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【Research report】

神澤氏葉蟎在桑樹上之株內分布【研究報告】

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Abstract

摘要

神澤氏葉蟎在桑樹之內層與外層間之分布無顯著差異。枝條上葉蟎較多之葉片常在第5至第11葉間，亦即枝條之中段。受枝條之長短影響，此區間之葉蟎約占全枝條之33-79%。其葉蟎總數與枝條上之葉蟎數具高度之相關性。作者建議在此區間取樣調查桑園中神澤氏葉蟎之密度。

Key words:

關鍵詞: 分布、葉蟎、桑。

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WITHIN-PLANT DISTRIBUTION OF *TETRANYCHUS KANZAWAI* KISHIDA (ACARI: TETRANYCHIDAE) ON MULBERRY

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Abstracts

Tetranychus kanzawai Kishida was observed to distribute equally between inner and outer layers of mulberry shoots. Higher population of spider mite was found frequently on leaf 5 to 11, the middle part, in a shoot. Approximately 33 to 79 percent of the spider mites in a shoot distributed in this zone depending on the length of the shoot. The correlation between the number of spider mites in this zone and in a shoot is very high. It is suggested to sample *T. kanzawai* population on mulberry trees in this zone.

(**Key words:** Distribution, spider mite, mulberry)

Introduction

There were three species of spider mites on mulberry in Taiwan, *Eutetranychus banksi* (McGregor), *Eotetranychus sp.*, and the Kanzawa spider mite, *Tetranychus kanzawai* Kishida (Chang, 1981; Shih, 1985). *T. kanzawai* is commonly found and is the second key pest of mulberry trees. The infestation of this mite species affects the quality of mulberry leaves (Ho, 1989; Huang, 1981) and reduces the number of silkworm raised, so that reduces the production of silk (Ho, 1989). A few ecological investigations have been conducted on this mite on mulberry trees (Chang, 1981; Shih, 1984). Predacious phytoseiids, *Amblyseius womersleyi* and *A. fallacis*, have been released every Spring in mulberry field to control this spider mite since 1983 under governmental support. Yet the management techniques for this mite is lacking. To manage pests, it requires a proper sampling method which is founded on the distribution of the pest inside the crop canopy. Therefore, this study was conducted.

Materials and Methods

Mulberry trees are pruned, accordant with the rearing of silkworm, to generate thirty or more shoots at approximately 40-50 cm above the ground. These shoots are allowed to grow upward 1.5 m before being cut to feed silkworms. The canopy of a mulberry tree could be imaged as a cylinder. Within-plant distribution of *T. kanzawai* on mulberry trees was studied both on horizontal and vertical aspects of this cylinder. The mulberry canopy could be differentiated horizontally into an outer layer and an inner layer by dividing the radius of the cylinder equally. Vertically the leaves on a shoot were numbered from the first fully opened leaf on the top down to the base of the shoot. Those unopened leaves on the top of shoot were grouped as 'tip'. To avoid the errors caused by transportation and artificial operation, spider mites were counted leaf by leaf with naked eyes in the field, and were recorded by the leaf sequence. This counted all postembryonic stages except larva.

For the horizontal distribution of *T. kanzawai*, three mulberry fields were sampled. These fields located at Yenpu, Pintung Prefecture (field YP), Dounan, Yenlin Prefecture (field DA), and Mingen, Nantou Prefecture (field MA). There were ca. 600 trees in each field. Systematic sampling method was followed to select the trees to be sampled. Field YP and MA were sampled on December 26, 1985 (59 trees) and April 17, 1986 (42 trees), respectively. Four samples were taken biweekly at field DA from March 15 to April 24, 1986, 90 trees for the first three and 65 trees for the last. While sampling, four shoots per tree, two from the outer layer and two from the inner layer, were selected diagonally. Spider mites on each leaf were counted. This gave 2016-4680 counts per smaple (Table 1).

