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Effects of environmentally realistic concentrations of neonicotinoid insecticides on an aquatic invertebrate community

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Claire Duchet, Alyssa Kraft, Cailin MacKenzie, John D. Stark

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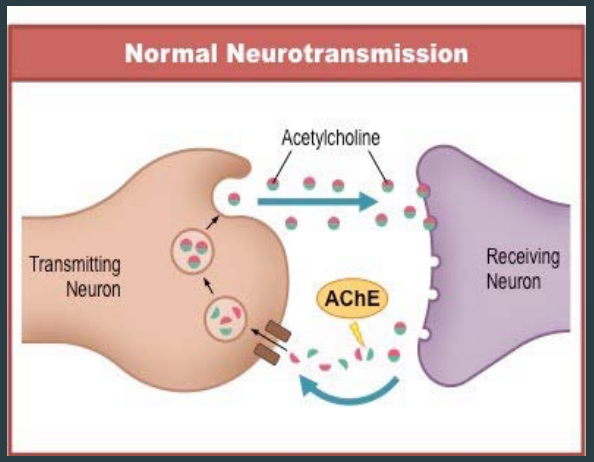
Introduction

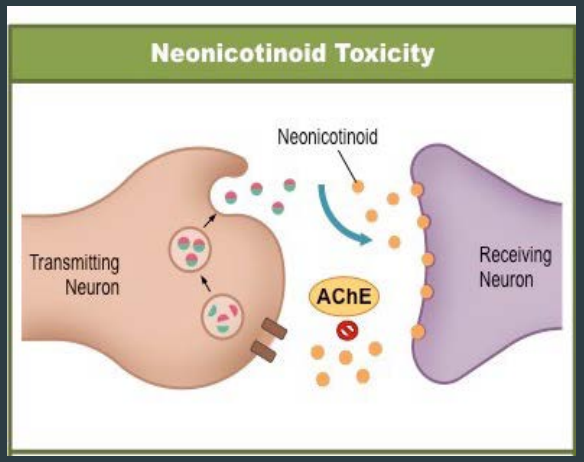
- Neonicotinoid insecticides represent 24 % of the global market, and their use is increasing globally.
- Clothianidin, imidacloprid, thiamethoxam are the most commonly-used neonicotinoids on corn and soybeans.
- Imidacloprid is also used privately: lawn and garden care, and topical flea medicines.

Introduction

- Used against insect pests but toxic to non-target organisms (e.g. crustaceans, bees, flies, birds)



Acethylcholinesterase (AChE) breaks down acetylcholine (Ach), preventing overstimulation and blockage of acetylcholine receptors



Acethylcholinesterase cannot break down neonicotinoids (ACh receptor agonists), leading to paralysis (due to blockage of ACh receptors

Mode of action of neonicotinoids.

Source: http://ib.bioninja.com.au/standard-level/topic-6-human-physiology/65-neurons-and-synapses/neurotransmitters.html

Introduction

- Not intended for direct use in water bodies, but they may enter in the aquatic compartment *via* spray drift, runoff or leaching.

- Soluble in water, persistent in soil, and may be found in surface waters and drinking water (Klarish et al., 2017).

Introduction

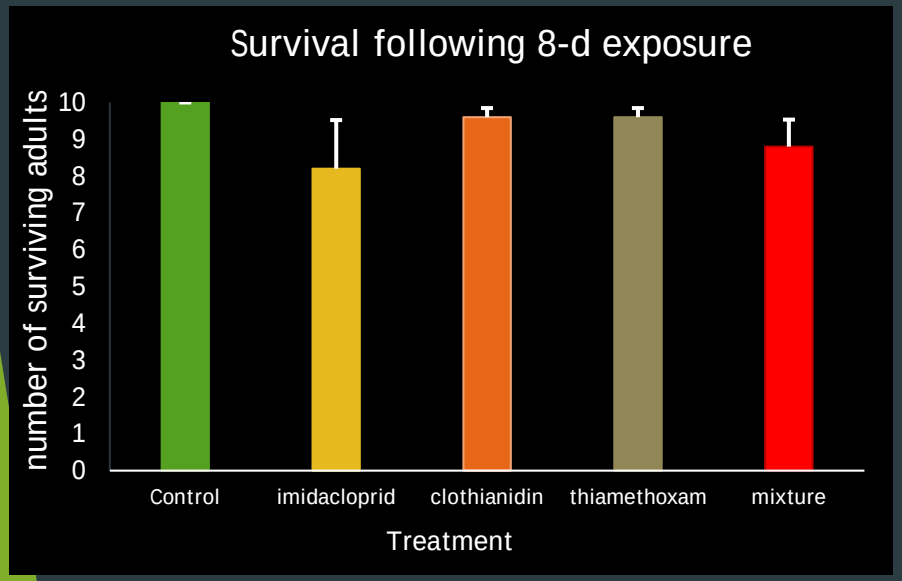
- In Canada, wetlands close to agricultural fields (Anderson et al., 2015) :
  - 3.11 µg/L clothianidin,
  - 0.256 µg/L imidacloprid,
  - 1.49 µg/L thiamethoxam.
- In Western Washington, imidacloprid almost always detected in surface water (WSDA source):
  - usually <0.1 µg/L, but >1 µg/L in some cases,
  - 1.74 µg/L in the Big Ditch slough, a creek providing habitat for salmons in the Skagit wildlife area.

