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# Don't Spray the Wasps! Using *Polistes* Paper Wasps for Pest Management in the Home Garden

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**Abstract.** Pest control poses a challenge to all gardeners, especially those wishing to use organic practices. We examined the potential use of *Polistes* paper wasps as a bio-control agent in the organic backyard garden. *Polistes* are important predatory insects which may potentially consume thousands of soft bodied pest insects per season. We planted 8 garden plots with leaf lettuce, cabbage, pole beans and tomatoes. In 4 experimental plots, we established 8 *Polistes dominulus* nests, while in the remaining control plots we did not establish wasp nests. We measured the abundance of pest insects, the extent of damage from insect pests, and the weight of the plants at harvest. We did not observe any statistically significant differences between the experimental and control plots, however, we did find that cabbage plants from plots with more wasps had less insect damage than plants from plots with fewer wasps. Although our study appears to demonstrate that *Polistes* wasps were not effective in controlling pests, the observation that wasp number influenced damage levels in cabbage suggests that, at least for that crop, there is a density of wasps that can be effective.

## Introduction

The realization that large-scale industrialized agriculture may have substantial ecological and medical costs has increased consumer appreciation of the benefits of organically grown food. The harmful chemicals and pesticides used in commercial agriculture can result in contamination of the food chain and ground water posing health risks to humans and wildlife (Blair *et al*., 2005; Devine and Furlong, 2007; Lew *et al*., 2009). This has led to an increase in home gardening, community gardens and farmers markets throughout much of the U.S. (www.ers.usda.gov/Data/Organic/). Organic gardening is defined as gardening with limited or no use of chemical fertilizers, pesticides and herbicides, naturally building the soil to support healthy plant life (Borsari, 2001). With an increasing interest in the benefits of organic gardening and home gardening, there has been an associated appreciation for the problems associated with chemical free gardening on a small scale.

For all gardeners, pest control is challenging, but especially so for those using pesticide-free organic practices. It is important to continue to find new approaches for pest control that do not rely heavily on pesticides. Many gardeners opt to use chemicals to control pests even though this is at odds with the very reasons they create their own home garden in the first place. However, by using natural predators of the pest they are trying to control, they may be able to find a suitable alternative to the chemicals and pesticides they are presently using.

Wasps are common and effective predators of other insects and have previously been used to control invasive or damaging pests in a variety of settings (Cox and Pinniger, 2007; Kimber *et al*., 2010; Gould and Jeanne, 1984). *Polistes* paper wasps prey on a variety of potential insect pests, exist at high densities, and are found throughout the world (Prezoto *et al*., 2005, 2006; Reeve, 1991). They are frequently found on houses and in backyards. In western Michigan, there are two common *Polistes* species: *Polistes fuscatus*, a native wasp species, and *Polistes dominulus*, an invasive species introduced to the US in the 1970's from Europe (Liebert *et al*., 2006). Ironically, home-owners and gardeners often spray these wasps with pesticides, lumping them in with the very pests they may potentially assist in controlling.

*Polistes* wasps initiate new colonies in late spring, when one or a few young females, or foundresses, emerge from a winter diapause. The foundresses build new nests out of macerated wood fibers (hence the common name "paper wasps"), constructing individual cells where they will oviposit eggs. Foundresses initially forage for food and defend the nest, raising the first generation of young. The young emerge after about 30 days and become the workers that take over foraging, defense, and raising the subsequent generations. The foundresses continue to lay eggs providing for continued growth of the colony over the summer season until late August/early September (Reeve, 1991).

In this study we investigated whether the presence of *Polistes* wasps reduced insect pests and the damage they cause in small gardens. We planted small, garden plots with leaf lettuce, cabbage, pole beans and tomatoes established *Polistes dominulus* nests in half of them. We compared the abundance of pest insects, the extent of damage from insect pests, and the dry or wet weight of the plants harvested to determine whether *Polistes* effectively controlled pest insects in each crop.

**Methods**

In the Spring, 2011 we built 8 raised garden beds measuring 3'x8'x10". To keep out unwanted predators, we built a 4' high fence around each plot that was 5' wide x 10' long. In order to leave a walkway for maintaining the garden beds, the fencing structure was placed leaving a 2 ft walkway on the north end of the box and also on the east side. We placed straw on the ground in the fenced in areas surrounding each bed to control weeds.

