³) 3-m monthly during April-September, preserved with acid Lugols solution and counted under the inverted microscope. Median biovolume was given in the years 2000-2002. Pelagic fish was caught in fishing gillnets, with a standardized set of mesh sizes, and preserved in formalin. Fish length and weight were measured. In shallow lakes (>10 m) catch data from benthic nets were used.

Results: Species number of zooplankton before liming were available from all lakes (Fig. 2). The number of taxa increased 2 times or more in 8 lakes after liming. This species richness increased mainly within the rotifer group followed by Cladocera. Pre-acidification data from Lake Sjömgörden indicate low rotifer species number, probably due to coarse net size. The number of zooplankton taxa in the limed lakes typically spanned 15-20 in northern Sweden and 20-25 in southern Sweden. The species analyses for the limed lakes and the two reference groups showed 32, 41 and 47 taxa in the acid, the neutral and the limed lakes respectively (Fig. 3). The differences were smallest between the limed and circumneutral lakes and would be even smaller if natural distribution patterns of copepods were considered. In the acid lakes there were no species common to all lakes, as compared to the other groups where several taxa were common to all lakes. There was a correlation between total phosphorus and phytoplankton biomass in all lakes (Fig. 4) showing that phytoplankton biomass decreases within the lake groups followed total phosphorus. However, in the acid lakes the phytoplankton/phosphorus ratio was less than half that of the other groups (Fig. 5a). The zooplankton biomass increased between lake groups; rotifers were more abundant in the acid group and copepods were more abundant in the neutral group (Fig. 5b). Total zooplankton biomass showed small differences between the groups (Fig. 5c) which was explained by a higher share of taxa with a small body size in the group of neutral references. This was particularly obvious within the rotifer group, where Asplanchna sp was dominant in several lakes (Fig. 5d). Fish predation pressure was indicated by catched biomass of pelagic fish, which was much higher in the reference and acid groups than in the limed group (Fig. 5e).

Fig. 1. Mean hydrochemical conditions and chlorophyll conc. of the studied lakes: Black dots=limed lakes
Red circles=neutral reference lakes
Blue crosses=acid lakes.

Fig. 2 Before and after liming of zooplankton taxa Nos.

Fig. 3 Taxa in the lakes (Occurrence in lakes within the groups)

Fig. 4 Phosphorus-chlorophyll and phytoplankton relationships

Fig. 5 Comparison between the lakes within the three groups: a) phytoplankton biovolume, b) zooplankton abundance, c) zooplankton biovolume, d) rotifer mean body size, e) pelagic fish catch

Conclusions: Zooplankton communities of acid lakes were poorer than those of circumneutral non-acidified lakes.Liming of acid lakes gave communities with a somewhat different structure as compared to naturally neutral lakes. A lower predation pressure from pelagic fish in the group of limed lakes might reduce diversity. Similar zooplankton biomasses in limed lakes relative to high-predation neutral lakes would also imply lower zooplankton productivity. This is an edge for higher production and high losses through other pathways.