Research with iPiPE: A Diverse Educational Experience

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Pests of Sweet Corn: Pestwatch

Introduction:

Zea mays L. ,(sweet corn), is a valuable commodity for farmers in Pennsylvania. The most recent census from the United States Department of Agriculture reported sweet corn was a 19.5 million dollar industry in 2016 (USDA, 2016). Corn accounts for 95% of all field grain production, making it the most widely produced feed grain *(Corn and Other Feed Grains: Overview*, 2012). Sweet corn is also a crop grown locally in the region of Centre County, Pennsylvania, whose crops are routinely threatened by pests. Damages and losses of crops are repeatedly attributed to pests such as *Spodoptera frugiperda* (fall army worm). *S. frugiperda* is a pest of a wide variety of crops, including *Zea mays* (corn), and is classified as highly mobile insect. Although it is known to overwinter in southern areas such as Texas and Florida, the infestation can reach areas of the Northeast as far as Quebec, Canada (Westbrook, Nagoshi, Meagher, Fleischer & Jairam, 2006). *Helicoverpa zea*, (corn earworm), and *Ostrina nubilalis*, (European corn borer), are two other notorious pests of sweet corn; damages from *H. zea* alone can be blamed for 50% of the losses in sweet corn in some states (*Corn Earworm (Helicoverpa zea*), 2004). In the interest of food security, it is vital that regions communicate and employ integrated pest management techniques to control these seasonal migratory and residential pests. Tracking their migration pattern and emergence through the northeast with pheromone traps is one damage prevention method that can be used to gather data for distribution. Pestwatch is a well-established program that was designed with that specific intention in mind. Pestwatch offers regional, interactive maps and information for farmers and growers to use to make informed decisions for insecticide spraying and other crop protection methods.

Our overarching objective of the Pestwatch project was to report catches of the three pests mentioned above within Centre county and to collaborate with other counties information to create a weekly bulletin with recommendations for spraying frequencies for farmers.

Methods

Pheromone traps were set at three different locations in Centre County and are pictured below in *figure 1.* Due to varying field sizes, site 1 and site 3 have only one pheromone trap for each pest, except for the European corn borer which has two traps because we have two different pheromone races. A total of 12 corn earworm (CEW) traps, 6 European corn borer (ECB) traps, and 4 fall army worm (FAW) traps were split across the three locations. We used a 2-component lure for FAW, based upon prior research indicating that other currently marketed versions are more likely to attract a bycatch of *Leucania phragmatidicola* (Fleischer, Harding, Blom, White & Grehan, 2005).

Collections were recorded on a semi weekly basis that was subject to change based on weather conditions. Pheromone lures were replaced every 4 weeks. Weekly catch values were reported directly to farmers per their request as well as uploaded on to Pestwatch. Catch values were reported with the following information: date, site name, type of trap, number of nights trapping, average catch value, and lure type. This information was then submitted and input into the mapping system.

Based on the number of trap counts, the map displayed a visual representation of the infestation that corresponded to advice on spray timing (*table 1, figure 2*). Catch classification, catch per week, and spray frequency were used to coordinate the color and size of the circle representation. The same range was used for all three pests. The map displayed other county's catches and offered viewing options such as satellite and terrain. The date could be scrolled along the bottom to allow for easy observation of past and current pest trends.

A weekly summary compiling information on each pest that included images of feeding damage was created to use for further distribution and extension in Pennsylvania. Spray frequency thresholds were based off of *H. zea (table1).*

Figure 1:.

Figure 2: Traps counts corresponded to color and size of the circle displayed on that week's map. This information was accessible in the legend of the map.

Table 1: Recommended *Helicoverpa zea* (corn earworm) spray frequencies based on the range of values for catches per week.

