Control of *Thrips palmi* KARNY (Thysanoptera: Thripidae)
by *Orius* spp. (Heteroptera: Anthocoridae)
on Greenhouse Eggplant

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The control effect of anthocorid predators, *Orius* spp., against *Thrips palmi* KARNY on greenhouse eggplant was evaluated by releasing various numbers of predator nymphs and then examining the population fluctuations of the prey and the predators. When two, three and five last instar nymphs of the predators were released per plant, the total density of *Orius* spp. adults and nymphs reached 0.1, and the *T. palmi* density decreased to 0.6 per leaf several weeks after the release (regardless of the number of predators released). Both populations fluctuated around that density afterwards. I concluded that *Orius* spp. could successfully control the population of *T. palmi* for a long period. In such successful control, the percentage of injured fruits is estimated to be 10%, but it appears that it would be impossible to further lower the *T. palmi* density by increasing predator density.

Key words: *Thrips palmi*, *Orius* spp., biological control, eggplant, greenhouse

INTRODUCTION

Thrips palmi KARNY is one of the most serious pests of eggplant both in greenhouses and in open fields in Japan. It is difficult to control *T. palmi* only with chemicals (KAWAI and KITAMURA, 1990), because this pest is characterized by a high reproductive rate (KAWAI, 1985), low sensitivity to a number of commercially available insecticides (MATSUZAKI et al., 1986), and behaviors of ovipositing in plant tissues and pupating in the soil. Several methods of cultural control against *T. palmi* are already developed (KAWAI, 1990), but it is also difficult to control this pest with only these methods. The development of a biological control system involved with this pest is needed.

Anthocorids belonging to the genus *Orius* are polyphagous predators of various minute insects and mites. Several species of *Orius* are responsible for the suppression of the populations of *Aphis glycines* MATSUMURA (OKU and KOBAYASHI, 1966), *Frankliniella occidentalis* (PERG.) (LETOURNEAU and ALTIERI, 1983), *Diatraea grandiosella* (DYAR) (KNUTSON and GILSTRAP, 1989) and *Tetranychus kanzawai* KISHIDA (OHTANI et al., 1991). Populations of *T. palmi* on open-field eggplant have also been suppressed by *Orius* spp. (KAWAMOTO and KAWAI, 1988; NAGAI, 1990), but its effectiveness as a biological control agent on greenhouse eggplant has remained unknown.

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In this study, *Orius* spp. were released on greenhouse eggplant infested by *T. palmi*, and the density of *T. palmi* under the control by *Orius* spp. and the effective period of the control were determined.

MATERIALS AND METHODS

Insects. *Orius* spp. adults and nymphs were collected on open-field eggplant in Kurume, Fukuoka Pref., in June of 1988 and 1989, and reared on *T. palmi* on potted eggplant. Several *Orius* species on Japanese eggplant often inhabit the same host (YASUNAGA and KASHIO, 1993) and are impossible to distinguish from one another. It is therefore probable that the population used in the present study consisted of more than one species.

T. palmi adults and larvae were collected on open eggplant fields in Takada and Asakura, Fukuoka Pref., in May 1981, and reared on potted cucumber for this study.

Outline of experiments. Two greenhouse experiments were conducted in the Kurume Branch of the National Research Institute of Vegetables, Ornamental Plants and Tea. The relationship between the density of *Orius* spp. released and the density of *T. palmi* was examined in small glasshouses (Experiment 1), and the effective period of the control was examined in a vinyl house (Experiment 2).

Experiment 1. In each of six glasshouses (10 m²), eight seedlings with *T. palmi* eggs of an eggplant cultivar "Shin-nagasaki-naga" were transplanted eight days before the release of *Orius* spp. Fourteen days before transplanting, the potted seedlings were placed in a glasshouse in which *T. palmi* had been reared. After 24 h, they were brought out of the glasshouse, and the *T. palmi* adults and larvae were removed from the seedlings. The number of *T. palmi* eggs on each seedling was not counted.

The last instar nymphs of *Orius* spp. were released on eggplant infested with *T. palmi* (10 Sept., 1988). The *Orius* nymphs were transferred with a fine brush from cultures on the potted eggplant mentioned previously to the leaves of each plant. The number of *Orius* spp. released per plant differed among the glasshouses as follows: (1) no predator was released (control), (2) one nymph was released on every other plant (0.5 nymphs per plant), (3) one nymph was released on each plant, (4) two nymphs were released on each plant, (5) three nymphs were released on each plant, and (6) five nymphs were released on each plant.

