Long-term responses of soft-bottom macroinvertebrate communities to liming

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Integrated Studies of the Effects of Liming Acidified Waters

1 ***Objectives*** **Possible changes in soft-bottom (profundal) macroinvertebrate community structure due to liming activities were evaluated in this 10-year (1989–1999) study.**

2 ***Introduction*** Acidification is a serious threat to the structural and functional biodiversity of Swedish inland waters. Though the short-term effects of acidification on aquatic biota are well understood, the long-term effects are poorly studied.

2 ***Methods*** Macroinvertebrate community structure in 13 limed lakes was compared with 13 neutral (mean annual pH > 6.0) and 9 acid (pH < 6.0) reference lakes using univariate and multivariate analyses. Community composition was compared by correspondence analysis (CA), and canonical correspondence analysis (CCA) was used to relate community structure to environmental variables. Differences between lake types was also evaluated by ANOVA on three metrics: total macroinvertebrate abundance, taxon richness, and site-loadings on the first CA axis. Linear regression was used to determine if significant trends occurred during the 10-year study period.

3 ***Results*** Limed and neutral reference lakes had lower abundance and taxon richness compared to acid reference lakes (Fig. 1). High abundances in acid lakes were often due to the high numbers of phantom midge larvae (*Chaoborus flavicans*), in particular in brownwater lakes. High taxon richness, on the other hand, is generally not associated with acid lakes, but is high here due to the inclusion of one lake with deviating high richness. CA site-loadings clearly separated all three lake types.

CCA generally placed limed lakes to the right in the ordination, positively correlated with the first CCA axis (and pH and alkalinity), while acid reference lakes were negatively correlated with the first and second CCA axes (Fig. 2). The first two axes accounted for 11% of the variance in the species data (eigenvalues = 0.208 and 0.153, respectively). Species indicative of brownwater systems (e.g. the midge *Zalutchia zaluchicola* and *Chaoborus flavicans*) were placed to the left in the ordination (i.e. indicators of acid lakes), while more oligotrophic taxa (e.g. the midge *Micropsectra* and the oligochaete *Spirosperma ferox*) were positively correlated with limed lakes.

Linear regression of macroinvertebrate abundance, taxon richness and CA site-loadings showed significant changes in 18 (6 limed, 4 acid and 8 neutral reference lakes) of the 35 lakes studied. The majority of changes occurred as negative trends (Table 1).

