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Exposure effects of thiamethoxam on the viability, growth, and behavior of Physa acuta

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Exposure effects of thiamethoxam on the viability, growth, and behavior of *Physa acuta*

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Introduction

Thiamethoxam is a neonicotinoid insecticide that is used widely in agriculture to control a wide range of insect pests (Finnegan et al. 2018). Due to thiamethoxams properties it can be applied in a variety of ways, such as application to the seed prior to planting, as a broadcast spray, or it can be applied to the soil either by applying it to the furrow during planting or on to the soil after planting (Finnegan et al. 2018). Thiamethoxam binds to the nicotinic acetylcholine receptors in insects (Finnegan et al. 2018). The binding of the nicotinic acetylcholine receptors will cause muscle paralysis, then death (Matsuo et al. 1998). There is a reduced potential of adverse effects for vertebrates and other non-target organisms when compared to other insecticides (Finnegan et al. 2018). The reduced risk towards non-target organisms lead to neonicotinoid insecticides like thiamethoxam replacing older, more dangerous pesticides such as pyrethroid, organophosphate, and carbamate (Hee-Joo et al. 2003). Aquatic organisms that are typically exposed to thiamethoxam in the wild experience a series of peaks in concentration that are followed by thiamethoxam dissipating rapidly within days. This peak and decline in concentration are due to event-driven exposures due to spray drifts and run off from precipitation events (Finnegan et al. 2018).

Objectives

In this study, the effects of Thiamethoxam on the viability, growth, and behavior of the freshwater invertebrate *Physa acuta* will be assessed. Mortality every 24hrs, behavior and growth every seven days.

Hypotheses

Mortality of *P. acuta* was expected to be higher when exposed to greater concentrations of Thiamethoxam. Growth rates were expected to decline in higher concentration groups. Average speed, average velocity, and total distance traveled was expected to increase among higher concentration groups. Average time. Average frozen events were expected to decrease among higher concentration levels.

Materials and Methods

- Juvenile *P.* acuta (1 week old) were exposed to (0 (EtOH control), 1.56, 3.13, 6.25, 12.5, or 25 ug/L) of thiamethoxam for 2 weeks.
- Mortality was assessed every 24 hours (n=6 for for all treatment levels)
- Growth and mobility assays were performed on days 7 and 14 (n=6 for all treatment levels).
- Mobility assays were performed in a lightbox chamber to ensure a controlled light source with 5 minutes of acclimation followed by 20 minutes of recording. The videos speed was increased by a factor of 4x using Animotica (v1.1.90.0) to ensure accurate assessment using tracking software ToxTrac (v2.83). The collected data was then corrected by dividing by a factor of 4. Speed, mobile speed, acceleration, total distance traveled, and frozen events were assessed over a 20 minute period.
- Growth data was collected by taking a picture of each individual snail on a 1mm micrometer slide using a dissection microscope The picture was then analyzed using ImageJ (v1.8.0).

Results

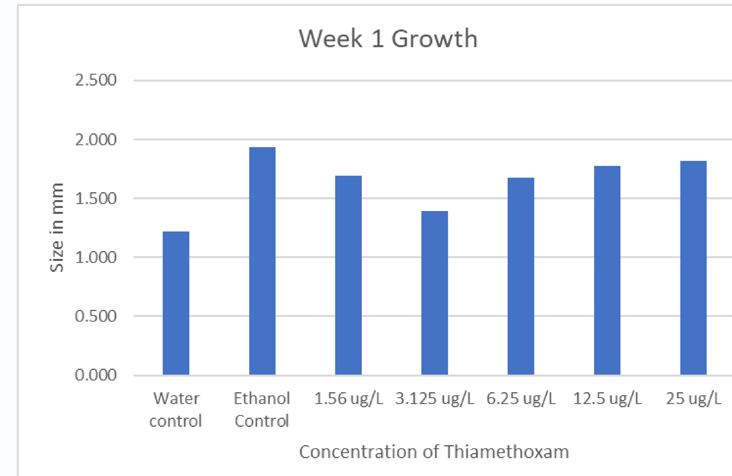

Figure 1- Average shell size on day 7 of exposure to varying concentrations of thiamethoxam.

