# Behavioural responses of invasive (*Gmelinoides faciatus*) and native (*Gammarus lacustris*) amphipods to predators on different bottom substrates

**Paul Teesalu[1], Fabio Ercoli[1,2], Arvo Tuvikene[1]**

1. Centre for Limnology, Estonian University of Life Sciences, 61117, Rannu parish, Tartumaa, ESTONIA paul.teesalu@emu.ee; arvo.tuvikene@emu.ee

2. Nautral Resources and Environment, Department of Biological and Environmental Sciences, University of Jyväskylä, Survontie 9C, 400014, Jyväskylä, FINLAND fabio.ercoli@emu.ee

## Background

The amphipod *Gmelinoides fasciatus* has invaded and established in numerous large lakes in Eurasia and, in the process, has displaced the native amphipod, *Gammarus lacustris*. In Lake Peipsi, *G. fasciatus* dominates the shoreline macroinvertebrate fauna, forming up to 99% of macroinvertebrate individuals (Fig. 1). The mechanism behind its invasion success is unclear and remains an important topic for invasion ecology.

In order to determine if different bottom substrates and predator avoidance behaviour contribute to the invasion success of *G. fasciatus* we conducted two laboratory experiments.

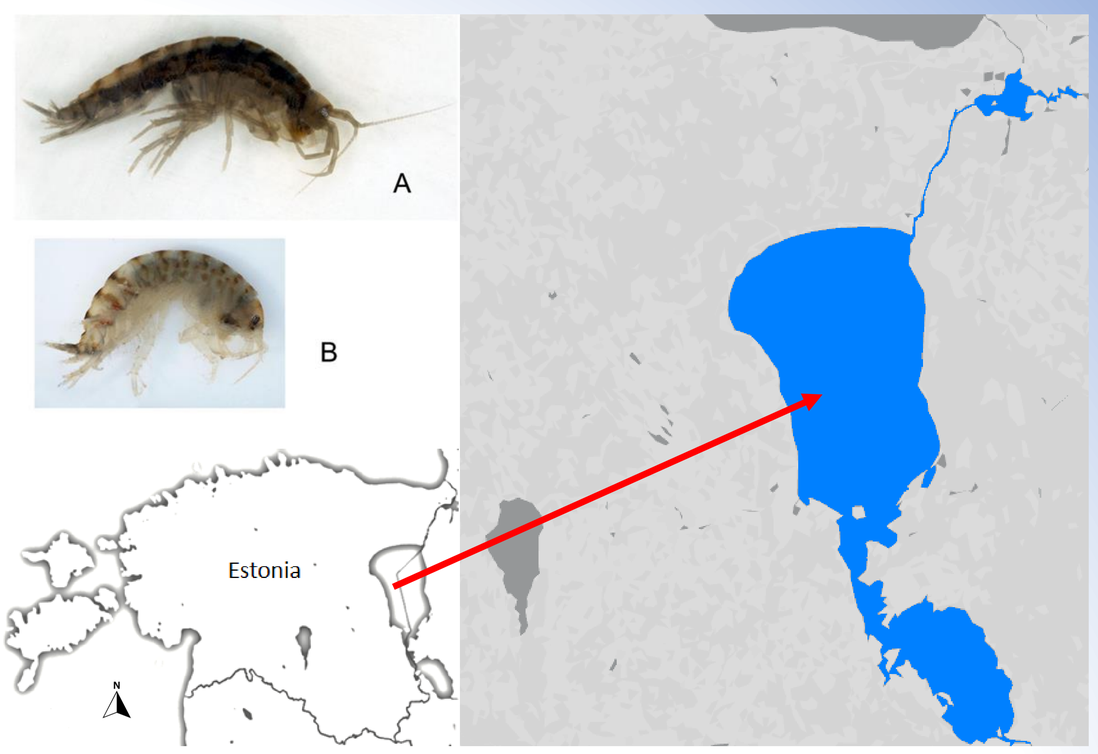


**Fig. 1.** Invasion of the Lake Peipsi system by *G. fasciatus* (blue). Native amphipod *Gammarus lacustris* (A) and invasive *Gmelinoides fasciatus* (B).

