Influence of Connectivity on Dung Beetle Communities

ERIC ESCOBAR-CHENA

Abstract

Habitat fragmentation threatens biodiversity across the globe as habitat loss, isolation, and edge effects become increasingly prevalent. Corridors have become an important tool in order to combat the negative effects of fragmentation, however they are difficult to study in natural systems without incurring confounding effects. To observe changes in insect community composition as an effect of landscape features we sampled dung beetles in a landscape scale experiment. We did not see a difference in species richness or diversity, but dung beetle abundances were higher in continuous forest habitat and open habitat patches connected by a corridors than in isolated patches.

INTRODUCTION

As human disturbances continue to expand into natural landscapes, intact habitats are becoming increasingly fragmented. This degradation lends to loss in biodiversity on a global scale and interruptions in ecosystem processes and functions (Haddad 2015). Effects from isolation can vary, however as habitats are broken down community structures are significantly altered (Laurance et al. 2018). Corridors have been shown to be an important mechanism for facilitating the movement of organisms through fragmented landscapes with the goal of minimizing negative consequences of fragmentation(Haddad et al. 2003). As disturbance continues to intensify, it is becoming increasingly more important to understand how different taxonomic groups. Here, we aim to gain an understanding of how dung beetles, a group of insects well known for strong dispersal ability in order to compete for ephemeral resources(Hanski and Cambefort 1991), interact with corridors in their landscapes.

Dung beetles have emerged as a model system with which to test spatial ecology hypotheses (Roslin 2000, Rös et al. 2012).They are an incredibly well studied group of insects which are well known for driving a multitude of ecosystem functions (Hasan et al. 2024). The removal, breakdown, and burial of animal feces is an important ecosystem service provided by dung beetles such as enhanced nutrient cycling and soil quality and reduction of parasites on methane emissions from dung (Iwasa et al. 2015, Slade et al. 2016). Local assemblages of dung beetles can be species-rich with species comprising a broad range of functional traits (e.g., size, foraging style, resource-use) (deCastro-Arrazola et al. 2023). Previous studies have shown that isolated patches of habitat frequently have lower dung beetle diversity and abundance than areas of continuous habitat, as well as documented their presence in linear strips of habitat that resemble corridors (Gray et al. 2022). Past studies have also focused on how landscape structure alters the community compositions of dung beetles(Costa et al. 2017), yet large landscape scale experimental studies with carefully controlled and replicated treatments are non-existent for this model species.

Here, we aim to determine how connectivity and fragmentation affect Species Richness and Diversity, Abundance, and functional diversity. We sampled dung beetle communities in experimental landscapes developed for the express purposes of comparing connected and isolated patches, as well as the effects of patch to edge ratio and distance to edge. To ask the question of (1) how landscape connectivity impacts dung beetle assemblages dung beetles were collected, identified, and counted with the expectation that biodiversity and abundance would be higher in patches connected by corridors. Additionally we asked (2) Are corridors benefiting any one functional trait over another? Since our experimental system consists of open habitats amongst a forested matrix, we anticipate that species preferring open areas and generalists may be more common in our sampling.

Methods

Study site

Our study took place at the Savannah River Site(SRS), a National Environmental Research Park in southern South Carolina, US(33.208 N, 81.408 W) in four of seven experimental landscapes designed for the purposes of directly observing the impacts of corridors and patch shape on the movements of plants and animals(Tewksbury et al. 2002). Each experimental landscape, termed blocks, consists of four patches of open habitat around a central patch all together within a matrix of pine savanna. In each replicant the central patch (100 x 100 m) is always connected to one peripheral patch with identical dimensions by a 150 x 25 m corridor, this will hereafter be referred to as the connected patch. The remaining patches are either “winged” or “rectangular”. The winged patch is also 100 x 100 m, however they exhibit their characteristic wings in the form of two 75 x 25 m offshoots meant to account for the extra area and edge space the corridor provides. The rectangular patch is 100 x 137.5 m also the same area as the space of the connected patch plus the corridor. Each block has a duplicate of either the winged or rectangle patch, all peripheral patches being 150 m from the center patch. For this study sampling was done in one of each patch type and in one matrix plot per block, all matrix blocks were set up 150 m away from the center as well.

