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

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Photo: Panu Oulasvirta

Background

Saarinen*, Vuori, Alasaarela and Kløve (2010):
- critically low pH in acid sulfate soil rivers, especiallly 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)

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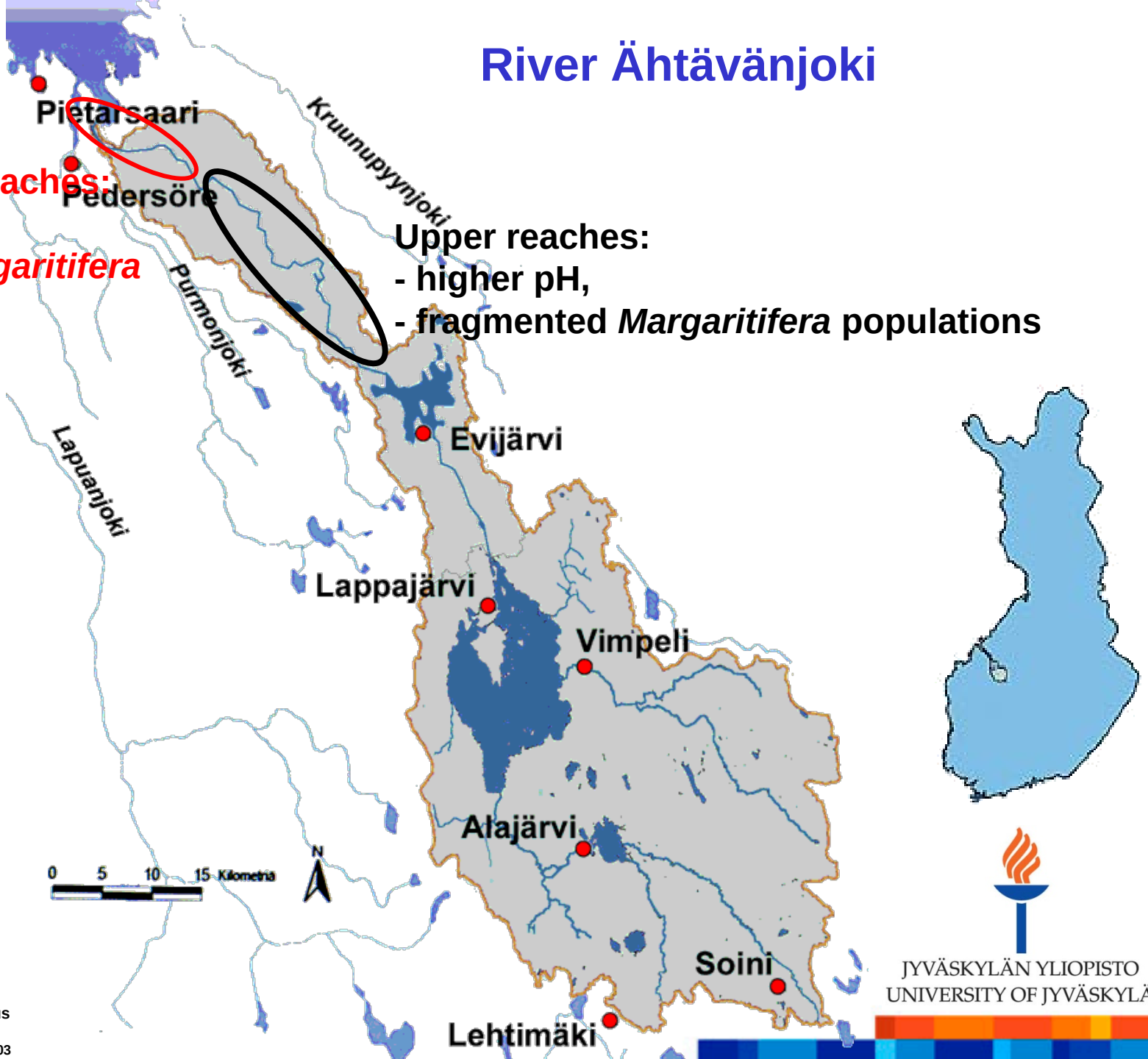
River Ähtävänjoki

Eero Mäenpää

River Ähtävänjoki



Lower reaches:
- low pH
- no *Margaritifera*

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

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Länsi-Suomen ympäristökeskus
Kartta: Juha-Matti Markkola/
Maanmittauslaitos lupa nro 7/MYY/03

Question:

Do the acid run-offs limit the distribution of freshwater pearl mussel in lower reaches of River Ähtävänjoki?

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pH in lower reaches of River Ähtävänjoki

