THE OHIO STATE UNIVERSITY / DEPARTMENT OF ENTOMOLOGY

Response of ground beetles (Coleoptera: Carabidae) to forest disturbance

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ABSTRACT

Theory predicts biodiversity is maximized at intermediate levels of disturbance due to trade-offs in traits for competition and colonization ability. To test the competition – colonization trade-off model, ground beetle assemblages were characterized along a gradient of forest disturbance intensity at Powdermill Nature Reserve. A disturbance intensity gradient was generated by imposing canopy gap and understory vegetation disturbance treatments in factorial combination. Ground beetle species composition changed along the disturbance gradient. However, ground beetle diversity was highest in the most disturbed plots, as the number of highly mobile, flying species increased, while interior forest species were retained. Understanding how changes in species diversity and composition affect ecosystem services is critical for fostering sustainable forest management.

INTRODUCTION

Disturbances such as wind, fire, invasive species and land-use change affect species diversity by modifying structure, resource availability and species composition (White and Pickett, 1985; Petraitis et al. 1989).

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The competition-colonization trade-off model predicts that biodiversity is maximized at intermediate levels of disturbance due to trade-offs between traits that enhance colonization and competitive ability, with good colonizers and competitors coexisting at intermediate disturbances (Hastings, 1980).

Ground beetles are highly diverse and responsive to environmental change (Rainio and Niemelä 2003). Their dispersal potential can be characterized based on wing development, making them ideal for testing effects of disturbance on community structure.

OBJECTIVE

Test the competition-colonization trade-off model by characterizing ground beetle assemblages along a gradient of forest canopy and understory vegetation disturbance intensity.