Dung beetle sampling

In the months of July and August 2024 dung beetles were sampled in 4 blocks spread across SRS, baited pitfall traps were placed in one of each patch type and in one matrix plot per block. Traps were placed in groups of 3 in the centers of each patch approximately 250 meters from the midpoint of the central patch 40 m from patch edge. Pitfalls were oriented in a triangular pattern with the bottom two traps positioned towards the center patch, each trap 20 m apart. Plots in the matrix were set up in a similar fashion with the center point 250 m from the center placed equidistant between adjacent patches. For each sample period, traps were baited with pig dung between 8-9 pm and picked up 12 hours later, all beetles captured were stored in ethanol for further processing. In total 16 sampling rounds were carried out with 4 rounds per block, 196 samples were collected. All beetles of subfamily Scarabaeinae were counted and identified to species using keys from Nemes and Price (2015) ### update bib. Overall 16 species were identified and approximately 5200 in total individual beetles were collected.

Analyses

Biodiversity between patch types was compared using Hill numbers (Jost 2006). We looked at community composition by increasing magnitudes of diversity components (qD) of 0D (species richness), 1D (Shannon entropy), and 2D (Simpson Diversity). Diversity numbers were calculated in R studio using package iNEXT (Chao et al. 2016). Bray-Curtis dissimiolarity values were calculated using package Vegan in R studio. Dung beetles were assigned traits by waste removal guild and habitat preference.

Insert description above of individual trap

1. **Functional Diversity:** Need to assign each species to a functional group: roller, tunneler. dweller, others?

- habitat preference (forest, pasture, generalist)

  Look through dung beetle pubs and see how/what people compare

- lets hammer this out
- modeling?
  - glmm with poisson dist reccomended by julian
- beta, abundance, biomass? per site
- species list by sampling blocks (anything with this?)
- habitat preference
- rarefaction

RESULTS

Overall, 5,213 total dung beetles were collected belonging to 16 species. The most dominant species were Canthon vigilans (n=1473), Ateuchus lecontei (n=1115), and Phanaeus igneus (n=958) (Table 1). All but one species was found in matrix plots. Four species (Onthophagus striatulus, Onthophagus concinnus, Geotrupes Blackburnii, Onthophagus truberculifrons) were the only species not representative in every patch type. We had two singleton species, Geotrupes Blackburnii appearing only once in winged, and Onthophagus tuberculiofrons in matrix.

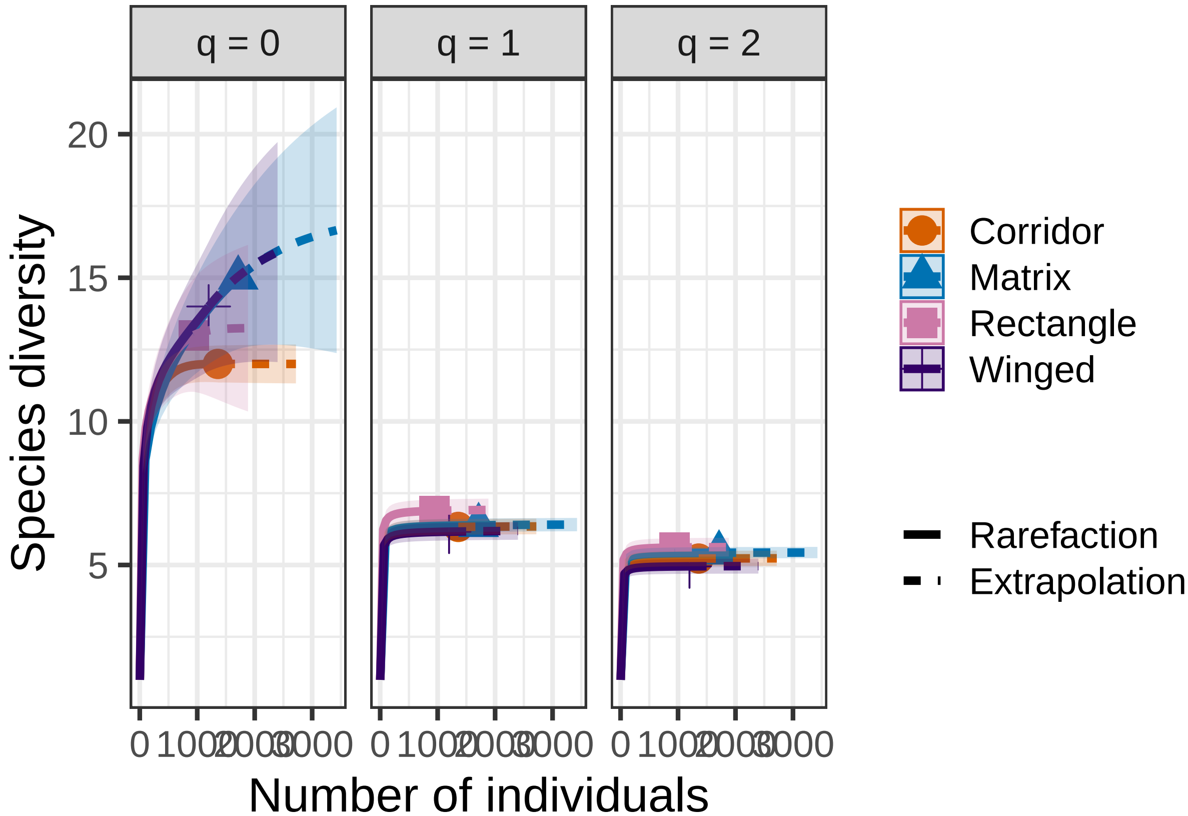
Beetle abundance was significantly higher in matrix plots with 33% (n = 1713) of captures followed by 26% (n = 1359) caught in connected patches, 23% (n = 1199) in winged, and lastly 18% (n = 942) from rectangular patches (Table 2).

