

Bee Sampling Has No Effect on Bee Abundance in Montane Meadows

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Abstract:

One of the most talked about potential consequences of climate change is that of phenological mismatches between interacting species, such as flowering plants and their pollinators. While there is ample long term data for plant phenology, there is little data on pollinator phenology. It is becoming more common to monitor pollinator (bee) populations over long periods of time to look for phenological mismatches. The standard method of bee population monitoring uses pan traps, which are small plastic bowls containing water with soap. The bowls are painted bright colors to mimic flowers and attract bees, killing them when they fall in the water. It is unknown if sampling using pan traps affects bee abundance, especially when implemented repeatedly, over long time periods. Thus, I asked two questions: Is there a difference in bee abundance between sites that have been repeatedly sampled using pan traps and sites that have never been sampled? And, how does bee abundance change over two years of repeated sampling? To address the first question I used ten control sites: five dry meadow sites and five wet meadow sites. Control sites were sampled once, and bee abundance was compared between these control sites and six sites (three of each habitat type) that were repeatedly sampled over the 2009 and 2010 flowering season using the same techniques. In total we caught 2060 bees at the repeated sites and 333 bees at the control sites. I found no significant difference in bee abundance at the control versus the repeatedly sampled sites. I also found no significant difference in bee abundance in 2009 versus 2010. I also compared floral abundance at the sites and weather data to ensure that factors other than sampling were not confounding my results. I found no significant difference in flower abundance or temperature between sites. Taken together, these data suggest that sampling using pan traps has no effect on bee abundance.

Keywords: Pan Traps, Pollinators, Population changes, Hymenoptera

Introduction:

The most important activity of bees, in terms of benefits to humans, is their pollination of flowers (Michener 2000). Pollination by insects and other animals is critical to the reproductive success of up to 90% of angiosperm species (Buchmann and Nabhan 1996). Pollination by native bees alone is directly responsible for \$3.1 billion annually in agricultural and forestry products (Losey and Vaughan, 2006). Although solitary bees comprise over 85% of bee species (Michener 2000), little research has been conducted on them compared to the number of studies on honey bees and bumble bees.

The most common method of sampling solitary bees is using pan traps. Pan traps are the most efficient bee catching method in both agricultural and semi-natural habitats (Westphal et al. 2008). A potential problem with using pan traps over long periods of time is that the sampling itself could affect the bee populations and drive any documented changes in the populations over time. To the best of my knowledge there have been no long term experiments to determine if repeated sampling using pan traps has an effect on bee populations. The objective of this project was to determine if repeated and long term sampling using standard pan trapping techniques has an effect on bee abundance. I compared bee abundance in sites that have never been sampled before (control sites) to sites that were sampled repeatedly over the 2009 and 2010 flowering seasons. Control sites were selected to mimic the established sites that have been sampled repeatedly. If pan trapping has a negative effect on bee abundance, I would expect sites that have been sampled multiple times to have lower bee abundance than sites that have been sampled only once. In addition, I would expect sites that have been sampled over multiple years to have lower bee abundance from one year to the next.

Methods:

Study Sites:

The control sites were selected to be similar in plant community composition to the sites that have been sampled repeatedly. I used two habitat types for this study: wet-meadow dominated by *Veratrum californium* and dry meadow. For the control sites I selected five areas of each habitat type, for a total of ten sites. I hereby refer to a coupling of dry meadow and wet meadow as a block. Both sites in each block were within 500m of each other. The control sites had never previously been sampled for bees using pan traps. I sampled each block only once because subsequent samplings could affect bee abundance. I compared the data collected from the control sites to the data collected from the sites that have been sampled multiple times.

The sites that have been sampled repeatedly, hereby referred to as repeated sites, were similar to the control sites in habitat type (dry meadows and wet-*Veratrum* meadows), plant community composition, and were sampled using the same methodology as the control sites. Each of the six repeated sites were sampled once every two weeks from June through August in 2009 and 2010

Bee Abundance

The primary form of sampling I used was pan traps which are small plastic bowls painted fluorescent yellow, fluorescent blue or white that contain soapy water (LeBuhn et al. 2003). Each study site contained two 42 m transects, and each transect was divided into 15 plot points, each separated by 3m. One pan trap was placed at every plot point: therefore, each site had a total of thirty pan traps. The traps were setup at one control block per week and three repeated blocks per week. On the date of each sampling, temperature, and rainfall were obtained from the nearest RMBL weather station to ensure that environmental factors are not driving any patterns

found in bee abundance between control and repeated sampling sites. Because large-bodied bees tend not to be caught by pan traps, I also netted at each of the sites for two hours, one hour in the morning and one hour in the afternoon, following standard protocol (LeBuhn et al. 2003). The pan traps were left in place at each site for four to six hours (depending on the weather). Bees were sorted by the color of the pan trap they were caught in, and preserved in 70% ethanol. I mounted, labeled and cataloged each bee. The data collected from the control sites were compared with the data being collected by, and previously collected, by Zak Gezon and Dr. Rebecca E. Irwin, who have been collecting data on bee populations for the past two flowering seasons.

