Effects of *Datura wrightii* herbivory on *Manduca sexta* performance

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Introduction

Manduca sexta (commonly known as the tobacco hornworm) feeds almost exclusively on plants in the family Solanaceae. On *Datura wrightii*, they can lay up to 100 eggs per night. *Datura wrightii* provides nectar for adult *M. sexta* in return for the benefit of pollination.

However, *Manduca* larvae rely exclusively on the plant for its complete nutrition. Thus, the interaction between *Datura* and *Manduca* is mutualistic when considered from the perspective of the adult insect, but antagonistic when considered from the perspective of the larva.

Manduca fitness, as measured by larval size (head capsule size, growth rate, mass), is affected by the amount and type of *Datura* leaves consumed. Previous research shows that the plant has the ability to distribute resources differently among the leaves, which can affect the caterpillars. Smaller leaves (newer growth) have high photosynthesis rates and thus have higher nitrogen and phosphorus contents, while larger, older leaves have higher photosynthetic rates and carbon/carbohydrate concentrations. These differences affect *M. sexta* consumption and growth in laboratory experiments.

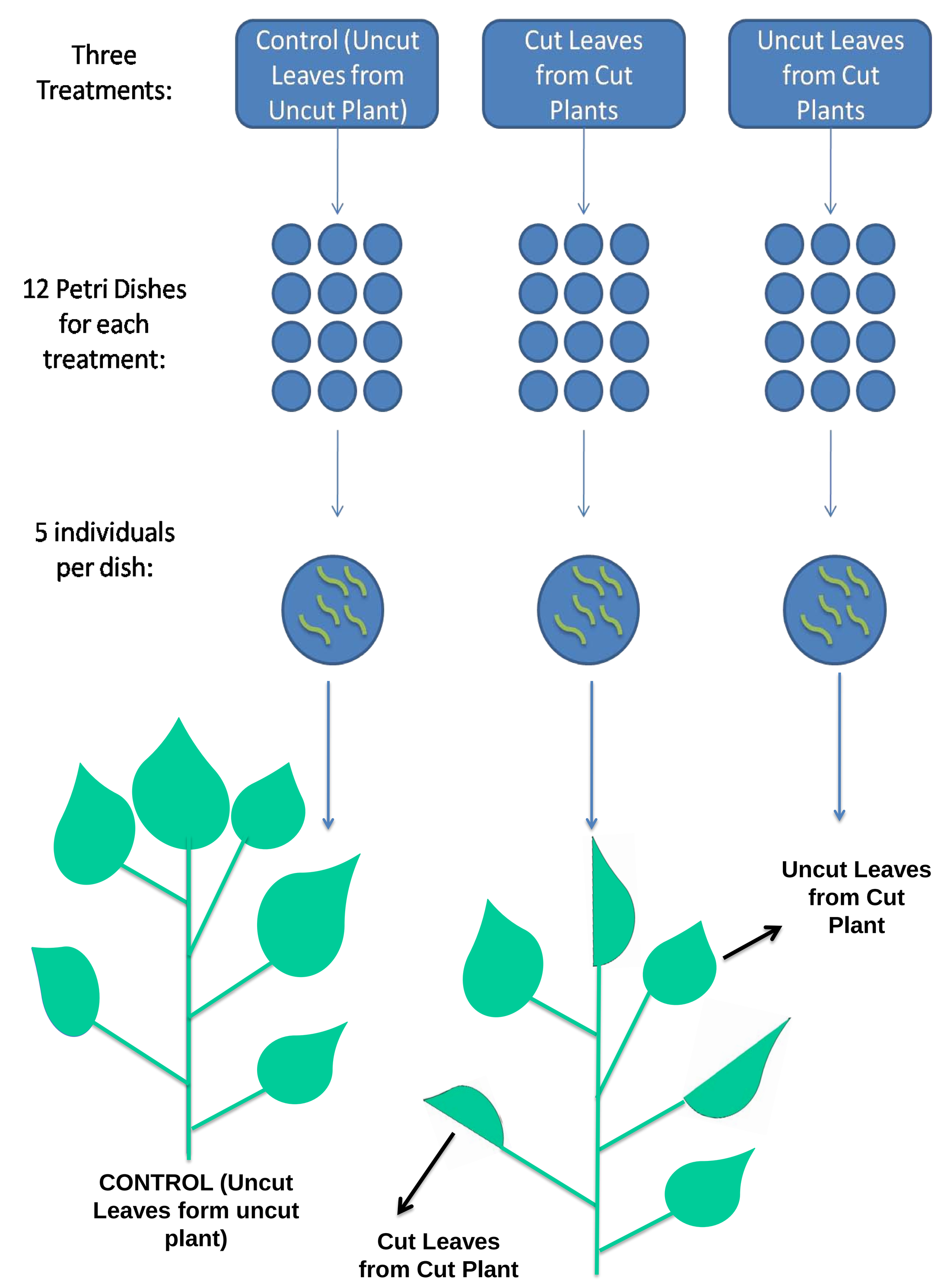
Upon reaching the fifth instar, a single *M. sexta* larva can consume an entire *Datura* plant. Thus, the plant can be expected to defend itself against *M. sexta* herbivory. Here, we look at whether herbivory produces changes in the quality of leaves that reduce the performance of subsequent herbivores that might attack the plant. We conducted a laboratory experiment to test whether *M. sexta* grow more poorly on plants that were subjected to an artificial herbivory treatment compared to a control. We also examined whether plants in the field that were subjected to an artificial herbivory treatment would accumulate less herbivore damage than would control plants.