Catch Classification	Catch per Week	Spray Frequency
Almost Absent	1 – 13	4 Days to No Spray
Very Low	14 – 35	5 to 6 days
Low	36 – 70	4 to 5 days
Moderate	71 – 349	3 to 4 days
High	> 350	2 to 3 days

Results

Helicoverpa zea (corn earworm) was the biggest pest threat in Centre County during the summer season, however the highest the catch classification reached was rare. The pest was most prevalent in the county from late June to late July. The average weekly catch was highest during late June when 40.3 catches were estimated at Site 3 *(figure 3*). Catches for both *Spodoptera frugiperda (*fall army worm) and *Ostrina nubilalis* (European corn borer) were very low for the duration of the season in Centre County. Catches for both pests did not exceed 15. *H. zea* was still the primary pest when factoring in all thirty trapping sites across the state. However, the prevalence differed from Centre County's, as most counties and sites reported a moderate to high pest presence starting from early August to early September *(figure 4*).

Figure 3: Site 3 had the highest average weekly catch during the week of June 20th, 2017.

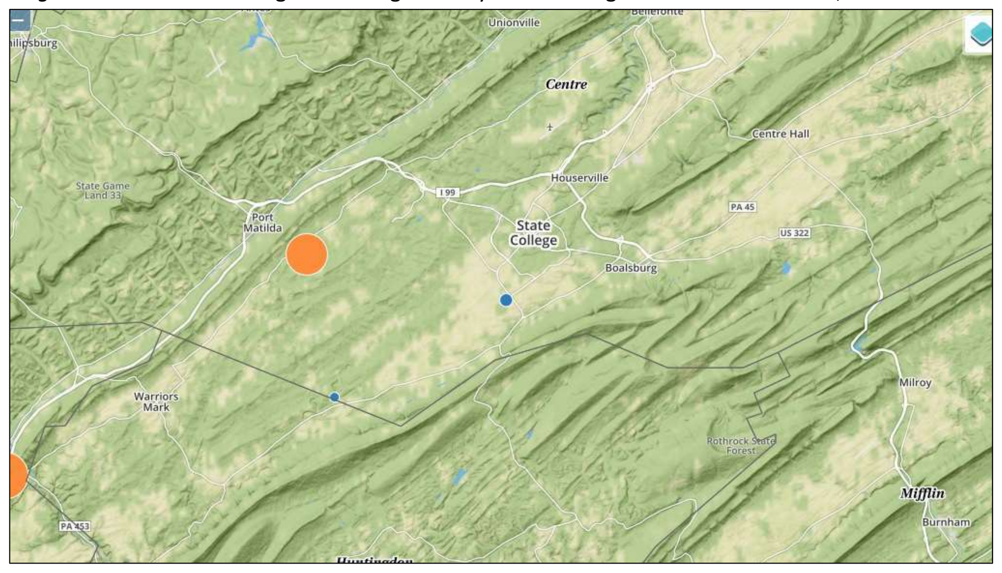
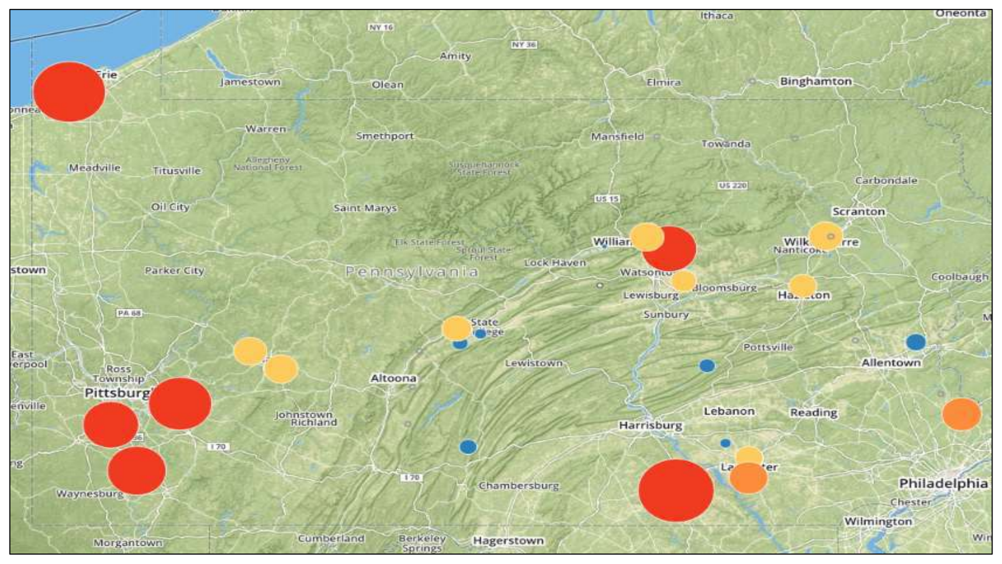