Bee Abundance Over Two Year Period.

To determine if repeated sampling has an effect on bee abundance over a two year period I compared the bee abundance data collected by my mentors over the 2009 flowering season to the data from the 2010 flowering season (Figure 3). The sampling scheme changed slightly from one year to the next, so I was unable to compare exact sampling dates between years; therefore I paired the four weeks of sampling that overlapped the most.

Floral abundance

Floral abundance is a factor that could affect the abundance of bees. To ensure that any patterns in bee abundance between years and between control and repeat-sampling sites were not driven by differences in the study sites, I had three randomly placed floral plots (each 2 x 2 m) along every transect. Each floral plot was measured by counting the number of flowering plants per plot and then counting the number of flowers on up to 10 randomly flowering plants per species (Figure 4).

Statistical Analysis

To ensure the differences in sampling effort at each site did not confound the results, bee abundance was calculated as bees caught per site per hour. To test whether bee abundance differed between control and repeat-sampling sites, I used a paired t-test. Comparisons were performed separately for dry and wet-Veratrum sites. To test whether bee abundance differed between the two years of sampling I used a paired t-test. I also used a paired t-test to compare the floral abundance of the control sites to the repeated sites, and to compare floral abundance of the repeated sites from one year to the other.

Results:

Bee Abundance Between Control and Repeat-Sampling Sites

I found no significant difference in bee abundance between control sites, and the 2010 repeated sites (Figure 1: Dry sites: $t_4 = 0.236$, $p = 0.824$; Figure 2: Wet sites: $t_4 = 1.22$, $p = 0.286$)

Bee Abundance over Two Year Period

There is no significant difference in the abundance of the repeated sites from 2009 to 2010. There is a nearly significant increase in the abundance of the wet sites from 2009 to 2010. (Figure 3: Dry sites: $t_3 = 1.29$, $p = 0.285$; Wet sites: $t_3 = 2.89$, $p = 0.063$)

Floral Abundance

There is a positive but weak correlation between floral abundance and bee abundance (Figure 4). I found no significant difference in floral abundance between the control and the repeated sites (Figure 5 & 6: Dry Sites: $t_4 = -2.1018$, $p = 0.1034$, Wet Sites: $t_3 = 0.3626$, $p = 0.480$). I found no significant difference in the floral abundance from 2009 to 2010 (Figure 7, Dry: $t_4 = 2.10$, $p = 0.103$; Wet: $t_4 = 0.777$, $p = 0.480$).

Discussion:

The objective of this experiment was to determine if sampling using pan traps has a negative effect on bee abundance. I found out that there is no significant difference in the abundance of bees when comparing the control and the repeated sites. There is also no significant difference in bee abundance between the 2009 and 2010 repeated sites. There is a positive but weak correlation between floral abundance and bee abundance, meaning that a difference in floral abundance between sites or between years could affect bee abundance. However, I did not find a significant difference in floral abundance between the control and the repeated sites, so it is unlikely that floral abundance is confounding the bee abundance results. I also compared the daytime high temperature of the control and repeated sites, and I found there to be no significant difference (Figure 8). Sampling was never conducted on rainy days, so rainfall is unlikely to be a confounding factor. The results support my null hypothesis that sampling has no effect on bee abundance. This study is important because it was the first investigation into whether repeated pan trapping over long time periods affects bee abundance. Pan traps are the most commonly used and efficient type of trapping used today (Westphal et al. 2008). This study offers an important control to studies that implement standard bee monitoring

techniques over long time periods and though repeated sampling. This investigation was conducted over a five week period and therefore cannot predict long term patterns. I believe there needs to be another control study performed after more time has passed to determine if repeated and long term sampling affects bee abundance over time periods that were not detectable in this investigation.