pH in UPPER reaches of 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

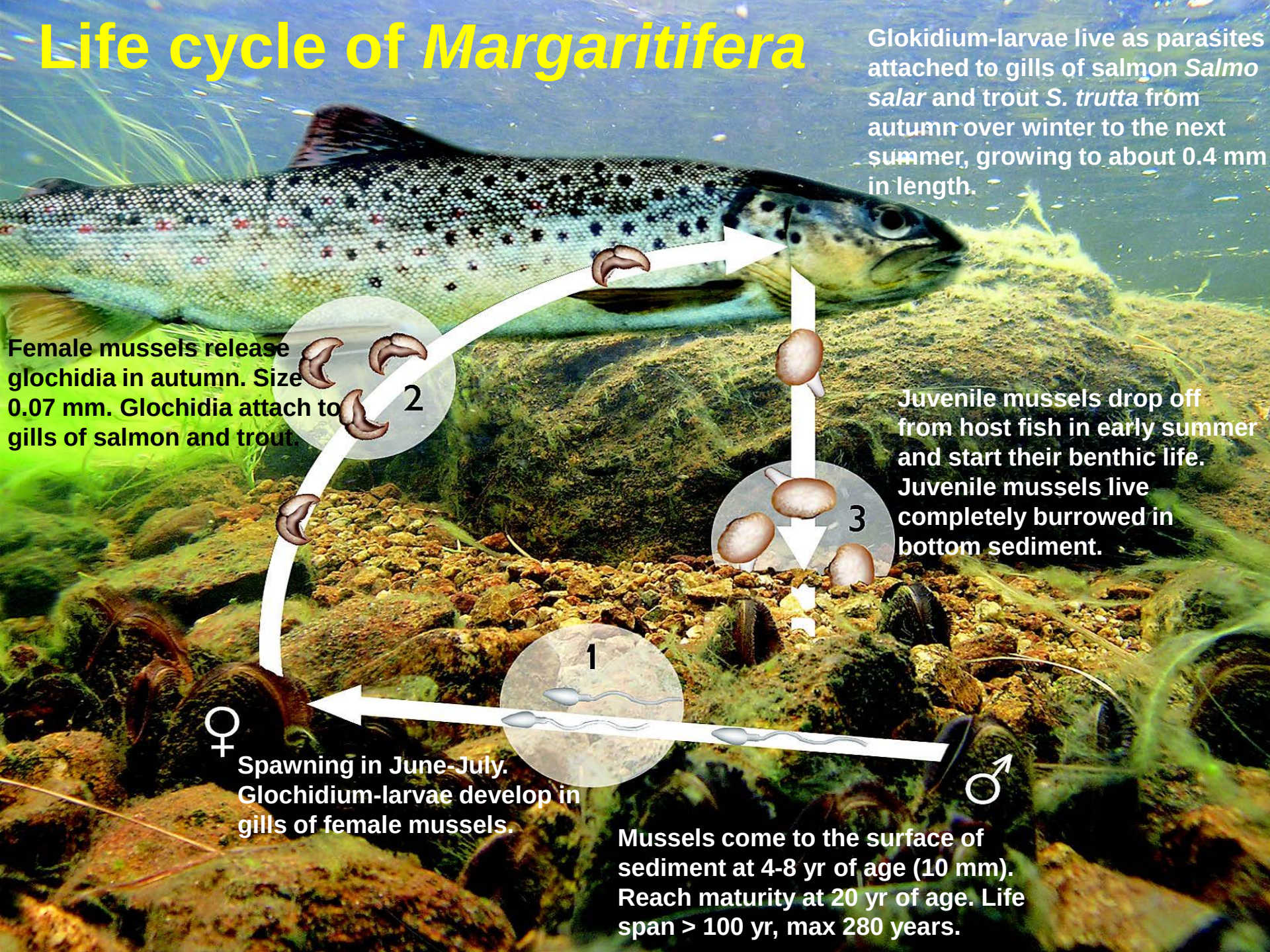
Al concentration (µg L^{-1}) in lower reaches of River Ähtävänjoki

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*



Freshwater pearl mussel *Margaritifera margaritifera* (Linneaus, 1758)

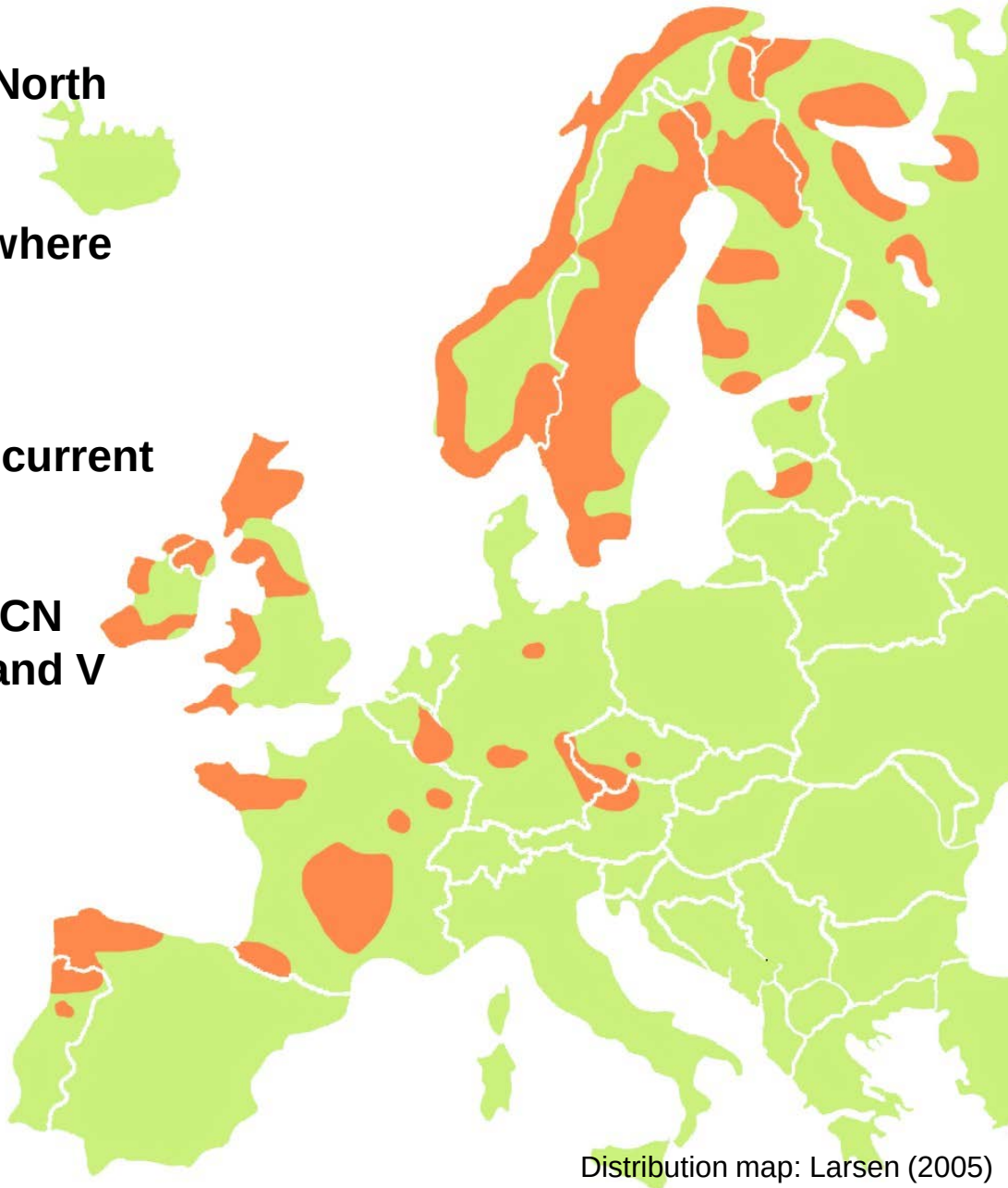
Distribution: Europe and east North America