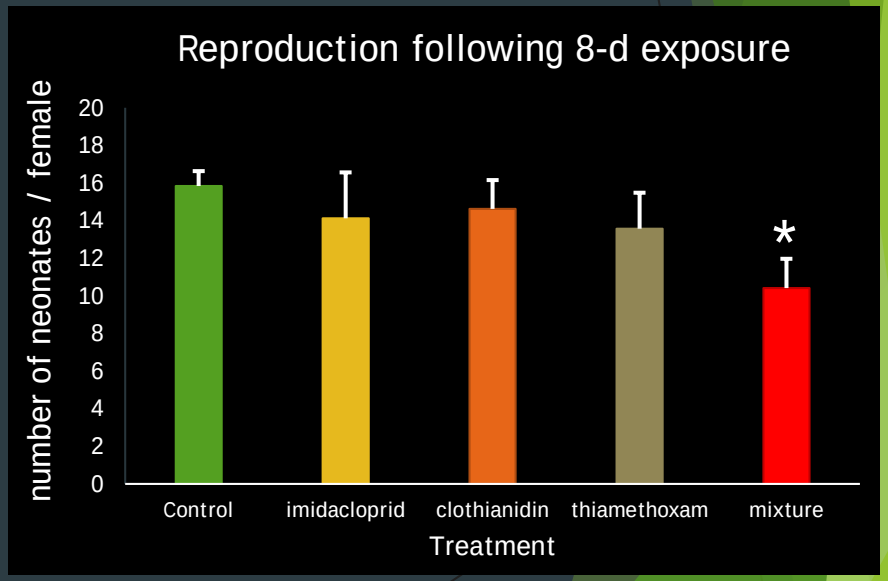
Objective

- Very few data about the effects of mixture of neonicotinoids available.
- Neonicotinoid contamination induce a top-down trophic cascade in a community dominated by invertebrate predators (Miles et al., 2017).
- Our objective: to test the effect of a mixture of imidacloprid, clothianidin and thiamethoxam on an aquatic invertebrate community.
- Hypothesis: By affecting predators, indirect positive effect on herbivores.

Preliminary experiment

- Test in control conditions on *Ceriodaphnia dubia* (semi-static test): imidacloprid (0.256 µg/L), clothianidin (3.11 µg/L), thiamethoxam (1.49 µg/L), and the mixture





Control Imidacloprid Clothianidin Thiamethoxam Mixture

*: Significant differences between the treatment and control (Tukey's HSD test, $p < 0.05$).