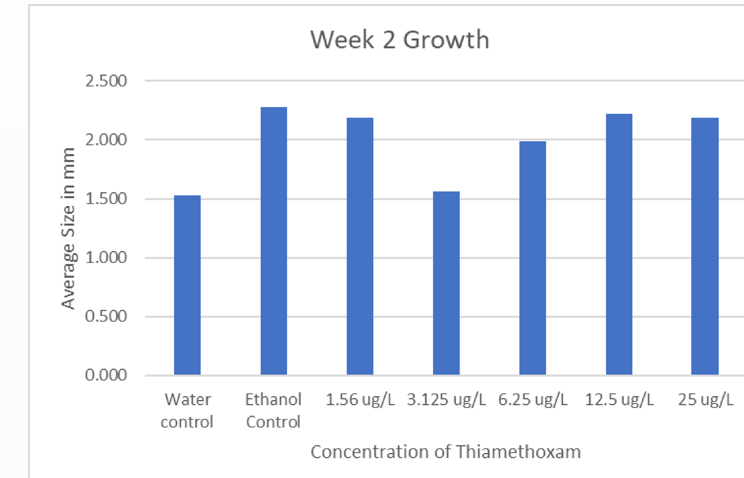

Figure 2- Average shell size on day 14 of exposure to varying concentrations of thiamethoxam.

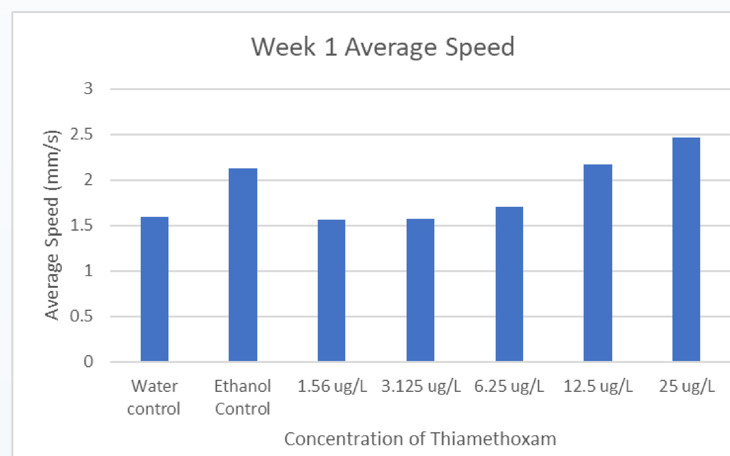

Figure 3- Average speed on day 7 of exposure to varying concentrations of thiamethoxam.

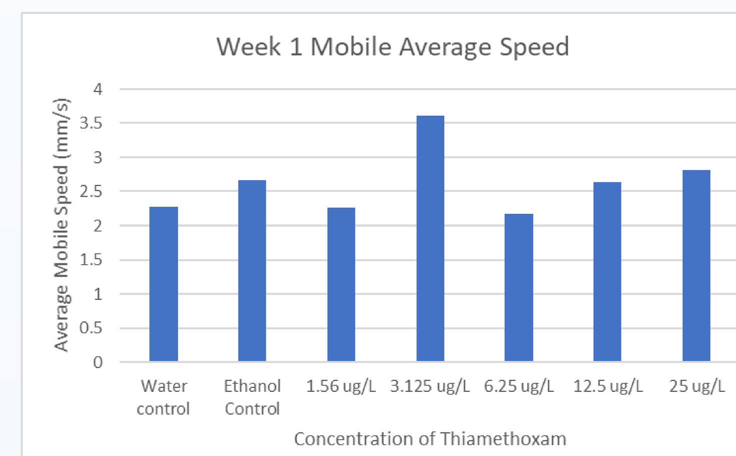

Figure 4- Average mobile speed on day 7 of exposure to varying concentrations of thiamethoxam.

