The Dependence of Butterfly Flight on Temperature

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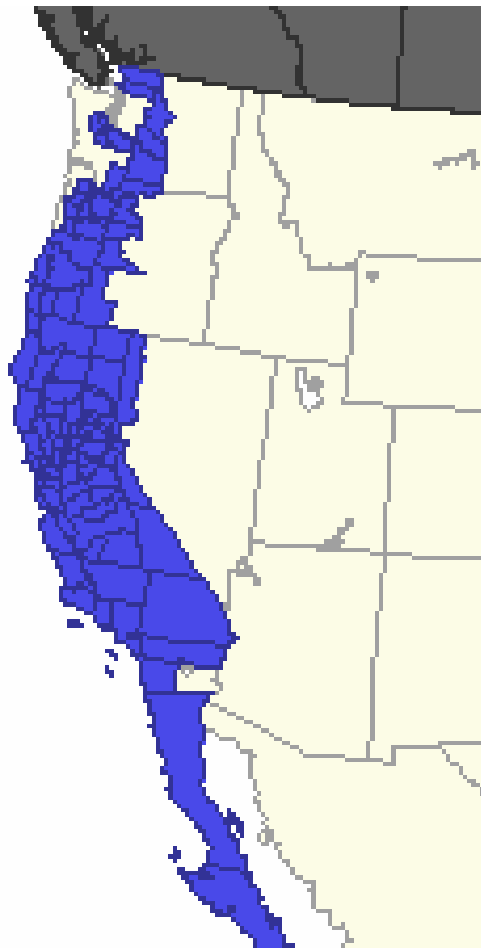
Summer Undergraduate Research Experience

Propertius Duskywing Skipper

- *Erynnis propertius*
- Oak specialist



Butterfly Flight

- Essential to male feeding, mate location and courtship
- Essential to female feeding and oviposition
- Limiting factor in reproductive output
- Key component of fitness

Temperature and Flight

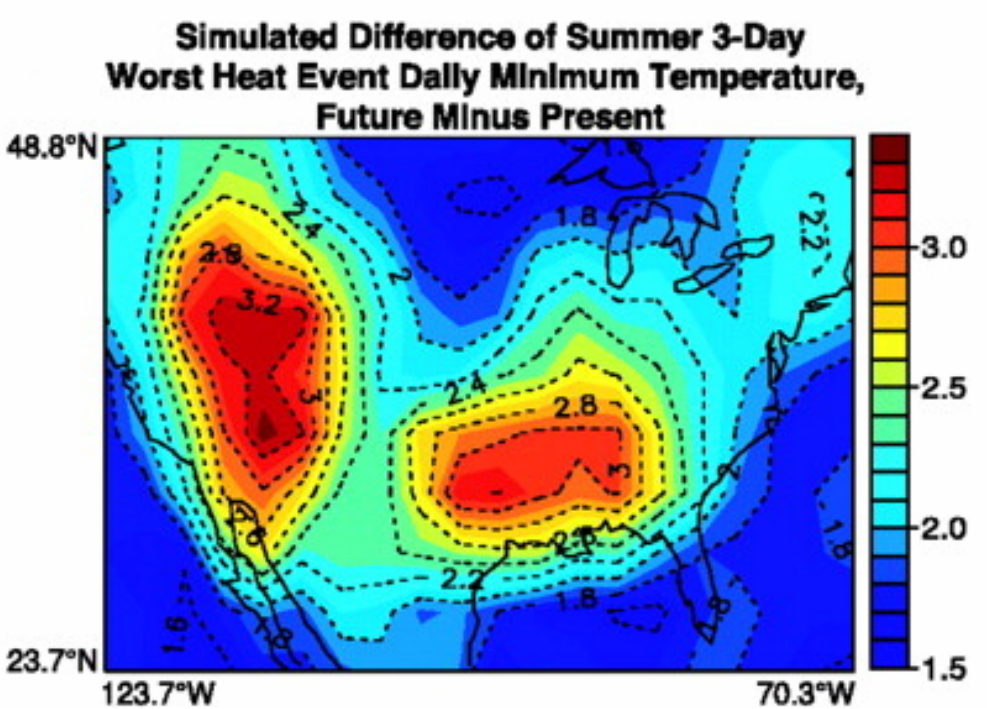
- Flight can only occur within the voluntary flight activity range
- Ectotherm
- Behavioral thermoregulation
- Air temperature is the best predictor variable of body temperature (Howe et al. 2007)