Table 1: Dung beetle species sampled in the SRS site and their total abundance over the course of the study.

Species	**N**	**Matrix**	**Corridor**	**Winged**	**Rectangular**
Canthon vigilans	1473	x	x	x	x
Ateuchus lecontei	1115	x	x	x	x
Phanaeus igneus	958	x	x	x	x
Aphodius Alloblackburneus	585	x	x	x	x
Dichotomius carolinus	556	x	x	x	x
Onthophagus pennsylvanicus	207	x	x	x	x
Phanaeus vindex	133	x	x	x	x
Melanocanthon bispinatus	83	x	x	x	x
Boreocanthon probus	47	x	x	x	x
Copris minutus	24	x	x	x	x
Deltochilum gibbosum	14	x	x	x	x
Aphodius oximus	11	x	x	x	x
Onthophagus striatulus	3	x			x
Onthophagus concinnus	2	x		x	
Geotrupes blackburnii	1			x	
Onthophagus tuberculifrons	1	x			

Table 2: Total dung beetles captured in all replicates of a patch type.

patch	**n**
Corridor	1359
Matrix	1713
Rectangle	942
Winged	1199



Species richness was distinctly different between patch types with matrix plots exhibited the highest richness while connected patches were lowest (Fig. 1). Estimations of Shannon diversity index were fairly uniform between patch types. Simpson diversity indices were similarly even however winged patches showed a lower value.

```
##               Corridor     Matrix  Rectangle
## Matrix     0.12695312
## Rectangle 0.21686223 0.31751412
## Winged     0.07740422 0.18887363 0.15646894
```

Notable Bray-Curtis dissimilarity values were between connected and matrix (BC = 0.127), connected and winged (BC = 0.077), matrix and rectangle (BC = 0.318), and matrix and winged (BC = 0.189) (Table 3).

DISCUSSION

1. dont forget o discuss the basic biology…why might a species be so common? why might one be rare?

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OTHER REQUIRED TEXT

Dedication

To my family who never stopped supporting me along this journey, my friends who kept me company along the way, and my mentors at VCU who believed in me before I did myself.

List of Abbreviations

1. SRS: Savannah River Site.
2. Another word: And the list continues with another definition.

Biographical Sketch

Eric Escobar-Chena completed his Bachelors education at Virginia Commonwealth University in 2023. During his time there he developed a fondness for insects which grew into a curiosity of the natural world. He later began to explore this curiosity deeper in beginning his graduate education at the University of Florida as a Master's Student under the supervision of Emilio Bruna.

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