Figure 4: A screenshot from Pestwatch displaying the weekly average catches for all 30 site in Pennsylvania (September 4th, 2017).



Discussion

Our results emphasize the importance of integrated pest management platforms with easy to use maps that allow users to observe trends outside of their counties and states. While Centre County's average weekly catch values did not exceed 41 *H. zea* during the duration of May through September, other counties reported values as high as 174. Centre County's highest average weekly catch count occurred early in the season while other counties were reporting higher counts towards the end of the season. Pestwatch allowed counties to review reports from their own area while considering other state intel.

There is a limit to the information Pestwatch can report. Different management techniques and insecticide type and usage is not considered when entering trap counts. One location may use a more efficient method or insecticide compared to another. Some locations may not be spraying at all. Weather, climate, and terrain are also not considered when making reports and entering the data.

Future research should strive to incorporate weather data in their reports. Weather may effect emergence date of both migratory and residential pests. Integrating this information into the site could assist researchers to better predict pest trends. Code is also currently in the works to create a data flow between Pestwatch and iPiPE (Integrated Pest Information Program for Extension and Education). Pestwatch and iPiPE are similar in the their objectives. Expansion and integration of information between sites would extend the reach of both platforms and further protect farmers' revenue and our food security.

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Bombus impatiens Population Abundance Study

Introduction

Recent declines in *B*ombus communities across the United States and in Europe have concerning implications for food security (Goulson, Lye, & Darvill, 2008, Grixit, Wong, Cameron, & Favret, 2009, Carvell *et al*., 2011). Pollination is essential for successful reproduction of crops and research has linked higher bee visitations to better fruit yields (Suni *et al*., 2017). Declines in pollination have led several farmers to start hiring honey bee hives in order to meet their pollination goals (Garibaldi *et al*., 2013). *Bombus impatiens*, the common eastern bumblebee, pollinates several important crops such as blueberries, cranberries, and pumpkins. *Cucurbita pepo*, otherwise known as field pumpkins, is grown locally in Centre County and studies have indicated that *Bombus impatiens* are the primary pollinator group of this crop (McGrady *et al*., unpublished). Pennsylvania was ranked as the 4th biggest of producer of field pumpkins in 2016 and was a 14.5 million dollar industry (USDA, 2016). Although *B. impatiens* is listed as a stable pollinator, very few population studies have been conducted to evaluate their health status. Declines of this particular pollinator could have devastating consequences for farmers and their crops.

Our objective was to asses *Bombus impatiens*' population abundance and stability in Centre County from 2013 to 2015 using detected colony numbers obtained from microsatellite technology and the sib-ship program, COLONY (Jones & Wang, 2007). Microsatellites are highly conserved noncoding repetitive tandem repeats that range in size. Microsatellites are surrounded by flanking regions which can be used to developed locus-specific primers, and those primers can then be used for a polymerase-chain reaction to extract and amplify the specimens' DNA. The results can then be sequenced, genotyped, and sorted into sib-ships to estimate population abundance at the level of the reproductive unit: the colony.

