AN ENTOMOPHTHORA ATTACKING CITRUS RED MITE

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One of the most serious pests of Citrus in Florida is the citrus red mite, *Paratetranychus citri* (McG.), which is commonly known in this state as the purple mite. Although this mite has been known in Florida since before 1885 [Riddle (5)], only during the past two decades has it assumed major importance in all of the citrus areas in this state. Because red mites have a short life cycle and are small in size, heavy infestations can build up quickly and rather inconspicuously. Mites may be found at almost any season of the year, but the damage they cause is negligible until they become abundant. These pests attack the leaves, young twigs, and fruit causing an injury which is grayish in color. This damage is difficult to measure or estimate unless there is a leaf drop. During the fall, winter, and spring months, the injury caused by heavy infestations has, at times, resulted in a heavy leaf drop in many groves.

In 1944 Thompson (14) pointed out that sulfur sprays had been effective in upsetting the natural balance of control of red mites, and that reinfestations of these mites were frequently more severe following a sulfur spray than in adjacent nonsprayed control plots. Previously, Thompson (13) had reported that red mites became more abundant following copper sprays than where no copper had been applied. In 1948 Thompson and Stearns (15), in a comparison of two post-bloom sprays, showed that the amount of copper deposited from a copper-wettable sulfur spray was, on the average, 1.8 mcg/cm² whereas a copper-oil spray resulted in an average deposit of 3.4 mcg/cm². Six months after these sprays the red mite infestations were 8 percent and 59 percent respectively. He suggested (14) the possibility that fungicidal sprays retarded the effectiveness of any entomogenous fungi that might be present.

Although a survey of the available literature has failed to show that a specific fungus has been found to be associated with red mites, the mites have been reported to disappear during the summer and early fall months (6, 14). These epizootics have in the main been attributed to high temperatures (6, 14) or to

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unknown causes (4). Griffiths and Thompson (3) reported four insect predators, a trash bug, an aphis-lion, and two ladybeetles, as being predaceous on red mites in Florida. They concluded that counts made on these predators could not be satisfactorily correlated with increases and decreases of infestations, and that there was apparently some other factor which played an important role in the natural control of red mite infestations.

In 1948, the writer observed fungus hyphal bodies and resting spores in red mites. However, the material was not sufficient to determine the identity of the fungus. In August of 1950 this fungus was observed again in our laboratory by Miss Jean Linebaugh. Since that time specimens have been numerous and all stages of parasitism have been found. This endoparasitic fungus attacking red mites has been identified as *Entomophthora* sp.

The genus *Entomophthora* belongs to the order Entomophthorales and to the class Phycomycetaceae. According to Bessey (1), “some species of this genus are called *Empusa* by some writers, but since this name was used earlier for a genus of Orchids the next later name, *Entomophthora*, must be used.” The members of this genus are all parasitic within insects (1) and were long thought to be obligate parasites. However, several species have been grown in culture (7, 8, 9 and 10). Probably other species will be induced to grow in culture when the proper media and conditions are provided.

A number of species of *Entomophthora* are economically important. Among these are *E. muscae* on the common housefly, *Musea domestica* Linn.; *E. grylli* on grasshoppers; and *E. fumosa* attacking the citrus mealybug, *Pseudococcus citri* Risso. Speare (11) has reported that in Florida *E. fumosa* was unquestionably the major factor in the natural control of the citrus mealybug. The species of *Entomophthora* attacking red mites is similar to *E. fumosa*, but does not appear to be the same species.

