Living in a lonely world: how would you adapt?

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INTRODUCTION

- The mountain pine beetle (MPB; *Dendroctonus ponderosae* Hopkins) is a species of bark beetle with four distinct density-dependent stages in its population cycle (Safranyik and Carroll, 2006);
  - Endemic; population density is low and beetles have the potential to mass attack one tree within 40.5ha of land (Amman 1984).
  - Epidemic; population density is high and MPB can mass attack many trees on the landscape level.
  - Incipient epidemic and post endemic stages are transition stages.
- Tree diameter is directly related to phloem width; thicker phloem provides more food for the MPB, but is characteristic of healthier trees with stronger defences (Safranyik and Carroll, 2006).
  - Endemic phase: MPB attacks small diameter trees and trees that have a secondary stressor.
  - Epidemic phase: MPB can attack large diameter, healthy trees.

- MPB flight capacity and reproduction are directly related to fat content (Evenden et al. 2014, Wijerathna et al. 2019), high distance flights negatively impact the amount of energy left to produce offspring, but in turn reduces intraspecific competition. Endemic MPB displays unique flight phenotypes that have yet to be explained (Fig 1).

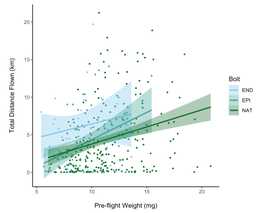

Figure 1: Bolt type affecting flight distance (Musso 2022, unpublished).

PURPOSE

- The purpose of this research was to identify differences in beetle condition and wing morphology between MPB in the endemic vs. epidemic population phases that may contribute to differences in beetle behaviour.

METHODS

- This study was possible via MPB from a previous experiment- MPB from lab simulated endemic, lab simulated epidemic, and naturally mass attacked pine were harvested and given a flight treatment or held at room temperature as control before physical measurements were taken.
- The pronotal width and body length were measured using a dissecting microscope.
- Wings were dissected from beetles and scanned. ImageJ was used to calculate wing area.

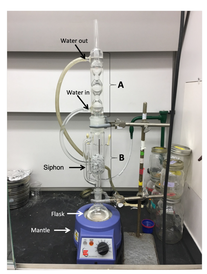

Figure 2: Soxhlet apparatus. Credit: Rebecca Pain

- Fat content was measured via a fat extraction.
  - Weights of the MPB were recorded before and after extraction, all mass lost was assumed to be fat.
  - Performed using a soxhlet apparatus, petroleum ether and cold water.

RESULTS

Below graphs show results of male and female MPB from lab simulated population states, endemic (END), epidemic (EPI), and naturally mass attacked trees (NAT).
Bar graphs are mean values which contain ± 95% confidence intervals.

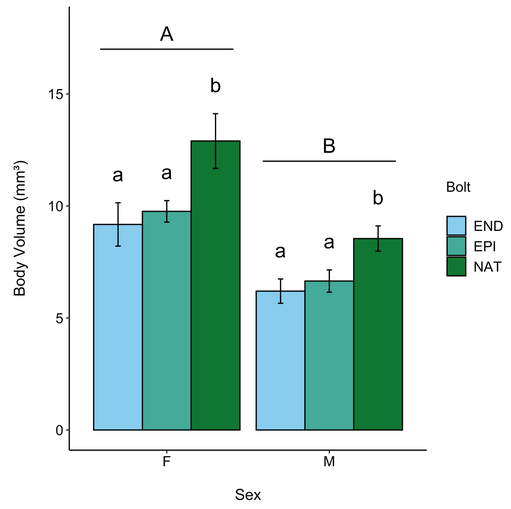

Figure 3: Mean body volume. Within each bolt type females were larger than males, denoted by an asterisk (χ^2 = 152.18, df = 1, p < 0.001). Significant differences between types of bolts are denoted by letters above bars for each group. Grouped bars with different letters have significantly different estimated marginal means at p < 0.05. Beetles from the lab simulation population states (END and EPI) were significantly smaller than beetles from naturally mass attacked trees (NAT) (χ^2 = 10.79, df = 2, p = 0.004).

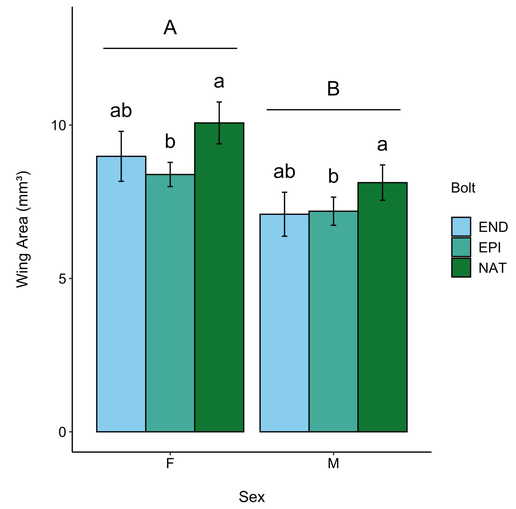

Figure 5: Mean wing area. Within each bolt type females had larger wings than males, denoted by an asterisk (χ2 = 36.24, df = 1, p < 0.001). Significant differences between types of bolts are denoted by letters above bars for each group. Grouped bars with different letters have significantly different estimated marginal means at p < 0.05. Beetles from epidemic simulations have significantly smaller wings than those from naturally mass attacked bolts (χ2 = 22.12, df = 2, p < 0.001).