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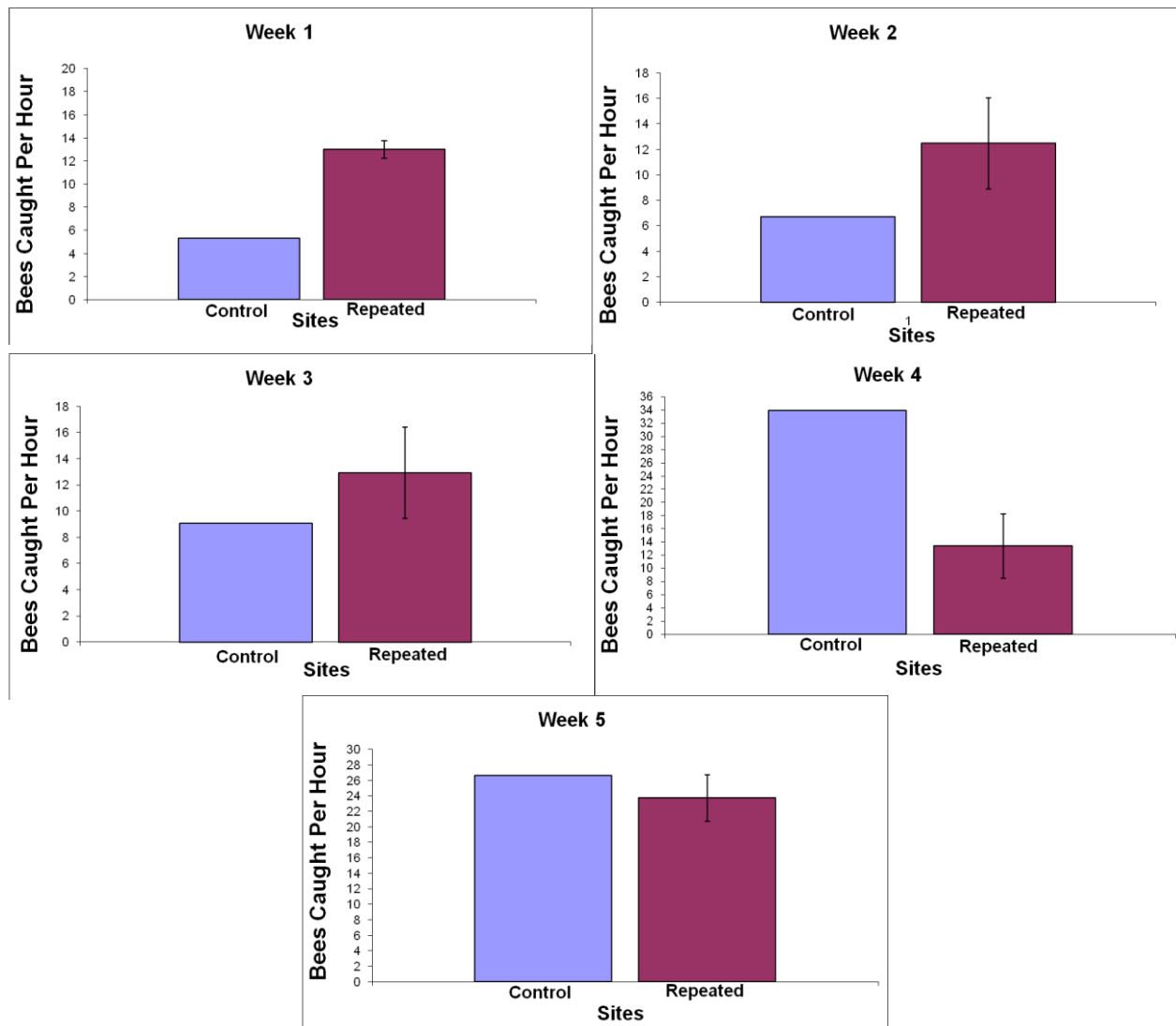


Figure 1: Dry Sites, Bar charts showing bee abundance at the dry sites for each week sampled. The control data is compared to the mean abundance from the three repeated sites sampled the same week. Bee abundance is reported as bees caught per site per hour.

