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Sometimes being small is better than large: American mink (neovision vison) preying on naïve and wild brown trout juveniles in semi-natural streams

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Predation has both direct and indirect effects on the structure of stream fish communities. Predatory fish are considered gape limited, and thus a larger body size provides shelter from predatory fishes. Whereas the effects of fish predation on salmonid fish populations are relatively well known, the effect of mammalian predators is less clear. The predation threat has been found to also affect habitat selection as small sized fish are found to take refuge in shallow areas to reduce predation risk. Although shallow areas are considered refuges against fish predators, they can increase encounters with terrestrial piscivores, as wading and diving predators forage effectively in shallow water. The vulnerability to predation also interacts with habitat complexity, because prey vulnerability generally decreases as the environmental complexity increases.

When large carnivores have been lost or have become rare, smaller sized "mesocarnivores" play a larger role in the prey community structure. In many European freshwater systems the otter (*lutra lutra*) and American mink (*neovison vison*) play a key role as semi-aquatic predators. Both predators feed on fish, including salmonids. The American mink was introduced to Europe from North America for fur farming. Escaped minks have established naturally reproducing populations around Europe. We have relatively limited knowledge of the impacts of this invasive alien species on its prey species.

In this study we present the results of two experiments run in semi-natural streams to test the hypothesis that 1) hatchery fish are more vulnerable to predation from the semi-aquatic predator, American mink, than wild fish, 2) a larger body size protects fish from mink predation, and 3) habitat complexity in the form of fine wood protects fish from mink predation. The original idea of Experiment 1 was to study the long-term patterns in the strength of competition between hatchery and wild brown trout (Huusko & Vehanen, 2011). In Experiment 2 the original aim was to examine possible growth differences in stream sections with and without wood addition (Enefalk *et al*. 2019). However, after several months from the start of the experiment in winter, we noticed tracks of feral mink in the experimental stream area, and it became obvious that the mink had preyed on the experimental fish on both occasions.

The study design

We conducted the experiments in 26 m long and 1.5 m wide outdoor artificial stream channels at the Kainuu Fisheries Research Station (Natural Resources Institute Finland, www.kfrs.fi/en/frontpage/, 64°30′ N, 27°10′ E). The stream bed consisted of natural material, a 10–15 cm layer of gravel and pebbles. Each stream was divided into three 8.5 m long sections (upstream–middle–downstream) with wire mesh panels (mesh size 10 mm (Experiment 1) or 6 mm (Experiment 2). In both experiments each study section comprised an upstream riffle and a downstream pool section. In the first experiment we compared the vulnerability of brown trout to predation, brown trout were age 1+ hatchery brown trout (HBT) (length 142 ± 16 mm, average ± SD) and wild brown trout (WBT) (112 ± 8 mm) fish of similar genetic origin. Substitute design was used with brown trout in sympatry (five wild brown trout and five hatchery brown trout) and allopatry (10 wild brown trout or 10 hatchery brown trout). In the second experiment we used age-0+ brown trout (79±5 mm), and a stratified random design with treatments of fine wood (FW) addition to increase habitat heterogeneity (bundles of willow branches) and controls (C), no wood added. We placed 20 brown trout in each stream section.

The brown trout juveniles used in the experiments originated from the River Kuusinkijoki stock. The river sustains wild lake migrating brown trout population. Smolts migrate to lakes in the Russian side (Lakes Pääjärvi and Paanajärvi). Stock has also been kept in the hatchery since 1990 for stocking purposes. Wild fish (age 1+) were electrofished from the Kuusinkijoki river and transported to the experiments at the same time as hatchery trout (F1) of similar age (Experiment 1). The brown trout used in Experiment 2 originated from wild parents, were produced in the same hatchery, and were transferred to the experimental site during the late yolk-sac period. Pit-tags were used for individual recognition (HDX Oregon 23 mm for 1+ and HDX Oregon 12 mm for 0+ fish). Portable PIT antenna was used to locate the fish, and fish were electrofished for measurements at equal intervals. Both experiments started in August and in Experiment 1 two feral mink arrived early in November and preyed on brown trout, whereas in Experiment 2 three feral mink arrived in January to feed on 0+ brown trout.

Results

Out of 87 brown trout in the Experiment 1, 58.6 percent or 51 fish (38 hatchery brown trout (HBT) and 13 wild brown trout (WBT) were killed by mink. Three fish (two HBT and one WBT) were lost: their fate could not be identified. When in the different units (allopatric treatment) there was a significant difference in survival of WBT and HBT: that the HBT had a survival of 10.4 percent, which was clearly lower than the 83.3 percent for the WBT. When in the same unit (sympatric treatment) WBT (46.7 percent) was significantly lower than the survival of the allopatric WBT. In both treatments the average length of HBT fish that had been preyed on was significantly greater than that of the surviving fish.

After the mink visits in Experiment 2 in total 56.6 percent of the trout in the treatments where the habitat complexity was increased by adding FW, and 35.7 percent in control sections were found alive, compared to the trout numbers present in early December. The survival of the brown trout was significantly higher in the FW treatment areas compared to control treatment areas with no wood addition. In treatment areas where the habitat complexity was increased by adding FW smaller trout seemed to survive better, but this was insignificant

Conclusions

Previous studies from small streams have shown that predation by mink can cause high mortality among juvenile salmonids. Our results from the semi-natural environment support these earlier findings. We found considerably lower survival rates in hatchery brown trout than in wild trout of the same genetic origin. These results are in accordance with earlier results that hatchery fish are more vulnerable to predation than wild fish. This was now confirmed under mink predation. The mortality of wild brown trout was significantly higher when in sympatry with hatchery trout than it was in allopatric wild trout treatments. This suggested that presence of hatchery fish can increase the predation effect from mink on wild brown trout juveniles. Smaller hatchery trout individuals survived better than larger individuals which is contradictory to “bigger is better hypothesis”, developed mainly for gape-limited predators. In small streams under predation from wading terrestrial predator stocking of large-sized juveniles might not be beneficial. Increased habitat complexity by FW in our small streams decreased the mortality of brown trout juveniles from predation by mink, suggesting that restoring habitat complexity can be used to decrease mink predation. We conclude that high predation by feral mink should be considered in management actions when restoring salmonid populations in small streams.

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