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Preliminary study on beetle biodiversity and its role as a metric for ecosystem heterogeneity in the Rowan County area

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ABSTRACT

This preliminary study focuses on ground beetles, which are important as bioindicators of habitat conditions and ecosystem heterogeneity, in Rowan County, Eastern Kentucky across three locations. Methods of quantitatively collecting samples include light traps, pitfall traps, leaf sifting, and pan traps. The primary method used in this study was leaf sifting and Berlese funnel, which is used to extract small insects and arthropods from leaf litter and other debris. Collected data are often analyzed using statistical analysis (ANOVA) that emphasizes the abundance of individuals, functional analysis that explores the diversity of different functional groups, or through various indices, including the Simpson and Shannon indices, that measure the richness and abundance of species.

INTRODUCTION

Biodiversity is important for maintaining ecosystem function. Insects are important for providing many ecological roles, including ecosystem engineers, soil modifiers, components of the food web, being general symbionts, and as pollinators. Creating a cumulative database of the diversity of insects in an area allows for an effective overview and assessment of overall biodiversity.

With approximately 400,000 described species worldwide, beetles (Order Coleoptera) are immensely diverse in their lifestyles and ecological roles (Fig. 1), thus making them valuable tools in environmental assessments of terrestrial and freshwater ecosystems. It also means that they provide a robust set of data for metrics of biodiversity.

Fig. 1: Examples of lead-litter dwelling beetles found in collected samples (pictures of beetles from https://bugguide.net/user/view/2697)

COLLECTION METHODS

Due to the diversity of habitats and feeding habits of many Coleoptera, it is necessary to use different types of traps. Several methods for collecting samples are found in *Methods For Catching Beetles* by Carlos Aguilar (2010), including: light traps, beating, sweeping, Lindgren funnel traps, pitfall traps, baited traps, pan traps, malaise intercept traps, and leaf-litter sifting with Berlese funnel extraction. Samples were obtained in fall 2019 and fall 2020 from forested habitats at Eagle Lake, Rodburn Hollow, and Stoney Cove; six samples collected from each site.

LINDGREN FUNNEL

Lindgren funnel traps (Fig. 2) consist of several plastic cones that are suspended from a branch or hung by a shepherd's hook, arranged and connected on top of each other, so when insects collide with them, they fall into a cup placed under the cones with alcohol, where they are preserved. Sometimes chemicals can be used as attractants, which simulate scents of decaying trees, which are attractive to a large number of Coleoptera which attack the wood. Lindgren funnel traps are an effective way to collect a variety of beetles such as Anobiidae, Buprestidae, Scarabaeidae, Bostrichidae, Chrysomelidae, Cerambycidae, Curculionidae, Anthribidae, Brentidae, etc.

Fig. 2: Lindgren funnel traps set up in a clearing adjacent to Eagle Lake

LIGHTS

Lights (Fig. 3) are effective for collecting many species of nocturnal beetles that are attracted to lights. For this method, ultraviolet (UV) light, mercury vapor lamps, or a combination of both is used in front of a suspended white bed sheet. Many species are attracted to both types of light, but some of them only come to one type or the other. Examples of beetles that can be collected using this method include: some species of Scarabaeidae *(Megasoma, Heterogomphus, Strategus*, etc.), some Cerambycidae (*Macrodontia, Mallaspis, Callipogon*, etc.), many Buprestidae, Hybosoridae, Ochodaeidae, Pleocomidae, and Belohinidae.

Fig. 3: Beetles and moths are attracted to an illuminated sheet during blacklighting

PAN TRAPS

Many flying insects settle onto surfaces whose tone and/or color contrast clearly with the background. Different colored flowers also attract many beetles, so colored pans imitating flowers can be used to deceive them. Pan traps (Fig. 4) are placed a few meters apart. After the pans are placed on the ground, a mixture of water, liquid soap, and salt is poured into the pan without filling the pan. The traps are then left for 2-4 days, after which their catches are filtered through a sieve and stored. Insects that live in organic matters such as flood debris, fungi, bark and rot, small pieces of wood, etc., are collected using this method, including: Buprestidae, Cantharidae, Melyridae, Cleridae, Dermestidae, Elateridae, Mordellidae, Chrysomelidae, Lucanidae, etc.

Fig. 4: Pan traps placed on the forest floor

PITFALL TRAPS

Pitfall traps (Fig. 5) are often used for necrophagous, coprophagous, and saprophagous beetles and their predators, which are often observed or used as model organisms in wildlife studies and environmental impact assessments worldwide. The pitfall trap consists of a container buried in the ground with its mouth level with the surface and various types of baits (meat, fruit, dung, etc.) in the container. There are several types of pitfall traps, the most common being burying a plastic cup or something similar with bait inside. The trap needs to be checked every day if no preservative is placed in the trap. Types of beetles that can be captured using this method include several large scarabs (such as *Coprophanaeus, Phanaeus, Diabroctis, Oxysternon*, etc.) as well as several species of *Deltochilum, Canthon, Dichotomius*, Silphidae, and other Scarabaeidae. Very tiny beetles falling into the traps can be stored in a bottle with ethanol (75%).

Fig. 5: Pit trap

SIFTING AND BERLESE FUNNEL

Sifting and Berlese Funnels (Fig. 6) are used to extract small insects and arthropods from leaf litter and other debris (dung, mushrooms, flood debris, etc.). A sifter is a device used to concentrate individuals by removing large pieces of substrate. This is done using a container with a wire mesh bottom. The debris is placed in the container, agitated, and the smaller particles as well as beetles and other organisms will fall through. A large amount of sifted debris can be collected if you place a cloth bag, such as a pillowcase, under the sifter. Then, the samples are placed in a Berlese funnel, which consists of a large metal funnel placed over a container with 70% ethanol. A grill is placed inside the funnel, covered with cheesecloth, wherein the organic materials would be collected. On the lid of the funnel there a light bulb. The insects are driven down through the material from the heat and are driven down into the container with ethanol. Types of beetles collected using this method include species of Carabidae, Staphylinidae, Ptiliidae, Pselaphidae, Curculionidae, Elateridae, Silphidae, Scarabaeinae, and Aphodiinae.