## Materials and Methods

**Experiment 1.** One common freshwater fish, perch (*Perca fluviatilis*) or roach (*Rutilus rutilus*) was placed in an aquarium to acclimate for 48 hours. During this time, no food was provided. Each aquarium Ten individuals each of *G. fasciatus* and *G. lacustris* were simultaneously released into the aquarium and left undisturbed for one hour. After one hour, the fish was removed and the remaining amphipods were counted and identified. The experiment was carried out with four different bottom substrates – control (no substrate), sand, gravel, and cobble stones (Fig. 2). This approach resulted in a total of eight combinations of treatments, with each combination replicated ten times.

**Experiment 2.** One individual amphipod (*G. fasciatus* or *G. lacustris*) was placed in a petri dish filled with water treated with fish kairomones (scent) or tap water. The behaviour of animals was recorded and analysed using LoliTrack animal tracking system (Fig. 3). This gave us an overview of change in locomotor activity of amphipods according to predator scent presence.

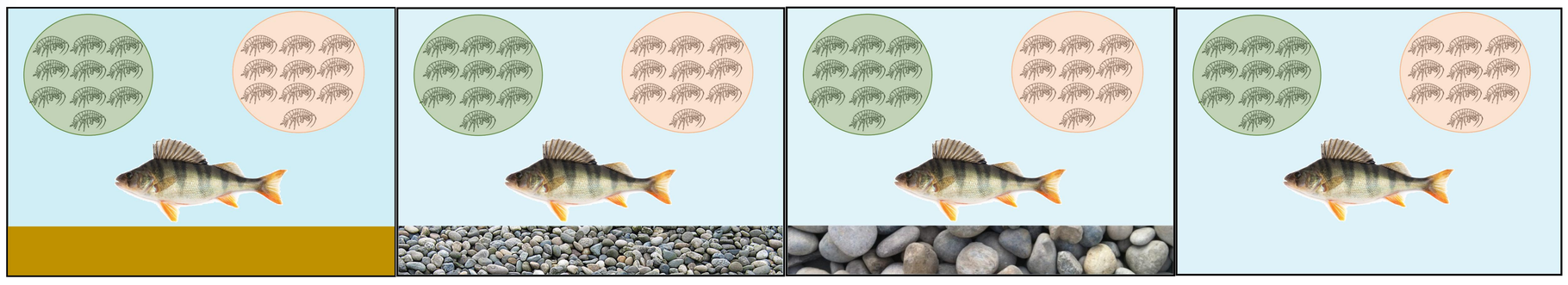

**Fig. 2.** Experiment 1 fish feeding setup with invasive and native amphipods being fed to perch with different substrates (sand, gravel, cobble stones and no substrate).

**Fig. 3.** Amphipods being filmed to assess the affect of fish scent on their locomotor activity.

## Results

**Experiment 1** results showed that on gravel and sand substrates, *G. fasciatus* exhibited superior digging behaviour to avoid predation by fishes (perch and roach), contrary to its native counterpart (Fig. 4). In the control aquarium with no substrate both amphipods were consumed at an equal rate. Both fish species consumed amphipods at equal rates on different substrates (Fig. 4).

**Experiment 2** results indicated a decrease in both amphipod species activity in presence of fish scent in the water (Fig. 5). The average time spent in motion during the 5-minute filming period of *G. fasciatus* (N = 30) decreased from 37.6% to 20.8% in the scented water, indicating a decrease in activity ($p < 0.01$) compared to the control group. *G. lacustris* (N = 33) also decreased in activity in the fish scented water ($p = 0.03$), from 21.8% to 17.4%, although less so than *G. fasciatus*.

No difference was found in the movement velocity for *G. lacustris* between control (average velocity = 42.6 mm/s) and kairomone treated water (average velocity = 41 mm/s; $p > 0.05$; Fig. 5). *G. fasciatus*, however, exhibited decreased movement speed ($p < 0.05$) between the control and kairomone groups (average velocity = 57.1 mm/s and 39.3 mm/s, respectively).