Fifteen more samples from 6 fields were taken during the fall and winter of 1986 for the analysis of the vertical distribution of *T. kanzawai* on mulberry trees. Some of these fields was sampled weekly for 2 or 3 weeks. The locations, fields and the number of samples (in parenthesis) were Dounan: fields DB (2), DC (1), DD (1), DE (2); Mingen: fields MB (3), MC (3); TARI (Taiwan Agricultural Research Institute), field TA (3). Systematic sampling method was also followed. The number of trees sampled in each sample varied from 20 to 62 in according to the size of fields and the labor available. Spider mites on one randomly selected shoot from each tree were counted leaf by leaf. The number of counts in each sample ranged from 288 to 1178 (Table 1). Two typhoons invaded western Taiwan in the fall of 1986 and interrupted the studies on fields in Dounan.

Results and Discussion

Studies on the within-plant distribution of crop pest used to sample the same field consecutively. The cultivation of mulberry trees in Taiwan differs from other crops. Eight generations of silkworm are usually raised, each year, alternatively by mulberry leaves grown from two mulberry fields. That is, from February to October a mulberry field will be pruned four times or more, in an interval of 2-3 months. This keeps on interrupting the population of *T. kanzawai* on mulberry trees and maintaining a source of *T. kanzawai* to invade newly generating mulberry shoots. These operations result in varied population of *T. kanzawai* in mulberry fields. Therefore, more than one mulberry field were sampled. Some informations on the 21 samples of this study are tabulated in Table 1. The mean number of leaves per shoot varied from 9 to 21, and the mean number of mites per shoot ranged from 4 to 1207.5.

Table 2 lists results of Duncan's multiple range test, at 0.05 level, regarding the distribution of *T. kanzawai* between the outer and the inner layers on mulberry trees. The tips were disregarded in earlier samples. This was rectified in later samples. As some shoots were short with fewer leaves in a sample, not every leaf sequence had the same number of counts in a sample. Therefore, only those leaf sequences with not less than 30 counts were compared. The average number of *T. kanzawai* per shoot ranged from 2 to 44 approximately.

Table 1. Informations on the twenty-one mulberry samples taking in 1985-1986

Location and field	No. mites/shoot		No. trees sampled	No. leaves/ shoot	Counts/ sample
	$\overline{X}$	SE			
Dounan					
DA	4.16	1.27	90	9	3240
	6.06	0.92	90	11	3960
	15.21	0.67	90	13	4680
	22.99	1.49	65	17	4420
DB	46.82	4.04	62	19	1178
	70.76	7.91	30	20	600
DC	123.50	14.91	20	21	420
DD	196.00	15.79	40	17	680
DE	11.29	1.72	31	19	589
	37.90	3.72	51	19	969
Mingen					
MA	40.79	4.01	42	12	2016
MB	60.00	18.31	24	12	288
	139.17	36.36	24	15	360
	379.92	64.99	24	15	360
MC	210.08	21.03	48	11	528
	467.79	47.23	48	15	720
	1207.65	78.33	48	14	672
Pintung					
YP	11.27	1.39	59	11	2596
TARI					
TA	156.70	45.93	20	19	380
	564.03	99.39	30	20	600
	801.67	67.59	30	15	450

The shoot total and a few leaf sequences of the two samples of field DA in April showed significant difference in the distribution of *T. kanzawai* between inner and outer layers. The rests had no difference at all (Table 2). Since the range of the mite density of the four samples which did not show any difference overlapped that of the other two which showed few differences, the similarity of population of *T. kanzawai* in these two layers was suggested. Herbert and Butler (1973) also revealed a similar results on the distribution of *Panonychus ulmi* eggs on apple trees.

