DISTRIBUTION AND POPULATION OF PAPAYA CARMINE SPIDER MITES AND THEIR PREDATORS

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ABSTRACT

Distribution pattern and population fluctuation of the carmine spider mite and its predators were studied in unsprayed Solo papaya trees grown at the Kauai Branch Experiment Station of the University of Hawaii, at Kapaa from 1978 to 1979. In the field, the carmine spider mites were found exclusively on the undersurfaces of bottom leaves. Initially, they started to infest papaya along borders of the fields. As soon as infestation increased, mites were distributed evenly on most trees. The number of mites decreased from the proximal to the distal portions of bottom leaves. For monitoring and surveillance work, therefore, mites should be counted first on edges of a field and on mature leaves. This procedure saves time, effort and money in surveying for mites especially when the population is low and is starting to build up. In the field, the staphylinid beetle, *Oligota* **sp.; the predatory mite,** *Phytoseiulus macropilis* **(Banks); the coccinellid beetle,** *Stethorus siphonulus* **Kapur; and 2 species of spiders,** *Theridion* **spp., preyed on the carmine spider mites. Of these predators, spider, staphylinid beetle and predatory phytoseiid mite increased with slight population buildup of the carmine spider mites. Rainfall and predators prevented outbreaks of carmine spider mites and continuously allowed the population to fluctuate at low levels.**

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INTRODUCTION

The carmine spider mite, *Tetranychus cinnabarinus* (Boisduval), is a major mite pest of papaya which feeds on the undersurfaces of leaves and produces characteristic webbing. Feeding punctures resemble stippling and are readily seen on the upper surfaces of leaves (Fig. 1). When a large number of these mites attack the papaya leaves, the leaves turn yellowish and then brown and drop prematurely.

An important aspect of ecological study is to describe and

Fig. 1. Leaf of papaya with characteristic feeding injury and webbing caused by the carmine spider mite.

understand the distribution pattern of organisms. The distribution pattern of some insect pests has been studied in detail on several crops but it is not known yet how infestation and pattern of movement, specifically by the carmine spider mites, occur in papaya orchards. This information will contribute immensely to our knowledge of population dynamics of this pest. This study assessed the vertical and horizontal distributions of mites on papaya; obtained data on monthly changes in the population of the spider mites; and determined possible factors that affected the population of carmine spider mites in the field.

MATERIALS AND METHODS

The study was carried out in a 0.2 ha Solo papaya orchard at the Kauai Branch Experiment Station of the University of Hawaii at Kapaa from May, 1978 to May, 1979.

Distribution of Carmine Spider Mites. — Twenty-two rows of flowering papaya trees were used to determine the distribution of mites within trees, between trees and between rows of trees. The vertical distribution of mites within each tree was determined by counting mites from random samples of leaves taken from the lower, middle and upper portions of the trunk bearing them. The horizontal distribution of mites on a leaf was determined by counting them on the bottom, middle and top sections of lower leaves. The distributions of mites were determined by making mite counts on leaves of 5 trees in each row selected at random. The trees were marked with flagging tapes to locate them readily when the subsequent sampling of leaves was taken later. The leaf samples were immediately examined for mite density by using a 10x Bausch and Lomb hand lens. The natural enemies of mites such as spiders, coccinellids, staphylinids and phytoseiids were enumerated, collected, and preserved in 70% ethyl alcohol for identification in the laboratory.

Population Fluctuation of Carmine Spider Mites. — To determine the population fluctuation of carmine spider mites and their predators in the papaya orchard, continuous leaf sampling, consisting of 4 randomly selected mature leaves from 8 trees in each of the 3 unsprayed plots, was done every month from July, 1978 to May, 1979. The 3 unsprayed plots which were replicated 3 times in a randomized block design consisted of (1) trees in which no predatory mites, *Galendromus occidentalis,* were released; (2) trees in which 3 monthly releases of *G. occidentalis* were made; and (3) trees which were sprayed once with malathion at 2.24 kg/ha, to kill existing predators one week before the start of the experiment and then left unsprayed for one year. Leaf samples were cut into 10 cm^2 pieces and placed in plastic bags, transported to the laboratory, and kept in the refrigerator for one day to facilitate counting. Carmine spider mites and their predators were counted by examining each leaf under a stereomicroscope.

Since the carmine spider mites seemed to be adversely affected by rainfall, daily spider mite population fluctuation was studied for 2 months and daily rainfall data were taken to determine how the mite population behaved after each rain. Eight mature leaves were harvested at random from trees in 4 border rows of papaya trees. They were cut into 10 cm^2 pieces, placed in plastic bags and refrigerated for 24 hours. Mites were counted under a stereomicroscope.