METHODS

Canopy Gap / Understory Vegetation Removal Manipulation

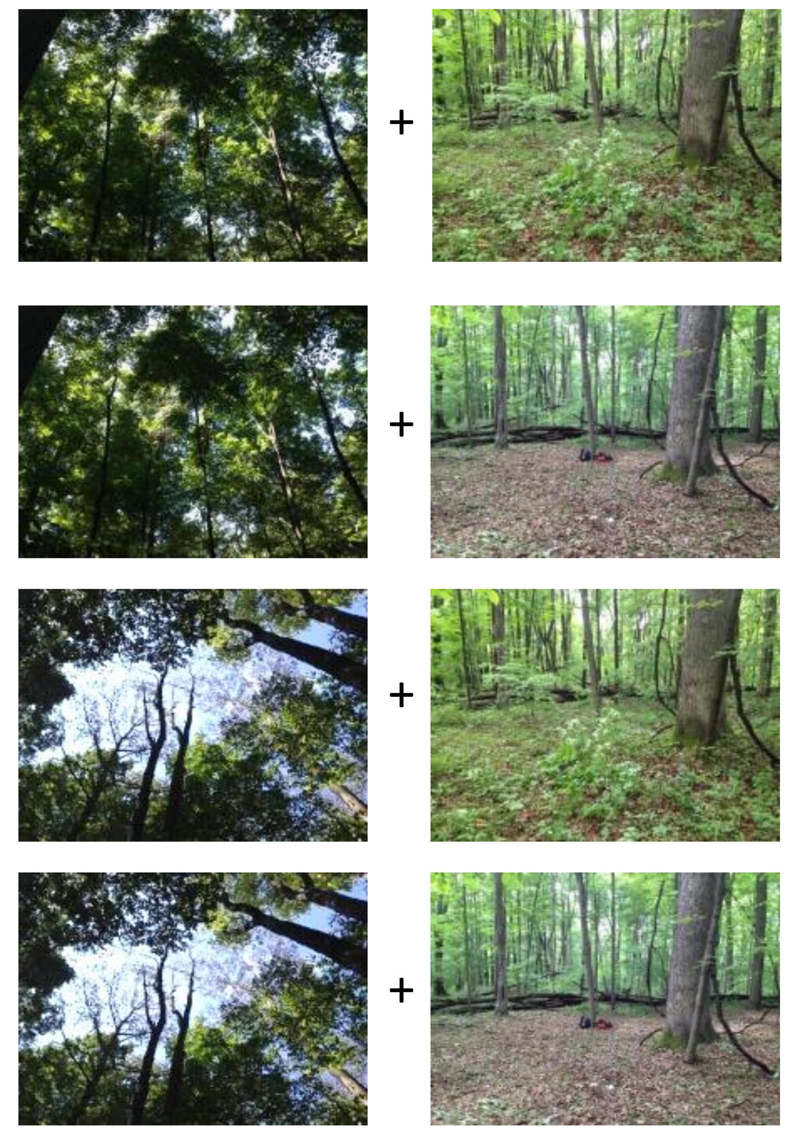

Figure 1. *Canopy gap and understory vegetation treatments.*

A manipulative factorial experiment was conduced at Powdermill Nature Reserve in Rector, PA in 2014 with two disturbance treatments (Fig. 1):

- Canopy gaps (presence/absence; gaps created by girdling trees)
- Understory Vegetation (presence/absence; vegetation removed with weed whips)

Experimental Design

- 24 quadrats (the experimental unit), each 30 m^2
- Each treatment combination replicated 6 times in completely randomized design

Model Predictions

1) Diversity highest in plots receiving one treatment, either canopy or understory disturbance (Fig. 2)
2) Change in assemblage composition from undisturbed forest to combined canopy and understory disturbance (Fig. 2)
3) Proportion of beetles capable of flight increases in combined canopy and understory disturbance (Fig. 2)

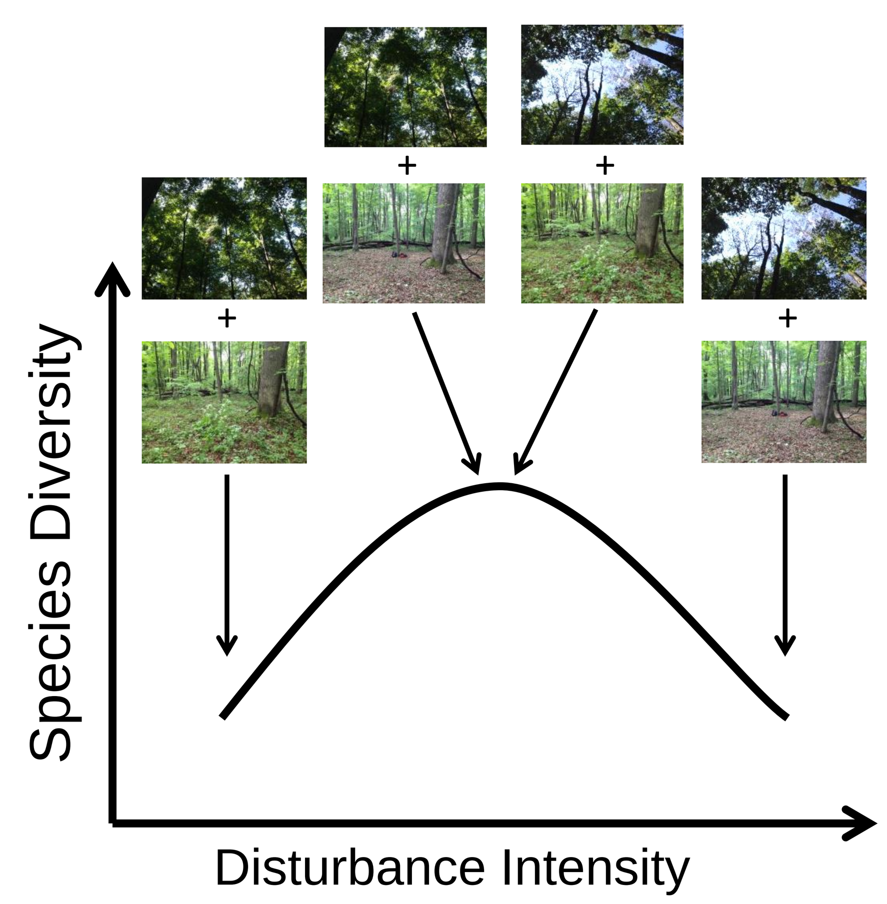

Figure 2. *Predictions for ground beetle species diversity for the competition-colonization trade-off model*