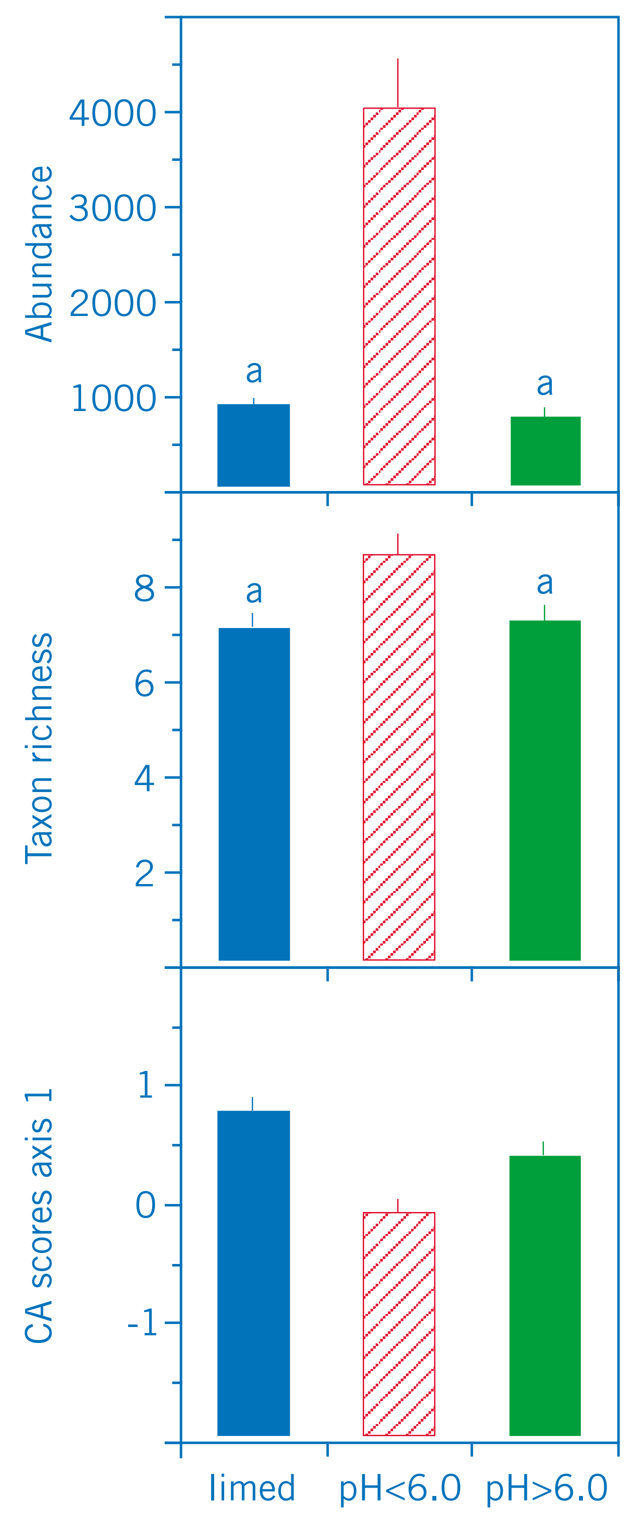


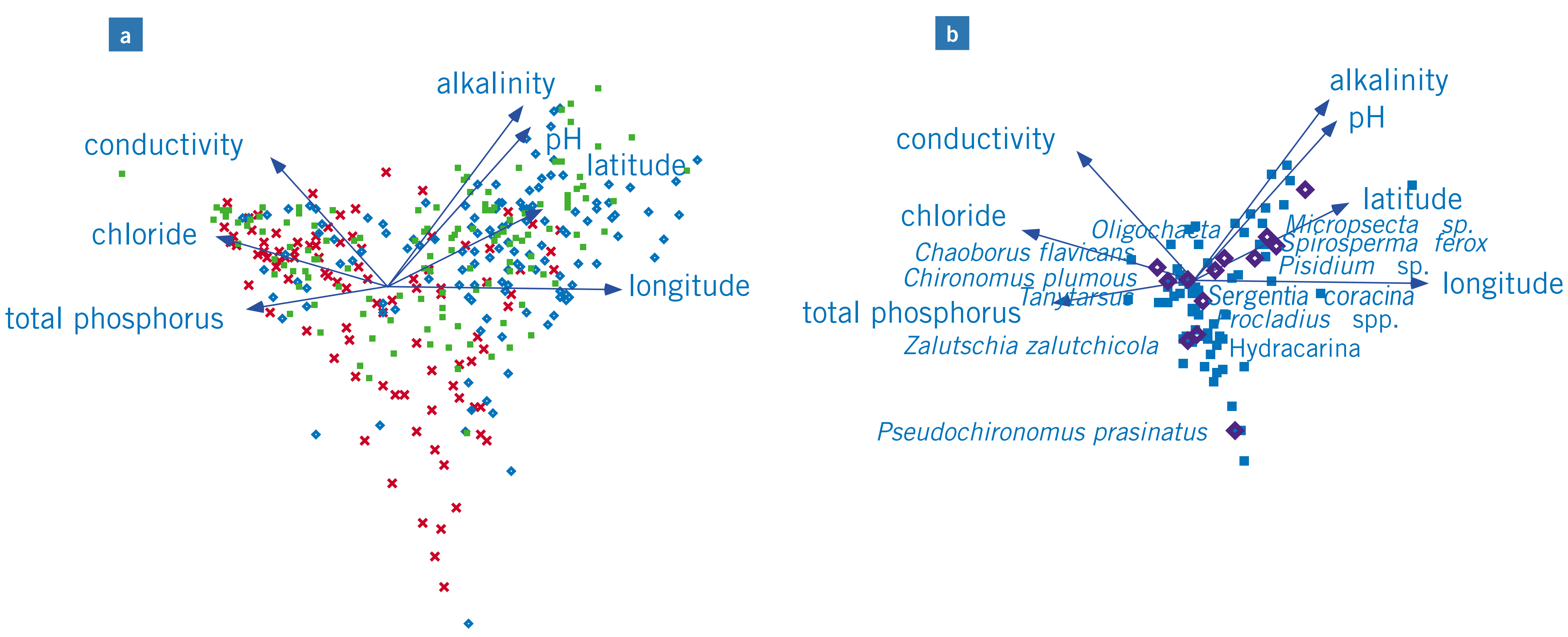
Figure 1. Mean abundance (ind m^{-2}), taxon richness and site-loadings on the first axis of correspondence analysis for limed, acid (pH < 6.0) and neutral (pH > 6.0) reference lakes. Shared lettering indicates no difference (p > 0.05) according to Tukey-Kramer HSD test.

4 ***Conclusions*** **Univariate and multivariate analyses showed that macroinvertebrate communities of limed lakes differed from acid and neutral reference lakes. Oligotrophic species were more indicative of limed lakes, while dystrophic and eutrophic taxa were generally indicative of acid and neutral reference lakes. Regression showed a number of significant trends (mostly negative) in both limed and reference lakes.**

Table 1. Results from regression analysis of limed (n = 13) and reference lakes with pH < 6.0 (n =9) and pH > 6.0 (n =13) for the years 1989 to 1999. Numbers show the number of significant trends and the +/- sign shows the direction of change.

	limed	pH < 6.0	pH > 6.0
abundance	4 -	2 -, 1 +	2 -
taxon richness	2 -	3 -	5 -
CA site-scores on axis 1	2 -	3 -	2 -, 1+

Figure 2. Biplots of the results of CCA of limed and acid (pH < 6.0) and neutral (pH > 6.0) reference lakes. Macroinvertebrate abundances were square root transformed and the downweighting of rare taxa option was invoked. Limed lakes were run as “passive” so as not to influence the ordination. Only the first two axes are shown. blue symbols = limed, red = acid, and green = neutral lakes.



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