RESULTS AND DISCUSSION

Distribution of Carmine Spider Mites.

The population of *T. cinnabarinus* remained generally low because of the cool and wet summer months (Table 1). The first counts in May, 1978 showed a maximum population of 25 mites/leaf on trees in Row 2 and a minimum population of 1 mite/leaf in Row 8. A month later, the mite population increased to an average of 48 mites/leaf on trees in Row 22, while the lowest count of 14 mites/leaf was recorded on those in Row 4. At these population levels, foliar injury was noticeable on the bottom leaves only. The results indicate that mites were

Table 1. Number of carmine spider mites and their predators per row of papaya at Kauai, Hawaii in May and June, 1978.[1]

Row number	Density of carmine spider mites	First count May 1978				Density of carmine spider mites	Second count June 1978			
		PREDATORS					PREDATORS			
		P. macropilis	Spider	*Oligota* sp.	*S. siphonulus*		*P. macropilis*	Spider	*Oligota* sp.	*S. siphonulus*
1	15 ± 1.36	0	1	1	1	28 ± 1.41	0	3	1	1
2	25 ± 1.80	0	1	1	1	34 ± 1.49	0	3	1	0
3	6 ± 0.63	0	0	1	0	16 ± 1.28	3	2	1	0
4	8 ± 0.74	0	0	0	1	14 ± 0.96	0	2	1	0
5	8 ± 0.74	0	0	0	0	28 ± 0.99	0	4	2	0
6	4 ± 0.59	0	0	1	0	25 ± 1.11	0	4	4	0
7	3 ± 0.56	0	0	0	0	29 ± 1.39	0	2	2	1
8	1 ± 0.26	0	0	1	0	21 ± 1.35	1	3	1	0
9	11 ± 1.15	1	1	0	2	23 ± 0.88	1	3	0	0
10	2 ± 0.35	0	0	1	0	20 ± 0.72	0	4	0	0
11	5 ± 0.49	0	0	0	1	18 ± 0.56	0	3	0	0
12	4 ± 0.59	0	0	0	0	20 ± 1.05	0	2	0	0
13	3 ± 0.41	0	1	0	0	26 ± 0.96	1	3	1	0
14	5 ± 0.49	0	0	1	0	19 ± 0.80	0	4	0	0
15	1 ± 0.26	0	1	0	0	27 ± 1.21	1	2	1	0
16	7 ± 0.74	0	0	0	0	27 1.21	0	3	0	0
17	6 ± 0.63	0	0	1	1	23 ± 0.14	1	3	0	0
18	6 ± 0.63	0	0	0	0	28 ± 0.92	3	4	0	0
19	7 ± 0.74	0	0	1	0	27 ± 0.63	0	3	1	0
20	8 ± 0.74	0	0	1	0	30 ± 1.96	0	5	0	0
21	8 ± 0.74	0	0	1	0	37 ± 1.16	0	4	1	0
22	—	—	—	—	—	48 ± 1.61	0	4	1	0
Total	143	1	5	11	7	568	11	70	18	2
Mean	6.8	0.04	0.24	0.50	0.30	25.8	0.50	3.20	0.8	0.09

[1] Based on 5 trees selected at random from each row.

sensitive to rainfall and low temperature.

All stages of the carmine spider mites were found to be distributed 80-83% of the times on bottom leaves, 17-19.8% of the times on middle leaves, and none on the top leaves (Table 2). On the bottom leaves, the mites were found mainly on the proximal portion (70%) especially near the juncture where the leaves are attached to the petioles. Only 10% of the carmine spider mites were found on the central and none were found on the distal portions of bottom leaves. Even when the population increased a month later, similar trend was observed with 54% of the mites concentrated on the bottom leaves, 22% on the central portion and only 6% on the distal leaves (Table 3). The results show that mites on the bottom leaves dispersed to the distal portions of leaves as population increased. It was also observed that at higher population densities, infestation started on the bottom leaves and on the proximal portion of those leaves (Fig. 2) but eventually spread out and damaged all the leaves on the entire tree.