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

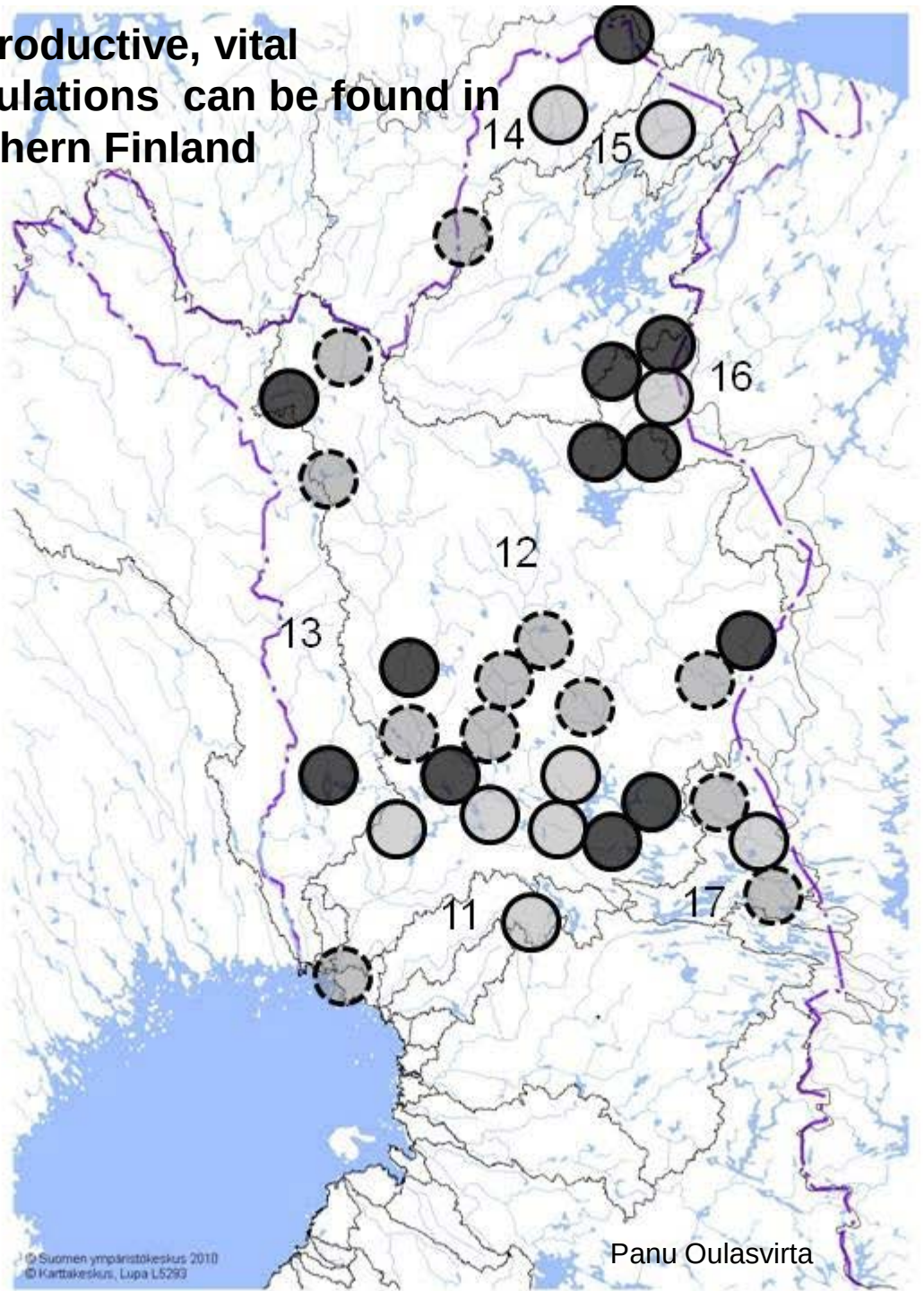
3. Deterioration of habitat
- silting
← ditching (forest, road, peat production), forestry practices
- juvenile mussels live buried in sediment interstitial water

