The Cladoceran community along a trophi gradient of Norwegian lakes

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Introduction

Cladoceran species composition reflects the functional conditions of lakes and changes with different types of stressors, including eutrofication. Zooplankton was left out as a biological quality element (BQE) in the EU Water Framework Directive (WFD). Prior to that, several indices were developed based on zooplankton to assess ecological status and water quality of lakes (e.g. Boix *et al.*, 2005, Moss *et al.*, 2003). Leading European freshwater scientist are now strongly recommending the EU to include zooplankton as a BQE in WFD assessments (Jeppesen *et al.*, 2011).

In Norway zooplankton is included in the national surveillance of lakes. Existing foreign classification systems do not necessarily apply to Norwegian conditions, partly because Norwegian lakes are relatively nutrient poor in a European context. **Therefore, we are developing a Norwegian assessment system. As a part of this work we here give some results from investigations of changes in the cladoceran community along a eutrophication gradient of Norwegian (and a few Swedish) lakes.**

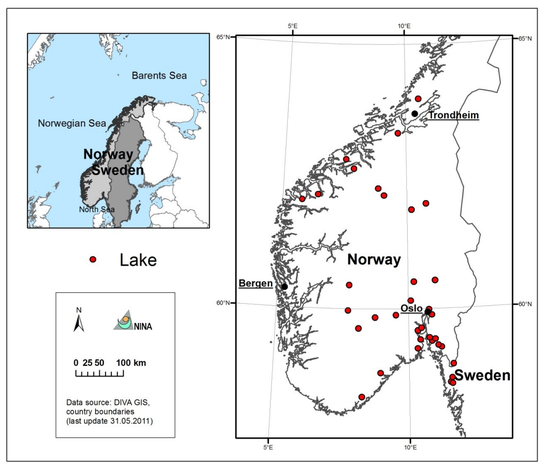

Fig. 1. Distribution of investigated lakes (red dots) in Southern Norway and western Sweden.

Methods

We analyzed changes in the cladoceran community related to trophic status parameters, in a set of 35 lakes mainly in Sourthern Norway (three lakes from western Sweden, Fig. 1). The dataset contains data on microcrustaceans (both littoral and pelagic), and water chemistry as well as altitude and area (Table 1). Data for each lake are from one year and represent averages from two sampling dates (June/July and August/September). The cladoceran community were analyzed using Detrended Correspondence Analysis (DCA, Hill and Gauch, 1980). CANOCO 4.5 (ter Braak 1998) was used for the analysis with dominans classes (< 1 %, 1–10 %, > 10 % of total number of individuals) as input data.

Table 1. Major characteristics for the 35 lakes. Averages for two samples (June/July and August/September).

	Average	Median	Max.	Min.	Number
Altitude (m)	362	204	1329	9	35
Area (km^2)	3,05	0,88	25,00	0,07	35
TOC (mg l^{-1})	4,7	4,4	16,0	0,4	35
Total-N (µg l^{-1})	401	303	1268	51	35
Total-P (µg l^{-1})	11,7	4,5	93,0	1,5	35

Lake Atnsjøen, one of the investigated lakes, with the mountain range Rondane in the background.