Methods

Approximately 200 *B. Impatiens* were collected out of three sites in Centre County over the course of three years *(figure 1, table 2*). Vials were carefully placed over a bee actively foraging in a *Cucurbita pepo* flower and then directly placed on ice. Once captured, the bees were transported back to the lab where they were then put in a -20 ◦C fridge for storage. Bees were removed and allowed to unthaw to remove their midleg which was placed in a well plate for the molecular procedure. The bees were pinned and preserved in a Cornell box located in the Fleischer lab. The well plates were prepped for a polymerase chain reaction and primed with the 11 loci markers. After amplification, the well plates were sent to the Penn State Genomics Core Facility for sequencing. All of the molecular work occurred in Dr. Grozinger's laboratory in the Center For Pollinator Research at Penn State University.

Results from the sequencing facility were then genotyped, a practice entailing calling peaks that represented different alleles of each bee, using the program GENEIOUS 10.0.09 (Biomatters Ltd) (Kearse *et al*., 2012). *B. impatiens* that were successfully genotyped were rarefied to 176 bees per site to standardize the sample size. The results were formatted to the correct input for the program COLONY V.2.0.6.2. (Jones & Wang, 2010) which used the maximum likelihood sibship method to estimate detected colony numbers. Colony ran three times per site and the mean of all three runs was used as the final detected colony number. The p-value for statistical tests was adjusted using Bonferroni corrections. One-way analyses were performed with the program JMP-PRO.

Table 2: Specimen collections occurred during peak blooming season.

Site	Year	Collection Date	Specimens Collected
1	2013	July 31st	245
2		August 18th	218
3		August 22nd	242
2	2014	August 24th	214
3		August 28th	220
2	2015	August 15th	232
3		August 26th	180

Results

The results from the program COLONY are listed in *table 3*. A one-way analysis of variance was performed to compare the average number of bees detected each year in Centre County. No significant difference between yearly means was found (p-value = 0.996) *(figure 5*). A one-way analysis of variance was performed to compare the means of the two sites, site 2 and site 3. Only site 2 and site 3 were compared because specimens were collected each year from the two locations. No significance difference was found between site location (p-value = 0.128) *(figure 6*).

Table 3:

Site	Year	Number of colonies detected
1	2013	147
2		129
3		145
2	2014	129
3		150
2	2015	143
3		138

Figure 5: The means for each year were $X_{2013} = 140 \pm 6$, $X_{2014} = 140 \pm 7$, and $X_{2015} = 141 \pm 7$, p-value = 0.996.

