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THE OVERWINTERING MODE OF *BEMISIA TABACI* AND ITS PARASITOIDS IN ISRAEL

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Wild and cultivated plants in the vicinity of Kibbutz Nahshon and a few additional locations in Israel were sampled for the presence of *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae). The whiteflies, together with their parasites, *Eretmocerus mundus* and *Encarsia lutea*, were found to develop on numerous host species throughout the winter. Especially high levels were reached on *Lantana camara, Abutilon grandifolium* and *Ipomoea batatas*. During late winter and spring the population on these hosts declined. From April onwards the populations increased on potatoes and sunflowers.
KEY WORDS: Whiteflies; Aleyrodidae; *Bemisia tabaci; Encarsia lutea; Eretmocerus mundus;* overwintering of *Bemisia* on host plants.

INTRODUCTION

During 1976 and 1977, the tobacco whitefly *Bemisia tabaci* Gennadius emerged as a prominent pest of cotton in Israel. Prior to that time, in spite of its extensive host range (1,3), it was primarily a pest of cucurbits and tomatoes (1,2). The severe nature of the summer outbreaks of *B. tabaci,* especially on cotton, prompted us to investigate the mode of overwintering of this pest. In particular, we were interested to learn in which stages *B. tabaci* and its parasites overwinter, and whether development occurs during the winter months. In addition, we wanted to determine the plant species that served as the most common hosts and to find out if a succession of such plants occurred. The possible role of spring crops was also of interest.

In the present paper results of a survey conducted during the winter of 1977/78 are recorded.

MATERIALS AND METHODS

Most of the studies were conducted in and around Kibbutz Nahshon (Fig. 1), in the Judean foothills, some 30 km SE of Tel Aviv. The area was chosen because it

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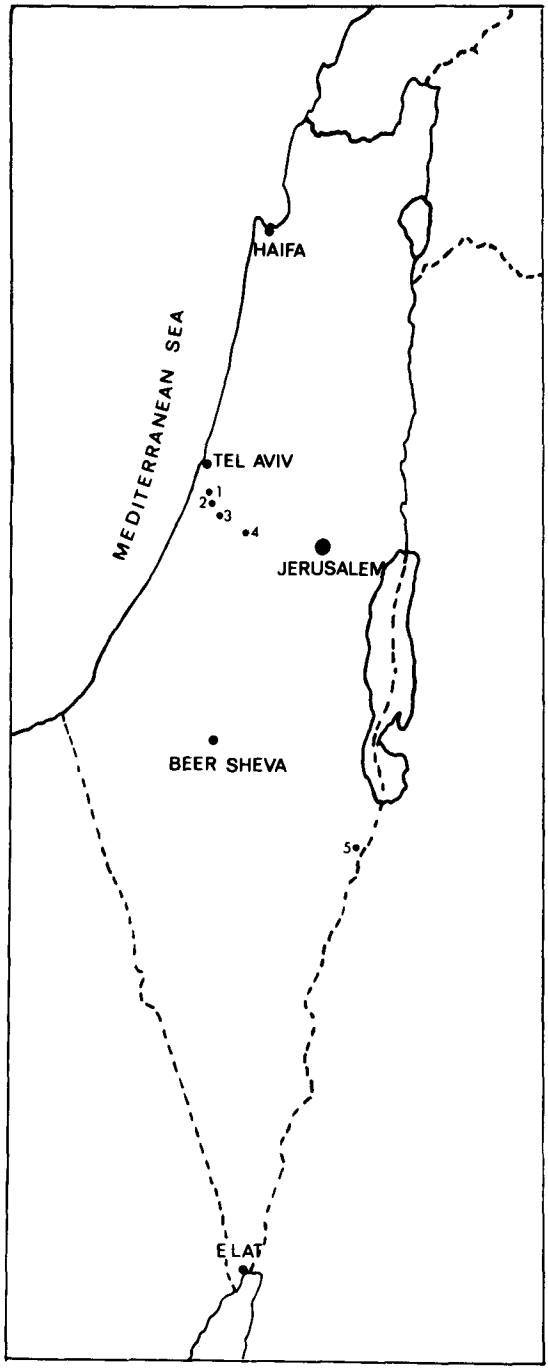