Although the within tree distribution of tuft apple bud moth was reported to be different among quadrants (Meagher, Jr. and Hull, 1987), studies of diamondback moth on cabbages (Harcourt, 1961), and spider mites on apple trees (Herbert and Butler, 1973), pear (Westigard and Calvin, 1971), and almonds (Wilson *et al.*, 1984) did not detect significant difference among quadrants. Previous observations on the distribution of *T. kanzawai* on mulberry trees did not show any directional difference (Ho, unpublished data). Therefore, mulberry canopy was not divided into quadrants in this study, and only one shoot was randomly selected from each tree for the rest 15 samples. Data from all 21 samples were used to analyze the vertical distribution of *T. kanzawai* on mulberry trees. Difference in the vertical distribution of pest on crops have been found in many cases (e. g. Bellinger *et al.*, 1981; Chandler and Corcoran, 1981; Herbert and Butler, 1973;

Table 2. The results of Duncan's multiple range test, at 0.05 level, on the distribution of *T. kanzawai* between the outer and the inner layers on mulberry trees

Leaf sequence	Field YP		Field DA								Field MA	
			Mar. 15		Mar. 28		Apr. 11		Apr. 24			
	I	O	I	O	I	O	I	O	I	O	I	O
tip	—		—		—		1.94	1.04	0.53	0.16	5.16	3.55
1	0.03	0.10	0.04	0.07	0.54	0.87	1.42	0.79*	0.73	0.76	2.77	2.68
2	0.11	0.17	0.11	0.20	0.18	0.23	1.46	1.09	0.70	0.67	2.85	2.71
3	0.48	0.55	0.09	0.47	0.17	0.30	1.54	1.21	0.85	0.94	3.38	3.41
4	1.01	1.05	0.19	0.46	0.21	0.45	1.36	1.42	1.13	0.78*	3.56	3.18
5	1.76	1.04	0.40	0.74	0.38	0.55	1.09	1.17	1.52	0.29	3.70	4.08
6	1.28	1.48	0.37	0.78	0.39	0.75	1.25	1.15	1.23	1.13	5.60	3.26
7	1.20	1.53	0.33	1.15	0.90	0.63	1.32	1.02	1.84	1.15*	5.00	3.76
8	1.16	0.94	0.33	0.91	0.75	0.69	1.18	1.13	1.69	1.05*	3.25	3.25
9	1.50	1.44	0.39	0.92	0.82	1.26	0.92	0.89	1.81	1.69	2.98	2.23
10	1.33	1.32	0.20	1.38	0.74	0.65	0.86	0.74	1.62	1.08*	1.97	2.73
11	0.90	0.84	—		0.40	0.96	0.75	0.93	1.83	1.16*	2.22	2.46
12	—		—		0.93	1.38	0.69	0.72	1.10	1.66	2.06	2.14
13	—		—		1.20	0.41	0.60	0.52	1.13	1.22	2.18	1.21
14	—		—		—		0.70	0.54	1.68	1.29		—
15	—		—		—		0.89	0.46	1.34	1.54		—
Shoot	12.5	10.06	2.39	5.80	5.57	6.54	16.9	13.9*	26.7	19.3*	44.01	37.58

I : Inner layer O: Outer layer *: Significantly different

Hollingsworth and Berry, 1982; Meagher, Jr. and Hull, 1987; Wilson *et al.*, 1984, etc.). The distribution of *T. kanzawai* on mulberry trees was studied according to the height of canopy by Chang (1981). This author concerned more on the influence by the age of mulberry leaf. Consequently, vertical distribution of *T. kanzawai* was surveyed and analyzed according to the leaf sequence in this study.