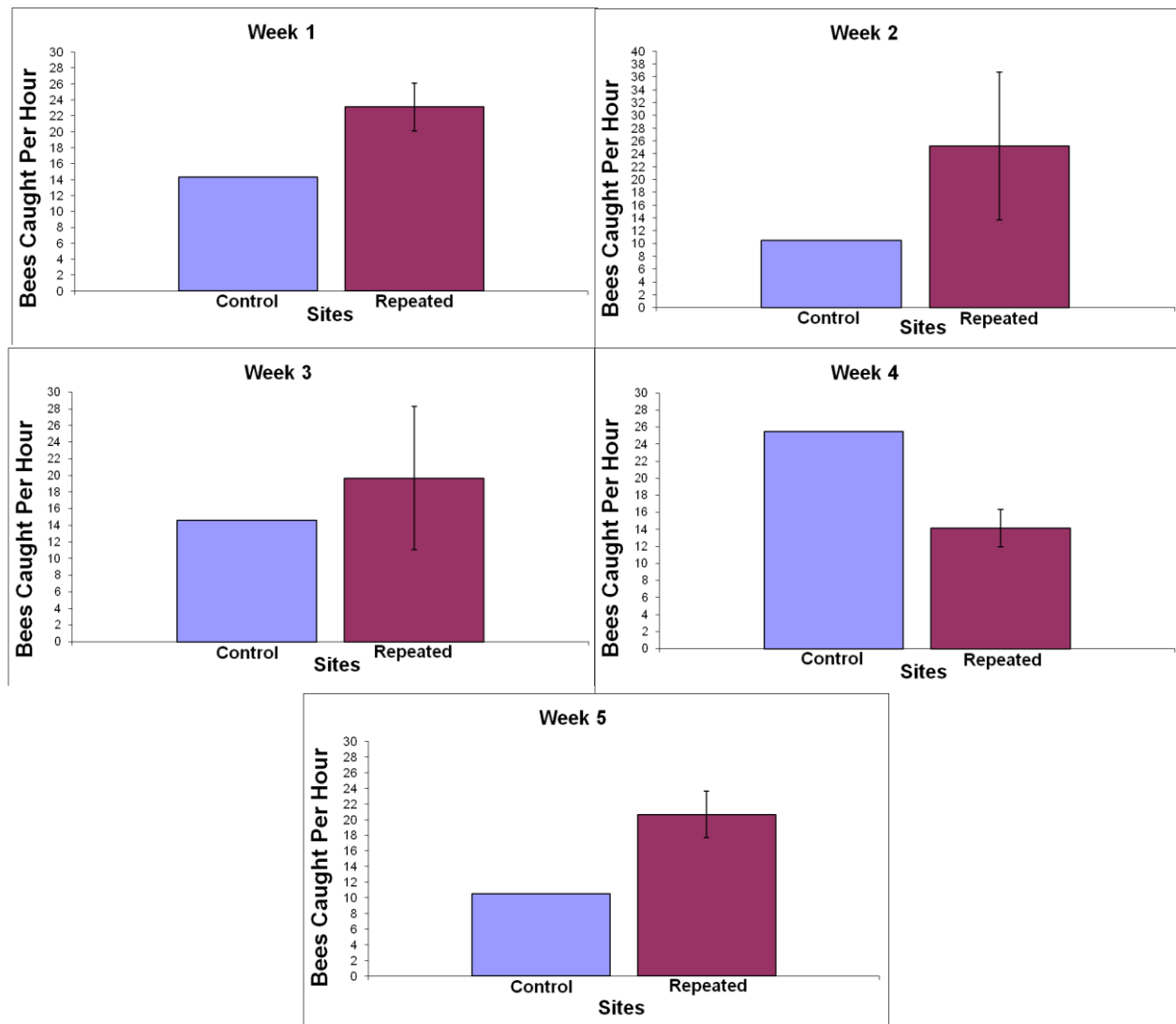


Figure 2: Wet Sites, Bar charts showing bee abundance at the dry sites for each week sampled. The control data is compared to the mean abundance from the three repeated sites sampled the same week. Bee abundance is reported as bees caught per site per hour.