Fig. 1. A map of Israel showing the collection sites: 1. Palmahim; 2. Nes Ziyyona; 3. Rehovot; 4. Nahshon; 5. En Yahav.

was the site of very heavy *B. tabaci* attacks during the summer (4). It also abounds in winter vegetation, both cultivated and wild, and is surrounded by a variety of agricultural crops. Weekly surveys for the presence of whitefly adults and immatures were made of the various plants that had green leaves at the time. The appearance of the plants and signs of whitefly infestation, such as dead pupae and sooty mold, were also recorded. More detailed examination consisted of picking ten leaves, usually of the same branch, and counting the number of live whiteflies belonging to the 3rd and 4th nymphal instars and pupae, since eggs were difficult to locate. Since immatures of *B. tabaci* are transparent, parasites could be seen through the pupal skin. Utilizing differences in larval and pupal shapes of the parasites, and the absence of meconia in the genus *Eretmocerus*, we were also able to determine the specific identity of the parasites. Following a number of visits, a list of continuously infested plants was compiled. These plants were checked regularly, in addition to the overall survey.

The work at Kibbutz Nahshon was supplemented by sampling of an extensively infested stand of *Lantana camara* at Palmahim Junction, and occasional sampling in a number of additional locations (Fig. 1). These occasional winter samples were aimed at spotting whitefly infestations on plant hosts and in ecological niches that differed from those at Nahshon.

The activity of *B. tabaci* adults, and the presence of eggs, were noted whenever possible and used as an additional indicator of the mode in which the pest overwintered.

RESULTS

The survey at Nahshon revealed 19 plant species that were hosts to *B. tabaci* during the winter: *Abutilon grandifolium, Lantana camara, Chrysanthemum indicum, Malva parviflora, Gerbera* sp., *Solanum vilosum, Withania somnifera, Celtis australis, Lonicera etrusca, Verbena* sp., *Cercis siliquastrum, Convolvulus arvensis, Plumbago europaea, Alcea setosa, Tropaeolum majus, Calendula* sp. and *Sonchus oleraceus.* Some, like *L. camara, A. grandifolium* and *C. indicum,* have abundant foliage throughout the year and harbor *B. tabaci* continuously; others, like *S. oleraceus, T. majus* and *C. australis,* are seasonal. Additional plant species, *Calendula* sp., *Inula viscosa, Urtica* sp., *Parietaria* sp. and *Ipomoea batatas,* harbored that pest in other places. *Ipomoea batatas* was found to be heavily infested only at En Yahav (Fig. 1, Table 1).

Several plastic-covered greenhouses at Kibbutz Nahshon, in which roses were grown, were also examined for the presence of *B. tabaci* on the roses as well as on the two weed species prevalent there: *Oxalis cernua* and *Solanum vilosum.* No whiteflies were found on the roses, whereas both weed species harbored the greenhouse whitefly *Trialeurodes vaporariorum* Westw. but not *B. tabaci.*

Extreme variations occurred in and among the samples. Leaves from the same branch often differed markedly in the degree of infestation, as did branches and plants sampled on the same date (Table 2), or on consecutive dates (Figs. 2-5). Still, even the evergreen plants could be grouped into the nearly always more infested species *A. grandifolium, L. camara, C. indicum* and *I. batatas* and the occasionally or sparsely infested ones (Table 3), like *L. etrusca* and *W. somnifera,* etc.