We placed the beds in 2 groups, 4 with wasp nest boxes attached to the fence posts surrounding each plot (experimental plots) and 4 without nest boxes attached to the fence posts (control plots). The plots were placed in a square, 22 ft apart. The two groupings were placed about 110 ft apart, separated by building structures to attempt to prevent the wasps from foraging in the control plots (Fig.1) This arrangement both facilitated garden maintenance and maximized the distance between beds while keeping the control and experimental plots separate.

We built the boxes out of ½" plywood with dimensions 8"x9"x8" with an 8"x9" piece of ½" hardware cloth on the bottom to keep out predators. The top had holes drilled on two ends, down into the sides of the box, with two nails inserted to keep the top from blowing off and for easy access for evaluating wasps and nests. The boxes were attached to the metal fence poles and poles were placed in the ground at each corner of the garden box so that the bottom of the nest box was approximately 4 ft. off the ground.

On May 3rd, we planted the garden beds with lettuce seeds (Green Salad Bowl) and cabbage seeds (Coeur de Boeuf) in separate rows by direct sowing the seeds to get 6 lettuce plants and 5 cabbage plants. On June 4, we planted pole beans seeds (Purple Podded Pole) at the foot of 8 trellis-strings in each plot. These were planted in the row with the cabbage. On June 15 we planted 5 tomato seedlings (Brandywine) per garden bed. These were bought from a local grower. They were planted in between the lettuce as the lettuce was going to be harvested soon. We watered plots as needed to ensure a minimum of 1" of water per week, and weeded on weekly basis to maintain weed free gardens.

From May 16 to June 2, we collected *P. dominulus* wasps and their nests from sites in the Grand Rapids, MI area and transferred them to the wasp boxes. To prepare nest boxes for the transferred nests, we stapled cardboard on the bottom to keep the foundresses from abandoning their nests immediately. We captured the foundresses with an insect net and held them while we transferred the nests to the boxes. To transfer nests we removed nests from their original substrate with forceps, and using Gorilla brand glue, we glued the pedicel (i.e., the top of the nest) to the inside of the nest box top so that the nest hung down when the top was placed on the box. Then the foundress was taken out of the net and placed in the box. An attempt was always made to put her on the nest but if this failed she was placed on the bottom of the box. The lid was then closed. We placed the occupied nest boxes back on the poles around the 4 experimental plots and removed the cardboard within a couple of days after transfer to subsequently allow the foundresses to forage.

Following nest transfer, we surveyed nests weekly to determine the number of adult wasps. We surveyed nests in the morning before they started foraging. After July 29$^{th}$, many of the nests became too aggressive to get accurate counts so from that date on, we only checked that the nests were still active, but did not keep counts of adult wasps.

On June 21$^{st}$, and again on June 29$^{th}$, we harvested the lettuce. We harvested half of the lettuce from each plot on each date and assessed the number of insects, the extent of leaf damage and the weight of each lettuce plant. We bagged the entire lettuce plant ensuring capture of as many pests as possible. We placed a plastic bag over the lettuce, cut the lettuce leaves off just above the ground and tied up the bag to prevent insects from escaping. We then put killing agent on a piece of paper towel to kill the insects for easier collection and placed the paper towel in the bag with the plant. In the lab, we removed all invertebrates from each leaf, and then scored the extent of damage to each leaf as 0=no damage, 1=minor damage (smaller than 2 cm), and 2=major damage (larger than 2 cm). We preserved any insect pests in 70% Ethanol for later counts. We washed and dried the leaves, placed them in paper bags, recorded the initial wet weight and the dry weight after 48 hours in a drying oven.

We harvested 2 cabbage plants from each plot on July 18 to count the number of insect pests and to score leaf damage. These cabbage plants were harvested in a similar manner as the lettuce. A bag was placed over the plant to capture as many insects as possible, the plant was cut from its roots at the ground, and the plant was frozen to kill insect pests. We counted the number of caterpillar larva belonging to the family Pieridae on each plant and counted the number of leaves with less than 10% of their surface damages, those with 10-50 % damage and those with greater than 50% damaged. We harvested the remaining plants as they matured, removing damaged leaves and weighing the undamaged cabbage head.