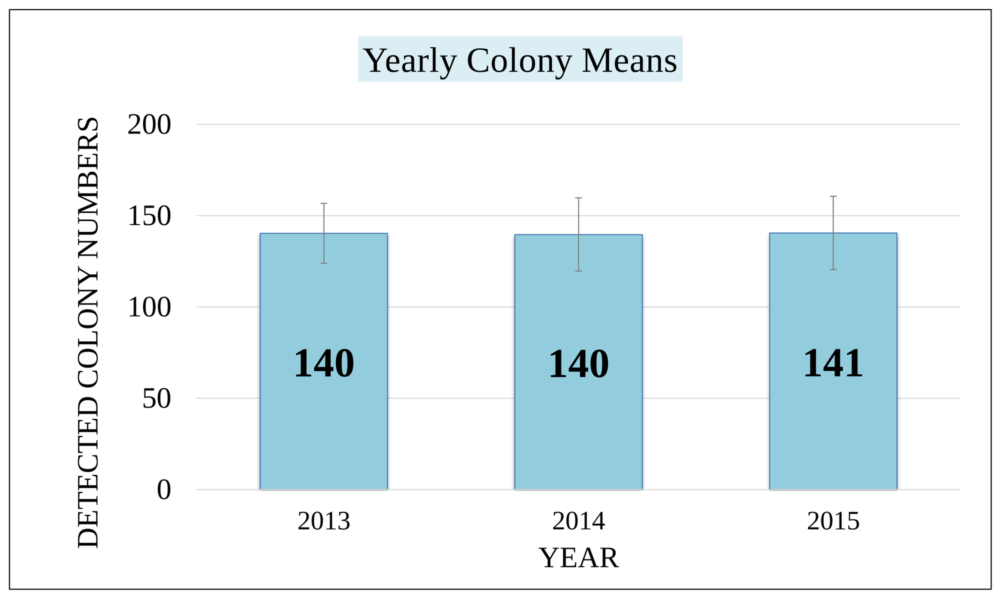
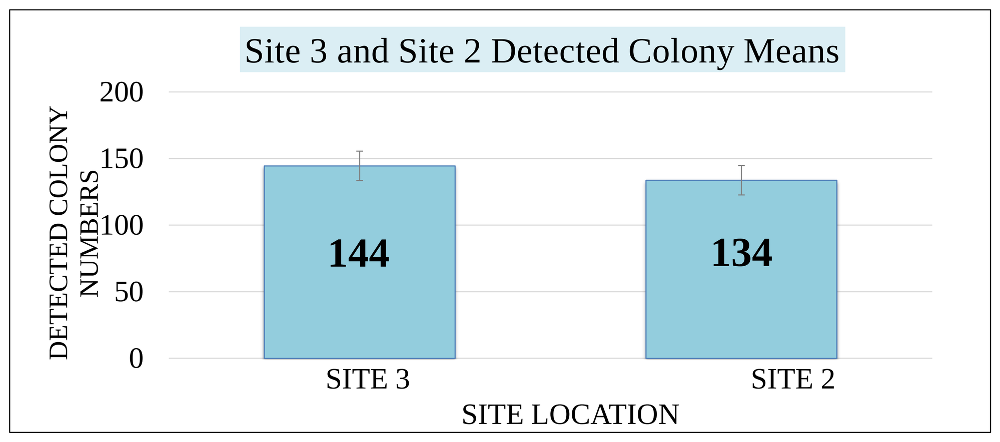


Figure 6: The colony means for each year were $X_{SITE\ 2} = 134 \pm 4$, $X_{SITE\ 3} = 144 \pm 4$, p-value = 0.128



Discussion

Centre County had abundant and stable *Bombus impatiens* population from 2013 to 2015. There was no difference between years suggesting that colonies were producing at a stable rate. When comparing site 2 and site 3, there was no difference between means which is evidence that the species was abundant across the county. We cannot conclude that abundance and stability of these pollinators will be a continued trend in Centre County because we were working with small sample size for the number of years.

Future research should strive to answer why *B. impatiens* are persevering when other species of *Bombus* are in decline. We did not incorporate terrain or landscape data or seek to control factors such as field size and management techniques and therefore can only speculate as to why our bees were stable and abundant. There is also plenty of support that genetic diversity is linked to health and survival of a populations in bees (Cameron *et al*., 2011). Further genetic analysis would be necessary to see if this was the case in Centre County.

Although this study was only focused in the agroecosystem, *Curcurbita pepo*, *Bombus impatiens* provide a valuable pollination service to several other crops and it should be in the interest of farmers to conserve their wild bee populations. Multiple studies indicate that bumblebees distribute more pollen and higher fruit yields, even in the presence of hired honey bee hives. *B. impatiens* are a crucial wild pollinator that deserve to be conserved for the sake of our crops.

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Managing *Acalymma vittatum*, Cucumber Beetles, While Conserving Pollinators

Introduction:

Research investigating the environmental impact of pesticides classified as neonicotinoids, continue to find adverse effects and alarming toxicity rates for pollinators exposed to the chemicals (Whitehorn, O'Connor, Wackers & Goulson, 2012, Goulson, 2013). Bees provide a crucial pollination service that crops depend on for their success. Both wild and managed pollinators are effected by neonicotinoids and both communities have experienced declines in relation to the pesticide. However, pests like *Acalymma vittatum*, commonly known as the cucumber beetle, assist with the spread of a bacterial pathogen and can cause serious damage if not curbed. Pesticides are useful in protecting plants against pests like the cucumber beetle.