Materials and methods

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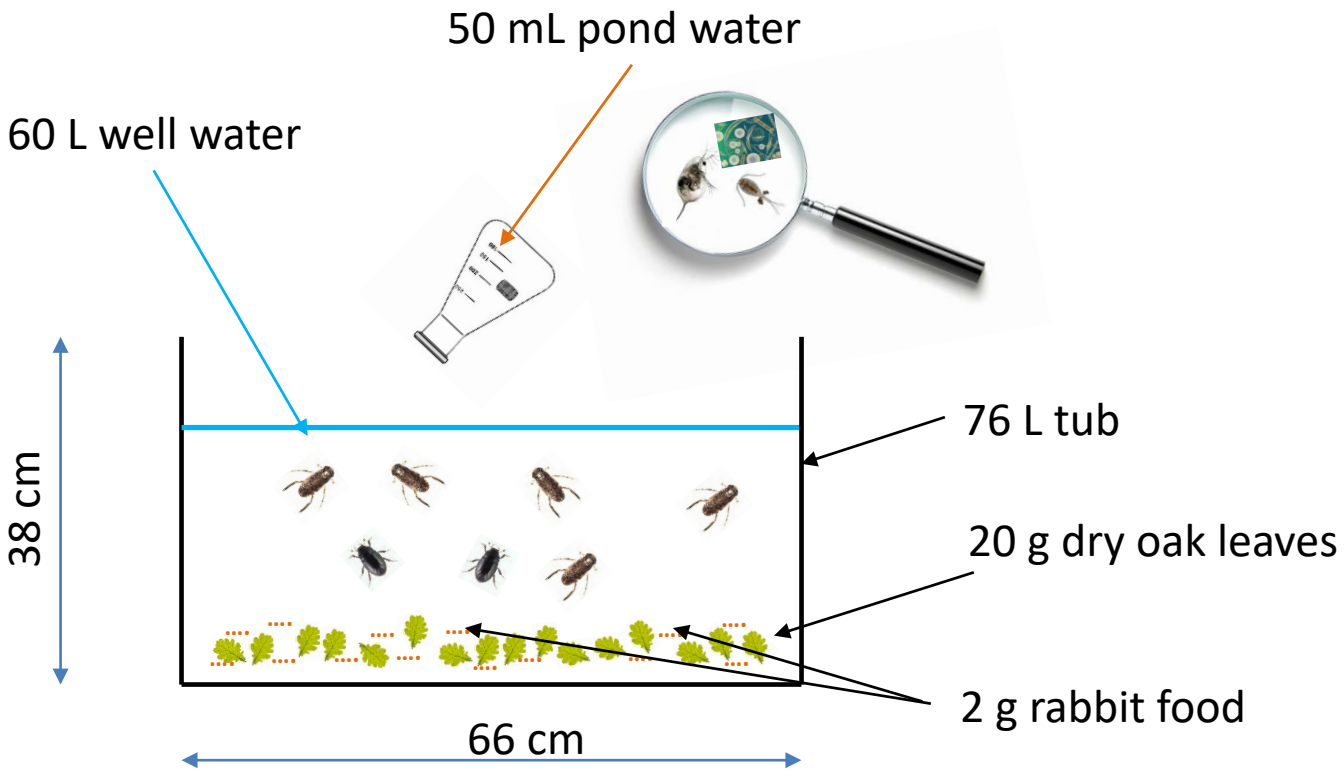

