

Impact of a Neonicotinoid on Motor Control and Navigation in Drone Honey Bees

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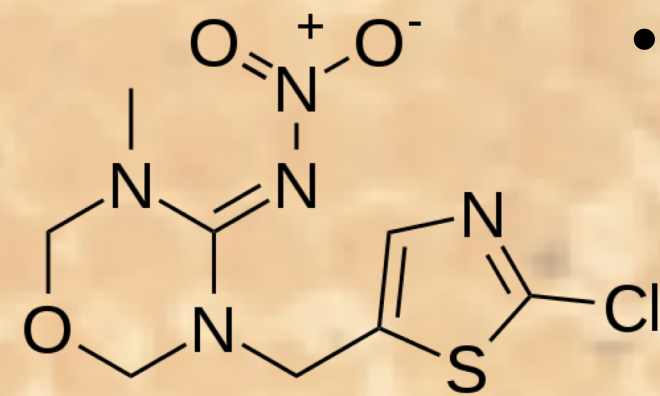
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Introduction

- Neonicotinoids have been widely used in agricultural settings for the past 45 years and its usage is growing (1).



- Thiamethoxam is a broad spectrum systemic neonicotinoid pesticide that widely used in North Dakota and found in honey at 1 to 10 nM concentrations (1).

- There are a number of reports on the effects of thiamethoxam on worker honey bees (2). However, the effects on the male/drone honey bee have not been widely investigated or publicized.



- The role of a drone in the hive is to fly to the mating congregation(s) and mate with a presumptive queen (3).
- The queen needs to mate multiple times in order for her to initiate and maintain a healthy hive (3).

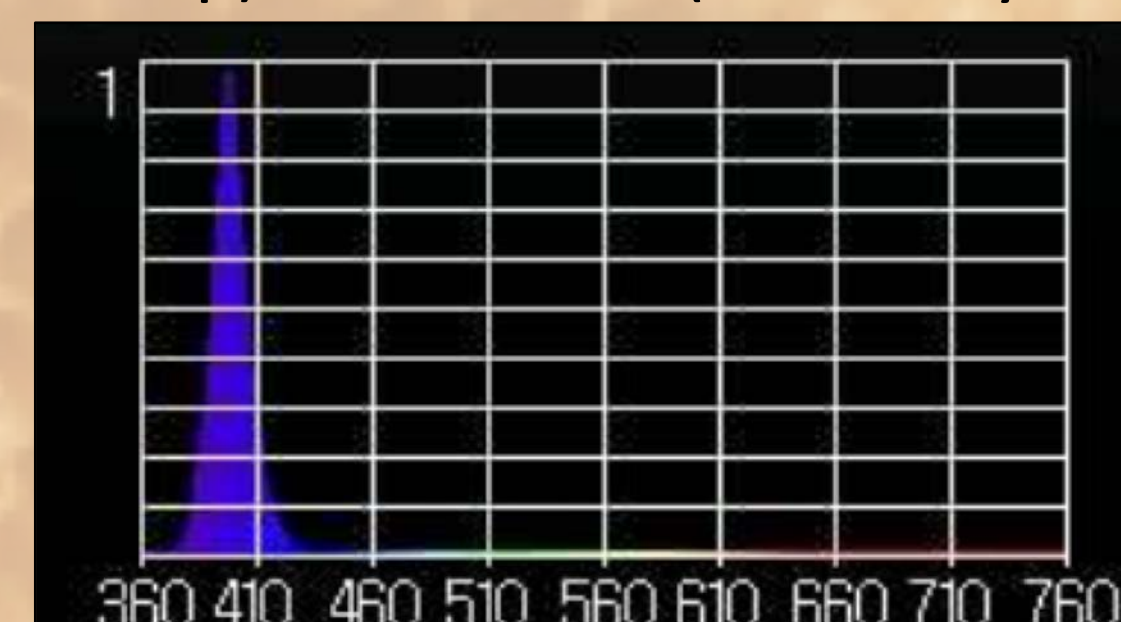
Hypothesis

Sublethal thiamethoxam exposure can impair motor functions including navigation in drone bees.

