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Are neonicotinoids a threat for leaf litter breakdown? A laboratory approach with leaf shredding invertebrates

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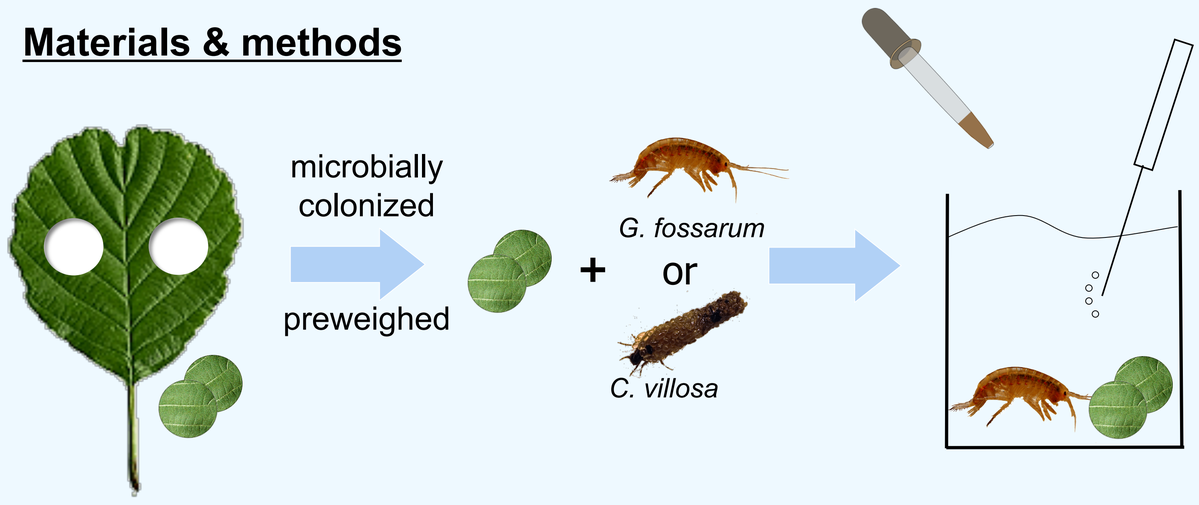
Introduction & objectives

Neonicotinoids are registered in over 120 countries for use against herbivorous insects in agriculture, horticulture, forestry, and tree nursery [1]. Due to their extensive application and chemical properties, neonicotinoids are susceptible to be transported into surface waters via various pathways [2]. There they might pose a threat to non-target species and associated ecosystem functions, such as the breakdown of leaf litter. This particular ecosystem function is critical in providing energy for local as well as downstream communities [3]. A) To assess for potential risks of three frequently used neonicotinoid insecticides (i.e. thiacloprid (THI), imidacloprid (IMI) and acetamiprid (ACE)) in this process, the feeding rate of *Gammarus fossarum* (Amphipoda) and *Chaetopteryx villosa* (Trichoptera) – two key leaf-shredding macroinvertebrates [4] – was assessed over seven days. B) As neonicotinoids are regularly detected as mixtures in the aquatic environment, an additional experiment accounted for the joint toxicity of a mixture composed of THI, IMI and ACE on the feeding rate of *G. fossarum*.

Materials & methods



A) single substance experiments with *G. fossarum* and *C. villosa*
- 3 neonicotinoids (THI, IMI, ACE)
- 6 concentrations (between 0-24 µg/L; n=30)
- endpoint: feeding inhibition (7d-$EC_{20, 50}$)

B) mixture experiment with *G. fossarum*
- similar experimental set up as used in A)
- mixture of THI, IMI, ACE based on EC_{50}s from A) [5]
- comparison with predictions by concentration addition model [6]

Tab. 1 Calculated 7d-EC_{20} and EC_{50} values (in µg/L) for *G. fossarum* and *C. villosa* after exposure to THI, IMI and ACE as well as the maximum detected field concentrations.

	G. fossarum		*C. villosa*		max. detected field
	EC_{20}±95%CI	EC_{50}±95%CI	EC_{20}±95%CI	EC_{50}±95%CI	concentrations
THI	1.7± 0.5	3.1± 0.8	4.5± 22.2		4.5 [7]
IMI	3.6± 1.7	8.3± 2.7	10.4± 2.3	19.3± 2.7	320 [8]
ACE	2.3± 2.2	8.4± 4.9	11.7± 11.1		44.1 [9]

Results & discussion

In all experiments exposure to neonicotinoids resulted in a concentration dependent decrease in the feeding rate of both shredders, while the amphipod *G. fossarum* was 3 to 5 times more sensitive (based on EC_{20}s) towards neonicotinoids than the caddisfly larvae *C. villosa* (Tab. 1). When comparing EC_{20}s, thiacloprid was – irrespective of the species investigated – the most toxic neonicotinoid. Moreover, the measured feeding rate of *G. fossarum* exposed to the neonicotinoid mixture agreed well with the predictions by the concentration addition model (i.e. prediction is within the 95% confidence intervals (CIs) of the observations – except for the highest concentration; Fig. 1).