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

4. Water quality
- eutrophication
- toxic substances
- acidity
- sulfate soils

Kuvat: Jouni Salonen

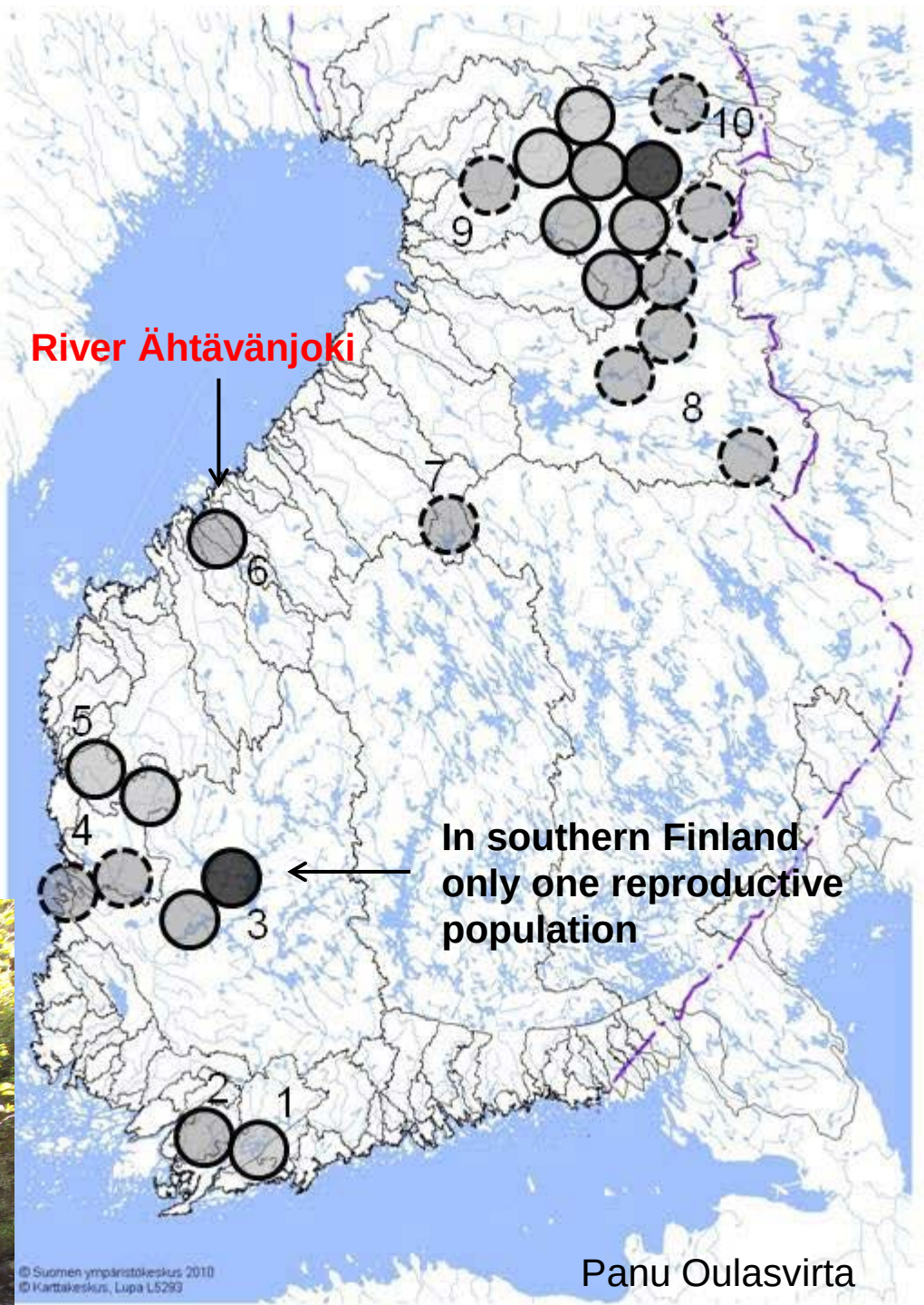
Reproductive, vital populations can be found in northern Finland



Panu Oulasvirta

Kuva: Panu Oulasvirta

Photos: Jouni Salonen



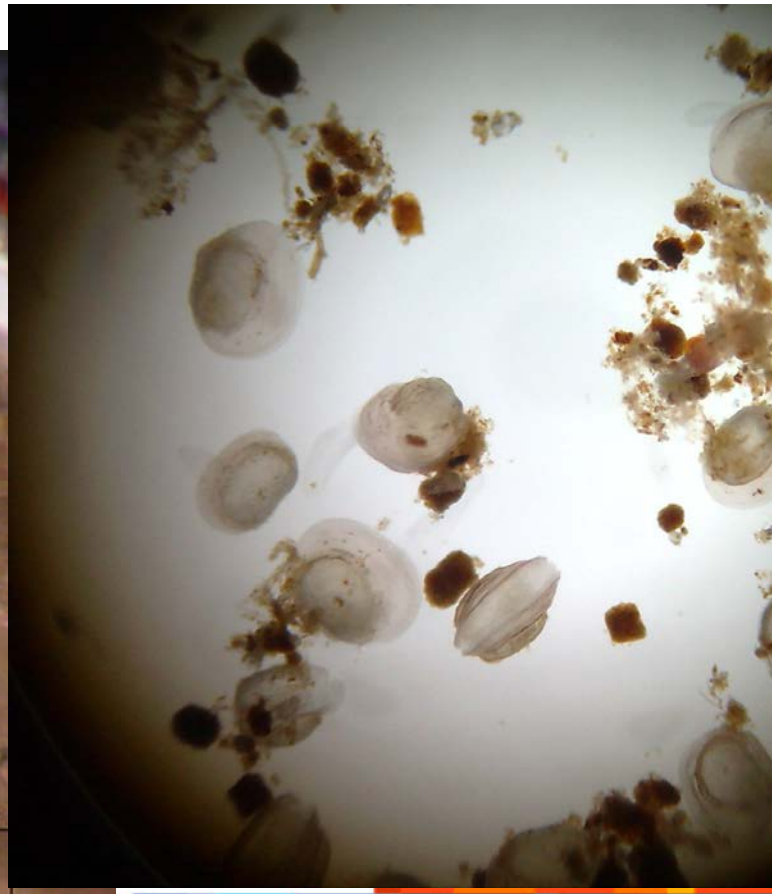
Panu Oulasvirta

Kuva: Mikko Ranta

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 mgL^{-1}
(3) Fe 1.0 mg L^{-1}
(4) Fe 1.5 mg L^{-1}
(5) Fe 2.0 mgL^{-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 0.75mg 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 1.5mg L^{-1}