The objective of this research was to determine if Exirel, a diamide systemic, which we believe to be less toxic than neonicotinoids to *Bombus* species, is effective against *Acalymma vittatum* in the agroecosystem, *Cucumis sativus* (cucumbers).

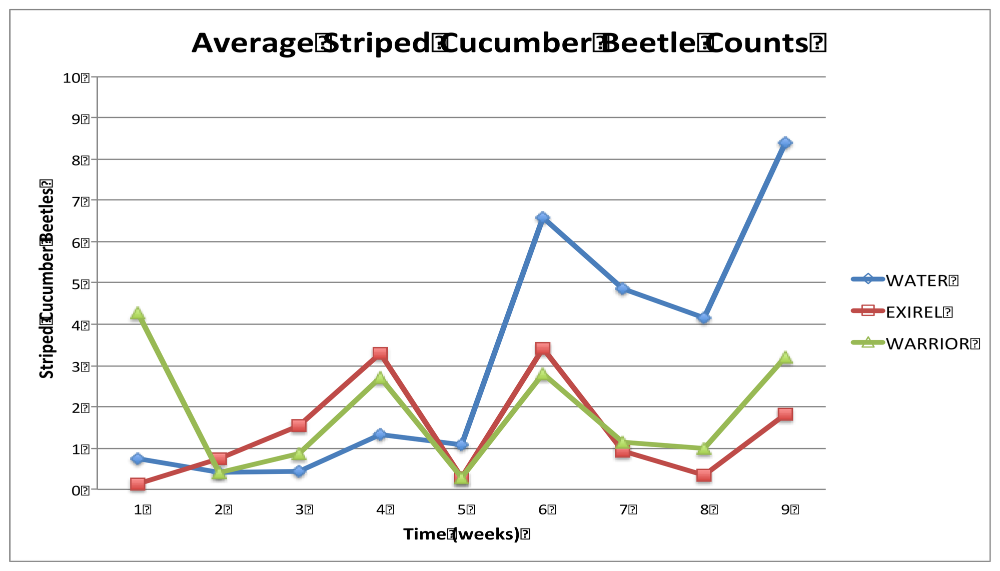
Methods:

A replicated complete block trial was set up with water as the control and Warrior, a standard pyrethroid, for comparison. Data was only collected in the middle three rows, as the outside row was to serve as a border row and protect from potential contamination. Approximately 25 to 30 cucumber plants were in each row. Three measurements of three plants each were randomly chosen to be assessed for the number of live and dead *A. vittatum*. If multiple plants were intertwined, the length of a yard stick was used as the sample unit. Treatments were delivered through drip irrigation.

Results:

The average striped cucumber beetles are represented in a line graph in *figure 7.*

Figure 7:



Discussion:

Based on the results of the trial, Exirel was as effective as Warrior. Exirel also reported low dead pollinator counts, and was therefore considered less toxic than neonicotinoids. Few plants had confirmed the bacterial disease and the plants which have bacterial disease did not correlate to a particular treatment.

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Acknowledgements and Related Experiences

This summer internship was conducted with the help of Christiana Sanden (the 2nd summer intern). The work with *Bombus impatiens* was with the supervision of a graduate student, Carley McGrady, and the work with *Acalymma vittatum* was with the supervision of a technician, Dana Roberts.

The field portions of the work occurred in grower's fields. We thank the farmers who allowed us to work in their farm sites.

In addition to these 3 projects, this internship included experiences with:

1. Evaluating floral resources for diverse bee assemblages achieved with cover crop mixtures, when these mixtures are managed for the purpose of provisioning nutrition for *Bombus* species. This work was done with the supervision of a graduate student, Erin Treanore.
2. Evaluating management of *Phytomyza gymnostoma* (Allium leafminer), a new invasive species, in onions and leeks, with the use of trap crops and insecticides. This work was done with a regionally based Extension Educator, Dr. Tim Elkner.