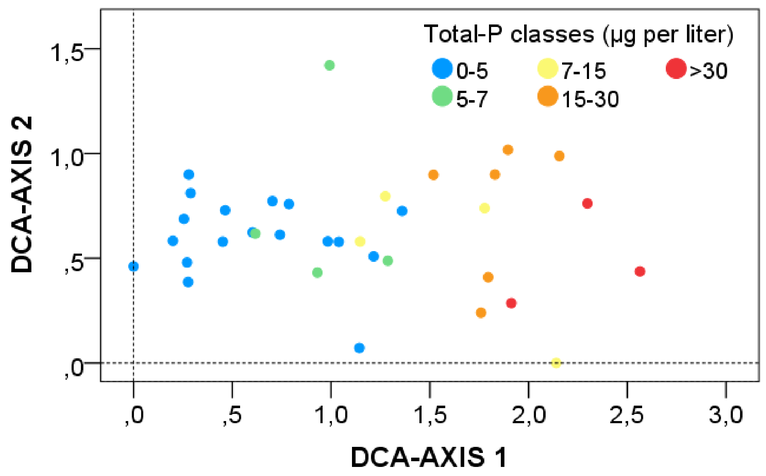

Fig. 2 DCA site plot for 35 lakes based on cladoceran fauna (dominance-classes). Different classes of phosphorus indicated in different colours.

Table 2 Results of the DCA, axis summary statistics of the two first axes.

	Axis 1	Axis 2
Eigenvalues	0.331	0.121
Lengths of gradient	2.564	1.421
Cumulative percentage variance of species data	18.1	24.7

Results and discussion

- **The lakes span a gradient from low to high nutrient concentrations (Table 1).**
  - Several of the physical and waterchemistry parameters were strongly correlated (Table 3).
- **64 cladoceran species were identified from the lakes.**
  - 81 cladocerans are registered in Norway.
- **The DCA indicate a shift in the cladoceran community with a change in nutrient- and TOC-concentrations and altitude.**
  - The first two axes in the DCA explained 18,1 % and 6,1 % respectively of the variance in the cladoceran-material (Table 2, Fig. 2). The first axis was most strongly positively correlated with total N, total P and TOC and negatively correlated with altitude (Table 3).
- **Cladoceran species richness showed a unimodal distribution along a total-P gradient.**
  - Highest species number found in lakes with total P of 15-30 µg l^{-1} (Fig. 3). In European lakes zooplankton species richness decrease with eutrophication (e.g. Jeppesen *et al., 2011).* Norwegian lakes are relatively nutrient poor in a European context. Considering a total-P gradient from below 2 µg l-1 to hundreds of µg l-1 we suggest that species richness show a unimodal distribution with maximum at around 15-50 µg l-1.
- **Individual species responded differently to increasing nutrient concentrations.**
  - For example the relative abundance of *H. gibberum* and *B. longispina*, decreased with increasing nutrient concentrations, whereas *B. longirostris and Daphnia cucullata* increased with rise in nutrient concentrations (Fig. 4).

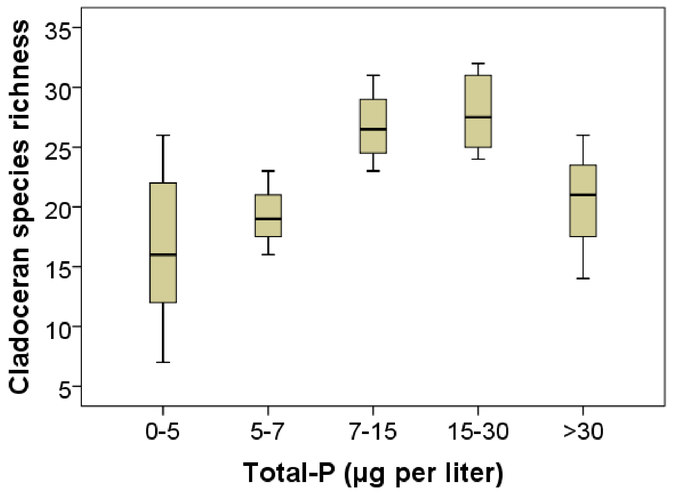

Fig. 3 Box-plot showing species richness of cladocerans in five different classes of phosphorus. Classes are based on the national classification of total phosphorus for low alkalinity/clear lakes (LN5)

Table 3 Correlation (Pearsons correlation coefficient) of environmental variables with ordination axes in the DCA.

