Native Bee Reproductive Success in Restored Habitats

Introduction: Ecological restoration can rehabilitate ecosystem services, but its success depends upon the ability of the restored site to sustain functional populations.[1] Restoration has been proposed as a way to promote conservation of native bee populations that have declined due to habitat loss and fragmentation.[2] Native bees are effective pollinators of many economically important crops,[3] and drastic crashes in managed, non-native honey bee populations due to colony collapse disorder have highlighted systemic vulnerability, as well as the need to diversify on-farm pollinator communities. Within agricultural systems, hedgerows (linear strips of native flowering shrubs planted in fallow field margins) are the preferred restoration method: In 2007, Congress passed the Pollinator Habitat Protection Act (S.1496), incentivizing the creation of pollinator-friendly hedgerows. However, agricultural landscapes have become increasingly simplified due to intensive farming practices, and potential source habitat may be too distant to provide reliable immigration to hedgerows.[4] In addition, recent research[5] suggests that hedgerows may be sink habitat, where the death rate is greater than the birth rate.[6] This research used species richness as a proxy for reproductive success, which is problematic because it gives no indication of long-term population viability within sites. If hedgerows are sinks, pollination services could be threatened.[3] *Therefore, I propose to directly measure native bee reproductive success in order to assess the sink hypothesis and the conservation potential of hedgerows.*

Background: Native solitary bees typically have one generation per year, therefore there are two main components that influence reproductive success: per female fecundity and offspring survival. Fecundity may be influenced by proportion of forage (pollen) available for provisioning of brood cells[7] at both the local and landscape level.[8] Hedgerows often contain low plant diversity (usually between 8 - 15 species); if these resources are inadequate, bees may need to forage in the surrounding landscape to obtain sufficient pollen to meet larval needs.[4,8] Limited or patchy landscape resources could reduce success as fewer nests could be created.

Larval mortality can be heightened by increased parasitism, and cleptoparasite and parasitoid abundance is often greater in restored sites than in natural areas.[10] Additionally, parasitism rates have been correlated with resource availability: in resource-poor environments, bees compensate for floral scarcity by increasing search time, broadening the window for successful parasitism.[11] While exposure to herbicides[12] and abiotic factors, such as high in-nest moisture and temperature levels,[13] can also be fatal to larvae, their effects are difficult to measure; therefore, I will divide causes of mortality into two categories: parasitism and unknown.[10]

In order to demonstrate the occurrence of source-sink dynamics it is necessary to compare population demographics in multiple habitats.[14] Thus, treatments will be in two habitat types, restored (hedgerow), and un-restored (fallow field margins), situated in either complex (heterogeneous) or simple (homogenous) landscapes (n = 18). Additionally, in order to have baseline data against which gauge the success of the restored sites, fecundity and offspring survival will be recorded in natural habitats (n = 4).

I will use trap-nesting bees (cavity-nesters) as my study taxon because ninety percent of the native bee species managed for agriculture are trap-nesters, and they readily occupy artificial "trap-nests," bundles of hollow reeds, that can be lined with removable straw inserts to facilitate monitoring of nest progress.[8]

Hypotheses: In order to examine the capacity of hedgerows to sustain viable populations of trap-nesting bees, I will measure fecundity and parasitism in two landscape contexts:

1. Fecundity of trap-nesting bees will decline with decreased resources. I hypothesize that landscape complexity will be more important to fecundity than local-level resources. In simple landscapes, I do not expect to find significant differences in fecundity between hedgerows and fallow field margins. In contrast, I predict that in complex landscapes fecundity will in higher in both treatment types, approaching observed levels in natural habitat. However, if fecundity in hedgerows in simple landscapes is higher than in fallow field margins, it would indicate that the local resources they provide are sufficient, bolstering claims that they are an appropriate restoration method in homogenous landscapes.

2. Parasite pressure on larvae will increase with decreasing resources, negatively impacting reproductive success. In simple landscapes, I expect to observe spikes in parasitism levels in both habitat types. I predict that the additional resources provided in heterogeneous landscapes will buffer larvae against heightened parasitism in hedgerows but not in fallow-field margins. Further, I predict that offspring survival in hedgerows and field margins in both landscapes types will be significantly lower than in natural habitat, signifying that disturbed landscapes subject larvae to increased threats from parasitism and other factors shown to increase mortality.

Methods: Study Location: This study will take place in Yolo County, an agricultural region in California's Central Valley. In the study region, complex landscape is a mosaic of natural habitat, riparian corridors, organic farms, and conventional agriculture; simple landscapes are dominated by intensive agriculture (> 80%). Landscape features will be categorized using GIS landsat data. Each site will contain a 300 m transect with a trap-nest in the center, and will be at least 2 km apart to ensure isolation.[15]

Floral Resources: Vegetation sampling will commence with nest initiation and terminate when nesting ceases. I will record flowering species and number of inflorescence in 1 m^2 quadrats along transects. To determine the proportion of local and landscape resources used, I will collect voucher pollen from all flowering plants within a 1500 m radius of trap-nests, and compare it with sub-samples of pollen from nests.[8]

Parasitism: Once nests are completed, I will x-ray larvae in the lab to ascertain which are parasitized;[8] parasitoids will be identified after emergence by Dr. Robbin Thorp, of the UC Davis Bee Biology Lab. Unparasitized pupae will be stored in optimal conditions at the UC Berkeley insectary and monitored for emergence of cleptoparasites.

Broader Impacts: *Due to the persistent, damaging effects of colony collapse disorder, restoration of native bees is essential for the maintenance of pollination services in agricultural areas.*[3] These findings could validate hedgerows as an effective restoration method, or illuminate its short-comings. Worldwide, native bees are the most important pollinators in natural systems, and are therefore necessary for preservation of biodiversity.[3,16] The result of this study will help identify factors that could contribute to the success of pollinator restoration at larger scales. I will submit papers to scientific journals, present at conferences, and share my results with farmers at annual workshops put on by the Xerces Society, a non-profit dedicated to insect conservation.

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