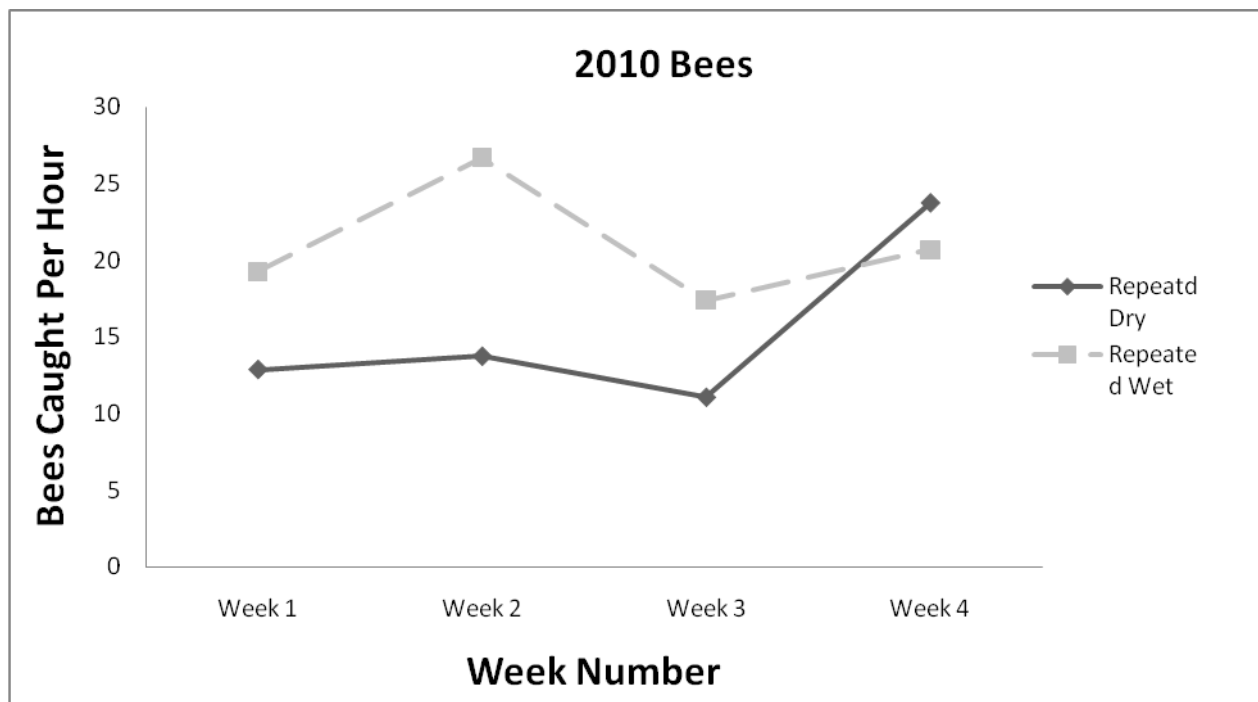
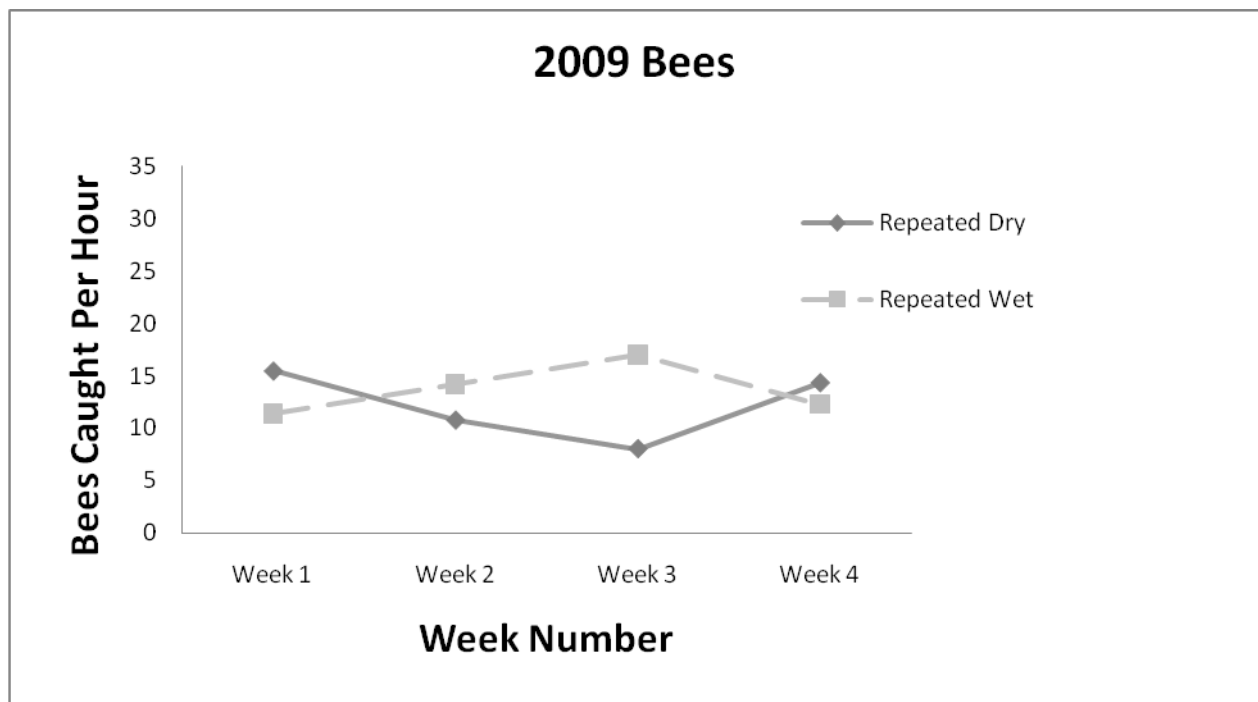


Figure 3: Line graphs showing the bee abundance from week to week for 2009 and 2010. Bee abundance is reported as mean number of bees caught per site per hour.

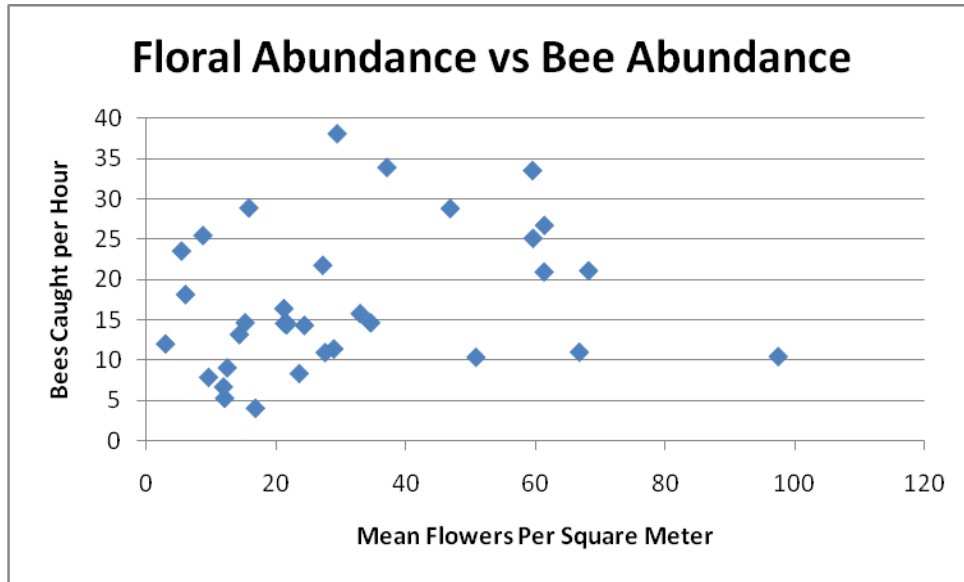


Figure 4: Scatterplot showing a weakly positive, although not statistically significant, correlation between bee abundance and floral abundance ($r_{32} = 0.2353108$, $p = 0.1804$). Bee abundance is reported as mean number of bees caught per site per hour, floral abundance is reported as mean number of flowers per square meter per site.

