Host Plants and Abundance of *Thrips palmi* KARNY (Thysanoptera: Thripidae), an Important Pest of Vegetables in Southeast Asia¹

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Field surveys were conducted to determine vegetable crops infested with *Thrips palmi* as host plants in Thailand, Malaysia and the Philippines in 1987 and to estimate the abundance of this thrips on different vegetable crops in Thailand in 1987–1988 and in Malaysia in 1987. *T. palmi* was found attacking angled loofah, bitter cucumber, cucumber, eggplant, goat pepper, muskmelon, pumpkin, squash, watermelon, wax gourd, yard long bean, two species of *Phaseolus* and one unidentified Cucurbitaceae. Of these crops, eggplant appeared to be most commonly infested with the thrips. The abundance of *T. palmi* on eggplant in Thailand appeared to be influenced by the weather, pesticide applications and fruit type. Heavy rainfall during the rainy season may be responsible for greatly reduced populations of *T. palmi* on eggplant. On the other hand, the high abundance of *T. palmi* observed in truck gardens growing a long fruit eggplant in the dry season may have been induced by destruction of natural enemy and competitor populations from heavy insecticide use.

Key words: *Thrips palmi*, host plants, vegetables, abundance, Southeast Asia

INTRODUCTION

Thrips palmi KARNY, which was first described in 1925 from specimens collected on tobacco plants in Indonesia (KARNY, 1925), is considered native to tropical Asia (HIROSE et al., 1993). Recently, this thrips has rapidly expanded its distribution to adjacent regions and caused serious damage to various crops.

Larvae and adults of *T. palmi* feed on leaves, flowers and fruits of various crops, leaving permanent scars and causing deformities of fruits (SAKIMURA et al., 1986). A positive correlation between the density of *T. palmi* and the incidence of fruit damaged by this thrips has been reported in Japan for cucumber (SUZUKI and MIYARA, 1983), eggplant (KAWAI, 1986) and sweet pepper (KAWAI, 1986). Because the insecticides available for growers in Japan have been less effective against *T. palmi* than expected (SUZUKI et al., 1982; MATSUZAKI et al., 1986), management tactics other than chemical control are needed to manage this thrips. Biological control is a sustainable and environmentally safe alternative to pesticides and offers an excellent opportunity for successful thrips management. Thus, we conducted explorations for natural enemies of *T. palmi* in Thailand, Malaysia and the Philippines in 1987–1988 to initiate a classical biological control program for this pest of vegetables in

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Japan (HIROSE et al., 1993). The present study reports a part of this exploration.

In this paper, vegetable crops infested with *T. palmi* in Thailand, Malaysia and the Philippines are reported. Furthermore, the abundance of *T. palmi* in different vegetable gardens in Thailand and Malaysia is estimated, and possible factors affecting its abundance in eggplant gardens in Thailand are postulated.

MATERIALS AND METHODS

To record vegetable crops infested with *T. palmi*, we collected the thrips in 63 vegetable gardens in Thailand, Malaysia and the Philippines (Table 1). Since it is difficult to identify small insects, such as *T. palmi*, by the naked eye in the field, vegetable crops infested with *T. palmi* as host plants were determined by collecting adult thrips from various vegetable gardens and by identifying the sampled thrips under the microscope in the laboratory. Identifying thrips larvae was often impossible, but they were usually associated with thrips adults on the same plant. For convenience, when *T. palmi* was dominant among thrips adults, we regarded the coexisting larvae as *T. palmi*. Vegetable gardens were arbitrarily visited. When the vegetable gardens were infested with any thrips, approximately 50 adult thrips were collected from leaves and flowers of the host plant in each of them and preserved in AGA fluid (95% ethanol 8 p., water 5 p., glycerine 1 p. and glacial acetic acid 1 p.) until they were identified microscopically.