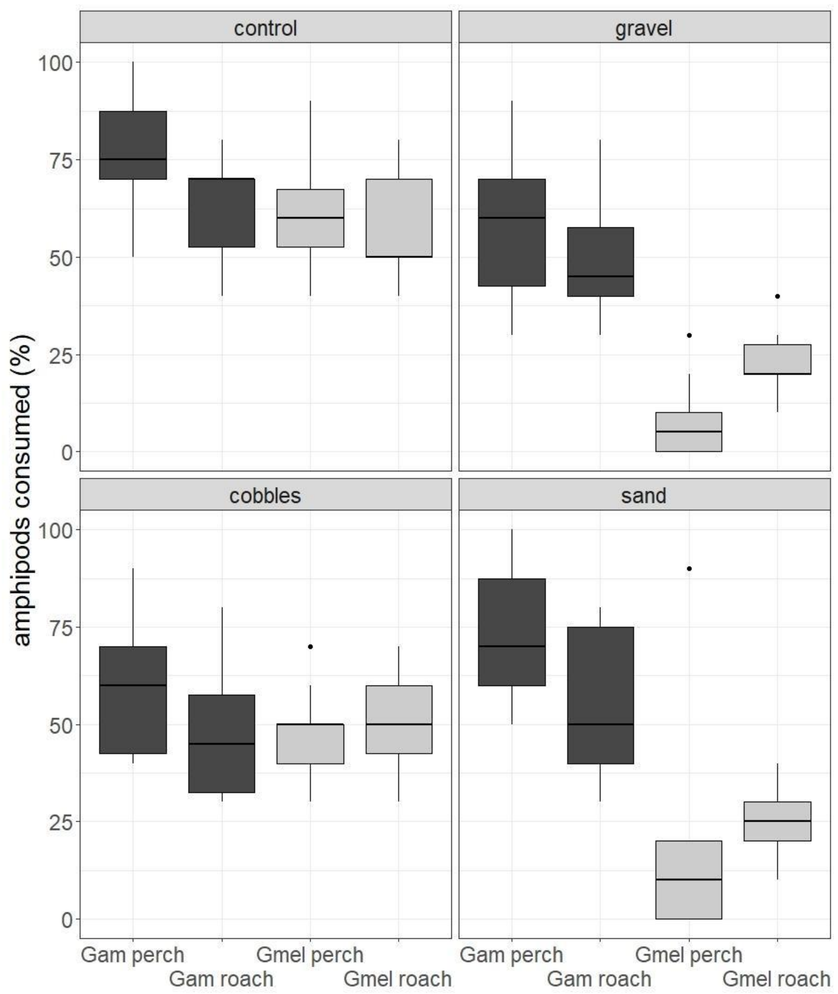


**Fig. 4.** Percentages of consumed amphipods on different substrates in the presence of either perch or roach. Dark box plots represent *G. lacustris* (Gam), and light box plots represent *G. fasciatus* (Gme).

