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SHORT RESEARCH ARTICLE

UPDATE Longhorned beetle (Coleoptera: Cerambycidae)
diversity in a fragmented temperate forest landscape [version
2; peer review: 2 approved]

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Abstract

Longhorned beetles (Coleoptera: Cerambycidae) are an important component of temperate forest ecosystems. We trapped longhorned beetles in forests in northwest Ohio during 2008 to test the hypothesis that larger forests have greater species diversity than smaller forests. Large forests had a significantly greater cerambycid species richness than small forests ($t = 3.16$, $P = 0.02$), and there was a significant relationship between forest size and cerambycid species richness.

Open Peer Review**Approval Status**

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14 Mar 2013
version 1
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1. **Patrick Tobin** , USDA Forest Service,
Morgantown, WV, USA

2. **Peter Silk**, Atlantic Forestry Centre,
Fredericton, New Brunswick, Canada

Any reports and responses or comments on the article can be found at the end of the article.

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The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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UPDATED Changes from Version 1

Upon the Recommendation of referee Patrick Tobin we have provided additional data that shows the relationship between log (species richness) and log (forest area). We have also updated Figure 6 to show if the respective area of each forest could explain the difference in species number. The large R² value does suggest that larger forests tended to have larger number of cerambycid species. We also estimated the diversity of Cerambycidae using the Shannon Diversity Index value for each of the forests. These calculated Shannon Index values allows comparisons to other studies that have examined cerambycid diversity (e.g., Ohsawa 2004; Holland 2007).

See referee reports

Introduction

Longhorned beetles, or cerambycids, are important species in temperate forest ecosystems, due to their feeding impacts on trees. Many cerambycids feed on dead wood and therefore assist in the decomposition of dead trees in forest ecosystems. Saproxylic cerambycids (dead wood dependent) and other saproxylic beetles are thought to be useful indicators of forest biodiversity¹. We were interested in testing the hypothesis that larger forests have greater cerambycid species diversity than smaller forests in NW Ohio, a highly fragmented landscape in terms of forest ecosystems.

Methodology

- Three types of traps (Lindgren funnel trap, Intercept Panel trap, and Window trap) were set up in each of 8 forests in northwestern Ohio. 95% ethanol was used to attract beetles (Figure 1–Figure 3).
- We started collecting beetles in early June, and we continued to collect them until early October (Figure 4).
- We put the traps into 8 different forest areas. Four forests were large (>100 hectares) and four forests were classified as small (<20 hectares).

Figure 1. Intercept Panel trap used for capturing Cerambycid beetles.

Figure 2. Lindgren Funnel trap used for capturing Cerambycid beetles.

Figure 3. Window trap used for capturing Cerambycid beetles.

Figure 4. Examples of Cerambycids species that were caught in the 8 forests sampled. *Strophiona nitens* (top left), *Gaurotes cyanipennis* (top right), *Urographus fasciatus* (bottom left) and *Microgoes oculatus* (bottom right).

Results and discussion

- Large forests had greater cerambycid species richness than small forests. (Figure 5, Figure 6).

The larger forests had larger Shannon Diversity index values compared to the smaller forests. The calculated Shannon Diversity Index Values allows comparisons to other studies that have focused on cerambycid diversity in forest ecosystems^{1,2}.

- Regression of log (species richness + 1) versus log (forest area + 1) indicated a strong linear relationship between cerambycid species richness and forest size ($R^2 = 0.80$). (Figure 7). The large R^2 value suggests that larger forests tend to have greater cerambycid species diversity than do smaller forests, perhaps due to greater amounts of resources for these beetles in the larger forests compared to the smaller ones.
- Future research should focus on the landscape matrix and degree of isolation of forests, especially isolation of smaller forests.

Figure 5. Comparison of Cerambycid species richness between large forests and small forests. The four large forests were Oak Opening, Secor, Pearson, and Wildwood, and the four small forests were Bradner Preserve, Fuller Preserve, Carter Woods, and Environmental Studies Woods. The t-test was significant ($t = 3.16$, $df = 6$, $P = 0.02$).

Figure 6. Total number of Cerambycid species caught in each forest during 2008. Oak Openings, Secor, Wildwood, and Pearson were the Large Forests, and Bradner Preserve, Carter Woods, Fuller Preserve, and ENVS Woods were the small forests.

Figure 7. Regression of Log (Cerambycid Species Richness + 1) versus Log (Forest Area + 1).

Table 1. Cerambycid (Coleoptera: Cerambycidae) Species Captured in Oak Openings Preserve, 2008 (Western Lucas County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Strangalepta abbreviata</i> (Germar)	35
<i>Cyrtophilus verrucosus</i> (Olivier)	8
<i>Xylotrichus colonus</i> (Fabricius)	8
<i>Clytus ruficollis</i> (Olivier)	5
<i>Gaurotes cyanipennis</i> (Fabricius)	3
<i>Neoclytus acuminatus</i> (Fabricius)	2
<i>Microgoes oculatus</i> (LeConte)	2
<i>Urographis fasciatus</i> (DeGeer)	2
<i>Pidonia ruficollis</i> (Say)	1
<i>Phymatodes testaceus</i> (Linnaeus)	1
<i>Sarosesthus fulminatus</i> (Fabricius)	1
<i>Strophiona nitens</i> (Forster)	1
<i>Urgleptes querci</i> (Fitch)	1
Total number of individuals (N)	70
Species richness (s)	13