Table 1. Localities where surveys were conducted for different purposes

Purpose	Date	Country	Locality
Record of the host plants of <i>T. palmi</i>	January 13–17, 1987	Thailand	Chiang Mai, Nakhon Pathom, Nonthaburi
	January 20–23, 1987	Malaysia	Kedah, Perak, Seberang, Perai, Selangor
	January 26–28, 1987	The Philippines	Laguna, Pampanga
	June 18–19, 1987	Thailand	Bangkok, Nonthaburi, Suphan Buri
	October 2, 1987	Thailand	Nakhon Pathom
	November 6, 1987	Malaysia	Cameron Highlands
Estimation of the abundance of <i>T. palmi</i>	June 14–19, 1987	Thailand	Bangkok, Chiang Mai, Nakhon Pathom, Nonthaburi, Suphan Buri
	September 27–October 3, 1987	Thailand	Bangkok, Chiang Mai, Nakhon Pathom, Nakhon Ratchasima, Nonthaburi
	November 5–9, 1987	Malaysia	Cameron Highlands, Penang, Perak
	December 9–18, 1987	Thailand	Bangkok, Chiang Mai, Kanchanaburi, Nakhon Pathom, Nonthaburi
	January 19–February 15, 1988	Thailand	Ayutthaya, Chiang Mai, Chiang Rai, Lamphun, Nakhon Pathom, Nonthaburi, Pathum Thani, Suphan Buri
Analysis of factors affecting the abundance of <i>T. palmi</i>	June 14–19, 1987	Thailand	Bangkok, Chiang Mai, Nakhon Pathom, Nonthaburi, Suphan Buri
	September 27–October 3, 1987	Thailand	Bangkok, Chiang Mai, Nonthaburi
	December 9–18, 1987	Thailand	Bangkok, Chiang Mai, Kanchanaburi, Nakhon Pathom, Nonthaburi
	January 19–February 15, 1988	Thailand	Ayutthaya, Chiang Mai, Chiang Rai, Lamphun, Nonthaburi, Pathum Thani, Suphan Buri

To estimate the abundance of *T. palmi* on different vegetables, we used the presence-absence sampling method (WILSON et al., 1983) in each of the 111 vegetable gardens in Thailand and Malaysia (Table 1). Thirty leaves and 30 flowers were randomly sampled in each garden. The abundance was expressed as a frequency of occurrence of *T. palmi* larvae and adults, i.e. the proportion of leaves or flowers with at least one larva or adult per leaf to the total sampled leaves or flowers.

To determine factors affecting the abundance of *T. palmi* on eggplant in Thailand, we used the above data of the thrips abundance in 71 gardens excluding those of immature plants without flowers (Table 1). Gardens were grouped into four classes according to the time (June, September–October, December, 1987 and January–February, 1988) and the abundance of the thrips was compared between classes. This classification facilitated a comparison of the thrips abundance between the rainy season from June to October and the dry season from November to February. For the same purpose, 16 commercial truck gardens of eggplant (larger than 20 m²) surveyed in Chiang Mai in December 1987 were grouped according to fruit type (long or round fruit) and insecticide application (sprayed or unsprayed garden) and the thrips abundance was subjected to ANOVA. The abundance data of the thrips on flowers were excluded from the comparison and the ANOVA, because more than 99% of the total population of the thrips infest leaves (KAWAI, 1988).

The data were subjected to statistical analyses after transformation using the formula $\sqrt{Y}$ but means represent actual frequency.

Table 2. Vegetables infested with *T. palmi* in Thailand, Malaysia and the Philippines in 1987

Country	Vegetable	No. of gardens surveyed	No. of gardens infested with <i>T. palmi</i>
Thailand	Angled loofah	4	2
	Cucumber	3	3
	Cucurbitaceae sp.	2	1
	Eggplant	5	5
	Goat pepper	3	2
	Muskmelon	2	1
	Squash	1	1
	Watermelon	1	1
	Wax gourd	1	1
	Yard long bean	3	2
Malaysia	Eggplant	5	5
	Goat pepper	2	1
	Muskmelon	1	1
	<i>Phaseolus</i> sp. A	1	1
	<i>Phaseolus</i> sp. B	2	1
	Yard long bean	3	2
The Philippines	Bitter cucumber	2	2
	Eggplant	2	2
	Goat pepper	1	1
	Muskmelon	3	3
	Pumpkin	1	1
	Watermelon	3	2