To find out is there an area on mulberry trees containing more spider mites, Duncan's multiple range test was carried out to detect the leaf sequences which had significantly higher density of spider mites. However, as the number of leaves per shoot was not uniform, the leaf sequences which possessed higher spider mite density might not be those leaf sequences that contained higher proportion of the total spider mite population. The later leaf sequences would be more valuable for sampling spider mite population. Therefore, the proportion of the total spider mite population contained in each leaf sequence (PSM) was calculated for each sample and are plotted in Fig. 1. Generally, the middle of the shoot had more spider mites than both end. This resembles the distribution of spider mites, *T. urticae*, *T. pacificus*, and *T. turkestani*, on cotton (Carey, 1982). Descending from the highest one the accumulated PSM was calculated for each sample, and 0.5 was selected artificially as the critic value. The accumulated top 8 PSM exceeded 0.5 for all 21 samples. Leaf sequences of these top 8 PSM in a shoot were plotted vs. the log of mites per shoot, and the number of leaves per shoot in Fig. 2 and Fig. 3, respectively. In both figures there seems a horizontal zone which contained most dots, i. e., more spider mites. As the sampling of pest population at some fixed leaf sequences is not feasible, the presence of this zone will be very meaningful. To analyze the position of this zone, the frequency of

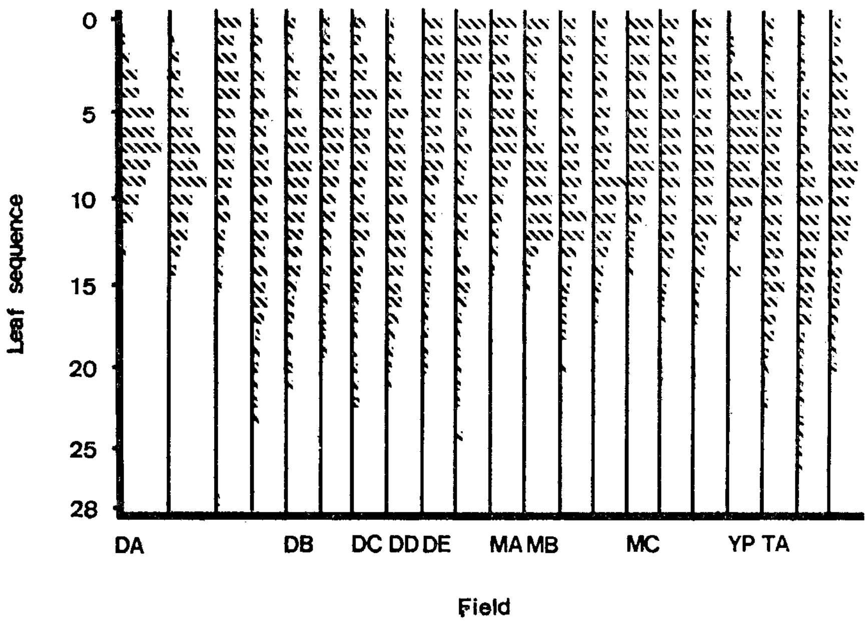

Fig. 1. Percent distribution of *T. kanzawai* on mulberry shoots, 21 samples, 1985–1986.

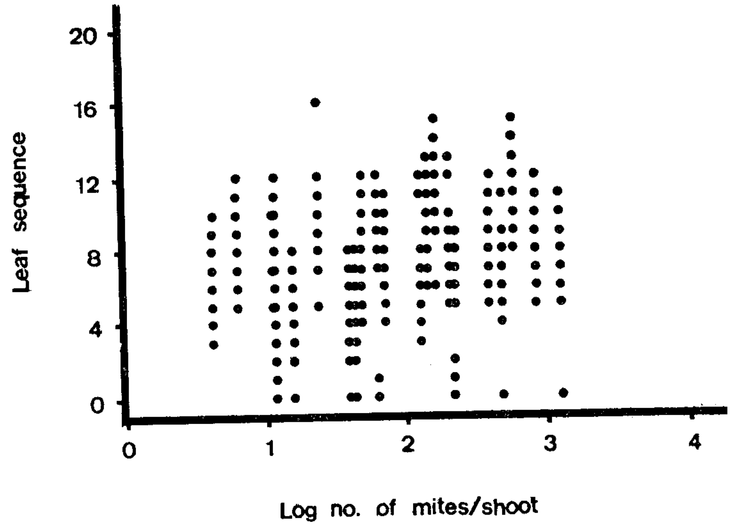

Fig. 2. Distribution of top PSM in relation with spider mite density. PSM: Proportion of total spider mites contained in leaves of the same sequence.

