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Reducing Crop Damage Caused by *Folsomia candida* by Providing an Alternate Food Source

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Summary

Collembola (*Folsomia candida*), hexapods found in nearly every land environment on earth, have been shown to be a crop pest. Researchers who culture Collembola in the laboratory often use yeast as a food source. A series of tests was conducted to 1) verify that *Folsomia candida* would feed on lettuce seedlings; and 2) determine if the availability of yeast as a food source would reduce damage to lettuce seedlings caused by feeding Collembola. The tests confirmed that *F. candida* will feed on lettuce seedlings. Results strongly suggest that the availability of yeast as a food source significantly reduces damage to lettuce seedlings caused by feeding activities. There is a strong suggestion that *F. candida* prefers yeast to lettuce seedlings.

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Introduction

Folsomia candida (Collembola) is an important arthropod that is used in many scientific experiments because it is easily maintained in a laboratory. Fountain and Hopkin described it as a traditional soil arthropod (1). *Folsomia candida* is a parthenogenetic (able to have offspring from unfertilized eggs) species and can be kept alive on a diet of granulated (ground) dry yeast (1). Because many tiny invertebrates that feed on plants and yeast share the same characteristics as *Folsomia candida*, these experiments could also be revealing of the ecology of those invertebrates.

Collembola eat decomposing organic matter and living plants, using their biting mouth parts (2). Other species of Collembola feed on pollen, fungi, bacteria or algae (2). Hopkin stated that Collembola eat a wide variety of food, especially fungal hyphae (3). Hopkin noted that, with the exception of a few small cases involving human infestation, the main impact of Collembola is when they feed on crops (3). Shimat demonstrated that Collembola are a pest of lettuce. His results showed that Collembola will feed on germinating lettuce seeds or young seedlings, resulting in a reduction in lettuce growth (4).

Last year another experiment for a science fair project was conducted that dealt with *Folsomia candida*, and the questions explored were similar to the questions in this new experiment, but the results were inconclusive. In that experiment, the first question was what effect Collembola have on lettuce seedlings. To test this, two Petri dishes were set up: one containing 28 Collembola and 15 seedlings (Petri dish A) and another containing 15 seedlings (Petri dish B). After ten days, Petri dish A seedlings had feeding injuries while Petri dish B displayed none, suggesting that Collembola negatively affect the germination of lettuce seedlings. The second question was how Collembola would react when introduced to an alternate food source. In another Petri dish (Petri dish C), 28 Collembola were placed on a dish with 15 lettuce seedlings on one side and ten grains of yeast on the other. However, after ten days, the results were inconclusive because the yeast grew to a point where it completely covered the Petri dish and became inedible to the Collembola, resulting in a decrease of living Collembola from 28 to 4. This was because there were too many yeast pellets and the water droplets got onto the yeast, causing the yeast to become active. From this past experiment it was concluded that Folsomia candida would be an excellent choice for a test subject and would most likely consume the seedlings and the yeast (Tamura, unpublished observations). By changing a few variables, the result could become understandable in a new experiment.

The question addressed in the current experiment was what the Collembola would do if given an alternate food source other than lettuce seedlings. The hypothesis was that the Collembola would prefer the yeast as a source of food compared to the seedlings. The intention behind these experiments was to find a more logical result to the earlier exploration and conclude whether or not the Collembola have a preference for the yeast or seedlings. In the experiments, Collembola, yeast, and lettuce seedlings were combined and the amount of

Figure 1. A photo of healthy lettuce seedlings. This photo is presented as a standard of a healthy lettuce seedling.

