L. trifolii reared from foliage of the weed species are not host-conditioned and will oviposit and develop on tomato.

ACKNOWLEDGMENT

We wish to thank Dr. David Hall for identification of the weed species utilized in these experiments.
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METHYL BROMIDE FUMIGATION AS A QUARANTINE TREATMENT FOR LATANIA SCALE, HEMIBERLESIA LATANIAE (HOMOPTERA: DIASPIDEIDAE)

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ABSTRACT

Fumigation tests using methyl bromide at normal atmospheric pressure showed that 16 g/m² for 2½ h at 22.8°C or above, or 32 g/m² for 2½ h at 18.3 to 22.2°C was sufficient as a quarantine treatment against latania scale, Hemiberlesia lataniae on nursery stock. For use on avocado fruits, recommendations are for 24 g/m² for 2½ h at 22.8°C or above, and 32 g/m² for 3 h at 18.3 to 22.2°C. Microscopic examination of fumigated and control scales showed that certain body movements, particularly pharyngeal pulsation, is a much more reliable indicator of scale viability than the mere presence of body fluids. Following fumigation, body fluids required up to 31 days to dehydrate completely, under humid conditions.
Pruebas de fumigación con bromura de metilo a una presión atmosférica normal demostraron que 16 g/m³ por 2½ horas a 22.8°C o más, o 32 g/m³ por 2½ horas de 18.3 a 22.2°C fue suficiente como un tratamiento de cuarentena contra la escama latania, Hemiberlesia lataniae en vivieres de plantas. Para usar en frutas de aguacate, las recomendaciones son 24 g/m³ por 2½ horas a 22.8°C o más, y 32 g/m³ por 3 horas de 18.3 a 22.2°C. Exámenes microscópicos de escamas fumigadas y el control demostraron que movimientos del cuerpo, especialmente pulso faríngeo, es un indicador mejor de la viabilidad de la escama que la mera presencia de los fluidos corporales. La pérdida total de fluidos corporales tomó hasta 51 días post-tratamiento en condiciones húmedas después de fumigarse.

Latania scale, Hemiberlesia lataniae (Signoret) is widespread throughout tropical and subtropical areas, and is also found in greenhouses in temperate climates (Dekle 1976, Hamon 1979, Nakahara 1982). The species is polyphagous, and is known to infest more than 300 plant species in Florida (Dekle 1976). It is a serious pest of palms and other ornamentals, particularly ponytail palm or elephant-foot tree (Beaucarnea recurvata Lem.), Australian pine (Casuarina equisetifolia), loquat (Eriobotrya japonica), and rose (Rosa spp.). Leaves, stems, and fruits may all be damaged as a result of the insects sucking plant juices.

H. lataniae was best described by Ferris (1938). The armor is usually round (female) or oval (male), but may be irregular in shape when several scales overlap or crowd together. The armor is strongly convex and 1.5 to 2 mm in diameter when mature. Exuviae are large, pale brown, centrally located to sub-centrally, and are surrounded by a dirty white area. When the armor is carefully removed with a pin, the soft, lemon-yellow, flattened, sac-like body is revealed. The body is attached to the host by thread-like stylets that are in the middle of the body, and extend as long or longer than the body. Legs are absent in all secondary stages except 1st instar nymphs (crawlers).

H. lataniae is quarantined in some foreign countries. This often presents a barrier to the free flow of international commerce. During the recent outbreaks of Mediterranean fruit fly (Ceratitis capitata (Wied.) in California, avocado fruits originating from outside regulated areas of that state were shipped to Japan and elsewhere. Shipments received a combined treatment of methyl bromide (MB) plus refrigeration as a precaution (i.e., MB @ 32 g/m³ for 2½ h at 21.1°C or above, followed by 7 days of storage at 7.2°C or below).\(^1\)

Subsequently, inspectors of the Japanese Ministry of Agriculture, Fisheries and Forestry (MAFF), reported live latania scales in 3 out of 5 sea containers of California avocados, which had received the USDA's precautionary treatment against Mediterranean fruit fly. The Japanese authorities re-treated these fruits with hydrogen cyanide (HCN). The California avocado industry then requested a fumigation schedule be developed which would allow acceptance of certified fruit. A predeparture treatment

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\(^1\)Equivalent to 32 oz./1000 ft.\(^3\). This is Treatment Schedule T 192(a)(1) of the USDA Plant Protection and Quarantine Programs Treatment Manual (Anon. 1981).
would eliminate the necessity and cost of an additional treatment upon arrival in Japan, and would give the avocados a longer shelf-life.