1. Air temperature
2. Microhabitat temperature
3. Windspeed
4. Solar radiation averaged over last 4 min
5. Instantaneous solar radiation intensity

Howe et al. 2007

Global Climate Change

- Increased severity of heat waves



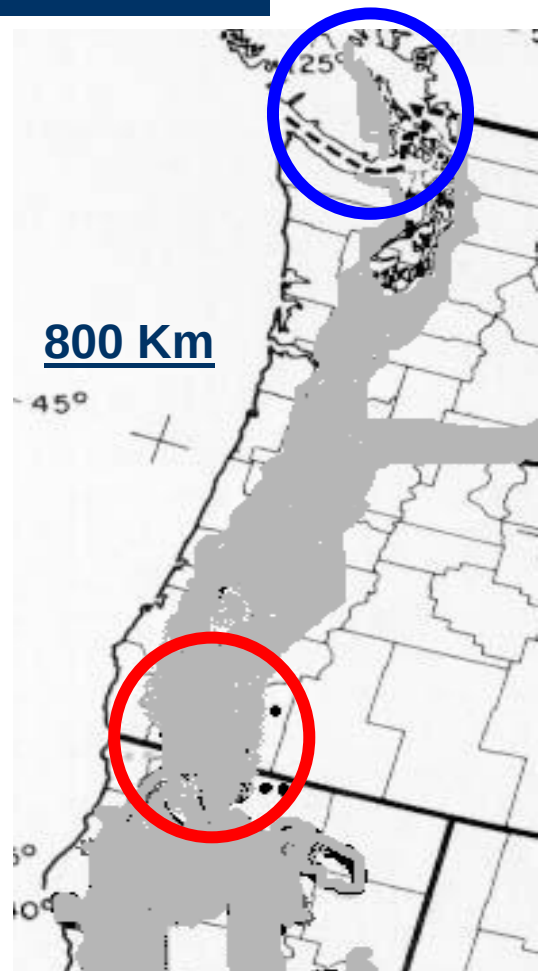
Meehl & Tebaldi (2004)

Research Questions

- How is flight related to air temperature?
- Is there a difference in the relationship between flight and temperature for butterflies of different:
  - Region
  - Sex
  - Age

Field Data Collection

- Data for 6 sites on Vancouver Island for 2003-2007 and 5 sites in Oregon and California for 2005-2007
- Observers walked along transects, spending 1-1.5 min per 30 m segment, recording all butterflies observed
- Weather data



