

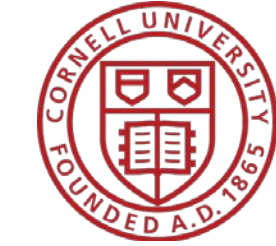
Assaying the effectiveness of acoustic monitoring for detecting bumblebee (*Bombus* spp.) abundance and diversity

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Abstract:

Our project is designed to determine the effectiveness of acoustic monitoring for surveying native bumblebee species and compare it to the traditional method of catch and release. To determine the effectiveness of acoustic monitoring, we compared traditional and acoustic survey techniques and conducted flight cage experiments to compare species-specific buzz frequencies. Bees were recorded while foraging in naturally occurring patches of wildflowers, such as *Asclepias syriaca* (Common milkweed) and *Anchusa officinalis* (Common bugloss). Traditional survey techniques outperformed acoustic methods for monitoring pollination services to blueberries and huckleberries. This project is important towards helping Brookhaven National Laboratory address pollinator health in its Natural Resource Management Plan.

Introduction:

- Recent declines in bee populations have been attributed agricultural intensification, pesticides, and climate change (Calderone, 2012).
- This decline poses a major threat to agricultural production, making pollinator conservation increasingly crucial.
- Acoustic monitoring is a less-intrusive method of wildlife monitoring that involves the set up of specialized outdoor microphones and recorders in the field, limiting major impacts of human activity.
- Bumblebees (*Bombus* spp.) create vibrations that can be recorded *in situ* as they fly, forage, or act in defense (De Luca, et al. 2014).
- Here, we explore the effectiveness of acoustic survey techniques for monitoring bumble bee pollination services to wild blueberry and huckleberries**

Materials and Methods:

Comparison of traditional and acoustic surveys:

- Four 15 acre (~1963.5m² area) circular sites were established in the pine barrens at Brookhaven National Lab. (fig. 1)
- Foraging bumble bees and blueberry bees were collected for 30 minutes via traditional netting surveys, identified to species and caste, and released.
- Bee buzzes were surveyed using Wildlife Acoustics Song Meter SM4 recorders fitted with SMM-A2 Acoustic Microphones, and extracted via Audacity v. 2.1.2
- Buzzes were counted during the 30 minutes preceding the netting surveys
- The relationship between traditional and acoustic estimates of bee density was tested using Pearson's correlation.
- The relationship between traditional and acoustic estimates of pollination services was determined by general linear model for each.

Flight Cage Experiments:

- Bees were allowed to forage from naturally occurring patches of host plants (e.g., *Asclepias syriaca*, *Echium vulgare*, and *Perovskia atriplicifolia*) in one of two flight cages (fig. 2 C & D)
- We recorded bees in flight using Wildlife Acoustics Song Meter SM4 recorders (fig. 3). A hand-held SMM-A2 Acoustic Microphone was used to closely follow the bees as they foraged and flew between plants
- Bees were measured, identified by species and caste, and marked to avoid repeat recordings.
- We tested for a difference in flight buzz frequency among species and castes via mixed-effects ANOVA: one for just the queen bees of two species (*B. bimaculatus* & *B. impatiens*) and one for the workers and males of all three species.