Figure 3. *Barrier pitfall trap design.*

Ground Beetle Assemblages

- Species diversity and composition quantified using pitfall traps (Fig. 3)
- Categorized based on dispersal strategy: macropterous (flying) or brachypterous (walking/running) (Larochelle and Larivière, 2003)

Statistical Analyses

- Repeated measures ANOVA was used to test for canopy gap and understory vegetation treatment effects and their potential interaction.
- Assemblage composition was evaluated using multivariate analyses.

RESULTS

Ground beetle species diversity marginally higher in most disturbed plots

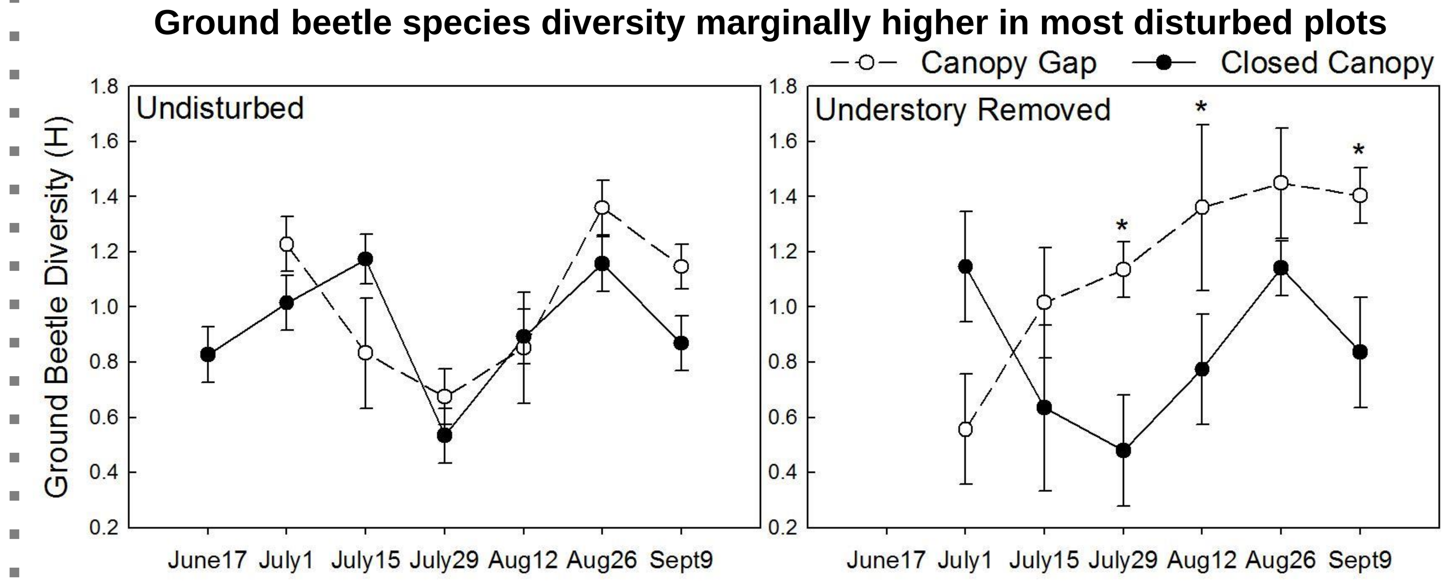

Figure 4. *Interaction plot for ground beetle species diversity (Shannon's Diversity Index, H) in canopy gaps with (right) and without (left) understory vegetation disturbance*

P1: Ground beetle species diversity was unaffected by canopy (F = 1.74; $P = 0.199$) and understory (F = 0.11; $P = 0.743$) disturbance. On some dates, diversity tended to be highest in plots with combined canopy and understory disturbance (F = 3.53; $P = 0.072$) (Fig. 4).

