Effects of systemic neonicotinoid insecticides: the importance of exposure pathways

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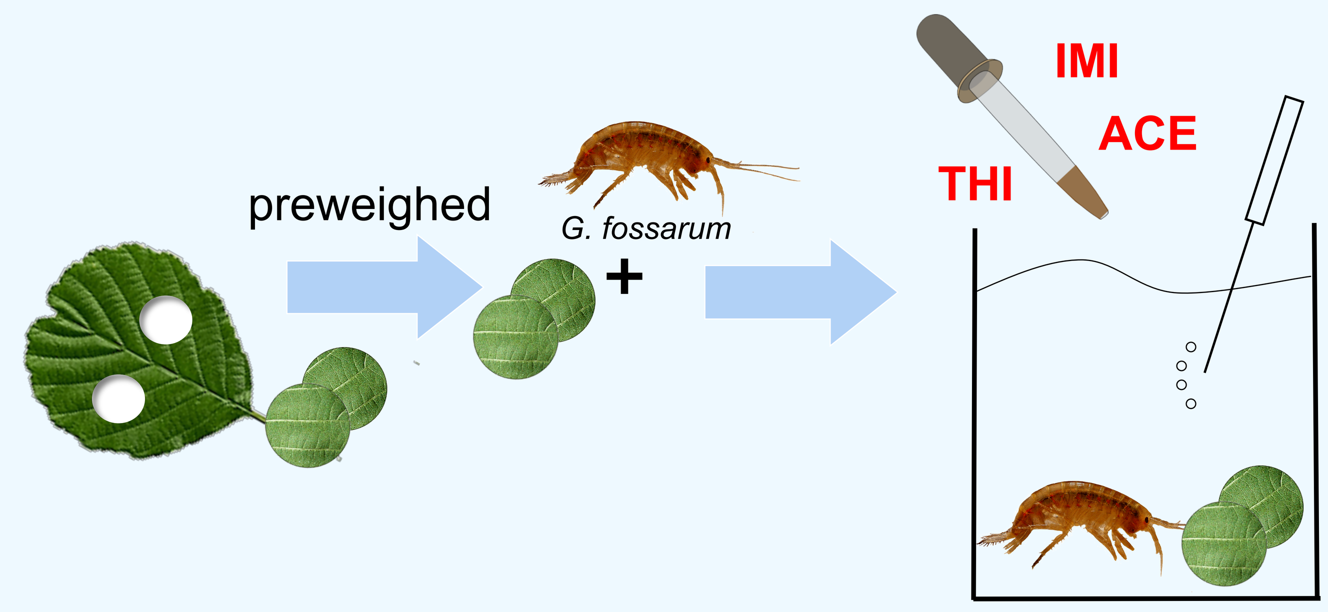
Introduction & objectives