Table 2. Cerambycid (Coleoptera: Cerambycidae) Species Captured in Secor Woods, 2008 (Northern Lucas County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Clytus ruficollis</i> (Olivier)	7
<i>Cyrtophilus verrucosus</i> (Olivier)	3
<i>Pidonia ruficollis</i> (Say)	3
<i>Gaurotes cyanipennis</i> (Fabricius)	2
<i>Microgoes oculatus</i> (LeConte)	1
<i>Psenocerus supernotatus</i> (Say)	1
<i>Trachysida mutabilis</i>	1
<i>Astylopsis collaris</i> (Haldeman)	1
Total number of individuals (N)	19
Species richness (s)	8

Table 3. Cerambycid (Coleoptera: Cerambycidae) Species Captured in Wildwood Preserve, 2008 (Northern Lucas County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Strangalepta abbreviata</i> (Germar)	3
<i>Clytus ruficollis</i> (Olivier)	2
<i>Gaurotes cyanipennis</i> (Fabricius)	2
<i>Microgoes oculatus</i> (LeConte)	2
<i>Cyrtophilus verrucosus</i> (Olivier)	1
<i>Analeptura lineola</i> (Say)	1
<i>Pidonia ruficollis</i> (Say)	1
Total number of individuals (N)	12
Species richness (s)	7

Table 4. Cerambycid (Coleoptera: Cerambycidae) Species Captured in Pearson Park, 2008 (Eastern Lucas County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Clytus ruficollis</i> (Olivier)	3
<i>Astylopsis macula</i> (Say)	2
<i>Urographis despectus</i> (LeConte)	1
<i>Cyrtophilus verrucosus</i> (Olivier)	1
<i>Psenocerus supernotatus</i> (Say)	1
Total number of individuals (N)	8
Species richness (s)	5

Table 5. Cerambycid (Coleoptera: Cerambycidae) Species Captured in Bradner Preserve, 2008 (Western Wood County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Xylotrichus colonus</i> (Fabricius)	2
Total number of individuals (N)	2
Species richness (s)	1

Table 6. Cerambycid (Coleoptera: Cerambycidae) Species Captured in Carter Woods, 2008 (Central Wood County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Heterachthes quadrimaculatus</i> Haldeman	4
<i>Xylotrechus convergens</i> LeConte	1
<i>Obrium maculatum</i> (Olivier)	1
Total number of individuals (N)	6
Species richness (s)	3

Table 7. Cerambycid (Coleoptera: Cerambycidae) Species Captured in Fuller Preserve, 2008 (Central Wood County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Heterachthes quadrimaculatus</i> Haldeman	4
<i>Neoclytus acuminatus</i> (Fabricius)	3
Total number of individuals (N)	7
Species richness (s)	2

- Many other beetle species from other families were also captured (e.g., Elateridae, Curculionidae), so these data should also be examined.

Author contributions

Daniel M. Pavuk set the traps, collected the beetles, identified the beetles to species, and performed the statistical analysis. Andrea M. Wadsworth assisted with the collection of the beetles and sorting the beetles.

Competing interests

No competing interests were disclosed.

References

- Holland JD: **Sensitivity of Cerambycid Biodiversity Indicators to definition of high diversity.** *Biodivers Conserv.* 2007; **16**(9): 2599–2609.
[Publisher Full Text](#)
- Ohsawa M: **Species richness of Cerambycidae in larch plantations and natural**

Table 8. Cerambycid (Coleoptera: Cerambycidae) Species Captured in BGSU-ENVS Woods, 2008 (Central Wood County, OH). Total number of individuals of each species caught during the entire trapping period (early June to early October). Traps were positioned in the approximate center of each forest and all checked each week.

Cerambycid species	Number of individuals
<i>Neoclytus acuminatus</i> (Fabricius)	2
<i>Sternidius variegatus</i> (Haldeman)	1
<i>Urgleptes signatus</i> (Fabricius)	1
<i>Anelaphus villosus</i> (Fabricius)	1
Total number of individuals (N)	5
Species richness (s)	4

Table 9. Shannon Diversity Index Values for Forest Study Sites.

Forest site	Shannon Index ($H' = -\sum p_i \ln p_i$)
Oak Openings	1.78
Secor Woods	1.81
Wildwood Preserve	1.86
Pearson Park	1.49
Bradner Preserve*	-
Carter Woods	0.87
Fuller Preserve	0.68
BGSU-ENVS Woods	1.33

*It is not possible to calculate a Shannon Diversity Index value for this site, because only one cerambycid species was caught.

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The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Peter Silk

Insect Chemical Ecology, Atlantic Forestry Centre, Fredericton, New Brunswick, Canada

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 18 March 2013

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Patrick Tobin

Ecology and Management of Invasive Species and Forest Ecosystems Unit,, USDA Forest Service, Morgantown, WV, USA

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 17 October 2012

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Insect Chemical Ecology, Atlantic Forestry Centre, Fredericton, New Brunswick, Canada

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 15 October 2012

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The overall merits of the study, general aspects of the experimental design, and hypothesis tested are interesting and conceptually sound.

The incredible amount of work involved in such a study is also recognized. A primary concern is that only one year of data was collected, which limits the interpretation of the findings. Measuring populations in the field over only one year, from which species richness was estimated, can be subject to annual variation that may lead to over- or underestimates of individuals in any given year. Moreover, some species of Cerambycidae may take more than one year to undergo a generation and thus these species could be undercounted. Regardless, the finding of increased richness with increased forest size confirms prior observations in related diversity studies. Also, the methods applied in this study are sound and thus provide a protocol in future endeavors.

One modification I would like to see in a revised manuscript is that instead of examining differences in richness between two categories (large versus small forests), I would prefer to see richness examined along a continuous measurement (i.e., the size of each forest), assuming that there is variation in sizes among the forests. In looking at Figure 6, I wonder if the respective area of each forest could explain the difference in species number. It also could be insightful to consider

estimating diversity using established indices (e.g., Shannon, Simpson), which could help relate your work to other similar studies.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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