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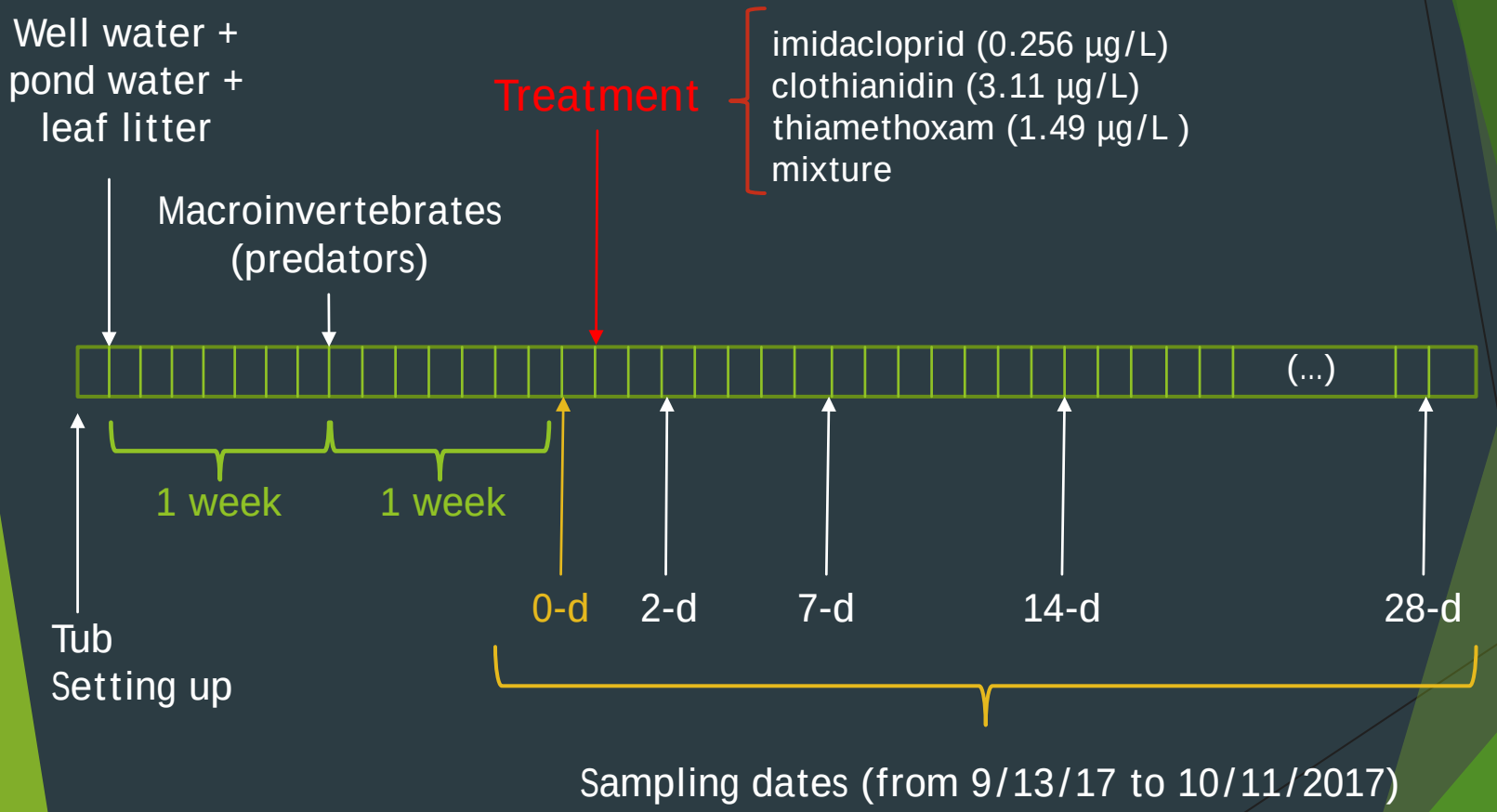


Materials and methods

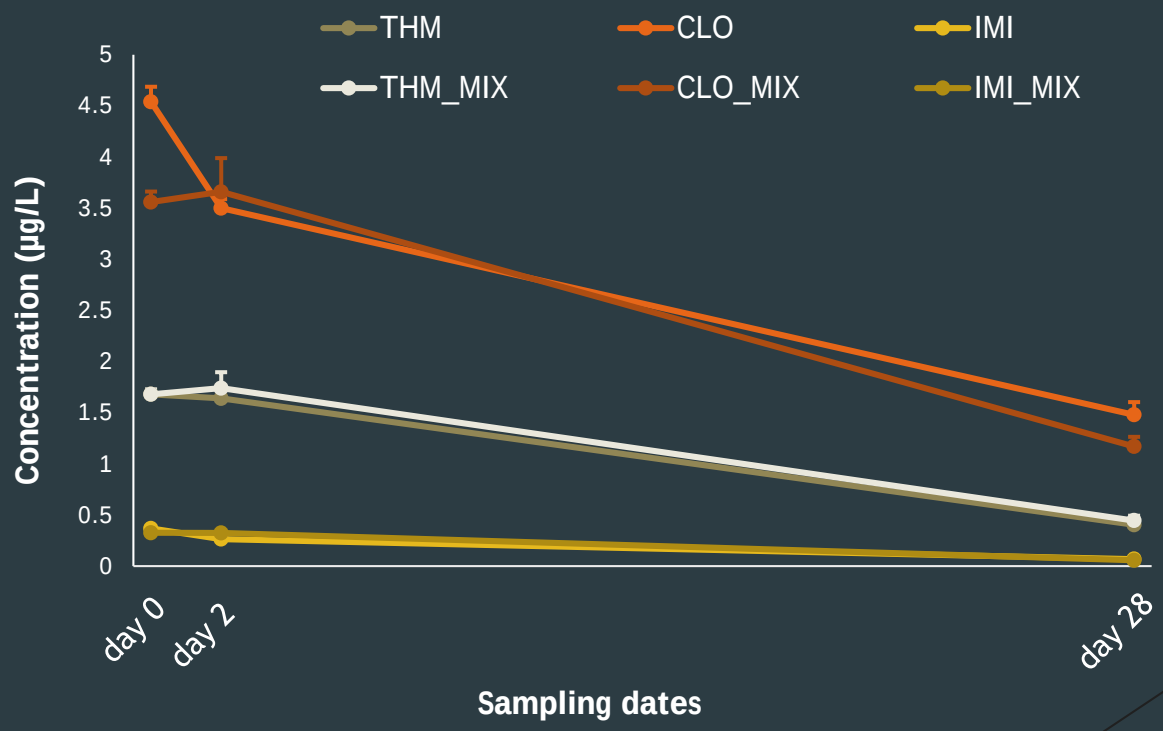
On each sampling date:

