Synchronism of immigration of adult yellow tea thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) to citrus orchards with reference to their occurrence on surrounding host plants

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Abstract

*Scirtothrips dorsalis* adults generally immigrate to citrus orchards after propagation on suitable host plants that grow near the orchards; however, it is not clear when these thrips immigrate. In this study, the time of *S. dorsalis* adult immigration to citrus orchards was examined in relation to their occurrence on surrounding host plants. The investigation was carried out in citrus orchards and the surrounding fields of the following three plants: tea groves, bigleaf podocarp trees, and Japanese pear trees. The average number of adults emerging from these four plant fields gave six or seven peaks from May to early September, notwithstanding the small number of adults emerging from the citrus orchards. The peak periods of trap catch in citrus orchards coincided with those of adult emergence from the fields of four plants. The peak periods of adult *S. dorsalis* density on citrus fruits and shoots coincided with those of trap catch in citrus orchards. These results demonstrated that *S. dorsalis* adults immigrated to citrus orchards immediately after emerging from other suitable host plants surrounding the orchards.

Key words: *Scirtothrips dorsalis*; citrus; immigration; adult emergence

INTRODUCTION

Yellow tea thrips, *Scirtothrips dorsalis* Hood, are one of the pests causing severe economic damage by affecting citrus fruits in Japan. Their feeding habits in the period from June to October cause severe rind blemishes on the fruit surface (Nishino and Kodomari, 1988; Tatara and Furuhashi, 1992) resulting in the loss of cosmetic quality of the fruits (Furuhashi et al., 1992; Tatara, 1995). Although *S. dorsalis* have a wide host range (Muraoka, 1988; Ohkubo, 1995), tea and sweet viburnum are better for their growth than citrus (Tatara, 1994). Thus, this pest generally immigrates to citrus orchards after propagating on other suitable host plants that grow near the orchards (Ohkubo, 2001); however, few studies have targeted the time of *S. dorsalis* adult immigration to citrus orchards with respect to its occurrence on surrounding host plants.

The number of *S. dorsalis* adults captured by yellow sticky traps in citrus orchards can be characterized as the rate of immigration from surrounding host plants because the number was not influenced by insecticide application on citrus trees (Tsuchiya and Nishino, 1984). Yellow sticky traps placed in citrus orchards have been used to monitor the immigration of *S. dorsalis* adults, which will help to determine the time of insecticide application (Ohkubo, 1989; Muraoka, 1990; Masui et al., 1995; Tatara, 1995); however, because the damage by *S. dorsalis* is caused when low densities of thrips are found on fruits (Takagi, 1981; Tatara and Furuhashi, 1992), it frequently becomes difficult to perform timely controls. Hence, if the immigration time of *S. dorsalis* to citrus orchards can be predicted before the fruits are infested by the pest, timely controls will become more feasible. *S. dorsalis* adults were observed to disperse by flying from their reproduction sites within a short time of reaching the peak densities in each period (Masui, 2007). This finding may indicate that the immigra-
tion time of adults to citrus orchards can be estimated through their occurrence on host plants surrounding citrus orchards. The aim of this study was to investigate the relationship between the time of *S. dorsalis* adult immigration to citrus orchards and their occurrence on surrounding host plants.

**MATERIALS AND METHODS**

**Study site.** The investigation was carried out from 1999 to 2001 in Shizuoka Prefectural Agriculture and Forestry College citrus orchards (mandarin orange: *Citrus unshiu* Marc.), a Japanese pear orchard (*Pyrus pyrifolia*), tea groves (*Thea sinensis*), and windbreaks of bigleaf podocarp trees (*Podocarps macrophyllus*) (Fig. 1). In the tea groves, shoots were harvested twice from late April to late June and the groves were trimmed clean once after each harvest every year. Trimming was performed twice after the second harvest only in 2000. The bigleaf podocarp trees were trimmed clean in June 2000 and July 2001. Pesticides were applied using conventional methods annually on the citrus trees, tea groves, and Japanese pear trees; however, insecticides were not sprayed on three and four citrus trees in 2000 and 2001, respectively, to census the density of thrips on those trees.