P2: Distinct assemblages were found in undisturbed forest compared to all other treatments ($P = 0.001 – 0.041$). Beetle assemblages were more similar in disturbed plots ($P = 0.073 – 0.385$).

Proportion of flying beetles marginally higher in most disturbed plots

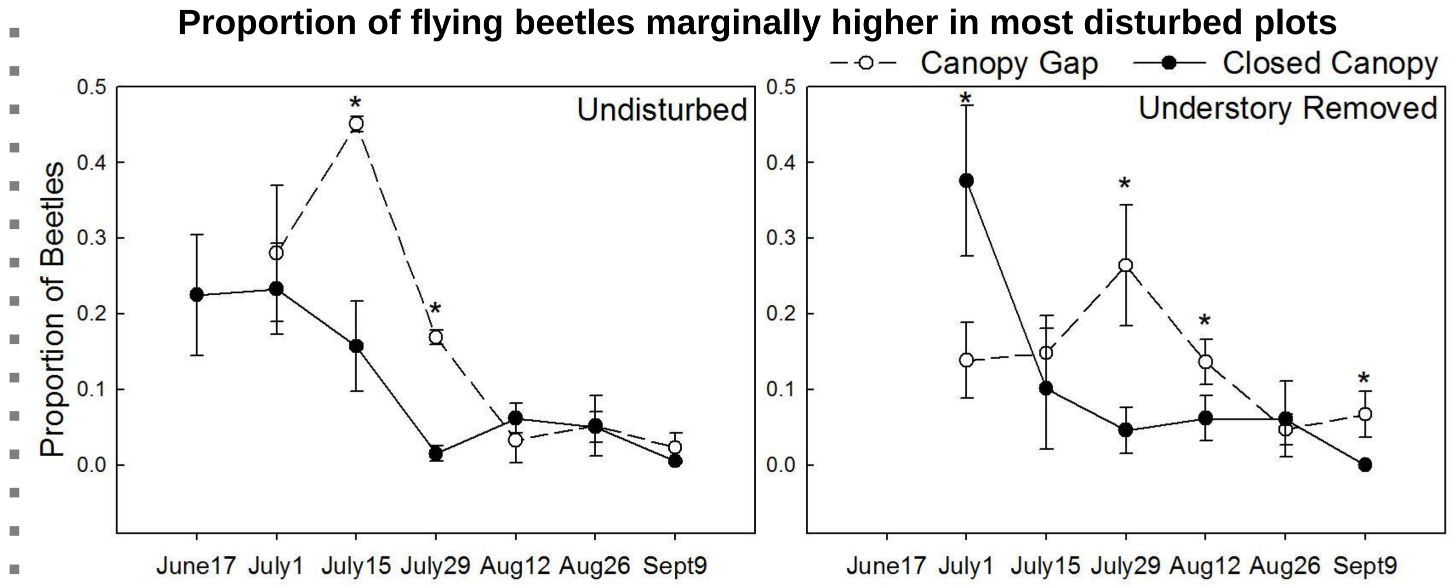

Figure 5. *Interaction plot for the proportion of macropterous ground beetles (capable of flight) in canopy gaps with (right) and without (left) understory vegetation disturbance*

P3: There was a trend for the proportion of ground beetles capable of flight to be higher in combined canopy and understory disturbance treatments (F = 3.26; $P = 0.078$) (Fig. 5).

CONCLUSIONS

- We found some support for the competition-colonization trade-off model, as assemblage composition changed along the disturbance intensity gradient (P2), and highly mobile, flying beetles marginally increased in the most disturbed plots (P3). However, species diversity tended to be highest in the most disturbed plots, instead of at intermediate intensities (P1).
- Elucidating mechanisms that explain the role of disturbance in maintaining species diversity is critical for fostering ecosystem services and sustainable forest management.

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