Methods



- Each flight box contained 6-10 drones and 30 workers
- While, the control bees were fed Pro-Sweet™, the treated bees were fed Pro-Sweet™ laced with 10 nM thiamethoxam (Sigma-Aldrich, MO, USA).
- During the duration of the experiment, bees were maintained in an incubator at 37°C and ~60% RH for 48, 168, and 336 hours.
- At each time point, drones were individually assayed for the following behaviors: (a) grooming/resting (b) flying/wing fanning (c) phototaxis (d) climbing and walking.
- Drones were exposed to a UV-Vis light source (see Figure below for spectral characteristics) from 10 feet to assess their response to light.
- Snapshots of both motor and navigation capabilities were obtained in 3 minute assessments.
- Data was assessed for normal distribution and analyzed using Mood's median (Pearson's Chi-Sq.) test in JMP (SAS, Cary, NC)



Results

Grooming and Resting

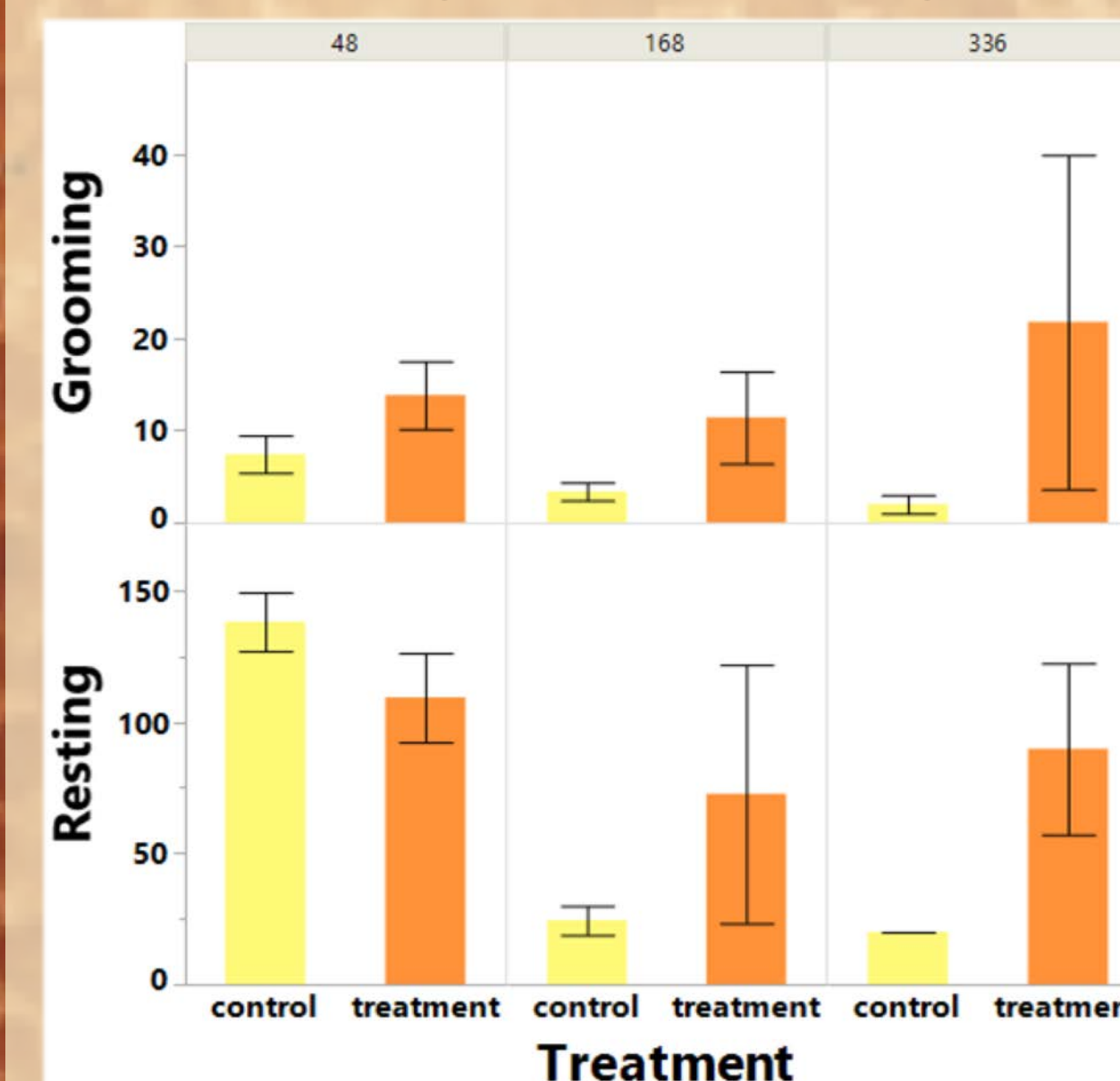


Figure 1 - Grooming and resting duration showed moderate changes with increasing exposure time to thiamethoxam. Controls spent less time resting and grooming compared to the treated bees which exhibited moderate levels of increased grooming ($p=0.009$; $n=21$) as well as resting behavior ($p=0.36$; $n=21$).