Similarly to the cabbage, we removed 2 of the 8 trellis-strings (each string having 3-4 bean plants) from each plot on July 25 to assess pest abundance. We placed the plants into a plastic bag and froze them to kill insect pests. In the lab, we collected insects using the same procedure as the lettuce but did not weigh the leaves since they are not the final consumable product of the bean plants. From August 5 to September 8, we harvested the beans. Because the bean plants all grow and wind up the trellis, it was not possible to assess production per plant, but only by plot. In the lab we weighed the undamaged beans and recorded the total weight per plot. If a bean was longer than 12cm we determined that it had not been harvested soon enough, and rather than use its weight for calculations of the total weight of the harvested beans, which would skew the weight of beans harvested, we used a weight of 3.06 g that reflected the average weight of beans that were harvested in a timely fashion.

On August 1, we harvested 2 tomato plants from each plot to assess pest abundance, primarily the tomato hornworm (*Manduca quinquemaculata*). We harvested tomatoes using a similar procedure as with the other 3 vegetables. We collected hornworms, preserving them in 70% Ethanol, and recorded the number from each plant and plot. From August 24 through September 30 we harvested mature, undamaged tomatoes. In the lab we recorded each tomato's weight and the total weight of tomatoes harvested from each plant.

**Results**

We transferred 15 *Polistes* nests (13 *P. dominulus* and 2 *P. fuscatus*) nests and 8 of them successfully established in the gardens (see Figure 1 for locations). All of the successful nests were *P. dominulus*. All nests were either pre-emergence nests (i.e., with no workers yet), or had 1-2 young workers. From June 21st until July 29$^{th}$, the number of wasps increased from 14 to 55 (Figure 2).

We did not find any differences between the control and experimental plots for lettuce, cabbage, beans or tomatoes. There was no difference in the average number of insects, the extent of damage to the leaves, or the harvested weight for either lettuce (Figure 3) or cabbage (Figure 4).Neither were there differences in the number of insects or the harvested weight for the beans (Figure 5) or the tomatoes (Figure 6).While there were no differences between the control and experimental plots, we did observe that cabbage leaves from experimental garden plots with more resident wasps had less damage that cabbage leaves from plots with few or no resident wasps (Figure 7).

**Discussion**

The garden plots with wasps did not have fewer pests, less damage or greater production of undamaged produce than the control plots that lacked wasps. However, we did detect an effect of the wasps for cabbage when we examined the manner in which the number of wasps in a specific plot affected damage level. Plots with more wasps had less damage. Previous work has demonstrated that *Polistes* wasps can be used to control pests in cabbage (Gould and Jeanne, 1984) and our results are consistent with those findings. The observation that plots with more wasps had less damage, even though the plots were relatively close to each other, suggests that wasps may focus their foraging effort relatively close to home. This may also depend upon the species of *Polistes*, as some *Polistes* wasps have been shown to forage over different ranges (Dew and Michener, 1978). Therefore, the backyard organic gardener should not count on wasps from distant nests to control pests, and could even benefit by encouraging wasps to nest close to their gardens.

This study sought to determine whether the effectiveness of *Polistes* wasps for controlling pests in cabbage could be extended to the backyard garden in which there are fewer plants and a greater variety of crops. Our results do not provide evidence of effectiveness for other crops. However, we were able to show an effect in cabbage even though they represented a small number of plants in a more diverse garden. Some of the crops matured and were harvested before the wasps had established nests, or had undergone significant portions of their growing season prior to the emergence of large numbers of workers. Thus, the smaller colonies that characterize the beginning of the season might not provide sufficient protection.

While *Polistes* are sometimes considered generalist predators, they may in fact be specialized to some degree on caterpillars (Reeve 1991). It's possible that *Polistes* are effective for the control of pests in cabbage, but not in other crops, because cabbage plants are predominantly attacked by Pierid moths. We did not find any caterpillars on either the beans or the lettuce. A major pest on the tomato plants was the tomato hornworm, also a caterpillar, but they grow quickly and may become too large for the wasps to efficiently kill and transport back to the nest.

While our study provides limited evidence that *Polistes* can be used to control pests in small gardens, it also suggests a number of limitations in their use. Because they are social, they live at high densities, but they don't achieve large colony size until later in the spring. Therefore, some crops, which mature in mid to late summer, will benefit more from their presence than others which mature early. Also, while they may be characterized as generalist predators, they probably do specialize to some extent on caterpillars, and certainly, on soft-bodied insects. They also forage for their prey on leaves and stems. Therefore, their utility can be limited when pests are not soft-bodied or are located in protected sites such as the soil. However, some specialization might allow them to be used in conjunction with other bio-control agents such as praying mantises, spiders and lady bugs (Snyder and Ives, 2003).