High population of carmine spider mites occurred along the

Table 2. Distribution of carmine spider mite (in %) on leaves of papaya located at three different parts of the tree.[1]

Row Number	First Count: Total No. of mites	Bottom	Middle	Top	Second Count: Total No. of mites	Bottom	Middle	Top
1	15 ± 1.36	86.7	13.3	0	28 ± 1.41	82.0	18.0	0
2	25 ± 1.80	76.0	24.0	0	34 ± 1.40	82.0	18.0	0
3	6 ± 0.63	100.00	0	0	16 ± 1.28	100.0	0	0
4	8 ± 0.74	87.5	12.5	0	14 ± 0.96	100.0	0	0
5	8 ± 0.74	87.5	12.5	0	28 ± 0.99	75.00	25.0	0
6	4 ± 0.59	100.0	0	0	25 ± 1.11	80.0	20.0	0
7	3 ± 0.56	100.0	0	0	29 ± 1.39	79.0	21.0	0
8	1 ± 0.26	100.0	0	0	21 ± 1.35	72.0	28.0	0
9	11 ± 1.15	63.6	36.4	0	23 ± 0.88	74.0	26.0	0
10	2 ± 0.35	50.0	50.0	0	20 ± 0.72	85.0	15.0	0
11	5 ± 0.49	60.0	40.0	0	18 ± 0.56	100.0	0	0
12	4 ± 0.59	75.0	25.0	0	20 ± 1.05	85.0	15.0	0
13	3 ± 0.41	100.0	0	0	26 ± 0.96	81.0	19.0	0
14	5 ± 0.49	60.0	40.0	0	19 ± 0.80	74.0	26.0	0
15	1 ± 0.26	100.0	0	0	27 ± 1.21	85.0	15.0	0
16	7 ± 0.74	57.1	42.9	0	27 ± 1.21	81.0	19.0	0
17	6 ± 0.63	66.7	33.3	0	23 ± 0.14	74.0	26.0	0
18	6 ± 0.63	66.7	33.3	0	28 ± 0.92	83.0	17.0	0
19	7 ± 0.74	71.4	28.6	0	27 ± 0.63	88.0	12.0	0
20	8 ± 0.74	75.0	25.0	0	30 ± 1.96	87.0	13.0	0
21	8 ± 0.74	100.0	0	0	37 ± 1.16	78.0	22.0	0
22	—	—	—	—	48 ± 1.61	81.0	19.0	0
Total	143	1683.2	416.8	0	586	1826	374	0
Mean	6.8	80.2	19.8	0	25.8	83.0	17.0	0

[1]Data collected in Kauai, Hawaii in May and June, 1978.

borders of the field. This suggests that the mites started infesting the border trees first and, as population increased, they spread throughout the field. Population of the carmine spider mites was lower at the center of the field as shown in Rows 11 to 15 (Table 1).

In concurrence, McMurtry and Flaherty (1977) found that the tetranychid mite, *T. urticae,* which attacks walnut, was generally more abundant on the periphery of the field and more numerous on the leaves from the lower crown of the trees. In contrast, mites were considerably fewer on the upper portions of the trees.

Based on these results, surveys should be concentrated first on papaya trees along edges of the field and population counts made only on

Table 3. Distribution of carmine spider mite (%) on different sections of the bottom leaves of papaya.[1]

Row Number	First Count: Total No. of Mites	Bottom	Middle	Top	Second Count: Total No. of Mites	Bottom	Middle	Top
1	12 ± 1.4	80.0	6.7	0	17 ± 1.8	56	18	8
2	18 ± 1.9	72.0	4.0	0	19 ± 2.2	56	18	8
3	8 ± 0.5	100.0	0	0	12 ± 1.3	75	25	0
4	7 ± 0.5	87.5	0	0	10 ± 1.0	72	14	14
5	7 ± 0.5	87.5	0	0	13 ± 1.5	46	29	0
6	3 ± 0.6	75.0	25.0	0	14 ± 1.4	56	24	0
7	3 ± 0.6	100.0	0	0	16 ± 1.8	55	17	7
8	1 ± 0.3	100.0	0	0	14 ± 1.4	67	5	0
9	6 ± 0.7	54.5	9.1	0	12 ± 1.3	52	22	0
10	1 ± 0.3	50.0	0	0	9 ± 0.9	45	30	10
11	3 ± 0.4	60.0	0	0	8 ± 0.8	44	22	34
12	4 ± 0.5	50.0	25.0	0	12 ± 1.3	60	20	5
13	2 ± 0.3	66.7	33.3	0	13 ± 1.3	50	31	0
14	3 ± 0.5	60.0	0	0	11 ± 1.1	58	16	0
15	1 ± 0.3	100.0	0	0	16 ± 1.7	59	22	4
16	3 ± 0.5	42.9	14.2	0	13 ± 1.3	48	26	7
17	3 ± 0.5	50.0	16.7	0	9 ± 0.9	39	26	9
18	2 ± 0.3	33.3	33.4	0	12 ± 1.3	43	36	4
19	4 ± 0.7	57.1	14.3	0	14 ± 1.4	52	19	7
20	5 ± 0.6	62.5	12.5	0	20 ± 2.2	67	20	0
21	7 ± 0.9	87.5	12.5	0	19 ± 2.2	51	22	5
22	—	—	—	—	26 ± 2.6	54	25	2
Total	103	1476.5	206.7	0	309	1205.0	487.0	124
Mean	4.9	70.3	9.8	0	14.0	54.8	22.1	5.6