The population densities of *T. palmi* and *Orius* spp. were examined every seven days after the seedling transplants. The number of insects on ten newly expanded leaves of all the plants was counted. If the number of newly expanded leaves was less than ten, then insects on all expanded leaves were counted.

Experiment 2. A vinyl house (20 m × 5.4 m) was divided into four plots. Twenty-four eggplant seedlings of the same cultivar used in the Experiment 1 were transplanted in each plot (three rows per plot, eight plants per row). The intervals between rows were 1.8 m, and the seedlings were planted at intervals of 36 cm along each row. Each plot was separated by white cheesecloth. The openings of the vinyl house were covered with white cheesecloth to prevent insects from entering, and the upper part of the vinyl house was covered with black cheesecloth to prevent it from heating excessively. *T. palmi* adults and larvae were released 16 days after transplanting by putting leaves of eggplant infested by *T. palmi* on the ground near the base of each plant. The number of *T. palmi* released was not counted.

Twelve days later, the last instar *Orius* spp. nymphs collected from cultures on the

potted eggplant previously mentioned were released on the eggplant infested with *T. palmi* (31 July, 1989). The release of *Orius* spp. was conducted in the same manner as in Experiment 1. The number of *Orius* spp. released per plant differed among plots as follows: (1) no predator was released (control), (2) two nymphs were released on each plant, (3) three nymphs were released on each plant, and (4) five nymphs were released on each plant.

The population densities of *T. palmi* and *Orius* spp. were examined in the same manner as in Experiment 1.

RESULTS

Experiment 1

Population fluctuations in the total number of *Orius* spp. adults and nymphs in each of the five glasshouses releases are shown in Fig. 1. In the glasshouse in which 0.5 nymphs per plant were released, the population increased slowly and reached a peak of 0.21 per leaf at the end of October. The peak value was the maximum among the five glasshouses. In the glasshouse in which one nymph per plant was released, the population gradually increased, and fluctuated between 0.05 and 0.07 per leaf during October. There was a similarity in population fluctuations among the three glasshouses in which two, three or five nymphs per plant were released; the density increased rapidly after the release and fluctuated around 0.1 per leaf from the middle of September to the end of October in every glasshouse. The densities in all the glasshouses decreased rapidly after mid-October.

In the three glasshouses in which two, three or five nymphs per plant were released, the peak density was attained one to two weeks after the release. However, the peak density was attained five to six weeks after the release in the glasshouses in which 0.5 or 1 nymph per plant was released.

Population fluctuations in the total number of *T. palmi* adults and larvae in each of the six glasshouses are shown in Fig. 2. Six days before the release or the predator, the density of *T. palmi* in each glasshouse was 1.27–1.89 per leaf, and there was no significant difference in density among glasshouses. In the control glasshouse, the population of *T. palmi* increased exponentially, attaining 13.8 per leaf by the end of the experiment. In the glass-

Fig. 1. Population trends for *Orius* spp. adults and nymphs in five glasshouses in Exp. 1. (A) Glasshouses in which one nymph was released on every other plant or on each plant; (B) glasshouses in which two, three or five nymphs were released per plant. Arrows indicate the time of release of *Orius* spp., and numerals in the figure represent the number of nymphs released per plant.

Fig. 2. Population trends for *Thrips palmi* adults and larvae in six glasshouses in Exp. 1. For explanation of (A), (B), arrows and numerals, see Fig. 1. For explanation of EIL 1 and EIL 2, see text. The ordinate is represented on log scale.

house in which 0.5 *Orius* spp. nymphs per plant were released, the *T. palmi* population increased similarly and attained a maximum of 14.9 per leaf. In the glasshouse in which one nymph of *Orius* spp. per plant was released, the *T. palmi* density gradually decreased after the release of the predators, became 0.7 per leaf in mid-October, and increased afterwards. The population fluctuations of *T. palmi* did not differ much among the glasshouses in which two, three or five nymphs of *Orius* spp. per plant were released. The density decreased rapidly after the release, fluctuated around 0.6 per leaf from the middle of September to the end of October, and slightly increased afterwards.

