Large-scale temporal and spatial variation in insect body size

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Ecological importance of insect body size

**Fecundity**  (Honěk 1993)
**Population biology**  (Siemann et al 1996; White et al 2007)
**Disease transmission**  (Russell et al. 2011)
**Food web structuring**  (DeLong et al 2015)
**Ecosystem services**  (Sheridan & Bickford 2011)
Temperature-Size Rule

e.g. *Drosophila*, mature at a smaller size when raised at warmer temperatures

www3.beacon-centre.org
Declining body size: a third universal response to warming?

Janet L. Gardner¹, Anne Peters².³, Michael R. Kearney⁴, Leo Joseph⁵ and Robert Heinsohn¹

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Trends in Ecology and Evolution, 2011
Climate is warming steadily. Are insects shrinking?

Berkeley, CA, 1900–2000 (Climate WNA)

![Graph showing mean annual temperature trends from 1900 to 2000 with data points for different locations including Vancouver, BC, and Whitehorse, YK.](image)
Use collections from the Beaty Biodiversity Museum to test insect responses to warming

Insect Ecology class project, spring 2016

Karen Needham
Assistant Curator
Spencer Entomological Collection
Beaty Biodiversity Museum

Biol411, Insect Ecology Students (23)
Why beetles?

- Hugely diverse: 350,000 described species
- Every ecosystem; diverse ecological roles
- Readily available in the Beaty Biodiversity Museum
First: Do beetles show ‘temperature-size rule’ in the lab? → meta-analysis
Do beetles show ‘temperature-size rule’ in the lab? Meta-analysis: Mostly Yes

20 studies:

Most species decreased in size as rearing temperature increased; no effect of sex

Temp: $\chi^2_{(3)} = 35.8, p<0.001$
Relationship between body size and how much a species responds to temperature?

![Graph showing the relationship between log dry mass (mg) and % change in mass per °C. The graph is a horizontal line at 0, indicating no change in mass per degree Celsius change.](image)
Are larger-bodied species reacting differently to temperature change?

RMA regression:
\[ p = 0.02; r = -0.32 \]

Avg change in body mass per °C
-0.77% (± 0.46 95% CI)

→ Larger beetles shrink more
Examine long-term body size trends using museum collections

**Region 1, BC**
- Pterostichus melanarius
- Staphinotus angusticollis
- Carabus nemoralis

**Region 2, BC**
- Amara quenseli
- Cymindis planipennis
- Harpalus fraternus
- Euryderus grossus
Region 1 All Years: 2/4 beetles decreased in size

![Graph showing the decrease in size of beetles over years for different regions, with images of Staphinotus angusticollis, Carabus nemoralis, Pterostichus melanarius, and Pterostichus aldigus.](image-url)
Region 1 post 1970: 4/4 decreased

- *Staphinotus angusticollis*
- *Carabus nemoralis*
- *Pterostichus melanarius*
- *Pterostichus aldigus*
Region 2: 2/4 beetles decreased in size (1980-2015)

- Euryderus grossus
- Harpalus fraternus
- Cymindis planipennis
- Amara quenseli
Museum data: are larger-bodies species reacting differently to temperature?
Museum data: larger-bodied beetles have shrunk more

RMA regression:
p<0.05; r = -0.54

Change in body size per °C
-4.8% (± 6.1 95% CI)

Tseng et al 2018
Changes in body size linked to autumn temperatures

Autumn temperatures have increased

Beetle body size decreases with increasing autumn temperatures
Shrinking beetles – Summary

• Beetles decrease in size as temperature warms

• Larger-bodied species decrease more

• Are these patterns reflected across latitudinal gradients?
Bergmann’s Rule: (Bergmann 1847)

Within species: larger-bodied individuals found at higher latitudes
Measured 4000 individuals, 12 species
Lots of interspecific variation in latitude-body size relationships
But similar to temperature results – larger beetles show

Exhibits Bergmann’s rule (body size increases with latitude)

Inverse Bergmann’s rule (body size decreases with latitude)
Most beetles decrease in size with latitude; but not larger-bodied beetles

- Inverse Bergmann’s rule (body size decreases with latitude)
- Bergmann’s rule (body size increases with latitude)

slope = 3.85, p = 0.029, r^2 - 0.29
Summary

- Larger-bodied beetles are shrinking with climate change;
- Larger-bodied beetles more likely to increase in size with latitude; opposite for smaller beetles.
Summary

• Lab responses to temperature predict
  - responses to temperature in nature
  - some responses to latitude in nature

• Understanding large-scale temporal and spatial patterns facilitated by physical and digital natural history collections
Thanks for listening!

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Acknowledgements

Karen Needham – Entomology Curator

Shrinking beetles coauthors
Katrina Kaur
Sina Soleimani Pari
Karnjit Sarai
Denessa Chan
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