Table 3. Abundance of *T. palmi* in vegetable gardens in Thailand during June 1987 and January–February 1988 and Malaysia in November 1987

Country	Vegetable	Mean proportion of leaves or flowers with <i>T. palmi</i> ^a	
		Leaf	Flower
Thailand	Angled loofah	0.63 (3) ^b	— (0) ^b
	Cucumber	0.50 (8) ac	0 (1)
	Eggplant	0.34 (71) abcd	0.46 (60) a
	Goat pepper	0.07 (7) bd	0.42 (6) a
	Squash	0.80 (1)	— (0)
	Watermelon	1.00 (1)	— (0)
	Wax gourd	1.00 (1)	— (0)
	Yard long bean	0.06 (5) abd	— (0)
Malaysia	Eggplant	0.73 (4) c	0.75 (2)
	Goat pepper	0.00 (5) d	— (0)
	Muskmelon	1.00 (1)	— (0)
	<i>Phaseolus</i> sp. A	0.03 (1)	— (0)
	<i>Phaseolus</i> sp. B	0.10 (2)	— (0)
	Yard long bean	0.03 (1)	— (0)

^a Values followed by the different letter in a same column are significantly different at the 5% level by TUKEY-KRAMER test. When the number of gardens surveyed per vegetable was more than 3, the vegetable was used for the test.

^b Numbers in parentheses indicate the numbers of gardens surveyed. The difference in the number of gardens surveyed between leaf and flower was due to the presence of immature plants without flowers.

RESULTS

1. Vegetables infested with *T. palmi*

T. palmi were found in many of the vegetable gardens surveyed in Thailand, Malaysia and the Philippines in 1987 (Table 2). Infested vegetables were: angled loofah, *Luffa acutangula*; bitter cucumber, *Momordica charantia*; cucumber, *Cucumis sativus*; Cucurbitaceae sp.; eggplant, *Solanum melongena*; goat pepper, *Capsicum annuum*; two leguminous crops belonging to the genus *Phaseolus*; muskmelon, *Cucumis melo*; pumpkin, *Cucurbita maxima*; squash, *Cucurbita moschata*; watermelon, *Citrullus lanatus*; wax gourd, *Benincasa cerifera*; and yard long bean, *Vigna unguiculata*. *T. palmi* were most common on bitter cucumber, cucumber, eggplant, goat pepper, muskmelon and watermelon. Of these vegetables, eggplant appeared to be most commonly infested with *T. palmi* in the three countries surveyed.

Although the number of surveyed gardens was limited, no *T. palmi* were collected from bottle gourd, *Lagenaria siceraria*; wild eggplants, such as *S. stramonifolium* and *S. torvum*; Leguminosae sp.; okra, *Hibiscus esculentus*; pigeon pea, *Cajanus cajan*; and yam bean, *Pachyrhizus erosus*.

2. Abundance of *T. palmi* in vegetable gardens

Table 3 shows the abundance of *T. palmi*, expressed as the proportion of leaves or flowers infested with thrips, in gardens of various vegetables in Thailand in 1987–1988 and Malaysia in 1987. Heavily infested leaves were observed in cucumber and eggplant. Flowers of eggplant and goat pepper were also heavily infested with *T. palmi*, and the abundance of

Table 4. Seasonal change in abundance of *T. palmi* in eggplant gardens in Thailand in 1987–1988

Season	Time	No. of gardens surveyed	Mean proportion of leaves with <i>T. palmi</i> ^a
Rainy	June, 1987	17	0.11 a
	Sept.–Oct., 1987	12	0.09 a
Dry	Dec., 1987	22	0.43 b
	Jan.–Feb., 1988	9	0.63 b

^a Values followed by the different letter in a column are significantly different at the 5% level by TUKEY-KRAMER test.