TABLE 1

PLANT SPECIES SAMPLED AT SITES OTHER THAN NAHSHON AND FOUND HARBORING *BEMISIA TABACI* DURING THE WINTER OF 1977/78

Plant species	*Place*	*Date*	*Avg. no. (±SE) whiteflies/leaf*
Calendula sp.	Nes Ziyyona	20.XII.77	24.5 ± 3.8
Inula viscosa	Tel Aviv	15.XI.77	2.4 ± 0.2
Inula viscosa	Tel Aviv	20.XII.77	2.3 ± 0.3
Ipomoea batatas	En Yahav	30.I.78	532.0 ± 82.5
Ipomoea batatas	En Yahav	5.III.78	524.0 ± 125.8
Ipomoea batatas	En Yahav	6.III.78	149.0 ± 40.8
Ipomoea batatas	En Yahav	15.IV.78	92.8 ± 32.0
*Lantana camara**	Bet Oved	22.I.78	149.3 ± 113.0
Lantana camara	En Yahav	30.I.78	43.0 ± 7.6
Lantana camara	Nes Ziyyona	26.XII.77	119.3 ± 28.9
Lantana camara	Nes Ziyyona	1.III.78	32.3 ± 8.2
Parietaria sp.	Nes Ziyyona	20.XII.78	4.4 ± 1.2
Urtica sp.	Nes Ziyyona	20.XII.77	49.4 ± 20.4

*For *Lantana camara* at Rehovot and Palmahim Junction see Figs. 4 and 5, respectively.

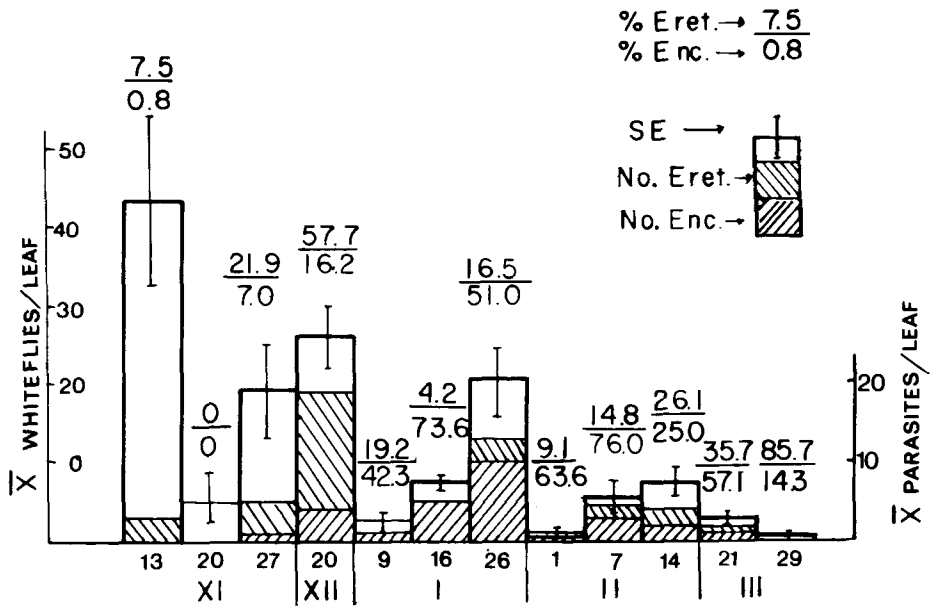

Fig. 2. Average number of *Bemisia tabaci* and percentage of parasitization thereof by *Encarsia lutea* and *Eretmocerus mundus*, on *Lantana camara* at Nahshon during the winter of 1977/78.

TABLE 2

SAMPLE PAIRS TAKEN ON FIVE DIFFERENT DATES FROM THE SAME *LANTANA* BUSH AT PALMAHIM JUNCTION, SHOWING VARIATIONS IN THE NUMBERS OF LIVE WHITEFLIES (3rd- AND 4th-INSTAR NYMPHS, AND PUPAE) AMONG THE SAMPLES FROM THE SAME DATE

Date	*Sample No.*	*Avg. no. (±SE) of whiteflies/leaf*
26.XII.77	1	124.4 ± 58.0
	2	95.1 ± 20.4
5.I.78	1	625.2 ± 104.8
	2	184.4 ± 64.2
16.I.78	1	36.4 ± 14.2
	2	19.6 ± 4.2
29.III.78	1	71.7 ± 11.7
	2	59.5 ± 13.1
5.IV.78	1	40.0 ± 5.8
	2	31.0 ± 6.3