(5) Al 1.0 + Fe 2.0 mgL^{-1}

Methods: Free glochidium larvae

Glochidia collected from River Ähtävänjoki mussels

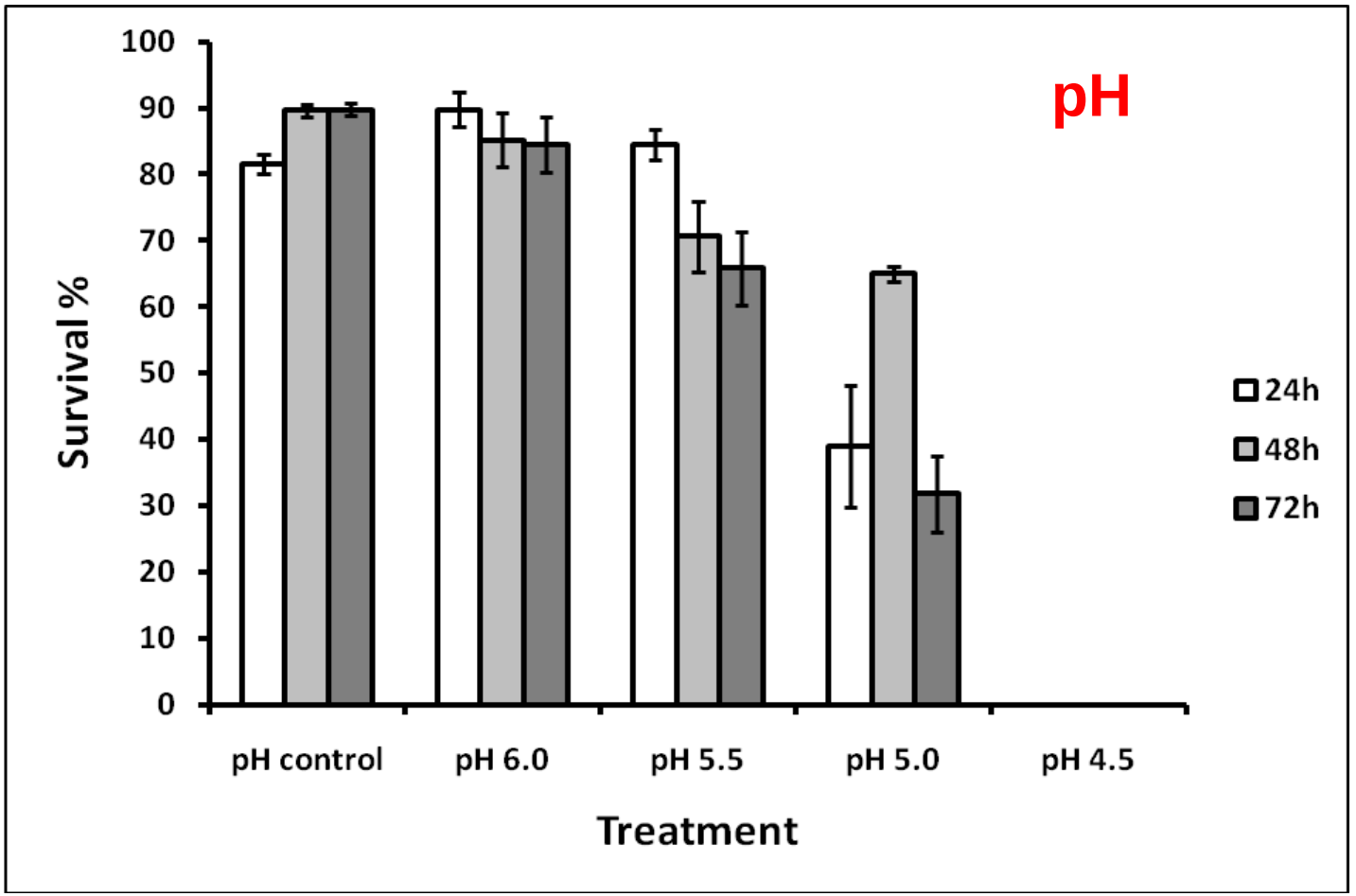
1000 freshly shed glochidia per treatment in 500 mL glass vial

pH, Fe and Al exposure in 6ºC, 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