	AX1	AX2	Alt	Area	TOC	TotN	TotP
AX1	1,00						
AX2	-0,07	1,00					
Alt	-0,73	0,08	1,00				
Area	0,45	-0,17	-0,25	1,00			
TOC	0,70	-0,04	-0,65	0,12	1,00		
TotN	0,88	-0,07	-0,65	0,50	0,51	1,00	
TotP	0,75	-0,07	-0,45	0,17	0,37	0,74	1,00

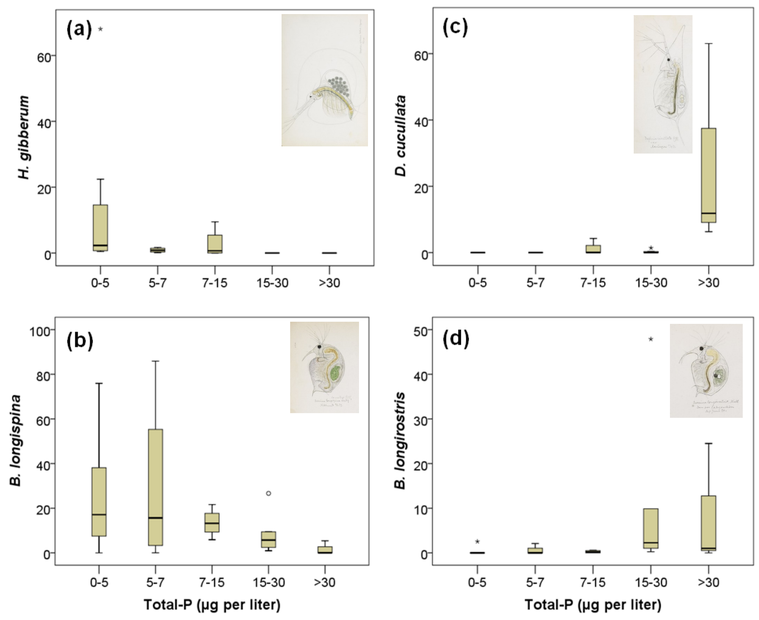

Fig. 4 Average frequencies of four common cladocerans, *Holopedium gibberum (a)*, *Bosmina longispina* (b) *Daphnia cucullata (c)* and *Bosmina longirostris (d)*, in five different total-P classes. Classes as in fig. 3. Illustrations of cladocerans are original drawings of G. O. Sars (1993 [1861]).

Conclusion

Our results indicated a **shift in cladoceran community with increasing nutrient content.** The results seem promising with regard to the use of **cladocerans as indicators of eutrophication** in Norwegian lakes. However, correlation of nutrient concentrations and other water chemistry parameters and zoogeographic gradients complicates the picture. Furthermore, the number of lakes in the dataset of medium and high nutrient content is limited.

Literature

Boix, D., Gascon, S., Sala, J., Martinoy, M., Gifre, J. & Quintana, X.D. (2005) A new index of water quality assessment in Mediterranean wetlands based on crustacean and insect assemblages: the case of Catalunya (NE Iberian peninsula). *Aquatic Conservation-Marine and Freshwater Ecosystems, 15, 635-651.*

Hill, M.O. & Gauch, H.G. (1980) Detrended correspondence analysis: An improved ordination technique. *Plant Ecology,* **43,** 47-58.

Jeppesen, E., No˜Ges, P., Davidson, et al. (2011) Zooplankton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD). *Hydrobiologia*.

Moss, B., Stephen, D., Alvarez, C., et al. (2003) The determination of ecological status in shallow lakes - a tested system (ECOFRAME) for implementation of the European Water Framework Directive. *Aquatic Conservation-Marine and Freshwater Ecosystems,* **13,** 507-549.

Sars, G.O. (1993 [1861]) *Om de i Christiania's Omegen forekommende Ferskvandskrebsdyr,* oix, D., Gascon, S., Sala, J., Martinoy, M., Gifre, J. & Quintana, X.D. (2005) A new index Universitetet i Bergen, Bergen.

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