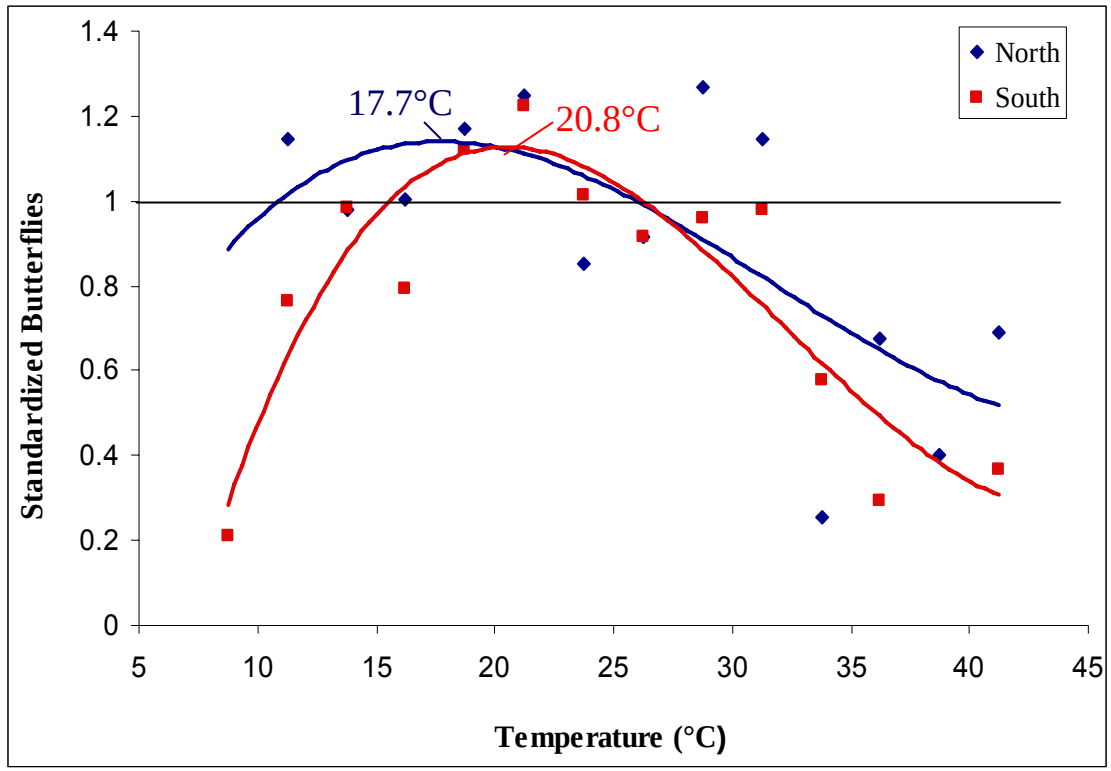
Field Data Results

$$\text{Standardized Butterflies per 2.5°C Increment} = \frac{\text{Butterflies Observed at Temperature}}{\text{Segments Temperature Observed}} \Big/ \frac{\text{Total Butterflies Observed}}{\text{Total Segments Observed}}$$

Paired T-Test: p = .106
Indicates a trend toward difference between North and South in standardized butterflies

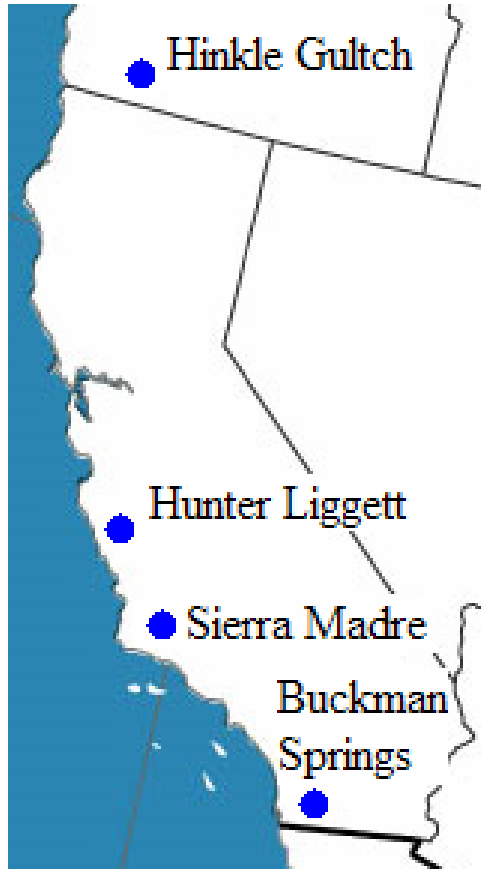
Optimum Activity Range
(Standardized butterflies ≥ 1)