To determine scale viability Japanese inspectors puncture or crush the scale, and if body fluids are present, the scale is considered to be alive. (This is the so-called “squash test”.) Determining scale mortality on commodities receiving quarantine fumigation treatment presents a special problem. Several factors are involved, including time elapse between treatment and inspection and temperature and RH during in-transit storage. Moreover, the waxy scale covering may prevent large female scales from desiccating, so that when the last scales have dehydrated, the commodity has exceeded its marketable shelf-life.

A more time consuming but more accurate method of assessing scale viability is the so-called “pump test”, an unpublished technique developed at the University of California, Riverside. Naked specimens are examined microscopically for vital signs, viz., slight body movements, particularly the pumping activity of the pharynx. The experiment reported here was designed to clarify the question of treatment efficacy by microscopically examining fumigated scales.

METHODS AND MATERIALS

Attempts to obtain scale-infested avocado fruits from packing houses in Florida and California were unsuccessful. Moreover, since avocados are not a favored host of this insect (D. Fiskaiali, California Dept. of Food & Agric., pers. comm.), securing sufficient numbers of infested fruits presented a formidable problem. Therefore, a more favored host was obtained, viz., ponytail palm or elephant-foot tree, Beaucarnea recurvata Lem. (Liliaceae). In addition, unpublished results of MB fumigations of latania scale, by the California Dept. of Food & Agriculture in 1938 through 1948, were obtained and analysed.  

Twenty moderate-to-heavily infested potted ponytail palms (ca. 46 cm tall) were purchased locally, and scales were microscopically examined to confirm that some scales were alive. Plants were stored overnight at the fumigation temperatures, in the room equipped with fumigation chambers. The following morning, plants were divided into treatment groups (1 or 2 plants each). There were approximately equal numbers of scale insects in each treatment group. Fumigation trials were conducted, using the following test schedules (MB at normal atmospheric pressure):

(A) 16 g/m² for 2½ h; 22.8-23.9 and 18.3°C temperatures
(B) 32 g/m² for 2½ h; 22.8-23.9 and 18.3°C temperatures
(C) 48 g/m² for 2½ h; 22.8-23.9 and 18.3°C temperatures
(D) 32 g/m² for 4 h; 24.4-25 and 20°C temperatures²
(E) Combination of MB fumigation plus cold treatment: 32 g/m² for 2½ h; 24.4-25 and 20°C temperatures, followed by 7 days in storage at 4.4-7.2°C³
(F) Controls (no treatment)

²This is Treatment Schedule T 108 (a) (1) of the USDA Plant Protection and Quarantine, Pesticide Treatment Manual (Anon. 1981), except that temperature during treatment must be 21.1°C or above. (Recommended for avocados.)
³This is Treatment Schedule T 102 (a) (1) of the USDA Plant Protection and Quarantine Programs, Pesticide Treatment Manual (Anon. 1982), except that the temperature during treatment must be 21.1°C or above; during storage, 7.2°C or below. (Recommended for avocados.)
MB gas concentrations within the fumigation chambers were monitored during the course of the treatments by using a Gow-Mac gas analyser.\footnote{Manufactured by Gow-Mac Instrument Co., Bridgewater, NJ (Model No. 20-350).}

Following treatment, plants were isolated from each other and placed in a greenhouse, except for plants receiving Treatment E. The latter were placed in a walk-in cold room (4.4-7.2°C, lights on), RH in the two locations ranged from 75 to 90%. Plants were watered (roots only) twice weekly, immediately following examination of scales.

A representative sample of 100 scales per treatment was microscopically examined twice a week post-treatment over a 31-day period to document the rate of desiccation and mortality. All stages were examined, except eggs.

During inspection, one or more leaves were removed from the plant, and examined under a binocular, dissecting microscope (15X), using a 30 W spotlight. Plants receiving Treatment E (fumigation plus refrigeration) were exposed to room temperature before they were inspected. High magnification (45 or 90X) was used to give a more detailed view. The scale cover (armor) was teased off with a pin to reveal the yellow, sac-like body beneath. The large body of mature females often had a cluster of yellow eggs and/or crawlers immediately adjacent to it. If alive, the female would contract, expand, undulate, or twist when gently prodded with a blunt object. If no movement was detected, the insect was teased from the substrate, and turned upside-down. The triangular-shaped base of the mouthparts was examined for pulsating or pumping action in the pharynx of live specimens. Often, also the threadlike styllet tube moved.

