Life Cycle and Population Dynamics of *Thrips palmi* KARNY

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Introduction

Thrips palmi KARNY has been distributed in South and Southeast Asia since old times[1], but it has never been a serious pest till quite recently. Since late 1970s, it has become the serious pest in wide area of the tropical and sub-tropical regions, including Southeast Asia, the Pacific Islands and the Caribbean Islands. In Japan, the first incidence of damages caused by this pest took place in 1978, and became the most serious pest in eggplant, sweet pepper and cucumber in the western part of Japan. During the last decade, ecological studies on *T. palmi* have been continued by the author in Japan with the purpose of analyzing population dynamics of this pest and establishing a population management system to control it. This paper presents results of the studies on the life cycle and the population dynamics of *T. palmi*, which have been found by the author and other researchers in Japan.

Life cycle and development

The life cycle of *T. palmi* is shown in Fig. 1. Eggs are deposited in plant tissues separately. Larvae have two stages, under both of which they feed on plant tissues. The second instar larvae, when matured, fall to the ground, where they moult to prepupae and to pupae as well in the soils. After emergence, the adults move to the growing parts of the plants such as young leaves, flowers and young fruits, where they feed and lay eggs.

Effects of the temperature on the population growth of *T. palmi* feeding on cucumber leaves in the laboratory are shown in Table 1. The generation time was shortened with the higher temperature of the chamber where *T. palmi* was placed. The net reproductive rate

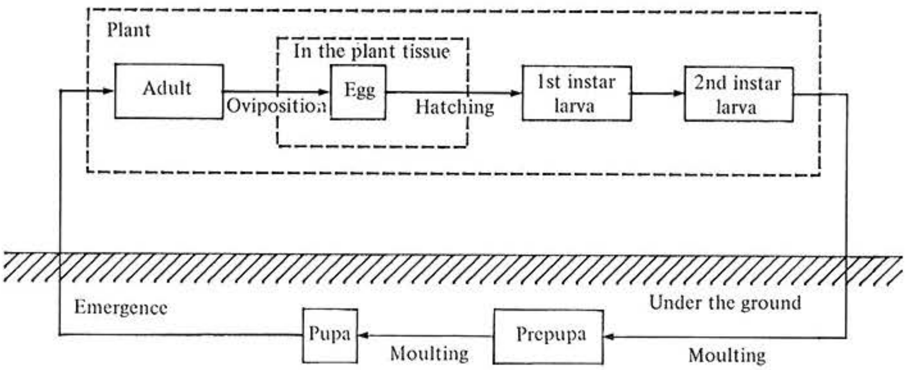

Fig. 1. Life cycle of *Thrips palmi*

Table 1. Population growth of *Thrips palmi* fed on cucumber leaves at different temperatures[4]

	15℃	20℃	25℃	30℃
Mean generation time (days)	80.2	40.7	24.8	20.5
Net reproductive rate	16.5	25.9	28.0	19.1
Intrinsic rate of natural increase/day	0.035	0.080	0.134	0.144
Reproductive rate/month	2.9	11.0	55.7	75.2

Table 2. Population growth of *Thrips palmi* fed on various crops[5]

Crop	Generation time (days)	Net reproductive rate	Intrinsic rate of natural increase/day	Reproductive rate/month
Cucumber	24.8	28.0	0.134	55.7
Melon	23.2	13.0	0.111	27.9
Pumpkin	24.8	7.3	0.080	11.0
Balsam pear	25.0	2.7	0.040	3.3
Eggplant	25.4	13.3	0.102	21.3
Sweet pepper	22.8	2.9	0.047	4.1
Kidney bean	25.2	4.7	0.061	6.2
Okra	25.9	0.5	−0.027	0.4
Chrysanthemum	21.2	0.1	−0.109	0.0

reached maximum at 25°C. A higher intrinsic rate of natural increase of population was seen under the higher temperature conditions (Fig. 1). The intrinsic rate of *T. palmi* was lower than that of *Myzus persicae* SULZER as well as of *Tetranychus urticae* KOCH, and was almost the same as that of *Flankliniella intonsa* TRYBOM and *Trialeurodes vaporariorum* WESTWOOD. The threshold temperature of development and thermal constant for the pre-adult stage was estimated at 11.6°C and 189.1 day-degrees, respectively.