Photo: Jouni Salonen

Results: Free glochidia



Clear negative effect of low pH on survival of glochidia

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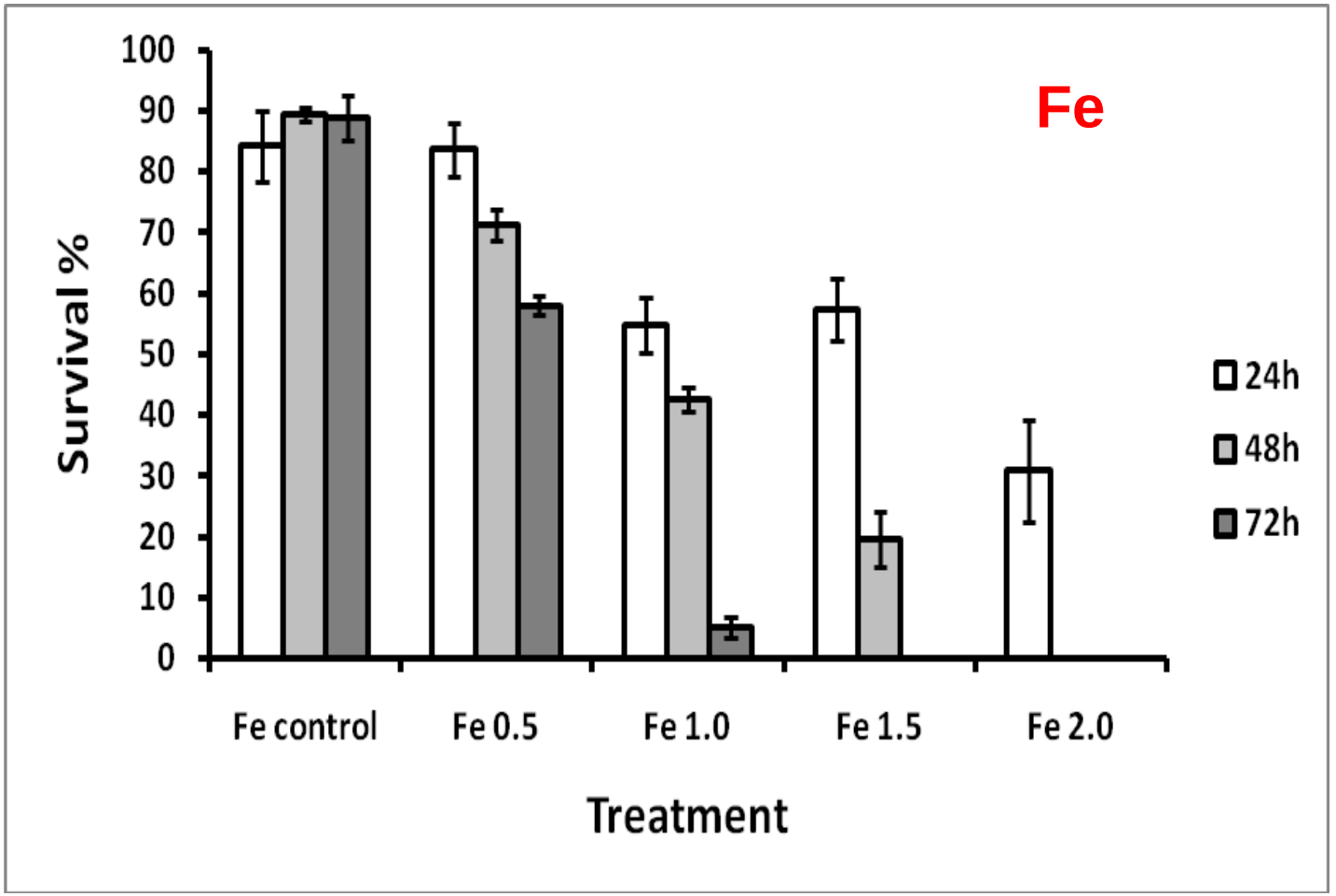
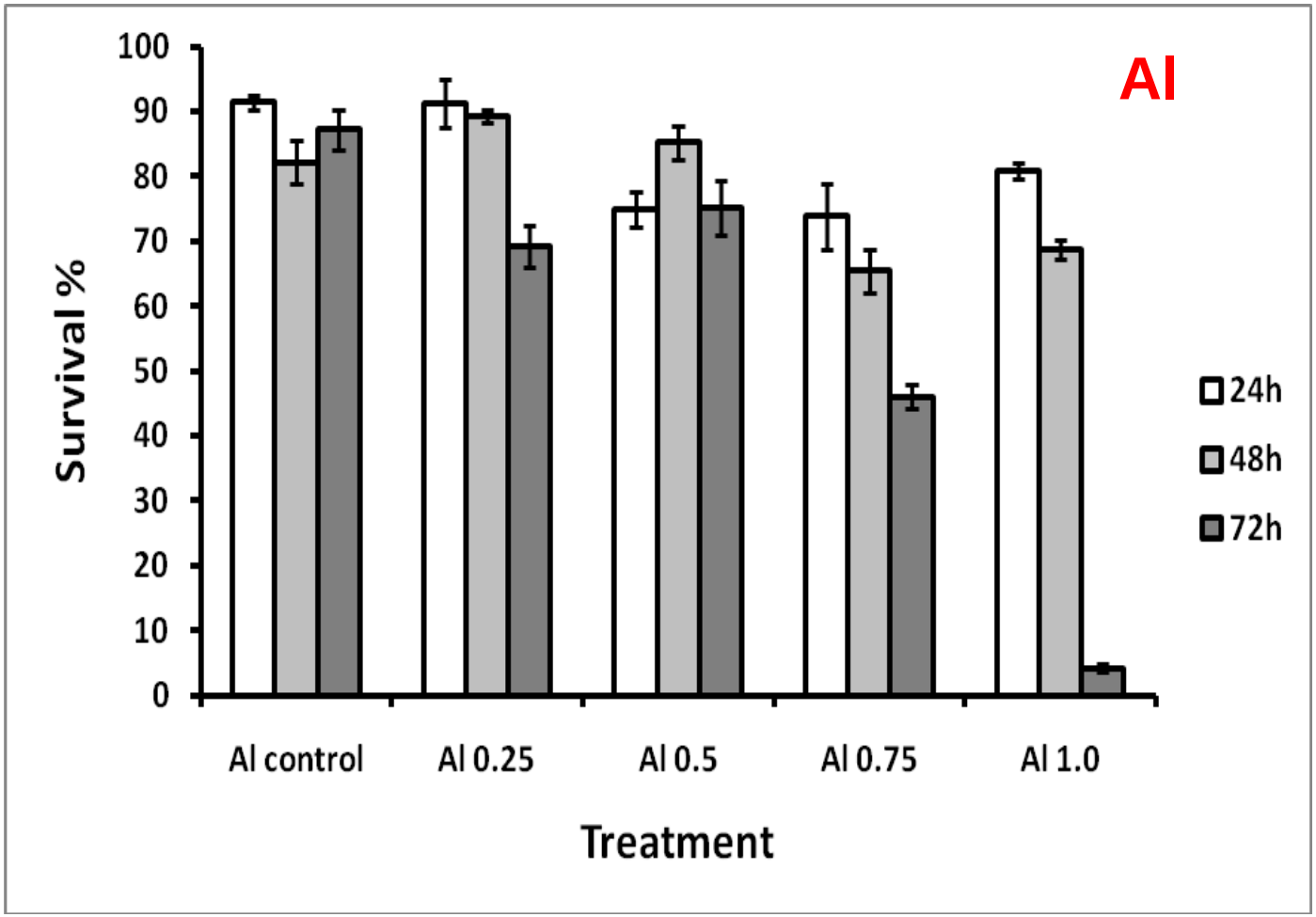
Results: Free glochidia