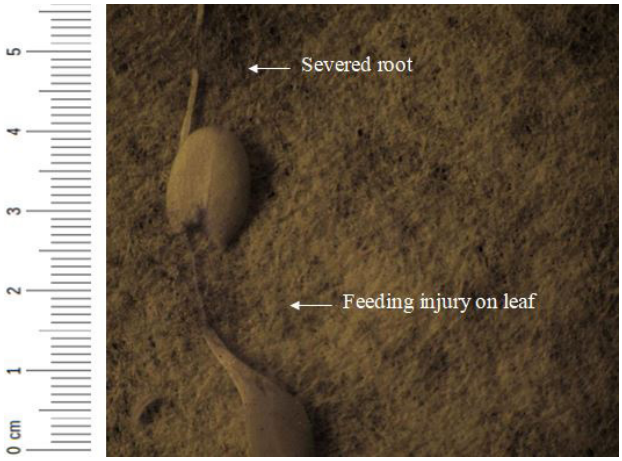

Figure 2: A photo of a feeding injury on a lettuce seedling. This photo is presented as a representative of a damaged seedling.

Figure 3. A photo of yeast pellets. These yeast pellets are the standard size of the pellets used in the experiments.

feeding on each food was measured. The conclusion of the experiments was that having yeast as a food source to the Collembola prevented feeding injuries on the lettuce seedlings.

Results

The results of the experiments agreed with the hypothesis. In the first experiment, the lettuce seedlings at the end of ten days looked very healthy. Most of the lettuce seedling leaves were green and the roots weren't severed by the Collembola (**Figure 1**). On five of the days the pieces of yeast had to be replaced because they were eaten by the Collembola. On Day 4, one piece was gone, two on Day 6, two on Day 7, one on Day 8, three on Day 9, and three on Day 10 (**Figure 4**). There were more yeast pellets consumed than seedlings consumed, suggesting that the Collembola had a preference for the yeast. In addition, the control group for this experiment that did not have any yeast available as food for the Collembola had an average of one seedling feeding injury per day whereas in the first experiment group, the average number of feeding injuries was 0.6 per day. This suggests that when yeast is available, Collembola will consume the yeast instead of the lettuce seedlings. In the second experiment, the average number of lettuce seedling injuries in Petri dishes without yeast was higher than the average number of lettuce seedling injuries in Petri dishes with yeast. The data demonstrates the average number of feeding injuries in the first five Petri dishes each day vs. the average number of feeding injuries in the second set of Petri dishes each day. (**Figure 5**). When the results are compared, the average number of feeding injuries each day in the second set of Petri dishes was greater than the average number of feeding injuries in the first set of Petri dishes.

Pellets of yeast had to be replaced in the first set of Petri dishes every day. This data suggests that the Collembola preferred the yeast to the seedlings, preventing feeding injuries on the seedlings. (**Figure 2**) In the third experiment, the number of Collembola near yeast was greater than the number of Collembola near the seedlings. The average number of Collembola attracted to the yeast was 7.2 and the average number attracted to the seedlings was 2.8 (**Figure 6**).

Discussion

The data from the three experiments suggests that the Collembola had a preference for the yeast in comparison to the lettuce seedlings. Without yeast pellets present as a food source for the Collembola, Collembola ate the lettuce seedlings, increasing the number of lettuce feeding injuries. Without a way to measure humidity, temperature, or weight, one of these factors could have influenced why the Collembola