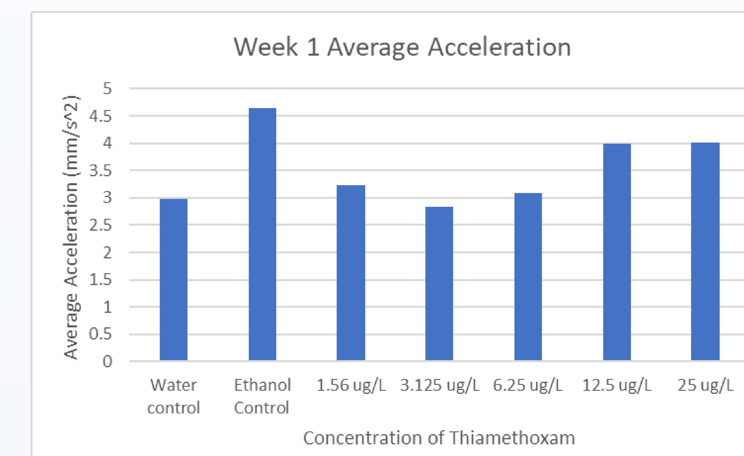

Figure 5- Average acceleration on day 7 of exposure to varying concentrations of thiamethoxam.

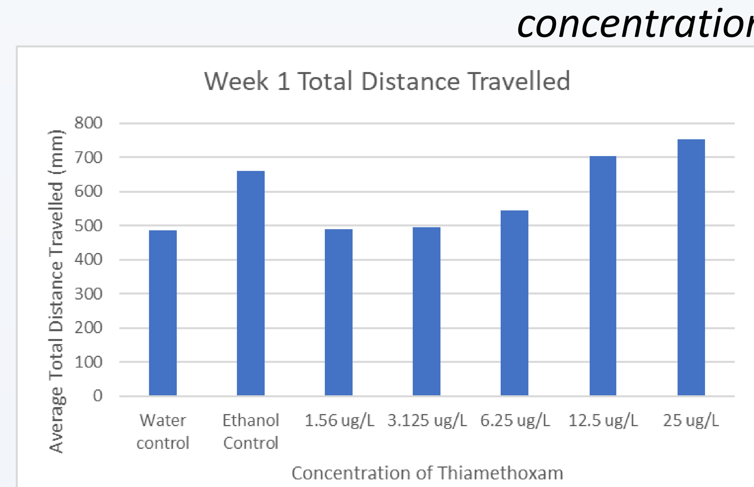

Figure 6- Average total distance travelled on day 7 of exposure to varying concentrations of thiamethoxam.

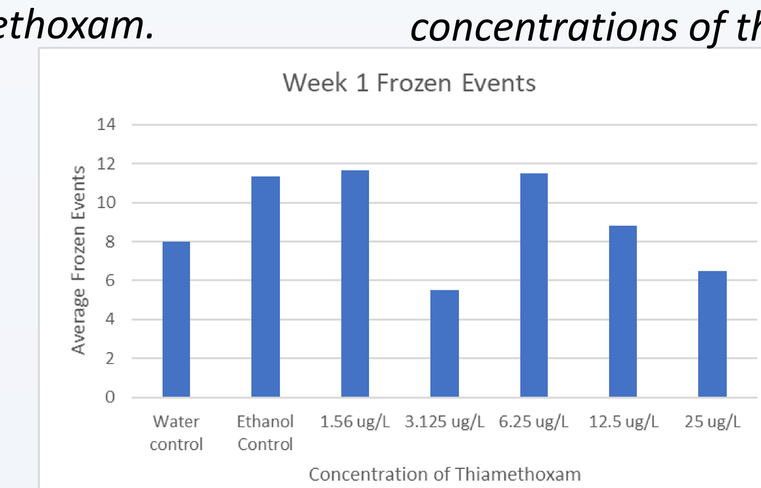

Figure 7- Average frozen events on day 7 of exposure to varying concentrations of thiamethoxam.