Manduca sexta life cycle

Manduca sexta

Datura wrightii

Greenhouse Methods



FIFTY PERCENT OF THE LEAVES WERE CUT ON EACH PLANT (EX. OUT OF 6 TOTAL LEAVES, 3 WERE CUT AT RANDOM)

Herbivory was simulated as follows: Leaves were carefully cut along the midrib, removing half of the total leaf area as shown above. Each petri dish contained a moistened filter paper to minimize leaf desiccation.

In order to give the plant time to reallocate resources, cut leaves were fed to caterpillars after a three day period.

Manduca caterpillars were fed *Datura* leaves at the same time every day for the span of the experiment (9 days), gradually increasing the leaf area as caterpillars grew.

Greenhouse Results

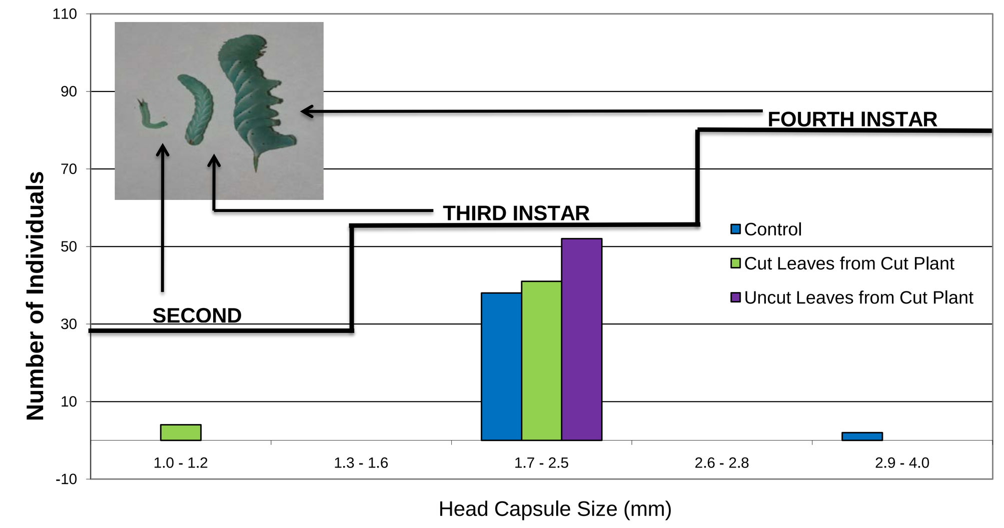


Figure 1. Head Capsule Distribution

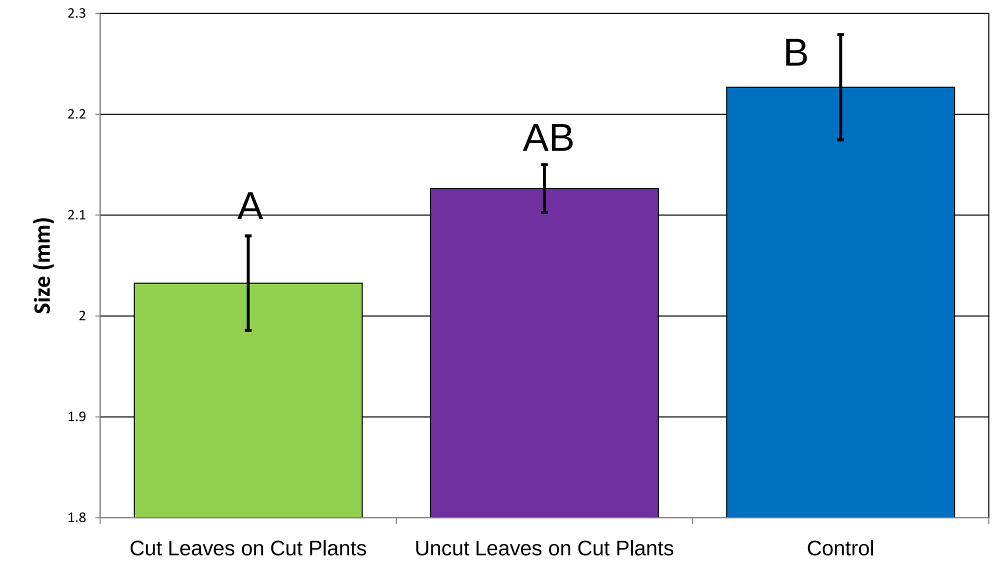


Figure 2. Head Capsule Size (ANOVA, F=5.31, P=<0.006, dF= 2, 137, α= 0.05)

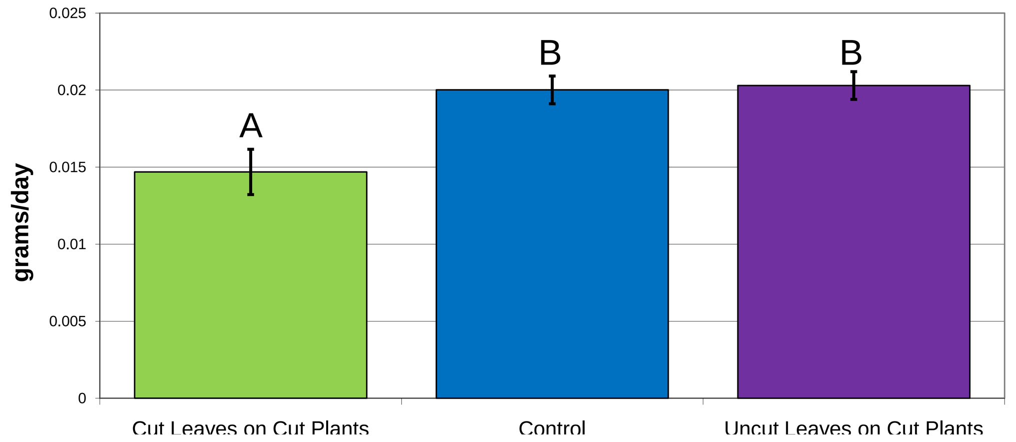


Figure 3. Development Time (ANOVA, F=10.81, P=<0.0001, dF= 2, 137, α= 0.05)