Scales examined were classified into 3 categories:

(1) \textit{Dead} (dry, with no body juices)

(2) \textit{Live} (showing pulsation or other body movements)

(3) \textit{Moribund} (body juices still intact, at least partially, but body showing no movement when prodded)

The latter category also included scales in various stages of decomposition, as well as those which were parasitized.

\section*{Results and Discussion}

Early unpublished work by the California Dept. of Food & Agriculture on MB fumigation for quarantine control of latania scale is summarized in Table 1. All treatments were reported as 100\% effective. Steinweden (1948), however, reported poor control with MB at 32 g/m$^3$ at 15.5°C against this scale on avocados (2-h fumigation).

In tests conducted in Miami, FL, the ponytail plants tolerated the treatments well, except for Treatment D at 24.4-25°C, which resulted in excessive browning of the outer whorls of leaves ("tip burn"). Latania scales showed a definite preference for the upper leaf surface of ponytail palm, and congregated in the leaf axils, where the tissue is succulent.

Thoroughness of treatment, as indicated by periodic monitoring of gas concentration during the course of fumigation, can be expressed in terms of a "CT product" (mean concentration of MB gas (g/m$^3$) $\times$ time in hours). The CT products of Treatments A through F were calculated as follows: tests at 22.8-25°C, 38.1, 71.9, 105, 113.2, 81.9, and 0, respectively, and tests at 18.3-20°C, 25, 73.8, 106.9, 126.7, 83.1, and 0, respectively.
**TABLE 1. Methyl bromide fumigation trials reported effective against Latania scale in California, 1936-1948.**

<table>
<thead>
<tr>
<th>Host</th>
<th>Fumigation temp. (°C)</th>
<th>MB dosage (g/m³)</th>
<th>Exposure time (h)</th>
<th>Post-fumigation storage conditions</th>
<th>Day of mortality counts</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Areca lutecers</em> (palm: leaves)</td>
<td>26.7</td>
<td>40</td>
<td>1.5</td>
<td>Not stated</td>
<td>7, 14, 15, &amp; 28</td>
</tr>
<tr>
<td></td>
<td>26.7</td>
<td>32</td>
<td>2</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td><em>Persea americana</em> (avocado: fruits)</td>
<td>25.6-26.7</td>
<td>32</td>
<td>2</td>
<td>4-7°C</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>22.8-25.6 &amp; 26.7</td>
<td>40</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.1-23.9</td>
<td>48</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>64</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Solanum tuberosum</em> (potato: tubers)</td>
<td>21.1</td>
<td>32</td>
<td>2</td>
<td>Rm. temp. for 35 days, then 5°C for 7 days</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26.7</td>
<td>32</td>
<td>Rm. temp. for 32 days, then 5°C for 7 days</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td>2</td>
<td>Rm. temperature</td>
<td>42</td>
</tr>
</tbody>
</table>

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*These data are summarized from unpublished reports of the California Dep. of Food & Agriculture (D. A. Fiskall, pers. comm.). The avocado data were summarized by Steinweden (1948).

1. g/m³ is equivalent to oz./1000 ft³.
2. Fumigated under 80 cm of vacuum. All other tests were conducted at normal atmospheric pressure.
3. Potatoes are not a normal host for Latania scale, and were used only for insectary rearing.
The efficacy of Treatments A through F is shown in Table 2. At the dosages used, MB fumigation was 100% effective at 22.8-25°C. Good results even at the low dosage of 16 g/m³ for 2½ h (Treatment A) confirms the validity of earlier data from California (Table 1). At cooler temperatures (18.3-20°C), fumigation was still effective, except in Treatment A (16 g/m³ for 2½ h), where 4-25% (x̄ = 13.1%) survival occurred. Similar scale survival was recorded in the controls (Treatment F), i.e., 1-26% (x̄ = 12.4% survival).

Body decomposition and moisture loss occurred over an extended period of time under the humid conditions prevalent in Florida, and at the high RH at which fresh fruits and vegetables are best stored. At 31 days post-treatment a few insects retained some body moisture. Among the controls examination revealed 32 to 99% (x̄ = 73.5%) of the scales were dead (D); 1 to 62% (x̄ = 22.4%) were alive (L); and 0 to 12% (x̄ = 3.5%) were moribund (M). For all practical purposes scales classified as “moribund” were dead. There was no “delayed-action mortality,” when lack of movement rather than lack of moisture was used as the criterion of death. A few fumigated scales recorded as “moribund” contained a wasp larva, which appeared to be dead.