Difference between samples $P < 0.01$

Variance components: Difference between dates 30.5%
Difference between samples 35.7%
Error 33.9%

TABLE 3

RESULTS OF TEN-LEAF SAMPLES FROM PLANTS HARBORING ONLY FEW, SPORADIC INFESTATIONS OF *BEMISIA TABACI* AT NAHSHON DURING THE WINTER OF 1977/78

Plant species	*Date*	*No. of leaves with B. tabaci*	*No. of whiteflies*		*% Parasitism*	
			total	avg. ±SE per leaf	*Encarsia*	*Eretmocerus*
Celtis australis	6.XI.77	4	20	2.0 ± 1.2	0	10
	20.XI.77	6*	59	9.8 ± 1.9	0	6.8
Lantana matevidensis	8.III.78	10	157	15.7 ± 2.8	7.0	19.1
	15.III.78	10	95	9.5 ± 3.0	20	26.3
Lonicera etrusca	13.XI.77	5	11	1.1 ± 0.4	0	0
	20.XI.77	7	13	1.3 ± 0.3	0	0
Plumbago europaea	6.XI.77	2	2	0.2 ± 0.2	0	0
Salvia spp.	9.I.78	6*	14	2.3 ± 0.9	14.2	0
Verbena sp.	13.XI.77	9	50	5.0 ± 1.3	0	0
	20.XI.77	10	167	16.7 ± 4.1	0.6	0
Withania somnifera	14.XII.77	9	30	3.0 ± 0.7	3.3	3.3

*Only six leaves sampled.

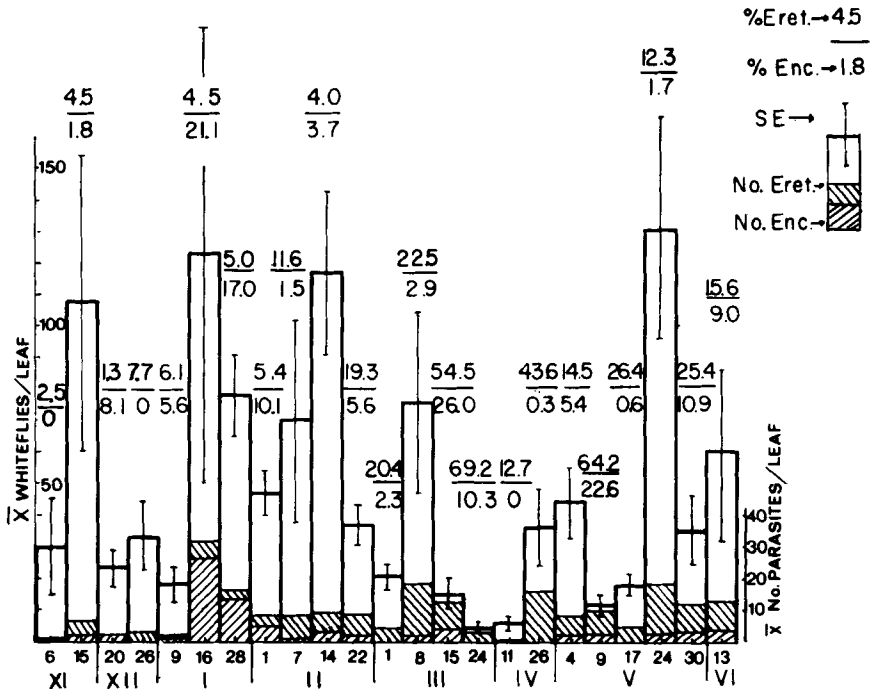

Fig. 3. Average number of *Bemisia tabaci* and percentage of parasitization thereof by *Encarsia lutea* and *Eretmocerus mundus*, on *Abutilon grandifolium* at Nahshon during the winter of 1977/78.