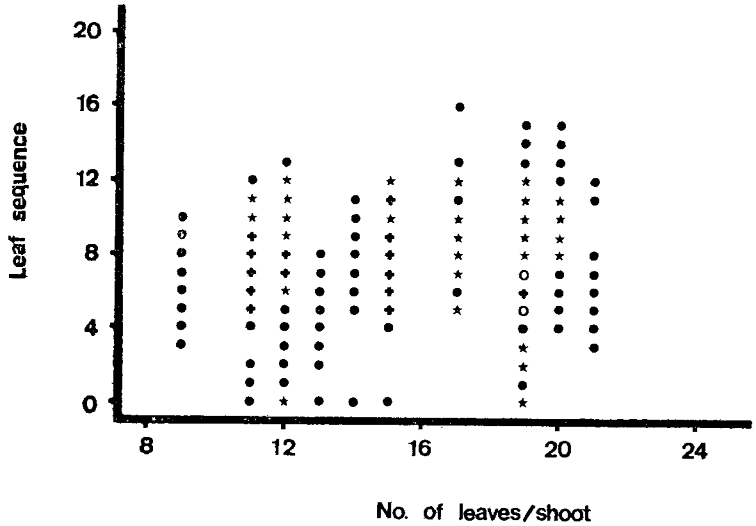

Fig. 3. Distribution of top 8 PSM in relation˚[with number of leaves per shoot. Solid circle, star, cross, and open circle represent 1, 2, 3, and 4 data at the same locus.

each leaf to be one of these 8 leaves is drawn in Fig. 4. Leaf 5 to leaf 12 had much higher frequency than others. Among 168 data points from these 21 samples, 129 (76.8%) fell between 5th to 12th leaves. The correlation of the mean of mites on each leaf to the total mites in a shoot were also calculated. The frequency of the correlation coefficient of each leaf to be the top 8 in a shoot are also graphed in Fig. 4. This frequency distribution of correlation coefficients was similar to that of PSM but more scattered with a narrower range, from leaf 5 to 11. In addition, the accumulated top 6 PSM of these 21 samples averaged

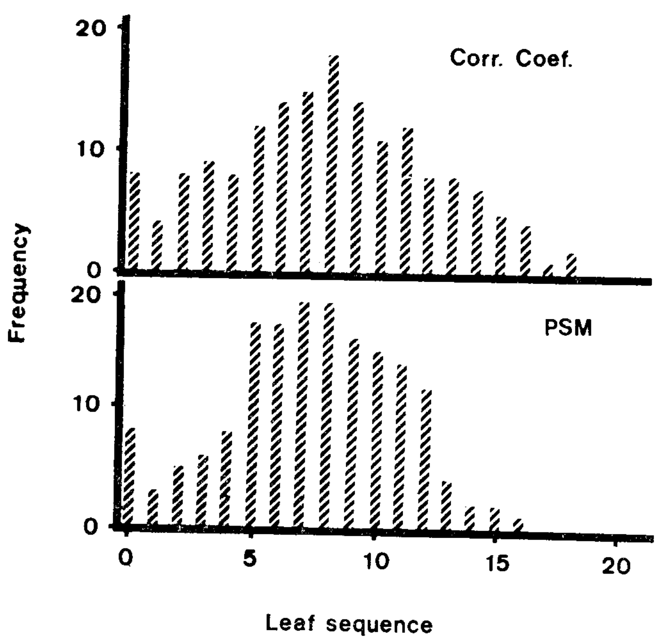

Fig. 4. Frequency of each leaf sequence to be in the top 8 PSM.

over 0.5, and only leaf 5 to 11 had higher frequency to be in top 6. Hence, leaf 12 was dropped from the list.