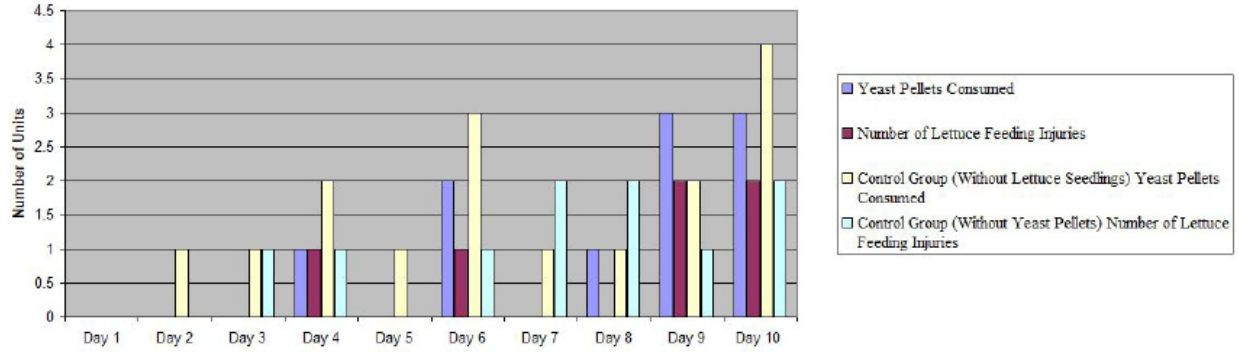

Figure 4. Consumption of yeast and lettuce seedlings by Collembola. Each bar on the graph demonstrates either the number of yeast pellets consumed or the number of lettuce feeding injuries for each of the ten days.

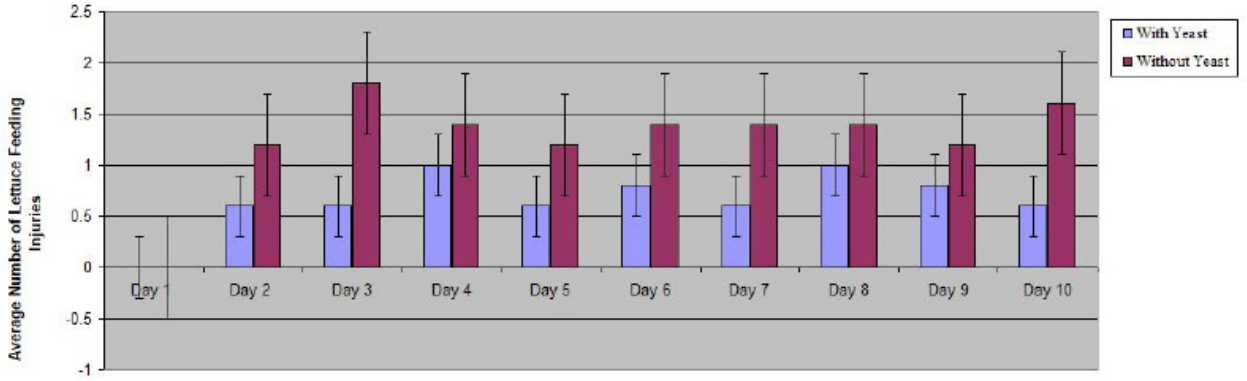

Figure 5. The average number of lettuce seedlings consumed by Collembola. Each bar on the graph shows the average number of feeding injuries on the five lettuce seedlings for each of the ten days in both sets of Petri dishes with and without yeast.

chose the food source they did. For example, since this particular experiment took place during the summer, the lettuce seeds could have been too dry to eat, but during any other time, the seedlings might have been moister. These results have significance for farmers, especially organic farmers. If people start to see a Collembola or another arthropod eating their crops and don't use pesticides, they might have to turn to a different solution. After this experiment, different Collembola species, other types of soil fungi, and seeds can be switched out to further clarify Collembola's preferences and suggest strategies for combating infestations.

Our work also suggested another experimental question about Collembola: why they seem to have disappeared from the wild. This question was prompted when we had to order Collembola because they couldn't be found in numerous spots during the summer. A previous study measuring the response of soil microarthropods to changes in precipitation and temperature found that Collembola abundance and richness were higher in soil that had a higher moisture content than in soil with lower moisture content (5). This finding may explain why it was a struggle to find Collembola in leaf litter. The lack of precipitation and high temperatures could have decreased the availability of the Collembola. Another reason why Collembola couldn't be found is that *Folsomia candida* reproduction stops during drought when the moisture in soil is lower than -7 bar (~99.4 RH) (6).

Materials and Methods

In the first experiment, a circle of coffee filter paper with a diameter of three inches was placed inside a Petri dish using a mixture of Paris and activated charcoal powder as a culture medium. Fifteen lettuce seedlings (Ferry-Morse) were placed carefully on the coffee filter. The lettuce seedlings had been grown in a separate Petri dish for ten days. Then 30 *Folsomia candida* (Josh's Frogs) were added. Five pieces of active dry yeast (Fleischmann's) were placed on the opposite side from the seedlings and off of the filter paper. All yeast pellets were roughly 1 mm in diameter and were measured with a standard 12 inch ruler. (**Figure 3**) Observations were made through a microscope with a magnification of 15X. Seedlings were watered every day of the ten days using a pipette to drop water onto the seedlings. Yeast pieces were replaced every time some went missing and should always add up to five.