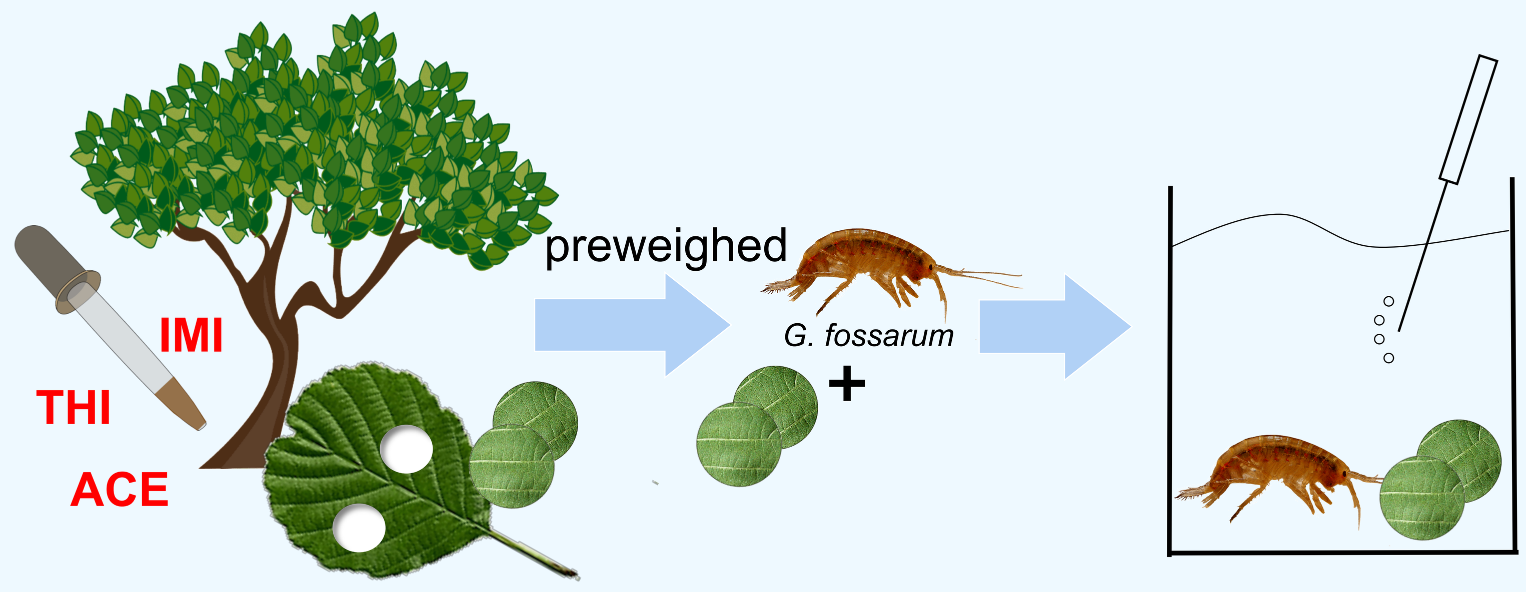
In recent years, systemic neonicotinoids have become one of the most widely used classes of insecticides worldwide in agriculture, horticulture, forestry, and tree nursery [1]. However, due to their extensive application, chemical properties (i.e., high water solubility) and environmental persistence, neonicotinoids are susceptible to be transported into adjacent surface waters via runoff either dissolved in the water phase or within the treated plant material (e.g., contaminated leaves) [2]. There, neonicotinoids may pose a threat to non-target species as well as associated ecosystem functions, such as the breakdown of leaf litter which is critical in providing energy for local as well as downstream communities [3]. In this context, leaf-shredding organisms participating in this function might experience neonicotinoid exposure via both the water phase and the ingestion of contaminated leaves. To assess the potential risks of three frequently used neonicotinoids – that is imidacloprid (IMI), thiacloprid (THI) and acetamiprid (ACE) – in leaf litter breakdown, *Gammarus fossarum* (Amphipoda), a key leaf-shredding macroinvertebrate [4], was chosen as test species using its feeding rate over seven days as ecotoxicological response variable.

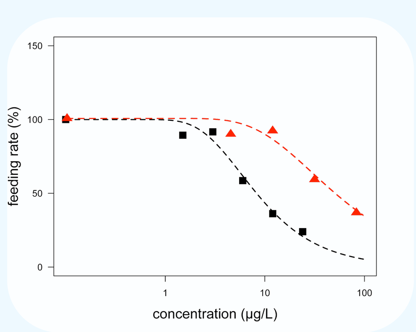
Materials & methods

In six independent experiments, *Gammarus* was exposed either to water spiked with different neonicotinoid concentrations (1 to 24 µg/L) and allowed to feed upon uncontaminated leaves…



…or to initially uncontaminated water in combination with leaves collected from trees treated with different amounts of the respective neonicotinoid (0.0375 to 9.6 g active ingredient per cm trunk diameter at breast height).





7d-EC$_{50}$s were derived from dose-response curves for the feeding rate of *Gammarus* based on concentrations measured in the respective water phase and finally compared for both exposure scenarios.

	A) EC$_{50}$ ±95%CI	B) EC$_{50}$ ±95%CI
thiacloprid	3.1± 0.8	2.4± 2.1
imidacloprid	8.3± 2.7	2.3± 2.2
acetamiprid	8.4± 4.9	0.3± 0.4

Tab. 1 Calculated 7d-EC$_{50}$ values (in µg/L for *G. fossarum* exposed to THI, IMI and ACE via A) the water phase or B) contaminated leaves.

Results & discussion

An exposure to neonicotinoids resulted in a concentration dependent decrease in the feeding rate of *G. fossarum* regardless of the exposure pathway. However, comparisons of dose response curves (see Fig. 1 for IMI) indicate that the adverse effect on the amphipods' feeding – resulting from ingestion of contaminated leaves together with exposure to neonicotinoids leached from leaves into water (scenario B) – differs from those of exposure via the water phase alone. This was underpinned by significantly different EC$_{50}$s for IMI and ACE but not THI (Tab.1).