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Figure 1. A diagram of the study site, including the location of the control plots (NO Wasps), the experimental plots (Wasps) and their relationship to each other and the other structures on the property.

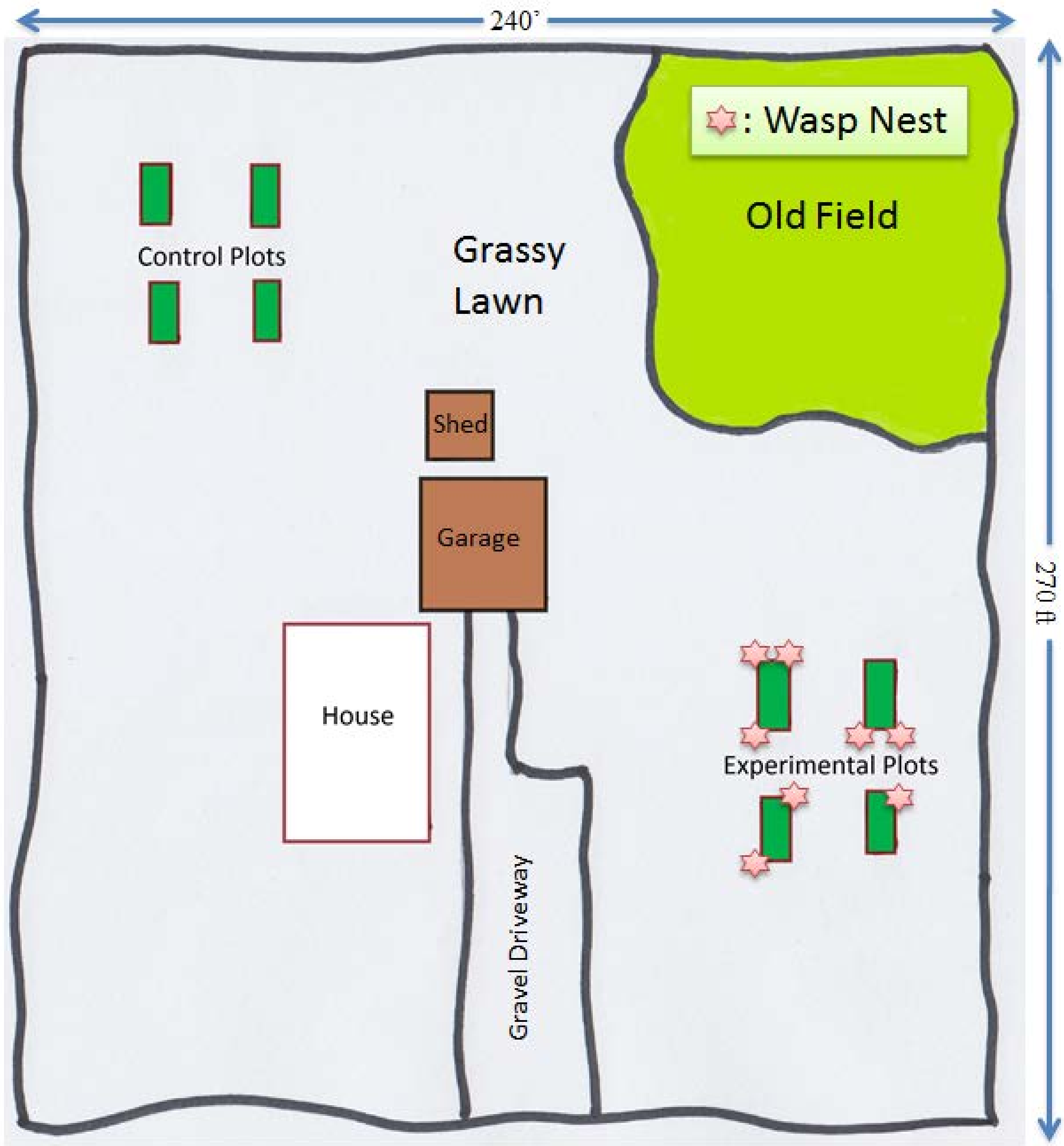


Figure 2. The total number of wasps in the experimental plots over the course of the growing seasons of the lettuce (blue), cabbage (green), beans (purple), and tomatoes (red). Surveys were not conducted after July 29th.

