Final Report: Woodland Bee and Wasp Diversity at Alice L. Kibbe Life Science Station, Hancock County, Illinois
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Introduction

The angiosperms (flowering plants) are the dominant group of plants on earth, and represent most of our agricultural crop species. The vast majority of flowering plant species depend on animals that transport pollen from plant to plant. Among the most important pollinators are the bees. Most of our knowledge of bees in general comes from studies of the familiar honey bee, *Apis mellifera*, a species that is not native to the U.S. but has been successfully introduced and domesticated. The honey bee is an efficient pollinator and is readily maintained in apiaries, transported, and used for its pollinating services. This species is now an essential part of our agriculture. But there are potentially negative aspects to our dependence on the honey bee. The fact that most bee research has focused on the honey bee means that there is a serious knowledge deficit in regard to most of the remaining bee fauna. This knowledge deficit has been brought to the public's attention dramatically by the appearance of colony collapse disorder (CCD), a syndrome that has led to dramatic reductions in honey bee populations (Cox-Foster et al., 2007). Problems associated with CCD have led many scientists and policy makers to consider the ramifications of a widespread honey bee decline. There is growing evidence that native bees can provide pollination "insurance" against honey bee losses (Winfree et al., 2007; Winfree et al., 2008). This has spurred interest in studies of the ecology and behavior of the remaining 99.9% + of bee species.

One of the most fundamental questions we can ask regarding diversity is, "what species are present in a given locality?" Bees and wasps are well-known inhabitants of grasslands and old field habitats, but little is known regarding their diversity in woodland habitats. Furthermore, while there are a variety of sampling methods, there is little information on how these methods compare in terms of the diversity they collect. The most commonly used method for sampling native bees and wasps involves pan traps, plastic bowls placed on the ground and filled with soapy water to trap the insects (Cane et al. 2000, Roulston et al. 2007, Westphal et al. 2008). However, there is evidence of trap bias associated with pan trap sampling (some species are over or underrepresented) (Bartholomew and Prowell 2005, Roulston et al. 2007, Tuell and Isaacs 2009). In addition, trap height may affect species collections, since different species may forage at different heights due to plant composition (Tuell and Isaacs 2009). In addition to pan traps, two other types of traps that have been used to sample bees and wasps are vane traps and malaise traps (Stephen and Rao 2005, Ozanne 2005, Bartholomew and Prowell 2005). These two methods have been less extensively tested than have pan traps. In general, there have been few quantitative studies comparing bee and wasp survey methods, especially in forests.

Project Objectives

The specific objectives of this study were to: 1) inventory the bee and wasp diversity of woodlands at Alice L. Kibbe Life Science Station, 2) examine seasonal patterns of woodland bee and wasp diversity, and 3) compare the species composition of bees and wasps collected using different sampling methods.

Materials and Methods

This study was done at Alice L. Kibbe Life Science Station in Hancock Co., Illinois from May to September 2011. Four sampling transects were established in oak-hickory forest. Each transect consisted of: 2 malaise traps, 6 pan traps (ground level), 6 pan traps (elevated 1 meter), and 4 vane traps (also elevated 1 meter). Traps were located 5 meters apart within transects, and positions of the traps within transects were assigned randomly. Sampling was done during one sampling period per month. Collected insects were pinned, labeled with collection information, and identified using a reference collection and the Discover Life online identification keys (www.discoverlife.org). For bees, species richness and Simpson's diversity indices (Simpson 1949) were calculated. The multi-response permutation procedure (MRPP) and indicator species analysis (ISA) were used to analyze species composition and to test for associations of particular species with particular trap types. MRPP provides a measure of the similarity in species composition between two species assemblages (McCune and Grace 2002). ISA measures the extent to which individual ground beetle species are *exclusive* (never occurring elsewhere) and *faithful* (always present) to particular trap type (McCune and Grace 2002). The chi-square test was used to analyze differences in total numbers collected by different trap types. Numbers of wasps collected were low and identifications haven't been completed, so those data have not been analyzed statistically.

Results & Discussion

A total of 175 bees were collected, representing 12 species. The most abundant species was *Lasioglossum versatum*, which represented slightly over 50% of captures (Table 1). Total numbers of bees collected varied significantly with trap type, based on the chi-square test ($P < 0.0001$). Elevated bowls collected the greatest numbers of bees, and malaise traps collected the fewest (Table 1). Greatest numbers of bees were collected in July (116), with the fewest (6) collected in May. Malaise trap sample sizes were too low to produce a reliable Simpson's diversity index but, among the other trap types, vane traps produced the highest diversity of bee collections, with elevated pan traps being intermediate and ground pan traps producing the lowest diversity. Elevated pan traps yielded the greatest species richness. There were no differences in species composition among the trap types, based on MRPP. ISA produced one indicator species, *Augochlorella aurata*, which was significantly associated with the elevated pan traps ($P = 0.03$). High numbers of *L. versatum* were collected in both ground and elevated pan traps.

These results suggest that bee abundance and diversity is low in the oak-hickory forests of west-central Illinois. In an earlier study of bee diversity in nearby prairie habitats, Geroff (2011) collected over 100 species of bees. The bees may not utilize the forest habitat very much, or may be restricted to the forest/prairie interface rather than dispersing deeper into the forest.

In terms of total numbers of bees collected, both ground and elevated pan traps were more effective than vane traps, with malaise traps being relatively ineffective (Table 1). However, vane traps did collect the greatest bee diversity, based on Simpson's diversity indices (Table 1). Simpson's diversity index is based on species richness and also on species evenness (how evenly distributed abundance is across species). Both ground and elevated pan traps were dominated by one or two particular species, whereas the vane traps collected a more even distribution of bees across species. This suggests that pan traps are better if larger numbers of bees are desired, or if monitoring of particular species such as *A. aurata* or *L. versatum* is important. However, vane traps may be more effective in monitoring forest bee species in general since the resulting collections would be less biased by one or a few dominant species. Both elevated pan traps and vane traps were elevated 1 meter from ground level. Results suggest that these elevated traps are more effective in collecting large numbers of individuals, high species richness, and high species diversity than are ground traps. In future studies of forest bee diversity and species composition, it would probably be best to rely on elevated pan traps and vane traps.

Summary

Bees are ecologically important insects, but relatively little is known about their habitat associations or about the most effective methods of monitoring their diversity. In this study, a variety of trapping methods were used to sample the bee diversity of a

west-central Illinois oak-hickory forest. Low bee abundance and diversity were found. Sampling methods varied greatly in their effectiveness, with elevated pan traps and vane traps appearing to be the best combination for monitoring bee diversity and species composition in this forest type.

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Table 1. Bees collected via four sampling methods at Alice L. Kibbe Life Science Station. GPT = ground pan traps, EPT = elevated pan traps, MT = malaise traps, VT = vane traps.

Species	GPT	EPT	MT	VT	Totals
Agapostemon sericeus		1			1
Andrena wilkella		1			1
Apis mellifera		2		1	3
Augochlorella aurata	6	30		3	39
Augochloropsis metallica		4			4
Bombus bimaculatus				3	3
Bombus impatiens	1	4		7	12
Ceratina dupla	5	8	1	3	17
Halictus ligatus	1	1		1	3
Hoplitus spoliata	1				1
Lasioglossum versatum	39	43	2	6	90
Melissodes bimaculata	1				1
Totals	54	94	3	24	175
Species Richness	7	9	2	7	12
Simpson's Diversity Index	0.465	0.685		0.837	0.674

Digital Images

1. A vane trap
2. An elevated pan trap
3. A bumble bee, *Bombus* sp.
4. A black malaise trap
5. A standard malaise trap