- Environmental parameters (pH, conductivity, dissolved oxygen, temperature)
- Invertebrate sampling
- Water samples for chemical analysis
- Water samples for chlorophyll *a* concentrations

- Dipteran colonization (mosquito oviposition habitat selection): every 2 days

Results

- Concentrations of the neonicotinoids over time



Results

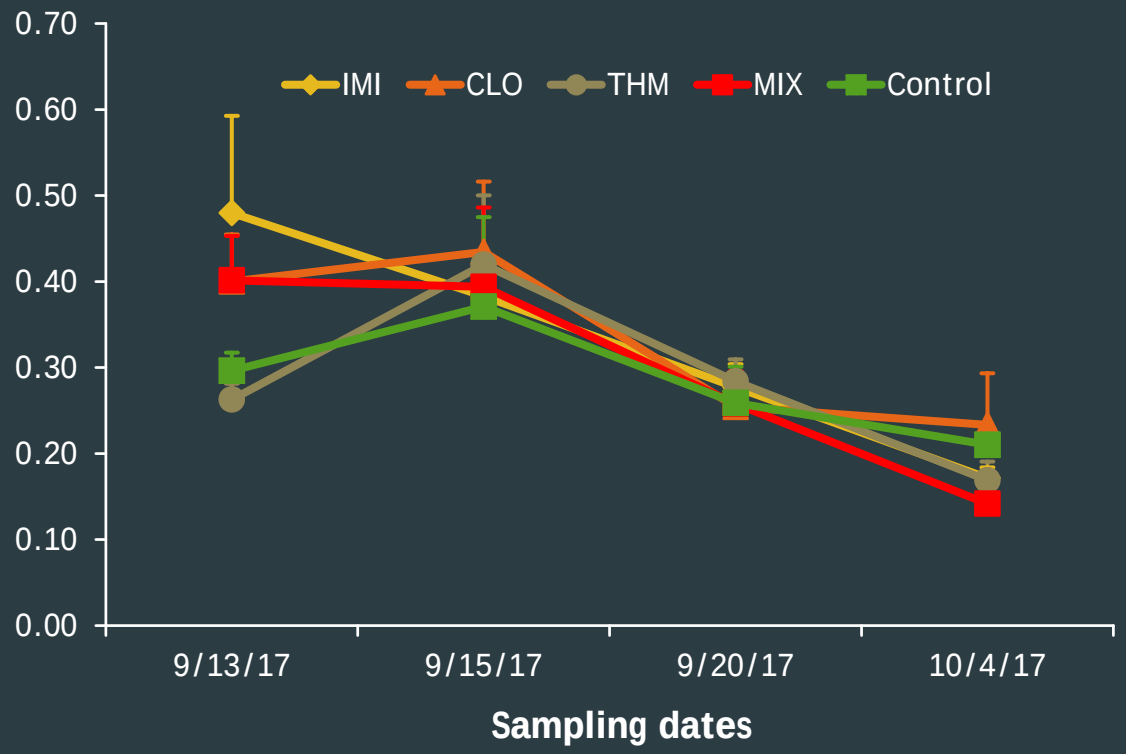
- Community:
  - Active dispersers (10 taxa):
    - mosquitoes (*Culex pipiens, Culiseta longiareolata),*
    - non-biting midges (Chironomids),
    - biting-midges (Ceratopogonidae),
    - ephidridae larvae,
    - mayflies (Ephemeroptera),
    - odonates,
    - water beetle (Hydrophilidae),
    - water boatmen (*Anisops sardea*),
    - hydracarians.