Clear negative effect of high Fe on survival of glochidia

Results: Free glochidia



Also negative effect of high Al on survival of glochidia

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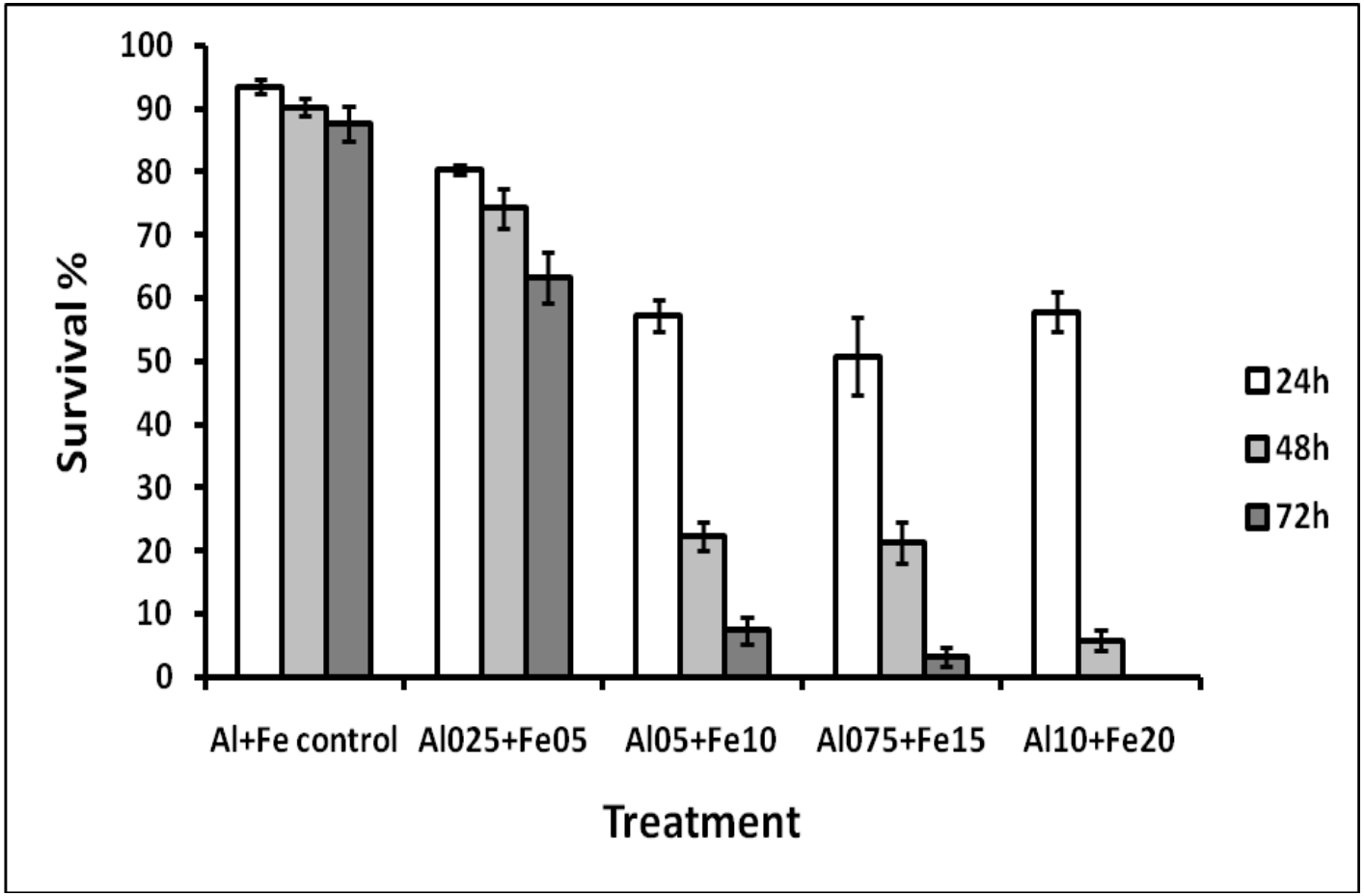
Results: Free glochidia



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

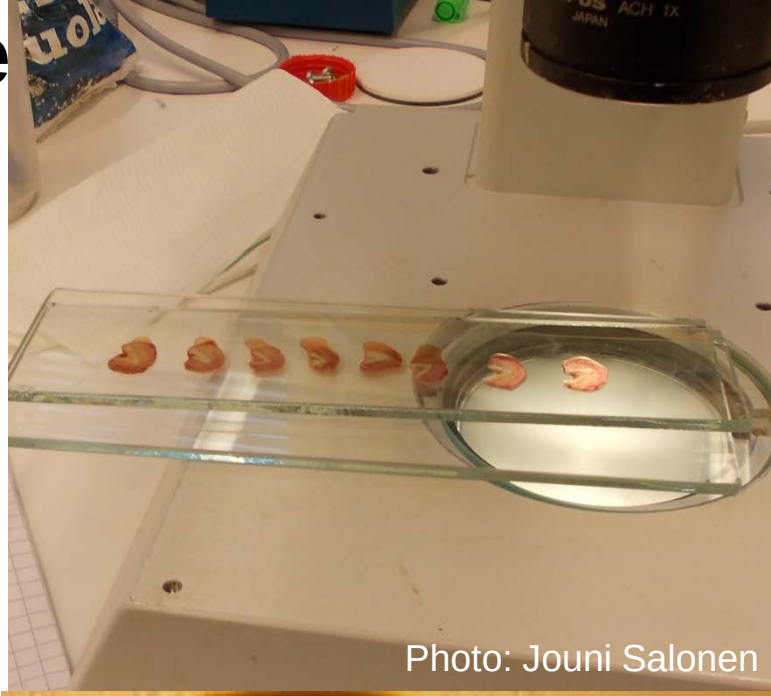
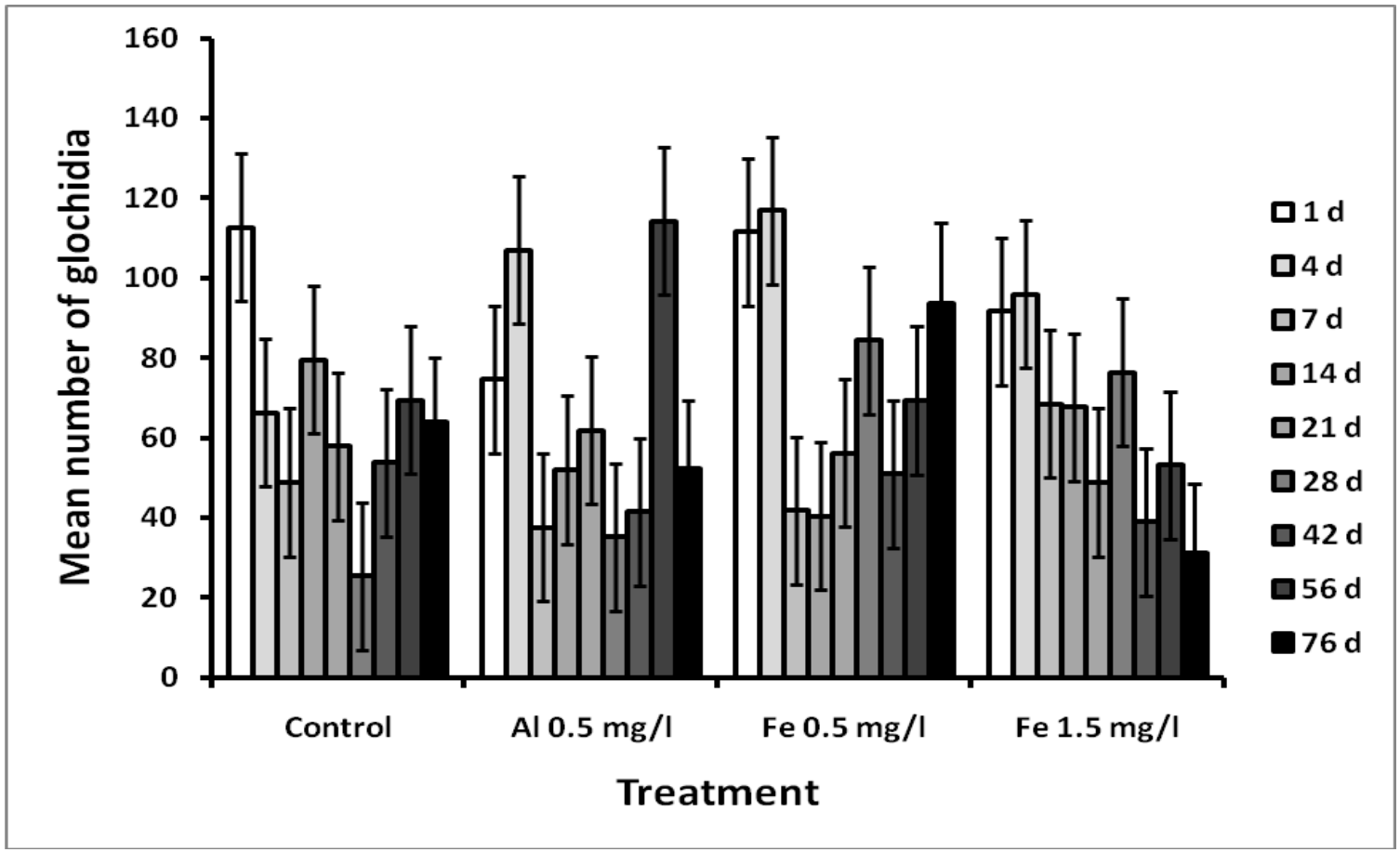