Fig. 6: Leaf sifting and Berlese funnel

SPECIMEN PREPARATION

Beetles were separated from other insects in the sample. After beetles were pointed, each specimen was labelled to indicate where, when, and how the specimen was collected (Fig. 7).

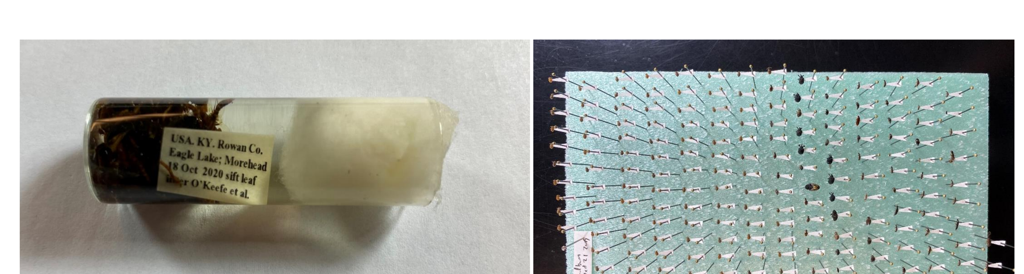

Fig. 7: Beetles before and after being pointed

SORTING

After beetles were prepared, they were sorted (Fig. 8) into different groups according to their morphology. Ultimately, these beetles would be grouped according their genera.

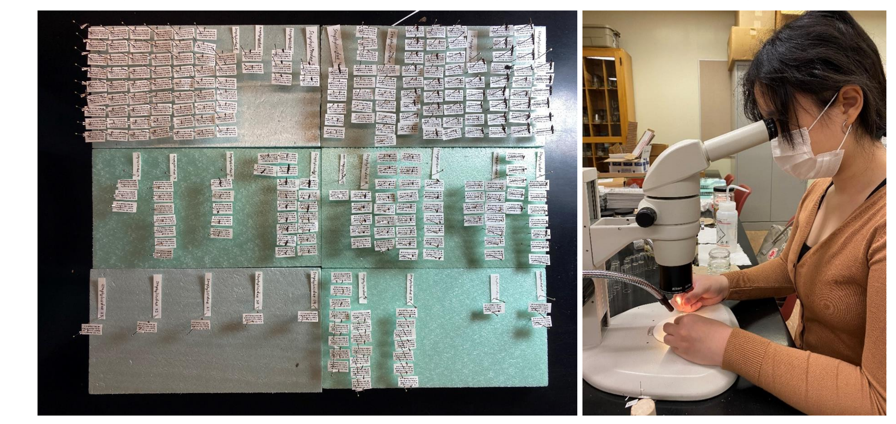

Fig. 8: Specimen sorting

ANALYSIS

Through a variety of statistical analyses, researchers can determine the extent of habitat heterogeneity. Beetles are good to analyze this information, as they display a great diversity of species and are quite numerous. There are beetles that are specific towards herbivore, omnivore, and carnivore diets, as well as other forms of nutrition, and the diversity of species helps display an accurate representation of ecological roles and the flourishing of the natural environment. There are three primary categories of diversity: Alpha, Beta, and Gamma. Alpha Diversity is commonly referred to as the diversity within a sample or of a specific area, typically within a defined spatial unit. Beta Diversity reflects the change in species number or the change in diversity between areas. Gamma Diversity is generally described as the total diversity occurring across a region. These are important when determining the scale that the analysis of data is performed on.

ALPHA DIVERSITY

Two of the most common indices are the Shannon Index and the Simpson Index. The Shannon Index calculates the total number of species estimated to be in one area based on the number of species gathered in a random sample. This assumes that all species are represented equally within an area, and although this can constrain the data, additional measures are generally taken to help decrease the constraints and even help identify specifics, such as changes in diversity. The equation is:

$$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

The Simpson Index has more impact describing a species abundance and how it is distributed throughout an area. It achieves this by first calculating the likelihood that any two individuals drawn from a sample would be of the same species. Using this, we can determine that as the likelihood increases, the diversity decreases. The Simpson Index is particularly important in having the ability to adapt and incorporate data that has an abundance in a particular species. The equation can is:

$$\lambda = \sum_{i=1}^{R} p_i^2$$

Additional indices that can be used include Smith and Wilson's evenness index, the Berger-Parker index, McIntosh's Measure of diversity, and the Brillouin Index. These calculate a variety of measures; however, Simpson and Shannon are the primary indices used for the purpose of this research. These are the primary analysis tools for this research.

BETA DIVERSITY

There are several ways to calculate the diversity amongst areas. These include ANOVA (Analysis of Variance) test, functional analyses, taxonomic diversity, and indices. ANOVA tests are useful for determining any differences among samples, including the abundance of individual species. Functional Analyses looks at the diversity of functional groups, such as herbivores, omnivores, fungivores, etc. and determines how many species or individuals fall into each guild. Functional analyses have also been shown to be useful in determining the functional consequences of a species extinction. Taxonomic diversity analyzes the proportion of individuals from different taxonomic groups and will be more varied at a higher level than species, such as family. Taxonomic Diversity can be used in tandem with species richness to help with efforts regarding conservation. There are different taxonomic indices, including the Clarke and Warwick's taxonomic distinctness index.

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REFERENCES