[1] Data collected in Kauai, Hawaii in May and June, 1978.

older leaves instead of inspecting all the leaves on each tree. This procedure would save time and effort in surveying for mites especially when the population is low and just starting to build up. In this way, infestation can be delineated and control measure directed only to the affected areas, rather than spraying the whole papaya field.

Natural Enemies.

Several species of natural enemies (Table 1) were observed among the colonies of *T. cinnabarinus* in papaya. These included: phytoseiid mite, *Phytoseiulus macropilis* Banks (Fig. 3); a staphylinid beetle, *Oligota* sp.; a coccinellid beetle, *Stethorus siphonulus* Kapur,

Fig. 2. Damaged caused by *Tetranychus cinnabarinus* (Boisduval) to different portions of a papaya leaf.

a species of thrips, *Scolothrips* sp. and 2 species of spiders, *Theridion* spp. Of these, *S. siphonulus* and *Scolothrips* sp. did not increase in number while the population of *T. cinnabarinus* increased four-fold. Probably, the increased population of this mite was not high enough to attract and sustain them. Besides, thrips are known to be effective predators of spider mites only on crops grown under greenhouse conditions. On the other hand, spiders became noticeably abundant as *T. cinnabarinus* became numerous. Initially, the spider counts averaged only 0.09/leaf, but with a 4-fold increase in *T. cinnabarinus* population within 30 days, the spider population increased to 1.1/leaf or a 14-fold increase. *P. macropilis* increased 11 times while *Oligota* sp. increased only 1.6 times with an increase of *T. cinnabarinus* population.

The population of carmine spider mite and its predators on unsprayed papaya trees is shown in Fig. 4-6. The spider mite population in unsprayed trees was highest in June 1978 with 19.6 to 26.0 mites/leaf. During the succeeding months, there was a general decline in the mite population showing a low population of 2.1 to 2.4 mites/leaf in November, 1978. The relatively dry period in December to January and March to April, however, caused a

Fig. 3. Some predators of carmine spider mite (A) Different stages of *Phytoseiulus macropilis* (Banks) (B) Adult of *Stethorus siphonulus* Kapur (C) Adult of *Scolothrips* sp.

slight build-up of population from 11 to 19 and 9 to 8 mites/leaf, respectively, showing two low peaks (Fig. 4).

Galendromus occidentalis, a predatory mite, was first recorded in high numbers in July 1978 at 1.7/leaf on the foliage of unsprayed trees where they were introduced (Fig. 4). However, the population decreased considerably to 0.2/leaf in February 1979 although a slight increase in population occurred in January at 0.4/leaf.