Figure 1: A map of the bumble bee and blueberry bee populations



Figure 3: Wildlife Acoustics recorders and microphones inside flight cage

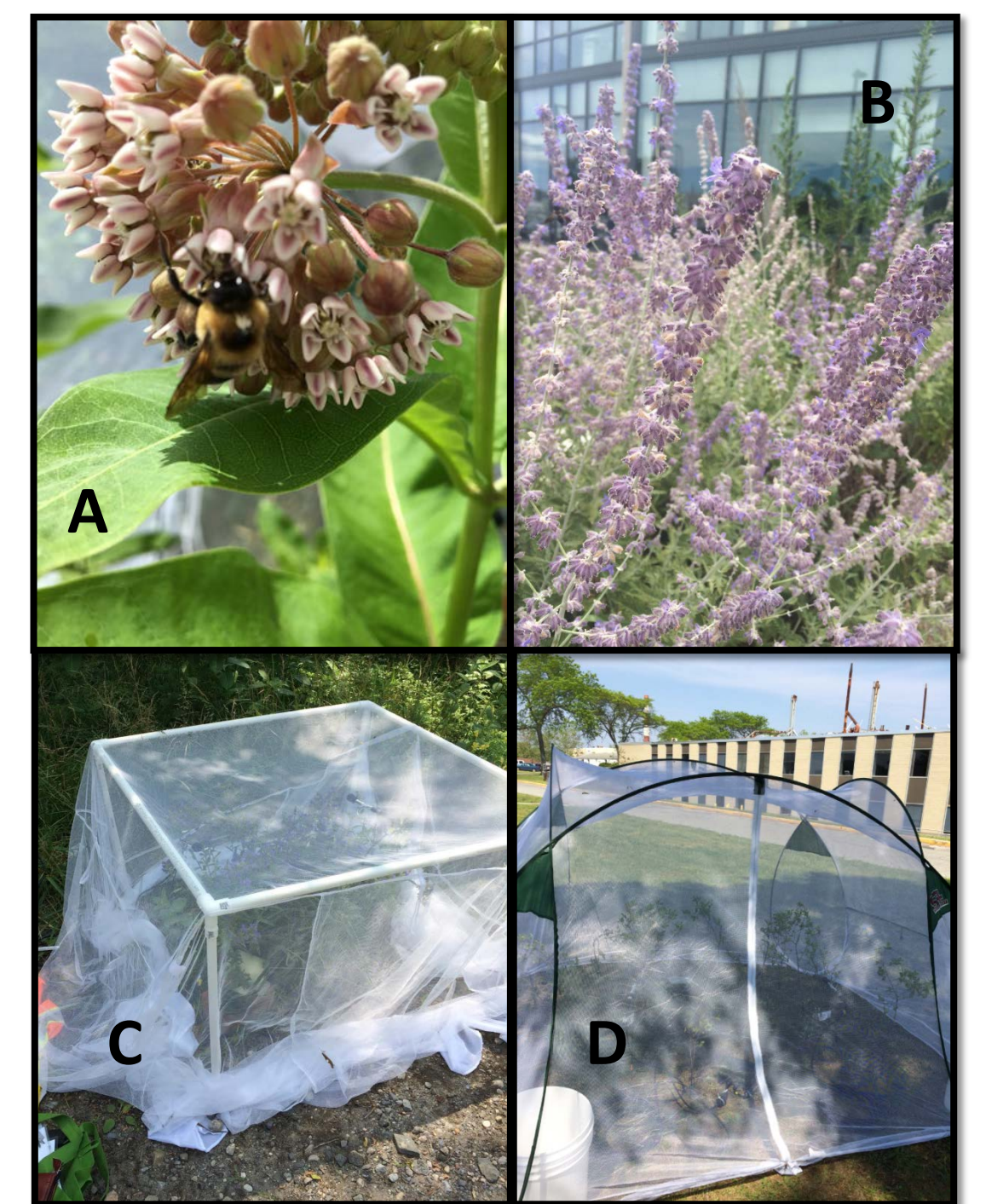


Figure 2: Bees were allowed to forage from patches of host plants (e.g., *Asclepias syriaca* (A) and *Perovskia atriplicifolia* (B) covered by one of two flight cages depending on plant size (C and D).

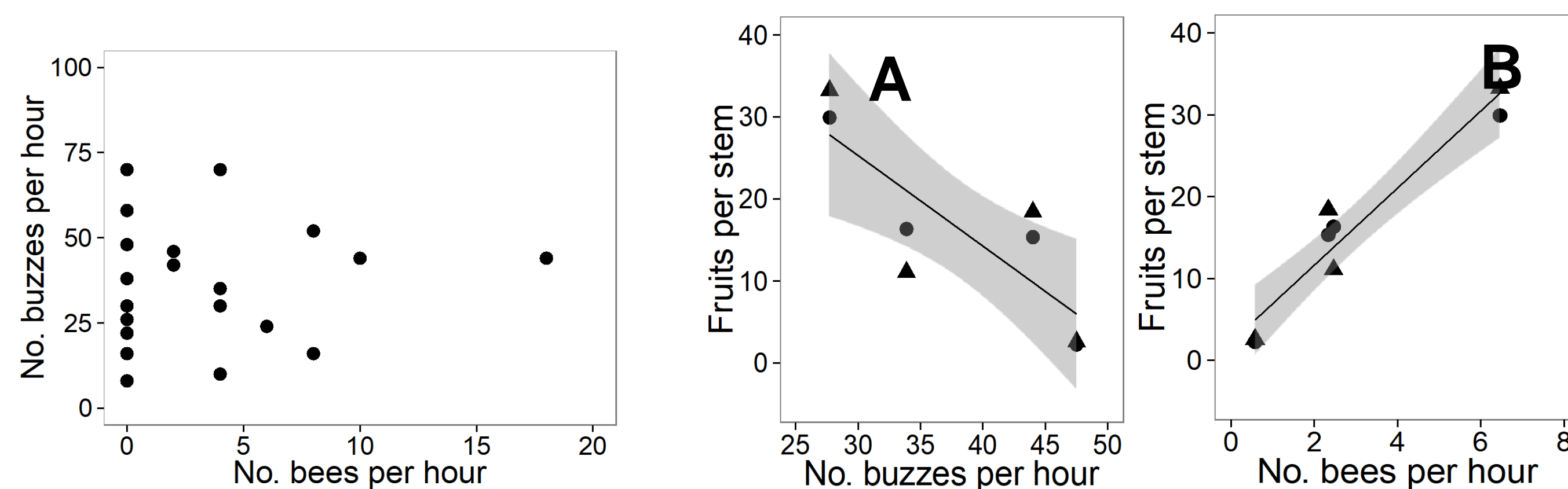


Figure 4. The relationship between buzz density and bee density at four sites located at Brookhaven National Lab, Upton, NY.