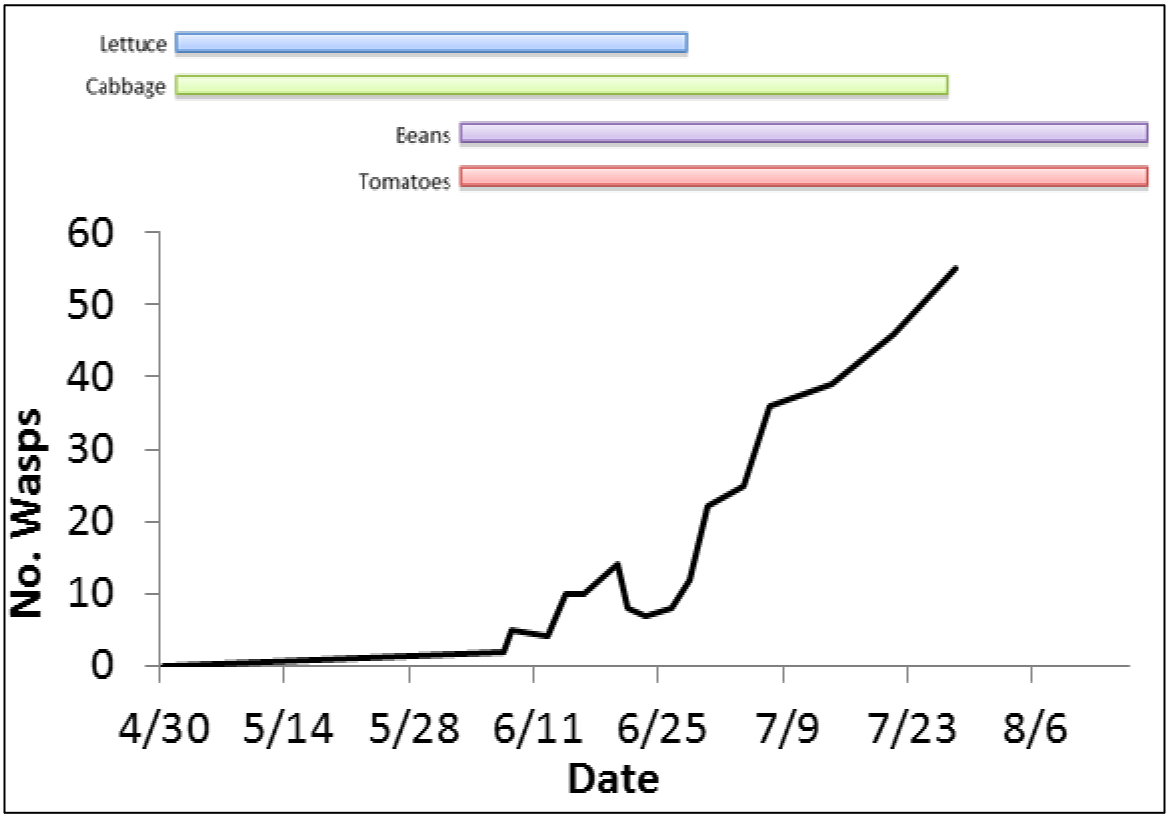
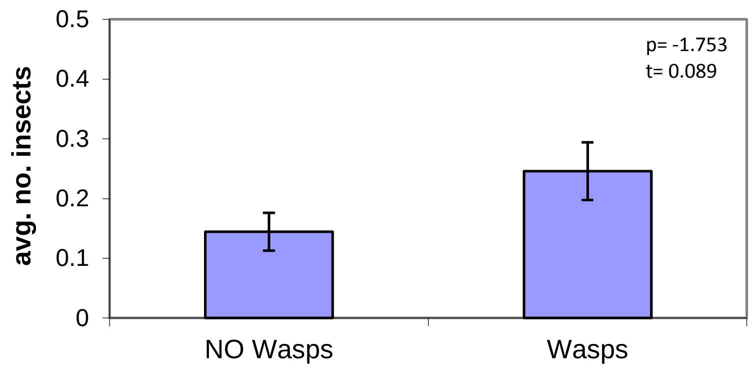


Fig. 3 A comparison of lettuce grown in the control plots (NO Wasps) and experimental plots (Wasps) for (a) the average number of insects on each lettuce head, (b) the average proportion of leaves that were damaged per lettuce head, and (c) the average dry weight of each lettuce head.

a)