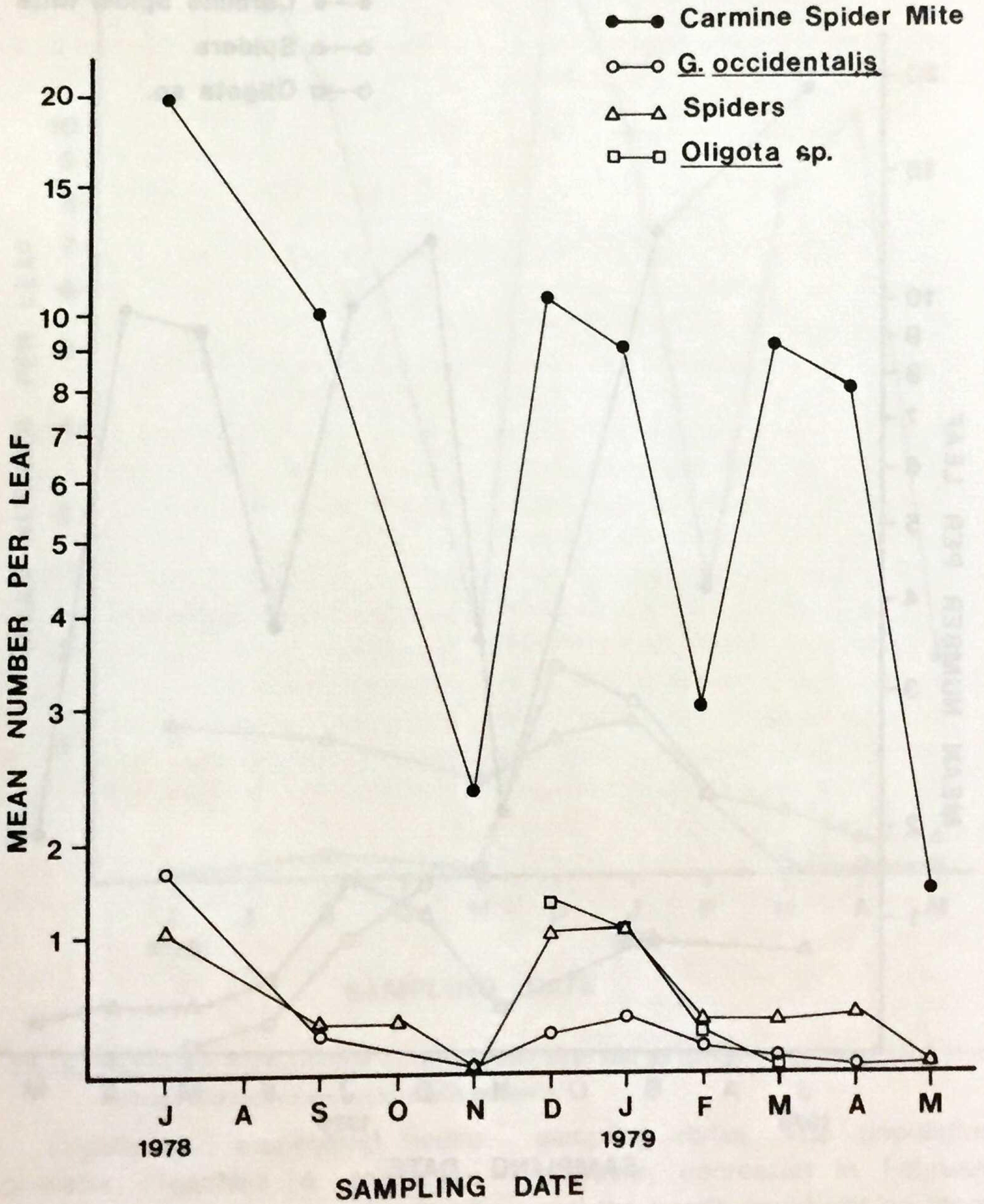

Fig. 4. Population fluctuation of carmine spider mite and its predators in unsprayed plots where *Galendromus occidentalis* were released.

On unsprayed trees, spiders were recovered at a population ranging from 0.7 to 1.2/leaf in July 1978, but the population decreased to 0.4 and 1.0/leaf in September and 0.3 to 0.7/leaf in November. By December, the spider population went up to 1.0/leaf and reached a maximum density of 1.1 to 1.4/leaf in January (Fig. 4-6) then declined again from 0.4 to 0.6/leaf in February 1979.