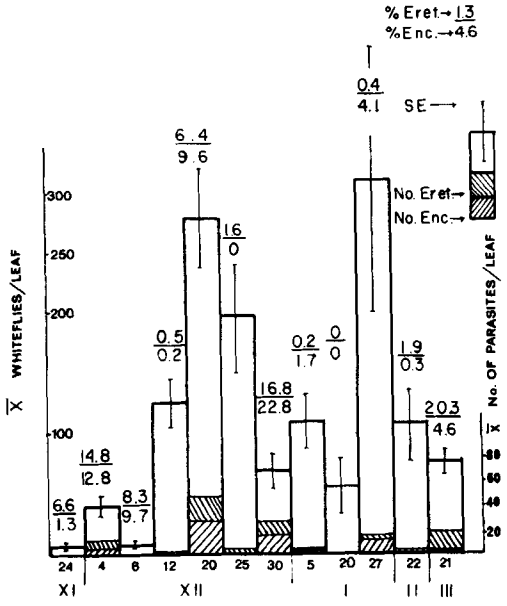

Fig. 4. Average number of *Bemisia tabaci* and percentage of parasitization thereof by *Encarsia lutea* and *Eretmocerus mundus*, on *Lantana camara* at Rehovot during the winter of 1977/78.

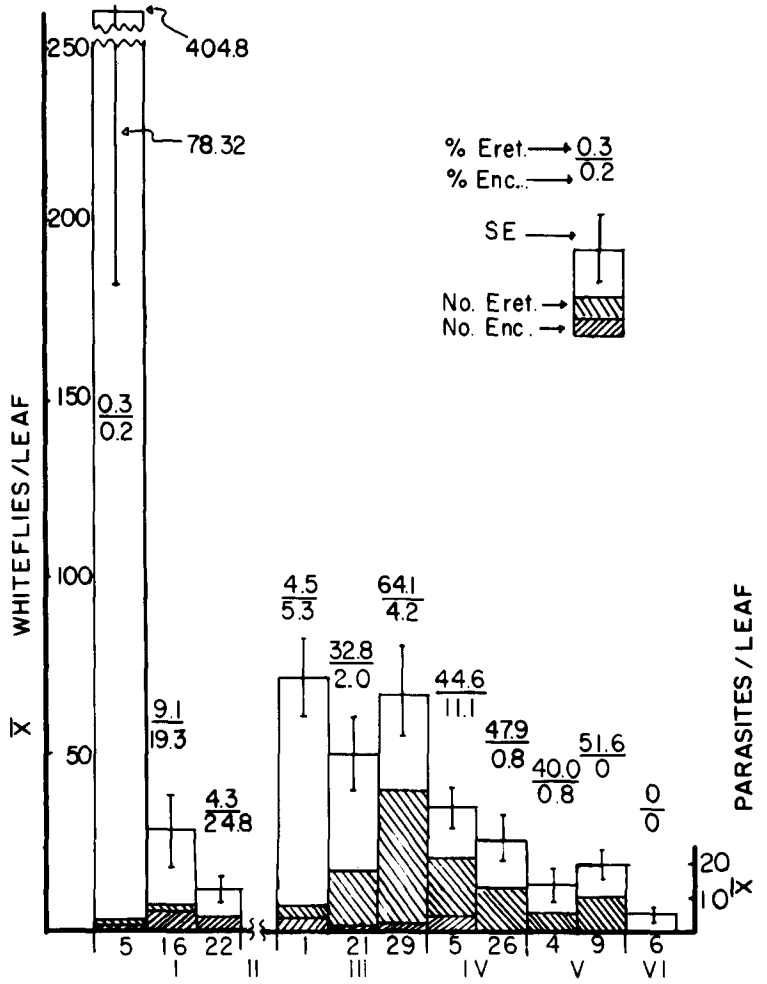

Fig. 5. Average number of *Bemisia tabaci* and percentage of parasitization thereof by *Encarsia lutea* and *Eretmocerus mundus*, on *Lantana camara* at Palmahim Junction during the winter of 1977/78.

High *B. tabaci* infestations were found throughout the winter and spring, and varied as to the host plant or location in which they occurred. At Nahshon, they were relatively low on *L. camara* (Fig. 2) and declined from January onward, whereas those on *A. grandifolium* (Fig. 3) were often higher and fluctuated, reaching peaks in February and in May. The infestation on *L. camara* at Rehovot (Fig. 4) had peaks in December and January; that at Palmahim Junction (Fig. 5) was very high when we started to sample it in January and declined and reached a lower peak in March; from then on it continued to decline, to very low levels in May and June.

