

The effect of 10 years of repeated lethal sampling on wild bee abundance

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Key Words: bees, lethal sampling, Apoidea, Bee Plot Protocol, catch rate, species richness

Abstract:

Insect pollinators serve vital roles in natural and agricultural systems. There is a lack of long-term data on wild bee populations in North America, so standardized sampling protocols have been developed to address this need. The purpose of this study was to determine the effect of 10 years of long-term, repeated lethal sampling through the use of aerial netting and pan traps on wild bee abundance. Several single-sample sites were sampled and compared to phenologically similar sites that had been repeatedly sampled for a decade. In this paper, we focus on the bumble bees only. We predicted to find no effect of repeated sampling on bumble bee abundance or diversity because they are not lethally sampled but, rather, identified in the field and released. We found no significant difference between the catch rate and species richness for bumble bees caught among single-sample and their paired repeated-sample sites. This suggests that the paired sites are suitably comparable, and allows us to move forward in the analysis of the lethally sampled, solitary bees' catch rate and species richness among the single-sample and repeated-sample sites.

Introduction:

Insect pollination is crucial to natural and agricultural systems. About 90% of flowering plant species rely on animal pollination (Ollerton, Winfree & Tarrant 2011), and pollinators contribute around \$202 billion annually to global agricultural systems (Gallai et al. 2009). Despite their significance, little is known about the population trends of insect pollinators, particularly the nearly 4,000 species of bees in North America (Michener 2007), beyond what can be gleaned from comparisons to historical records and museum specimens (Bartomeus et al. 2013; Burkle, Marlin & Knight 2013).

The lack of long-term data on wild bee populations in North America has prompted the development of standardized bee sampling protocols (LeBuhn et al. 2003; Westphal et al. 2008), including a standardized method of bee capture through a combination of pan trapping and aerial netting, referred to as the Bee Plot Protocol (Wilson, Messinger & Griswold 2009; Neame, Griswold & Elle 2013; Winfree et al. 2014). Gezon et al. (2015) found no significant effect of repeated lethal sampling on wild bee abundance and diversity after three years of sampling using the Bee Plot Protocol. However, to be able to assess long-term trends in bee populations, researchers need longer time series of data. The majority of solitary bees need to be lethally sampled for identification. Moreover, the specimens are also useful themselves for taxonomic revisions and to understand how environmental change may affect the traits of bees important for their survival and pollination. However, data are needed to assess whether lethal sampling for longer than 3 years has an effect on wild bee populations. The United States General Accountability Office issued a statement in 2016 recommending the monitoring of native bee populations in the US. To be able to implement a national native bee monitoring plan, a sampling method is needed that has no effect on long-term bee populations. Thus, the results of this research are very timely in the development of that protocol.

The purpose of this study was to determine the effect of long-term, repeated lethal sampling on wild bee abundance and functional diversity. Based on the results from Gezon et al. (2015), we predicted that lethal sampling would have no significant effect on bee abundance or diversity. Alternatively, if lethal sampling has an effect on bee abundance, then we would predict to find a reduction in bee populations comparing areas sampled repeatedly to areas that have not been repeatedly sampled. The results from this study will either strengthen the case for pan trapping and netting as a standardized sampling approach or show a need to alter the sampling approach to minimize negative impacts on wild bee populations.

Methods:

Sixteen repeated-sample sites are located in and near Gothic, CO, ranging from Almont, CO (2,500 m) to Mexican Cut (3,250 m). These sixteen sites have been sampled approximately every 2 weeks during spring and summer months for the past 10 years (See Figure 1). Each site has a 42x42m transect, typically shaped in a cross. My comparisons focus on the repeated-sample sites (9 sites total) around Gothic, CO.

Long-term bee sampling. We employed a standardized method of bee capture through a combination of pan trapping and aerial netting (Wilson, Messinger & Griswold 2009; Neame, Griswold & Elle 2013; Winfree et al. 2014). The pan traps we set - 10 fluorescent blue, 10 white, and 10 fluorescent yellow in an alternating pattern - were placed every 3 meters along each transect. Pan traps were filled with soapy water (Dawn blue dish soap); bees mistake them for flowers resulting in passive sampling. The pan traps typically collect smaller-bodied bees, but not larger-bodied bumble bees and some larger *Megachile*. Thus, after setting the traps, we hand-netted bees for 1 hour at each site in the morning, and another hour in the afternoon. For all netted bees, we record the floral host plant the bees were collected from. Bumble bees were netted in the field, identified, marked, and released. All other netted bees were collected for later identification. We then collected the 30 pan traps and any bees they contained. We also recorded flowering phenology - including the species present, number of plants, and number of flowers on 10 random plants of each species - at 6 random 2x2m plots along the transects of each site. After field collection was complete, we pinned, labeled, and identified all bee specimens. In the summer of 2019, we are still in the process of pinning, entering, and labelling the sampled bees and have not started on their identification yet. Data for the long-term bee collection from prior years can be found at: DOI 10.17605/OSF.IO/KMXYN.