Flying and Wing Fanning

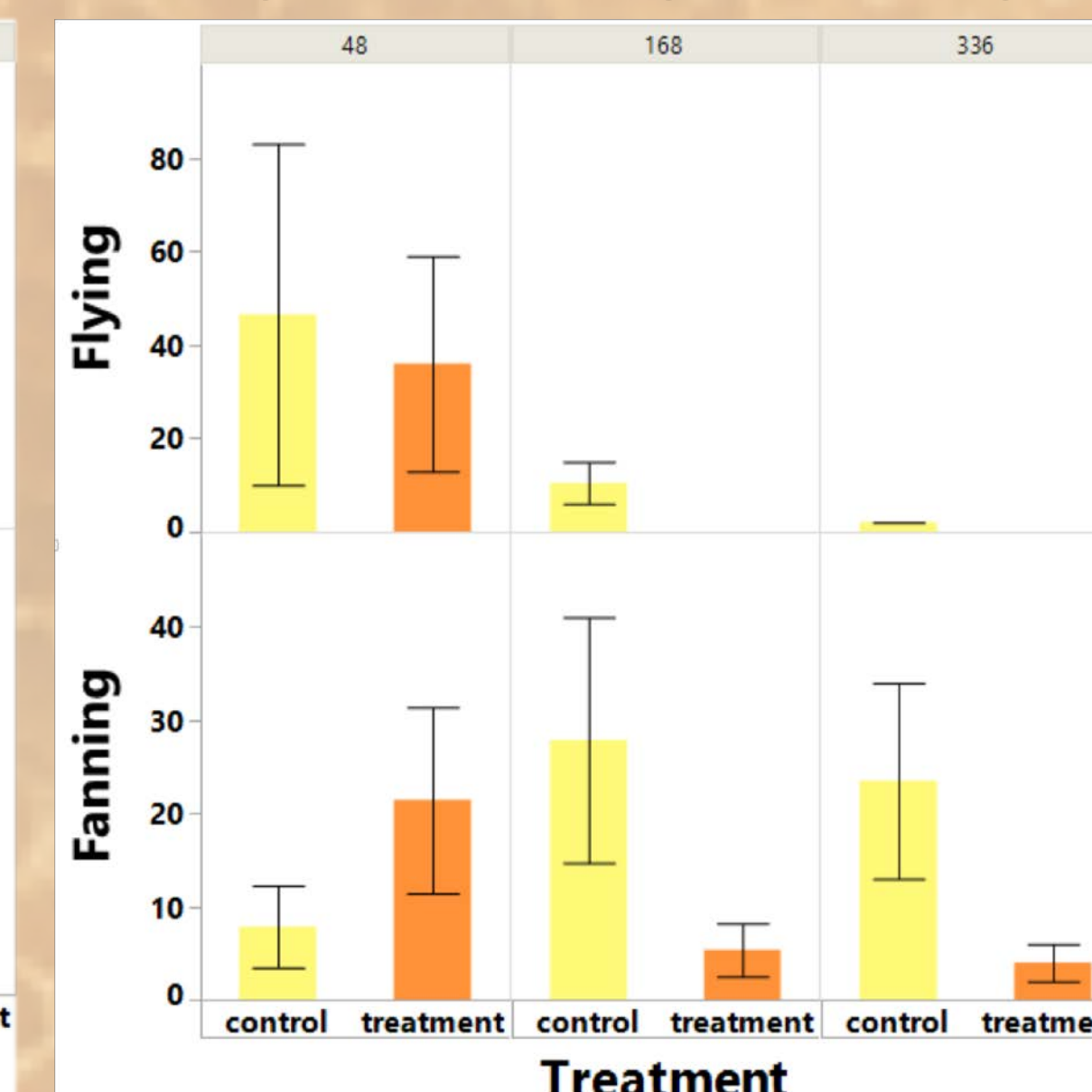


Figure 2 Thiamethoxam treated drones spent less time fanning after 336 hours of exposure compared to the controls ($p=0.08$, $n=11$), showing moderate significance. However, there was no significant difference in flight time among the controls and treatment.