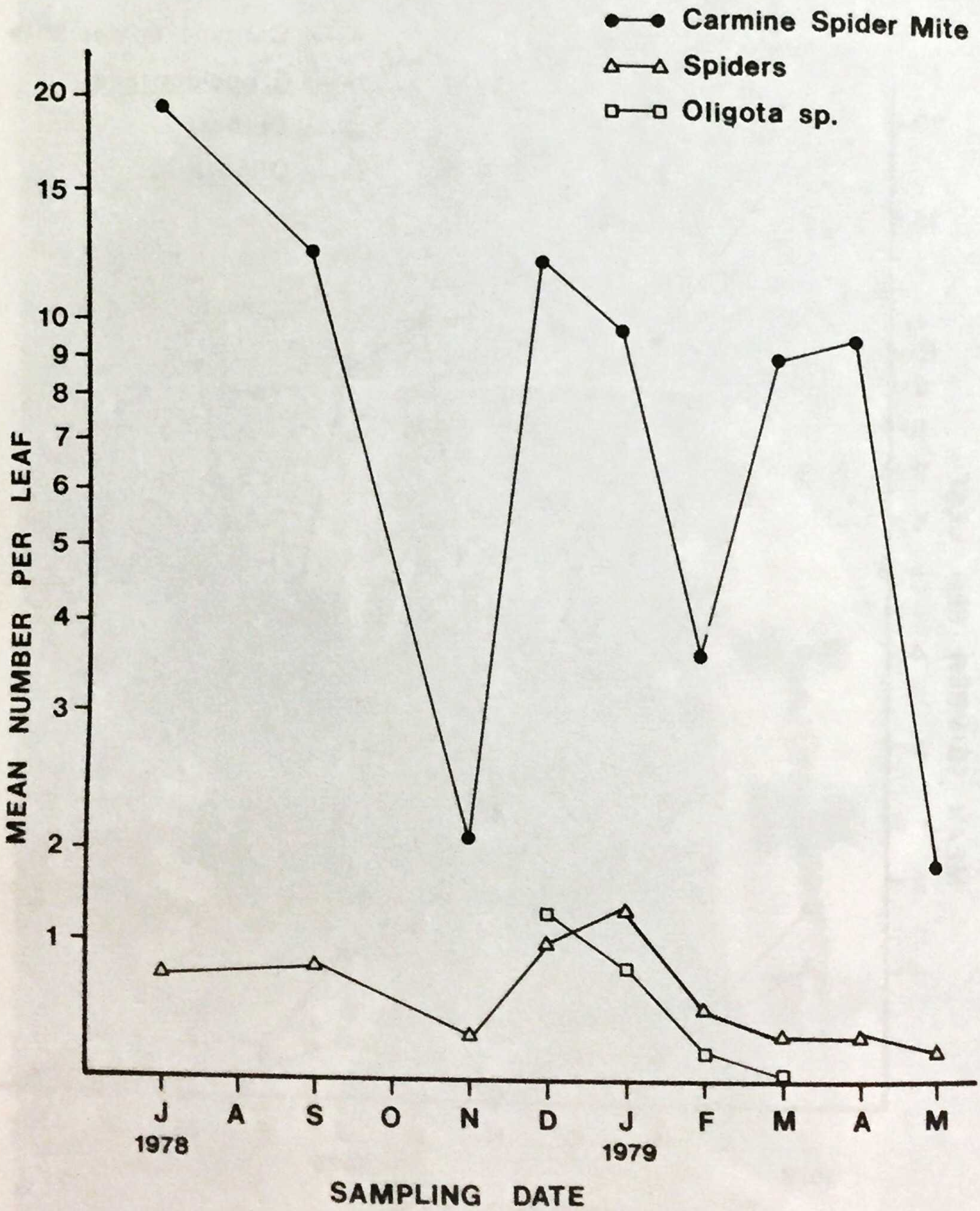

Fig. 5. Population fluctuation of carmine spider mite and its predators on unsprayed plots without *Galendromus occidentalis* releases but were sprayed with malathion one week before the start of the experiment.