Table 5. Effect of fruit type and insecticide application on abundance of *T. palmi* in commercial truck gardens of eggplant in Chiang Mai, Thailand in December 1987 and ANOVA of the data

Type of fruit	Insecticide application	No. of gardens	Mean proportion of leaves with <i>T. palmi</i>
Long	Sprayed	4	0.80
	Unsprayed	4	0.30
Round	Sprayed	4	0.38
	Unsprayed	4	0.53

Source of variation	df	Sum of squares	F
Fruit type (A)	1	0.028	0.93
Insecticide use (B)	1	0.036	1.18
Interaction (A × B)	1	0.191	6.28*
Residual	12	0.366	

* Significantly different at the 5% level.

larvae and adults on flowers of these vegetables in Thailand was higher than on leaves (STUDENT's *t* test, $p < 0.01$ for both).

3. Factors affecting *T. palmi* abundance in eggplant gardens

The seasonal change in the abundance of *T. palmi* on eggplant leaves in Thailand is shown in Table 4. The abundance on leaves was lower in June and September–October 1987 than in December 1987 and January–February 1988, indicating that the abundance was lower during the rainy season than during the dry season.

Table 5 shows the abundance of *T. palmi* on leaves, as influenced by fruit type and insecticide usage in commercial truck gardens of eggplant in Chiang Mai, Thailand in December 1987. Sprayed commercial truck gardens were subjected to frequent applications of pesticides such as the organophosphates, methamidophos and methyl parathion. In the gardens of long fruit eggplant sprayed with insecticides, *T. palmi* was extremely abundant. The analysis of variance for *T. palmi* abundance showed that the abundance did not differ significantly at the 5% level between long and round fruit eggplants or between sprayed and non-sprayed gardens, but that there was a significant difference in the interaction (fruit type × insecticide usage).

DISCUSSION

In this study, we found that *T. palmi* attacked various vegetables in Thailand, Malaysia and the Philippines, and that this thrips was as abundant on cucurbitaceous and solanaceous crops, as reported in Japan (MIYAZAKI and KUDO, 1988) and Hawaii (NAKAHARA, 1984). These results are compatible with those of our survey of thrips species (OKAJIMA et al., 1992) and a literature survey in Southeast Asia (WATERHOUSE, 1993).

Why *T. palmi* was not known to be a serious pest of vegetables in Southeast Asia until recently may be explained by examining four aspects. First, a considerable number of cultivars of vegetables in Southeast Asia are resistant to *T. palmi*. For example, YASUDA and MOMONOKI (1988) determined the degree of damage by *T. palmi* to 24 different eggplant cultivars from Malaysia and the Philippines and found that the incidence of damage by *T. palmi* to eggplant fruits varied among cultivars. Second, apparently consumers in Southeast Asia are much less strict about cosmetic scars left on eggplant fruits by *T. palmi* feeding than Japanese consumers and susceptible eggplant cultivars are commonly grown for local consumption. Third, *T. palmi* was sometimes confused with other thrips on vegetables such as *T. flavus* SCHRANK in Formosa (WANG and CHU, 1986), *T. gossypicola* PRIESNER in Formosa (BHATTI, 1980) or *T. tabaci* LINDEMAN in the Philippines (BOURNIER, 1983) and these thrips were reported as pests of vegetables when *T. palmi* was the real pest. Finally, *T. palmi* populations may have increased under heavy insecticide use. Recently, insecticide uses for control of insect pests in Southeast Asia have increased in volume (YAMAMOTO, 1988). Applications of organophosphates such as diazinon (ETIENNE et al., 1990), fenthion (NAGAI, 1990) and profenofos (ETIENNE et al., 1990) experimentally induced a remarkable increase in *T. palmi* populations on field eggplant.

In the Philippines, *T. palmi* has been a major pest of cucurbits since its first reported outbreak in 1977 (RUHENDI and LITSINGER, 1979; MEDINA, 1980). In Thailand and Malaysia, no outbreaks of *T. palmi* have been reported to date, however, our surveys showed that in Chiang Mai, Thailand, *T. palmi* was highly abundant in commercial truck gardens of long fruit eggplant sprayed with insecticides.

