Influence of corridors on dung beetle diversity, dispersal, & ecosystem services

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Research proposal

***Background*:** Corridors are considered an important mechanism for promoting connectivity and facilitating the movement of organisms through fragmented landscapes. These movements are hypothesized to help maintain species diversity in fragments; it could also have patch- and landscape-level consequences for the ecosystem processes in which influenced by these species. Although there is some evidence that animals disperse between patches via corridors, and that connected patches have higher species diversity than unconnected ones, little work to date has investigated the consequences of these corridor-driven patterns for ecosystem ecosystem.

Dung beetles have emerged as a model system with which to test hypotheses on how changes in landscape structure driven by human activities influence biodiversity. They are locally species rich, exhibit variety in key functional traits (e.g., size, foraging style, resource-use), are capable of long-distance dispersal (e.g., up to 1 km for some tropical species), and that they influence a number of critical ecosystem services (e.g., seed dispersal, nutrient cycling). Previous work has 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. However, it remains unknown if corridors can reduce the loss of species from fragments, how such declines are influenced by inter-specific differences in dispersal capability, and what the consequences of these patterns are for the ecosystems services provided by dung beetles. Though there are several reasons for this, one major factor is the challenge in finding locations where one can assess the role of corridors while also while controlling for confounding factors such as patch size, edge, and corridor length.

We propose using the community of dung beetles at the SRS Corridor Experiment to test for (1) higher species richness, species diversity, and functional diversity in patches connected by corridors than in unconnected patches **(2)** interspecific differences in corridor use and inter-patch movement, and **(3)** higher rates of dung removal in connected than unconnected patches.

The Corridor Experiment is an ideal location in which to conduct this project. The design overcomes the primary technical impediments to isolating the effects of corridors *per se*, its spatial scale allows for drawing and realistic and relevant conclusions regarding dung beetle dispersal in fragmented landscapes, and the local dung beetle assemblage is a highly tractable one with which to address our questions (i.e., taxonomically and functionally diverse, keys for species identification are readily available, there are multiple abundant species from different functional groups with which to conduct experiments, and the experimental/survey methods are standardized and straightforward). ***Our sampling and experiments will be used to test the following predictions:***

1. **Prediction 1:** Species Richness, Species Diversity, and Functional Diversity will be higher in patches connected by corridors than in unconnected patches
2. **Prediction 2:** Corridors are suitable habitat for all species. However, the speed at which in individuals move through corridors and the probability of successful inter-patch movement is size-dependent (i.e., larger beetle species move more quickly and are more likely to reach the connected patch).
3. **Prediction 3:** Dung removal rates will be highest in connected patches. This is due to the higher functional diversity of beetles in these locations.

Below we describe the location of sampling or experiments with which we will test these predictions.

Study Site and Methods

We propose to conduct the field component of our study in seven of the Savannah River Site's experimental landscapes (i.e., 'blocks') designed to assess the ecological effects of corridors. Each experimental landscape block consists of a 1-ha square center patch surrounded by four peripheral patches that are equal in area (~1.4 ha) but differ in the amount of habitat connectivity or edge (Figure 1). One peripheral patch is connected to the center patch by a 150 × 25m corridor (hereafter "connected"). The isolated patches are also 150 m from the center patch and vary in their edge amount. The winged patch type (hereafter "isolated high edge") is a 100m × 100m square with two 75 × 25 m projections on either side of the patch. The rectangular patch type (hereafter "isolated low edge") consists of a 100m × 100m square with an area equal in size to the corridor added to the part of the patch farthest from the center patch. Each block contains one of each patch type and a duplicate of one of the isolated patch types.