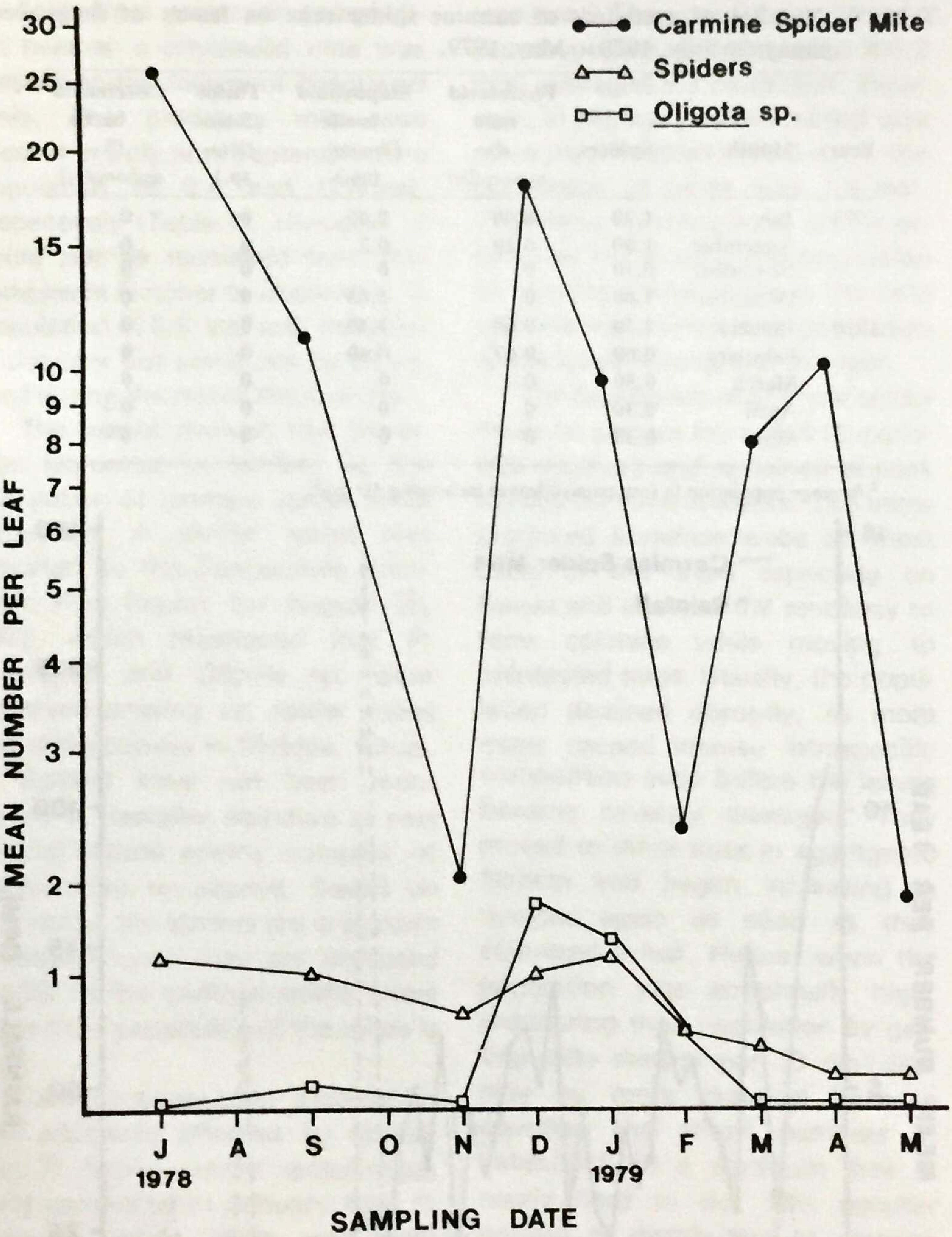

Fig. 6. Population fluctuation of carmine spider mite and its predators on unsprayed plots without *Galendromus occidentalis* releases.

Oligota sp., staphylinid beetle predator, reached a maximum population density of almost 2 beetles/leaf in December, although it was not collected in previous sampling dates. The population, however, decreased in February, and the beetle could not be recovered in leaf samples in March through May.

Table 4. Number of predators of carmine spider mite on leaves of unsprayed papaya in July, 1978 to May, 1979.

Year	Month	Spiders	Phytoseeid mite (*P. macropilis*)	Staphylinid beetle (*Oligota* (sp.)	Thrips *Scolothrips* sp.)	Coccinellid beetle (*S. siphonulus*)
1978	July	1.20	0.40	0.06	0	0
	September	1.00	0.20	0.2	0	0
	November	0.70	0	0	0	0
	December	1.00	0	1.83	0	0
1979	January	1.30	0.60	1.40	0	0
	February	0.60	0.07	0.60	0	0
	March	0.50	0	0	0	0
	April	0.30	0	0	0	0
	May	0.30	0	0	0	0

[1] Average population in four papaya leaves measuring 10 cm^2.