**Larval density in tea groves and bigleaf podocarp trees.** In each of the tea groves and bigleaf podocarp trees, eight census spots were randomly selected and larvae were captured using a sticky plate (20 cm × 15 cm) using the beating method. Sampling was carried out annually at intervals of five or six days from early March to early September, and larvae were counted under a stereomicroscope.

**Adult emergence.** In each field of the tea groves, bigleaf podocarp trees, citrus trees and Japanese pear trees, four ground traps (Fig. 2) were placed under the trees. Flowerpots were placed upside down on the ground with transparent sticky tape covering the drainage hole; adults were caught when they emerged from the ground and flew toward the light passing through the drainage hole covered by the sticky tape. The positions of these traps were changed every few days, and the number of adults captured from early March to early September was counted under a stereomicroscope. The investigation was not carried out in the Japanese pear orchard in 1999.

**Adult immigration to citrus orchards.** A yellow flat plate (20 cm × 20 cm) with a sticky sheet (20 cm × 15 cm) on both sides (Muraoka, 1990) was placed vertically at a height of 1.5 m in the citrus orchard. The number of captured adults was counted every few days from early March to early September.

**Adult and larval density on citrus trees.** Annually, three to four nonadjacent trees were evenly selected as census trees in the orchards. Three trees in 2000 and four trees in 1999 and 2001 were used, in each of which 40 fruits (25 fruits in 1999) were randomly selected at five- or six-day intervals from early June to early September, and the number of adults and larvae infesting the fruits was counted visually. Twenty young shoots were also randomly selected from the census trees and washed using spreader solution (0.05% polyoxyethylene hexytan fatty acid ester solution) at five- or six-day intervals from early May to early September. The washings were filtered using filter paper and the number of adults and larvae caught on the filter paper was counted under a stereomicroscope.

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![Fig. 1. Map showing the experimental fields. c: citrus orchard, t: tea groves, jp: Japanese pear orchard, w: windbreak of bigleaf podocarp trees, cg: citrus greenhouse, pe: persimmon orchard, l: lawn field, v: vegetable field, o: ornamental plants greenhouse, pa: park, po: pond and b: barn.](image1)

![Fig. 2. Ground trap for monitoring adult emergence of *S. dorsalis*.](image2)
Statistical analyses. Regression analysis was used to detect a significant correlation between the number (transformed to log\(x+1\)) of adults captured by the trap in citrus orchards and the following two variables: the number (transformed to log\(x+1\)) of adults emerging from four plant fields and the number (transformed to log\(x+1\)) of adults infesting fruits or shoots in citrus orchards.

RESULTS

Larval density in tea groves and bigleaf podocarp trees

The seasonal prevalence of *S. dorsalis* larvae in tea groves and bigleaf podocarp trees is shown in Fig. 3. In tea groves, larvae were observed from late April and showed several peaks of occurrence constantly to early September. The density of the larvae in tea groves decreased temporarily after trimming or insecticide application. In bigleaf podocarp trees, larvae were observed from late May, and the density increased during the period of young shoot growth (July 2000, June 1999 and 2001); however, the density was low during other periods.

Adult emergence

The seasonal prevalence of *S. dorsalis* adults emerging from the ground in each plant field is shown in Fig. 4. A small number of adults was first caught in each field from late March to early April. In the tea groves, peaks of adult emergence were detected five or six times from May to early September each year. In the field of bigleaf podocarp trees, peaks of adult emergence were observed three or four times from June to early September, and the number of emerging adults was highest in June or July each year. Adult emergence from tea groves and bigleaf podocarp trees occurred a little later than the occurrence of larvae in each period (cf. Fig. 3). In the Japanese pear orchard, adult emergence increased from July to August, and peaks were detected two or three times during this period in 2000 and 2001. In the citrus orchard, adult emergence was observed to a small extent from June to early September. The average number of adults emerging from these four plant fields gave six or seven peaks from May to early September. The interval from the peak of adult emergence in May to that in June was approximately four weeks each year. These intervals shortened to two or three weeks in summer from July to August.