***Methods: Beetle Diversity*:** To test the effect of corridors on species richness, species diversity, and functional diversity we will sample the dung beetle community in each location with pitfall traps baited with cow dung. Sampling will be conducted in four locations within in each landscape: the "connected" patch, the "rectangular" patch, one of the "winged" patches, and an area of matrix habitat at least 100 m from any of the patches (Fig. 1). In each location we will arrange N = 5 pitfall traps in a grid in the center of the patch; the grid will be 25 m from the edge of the patch to reduce the likelihood of attracting beetles from the matrix habitat into the patch. The trap will be baited with 300 mg of cow dung

(collected at the University of Florida's Beef Teaching Unit and frozen until needed) suspended over a cup with 96% ethanol. All traps in a landscape will be set on the same day and left open for 24 hours; sampling will be conducted monthly in each landscape for 6 months to capture potential monthly and seasonal (wet/dry) variation in species abundance. A collection of voucher specimens will be deposited at the Florida Museum of Natural History, with a reference collection left at the Corridor Project.

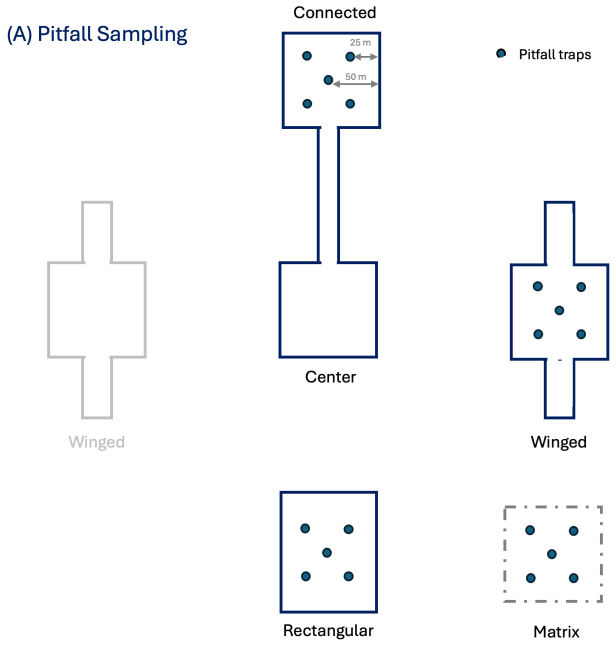

Figure 1: Design for pitfall sampling in each of the seven blocks.

***Methods: Beetle dispersal*:** To determine if beetles use corridors to move between patches, and if patterns of movement differ between species, we will conduct a mark-release-recapture (i.e., MRR) experiment. A pitfall trap will be placed in the middle of the landscape's "center" patch and baited with 300 g of cow dung. We will then release marked beetles at two points equidistant from the bait: the "connected" patch and the edge of the "rectangular" patch(Figure 2); these locations are separated from the bait by either the corridor or matrix habitat, allowing us to determine if corridors allow for more rapid movement and how this might vary by beetle species or functional group. We will check the pitfall trap for marked beetles twice per day for three days following their release.

We anticipate initially conducting this experiment with two species:LARGE AND SMALL, but may modifify rthethe choice of species based on our initial sampling. We will also conduct preliomiary expertiments to determine the beetle dispral, and may place passive (i.e., unbaited) traps in the corridor, matrix, and patches.

***Field Methods: Dung removal*:** The removal, breakdown, and burial of animal feces is an important ecosystem service provided by dung beetles. We will compare the efficacy of dung removal by beetle communities in connected, unconnected, and winged patches using both mesocosms (at the University of Florida) and a field experiment conducted in seven of