Phototactic Reorientation

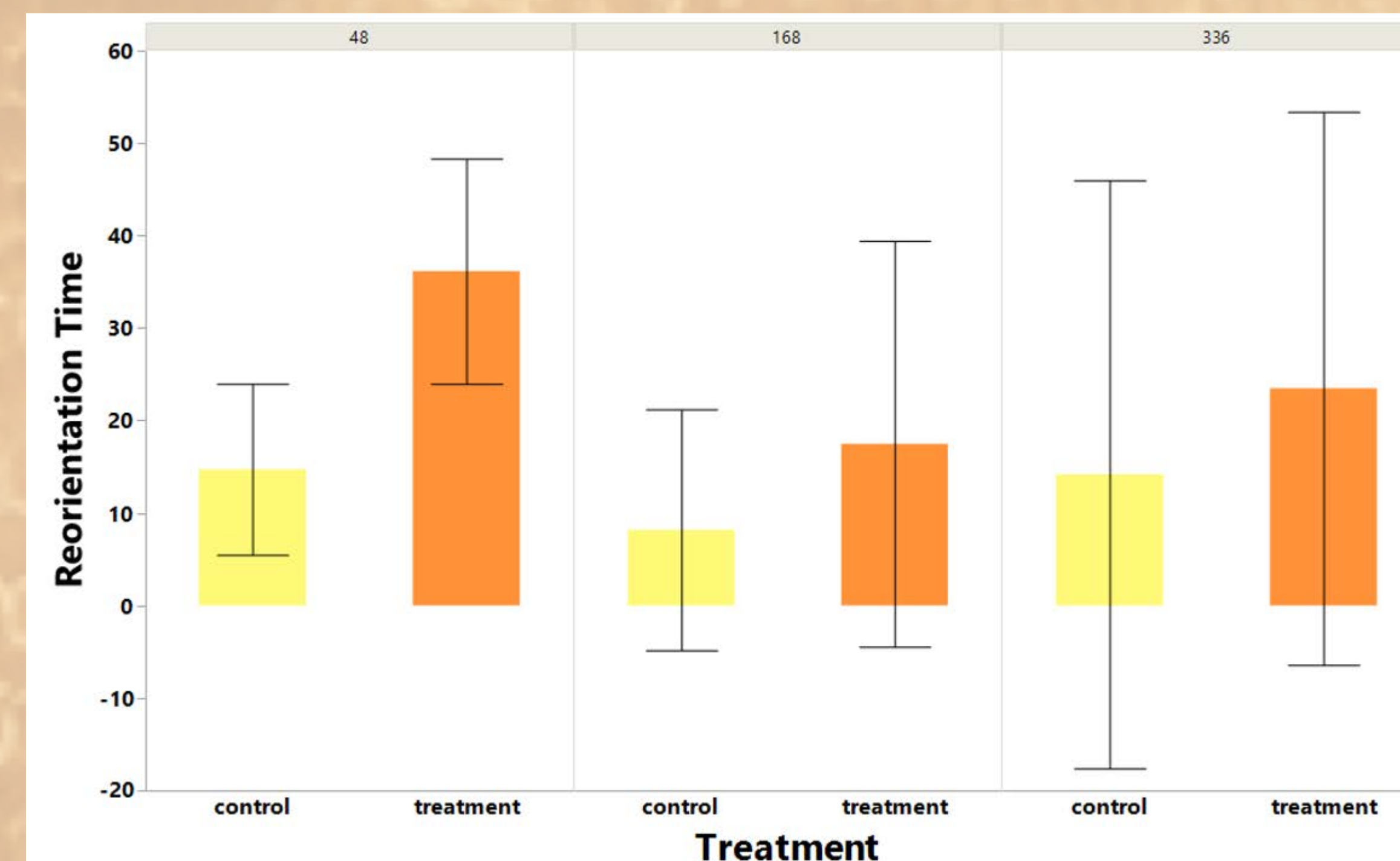


Figure 3 – The confidence interval graph shows that thiamethoxam treated drones are significantly slower at phototactic reorientation relative to controls ($p=0.02$; $n=50$) after 48 hours of treatment.