Adult and larval density on citrus trees

The seasonal prevalence of *S. dorsalis* in citrus orchards is presented in Fig. 5. The trap catch of adults was first observed in March. Five or six peaks of trap catch were detected from May to early September. There were significant correlations between the numbers of *S. dorsalis* adults captured by the trap in citrus orchards and the average number of adults emerging from four plant
fields in three years (1999: \( r=0.387, p=0.0015 \); 2000: \( r=0.728, p<0.0001 \); 2001: \( r=0.418, p=0.0009 \)) on logarithmic transformed data. These results suggest that the peak periods of trap catch in citrus orchards coincided with those of adult emergence from four plant fields in Fig. 4.

Two to five peaks of adult density on fruits and shoots were observed in citrus orchards from May to early September. The number of adults on shoots increased rapidly when the shoots were growing. The density of larvae on fruits and shoots were low in comparison with that of adults in each year. There were significant correlations between the numbers of \( S. \) dorsalis adults captured by the trap...
in the citrus orchards and the density of the adults on citrus fruits (1999: \( r=0.302, p=0.22351 \); 2000: \( r=0.653, p=0.0033 \); 2001: \( r=0.575, p=0.0125 \)) and citrus shoots (1999: \( r=0.588, p=0.0020 \); 2000: \( r=0.465, p=0.0193 \); 2001: \( r=0.171, p=0.4135 \)) on logarithmic transformed data. These results suggest that the peak periods of adults density on citrus fruits and shoots coincided with those of trap catch in citrus orchards.

**DISCUSSION**

Since *S. dorsalis* females lay their eggs mainly in the tissues of buds and young leaves (Dev, 1964; Nishino and Kodomari, 1988), their abundance is influenced by the quantity of available resources such as young shoots for feeding and oviposition (Shibao et al., 1993). In this study, in tea groves, repeated harvesting and trimming resulted in the continuous growth of young shoots; this was considered to facilitate the occurrence of *S. dorsalis* larvae (Fig. 3). In bigleaf podocarp trees, the number of larvae increased temporarily only during the periods when young shoots grew (Fig. 3). In these plant fields, the number of emerging adults reached a peak immediately after the larval growing period on the young shoots (Fig. 4). On the other hand, only a few larvae occurred even during the growth of young shoots and young fruits on citrus trees (Fig. 5), few adults emerged from the citrus orchards (Fig. 4), indicating that citrus was not suitable for larval development.

*S. dorsalis* overwinter in the adult stage, and overwintered adults move from the trunk or the
ground to the foliage in late March in mid-Japan (Okada and Kudo, 1982). The developmental zero and the effective accumulative temperature from oviposition to adult emergence of the thrips were 9.7°C and 265 degree-days on sweet viburnum, respectively (Tatara, 1994), 8.5°C and 294.1 degree-days on grapes, respectively (Shibao, 1996). Therefore, the duration from oviposition to adult emergence was calculated as 43.7 to 54.6 days in April (14.6 to 15.2°C); 26.5 to 28.4 days in May (19.0 to 19.6°C); 20.0 to 21.8 days in June (22.0 to 22.9°C); 14.8 to 17.3 days in July (25.5 to 27.6°C); 14.8 to 15.9 days in August (27.0 to 27.7°C), respectively, from the data of the AMeDAS station in Hamamatsu from 1999 to 2001. Based on these results, the first small peaks of the average number of emerging adults in March were estimated as the overwintered generation (Fig. 4). Each peak of the average number of emerging adults from four plant fields was estimated as one generation because the intervals of these peaks were equivalent to the developmental durations at various temperatures.

In this study, the synchronism of the adult immigration periods to citrus orchards with reference to its emergence in the fields of surrounding host plants proved that most adults on citrus trees immigrated from surrounding host plants; it was considered that the source host plants of immigrating adults were different in each period because the number of emerging adults differed among plant fields and periods. This study also demonstrated that S. dorsalis adults actively disperse during the peak periods of adult emergence. Thus, we will be able to predict the time of immigration of S. dorsalis adults to unsuitable host plant fields such as citrus orchards in each generation by developing a total effective temperature model supported by trap data. Further studies will be necessary to elucidate the relationship between the time of adult immigration and total effective temperature to predict immigration timing and to perform timely control.

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