As the scales decomposed and lost moisture, their bodies changed from a bright lemon-yellow color, bloated and flexible, to an amber, moist, to straw colored and dehydrated. Immature scales, especially, desiccated quickly, became dry, brittle, and dark brown in color. Fully mature female scales dehydrated more slowly than others. Occasionally the armor of dead scales sloughed off prior to inspection. Also, some of the dead scales examined contained an opening made by thrips or emerging wasps. In controls, live thrips were occasionally found within hollowed-out scales. Whether these thrips were predators or merely scavengers is unknown.

Color and consistency provide good evidence of mortality, but should not be the only consideration when examining freshly fumigated scales. The progression of color changes was somewhat slower among scales which had received Treatment E. This is probably a result of the preservative effect of refrigeration. Inasmuch as these scales retained their lemon-yellow color longer, warming them and checking for slight movement was deemed especially important for this group. No movement, however, was ever observed.

Conclusions and Recommendations

The results of this study lead to the following conclusions and recommendations:

1. The “squash test” for determining viability of armored scales in the field is not an adequate test for fumigated specimens. An accurate assessment of treatment efficacy can be made only by microscopic examination to detect slight body movements and pharyngeal pulsations.

2. During fumigation, the dosage, length of exposure, and temperature of the commodity are factors critical to the success of treatment. Higher dosages of a fumigant are required at lower temperatures, in order to effect a complete kill, because of reduced metabolism in the insects (Monro 1969, Anon. 1981). Data from California (D. Fiskaali, unpubl, Steinweden 1948) illustrated that MB at a dosage of 32 g/m³ for 2 h was completely effective

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fumigation temp. (°C)</th>
<th>Viability of scales after treatment&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2</th>
<th>7</th>
<th>10</th>
<th>14-15</th>
<th>17</th>
<th>21</th>
<th>24</th>
<th>28</th>
<th>3.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>D</td>
<td>L</td>
<td>M</td>
<td>D</td>
<td>L</td>
<td>M</td>
<td>D</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>A</td>
<td>22.8-23.5</td>
<td></td>
<td>81</td>
<td>0</td>
<td>19</td>
<td>51</td>
<td>0</td>
<td>9</td>
<td>98</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>18.3</td>
<td></td>
<td>91</td>
<td>5</td>
<td>4</td>
<td>67</td>
<td>23</td>
<td>10</td>
<td>70</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>B</td>
<td>22.8-23.5</td>
<td></td>
<td>99</td>
<td>0</td>
<td>1</td>
<td>18</td>
<td>0</td>
<td>2</td>
<td>97</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>18.3</td>
<td></td>
<td>93</td>
<td>0</td>
<td>7</td>
<td>97</td>
<td>0</td>
<td>3</td>
<td>99</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>22.8-23.5</td>
<td></td>
<td>80</td>
<td>0</td>
<td>20</td>
<td>99</td>
<td>0</td>
<td>1</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>18.3</td>
<td></td>
<td>80</td>
<td>0</td>
<td>20</td>
<td>98</td>
<td>0</td>
<td>2</td>
<td>98</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>24.4-25</td>
<td></td>
<td>95</td>
<td>0</td>
<td>5</td>
<td>99</td>
<td>0</td>
<td>1</td>
<td>100</td>
<td>0</td>
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<tr>
<td></td>
<td>20</td>
<td></td>
<td>84</td>
<td>0</td>
<td>16</td>
<td>95</td>
<td>0</td>
<td>5</td>
<td>96</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>24.4-25</td>
<td></td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
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<td></td>
<td>20</td>
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<td>---</td>
<td>95</td>
<td>0</td>
<td>15</td>
<td>95</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>F (control)</td>
<td>24.4-25</td>
<td></td>
<td>66</td>
<td>24</td>
<td>10</td>
<td>90</td>
<td>0</td>
<td>6</td>
<td>38</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>18.3</td>
<td></td>
<td>73</td>
<td>36</td>
<td>1</td>
<td>90</td>
<td>20</td>
<td>1</td>
<td>93</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

<sup>a</sup>Numbers in heading across top of table indicate the days on which scale viability was evaluated. Abbreviations: D = % dead; L = % live; M = % moribund. Percentages are based on 100 scales.

