



Strength in numbers: Parasite transmission & virulence in monarch butterflies

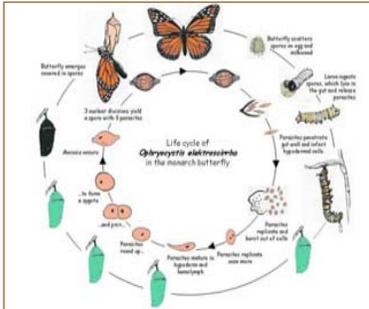
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Abstract

The protozoan parasite, *Ophrocystis elektroscirra*, has been observed to decrease fitness and longevity in monarch butterfly hosts. Because high infection levels (i.e. heavy spore load) cause high virulence within the host, we tested if high infection loads are also advantageous to the parasite through increased transmission. Monarch larvae were infected with various doses of parasites and reared to adulthood, and parasite spores on milkweed leaves and eggs were counted. Results showed that heavily infected monarchs transmitted more spores onto leaves and eggs than lightly infected monarchs, and that when females laid eggs, they also transmitted more spores. Spore counts taken from two dates did not significantly differ, implying that once a host is infected, the parasite can be transmitted over a certain time interval without decreasing in number. These results suggest that parasites require a high level of infection to transmit most effectively, and that host health deterioration is an unavoidable cost to parasite survival.

Background

- *Ophrocystis elektroscirra* is a naturally-occurring protozoan parasite found in monarch butterfly (*Danaus plexippus*) populations around the world.
- The primary method of infection is through larval consumption via spore deposition on eggs and milkweed plants by infected adult female monarchs during oviposition.
- After passing through the larval gut wall, the parasite travels to the hypoderm and replicates; parasite spores appear on the outside of the adult monarch's body following emergence.



- Research has shown that negative effects of the parasite on monarch fitness (e.g. reduction of lifespan) are attributed to higher spore loads through within-host replication.
- However, as parasites depend on their hosts for survival, this leads to the question of **whether high spore loads provide an advantage to the parasite in the form of increased transmission despite increased virulence in the butterflies.**

Questions

- Is there a relationship between spore load (i.e. infection levels) and spore deposition levels on both host plant leaves and eggs?
- Is there increased transmission from higher spore loads for the parasite?

Methods



- Monarch larvae were inoculated with varying dosages of parasites (1, 10, or 100 spores), while some remained uninfected as controls.



- 540 caterpillars were reared in individual containers to ultimately obtain 45 females with varying levels of infection.



- Females were mated, placed in individual cages, and supplied with honey water and a milkweed stalk.



- Milkweed stalks were replaced every 1-2 days and checked for eggs.



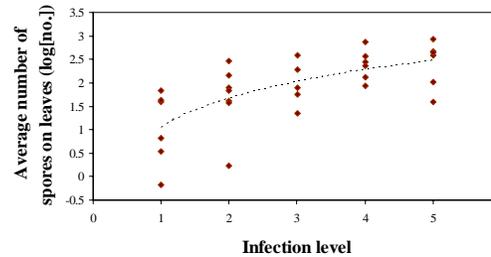
- Milkweed leaves were collected at random from the top, middle, and bottom of the stalk, then numbered and taped to collect spores from them.



- Spores from leaf samples and eggs were counted under a dissection microscope.

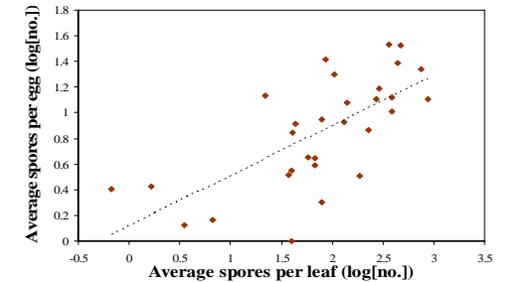
Results

Fig. 1: Relationship between infection level and spore deposition on leaves



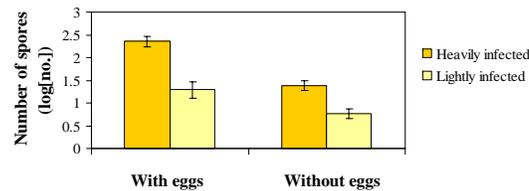
- The average number of spores on leaves per butterfly increased with host infection level, here quantified on a scale from 1-5 ($R^2 = 0.460$, $p < 0.001$).

Fig. 2: Spore deposition on leaves and eggs



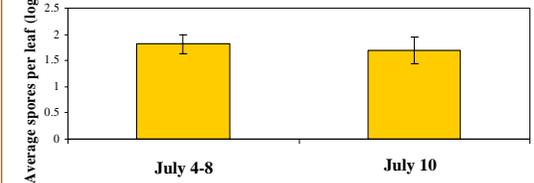
- There was a significant positive linear relationship between the number of spores on leaves and on eggs ($R^2 = 0.473$, $p < 0.001$), such that higher infection loads resulted in higher transmission through both eggs and leaves.

Fig. 3: Spore deposition on leaves with and without eggs



- Overall, leaves with eggs had more spores than leaves without eggs ($p < 0.001$), and this was true for both heavily infected monarchs (3-5 infection level) and lightly infected ones (1-2 infection level).

Fig. 4: Spore deposition over time



- Spore counts for leaf samples taken on the first day of egg-laying for individual monarchs (Jul. 4-8, 2006) were compared to leaf samples on Jul. 10, 2006; there was no significant difference in numbers between the two egg-laying days ($p = 0.695$).

Conclusions

- On average, butterflies with higher infection rates deposited more spores on both leaves and eggs, showing a transmission advantage of high infection levels for the parasite (Fig. 1, Fig. 2, Fig. 3).
- When butterflies laid eggs, they deposited more spores on leaves than when they did not lay eggs (Fig. 3). This is most likely due to the fact that females that lay eggs spend more time on the leaves and therefore have more contact with the leaf surfaces.
- Spore deposition over time stayed relatively constant, allowing the parasite more time to transmit without decreasing in number (Fig. 4).
- These results show that higher spore loads are beneficial to parasites because of increased transmission on leaves and eggs, both of which will eventually be ingested by larvae. Virulence, therefore, appears to be an unavoidable consequence of parasite transmission.

Acknowledgements

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