High infestations were also found at other sites (Fig. 1) and on various hosts. At Nes Ziyyona there was a very heavy infestation at the end of December, and high numbers were also registered there in March on *Urtica* and *Calendula*. At En Yahav heavy infestations were recorded in January and March (Table 1).

During the spring, from April onward, a shift in host occurs as the whiteflies start to oviposit on new spring plants. Two species grown extensively in Israel are potatoes and sunflowers, both of which harbor considerable populations as early as May (average whitefly immatures per leaf (± SE) = 109.22 ± 18.68, n = 65 and 36.77 ± 12.04, n = 24, for sunflowers and potatoes, respectively). These populations are destined to develop until the sunflowers dry out and the potatoes are harvested. Additional spring and early summer hosts included vegetables, such as tomatoes, melons, cucumbers and beans (1).

Occasional adults were seen on sunny days throughout the sampling period at all sampling stations. At En Yahav adults were very abundant and flew about in great numbers whenever the plants were touched. There was also an abundance of eggs at that location. At the other sampling locations eggs were also found during all the months of the survey, but their presence was sporadic.

Both species of parasites known to attack *B. tabaci* in Israel, *Eretmocerus mundus* and *Encarsia lutea,* were present in nearly all samples throughout the winter and spring (Figs. 2-5). Percentage of parasitism varied, and was particularly low on the plants that were infested only sporadically, and on potatoes and sunflowers, where parasitism reached maxima of only 3%. On evergreen plants parasitism was often low, especially with high host populations. However, there were also cases when more than 50% of the hosts were parasitized (Figs. 2-5). Both species of parasites were usually present in each sample, and one was often predominant. No regularity was found as to which species was more abundant, although in some cases, as at Palmahim Junction and at Nahshon on *A. grandifolium, E. mundus* usually predominated.

DISCUSSION

The overwintering of *B. tabaci* in India was examined in detail by Husain *et al.* (5) and later also by Pruthi and Samuel (8). In spite of some differences between India and Israel in host plant species and climate, they, too, found mainly immature whiteflies during the winter; they also were confronted by extensive variations in the intensity of infestation in relation to time, place, and host plant. The causes for these variations could be ascribed to a number of phenomena.

The uneven distribution of the immatures upon the leaves is the result of the immobility of the whitefly nymph and of the habit of the female to deposit her eggs on upper leaves. Such a tendency has already been described by Avidov and Harpaz (1) and determined by Ohnesorge *et al.* (6,7). The same biological reason can also account for uneven distribution within one plant or among adjacent plants, especially in the winter, when, due to cold weather, few adults emerge and do not tend to disperse.

Since whitefly populations fluctuated during the winter, newly sprouted and germinated plants were found infested, and adults and eggs were found occasionally, one can conclude that *B. tabaci* overwinters as actively developing populations rather than in a dormant stage. The successful overwintering of the whitefly permits it to

infest large acreages of potatoes and sunflowers that abound during the spring and early summer. The whitefly populations are capable of increasing to very large numbers on these hosts, and move on to summer crops, especially cotton, Cucurbitaceae and Solanaceae.

The same two parasite species remain with the pest throughout the year. They showed up in most of the samples and at all sites, but their relative abundance varied with the season, plant species, location, and host abundance.

The highest parasitization occurred on perennial host plants such as *L. camara* and *A. grandifolium* that harbor *B. tabaci* throughout the year and therefore afford a more stable habitat for the whitefly and its parasites. These results are commensurate with the prevailing theory that the comparative stability of the plant habitat affords the parasites better developmental conditions (9).

Very high whitefly populations, of more than 100 immatures per leaf, often showed low parasitization, even on stable, perennial hosts. The same phenomenon was observed on populations infesting cotton during the summer (4) and can probably be attributed to a slower rate of increase of the parasites than of the host.

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