

Assessing the impacts of long-term pan trapping on native bee populations in sub-alpine ecosystems

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Abstract

Pollination by native bees is an essential ecosystem service in both natural and agricultural systems. During the last several decades, there have been reported declines in native bee populations worldwide. Due to recent declines, there is an increasing need for standardized population monitoring programs worldwide. The standardized method of monitoring bee populations is the use of pan traps, which destructively sample bees by removing them from the ecosystem. Very little investigation has been done to date into the long-term impacts of using pan traps on native bee populations. This study tries to assess whether long-term use of pan traps has a negative impact on bee populations in sub-alpine ecosystems in the Colorado Rocky Mountains. Our results suggest that repeated, long-term sampling for bees does not affect bee abundance. However, due to an unexpected but marginally significant difference in bee abundance between the three valleys where samples were taken, our results should be interpreted cautiously. Further investigation is required to understand the impacts of these monitoring methods on bee abundance and diversity.

Introduction

Pollination by insects is an important ecosystem service in both natural and agricultural systems. Approximately 90% of the 240,000 recorded flowering plant species worldwide rely on pollination by insects and other animals for reproduction (Buchmann and Nabhan 1997). Bees have been recorded as pollinators for at least 40,000 different plant species (Buchmann and Nabhan 1997). Bees are the most important pollinator worldwide with an estimated 20,000 species of bee globally including 4,000 species native to North America (Buchmann and Nabhan 1997). In addition to its value to natural systems, pollination by native bees accounts for approximately \$112 billion per year globally in agricultural products (Constanza et al. 1998).

During the last several decades there has been growing concern over declines in pollinator abundance and diversity in many parts of the world. There have been reports of declines in wild bee populations from several countries including Austria, Germany, Great Britain, the Netherlands, Poland, Russia, Canada, and the United States (Moron et al. 2008). There are several factors contributing to these declines including habitat loss and fragmentation, agricultural intensification, introduction of pathogens, phenology mismatches caused by climate change, and competition with managed populations of honey bees (*Apis mellifera*) and bumble bees (*Bombus terrestris*) (Committee on the Status of Pollinators in North America 2007; Carré et al. 2009; Moron et al. 2008).

Although declines have been reported in populations of native pollinators, reliable and comparable data on these declines does not currently exist due to a lack of standardized monitoring programs (Committee on the Status of Pollinators in North America 2007). The Committee on the Status of Pollinators in North America recommends the implementation of long-term monitoring programs that employ standardized methods to begin to create databases of the abundance and diversity of native pollinators (Committee on the Status of Pollinators in North America 2007). In order for global pollinator data to be reliable and comparable across time and space a standardized method of monitoring is necessary.

There are five commonly employed methods for sampling pollinator populations: (1) the use of observation plots, (2) standardized transect walks, (3) variable transect walks, (4) pan traps and, (5) trap nests (Westphal et al. 2008). Studies by Westphal et al. and Nielsen et al. comparing these methods through field studies determined that a combination of pan traps and transect walks provide the most reliable and unbiased sampling methods for estimating bee species richness, abundance, and diversity (Westphal et al. 2008; Nielsen 2011). As a result of these findings, the use of pan traps in combination with transect walks has become a standardized method for long-term monitoring of pollinator populations worldwide (LeBuhn et al. 2003). When compared with other methods, pan trapping was found to have the highest sample coverage, catch the largest number of species, and catch the most individuals (Westphal et al. 2008). The greatest advantage of using pan traps is that it greatly reduces collector bias, which is more common with other methods (Westphal et al. 2008). Reduction of collector bias is especially important in large-scale, long-term monitoring studies that are needed to monitor pollinator populations now and in the future (Westphal et al. 2008).