T. palmi has a very wide range of its host plants, including vegetables, flowers and weeds, which however cause a considerable variation in population growth among the hosts. The feeding plants during the growth stage of larvae and adults have limited effects on pre-adult development and adult longevity, while they seriously affect fecundity[6]. The maximum intrinsic rate of natural increase of *T. palmi* is seen on cucumber, and a fairly high rate on melon, eggplant and pumpkin (Table 2). Although *T. palmi* is an important pest of sweet pepper in Japan, the population growth on sweet pepper is not high. The larvae fed on tomato and strawberry are unable to pupate.

T. palmi reproduces itself parthenogenetically[15] as many other thrips do. The progenies of unmated female are all males, while 70–80% of the progenies of mated female are female. The fecundity of the unmated female is the same as that of the mated female[13].

Pupae can torelate the low temperature for a long time. However, the duration before all pupae die is 8 days at 0°C, 255 min at −5°C or 35 min at −10°C[12]; *T. palmi* cannot live out the winter in Japan under the natural conditions. The duration before *T. palmi* of all stages dies under high temperature is 23 hr at 40°C, 30 min at 48°C or 7 min in 55°C[12] and *T. palmi* cannot develop itself at 35°C and beyond[8].

Population growth in the field

Both in the greenhouse and the open field in Japan as well, *T. palmi* reproduces itself exponentially until the feeding plants are

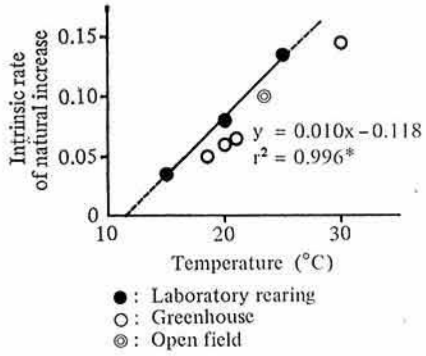

Fig. 2. Relationship between the temperature and the intrinsic rate of natural increase of *Thrips palmi*[4)]
Tempratures are constant in laboratory rearing, and mean temperatures are used for the data of experiments in open field and a greenhouse.

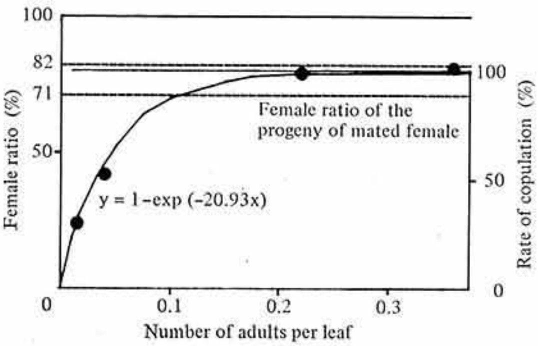

Fig. 3. Relationship between the density of adult females of *Thrips palmi* per leaf of cucumber grown in a greenhouse and the female ratio[8)]

seriously injured by infestation. The intrinsic rate of natural increase varies owing mainly to the temperature during the crop cultivation period. It was observed that the rates of increase estimated from the population data in the greenhouse and the open field were 80–90% of those calculated from the rearing experiments (Fig. 2), in which sufficient feeding materials were continuously supplied to ensure the reproduction of *T. palmi*. This result indicates that *T. palmi* reproduce itself exponentially as long as its host plants grow, providing that other mortality factors are negligible.

Several anthocorid species, predacious mite and predacious thrips are known as the predators of *T. palmi*, and an eulophid wasp is known as a larval parasite. The effect of these natural enemies on the population increase of *T. palmi* is not clearly identified yet.