Results

- Community:
  - Passive dispersers (11 taxa):
    - Copepods (cyclopoids).
    - Cladocerans:
      - *Scapholeberis, Chydorus, Pleuroxus, Ceriodaphnia, Daphnia, Simocephalus, Alona, Macrothricidae, Diaphanosoma.*
    - Ostracods.

Results

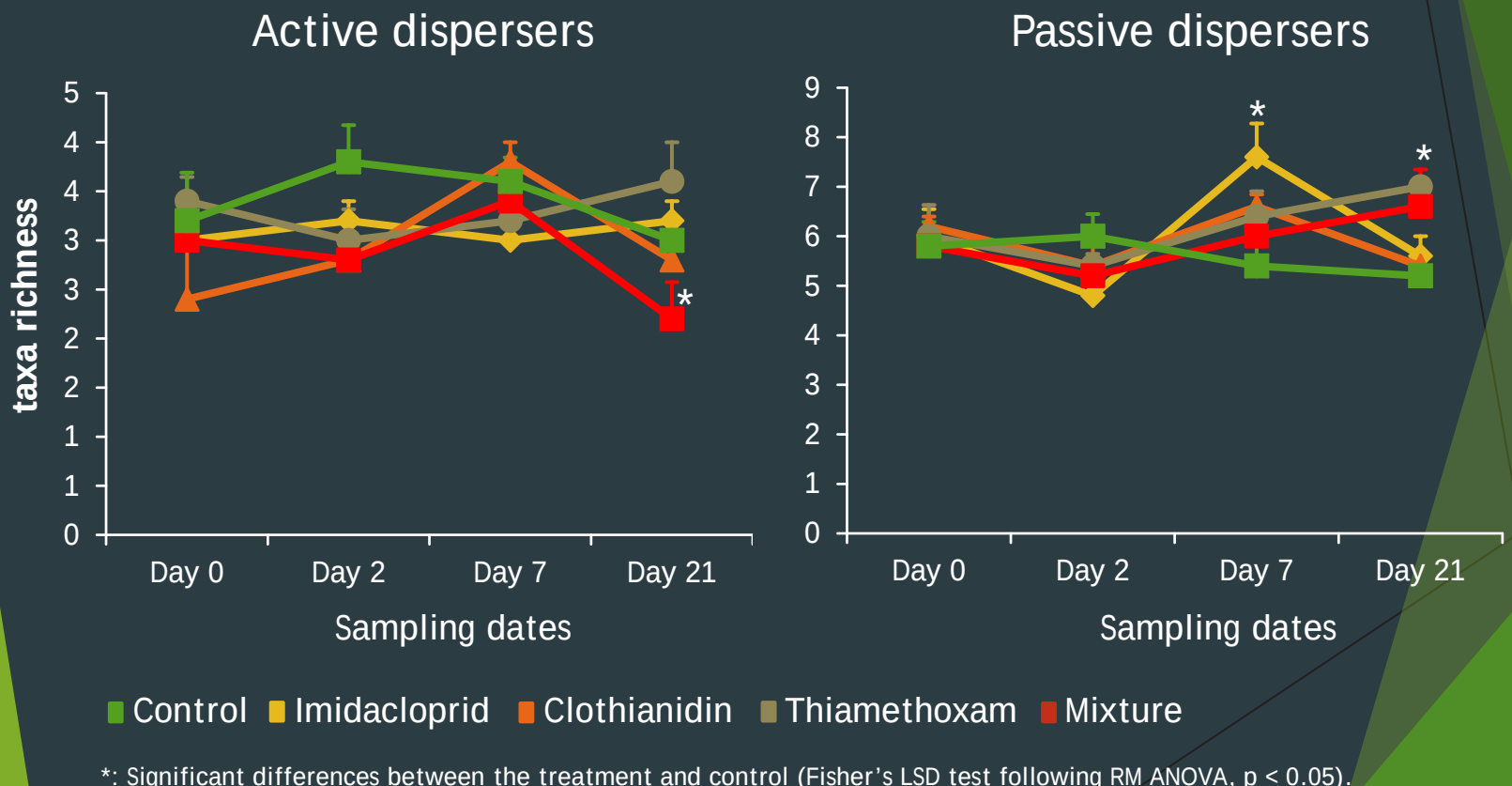
- Species eveness



RM ANOVA: $F_{4, 20} = 0.38$, $p = 0.82$

Results

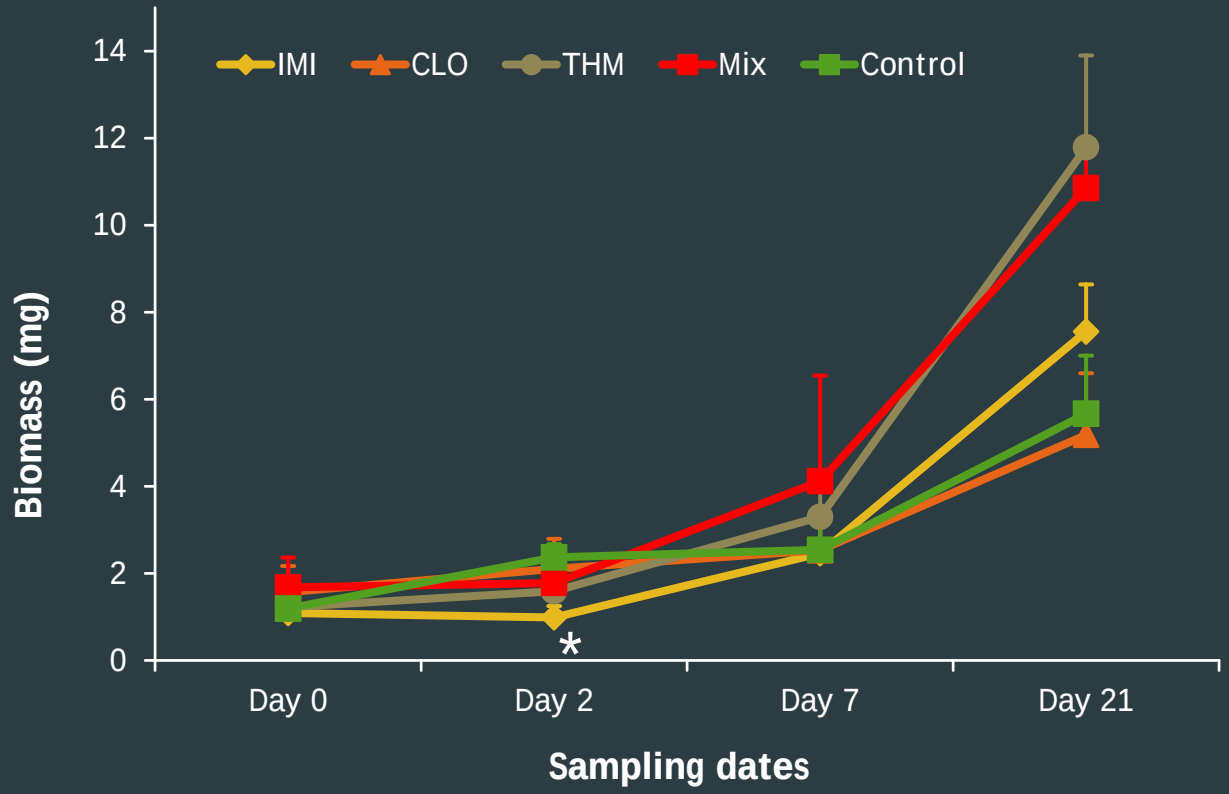
- Effect on taxa richness



*: Significant differences between the treatment and control (Fisher's LSD test following RM ANOVA, $p < 0.05$).

Results

- Herbivore biomass



*: Significant differences between the treatment and control (Fisher's LSD test following RM ANOVA, $p < 0.05$).

Conclusions - Perspectives

- Effects on the community:
  - Decrease of the active dispersers 3 weeks after exposure to the mixture
  - Increase of the passive dispersers 1 week after exposure to imidacloprid and 3 weeks after exposure to thiamethoxam
  - Increase of the zooplankton biomass 3 weeks after exposure due to lack of predators?
- Still have to analyze the chlorophyll *a* data
- Next study: run the experiment in early stage population development (late spring / early summer)

Acknowledgments and Funding

- Funding: Stormwater strategic initiative program

- *Thank you!*

Questions?

References

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