Does acidification explain distribution of large branchiopods in the Scandinavian mountains?

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INTRODUCTION

Scandinavian mountains are **climate hot spots** where both precipitation and temperatures are increasing (Fig. 1). They are home to many Arctic species, which are valuable indicators of climate change[2,3,4]. Many studies have focused on global warming, whereas acidification has received less attention. **Arctic tadpole shrimp** (*Lepidurus arcticus*) can be used as an **indicator species of climate change and acidification[3].** *L. arcticus* live within a narrow temperature range and is not present in acidic waters. The juveniles are especially sensitive to acidification.

Arctic tadpole shrimp face a particularly challenging life beyond the Arctic circle. Firstly, they spend much of their life as resting eggs to survive through long and cold winters. Secondly, winter is followed by a short active season, during which they must survive and obtain enough energy to produce new resting eggs.

It is unclear if the **increasing precipitation** form a potential risk for the acid sensitive Arctic species living in the **Scandinavian Mountains**.

RESEARCH QUESTIONS

Why are Arctic tadpole shrimp only present in lakes, and not in small ponds in the Scandinavian mountains (Fig. 2)?

Is rainwater too acid for Arctic tadpole shrimps in the Scandinavian mountains?

BACKGROUND

Study species:

Arctic tadpole shrimp (*Lepidurus arcticus*)

- Indicator species for climate change[1,2]
- Arctic species

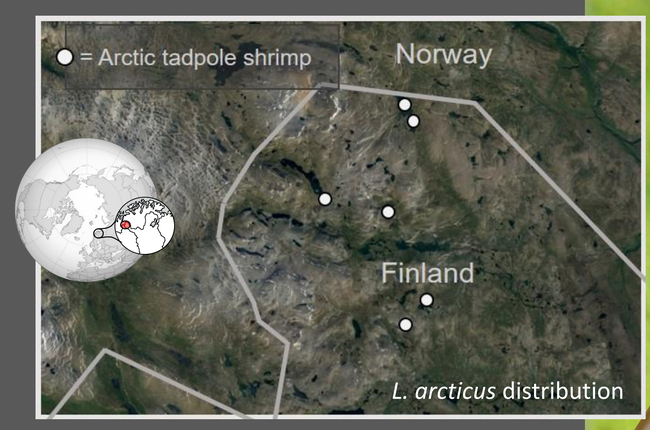
→ Temperature range 0.8–16.5°C

→ Sensitive for acidification;
Extinct at pH < 6.1
Mortality and delayed moulting of young animals at pH < 5.5

- One generation per year

Study area:

- 24 lakes and ponds in Northern Finland



To characterize the rainwater quality (pH) and temperature in the region the data monitored by the Finnish Meteorological Institute were used.

RESULTS

99 % OF RAIN IS TOO ACID FOR THE ARCTIC TADPOLE SHRIMP

Rainwater pH < 5.5 between 2000 – 2015 in Northern Finland (Fig. 3)

THE TIMING OF ACID PRECIPITATION IS BIOLOGICALLY IMPORTANT

Acid rain is particularly harmful to the young animals (Fig. 4)

POPULATIONS LIVING IN PONDS ARE PARTICULARLY SUSCEPTIBLE FOR EXTINCTION

Relatively large amounts of acid water rains directly to small ponds in comparison to larger lakes (Fig. 5).