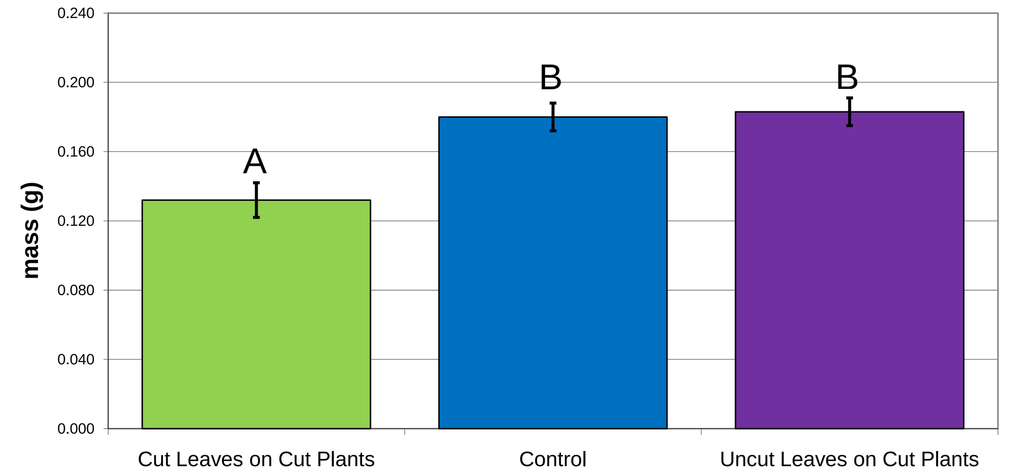


Figure 4. Mass (ANOVA, F=10.81, P=<0.0001, dF= 2, 137, α= 0.05)

* Different letters above each bar indicate treatments that are significantly different
** Head capsule size was measured using a hand held micrometer

Field Methods and Results

The greenhouse treatments had been roughly replicated in a plot of 92 *D. wrightii* established at the Campbell Avenue Farm for another experiment. In order to test whether less damage accrued on cut vs. uncut field plants, herbivory data were collected on:

- A control group, made up of 10 randomly chosen plants on which no leaves were cut.
- A light herbivory group, made up of 10 randomly chosen plants on which one-third of leaves had been cut in half along the midrib.
- A heavy herbivory group, made up of 10 randomly chosen plants on which two-thirds of leaves had been cut in half along the midrib.

Data from six leaves per plant in the control group were taken. From the herbivory groups, data were collected from three cut leaves and three uncut leaves per plant. Herbivory data were collected three times per week for three weeks. Leaf condition was assessed by assigning a damage class of 0 – 5: 0 = no damage, 1 = 1–25% damage, 2 = 26–50% damage, 3 = 51–75% damage, 4 = 76–99% damage and 5 = 100% damage.

No significant difference in average herbivory damage class was found among these groups (ANOVA, *P*=0.11), suggesting that differences in leaf quality documented in the greenhouse do not translate into different levels of damage in the field. The field results, however, could have been affected by leaf damage prior to the experiment, size differences of the plants, or uneven watering of the plot. In addition, the field data were taken before *Manduca* typically begin to start feeding on Datura, so the damage observed was mainly from other herbivores.

Conclusions

Our hypothesis was that, once a plant suffers herbivory, it would begin to defend itself by removing resources from all of its leaves to reduce the rate of subsequent consumption. To some extent, our hypothesis was supported. Head capsule measurements indicate that *Manduca* fed on control leaves grew significantly larger than those fed on cut leaves, as seen in figures 1 and 2. Surprisingly, the data show a significant difference in growth rate and mass between *Manduca* that were fed cut leaves from cut plants, and those that were fed from the control leaves and uncut leaves from cut plants (figures 2, 3). There was no significant difference in these measurements between the control group and the group that was fed uncut leaves from a cut plant (figures 2, 3). This indicates that *Datura* can selectively pull resources from individual, partially damaged leaves, instead of unselectively from all leaves on the plant.

Plants' ability to allocate resources strategically is likely to increase their fitness. However, we did not find evidence that this ability translated into differential levels of herbivory in the field. Initial field census data did not suggest any difference between subsequent herbivory on cut and uncut leaves. However, the field census was conducted before the monsoons, which is a cue for *Manduca* emergence. It is possible that differential herbivory will be detected as the census continues throughout the summer.

Acknowledgements

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