In 2009 a long-term bee monitoring study was initiated at Rocky Mountain Biological Laboratory (RMBL) in Gothic, Colorado. Despite the fact that bees have been collected and preserved for centuries, and long-term flowering phenology data sets are not uncommon, very little data exist about plants and their associated pollinators collected at the same time and location. This study aims to provide data on both flowering and bee phenology in sub-alpine ecosystems. Using three blocks of sites each containing a wet-Veratrum meadow, a wet-willow meadow, and a dry meadow, each site is sampled every other week for the duration of the field season (late April-August). To date, this study has removed an average of 3,172 bees per year, removing approximately 12,678 bees total since it began in 2009. **The objective of my research was to try to assess whether the long-term use of pan traps at these repeated sites has a negative impact on native bee populations and species diversity in these sub-alpine ecosystems.**

With the growing concern over decreases in pollinator populations, there is a need for an increase in monitoring programs to quantify these declines. As a consequence, pan traps are being employed at an increasing rate, following the guidelines of the standardized method laid out by LeBuhn et al. (2003). Because the standardized methods destructively sample bees, bee-monitoring programs have the potential to contribute to the declines in populations and diversity, and drive any observed population trends over time. To date very little investigation has been done into what the long-term impacts of pan trapping may be. Determining the impact of pan trapping on bee populations is relevant because it may be a factor driving observed trends in population declines. The findings of my study have implications not only for future work at RMBL, but for other sites employing these methods. In our effort to understand and quantify these declines, it is important to understand what role, if any, we as scientists may be playing in these declines, and more studies of the impacts of these programs are needed.

Methods

Study sites

The sites used in the long-term study are grouped into three blocks of sites each containing a dry meadow, a wet-Veratrum meadow, and a wet-willow meadow. The sites I sampled were chosen

based on their similarity in habitat type to these long-term flowering and bee phenology plots. I chose to focus on dry meadows and wet-Veratrum meadows for my study and did not include any wet-willow meadows in my sampling. In addition to the repeatedly sampled sites, I established twelve additional sites – six wet-Veratrum meadows and six dry meadows- at which sampling with pan traps had not previously occurred. Sampling at previously unsampled sites allowed us to assess whether these sites had higher bee abundance than the repeated sites. Specific site information is provided in Table 1.

Table 1. Specific site information for control sites.

Site Name	Location	Elevation	GPS location
401 Wet	East River Valley (401 trail)	9993 ft.	38.97492N, 106.99167W
401 Dry	East River Valley (401 trail)	9988 ft.	38.97503N, 106.99266W
Washington Gulch 1 Wet	Washington Gulch	9363 ft.	38.89477N, 106.98109W
Washington Gulch 1 Dry	Washington Gulch	9443 ft.	38.89622N, 106.98402W
Lower Loop Wet	Slate River Valley	9050 ft.	38.89534N, 107.01242W
Lower Loop Dry	Slate River Valley	8944 ft.	38.898077N, 107.014809W
Slate Wet	Slate River Valley	9068 ft.	38.92410N, 107.040720W
Slate Dry	Slate River Valley	9121 ft.	38.92808N, 107.04343W
Washington Gulch 2 Wet	Washington Gulch	9657 ft.	38.93476N, 107.01488W
Washington Gulch 2 Dry	Washington Gulch	9676 ft.	38.93381N, 107.01893W
Rosey Point Wet	East River Valley (Gothic Road)	9519 ft.	38.93271N, 106.96950W
Rosey Point Dry	East River Valley (Gothic Road)	9592 ft.	38.93312N, 106.97050W

Experimental Design

This study employed the standardized methods for monitoring bee populations outlined by LeBuhn et al. (2003). The primary method I used to collect bees was pan traps (hereafter referred to as bee bowls). Bee bowls are small 6oz. bowls that are painted either fluorescent yellow, fluorescent blue, or white. These bowls are filled with soapy water. Bees and other pollinators visit these bowls thinking they are flowers and end up drowning in the soapy water.