Ability to Walk and Climb

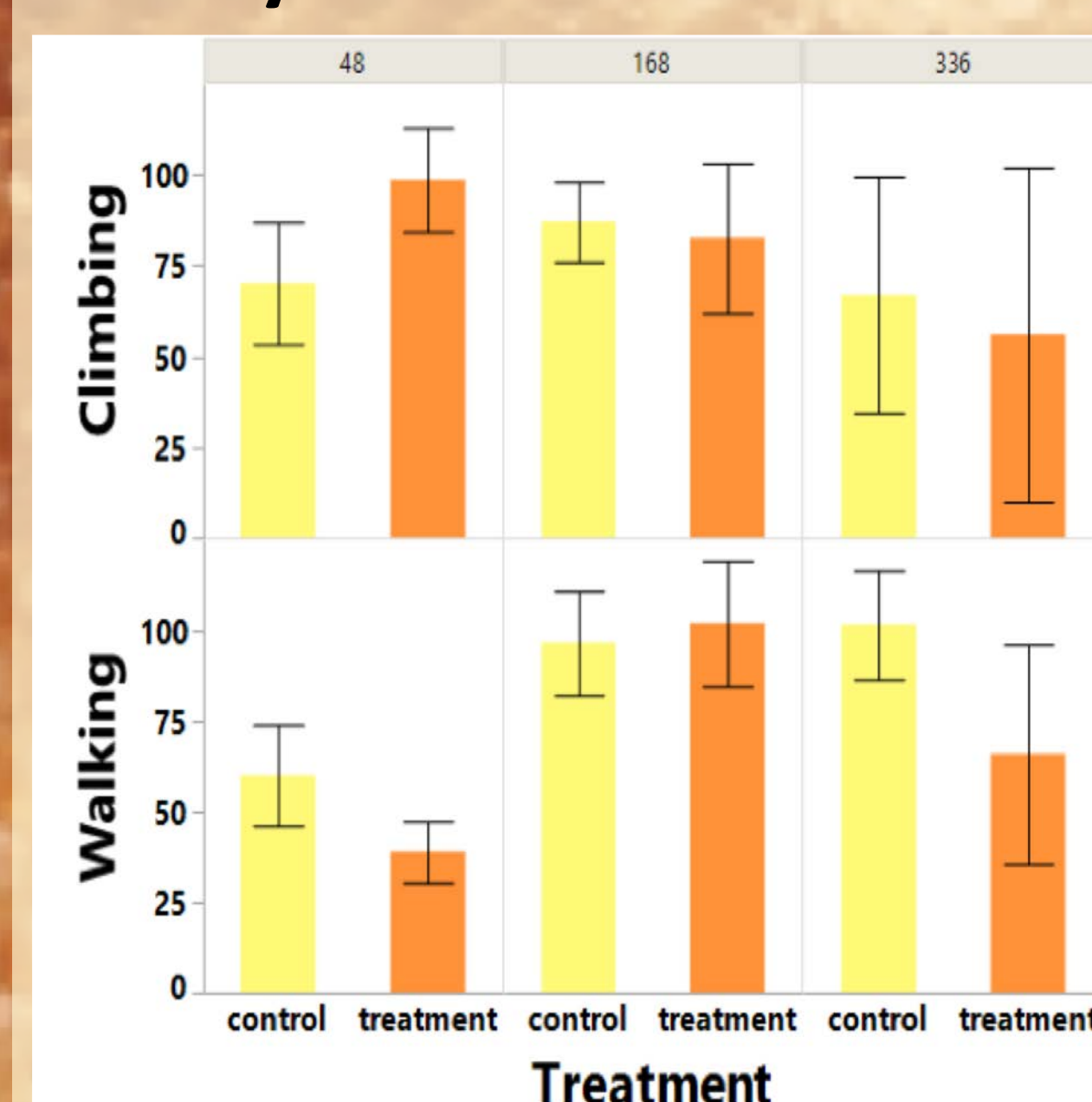


Figure 4 – Untreated and treated drone bees showed no difference in the time spent climbing ($p=0.74$; $n=10$). However the time spent walking among the treated bees was visibly depreciated ($p=0.072$; $n=10$).

Conclusions

- The increase in grooming and resting period (Fig. 1) shows that thiamethoxam does affect drone bees. Previous studies have noted that this is a sign of significant neuromuscular stress in insects (4).
- With increasing treatment time, drones showed significant decline in flying and wing fanning behavior (Fig. 2). Fanning versus flying behavior is age dependent in drones. This observation supports the hypothesis that thiamethoxam interferes with normal wing muscle functions.
- Exposure to thiamethoxam significantly impaired the time taken by drones to orient towards light (Fig. 3). The importance of phototactic impairment in the field could mean that the bee will not be lost.
- There was not much variability in the treated bees' climbing and walking parameters (Fig. 4). However, the study did not analyze walking patterns, speed, distance, etc.



Future Directions

- Assess for incoherence in motility parameters such as directionality, pause, etc. related to stress related indecision.
- Comparative toxicology of neonicotinoids to identify chemicals that are less detrimental to drones.
- Physiological effects of neonicotinoids on acetylcholine esterase activity and neuromuscular dysfunction.
- Transfer of neonicotinoids to queen bees via seminal plasma and their role in spermatozoa physiology.

Acknowledgements

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References

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