Single-sample sites. Eight pairs of single-sample sites are located near the repeated-sample sites. They were treated with the same sampling methodology, but only sampled once during the summer within approx. 3 days of the sampling that occurred at their paired repeated-sample site(s). All collected specimens will be pinned, labeled, and identified. We compared the abundance and diversity of bumble bees caught at the single-sample sites to that of bumble bees caught at their phenologically similar repeated-sample sites this year given that we are still in the processing of pinning and entering collected bees from 2019.

On each sampling day, we used local weather stations to record temperature, precipitation, and wind. We also recorded start and stop time of aerial netting sessions, as well as the amount of time bee bowls were placed in the field to control for sampling effort.

Statistical analyses. We calculated bumble bee catch rate per site as the number of bees netted per minute. We analyzed the catch rate and species richness of bumble bees at single sample sites versus their paired repeated-sample sites with box plots using a simple nested ANOVA with single/repeat tested over block (week). Eventually, a more complex mixed model with site type (single or repeated) as a factor, pair as a random effect, and floral density and weather as covariates will be utilized. Repeated measures models will be used to compare long-term trends in bee abundance and diversity.

Results:

We netted a total of 401 bumble bees, 171 from the selected repeated-sample sites and 230 from single-sample sites, from 12 different species. The mean catch rate was 8.35 at selected repeated-sample sites, and 9.06 at single sample sites. There was no significant difference between the mean catch rates among site types (Figure 2; $P = 0.8978$). The mean species richness was 0.90 at selected repeated-sample sites, and 3.36 at single sample sites. There was also no significant difference between the species richness among site types (Figure 3; $P = 0.3794$).

Discussion:

We found no significant difference between the catch rate and species richness for bumble bees caught among single-sample and their paired repeated-sample sites. This finding aligns with our hypothesis, since we would not expect to find any difference in non-lethally sampled bumble bees between site types. This finding suggests that the sites are suitable for comparison with the lethally sampled bees. The next step for this project is to introduce further site factors (temperature and flower phenology) for a more complex mixed model statistical analysis. Then, once the lethally sampled bees have been pinned and identified, we will use the same type of model to evaluate the differences in catch rate and species richness for the rest of the wild bee communities.

Tables and Figures:

Sites from Almont to Mexican Cut

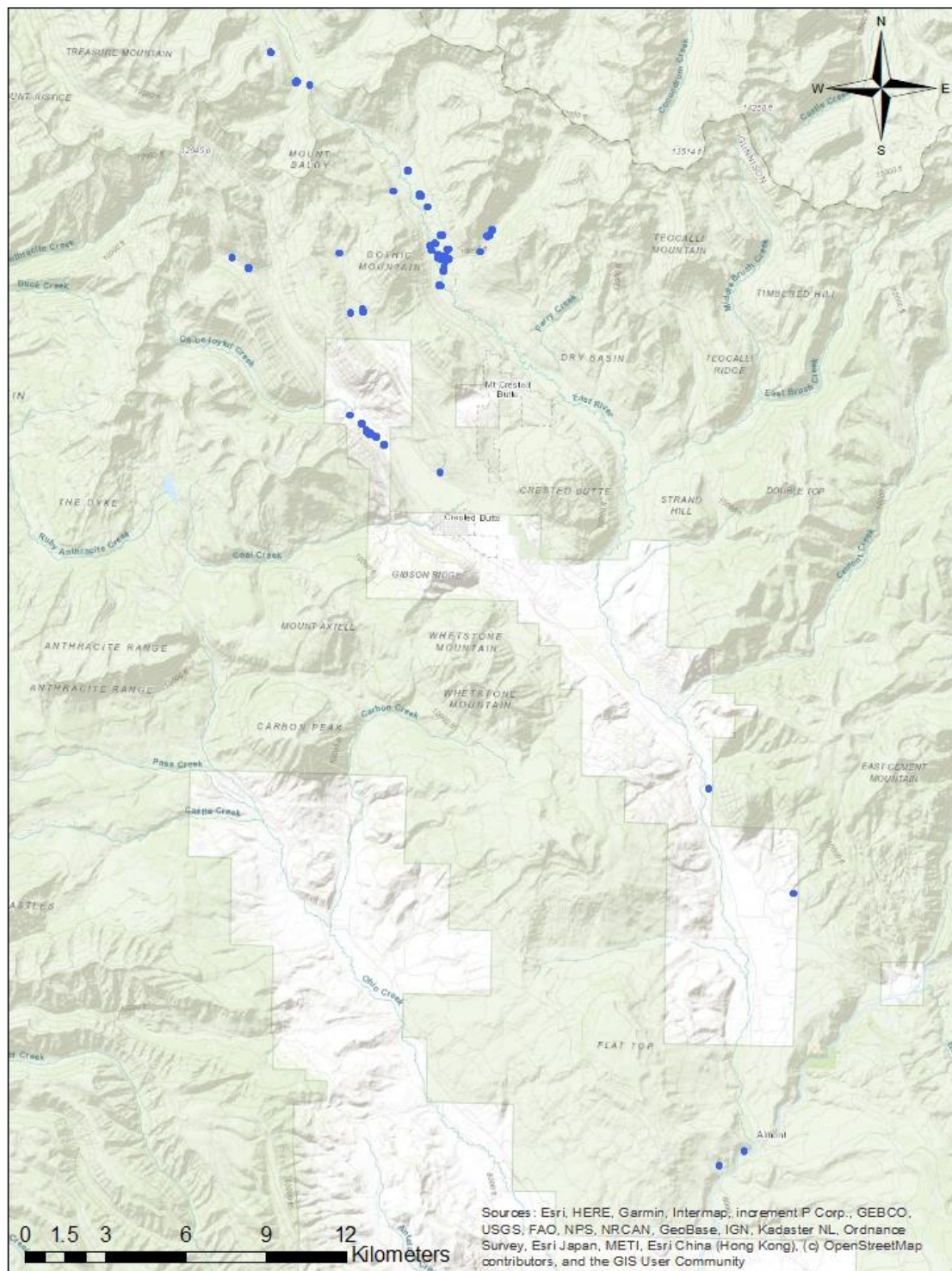


Figure 1: Map of all sites (single-sample and repeated-sample)

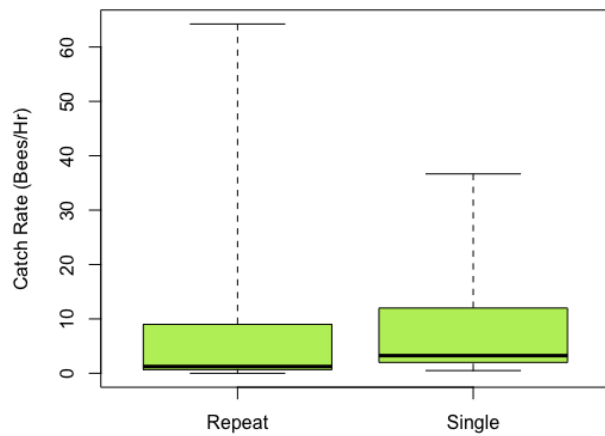


Figure 2: Catch rate (bumble bees/hour) among repeated-sample and single-sample sites. The figure depicts box plots. The sold dark line is the median, the edges of the boxes are the first and third quantiles, and the bars depict the minimum and maximum of the data range.

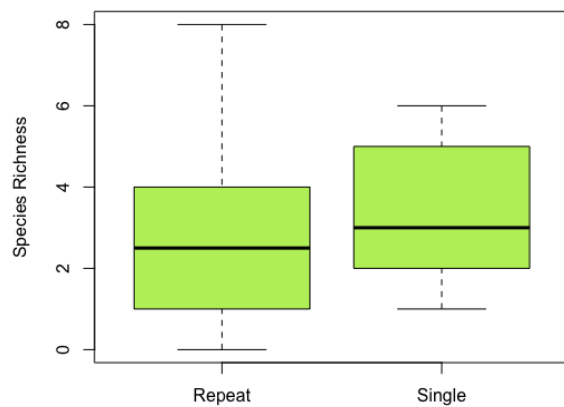


Figure 3: Bumble bee species richness among repeated-sample and single-sample sites. The figure depicts box plots as in Figure 1.

Acknowledgements:

Special thanks to the Rocky Mountain Biological Laboratory for funding this research, Becky Irwin for her mentorship, Rachel Dickson for her guidance and support in the field and lab, and Michael Stemkovski and Becky Dalton for help with statistical analyses.

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