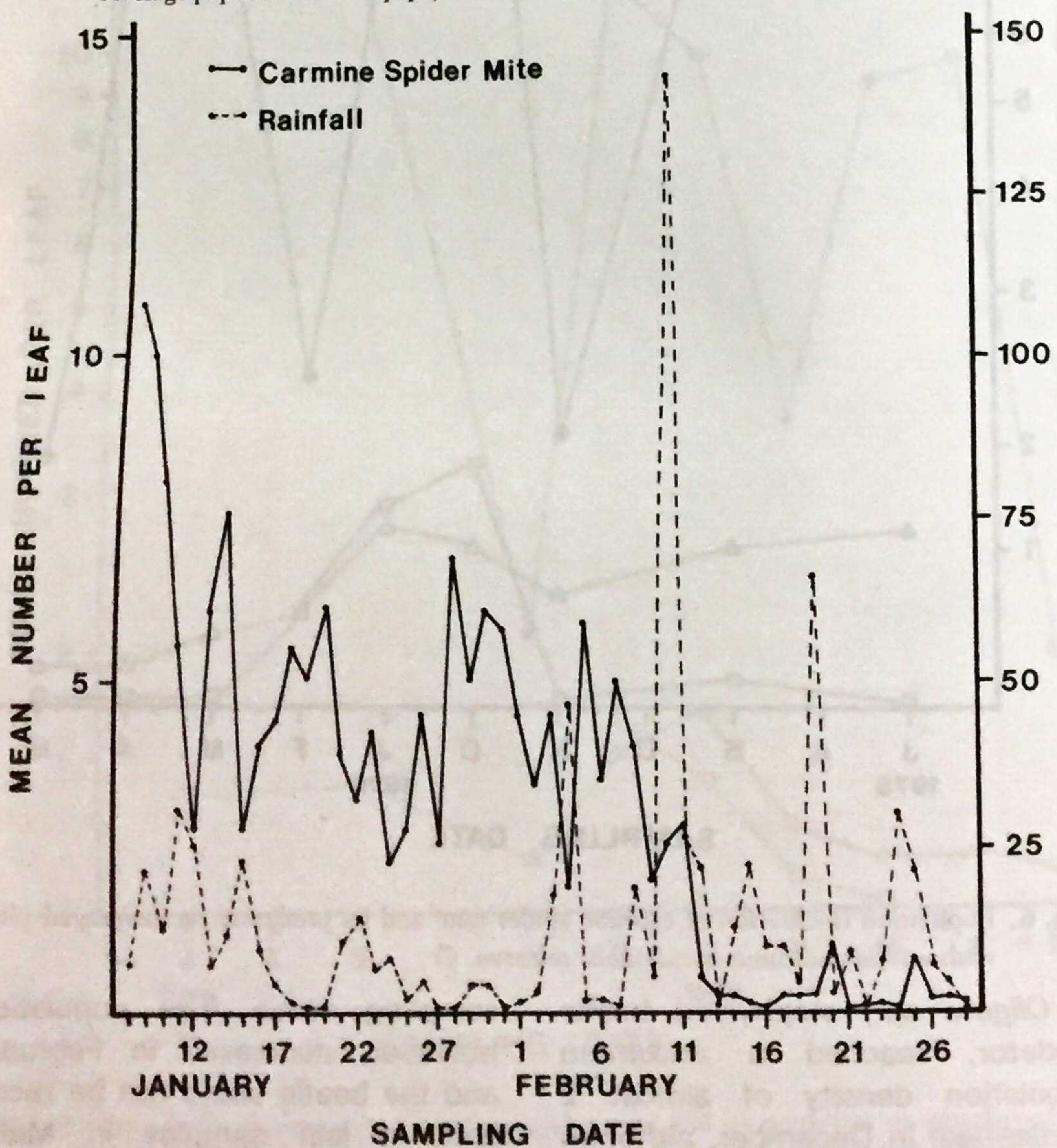

Fig. 7. Relationship between rainfall and carmine spider mite population on papaya.

Aside from spiders and staphylinid beetles, a phytoseiid mite was present on the foliage of unsprayed trees. The predatory mite was present in July and September at a population of 0.4 and 0.2/leaf, respectively (Table 4). However, it could not be recovered from leaf samples in October to December. A population of 0.6/leaf was recorded in January but could not be recovered during the rest of the months.

The results showed that predators increased in number as the population of carmine spider mites increased. A similar result was reported by the Cooperative Economic Pest Report for August 26, 1977, which mentioned that *P. macropilis* and *Oligota* sp. were observed preying on spider mites attacking papaya in Moloaa, Kauai.

Spiders have not been mentioned in Hawaiian literature as part of the natural enemy complex of spider mites on papaya. Based on this study, the spiders are important predators since they are attracted readily to the carmine spider mites even if the population of the mites is low.

Carmine spider mite population was adversely affected by rainfall (Fig. 7). More carmine spider mites were recovered in January than in February when there was high rainfall. Rain washed away and killed the mites causing continuous downward trend in their population. In the latter part of February, the population fluctuated at very low levels, ranging from 0.1 to 2.8 mites/leaf and, in 16% of the leaf samples, mites could hardly be recovered. The population counts in January, when rainfall totalled 206.2 mm, averaged 5.3 mites/leaf. However, in February, when rainfall was more than doubled (491.0 mm), the population of mites was 1.6/leaf. Therefore, rainfall played an important role in reducing the population of carmine spider mites in the field and also maintained their population at low levels throughout the year.

The population of carmine spider mites on papaya increased to explosive numbers and remained at peak density for several weeks. The mites produced immense webs on most parts of the trees especially on leaves and showed the tendency to form colonies while moving to uninfested trees. Usually, the population declined abruptly, as more mites caused intense intraspecific competition even before the leaves became severely damaged. They moved to other trees in aggregated fashion and began increasing in number again as soon as they colonized a leaf. Hence, when the population was abnormally high, monitoring their population by getting mite density per 10 cm^2 leaf may be more practical because counting the actual numbers of mites/leaf on a particular tree is nearly hard to do. This peculiar pattern of distribution of carmine spider mites should be considered in understanding their population dynamics.

Furthermore, counting mites on the bottom leaves does not usually reveal their actual density especially when the population is very high. Most mites tend to transfer to younger leaves or other parts of the tree as soon as the bottom leaves showed signs of damage. This is probably because, before the bottom leaves get severely infested, the nutrients are already depleted so that mites move readily to other parts of the tree.

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