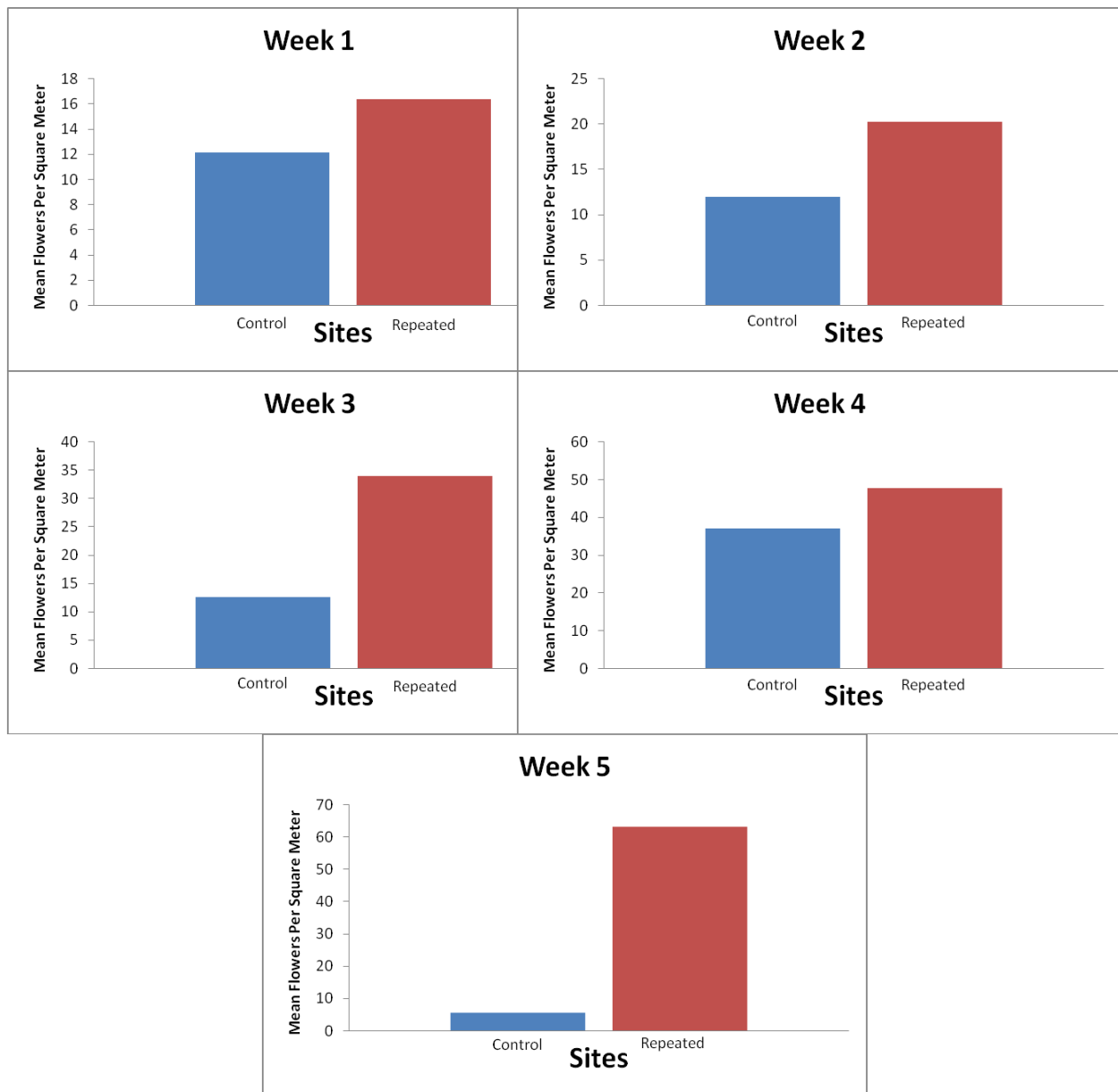


Figure 5: Dry Sites, Bar graphs showing the floral abundance for each week sampled. The control data is compared to the mean abundance from the three repeated sites sampled the same week. Floral abundance is reported as mean flowers per square meter.

