The Impact of Predator Non-Consumptive Effects on Transmission of a Plant Virus

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Abstract

It is well documented that arthropod predators play an important role in insect pest control. Along with predation, non-consumptive effects may also alter the feeding behavior of plant virus vector species, and thus alter virus transmission efficiency. We tested this hypothesis by exposing Maize Fine Streak Virus (MFSV) inoculative leafhoppers to corn plants in the presence and absence of jumping spiders or lady beetles in mesocosm and macrocosm arenas. Mesocosm trials consisted of a single corn plant enclosed in an 8" tube, with 5 inoculative leafhoppers and a predator (single jumping spider or five lady beetles). Macrocosm arenas were 10 plants placed diagonally in 2'x2'x4' cages, with 50 inoculative leafhoppers and a caged spider propped against each plant. In mesocosm arenas, the presence of jumping spiders in close proximity to the leafhoppers led to a decrease in transmission of MFSV. However, in larger-scale macrocosm studies, there was no change in virus transmission. The presence of lady beetles did not impact virus transmission. These results suggest that certain predators in close contact with vector species could potentially limit plant-to-plant transmission of viruses.

Introduction

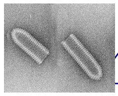
Arthropod predators are an important component of insect pest control, as they can drastically reduce pest populations in crops. In addition to predation, the presence of a predator alone may deter pests from feeding. These non-consumptive effects may alter the feeding behavior of vector species of plant viruses, and thus alter their virus transmission efficiency. Tholt et al., (2018) hypothesized that these effects may interrupt the virus transmission process. In a similar study, it was determined that the presence of a spider altered the feeding behavior and movement patterns of leafhoppers, causing a delay in feeding (Beleznai et al., 2015). To test Tholt's hypothesis, the impact of non-consumptive effects on plant virus transmission, *Graminella nigrifrons* that previously acquired Maize Fine Streak Virus (MFSV) were introduced to healthy maize plants in the presence and absence of jumping spiders or lady beetles. Resulting transmission of MFSV was then assessed and compared.

The System

The Insect Vector:
Graminella nigrifrons
- Can acquire the pathogen as nymphs, and transmit as adults
- Colonies maintained in lab

The Predators:
- Predation or non-consumptive effects can impact virus transmission
- Jumping spiders were wild-caught in Stillwater, and ladybugs were purchased

The Pathogen: MFSV
- Persistent propagative rhabdovirus
- Maintained within plants in lab



The Host: Young corn plants
- Plants were grown in greenhouse on site

Materials and Methods

Mesocosms:
- Young maize plants were placed into a 2'x2'x4' Bioquip cage.
- Jumping spiders or lady beetles were placed onto the plant and covered with an 8" x 2.75" tube cage.
- Five MSFV-inoculative leafhoppers were then added to each tube.
- 5-15 cages/treatment were run for each replication. 5-7 replications were run for each predator.
- The leafhoppers and predators were removed from the plants after 24 hours, and the plants were placed into a growth chamber for MFSV symptom expression.

Macrocosms:
- 10 young maize plants were placed diagonally across a 2'x2'x4' cage.
- Jumping spiders were placed into 1.5" Petri dish cages to prevent them from predating the leafhoppers, and these cages were leaned against each treatment plant.
- An 8" x 2.75" tube cage was placed over the first plant in both the control and treatment groups, and 50 inoculative leafhoppers were added.
- The tube cage was then removed to release the leafhoppers.
- The leafhoppers were removed from the plants after 24 hours, and the plants were placed into a growth chamber for symptom expression.

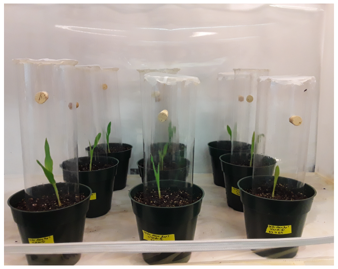


Figure 1. Example of a mesocosm setup. All replicates contained 5 inoculative leafhoppers; treatment groups also had a single spider or 5 ladybugs present.

Figure 2. Example of a macrocosm setup, showing the release cage containing 50 LH at far left and small spider cages propped against each test plant.

Table 1. Results of MFSV transmission in spider mesocosms. Variable number of mesocosms run per replication. Results expressed as # of plants positive/# plants exposed.

Replication	Spider	No Spider
Rep 1	3/11	3/11
Rep 2	3/12	7/12
Rep 3	4/14	8/14
Rep 4	6/15	6/15
Rep 5	3/15	9/15
TOTAL	**19/67**	**33/67****

**Significantly higher MFSV transmission in mesocosms with no spider present, Chi Square Distribution analysis

Table 2. Results of MFSV in spider macrocosms. Results expressed as # plants positive/# plants exposed.

Replication	Spiders	No Spiders
Rep 1	2/10	4/10
Rep 2	1/10	0/10
Rep 3	2/10	2/10
Rep 4	1/10	1/10
Rep 5	0/10	3/10
Rep 6	1/10	0/10
Rep 7	5/10	3/10
Rep 8	2/10	1/10
TOTAL	**14/80**	**14/80**

Figure 3: Close-up of corn leaf showing symptoms of MFSV.

Table 3. Results of MFSV transmission in ladybug mesocosms. Variable number of mesocosms run per replication. Results expressed as # plants positive/# plants exposed.

Replication	Coccinellids	No Coccinellids
Rep 1	0/5	2/5
Rep 2	1/10	2/10
Rep 3	2/5	0/5
Rep 4	1/5	1/5
Rep 5	2/5	1/5
Rep 6	0/10	1/10
Rep 7	2/10	5/10
TOTAL	**8/50**	**12/50**

Results

Spider Mesocosms:
- The presence of a jumping spider in proximity to the leafhoppers significantly decreased the transmission rate of MFSV. (Chi square statistic: 6.14, df = 1, p = 0.025)

Spider Macrocosms:
- No significant difference in virus transmission was seen between the control and treatment groups- in fact, the total number of infected plants was equal.
- Overall, the baseline transmission rate for these macrocosm studies was relatively low.

Ladybug Mesocosms:
- Mesocosms containing ladybugs had a slightly lower transmission rate, but this difference is not significant.
- Similar to the spider macrocosms, baseline transmission rate for these mesocosms was low.

Discussion

- The impact of non-consumptive effects seems to be dependent upon the predator present and the size of the arena.
- Unlike in macrocosm replicates, leafhoppers in mesocosms were unable to disperse, and jumping spiders were able to actively move around the tube and disturb the leafhoppers.
- The baseline transmission in ladybug mesocosm studies was low. This may be due to two factors:
  - 1: Leafhoppers used had poor acquisition of the virus
  - 2: Ladybugs congregated at the top of the tubes, and never really disturbed the leafhoppers on the plants.
- To further test Tholt's hypothesis, feeding behavior of leafhoppers in the presence of a spider will be examined using electropenetrography.

References

- **Beleznai, O., G. Tholt, Z. Tóth, V. Horváth, Z. Marczali, and F. Samu**. **2015**. Cool headed individuals are better survivors: Non-consumptive and consumptive effects of a generalist predator on a sap feeding insect. Plos One. 10.
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