- North: 11.2 – 26.0°C
- South: 15.6 – 26.2°C



Laboratory Experiment

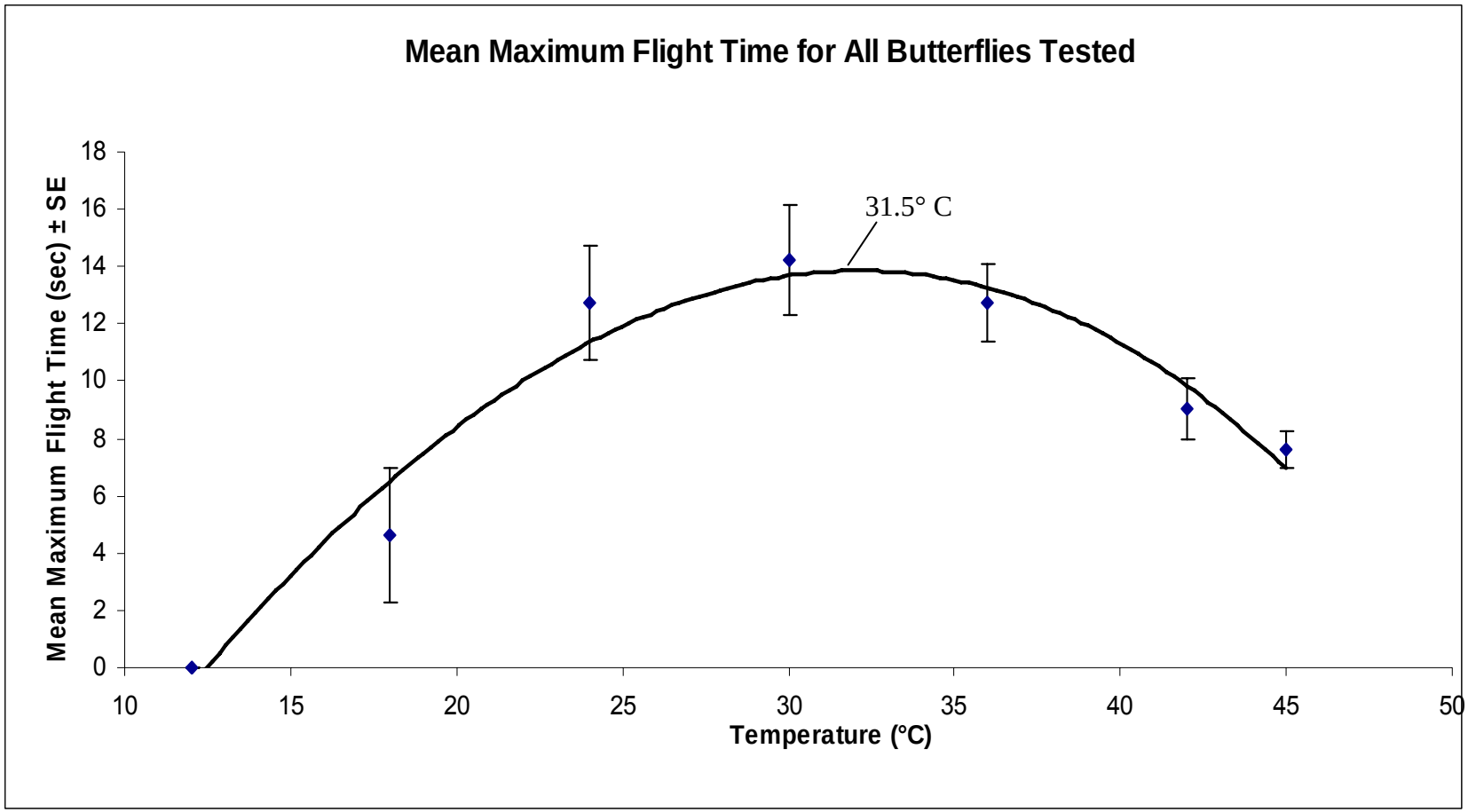
- 4 sites
- Field-collected eggs reared in greenhouse
- Tested flight ability at 12 - 45°C
- Temperature sequence tested
- Flight box within temperature controlled chamber
- Agitated to induce flight
- Recorded on digital video camera
- Maximum flight time determined for each temperature



