Invasives, introductions and acidification: the dynamics of a stressed river fish community

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INTRODUCTION

In southern Norway, acidification due to atmospheric deposition (acid rain) has caused local extinction of thousands of inland fish stocks. Over the last decade, reduced levels of acidifying emissions and liming of water courses, has improved living conditions for fish. A threat to natural biodiversity in these waters is the intended or unintended introduction of exotic and invasive species. How do environmental conditions and introductions of aliens influence the population of the naturally occurring brown trout *(Salmo trutta)*?

STUDY AREA AND METHODS

The river Litleåna is a tributary to the river Kvina in Vest-Agder County, southern Norway (***Figure 1***). In order to chemically restore the river, a liming facility was installed in 1994. The water quality shows a typical trend with mean pH at 4.9-5.0 above and 6.1-6.4 below the liming facility.

Fishing was performed with a portable electrofisher at four localities below the liming facility in August every year over the ten year period 1995-2004. Each locality was fished three times (removal method), and all fish was identified to species. All body lengths were measured in the field.

RESULTS

- Since 1980, brook trout (*Salvelinus fontinalis*) have been introduced several times, and natural reproduction has been recorded. Over the ten year period 1995 – 2004, densities of brook trout have steadily decreased from 11 to less than 1 fish 100 m^{-2}, i.e. the species is now nearly extinct in the river.
- European minnow (*Phoxinus phoxinus*) has most likely been introduced to a tributary to Litlåna in the 1980s, but was first detected in the main stem of Litlåna at low densities in 1997. A swift population increase brought the minnow density at this locality to a maximum of more than 500 fish 100 m^{-2} in 2003 (***Figure 2***). Downstream migration of minnow has occurred in conjunction with the population expansion at the upper locality, and there has been a downstream migration rate of 19.0 km over seven years, i.e. approximately 2.7 km yr^{-1}. The adult minnows (60-80 mm in length) are the pioneers of downstream migration, and become the first colonizers of new habitats in the river. During the post-establishment years, minnow density was marginally (P=0.09) correlated to the pH i.e., low pH values in the water appear to cause mortality in the minnow population (***Figure 3***).
- Brown trout (*Salmo trutta*) was close to extinction before liming was initiated. There was a clear increase in densities of brown trout fry from 1995 to 1999 (***Figure 4***). Due to the varying water quality, there was a reduction in trout fry density in 2000 and 2001. The subsequent population recovery has been slow.
- Considering the correlation between densities of the fish species, there are no correlations between minnow and brook trout densities or between brown trout and brook trout densities during 1995-2004 in Litlåna. Based on the limited number of sampling years, there is , however, a tendency that brown trout density increases with minnow density up to around 100 minnow per 100 m^2, while decreasing at higher minnow densities (P=0.15).
- There is a significant reduction in body length of brown trout fry during 1995-2004 (P<0.005), and the length of trout fry decreases with the increasing numbers of European minnow (P<0.05) (***Figure 5***).

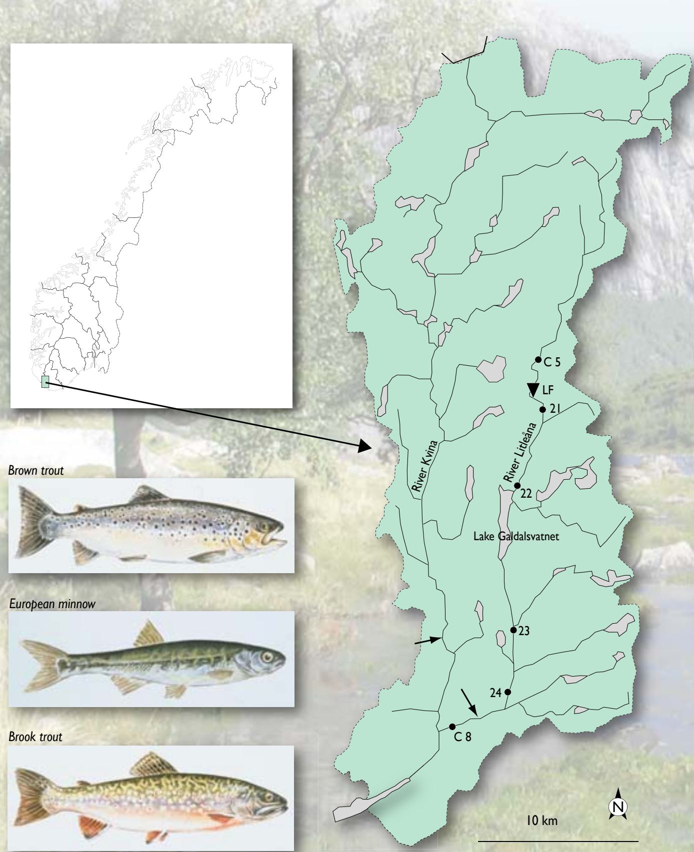

Figure 1. Location of the study area in River Litlåna with electrofishing localities (21-24), the liming facility (LF), and localities for chemical analysis (C5 and C8). The arrows indicate the upper part of the river sections with anadromous salmonids.