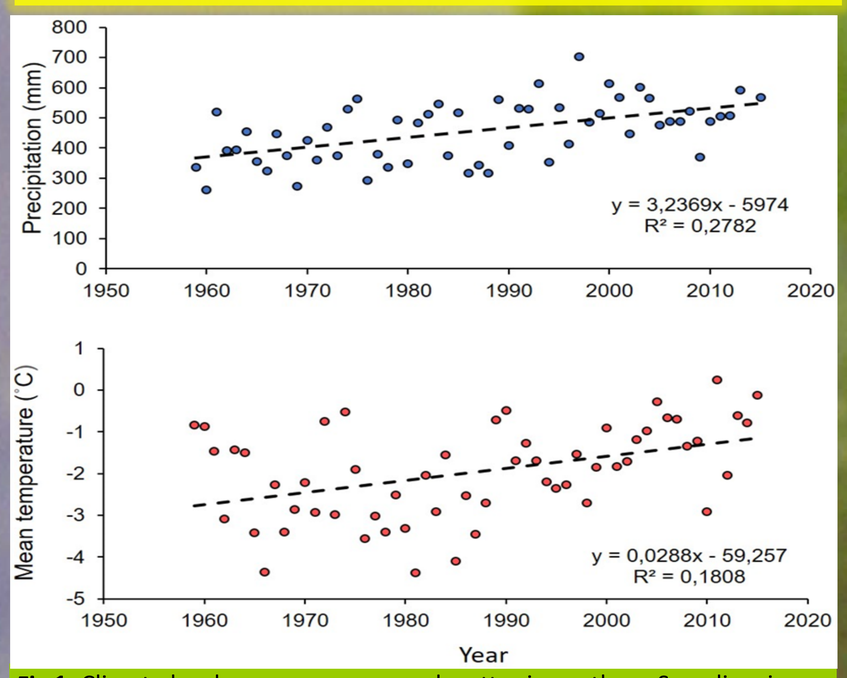


Fig 1. Climate has become warmer and wetter in northern Scandinavian mountains. Over the past 56 years, Kilpisjärvi, the northernmost point of Finland, has warmed by 1.6 ˚C and precipitation has increased by 181 mm.

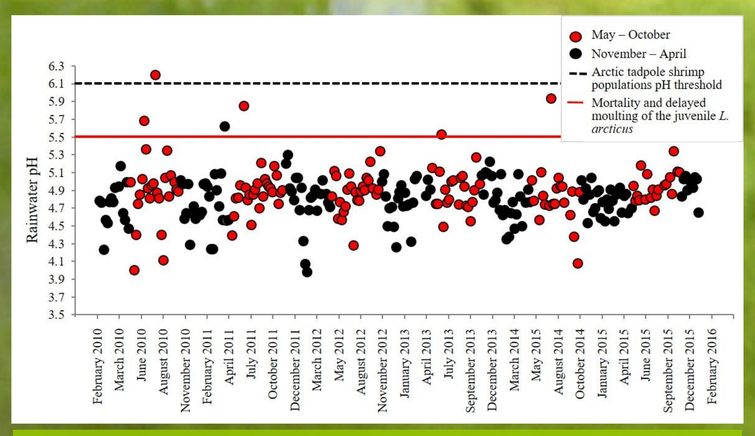


Fig 3. Rainwater is too acid for Arctic tadpole shrimp in Northern Finland.

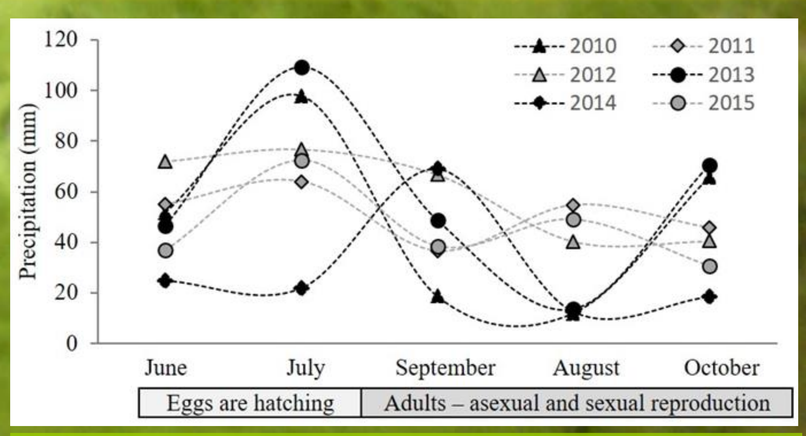


Fig 4. The timing of acid precipitation is biologically important. If large amount of acid rain is coming to the lake the same time when the animals are hatching or young animals are present in the lake, these sensitive life stages will die.