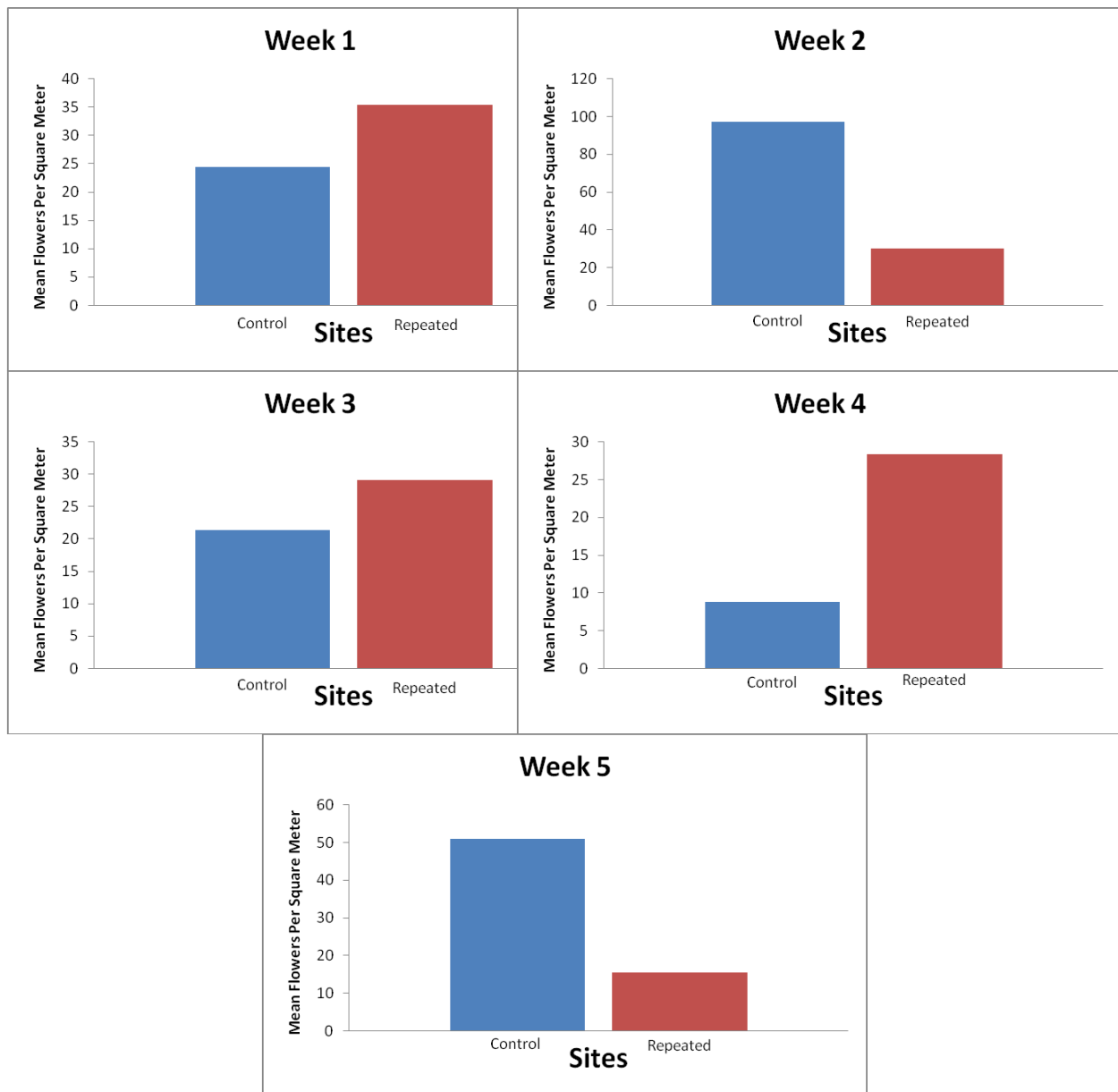


Figure 6: Wet Sites, Bar graphs showing the floral abundance for each week sampled. The control data is compared to the mean abundance from the three repeated sites sampled the same week. Floral abundance is reported as mean flowers per square meter.

