SURVIVAL OF STORED AND SHIPPED PHYTOSEIULUS PERSIMILIS PREDATORS FOR TWOSPOTTED SPIDER MITE CONTROL IN STRAWBERRY (FRAGARIA XANANASSA DUCH.)

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Abstract. Phytoseiulus persimilis Athias-Henriot (Acari: Phytoseiidae) predators were shipped overnight on the day of their harvest from a commercial insectary in order to determine the effects of 4 °C storage at strawberry production sites in Florida. Beginning on the day of arrival and on each of the next 6 days, eight replicates of 5-ml samples were taken from a different bottle. Samples were placed in bottoms of 85 mm diameter × 80 mm high cardboard ice cream containers and maintained at 27 °C in full laboratory light. Predators that reached tops of containers during each 5-minute interval were counted during 2 hours as a measure of dispersal fitness. Predators that did not reach the top were counted after 2 hours and were assumed poorly fit for dispersal. Concurrently, eight replicates of five apparently gravid females from the same source were caged to lay eggs for 5 days in order to determine average numbers of larvae produced per female per day. There was a positive linear response (Y = 2.718 + 3.886X) to days of storage in the portion of predators that failed to disperse in 2 hours. A positive quadratic response (Y = 12.131 - 0.480X + 0.292X²) was observed in the time for 50% of the population to disperse. There was no significant effect of storage period on the average number of larval predators produced. Strawberry producers should release predators as quickly as possible, given that indicators of dispersal fitness decreased greatly after 5 days.

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Phytoseiulus persimilis spider mite predators have become important elements of integrated pest management (IPM) in Florida strawberry production (Decou 1994; van de Vrie et al., 1994). The predators are shipped by air from The Netherlands or distant North American locations. Producers recommend that growers release predators immediately upon receipt. Florida strawberry farmers find that this is oftentimes impractical due to factors such as rain, wind, availability of labor, or recent application of a pesticide potentially hazardous to the predator. Farmers must make the decision to release the predators during suboptimal periods, discard the shipment and order more, discard the shipment and abandon biological control, or withhold the release until conditions are favorable.

Predators must be fit to disperse quickly in order to locate a spider mite colony, otherwise they will starve. Since predators are not released on every plant, but rather on about every fifth plant (van de Vrie et al., 1994), the predators must be fit to disperse not only within a plant, but among the leaves of distant plants as well. In addition, poor fitness to disperse and find spider mite colonies efficiently results in reduced spider mite control.

Published literature does not address the effect of post-shipment cold storage on the fitness to disperse. Consequently, farmers are making decisions to release predators based on insufficient information. This study was conducted in order to provide data upon which the decision of a farmer to release predators during suboptimal periods could be based.

Materials and Methods

Seven, 550 ml bottles of ca. 2,000 P. persimilis predators were harvested at Bunting Biological North America, Inc. in Oxnard, California, mixed with vermiculite, and were shipped overnight to Bradenton, Florida. Bottles were stored in their original shipping box in a 4 °C cooler. Beginning on the day of arrival (after 2 h in the cooler) and daily thereafter for 6 more days, a bottle was taken to the laboratory then rolled and tumbled gently for 15 s to obtain a homogeneous mixture of predators and vermiculite. Eight replicates of 5-ml samples were placed into bottoms of 85 mm diameter × 80 mm high cardboard ice cream containers and held at 27 °C in a lighted laboratory. Observers counted and removed predators that reached the top of the top of the container every 5 min for 2 h as one measure of fitness to disperse. The time for 50% of the successful predators to reach the top was calculated and a regression analysis (PROC GLM, SAS 1994) of the relationship of that response to the number of days in storage was performed.

Another measure of dispersal fitness was calculated by counting the numbers of predators (dead, moribund or ac-
tive) that failed to reach the top of the container. Their percentage was calculated from the total population. A regression analysis (PROC GLM, SAS 1994) of the relationship of that response to number of days of storage was performed.

Each day as the samples of the above experiments were taken, an additional eight replicates of five apparently gravid females were collected to measure the response of female fecundity and fertility to storage period. The five females were isolated on a 2.4 cm diameter strawberry leaf disc, then they were confined by wet tissue and a water mote in a 14 cm diameter × 4 cm high covered dish and held at 28 °C for 5 d. Females were provided with ample twospotted spider mites (*Tetranychus urticae*) daily as food. Larvae that hatched from eggs produced by predators were counted and removed daily. The average numbers of larvae resulting per female per day were calculated for predators taken from plants under each of the 7 d of storage. An analysis of variance (PROC ANOVA, SAS 1994) was performed to detect any response to storage period and treatment means were calculated. LSD determined significant differences among means.

Each of the above experiments was performed three times. Data of each three were combined before analysis.

**Results and Discussion**

The relationship of the percentage of predators that did not reach the top of the test container to period of storage is represented by the linear equation, \( Y = 2.718 + 3.886X \), where \( Y \) is the percent that did not reach the top and \( X \) is the period (days) of storage. These data indicate that, during the first week of storage, there is an attrition, at a constant rate, in the portion of predators that can complete the dispersal activity. Only 6.6% failed to reach the top of the test container in 2 h after 1 d of storage, but by 7 d, 29.9% failed (Table 1).

The relationship between the time for predators that reached the container top to complete the above activity to period of storage is represented by the quadratic equation, \( Y = 12.131 - 0.480X + 0.292X^2 \), where \( Y \) is the minutes required for 50% of the test population to complete the activity and \( X \) is the period (days) of storage. It required 11.9 min for 50% of the predators to reach the top of the test container after only 1 d of storage and 14.9 min after 4 d, an increase of only 3 min. However, after an additional 3 d of storage, the period required to reach the container top increased an additional 8.2 min, indicating a decrease in activity that could affect their ability to disperse and find prey (Table 1).

There was no significant effect of storage period on the ability of females to produce eggs that hatched to the larval stage (Table 1).

The results of this study indicate that strawberry growers may hold *Phytoseius persimilis* shipments in produce coolers for up to 5 d with minimal disruption to their dispersal activity or fecundity. Slightly longer periods of cold storage could be practical if spider mite prey are distributed more evenly in the area of release.

**Table 1.** Predicted \((Y = 2.718 + 3.886X)\) percentage of *Phytoseius persimilis* predators that failed to reach the top of an 80 mm high test container in 2 h, the predicted \((Y = 12.131-0.480X+0.292X^2)\) minutes required for 50% of the predators that successfully reached the container top to do so, and the larval predators produced per female per day during a 5-d period, after 1–7 d of simulated shipping and storage at 4°C.

<table>
<thead>
<tr>
<th>Days of storage</th>
<th>% Failed to reach top</th>
<th>Minutes for 50% to reach top</th>
<th>Larvae/ female/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.6</td>
<td>11.9</td>
<td>1.8 a</td>
</tr>
<tr>
<td>2</td>
<td>10.5</td>
<td>13.2</td>
<td>1.6 a</td>
</tr>
<tr>
<td>3</td>
<td>14.4</td>
<td>13.3</td>
<td>1.3 a</td>
</tr>
<tr>
<td>4</td>
<td>18.3</td>
<td>14.9</td>
<td>1.4 a</td>
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<td>22.1</td>
<td>17.0</td>
<td>1.4 a</td>
</tr>
<tr>
<td>6</td>
<td>26.0</td>
<td>19.8</td>
<td>1.4 a</td>
</tr>
<tr>
<td>7</td>
<td>29.9</td>
<td>23.1</td>
<td>1.8 a</td>
</tr>
</tbody>
</table>

Values within a column followed by the same letter are not significantly different (5%) by LSD.

**Literature Cited**