Laboratory Experiment Video

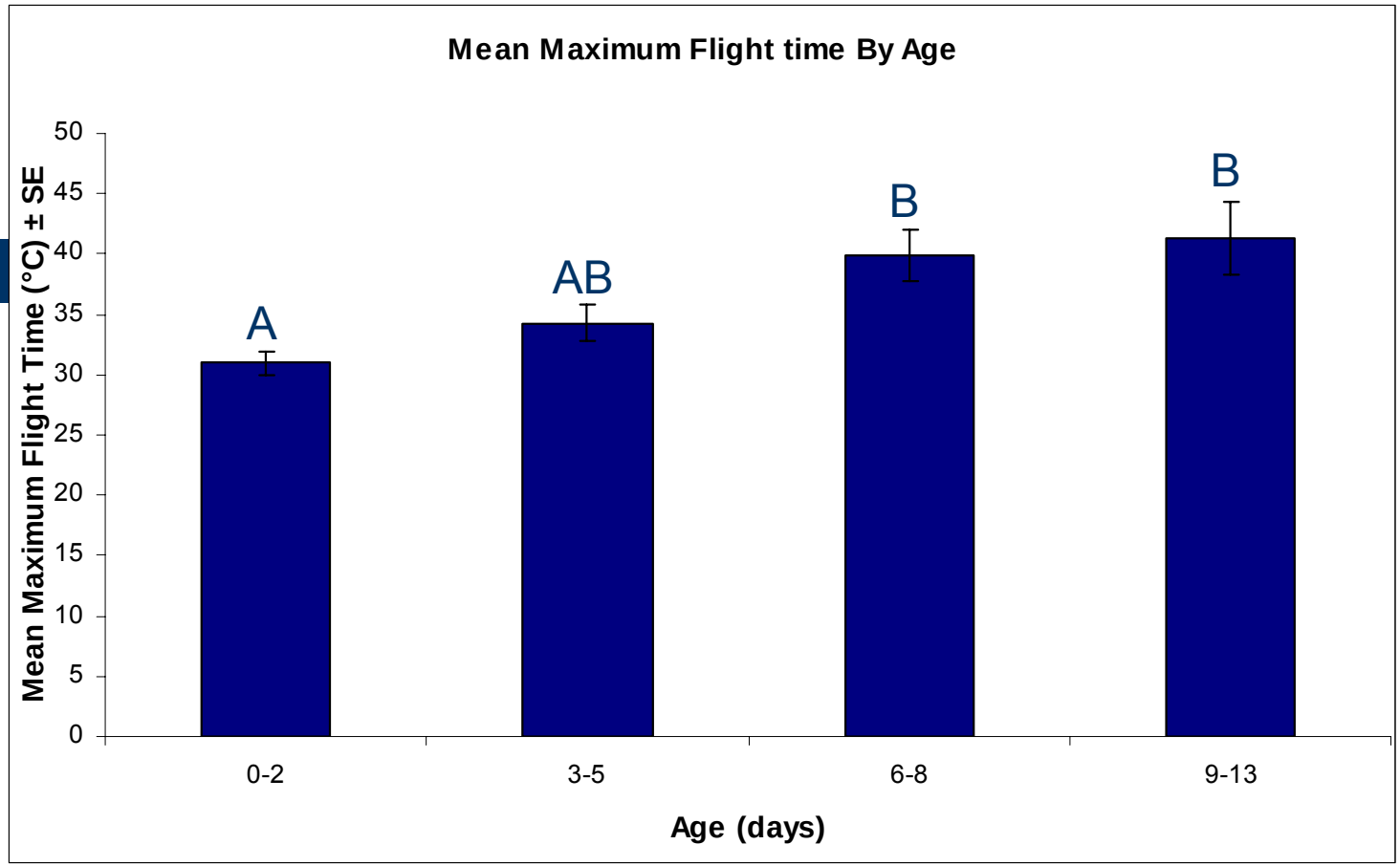
http://www.nd.edu/~hellmann/movie1.swf

Laboratory Experiment Results

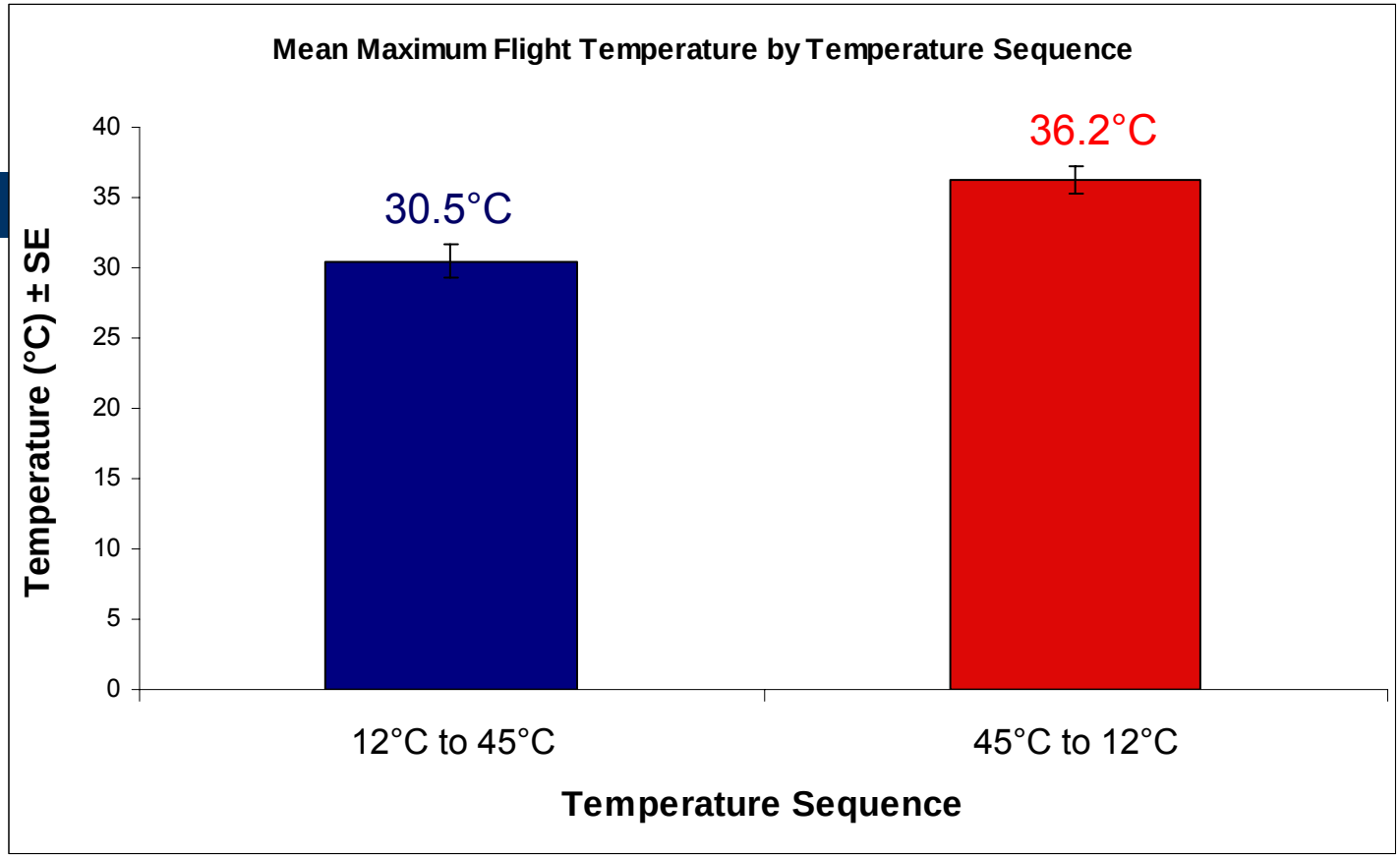


Laboratory Experiment Results

- MANOVA for maximum flight time and temperature
  - Site not significant
    - Genetics show little population variation in neutral markers in this region (Zakharov & Hellmann 2008)
  - Sex shows trend toward difference of maximum flight time ($p = 0.135$)
    - Greater maximum flight time in males
    - Decreasing available flight time may most affect females
  - Age significant to maximum flight temperature ($p = 0.000$)
  - Temperature sequence significant to maximum flight temperature ($p = 0.001$)



- Significant difference in maximum flight temperature between different age groups (ANOVA: p = 0.000)
- Increasing temperatures may most affect the youngest butterflies



- Significant difference in maximum flight temperature when butterflies were tested from 12°C to 45°C or 45°C to 12°C (T-Test: p = 0.001)

Conclusions

- **Increased severity of heat waves and other temperature changes caused by climate change may negatively affect flight by shifting temperatures outside of the optimum activity range in all regions of the habitat range of *E. propertius***

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