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Dynamics of *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) attacking cotton in the coastal plain of Israel

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Abstract

The dynamics of *Bemisia tabaci* (Gennadius) were followed during two years in treated and untreated cotton fields in three locations in Israel. Two parasite species, *Encarsia lutea* (Masi) and *Eretmocerus mundus* Merc., were the only important natural enemies, but percentage parasitism did not rise with increase in the host population. The whiteflies reached peak populations at the end of the summer. Their distribution upon the plants was not uniform, rather, they tended to concentrate on a few leaves. The leaf bearing the maximal population was the sixth or seventh until mid-July. From then on, its location was variable according to the growth pattern of the foliage. Insecticide treatments, in particular with aldicarb, resulted in depression of both whitefly and parasite populations, but neither was exterminated.

Introduction

The tobacco whitefly, *Bemisia tabaci* (Gennadius), is a well-known pest over much of the tropical and subtropical world. Its host list is extensive (Avidov & Harpaz, 1969; Azab et al., 1971). It damages plants both by the transmission of virus diseases (Cohen et al., 1974; Hill, 1968; Dickson et al., 1954) and by direct feeding upon the plant (Husain & Trehan, 1943). When attacking cotton, it also causes damage through the contamination of the cotton lint with honeydew and sooty mould.

B. tabaci was not a serious pest of cotton in Israel prior to 1975 and 1976, when it became so prominent and the severity of its attacks so intensive that it was the main pest of that crop. In order to determine the best strategies for the control of this pest, the population dynamics of the whitefly and of its natural enemies were studied in treated and in untreated cotton fields in Israel throughout two seasons.

Materials and methods

The studies were conducted at Habonim, Nachshon and Kfar Aza in fields of commercial cotton (variety SJ 2). At Habonim during the 1977 season, one of the two plots (HS 7) received commercial insecticide treatments, whereas the other (HC 7) was untreated. At Nachshon in 1977, two plots (NS 7) received commercial insecticide treatments and one (NT 7), in addition, also received a treatment with aldicarb. In 1978, one plot (NS 8) received commercial insecticide treatments, one (NT 8) received in addition an application of aldicarb, and one (NC 8) received no insecticide treatment until the end of July, and thereafter was treated like NS 8. At Kfar Aza, insecticide-free

plots were sampled during 1977 and 1978 (K 7 and K 8, respectively). Care was taken that the untreated plots remained as free as possible from insecticide drift.

Samples were taken once a week. These consisted of 8–10 plants per plot. At Habonim and Kfar Aza, whole plants were searched for whitefly 'pupae' until 14 July. Thereafter, this became impossible because of the size of the plants and the leaf with the largest number of whiteflies on it was examined. At Nachshon, this practice was followed throughout the season. At Habonim, the second younger (−2) and the second older (+2) leaves in relation to the leaf with the largest population (leaf 0) were also examined. The examination included a count of all living whitefly 'pupae' present and their classification into unparasitised and parasitised individuals. The parasitised ones were classified as to the parasite species involved. A search for other organisms affecting whitefly populations was also carried out.

Results

Population size

The population of *B. tabaci* fluctuated in a similar pattern in all the plots during both years, but the levels reached differed. Although the cotton season starts in May,

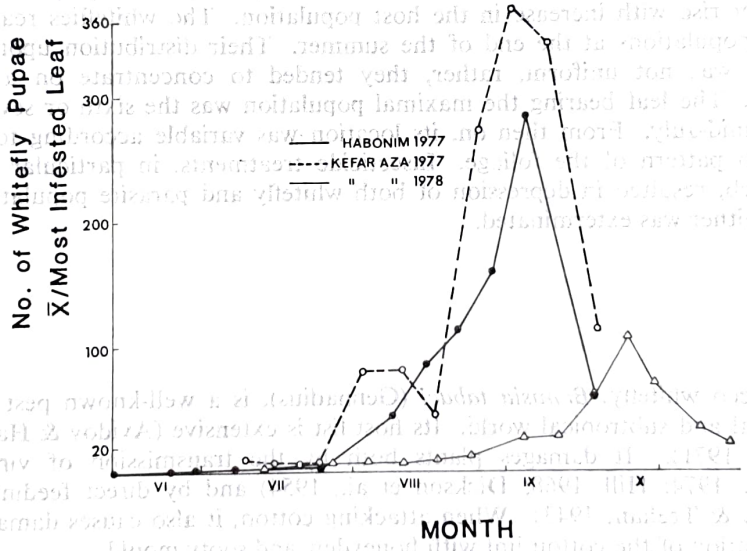

Fig. 1.—Populations of *Bemisia tabaci* in untreated plots.