In case where the population density becomes very low, it is difficult for *T. palmi* to copulate. Then, female adults oviposite male progenies without copulation, and the rate of reproduction is lowered. An example of the effect of such a low density is shown in Fig. 3, the data of which were obtained in a *T. palmi* population fed on cucumber in a greenhouse. This result suggests that in controlling *T. palmi*, it be very important to keep its population density at a very low level possible.

Distribution in the field

In the host of cucumber plants, adults of *T. palmi* are usually found on young leaves, while larvae are on lower leaves (Fig. 4). Few insects are found on flowers and fruits. In eggplants, adults are seen on young leaves and flowers, and larvae are on lower leaves and fruits (Fig. 5). In sweet pepper plants, adults are generally found on flowers and buds, and larvae are on fruits (Table 3).

T. palmi has different preferences in its dwelling part of the host crops. Adults are usually found on young tissues, while larvae are on slightly older tissues. Caused by such a difference of the distribution in a host plant, different types of injuries take place among the host plants. For cucumber, injuries on leaves are economically important, whereas for sweet pepper injuries on fruits are more important. In case of eggplant, both fruits and leaves are injured but damages on fruits are of practical importance from economic viewpoint. The economic injury level (EIL) is low when the host plants are directly injured in their fruits. However, when the plants are injured in other parts, the EIL is generally high. The EILs for eggplant and cucumber are 0.08 and 4.4 adults per leaf, respectively, and the EIL for sweet pepper is 0.11 adult per flower, on the assumption that the acceptable level of yield loss of uninjured fruits is 5% of the maximum yield.

The distribution of *T. palmi* on the cucumber plants grown in a greenhouse was analyzed using $\overset{*}{m}$-m regression method (Fig. 6). Adults were randomly distributed among the plants, while the distribution of larvae was moderately contagious. When the analysis was made on the basis of each cucumber leaf as a sampling unit, the distribution of both adults and larvae was highly contagious. The adults that had newly emerged distributed dispersedly, and then flocked on the young leaves, where they laid eggs[2].

The distribution on the cucumber plants grown in the open field was similar to the above materials in a greenhouse, with an exception for the larvae which randomly distributed among the plants in the field[3]. The natural wind blow might have caused such