In Thailand, eight species of arthropods including the eulophid parasitoid, *Ceranisus menes* (WALKER), have been reported as natural enemies of *T. palmi*. However, parasitization of *T. palmi* by *C. menes* was low in eggplant truck gardens using insecticides (HIROSE et al., 1993). Also important predators, such as the anthocorid *Wollastoniella rotunda* YASUNAGA et MIYAMOTO (= *Bilia* sp.) (HIROSE et al., 1993; YASUNAGA and MIYAMOTO, 1993) probably experiences heavy mortality from broad spectrum insecticides. Recently, NAGAI (1990) and ETIENNE et al. (1990) showed experimentally that an increase in *T. palmi* populations on eggplant was induced by destruction of natural enemy populations by insecticide applications. Heavy infestations of *T. palmi* in sprayed truck gardens of long fruit eggplant in Thailand may have been induced by releasing *T. palmi* from suppression by its naturally occurring biological control agents as a result of insecticide treatments.

A significance in the interaction (eggplant fruit type $\times$ insecticide usage) in the ANOVA (Table 5) could be explained by the difference in frequency of insecticide applications between fruit types of eggplants. Although we grouped eggplants in Thailand into the long and round fruit types, YASUDA and MOMONOKI (1988) grouped eggplants in Malaysia and the Philippines into six fruit types. The long fruit type in our study consists of the 'middle' and 'long to extremely long' fruit types described by YASUDA and MOMONOKI (1988), and the round fruit type in our classification consists of the 'spherical,' 'spheroidal,' 'egg-shaped'

and 'long egg-shaped' fruit types as designated by them. According to YASUDA and MOMONOKI (1988), the 'middle' fruit type received significantly higher damage by *T. palmi* as compared with five other fruit types, and the 'long to extremely long' fruit type contained some cultivars susceptible to *T. palmi*. This suggests that the long fruit type in our classification may be seriously injured by *T. palmi*. Thus, we suspect that insecticide applications are more frequent in commercial truck gardens of the long fruit type than in those of the round fruit type. Available insecticides do not effectively suppress *T. palmi* populations (SUZUKI et al., 1982; MATSUZAKI et al., 1986), but rather eliminate its parasitoids, predators (HIROSE et al., 1993) and competitors such as *Aphis gossypii* GLOVER (KAWAI, 1985 b).

LEWIS (1973) stated that weather usually affects thrips populations either directly, or indirectly through their host plants; temperature and rainfall are the most important factors affecting the abundance of thrips in the field. According to the meteorological station in Bangkok, Thailand, the mean daily temperature in the rainy season from June to October 1987 and the dry season from November 1987 to February 1988 was 29.7°C and 26.9°C, respectively. Temperature in the rainy season in Bangkok might be optimum for growth of *T. palmi* populations because the intrinsic rate of natural increase of the thrips increases with temperature, reaching its maximum at 30°C (KAWAI, 1985 a). However, the abundance of *T. palmi* on eggplant leaves in the dry season was higher than in the rainy season, suggesting that rainfall, rather than temperature was the primary abiotic factor responsible for the seasonal change in thrips abundance. WANGBOONKONG (1981) reported that *T. palmi* on cotton in Thailand increased rapidly after long drought spells during the early rainy season. Probably, heavy rainfall in the rainy season in Thailand in 1987 washed larvae and adults of *T. palmi* from eggplant leaves and drowned pupae in soil. Similar effects of rainfall on *T. palmi* populations on eggplant have been reported in Guadeloupe (ETIENNE et al., 1990).

The results in the present surveys lead to the conclusions that the exploration for natural enemies of *T. palmi* in Southeast Asia should be conducted in unsprayed eggplant gardens during the dry season. Accordingly, a thorough and intensive exploration for natural enemies of *T. palmi* coupled with estimating their role as biological control agents was conducted in unsprayed eggplant gardens in Thailand in January–February 1988 (HIROSE et al., 1993).

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