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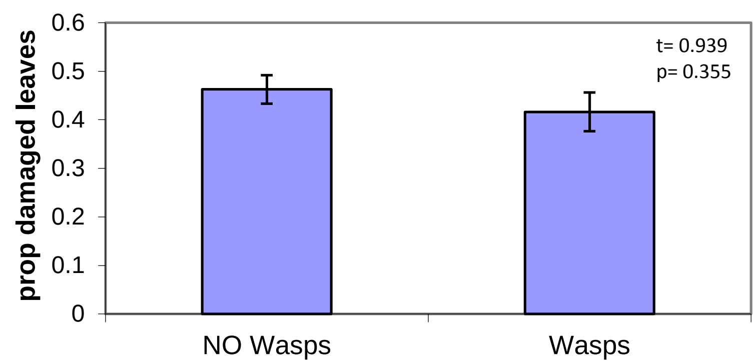


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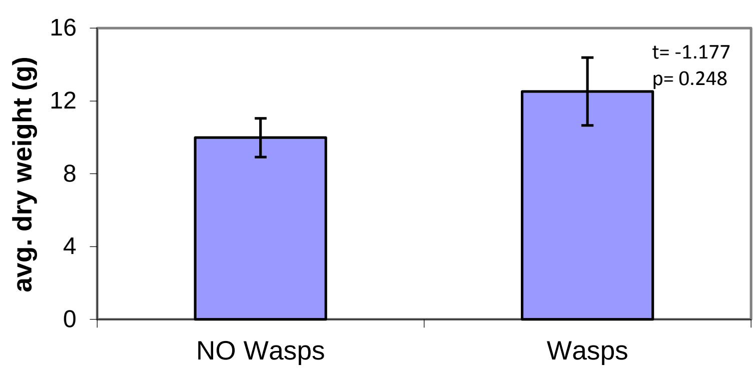
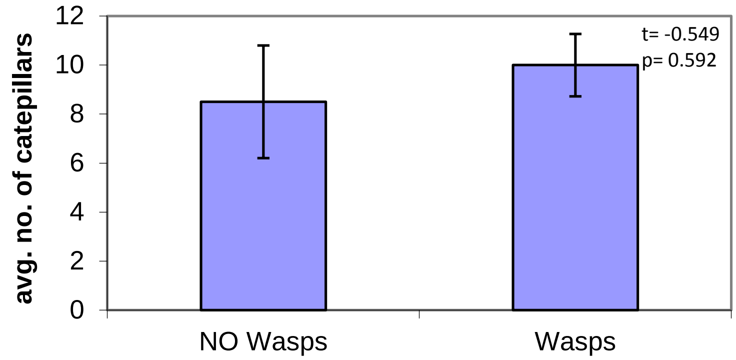


Figure 4.  A comparison of cabbage grown in the control plots (NO Wasps) and experimental plots (Wasps) for (a) the average number of catepillars collected from each cabbage head, (b) the average proportion of leaves with >10% damage from each cabbage head, and (c) the average weight of each cabbage head.

a)

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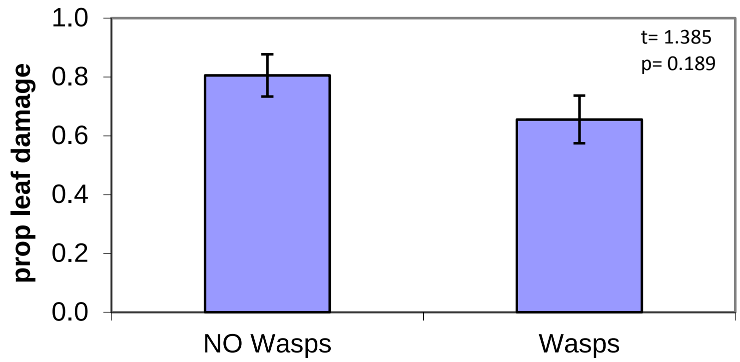