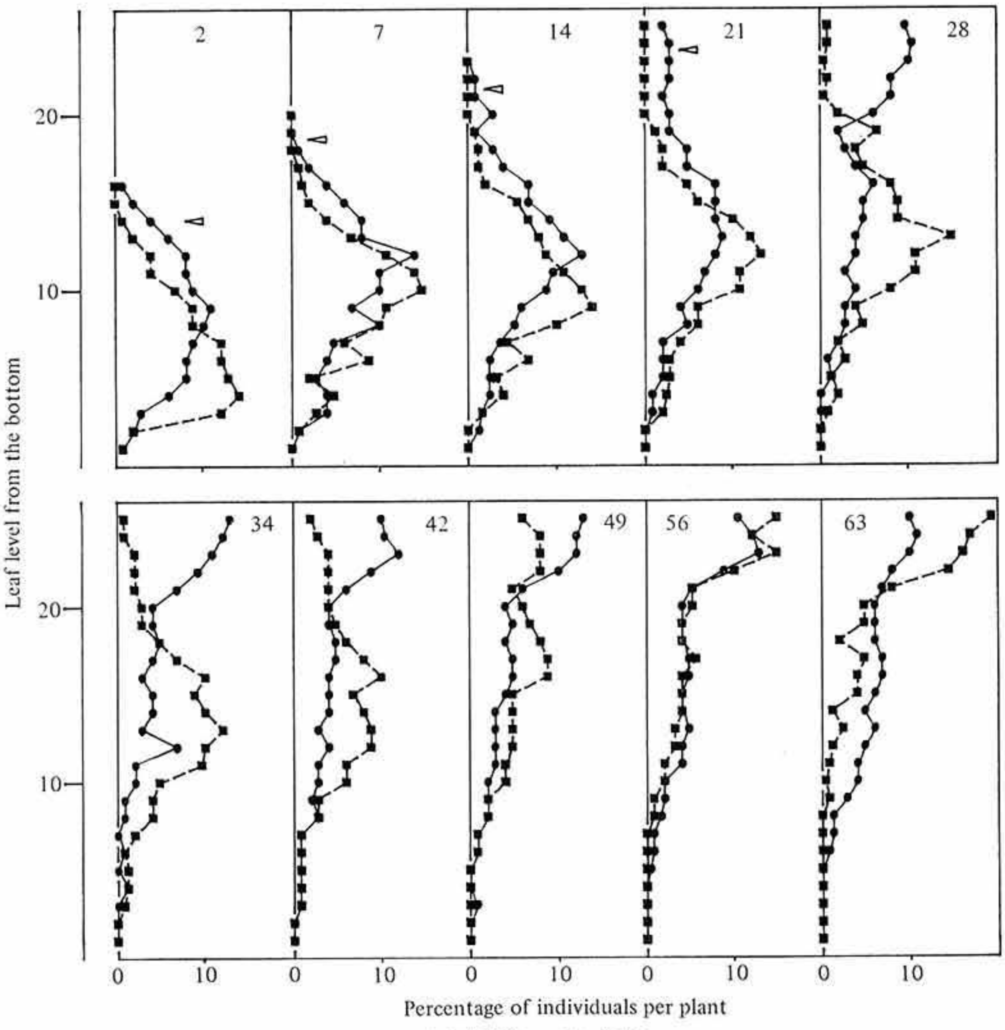

Fig. 4. Micro-distribution of *Thrips palmi* on the cucumber plants grown in a greenhouse in relation to the position of leaves[2]
Numerals in the figure indicate the days after release and triangles show the average position of top leaves.

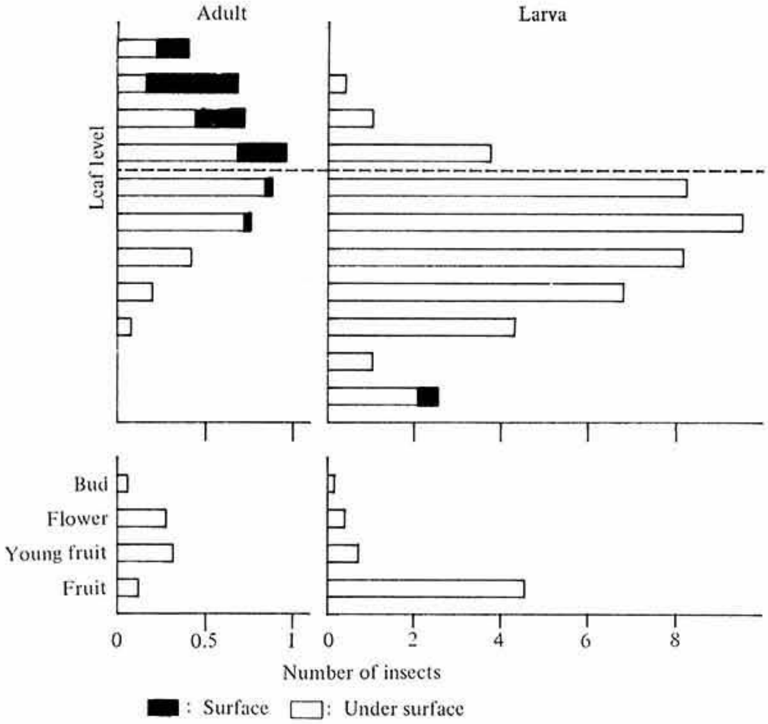

Fig. 5. Micro-distribution of *Thrips palmi* on the eggplants grown in a greenhouse[9]
Broken line indicates the level of the top of developed leaves.

