

A protozoan parasite weakens the stress reaction of monarch butterflies

Background

The eastern North American monarch butterfly (*Danaus plexippus*) is known for its annual migration to overwintering areas which covers thousands of miles. During these migrations, monarchs are exposed to many physical, physiological, and environmental stressors, and they must be capable of reacting to these stressors with neuroendocrine, physiological and behavioral changes (i.e. the 'fight-or-flight response') to maximize survival.

Monarchs are also susceptible to a protozoan parasite *Ophryocystis elektroscirrha* (OE) which affects pre-adult mortality, longevity, body size, and flight ability. The parasite is transmitted when spores from infected adult butterflies are scattered onto the eggs and milkweed leaves. Larvae eat the spores to become infected.

The goal of this project was to determine if the OE parasite affects the physiological fight-or-flight response (heart rate) in monarchs.

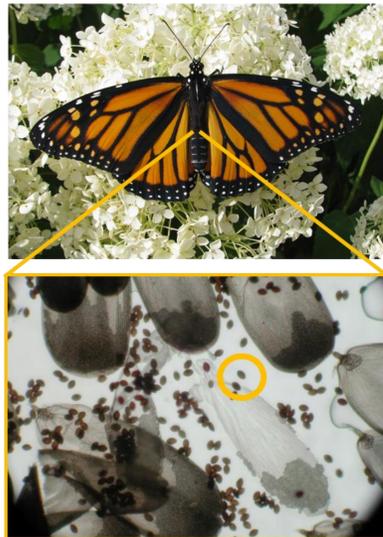


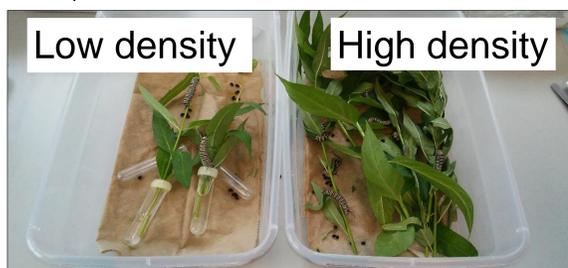
Photo of monarch butterfly and microscopic image of OE spores from its abdomen. Large objects are scales

Study Design

Five family lines (lineages) of monarchs were reared in captivity. All larvae were fed greenhouse-grown milkweed (*Asclepias incaranta*). 80 larva were reared for each lineage (400 total). Larvae were reared in two density treatments (low or high).

Half of the larvae from each lineage were given the OE parasite at second instar, by feeding them 10-20 parasite spores placed onto milkweed pieces. The other 40 larva for each lineage (control larvae) were sham-inoculated (no spores).

Larvae were fed daily with milkweed cuttings until they reached pupation. Then, we assessed the **stress reactions** of each pupa (see description above).



Experiment data

Predictors:

- Monarch family
- Parasite treatment
- Density treatment
- Pupa weight
- Monarch gender

Dependent variables:

- *Stress magnitude* (heartrate elevation)
- *Stress duration* (time to return to baseline)

Other data:

- Adult longevity

Measuring Stress Reaction

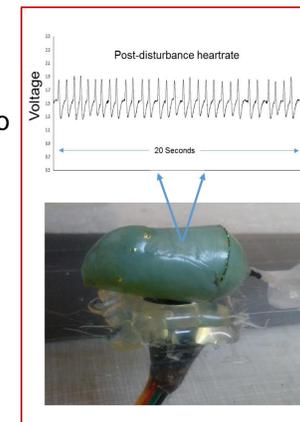


Jovani stressing a monarch pupa

Monarchs, like all insects, react to stressors by increasing their heart rate.

We subjected each pupa to a 20-second physical disturbance (moving pupa between cupped hands)

We measured heart rate elevations using an electronic, infrared probe that records movement of the insect heartbeats (pictured right).



Results

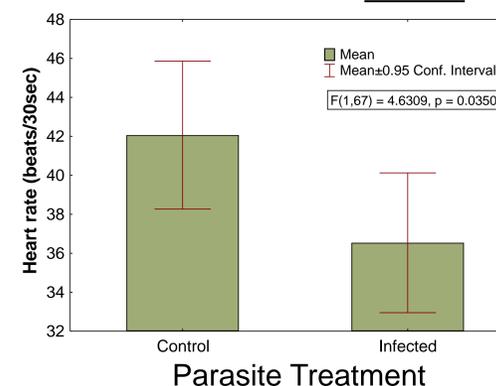
General Results

- A total of 244 larvae survived to pupation (61%). We assessed HR on 179 pupa.
- Survival did not differ between density or parasite treatments
- Average length of larval stage was 9 days in both infected and uninfected groups.
- Pupal weight was not affected by larval density or parasite infection

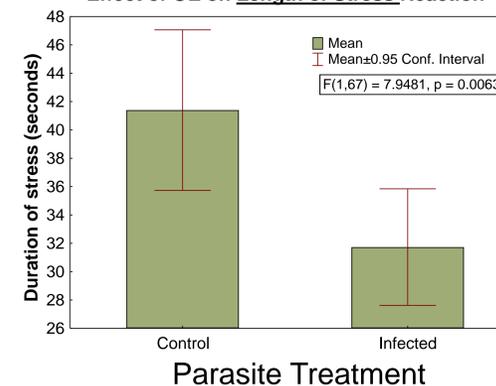
Results on Stress Reactions

- Average heartrate following disturbance was 80 beats/min across all treatments
- Infection was a significant predictor of the magnitude and duration of pupa HR (see graphs); infected monarchs had lower reactions
- Pupa weight was negatively correlated with stress magnitude in **uninfected monarchs**

Effect of OE on stressed Heart Rate

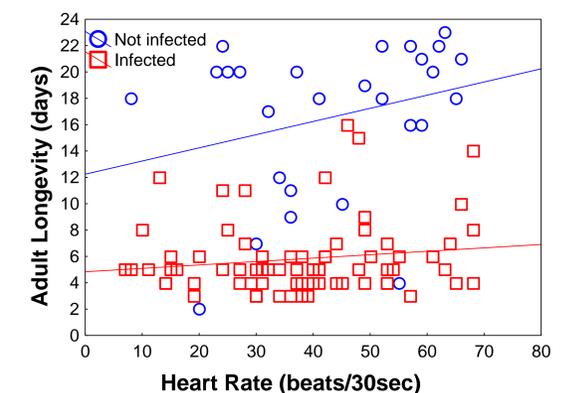


Effect of OE on Length of Stress Reaction



Discussion

- Our results indicate the OE parasite weakens the fight-or-flight response of monarchs (i.e. lower HR following stress).
- Slower heartrates following stress means less blood is pumped to muscles during critical times when demand for energy is high (encounters with predators, etc.)
- Assuming that the pupal stress response carries over to the adult stage, this would negatively affect how well infected monarchs could cope with daily stressors, especially during the arduous fall migration
- Other data is currently being collected on adult lifespan, to determine associations with stress reactions. Preliminary data shows high stress responsiveness in pupal stage leads to longer adult lives (see graph below).



Preliminary graph (not all results in) showing magnitude of stress reaction predicts adult lifespan

Acknowledgements

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