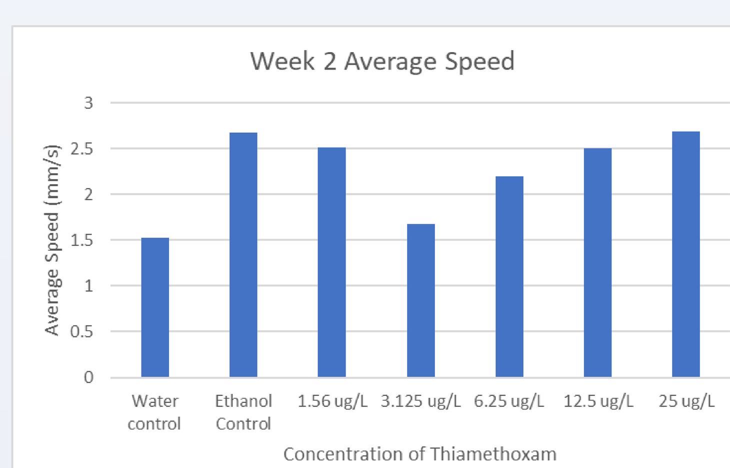

Figure 8- Average speed on day 14 of exposure to varying concentrations of thiamethoxam.

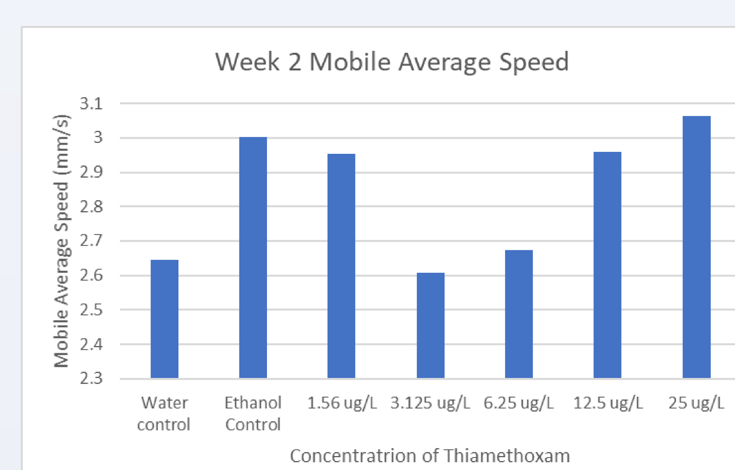

Figure 9- Average mobile speed on day 14 of exposure to varying concentrations of thiamethoxam.

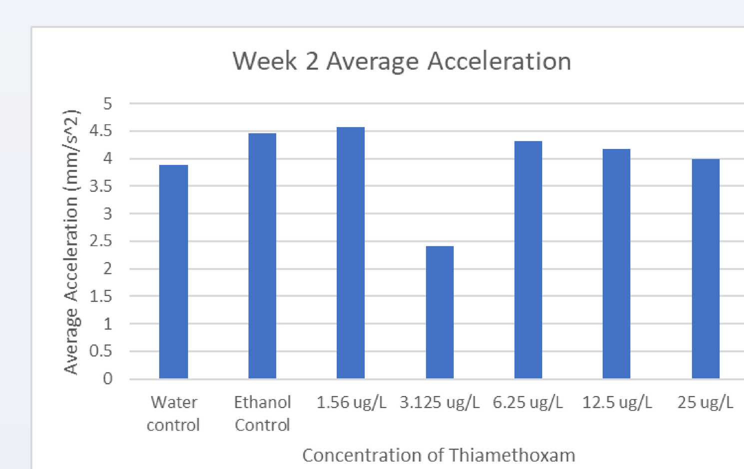

Figure 10- Average acceleration on day 14 of exposure to varying concentrations of thiamethoxam.