Photo: Jouni Salonen


Photo: Mikko Ranta

Results: Glochidia in fish



No effect of Al or Fe exposure on survival of glochidia in fish

Methods: Juvenile mussels

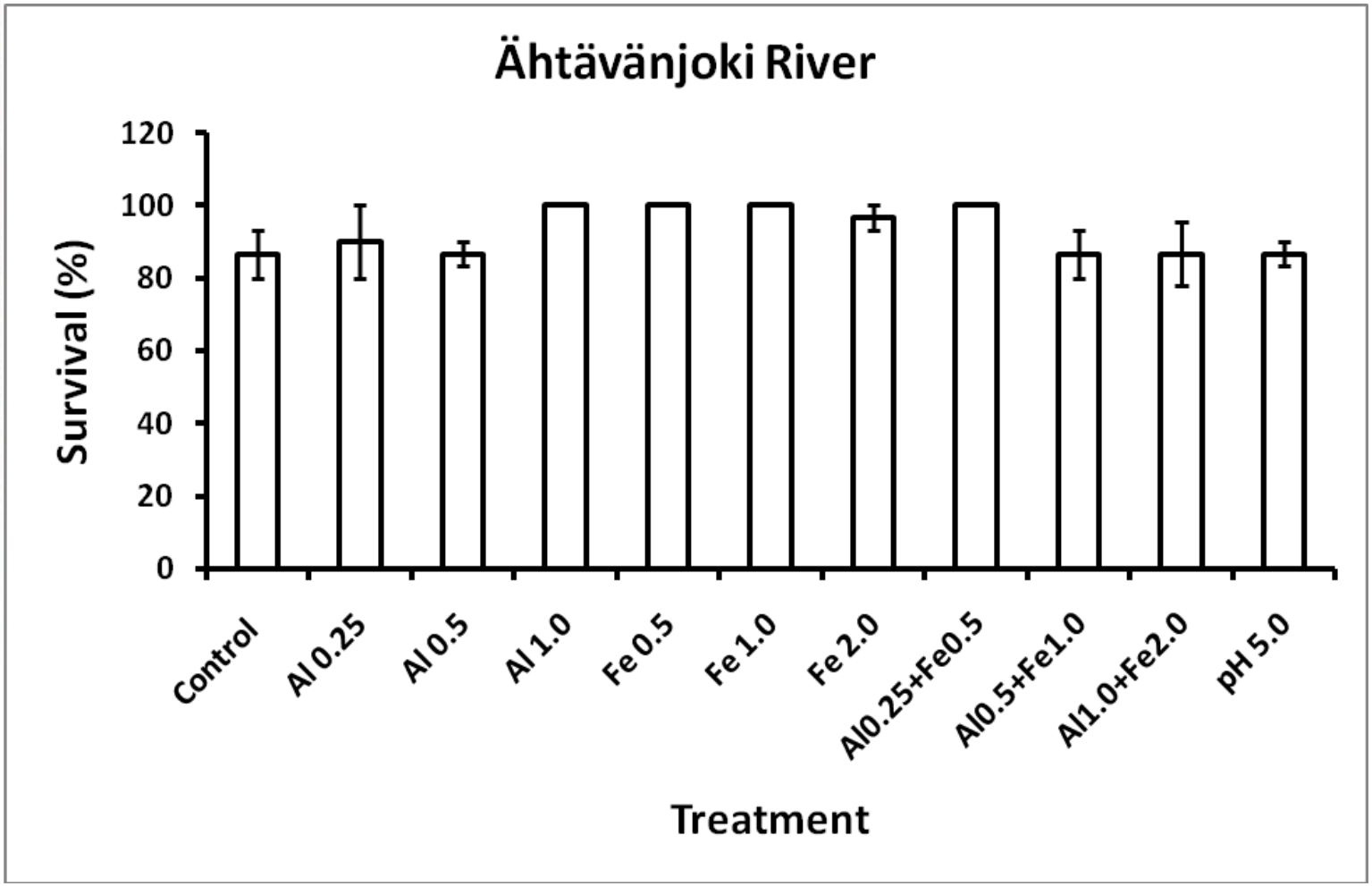
Glochidia and brown trout from River Ähtävänjoki, fish infected in laboratory
→ developed juveniles that dropped off from the fish were collected from bottom of tank

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

Five time points: 24, 48, 72, 120 and168h
- mean survival rate (%) at each time point

Photos: Päivi Berg

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

TASKINEN, J., BERG, P., SAARINEN-VALTA, M., VÄLILÄ, S., MÄENPÄÄ, E., MYLLYNEN, K. and PAKKALA, J. 2011. Effect of pH, iron and aluminum on survival of early life history stages of the endangered freshwater pearl mussel, *Margaritifera margaritifera*. *Toxicological and Environmental Chemistry* 93(9): 1764-1777.

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