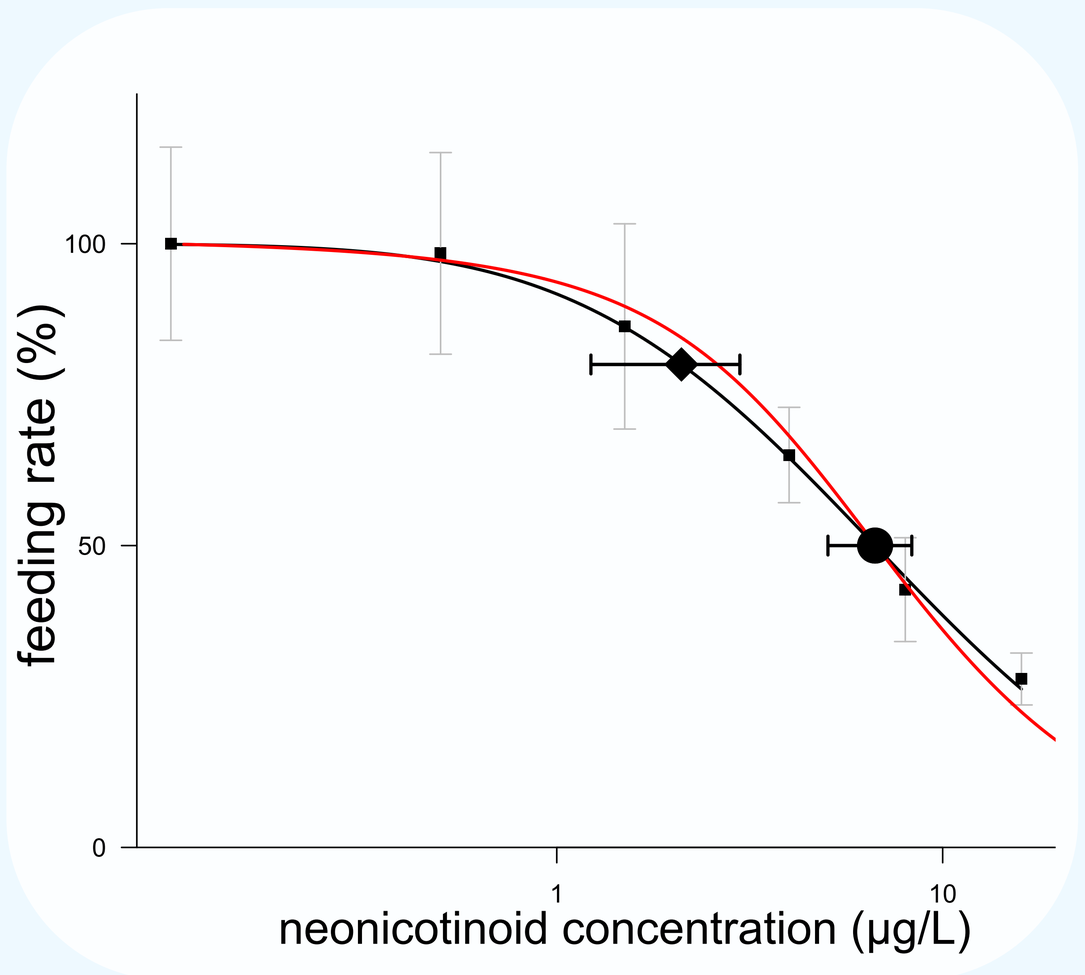


Fig. 1 Mean feeding rate of *G. fossarum* (■; ±95%CIs) exposed to the neonicotinoid mixture, the best fitting model (black line) and the predictions derived from the concentration addition model (red line). 7d-EC_{20}s (◆) and EC_{50}s (•) ±95%CIs are also displayed.

Conclusions

The present study indicates a risk of neonicotinoids and their mixtures at field relevant concentrations (Tab.1) to adversely affect leaf shredding invertebrates that are considered as key species in the ecosystem function of leaf litter breakdown. Such implications might restrict the energy availability (in the form of feces) e.g. for collectors and consequently reduce the prey availability (in the form of both shredders and collectors) for aquatic (e.g. fish [10]) and – following the emergence of insects (such as *C. villosa*) – terrestrial predators (e.g. spiders, birds, bats [11]).

References

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