The bee bowling methods employed at each of the twelve sites was identical to the methods employed at the repeatedly sampled sites. At each of the twelve sites I laid two 42m transects perpendicular to one another. A bee bowl was placed at every 3m along each transect,

alternating bowl color. I put out a total of 30 bowls at each site, 15 per transect. The bee bowls were left out in the field for between four to six hours during the peak hours of bee activity from 8am to 5pm. I recorded the times the bowls were put in and taken out of the field, which allowed me to calculate the bee capture rate (bees caught per hour) for each site, which is a more meaningful method for comparison between sites than bee abundance alone. At the end of each sampling day, the contents of the traps were collected and placed in vials of 70% ethanol alcohol corresponding to the color of the trap in which they were caught. The bees were put in ethanol to preserve them until they could be pinned in the lab.

Pan traps typically collect small species of bees, but larger bee species such as *Bombus* are not well represented in these traps. Therefore, at each site I also netted for bees for one hour during both the morning and afternoon along each transect. Any bees caught that could be easily identified in the field (primarily those in the genus *Bombus*) were recorded, marked with a small paint-pen dot on the thorax to avoid being counted twice in the event of recapture, and released. Any bees caught that could not be identified in the field were collected and taken back to the lab for pinning and identification. The combination of pan trapping and netting at each site provide reliable estimates of bee abundance, richness, and diversity (Westphal et al. 2008). However the captured bees were not identified by the time of writing, thus only bee abundance is addressed in the present investigation.

In addition to pan trapping and netting at each site, I also made a record of floral abundance. To do this, I set up three 2x2m quadrats along each transect and made a note of the species present and the number of flowers of each species per quadrat. A random number generator was used to assign quadrat locations along each transect to eliminate bias. Floral abundance data was taken in order to compare floral resources between control and repeated sites to eliminate this as a factor affecting bee capture rate.

In the lab, I pinned and labeled all the bees caught on each sample day to measure bee abundance and recorded data on the method by which each bee was caught. I compared these numbers with the mean number of bees caught in the long-term plots during the same week from the same type of habitat. Comparing these data within the same week was done to eliminate any effects of weather. These data allowed me to determine if bee populations decline in the long term sampling sites over the course of one season due to repeated sampling and if bee abundance is higher at new sites than at repeated sites.

Statistical Analysis

For each site, I calculated bee capture rate as total bees caught using pan traps per hour. I then used a nested ANCOVA with site type (repeated or single sampling), block (week), and valley as factors, and mean maximum daily temperature and mean floral density as covariates. Block was included as a random effect to control for the time of the season the samples were collected in, and site-type was tested over the block term. Valley was included as a factor because samples were collected in three valleys: East River, Slate River, and Washington Gulch valleys. Temperature has well-known effects on insect activity and so was included as a covariate to control for any weather-dependent effects on bee activity.

Results

There was no effect of repeated sampling on bee capture rates in either dry meadows ($F_{1,8.3} = 0.2503$, $P=0.6298$, Figure 1) or wet-Veratrum meadows ($F_{1,8.0} = 1.9054$, $P = 0.2047$, Figure 3). However, other covariates and factors in the statistical model were associated with bee capture rates. Bee capture rates had a negative relationship with temperature in dry meadows ($F_{1,8.8}=6.3809$, $P=0.0329$, Figure 5) but had no significant relationship with temperature in wet-Veratrum meadows ($F_{1,8.4}=0.6043$, $P=0.4582$, data not shown). Bee capture rates were marginally lower in dry meadow sites within the East River Valley ($F_{2,8.9} = 3.5057$, $P = 0.0755$, Figure 4) suggesting that there may be a difference in bee abundance between valleys, although there was no difference in bee capture rates between valleys in wet-Veratrum meadows ($F_{2,8.1}=1.6988$, $P=0.2421$).