The number of *T. kanzawai* on leaf 5 to 11 was pooled. This sum correlates highly to the total spider mites in a shoot. The correlation coefficient ranged from 0.821 to 0.993, mostly above 0.9 (Table 3). The accumulated PSM of leaves 5-11 ranged from 0.33 to 0.79 (Table 3). These PSM varied according to the mean number of leaves per shoot, $Y=0.8679-0.0222X$, $R^2=0.5185$ (Fig. 5), not to the density of mite. This provides estimation on the total spider mite population by the population on leaf 5 to 11. Therefore, the author suggests to sample the population density of spider mites on mulberry trees in this zone of leaf 5 to 11.

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Table 3. *T. kanzawai* on leaf 5-11 and the comparisons of it to the total in a shoot

Location and field	No. mite/ leaf	Pooled PSM	Correlation coefficient
Dounan			
DA	0.65	0.786	0.993
	0.70	0.728	0.948
	1.03	0.463	0.853
	1.43	0.436	0.821
DB	3.75	0.501	0.947
	5.48	0.446	0.944
DC	7.86	0.542	0.953
DD	13.00	0.464	0.884
DE	2.37	0.437	0.925
	0.53	0.326	0.835
Mingen			
MA	3.39	0.539	0.930
MB	4.98	0.543	0.966
	10.02	0.504	0.980
	28.40	0.558	0.965
MC	18.05	0.539	0.947
	33.95	0.523	0.984
	96.50	0.529	0.890
Pintung			
YP	1.28	0.730	0.909
TARI			
TA	9.48	0.423	0.992
	33.62	0.417	0.931
	67.33	0.555	0.904

PSM: *T. kanzawai* of leaves 5-11/total

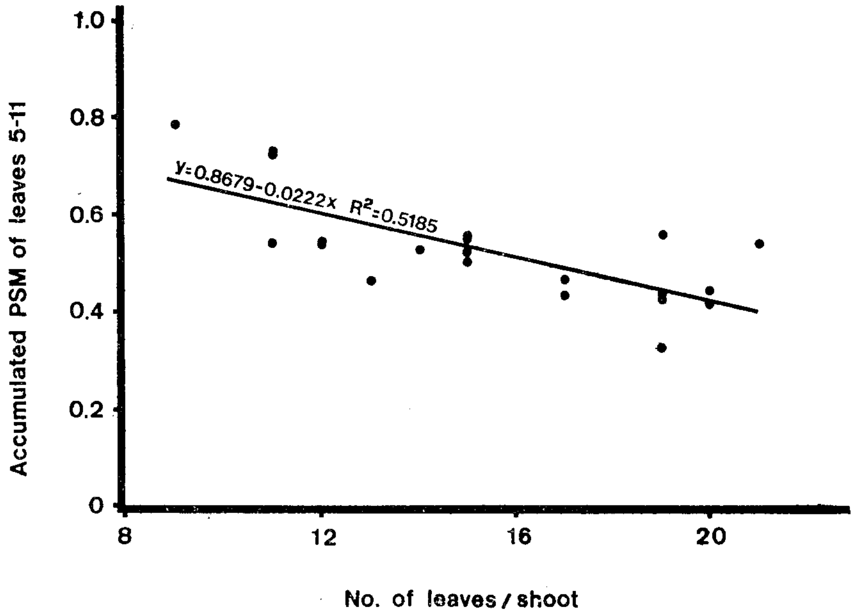

Fig. 5. Correlation of the proportion of total *T. kanzawai* contained in leaves 5-11 and the number of leaves per shoot.

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神澤氏葉蟎在桑樹上之株內分布

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神澤氏葉蟎在桑樹之內層與外層間之分布無顯著差異。枝條上葉蟎較多之葉片常在第5至第11葉間，亦即枝條之中段。受枝條之長短影響，此區間之葉蟎約占全枝條之 33-79%。其葉蟎總數與枝條上之葉蟎數具高度之相關性。作者建議在此區間取樣調查桑園中神澤氏葉蟎之密度。

(關鍵詞：分布，葉蟎，桑)