<sup>b</sup>Treatments were as follows: A, B, and C: 16, 32, and 48 g/m<sup>2</sup>, respectively, for 2.5 h; D: 32 g/m<sup>2</sup> for 4 h; E: 32 g/m<sup>2</sup> for 2.5 h, followed by refrigeration for 7 days at 4.4-7.2°C; F, control (no treatment). g/m<sup>2</sup> is equivalent to oz./1000 ft<sup>2</sup>.

<sup>c</sup>No data, because scale supply was exhausted.

- No data, because plants were undergoing 7 days of refrigeration.
at 21.1°C, but killed only 28.3% of the latania scales at 15.6°C. Based on
the results of the present study, the following are the minimum schedules
that can be recommended as effective against latania scale on ornamentals
(MB at normal atmospheric pressure):
16 g/m³ for 2⁵/₅ h; 22.8°C or above.
32 g/m³ for 2⁷/₃ h; 18.3 to 22.2°C.
Air circulation should be provided so that temperatures throughout the
chamber load are relatively uniform, and never below 18.3°C.
(3) If the scale-infested commodity being fumigated is avocado, one
should bear in mind that these fruits, like many others, tend to absorb MB
gas (P. C. Witherell, unpub. data). Gas loss is even greater if the fruits
are packed in corrugated fiberboard cartons or under tarpaulin. Accordingly,
fumigation schedules of slightly higher dosage or longer exposure time than
aforementioned would be advisable. The following schedules, therefore, are
recommended for use against latania scales on avocado (MB at normal
atmospheric pressure):
24 g/m³ for 2⁵/₃ h; 22.8°C or above.
32 g/m³ for 3 h; 18.3 to 22.2°C.
Fruit load in the chamber or under tarpaulin should be 70% or less, cal-
bulated by the height of the chamber or enclosure. Treatments D and E, at
21.1°C or above—both of which are prescribed for use on avocados against
eggs and larvae of fruit flies (Anon. 1981)—are also 100% effective against
latania scale. These schedules, however, may cause some phytotoxic damage
to the fruit. Tolerance of avocado to fumigation depends, to some extent,
on the variety of fruit. Varieties exhibit a wide range of tolerance to MB
(Witherell et al. 1982). Normal fruit rots, particularly anthracnose, de-
velop faster after MB fumigation, since the ripening process is accelerated
by 2 to 4 days. Vigorous brushing of fruits to remove scales is also possible,
but probably impractical for large shipments.

Acknowledgments

I wish to thank Mr. Kenneth D. Havel (USDA,APHIS, PPQ, Hoboken,
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(California Dept. of Food & Agric.) for their help with this manuscript. I
also thank Mr. David Lowe (formerly with Florida DACS, DPI) for pro-
viding a source of infested material.

Post Script: In a recent meeting between USDA and Japanese MAFF
officials in Tokyo, the data in this paper were presented. Agreement was
reached that Japanese inspectors will use microscopic examination to de-
termine scale insect mortality in fumigated commodities.

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DACS, DPI, Gainesville, FL.
RESPONSE OF TRICHOGRAMMA PRETIOSUM AND T. EVANESCENTS TO WHITELIGHT, BLACKLIGHT OR NO-LIGHT SUCTION TRAPS

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ABSTRACT

The response of Trichogramma pretiosum Riley and T. evanescens Westwood to blacklight, whitelight, or no-light suction traps in empty 44.7 m³ rooms showed that significantly more (P<0.01) of both species responded to blacklight than to whitelight or no-light traps. About 40% and 69% of the T. evanescens and T. pretiosum, respectively, were caught in the blacklight trap. No significant difference (P>0.05) was found in the response of T. pretiosum to whitelight and no-light traps, while significantly more (P<0.05) T. evanescens were caught in the whitelight trap than in the no-light trap. Females, especially those of T. evanescens, appeared to be more responsive than males as more females than males of both species were usually caught. The implications of these findings should be considered in planning releases of Trichogramma for control of storage moths in warehouses.

RESUMEN

El comportamiento de Trichogramma pretiosum Riley y T. evanescens Westwood hacia trampas de succión de luz negra, luz blanca, o trampas sin luz en cuartos vacíos de 44.7 m³, indicó que significativamente (P < 0.01) ambas especies respondieron más a las trampas de luces negras que a las trampas de luces blancas o a las de sin luces. Alrededor de 40% y 60% de T. evanescens y T. pretiosum respectivamente fueron atrapadas en la trampa de luz negra. No se encontró ninguna diferencia significativa (P >

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1Hymenoptera, Trichogrammatidae