Sensitivity of the endangered freshwater pearl mussel, *Margaritifera margaritifera*, to pH, iron and aluminium in an acid sulfate soil river

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Background

- critically low pH in acid sulfate soil rivers, especially during autumn-winter runoff period

Climate change is predicted to increase river flow and winter discharge
- acidity problems in acid sulfate soil rivers may increase

Mussels can be sensitive to acidity
→ impact on the endangered freshwater pearl mussel populations in those rivers?

*Long-term trends and variation of acidity, COD$_{Mn}$ and colour in coastal rivers of Western Finland in relation to climate and hydrology (Sci Tot Env 408: 5019–5027)
River Ähtävänjoki
Lower reaches:
- low pH
- no *Margaritifera*

Upper reaches:
- higher pH,
- fragmented *Margaritifera* populations
Question:

Do the acid run-offs limit the distribution of freshwater pearl mussel in lower reaches of River Ähtävänjoki?
pH in lower reaches of River Ähtävänjoki
pH in UPPER reaches of River Ähtävänjoki
Fe concentration (µg L⁻¹) in lower reaches of River Ähtävänjoki
Fe concentration (µg L⁻¹) in UPPER reaches of River Ähtävänjoki
Al concentration (µg L⁻¹) in lower reaches of River Ähtävänjoki
Aim:

To study effects of pH, iron and aluminium on survival of the freshwater pearl mussel, *Margaritifera margaritifera*
- free glochidium-larvae
- glochidia attached to fish host
- juvenile mussels
Life cycle of *Margaritifera*

Glokidium-larvae live as parasites attached to gills of salmon *Salmo salar* and trout *S. trutta* from autumn over winter to the next summer, growing to about 0.4 mm in length.

Juvenile mussels drop off from host fish in early summer and start their benthic life. Juvenile mussels live completely burrowed in bottom sediment.


Female mussels release glochidia in autumn. Size 0.07 mm. Glochidia attach to gills of salmon and trout.

Mussels come to the surface of sediment at 4-8 yr of age (10 mm). Reach maturity at 20 yr of age. Life span > 100 yr, max 280 years.
Freshwater pearl mussel *Margaritifera margaritifera* (Linnaeus, 1758)

Distribution: Europe and east North America

Once huge abundances everywhere with *Salmo salar, S. trutta* and *Salvelinus fontinalis*

Now in trouble throughout its current distribution area

Listed as endangered in the IUCN Red List, included in Annex II and V of the EU Habitats & Species Directive

Fully protected by law

Distribution map: Larsen (2005)
Freshwater pearl mussel *Margaritifera margaritifera*

Decline in Finland:
- 250 rivers in early 1900’s
- now 70 rivers
- only few populations with successful reproduction
Causes of decline

1. Pearl fishing

3. Deterioration of habitat
- silting
- ditching (forest, road, peat production), forestry practices
- juvenile mussels live buried in sediment interstitial water

2. Decline of salmonid fish host populations
- damming
- overfishing
- habitat loss
- etc.

4. Water quality
- eutrophication
- toxic substances
- acidity
- sulfate soils
Reproductive, vital populations can be found in northern Finland.
In southern Finland, only one reproductive population:

River Ähtävänjoki

Photos: Jouni Salonen

Panu Oulasvirta
Methods

pH, Fe and Al → survival of *Margaritifera margaritifera*

- Free glochidium-larvae
- Glochidia attached to fish host
- Juvenile mussels
pH treatments
(1) pH control, unmodified river water from upper part of the river, pH 6.8
(2) pH 6.0
(3) pH 5.5
(4) pH 5.0
(5) pH 4.5
- control water modified by adding hydrochloric acid HCl

Fe treatments
(1) Fe control, unmodified river water from upper part of the river, Fe concentration 0.28 mg L\(^{-1}\)
(2) Fe 0.5 mg L\(^{-1}\)
(3) Fe 1.0 mg L\(^{-1}\)
(4) Fe 1.5 mg L\(^{-1}\)
(5) Fe 2.0 mg L\(^{-1}\)
- control water modified by adding FeSO\(_4\)
Al treatments
(1) Al control, unmodified river water from upper part of the river, Al concentration 0.007 mg L\(^{-1}\)
(2) Al 0.25 mg L\(^{-1}\)
(3) Al 0.5 mg L\(^{-1}\)
(4) Al 0.75 mg L\(^{-1}\)
(5) Al 1.0 mg L\(^{-1}\)
- control water modified by adding AlCl\(_3\)

Combined Al and Fe
(1) Al+Fe control, unmodified river water
(2) Al 0.25 + Fe 0.5 mg L\(^{-1}\),
(3) Al 0.5 + Fe 1.0 mg L\(^{-1}\)
(4) Al 0.75 + Fe 1.5 mg L\(^{-1}\)
(5) Al 1.0 + Fe 2.0 mg L\(^{-1}\)
Methods: Free glochidium larvae

Glochidia collected from River Ähtävänjoki mussels

1000 freshly shed glochidia per treatment in 500 mL glass vial

pH, Fe and Al exposure in 6°C, dark room

Three time points: 24h, 48h and 72h
- five samples of 30 glochidia collected at each time point
- glochidium classified as dead if not closed the valves when disturbed
- mean survival rate (%) at each time point
Results: Free glochidia

Clear negative effect of low pH on survival of glochidia
Results: Free glochidia

Clear negative effect of high Fe on survival of glochidia
Results: Free glochidia

Also negative effect of high Al on survival of glochidia
Results: Free glochidia

Negative effect of combined Al+Fe on survival of glochidia
Methods: Glochidium larvae attached to fish

Glochidia and brown trout from River Ähtävänjoki, fish infected in laboratory

Treatments (55 fish per treatment)
(1) Control
(2) Al 0.5 mg L\(^{-1}\)
(3) Fe 0.5 mg L\(^{-1}\)
(4) Fe 1.5 mg L\(^{-1}\)

Nine time points: 1, 4, 7, 14, 21, 28, 42, 56 and 76 days post infection
- six fish examined per time point
- mean number of glochidia per fish at each time point
Results: Glochidia in fish

No effect of Al or Fe exposure on survival of glochidia in fish
Methods: Juvenile mussels

Glochidia and brown trout from River Ähtävänjoki, fish infected in laboratory → developed juveniles that dropped off from the fish were collected from bottom of tank

11 treatments (next slide)
Three replicate dishes per treatment
10 juveniles per treatment

Five time points: 24, 48, 72, 120 and 168h - mean survival rate (%) at each time point
Results: Juvenile mussels

No differences between treatments in survival of juveniles
Summary
Low pH, high Fe and high Al decrease survival of *Margaritifera* glochidia (but not fish-attached glochidia or juveniles)

Conclusions
1. Acid run-offs will probably limit occurrence of *Margaritifera* in lower reaches of River Ähtävänjoki
... as well as in other acid sulfate soil rivers

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