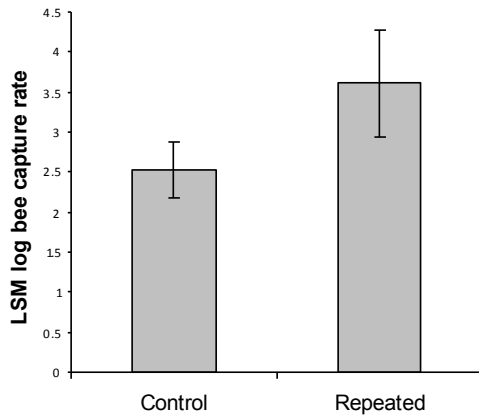


Figure 1. Least square means of log bee capture rate within wet-Veratrum meadows did not vary between control and repeated sites.

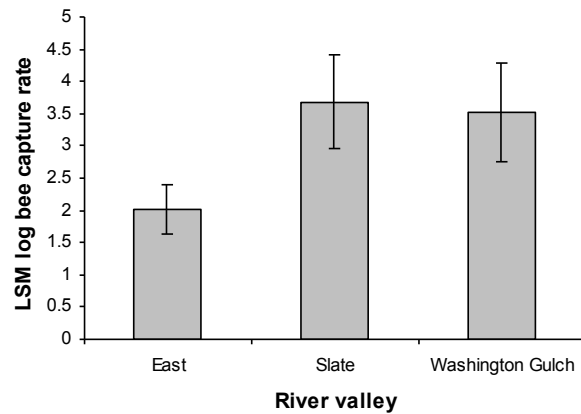


Figure 2. Least square means of log bee capture rate within wet-Veratrum meadows did not vary significantly between valleys.

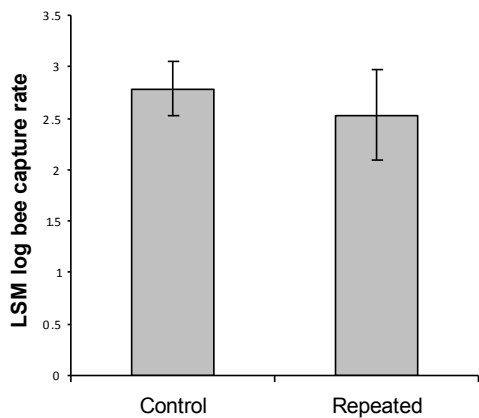


Figure 3. Least square means of log bee capture rate within dry meadows did not vary significantly between control and repeated sites.

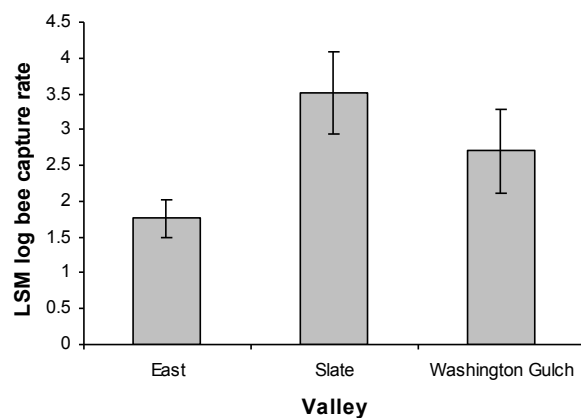
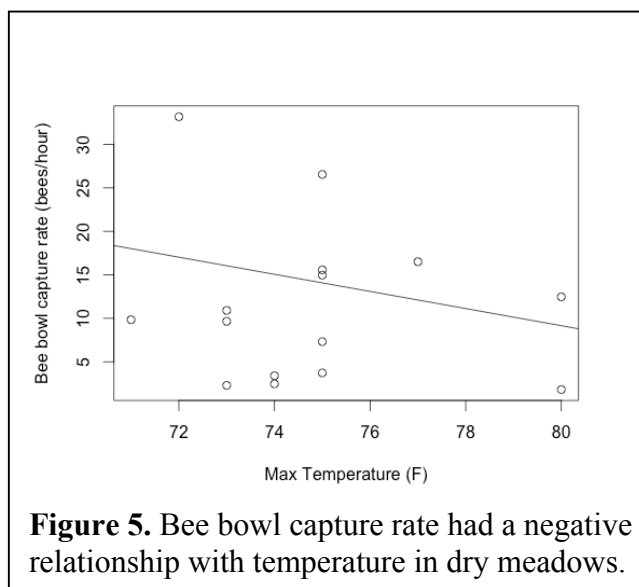