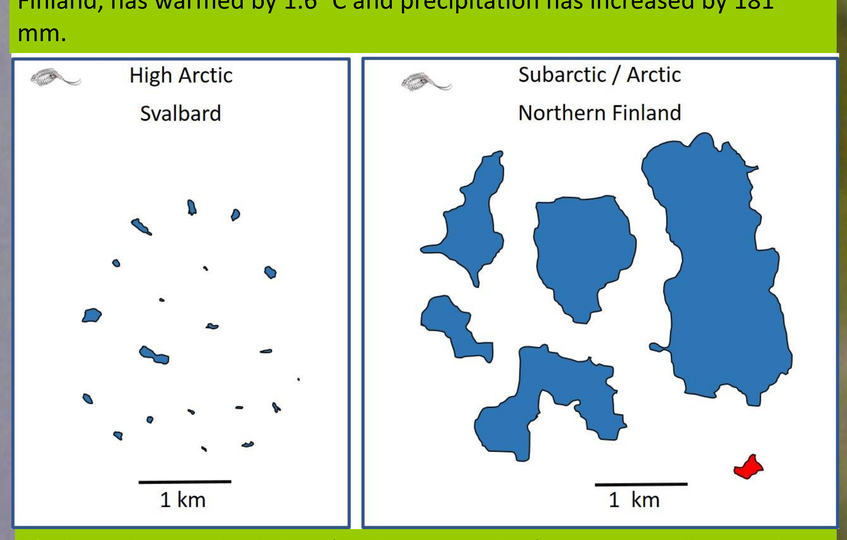


Fig 2. Arctic tadpole shrimp (*Lepidurus arcticus*) present small ponds in High Arctic, Svalbard, (left[1]). On the contrary in subarctic / arctic areas in Northern Finland, Arctic tadpole shrimp are present only in lakes (right). The red lake in the right is a pond where Arctic tadpole shrimp was present in 1955[1] but not anymore.

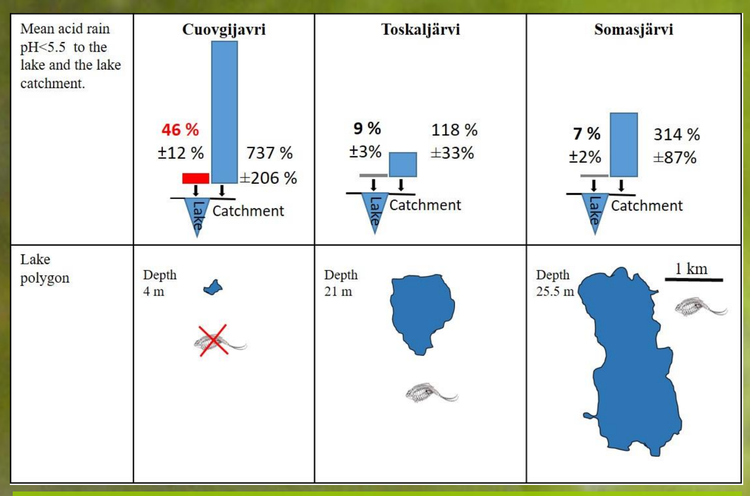


Fig 5 . Relatively large amounts of acid water (bold, proportion of lake volume per year) rains directly to the small Cuovgijavri pond in comparison to the larger lakes Toskaljärvi and Somasjärvi in the same region. Arctic tadpole shrimp is no longer present in the small pond. Percent in the left (bold) is the acid rain to the lake and % on right is the acid rain to the lake catchment.

TAKE HOME MESSAGES:

- **Small and shallow waterbodies can be too acid for Arctic tadpole shrimp and other acid sensitive species in Northern Scandinavian Mountains**
- **Future monitoring studies urgently needed to predict and mitigate potential future changes in community compositions and ecosystem status in subarctic ponds**

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