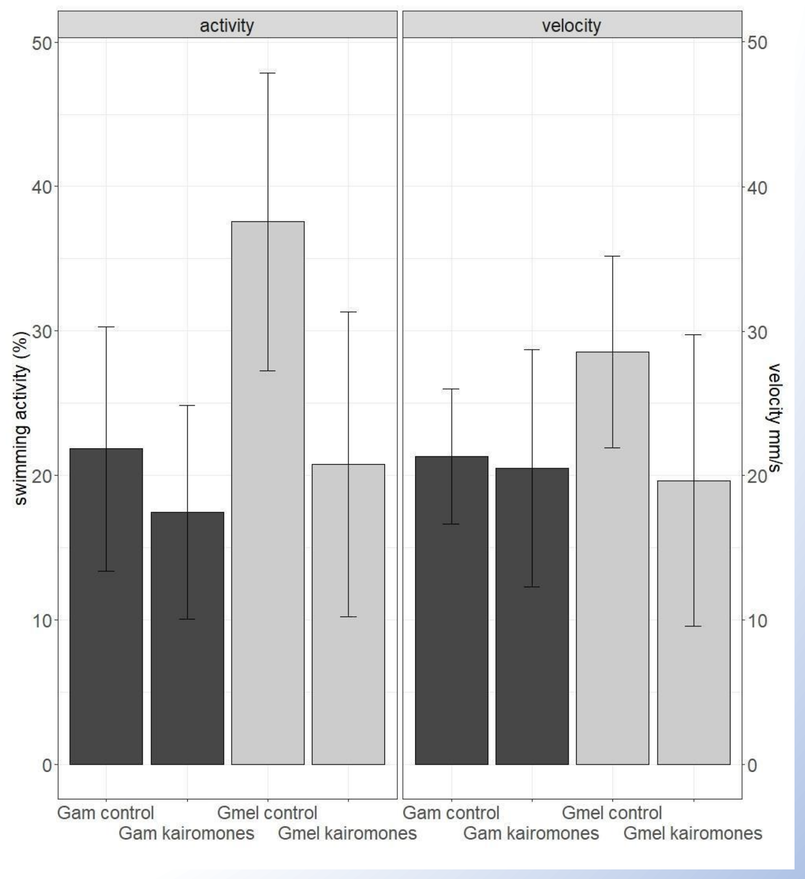


**Fig. 5.** Effects of chemical cues on swimming activity (percentage of time spent in motion) and velocity (mm/s) of *G. lacustris* (Gam) and *G. fasciatus* (Gme) in water with (kairomones) and without (control) chemical cues. Dark grey and grey columns (± standard errors) represent *G. lacustris* and *G. fasciatus* activities, respectively.

## Discussion

In Lake Peipsi, *G. fasciatus is* most abundant on coarse particle substrates, most notably gravel and sand, while its abundance on silt is minimal. This made us question how they are not predated on by fish in an area with a lack of hiding places. Our results show that *G. fasciatus* appears to exhibit greater predator avoidance behaviour in the form of digging into gravel and sand substrates, which are subsequently the substrates that *G. fasciatus* is most abundant on. Therefore, the ability of *G. fasciatus* to bury within coarse substrate could provide an effective strategy to escape predation, including from fish that rely primarily on sense of smell for finding prey, like roach. Furthermore, *G. fasciatus* exhibits a greater response to fish (predator) kairomone cues in the water by reducing its overall activity and movement velocity in the presence of predators. Of course, amphipods could also react to visual and mechanical (ie. fish sieving in the substrate) cues, this aspect remains to be studied further.

## Acknowledgements

We would like to thank Dr. Henn Timm for assistance in the field and conceptualising ideas. This project was financed by the Estonian Environmental Investment Centre (project number 16442) and by Estonian University of Life Sciences (project number P190254PKKH). This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 951963. All work was carried out in the Centre for Limnology station of the Estonian University of Life Sciences.

## References

**Berezina NA** (2009) Interspecific interactions of amphipods *Gammarus lacustris* and *Gmelinoides fasciatus*. Rus J of Ecol. 40:81-85

**Kangur K, Kumari M, Haldna M** (2010) Consequences of introducing the invasive amphipod *Gmelinoides fasciatus* into large shallow Lake Peipsi: present distribution and possible effects on fish food. J of Appl Ichthyol.

**Panov VE, Timm T, Timm H** (2000) Current status of an introduced Baikalian amphipod, *Gmelinoides fasciatus* (Stebbing), in the littoral communities of Lake Peipsi. Proc Estonian Acad Sci Biol Ecol 49:71–80

**Timm V, Timm T** (1993) The recent appearance of a Baikalian crustacean, *Gmelinoides fasciatus* (Stebbing, 1899) (Amphipoda, Gammaridae) in Lake Peipsi. Proc Estonian Acad Sci Biol Ecol 42: 144–153