Figure 4. Least square means of log bee capture rate within dry meadows varied between valleys although the difference was only marginally significant

Discussion

Our results indicate that the standardized methods for collecting bees do not affect overall bee abundance in our study region (Rocky Mountain West); thus, the bi-monthly standardized sampling methods will have little impact on bee populations and ecosystem health. Bees need to be identified to species level in order to determine if bee species richness and diversity are affected by repeated and long-term sampling using pan traps. Caution should be taken when interpreting our results, however, because of the marginally significant difference in bee capture rates between valleys. Bee capture rates were lowest in the East River Valley, where all of the long-term sites are located, and were higher in both the Slate River Valley and Washington Gulch. Bee capture rates did not differ between repeatedly sampled and single sampled sites within the East River valley, however, the small sample size within the East River valley makes it difficult to completely rule out the effect that repeated sampling may be having on bee populations.

As maximum daily temperature increased, bee capture rate decreased. Temperatures for the sampling period ranged from 21.7°-26.7°C. Several studies have shown that foraging activity in bees increases with temperature up to a certain threshold, after which levels of activity decrease (Totland 1994). This temperature threshold varies between ecosystems and has not been well defined in previous studies, but many studies support that bee foraging activity is strongly constrained by temperature and is limited to a particular thermal window in which it is warm enough for bees to be active but not so warm that they overheat during flight (Stone et al. 1999; Totland 1994; Corbet et al 1993; Willmer 1983). The National Oceanic and Atmospheric Administration (NOAA) National Weather Service reports that the average temperatures for June in the Gunnison Basin were 2°-6°F above normal and the average temperatures for July were 1°-4°F above normal (NOAA 2012). Additionally, the Gunnison basin has received only 72% of the average annual precipitation resulting in extreme drought conditions (NOAA 2012). It is likely that these drought conditions and higher than average temperatures have had a greater impact in dry meadow ecosystems than in wet-*Veratrum* ecosystems, which helps to explain the negative relationship we see between temperature and bee capture rate in dry meadow sites, but not wet meadow sites, in this study.



Bee foraging range is dependent on body size, meaning larger bees can travel farther distances to forage (Gathmann and Tscharntke 2002; Greenleaf et al. 2007). The maximum foraging range for wild solitary bees is between 150m and 600m from the nest site, depending upon the specific bee species (Gathmann and Tscharntke 2002). This limited foraging range has implications for species distribution across ecosystems and is especially relevant to the study of the impact of

long-term pan trapping. Since bees only travel within a certain range from their nest sites, repeatedly sampling within a small area could lead to localized declines in either species abundance or diversity. Although there was not time during this study to examine any differences in species diversity between repeated and control sites, this is an ecologically important topic to investigate. There is the possibility that although total abundance may not differ significantly between repeated and control sites, there may be significant differences in what species are most abundant between repeated and control sites as a result of selective removal of certain species by pan trapping based on foraging range and other species specific factors such as body size or foraging habits.

There is a need to understand the impacts of long-term collection of native bee species on both abundance and species diversity, especially since many of these species are already vulnerable due to declines driven by other factors. Future research should be conducted within a smaller geographic region that focuses specifically on areas near sites that have been repeatedly sampled to eliminate effects of microclimate. Additionally, increasing the sample size in the East River valley would allow for a stronger test between control and repeated sites. The Irwin lab is currently conducting such sampling.

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