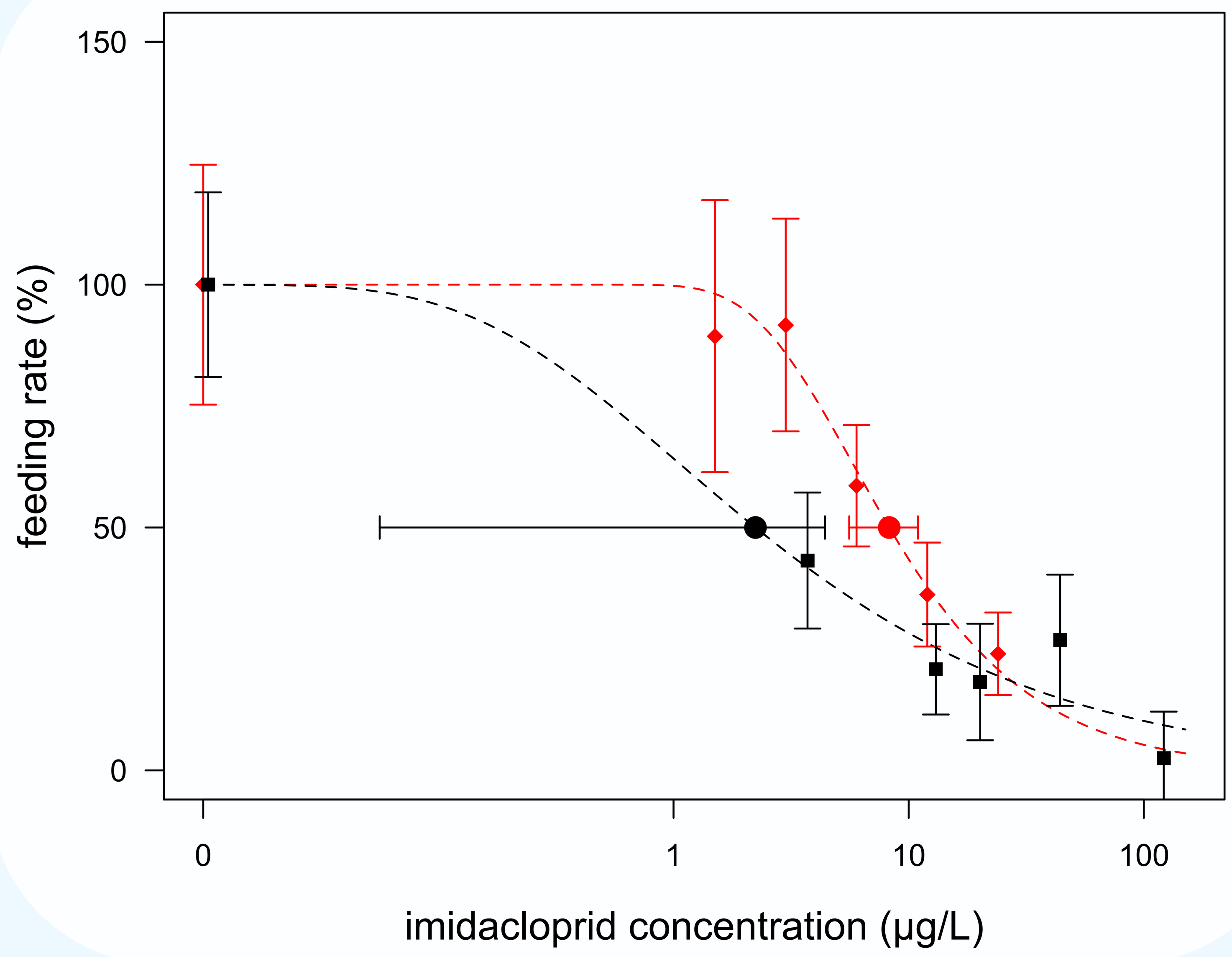


Fig. 1 Feeding rate (±95%CIs) and obtained dose-response curves of *G. fossarum* exposed to the neonicotinoid insecticide imidacloprid via water phase (◆; red line) and contaminated leaves (■; black line). 7d-EC$_{50}$s (•) ±95%CIs are also displayed.

Conclusions

The present study indicates a risk of neonicotinoids to adversely affect leaf shredding invertebrates that are considered as key species in the ecosystem function of leaf litter breakdown via two different exposure pathways, i.e., water phase and ingestion of contaminated leaves. Such implications might restrict the energy availability (in the form of feces) for instance for collectors and consequently reduce the prey availability (in the form of both shredders and collectors) for aquatic (e.g., fish [5]) and – following the emergence of insects – terrestrial predators (e.g., spiders, birds, bats [6]).

References

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