Extreme Heat Reduces Fitness of Monarchs & their Parasites

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Background
- Environmental temperature affects insect development, survival, physiology, and distribution
- Insects are important pollinators and vectors of disease; it is vital to understand how climate warming affects insect-parasite interactions
- A debilitating protozoan parasite, Ophryocystis elektroscirrha (OE) is present in all Monarch (Danaus plexippus) populations.
- Temperature’s effect on within-host OE development or Monarch immune function is not known

Experimental Design
- The Life Cycle of the OE parasite in Monarch butterflies
- Adults emerge covered with spores
- Larvae consume spores which penetrate the gut wall
- OE undergoes multiple replication stages as larva pupates
- Adults scatter spores on milkweed, eggs, and other adults
- Larva pupates

Methods & Measurements
- Three lineages of migratory monarchs test genetic effects while 3 spore treatments test sporocidal virulence effects within 5 different temperature treatments.
- Monarch Condition:
  - Survival (to pupation & emergence)
  - Development time (days)
  - Mass (pupal & larval)
  - Adult longevity
- Immune Function:
  - Hemocyte counts (larval & pupal bleeds)
- Infection Measurement:
  - Merozoite counts (pupal bleeds)
  - Infection scores (adult taping)

Results
- Figure 1. Survival and infection success
- Figure 2. Average pupal mass (top) & development time until pupation (bottom)
- Figure 3. Percent wing deformities across treatments
- Figure 4. Larva & pupa hemocyte counts

Conclusions
- The study provides new evidence that high environmental temperatures decrease infectivity of a parasite in Monarchs
- Moderate warming is predicted to lead to more monarch generations per season and higher parasite fitness
- More extreme heat events, which are predicted with climate change, will be harsh on both monarchs and their parasite

Future Directions
- Complete and analyze spore load, immune assays, & adult longevity
- Investigate the effects of temperature extremes (30-34°C & <18°C) and fluctuations in temperature on the host-parasite interaction

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