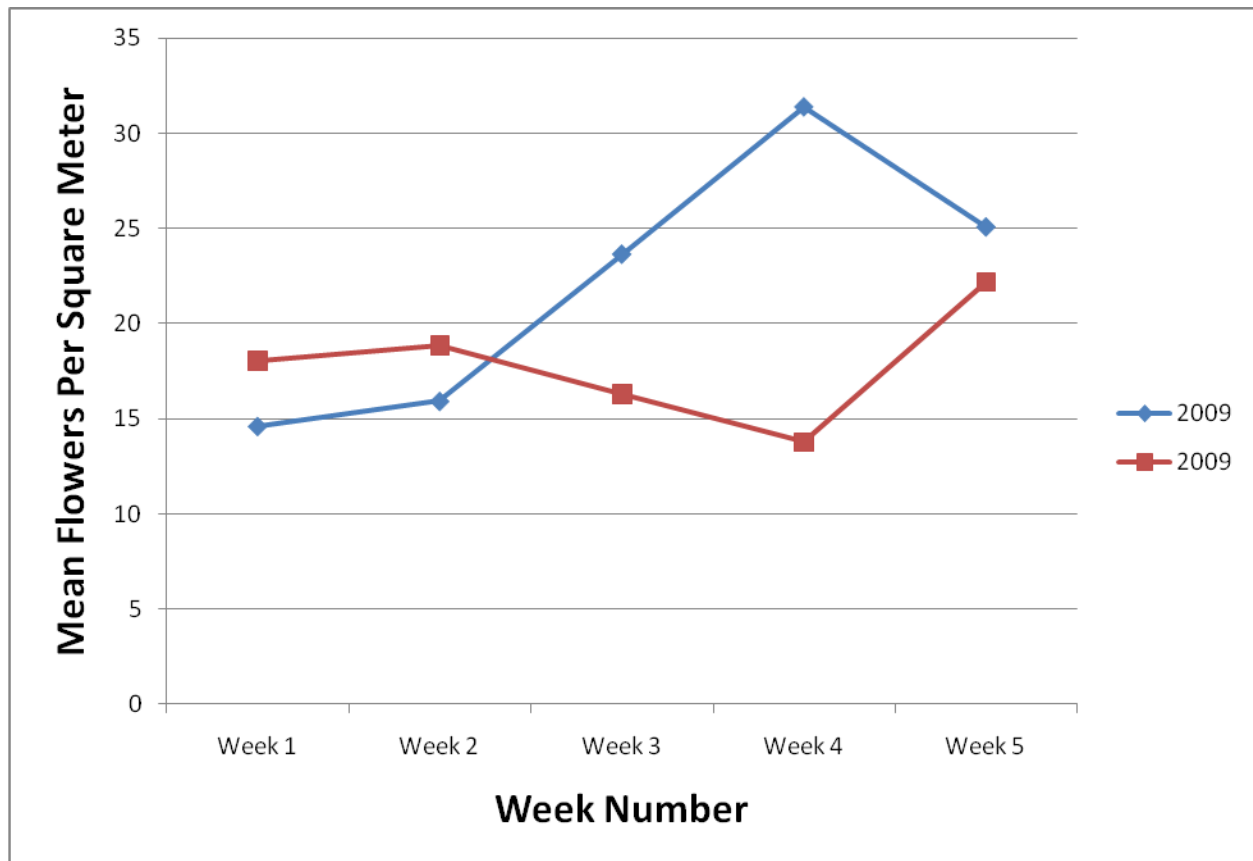


Figure 7: Line graph showing the floral abundance fluctuations from week to week for 2009 and 2010.

Floral abundance is reported as mean number of flowers per square meter.

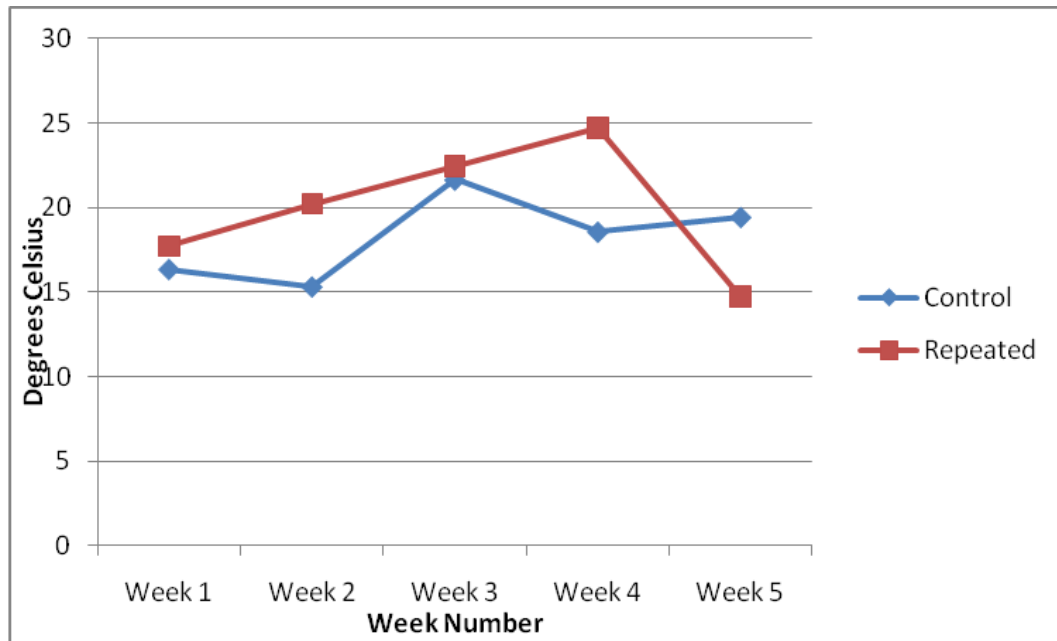


Figure 8: Line graph showing the temperature fluctuations over the course of the five weeks of sampling. No significant difference was found in daytime high temperature ($t_4 = 0.8941$, $p = 0.4218$).