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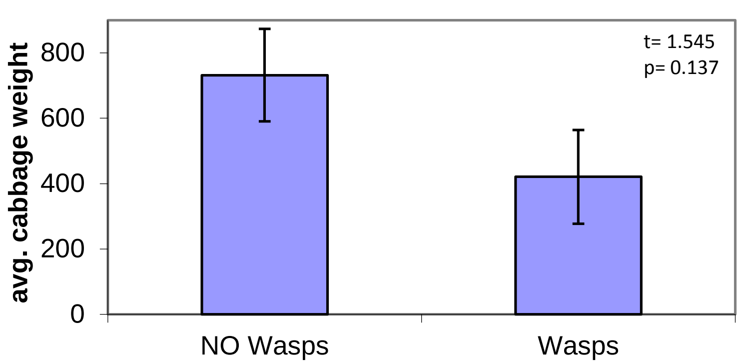
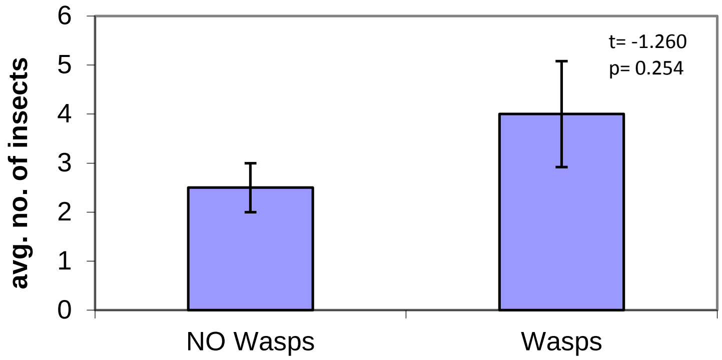


Figure 5. A comparison of beans grown in the control plots (NO Wasps) and experimental plots (Wasps) for (a) the average number of insects collected, and (b) the weight in grams of beans produced.

a)




b)

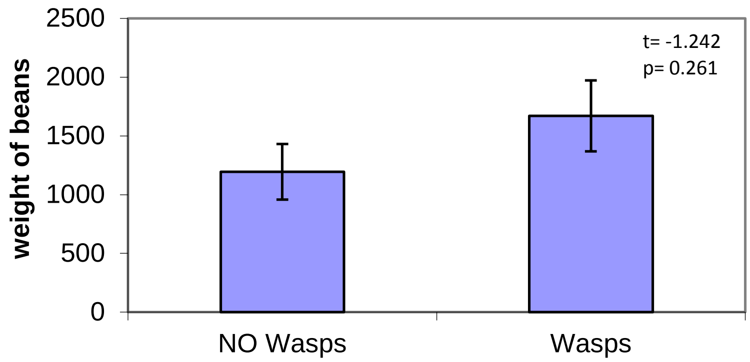
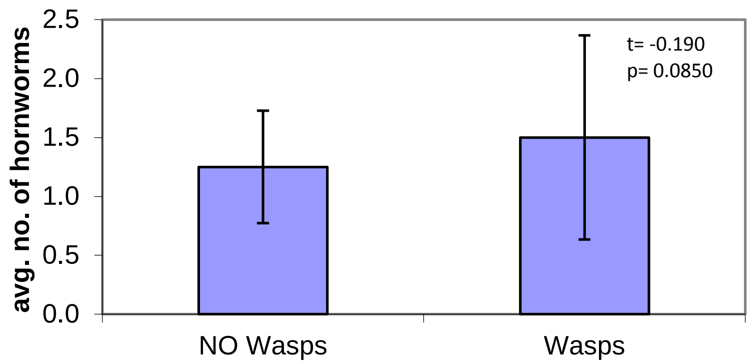


Figure 6. A comparison of the tomatoes grown in the control plots (NO Wasps) and the experimental plots (Wasps) for (a) the average number of hornworms per plant, and (b) the total weight of tomatoes (g) produced.

a)




b)

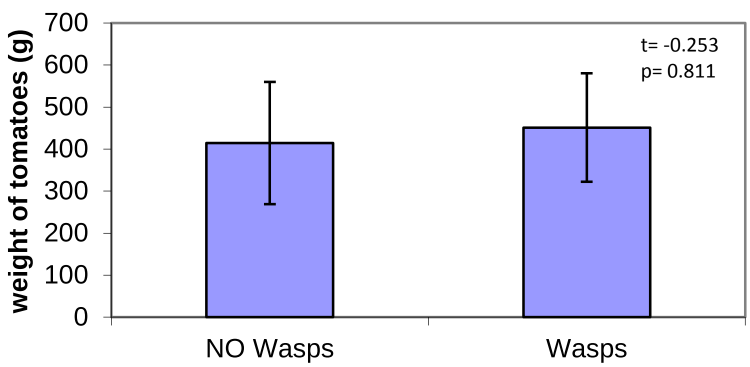


Figure 7.  The relationship between the level of damage on each cabbage plant and the number of wasps resident in the garden plot.