Experiment 2

Population fluctuations in the total number of *Orius* spp. adults and nymphs in each of the three release plots are shown in Fig. 3. The densities in the plot where five nymphs were released per plant were higher for several weeks after the release than those where two or three nymphs were released per plant. But the densities in these three plots were at a similar level in the latter half of the experiment regardless of the number of the predators released, and fluctuated around 0.1 per leaf. The peak density of each plot was achieved one to three weeks after the release.

Population fluctuations in the total number of *T. palmi* adults and larvae in each of the four plots including the control are shown in Fig. 4. At a time when the predators were

Fig. 3. Population trends for *Orius* spp. adults and nymphs in three plots in Exp. 2. For explanation of the arrow and numerals, see Fig. 1.

Fig. 4. Population trends for *Thrips palmi* adults and larvae in four plots in Exp. 2. For explanation of the arrow and numerals, see Fig. 1. For explanation of EIL 1 and EIL 2, see text. The ordinate is represented on log scale.

released, the density of *T. palmi* in each plot was 3.34–4.31 per leaf, without any significant difference among the plots. In the control plot, the *T. palmi* population increased exponentially, reaching a peak density of 26.6 insects per leaf four weeks after the release. Afterwards, the population fluctuated between 10 and 20 per leaf, as the leaf became less suitable due to injury by *T. palmi*. *T. palmi* density in the release plots fluctuated similarly, regardless of the number of predators released. In all plots, the density decreased gradually after the release of the predator, and fluctuated around 0.6 insects per leaf.

DISCUSSION

KAWAI (1986) estimated economic injury levels (EILs) of *T. palmi* for eggplant, expressing them as the number of adults per leaf with a permissible level of yield loss of 5%. He also showed a relationship between the number of adults and the number of larvae on eggplant leaves. From these results, two EILs expressed as the total number of adults and larvae were calculated, and shown in Figs. 2 and 4. EIL 1 (0.33 per leaf) is an estimate for an uninjured fruit yield with a permissible level of yield loss of 5%. EIL 2 (0.55 per leaf) is another estimate in which fruits with slight injury on the pericarp are included in the group of uninjured fruits. When the density is at EIL 2, the percentage of uninjured fruits becomes 10%, provided that no injury on the pericarp is permitted. In any plot in which two or more *Orius* spp. nymphs per plant were released, *T. palmi* density decreased to about 0.6 per leaf two to three weeks after predator release, and this level of density was maintained afterwards. This shows that *Orius* spp. effectively controlled the *T. palmi* population for a long period. The fact that *T. palmi* density was maintained at a similar level in any plot in which two or more *Orius* spp. nymphs per plant were released suggests that *T. palmi* density level does not decrease even if more predators are released. Density level was nearly equal to EIL 2, and greater than EIL 1. On eggplant grown in open fields, the *T. palmi* density in plots with *Orius* spp. predation was higher than that in the present experiments and did not stabilize (KAWAMOTO and KAWAI, 1988; NAGAI, 1990). The restriction of emigration and immigration in the present experiments might be responsible for these differences.

The release of *Orius* spp. was successful even when the initial density of *T. palmi* was as high as four insects per leaf, as in Experiment 2. This suggests that predator release could be effective for controlling populations of *T. palmi* at such a high density.

As the density of *Orius* spp. decreased after mid-October, the *T. palmi* density increased in Experiment 1 (Figs. 1 and 2). KINGSLEY and HARRINGTON (1982) stated that *Orius insidiosus* (SAY) females entered into a reproductive diapause and did not lay eggs under short-day conditions. NAGAI (1993) also noted that the percentage of ovipositing females of *O. sauteri* decreased under short-day conditions. The decrease in *Orius* spp. and a corresponding increase in *T. palmi* after mid-October may have been due to adult diapause in *Orius* spp. In order to control *T. palmi* utilizing *Orius* spp. in winter, it may be necessary to lighten in greenhouses or to use other predators without adult diapause.

In conclusion, *Orius* spp. could successfully control the population of *T. palmi* for a long period by releasing two or more nymphs per plant several weeks after transplanting. In this successful control, the percentage of injured fruits becomes about 10% if no injury on the pericarp is permitted. However, if fruits with slight injury on the pericarp are included in the group of uninjured fruits, the percentage of injured fruits could be reduced to about 5%.

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