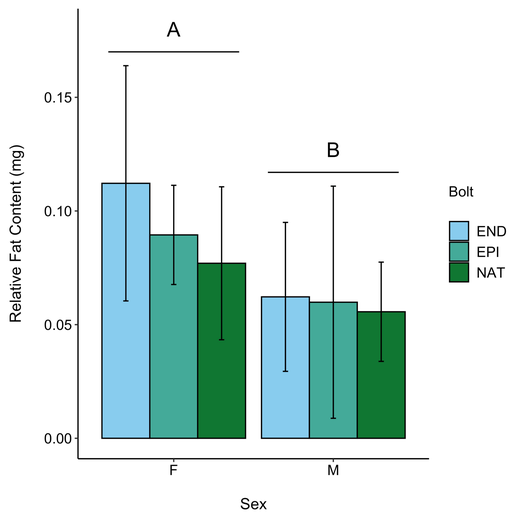

Figure 4: Mean relative fat content. Within each bolt type females were larger than males, denoted by an asterisk. (χ^2 = 7.74, df = 1, p = 0.005). No significant difference depending on bolt type (χ^2 = 1.16, df = 2, p = 0.56).

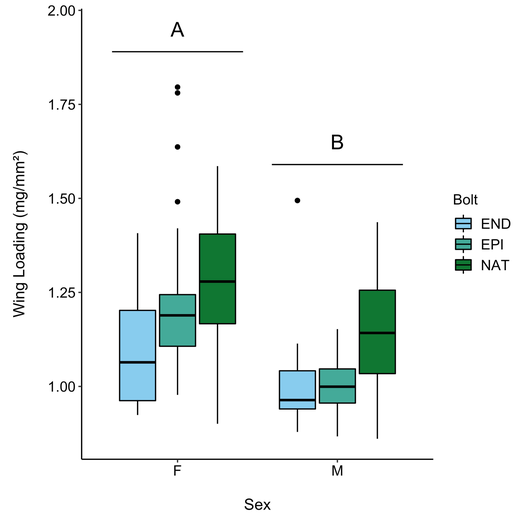

Figure 6: Mean wing loading. Within each bolt type, females had greater wing loading than males, denoted by an asterisk (χ^2 = 28.99, df = 1, p < 0.001). Type of bolt does not significantly affect wing loading (χ^2 = 3.79, df = 2, p = 0.15).

CONCLUSIONS

- Our results showed that the sex of the MPB significantly affects their physical condition, regardless of population state.
  - Females have statistically more fat in their bodies, higher body volume, larger wings, and higher wing loading than males.
  - This may explain why female MPB have fat leftover for reproduction after flying similar distances as male MPB.
  - Lower wing loading in males could mean more energy efficient flights, resulting is further flights despite lower weights.
- Physical differences between the natural epidemic and lab simulated populations can be observed.
  - Given that the host cells begin to die when cut down, the phloem that the MPB was introduced to in the lab simulation was not as healthy as naturally mass attacked trees could provide. This could explain why the lab simulated epidemic MPB body volume and wing area are smaller than the natural MPB.
- While there was not a statistically significant difference between bolt type and relative fat content, a trend can be seen.
  - Endemic MPB have higher relative fat content and lower wing loading. With a larger sample size, these differences could become significant and might explain their high flight capacity at such small body sizes.

REFERENCES

Amman, G.D. 1984. Mountain pine beetle (Coleoptera: Scolytidae) mortality in three types of infestations. Environmental Entomology 13:184-191.

Evenden, M. L., Whitehouse, C. M., & Sykes, J. (2014). Factors influencing flight capacity of the mountain pine beetle (Coleoptera: Curculionidae: Scolytinae). *Environmental Entomology*, *43*(1), 187–196.

Safranyik, L., and Carroll, A.L. The biology and epidemiology of the mountain pine beetle in lodgepole pine forest. In: The mountain pine beetle: A Synthesis of Biology, Management, and Impact on Lodgepole Pine. pp 3-66. Victoria, BC. Pacific Forestry Centre. 2006.

Wijerathna, A., Whitehouse, C., Proctor, H., & Evenden, M. (2019). Testing for trade-offs between flight and reproduction in the mountain pine beetle (Coleoptera: Curculionidae) on two pine (Pinaceae) hosts. *The Canadian Entomologist* , *151*(3), 298–310.

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TRIA-FoR: Transformative Risk Assessment and Forest Resilience Using Genomic Tools for the Mountain Pine Beetle Outbreak