Table 3. Micro-distribution of *Thrips palmi* on various parts of the sweet pepper plants grown in a greenhouse[12]

Part of plant	Parasitic ratio with *T. palmi*[1] (%)	Number of *T. palmi*[2]			Degree of injury (%)
		Adult	Larva	Total	
Bud	50	0.4	0.4	0.8	50
Expanded leaf	1	0	0.0	0.0	38
Flower	80	1.6	1.5	3.1	0
Fruit (size of calyx)					
Less than 5 mm	30	0.1	0.3	0.4	50
5 ~ 10 mm	65	0.1	1.4	1.5	90
10 ~ 20 mm	85	0	2.6	2.6	100
20 ~ 30 mm	90	0.1	3.5	3.6	100
More than 30 mm	35	0.1	0.5	0.6	100
Mean	60	0.1	1.7	1.8	88

1): Percentage of the relevant part of the plants parasitized to *T. palmi*.
2): Number of *T. palmi* per relevant part of the sweet pepper plants.

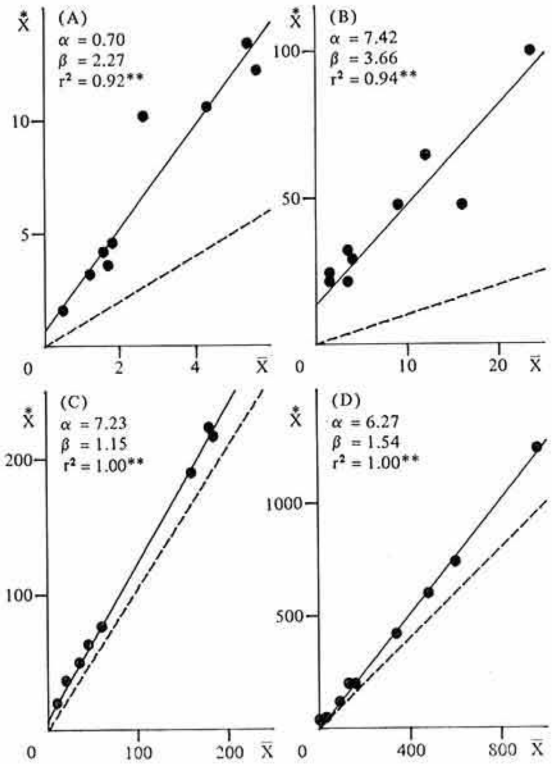

Fig. 6. Relation of mean crowding ($\overset{*}{X}$) to mean density ($\bar{X}$) in the number of *Thrips palmi* on cucumber ($\overset{*}{X}=\alpha+\beta\bar{X}$)[2]
Broken line indicates Poisson distribution.
A: Adult per leaf, B: Larva per leaf,
C: Adult per plant, D: Larva per plant.

a random distribution. The distribution of *T. palmi* in the field of eggplant and sweet pepper was generally equal to the case in cucumber as mentioned above.

Characteristics as a pest

The following characteristics of *T. palmi* as a pest could be specified from its life cycle and population dynamics: (1) preference of young tissues as a host[2]; (2) a high reproductive rate[7]; (3) a wide range of host plants[6]; (4) inability of survival under the very low temperature and the high temperature as well[12]; (5) low sensitivity to insecticides[14]; and (6) repression of its increased population caused by aphids through interspecific competition[10].

T. palmi is well adapted to the growth stages of eggplant and cucumber: it lives effectively on the successively growing young tissues and its high reproductive rate is well accompanied by a rapid increase of the feed resources. It survives without any crops in a field but with host weeds. It can reproduce itself exponentially under the condition where no natural enemies attack the *T. palmi* due to the frequent uses of insecticides. It can also survive in a heated greenhouse during the winter season of the temperate region. In a special case of eggplant, the fact that its economic injury level is extremely low is closely related to the high-quality requirement in markets in Japan. In other words, the high-quality requirements and wide cultivation of eggplant and cucumber place the *T. palmi* as a serious pest.

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