Figure 5. The relationship between reproductive success (i.e., fruits per stem) and bee density estimated by traditional methods (A) and acoustic methods (B).

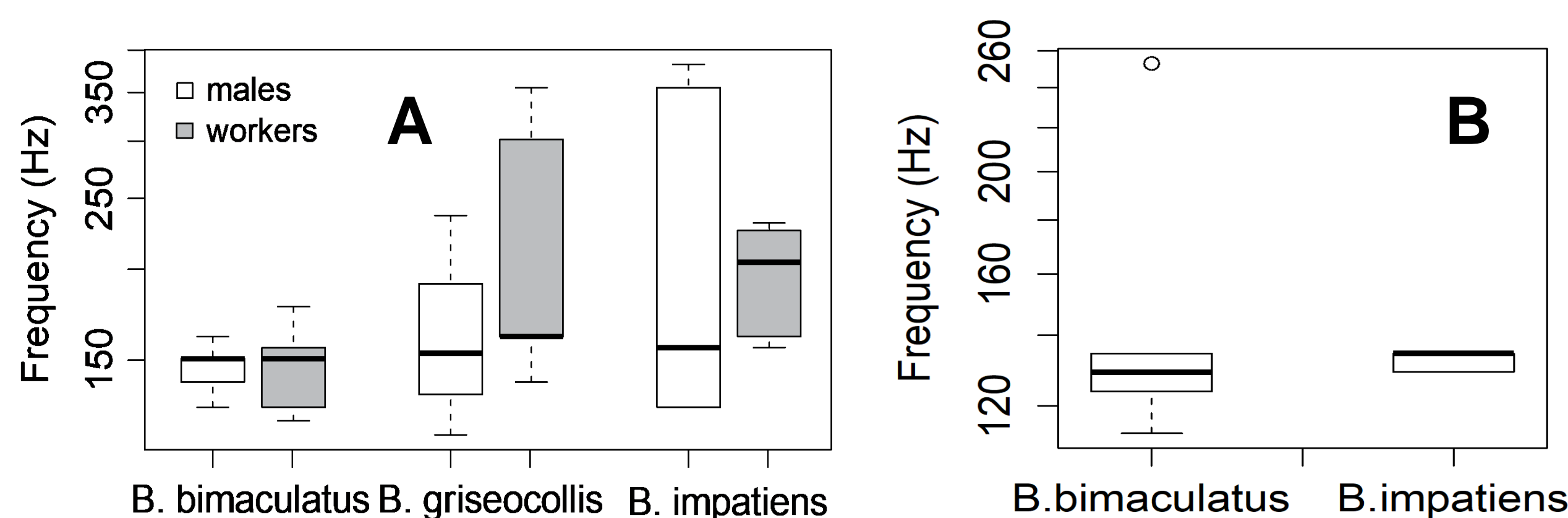


Figure 6. Flight buzz frequency of workers and males (A) and queens (B) did not differ among castes or species.

References:

Calderone, NW. 2012. Insect Pollinated Crops, Insect Pollinators and US Agriculture: Trend Analysis of Aggregate Data for the Period 1992–2009. PLoS ONE 7(5): e37235. doi:10.1371/journal.pone.0037235

De Luca, P. A., Cox, D. A., & Vallejo-Marín, M. (2014). Comparison of pollination and defensive buzzes in bumblebees indicates species-specific and context-dependent vibrations. *Naturwissenschaften*, 101(4), 331-338. doi:10.1007/s00114-014-1161-7

Results:

Comparison of traditional and acoustic surveys:

- There was no correlation found between traditional and acoustic estimates of bee density (fig. 4)
- We found a positive correlation between fruit abundance and bee density collected via traditional methods ($F_{1,5} = 75.25$, $P = 0.0003$; fig. 5A)
- There was a negative correlation between fruit abundance and buzz density collected via acoustic monitoring ($F_{1,5} = 12.84$, $P = 0.016$; fig. 5B)

Flight Cage Experiments:

- The buzz frequencies of workers and males ($F_{1,12} = 0.58$, $P = 0.57$; fig. 6A) and queens ($F_{1,3} = 0.074$, $P = 0.80$; fig. 6B) of the three species tested did not differ significantly.

Discussion:

- Buzz density did not reflect bee activity or population density
- Traditional methods of bee density effectively estimated pollination services, as indicated by a positive relationship between bee density and fruit set.
- However, estimates resulting from acoustic monitoring did not perform well as predictors of pollination services. The negative correlation between buzz density and fruit set suggests that buzzes could have originated from insects that were not effective pollinators (e.g., flies).
- There is no significant difference in flight buzz frequency (Hz) between the three species and castes tested.
- Our results are preliminary, as we only tested 3 individuals per species over the course of the summer.
- Acoustics is promising for monitoring in some systems (ie. the Alpine Study System in Colorado), and we hope to see if it will work in other buzz pollinating systems in future studies.

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