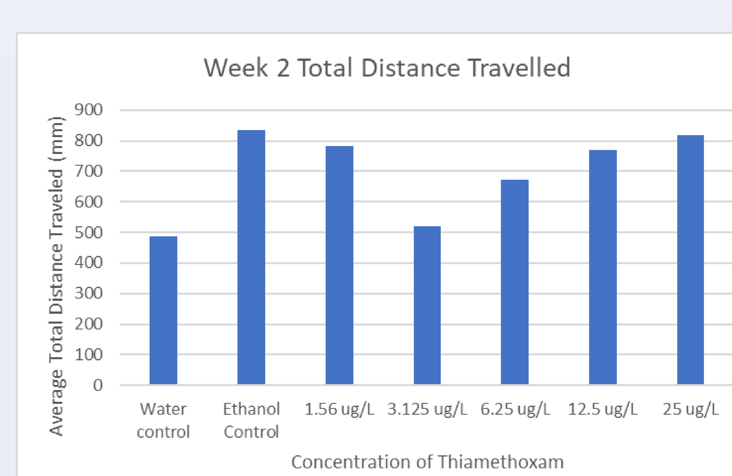

Figure 11- Average total distance travelled on day 14 of exposure to varying concentrations of thiamethoxam.

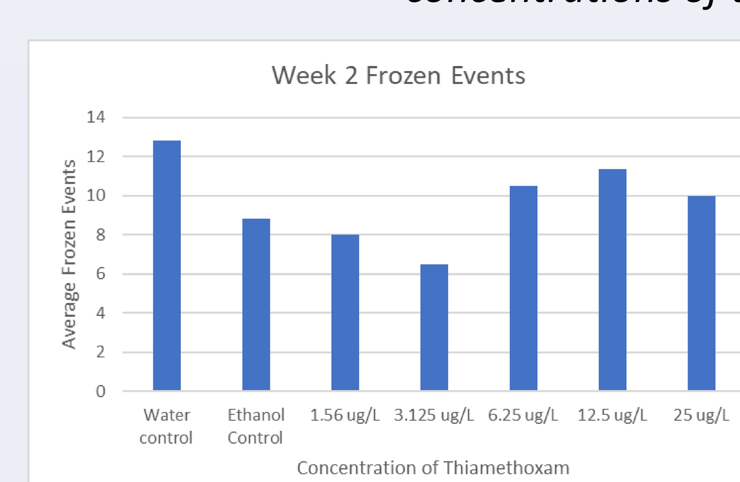

Figure 12- Average frozen events on day 14 of exposure to varying concentrations of thiamethoxam.

Results (cont.)

Growth

- *P. acuta* showed an increase in growth in all treatment levels that contained levels of thiamethoxam, with substantial increases in growth in higher concentration levels. Smaller shell size in the 3.125ug/L treatment level could be due to the higher mortality in that treatment level (2 mortalities).

Mobility and Behavior

- In both week 1 and week 2 the average speed, mobile average speed, and total distance travelled shows a strong trend of increasing values with increasing concentrations of thiamethoxam.
- Week 1 average acceleration shows a trend of faster acceleration in higher concentration levels of thiamethoxam. Week 2 average acceleration shows an increase in acceleration at 1.56ug/L but a slight decrease beginning at concentrations higher than 6.25 ug/L.
- Week 1 frozen events showed a decrease in frozen events at higher concentration levels. Week 2 frozen events showed an increase in frozen events at higher concentration of thiamethoxam.

Conclusions

The higher than average shell sizes in thiamethoxam treatments show an effect of increased growth in *P. acuta.* The increases in mobility data shows an effect on the behavior of *P. acuta* which could harm them in the wild by counteracting their natural defense system of camouflage.

Future Studies

The next phase of this study will examine the effects of thiamethoxam on the reproductive system and embryonic development of *P. acuta*. This will assess if Thiamethoxam could contribute to a population decline of *P. acuta* due to a change in reproductive habits and function. This will also assess if thiamethoxam exposure could in a decline of embryonic development. This could lead to a population crash due to new individuals not entering the population of this r-selected species.

References

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- Matsuo H, Tomizawa M, Yamamoto I. 1998. Structure–activity relationships of acyclic nicotinoids and neonicotinoids for insect nicotinic acetylcholine receptor/ion channel complex. Archives of Insect Biochemistry and Physiology. 37(1):17–23.

Acknowledgements

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