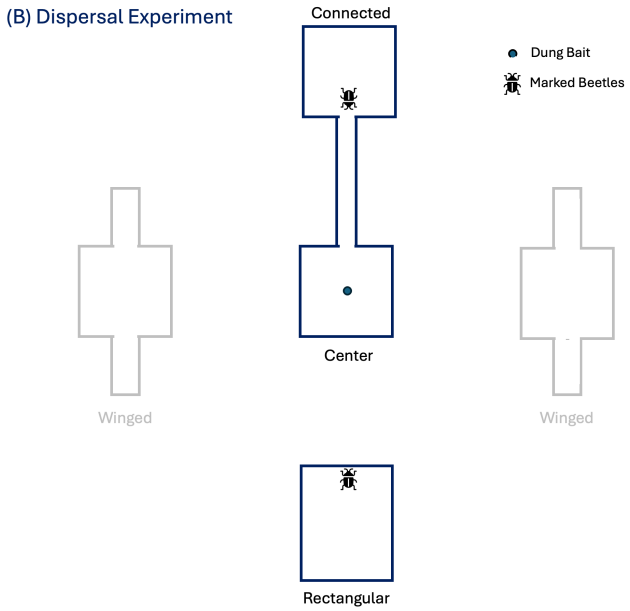

Figure 2: Design for experimental assessment of beetle dispersal.

the experimental blocks. In each of the patches and a equally sized plot in the matrix we will establish a grid of four points (Figure 3). Each point of the grid will be 25 m from the patch edge to avoid attracting beetles from the matrix surrounding the patch. At each point we will place two 'plant saucers' filled with 3 inches of homogenized local soil in which we place 300 g of cow dung; one of the saucers will be protected with mesh to prevent beetle access. After 48 hours the saucers will be removed and the remaining dung will be weighed (the weight of the protected dung is used to correct for weight loss due to desiccation). Experiments will be conducted monthly in each landscape for 6 months to capture potential monthly and seasonal (wet/dry) variation.

Focal Species Assemblage

1. How many species, functional groups, range in size, what is known about them
2. Table of expected species

Potential impacts on corridor plots and ongoing studies

1. no holes are being dug for pitfalls: no disturbance of the seeds or soil
2. changes in dung beetle abundance due to collection: short term, unlikely to be high impact
3. Dung introduced into plots: contained in above ground traps, so also unlikely, standardized and from cows taking abntibiotics, so no disease introduced,.

Study duration

1. Preliminary sampling during Spring 2023
2. Summer and Fall Sampling
3. All traps and pin flags will be removed after each sampling bout

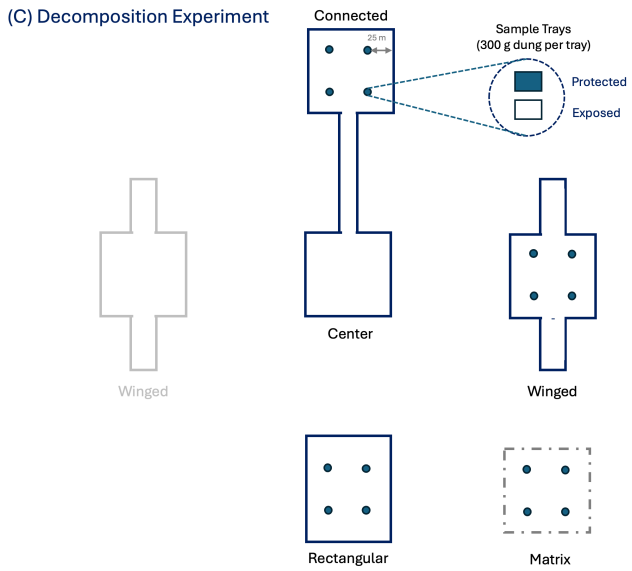

Figure 3: Arrangement of the dung removal experiment to be conducted in each of the seven experimental blocks.

Funding sources (if applicable)

Plan for making data publicly accessible

Data will be entered into spreadsheets and backed up by saving them to a repository on the Bruna Lab's Github site (https://github.com/BrunaLab) along with a .txt file of metadata and all R scripts for data correction and analysis. When new data are added they will be automatically validated using Github actions and the `pointblank` library (e.g., https://brunalab.github.io/HeliconiaSurveys/survey_validation/survey_validation.html). This approach allows us to share the all materials with collaborators and easily archive code and data at Zenodo and Dryad (respectively) upon the acceptance of a manuscript. For an overview of our approach to data archiving and accessibility see https://github.com/BrunaLab/HeliconiaSurveys