The second experiment required the same materials but in different amounts. Five Petri dishes with filter paper

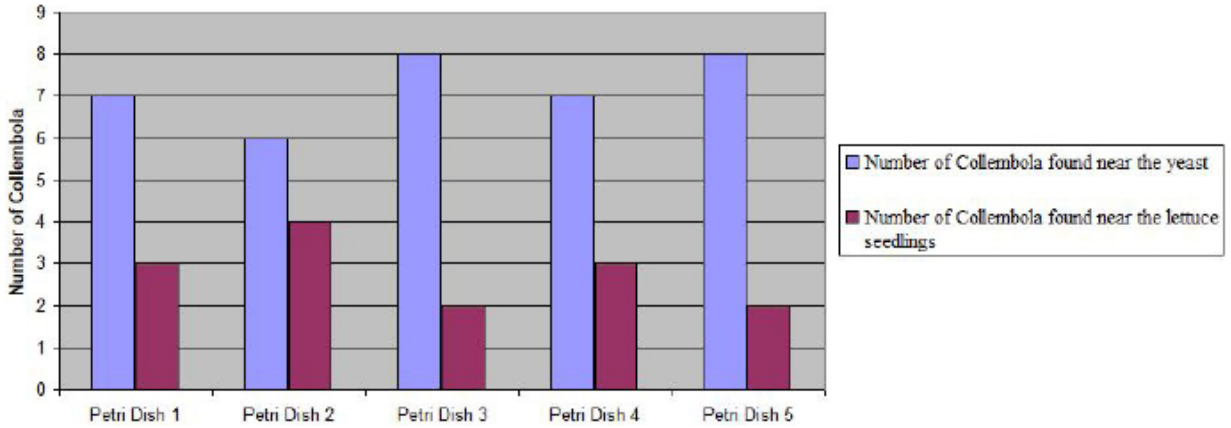

Figure 6. Collembola preference to yeast or seedlings. Each bar on the graph tracks how many Collembola were found near the lettuce seedlings or yeast pellets.

inside with ten Collembola, five yeast pellets, and five lettuce seedlings each were observed for ten days. For the same ten days, another set of five Petri dishes with filter paper inside with ten Collembola and five lettuce seedlings were observed. In the first five Petri dishes, the number of yeast and missing yeast were recorded and the missing yeast were replaced. Also, the number of feeding injuries on the seedlings was recorded. In the second set of five Petri dishes, the number of feeding injuries was recorded.

As controls for the first two experiments, 15 Collembola and 5 seedlings were observed in a Petri dish for 10 days and 15 Collembola and 5 yeast pellets were placed in another. In the control group with 15 Collembola and 5 lettuce seedlings, the average number of feeding injuries per day was 1, while in the control group with 15 Collembola and 5 yeast pellets the average number of yeast pellets consumed per day was 1.5. (Figure 4) This data can be compared to the results of the first and second experiments to demonstrate the decrease in the number of lettuce feeding injuries when yeast pellets are present. For example, in the first experiment, the average number of lettuce feeding injuries decreased from one per day in the control group with lettuce seedlings and Collembola to 0.6 per day in the Petri dishes with lettuce seedlings, Collembola, and yeast pellets. Also, in the second experiment, the average number of lettuce feeding injuries in the control group decreased from one per day to 0.66 per day in the Petri dish with yeast pellets, Collembola, and lettuce seedlings. (Figure 5)

A new experiment was conducted to determine if Collembola have a preference for yeast or lettuce seedlings. 5 Petri dishes with filter paper inside with 15 Collembola, 5 yeast pellets, and 5 seedlings were prepared and observed for 2 days.

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