In general, species of *Entomophthora* infect insects by the penetration of the integument and the appendages (12). After the conidium germinates and the germ tube penetrates into the body cavity, the hypha forms thick segments which break apart from one another. These are the hyphal bodies which multiply and which dissolve the internal organs of the host, presumably by enzymes which the fungus secretes (1). After the insect is dead and the food supply depleted, the hyphal bodies may develop in one of two ways. Under unfavorable environmental
conditions, the hyphal bodies may develop thick walls and form resting spores (2). Under favorable conditions the hyphal bodies form conidiophores which emerge through the integument of the insect and produce conidia. As the conidium matures, the conidiophore and the conidium absorb water. Finally a strong pressure is developed which causes the conidium to be violently discharged into the air. If the conidium fails to strike an insect it may germinate forming a secondary conidium which is, in turn, discharged. This process may take place until a host is located or the protoplasm in the conidium is exhausted. In some species true zygospores may be formed, but in others the resting spores are asexually developed.

Red mites infected with *Entomophthora* may show one of several external manifestations. The first indication of disease can be determined in living mites by observing the movement of the adult mite. In all cases, to date, mites which move slowly in a staggering or weaving manner have been found to be infected with hyphal bodies. These mites may contain from 2 or 3 long-ovoid hyphal bodies to a larger number which fill approximately one-half of the body cavity. Mites which have recently died appear normal at first glance, but do not move when touched with a needle. These mites have been found to be completely, or almost completely, filled with hyphal bodies. No remaining part of the internal organs can be distinguished, but the red pigment is still present and is distributed throughout the body between the hyphal bodies.

Mites killed by the fungus generally exhibit one of two appearances. If favorable development of the fungus has taken place, the body of the mite will be somewhat distended, cheesy in consistency, and dark red or dark purple in color, occasionally with a grayish tinge. These mites usually show some stage of conidiophore development. The grayish tinge if present, is indicative that the fungus is mature and that conidia have been produced by the conidiophores. Under unfavorable conditions, mites contain resting spores, are usually very hard when cut with a needle, and are dark purple to black in color. These mites are generally a little smaller than normal or hyphal-body-filled mites; rarely are they distended.

Figure 1 shows a side view of an adult, dead, red mite which was killed by *Entomophthora* sp. It should be noted that the conidia which are just outside of the integument are formed
on the dorsal side of the mite. To date the formation of directly-ventral conidiophores and conidia has not been found.

Fig. 1. Photomicrograph of citrus red mite killed by *Entomophthora* sp.

Although this disease is more prevalent and the fungus development is more typical in adult mites than in younger stages, it has been found to attack deutonymphs. No visible infection has been found in protonymphs.

This species of *Entomophthora* has been found throughout peninsular Florida, south of Mount Dora to Avon Park and from
east of Tampa to Fort Pierce. All examinations of heavy mite infestations in groves between these points have shown the disease to be present. Because of this occurrence in groves scattered over such a wide area, it is probable that the fungus is present throughout the citrus belt.

During September and October, counts made in groves with heavy infestations showed adult mortalities ranging from 32 to 95 percent. In October four counts were made in a Temple grove near Tampa in order to learn more about the mortality of the population as the various generations matured. Table 1 shows the percent infestation in this grove, the percent adults, and the percent mortality of adult mites due to *Entomophthora* sp. It is interesting to note that during the period of highest mortality, the percent of leaves infested was the lowest. No predators were found during this period of observation.

<table>
<thead>
<tr>
<th>Date</th>
<th>Percent Leaves Infested</th>
<th>Percent Adult Mites</th>
<th>Percent Adult Mortality</th>
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<tr>
<td>October 11</td>
<td>96</td>
<td>13.23</td>
<td>37.60</td>
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<tr>
<td>October 20</td>
<td>84</td>
<td>25.28</td>
<td>70.54</td>
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<tr>
<td>October 27</td>
<td>93</td>
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<tr>
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<td>90</td>
<td>27.89</td>
<td>58.82</td>
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<tr>
<td>Average</td>
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<td>19.67</td>
<td>49.74</td>
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</table>

Additional study of this disease will be necessary in order to determine its importance in the biological control of red mites. The climate, *Entomophthora*, and the various predators undoubtedly have interacting effects on the red mite infestations.

**LITERATURE CITED**

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