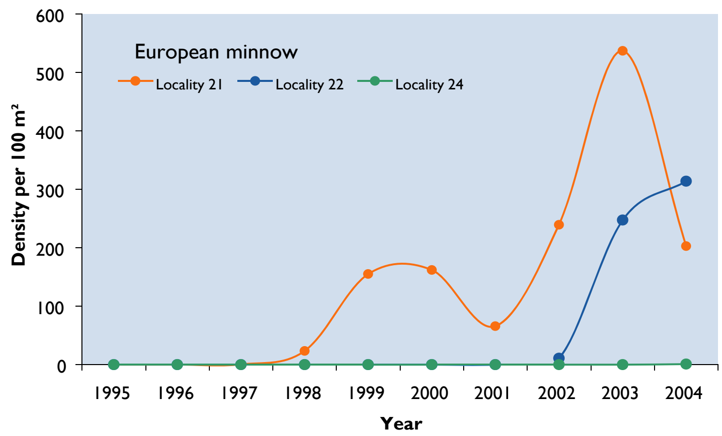

Figure 2. Densities of European minnow in Litlåna, localities 21, 22 and 24 during 1995-2004.

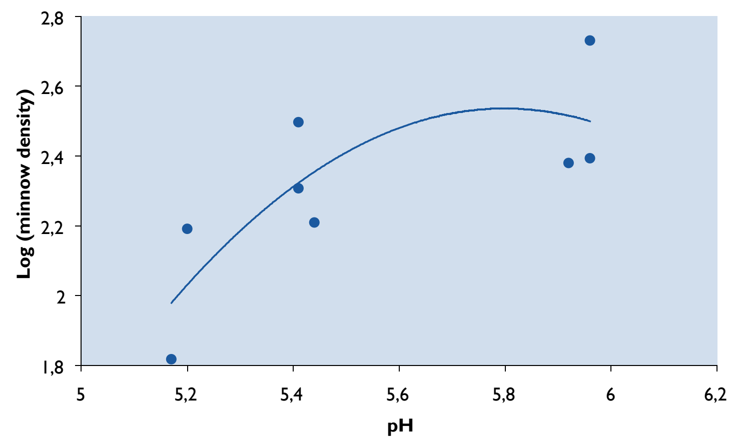

Figure 3. Minnow density in August at locality 21 (1998-2004) and locality 22 (2003-2004) as a function of the minimum pH recorded the preceeding 10 months. The selected years are subsequent to the population establishment ("boom") phase years.

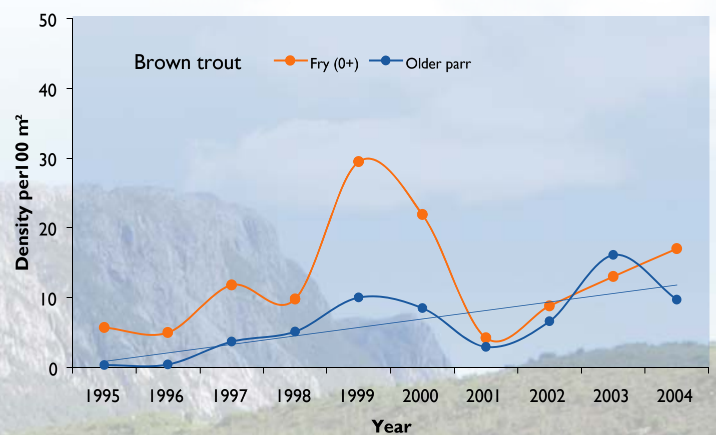

Figure 4. Densities of brown trout fry (age 0+) and older parr (age ≥1+) in Litlåna, 1995-2004. The sampling localities 21-24 were pooled.

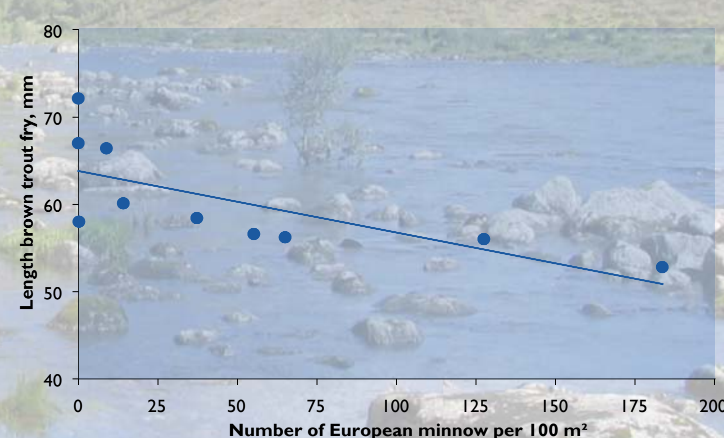

Figure 5. The correlation between densities of European minnow with length of brown trout fry (age 0+) in Litlåna, 1995-2004.

CONCLUSION

Minnow was established in a tributary to Litlåna before liming was initiated in 1994. The improved water quality caused rapid expansion to the main river, covering 19 km over seven years. The species will soon enter the river section with anadromous salmonids. Minnow expansion has negatively affected brown trout growth, and brown trout densities are lower than expected when minnow densities exceed a certain level.