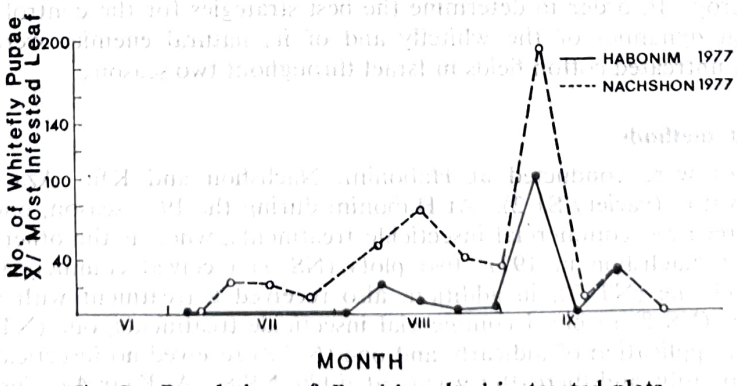

Fig. 2.—Populations of *Bemisia tabaci* in treated plots.

it was not until July that whitefly populations started to build up. They reached a maximum in early September, and a steep decline occurred in the second half or the end of that month (Fig. 1 & 2). This is associated with changes in the physiological state of the cotton plant and probably also with the cooler weather at that time. The populations in the plots treated with aldicarb (NT 7 and NT 8) were much lower than in any of the other plots examined.

Parasites

The observations on plants and infested leaves from treated and untreated fields revealed only two species of aphelinid parasites, *Encarsia lutea* (Masi) and *Eretmocerus mundus* Mercet, as natural enemies of *B. tabaci*.

At Habonim and Nachshon in 1977, small parasite populations were observed at the beginning of the season, which increased and reached a maximum in the second half of August. The peak of *Encarsia lutea* preceded that of *Eretmocerus mundus* by about a week. A very steep drop occurred at the end of August or at the beginning of September, just at the time host populations were building up to a maximum; parasitism dropped rapidly to nil early in September (Fig. 3).

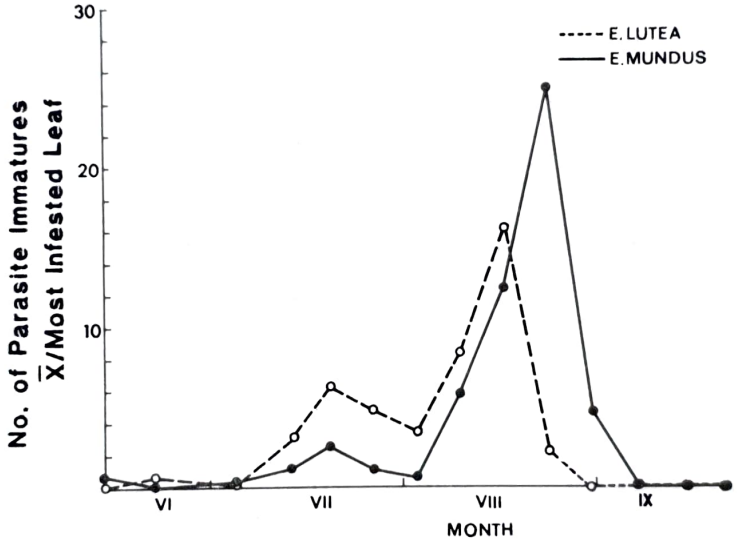

Fig. 3.—Populations of *Eretmocerus mundus* and *Encarsia lutea* in untreated cotton at Habonim (HC 7) in 1977.

In 1978, *Encarsia lutea* hardly appeared at Nachshon, and *Eretmocerus mundus* was present only in the control plot in small numbers in August. At Kefar Aza, similar patterns were observed in 1977 and in 1978. The populations of the two parasites increased from July to a maximum in the second half of September. Unlike the situation at Habonim and Nachshon, the populations reached a peak after the host populations began to diminish (Fig. 4 & 5). In 1977, for example, percentage parasitism increased to 76% in the second half of September after having oscillated between 12 and 55%.

Treatment with aldicarb combined with the usual insecticide spraying prevented to a large extent the development of large parasite populations (although parasites were still present). Insecticide treatment without aldicarb had different effects at Habonim and Nachshon. Whereas at Habonim (HS 7) these treatments resulted in small whitefly

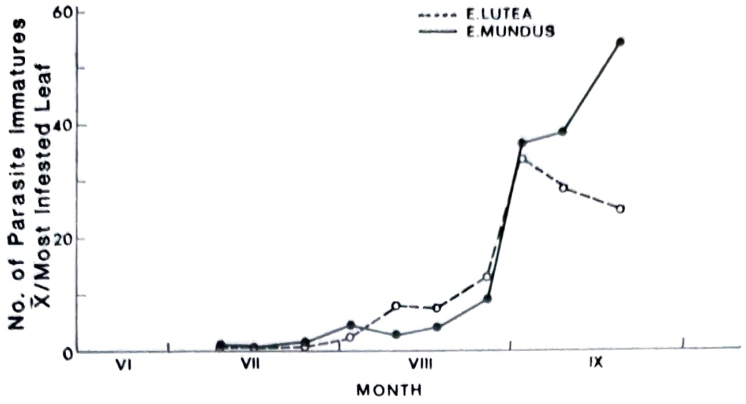

Fig. 4.—Populations of *Eretmocerus mundus* and *Encarsia lutea* in untreated cotton at Kfar Aza in 1977.

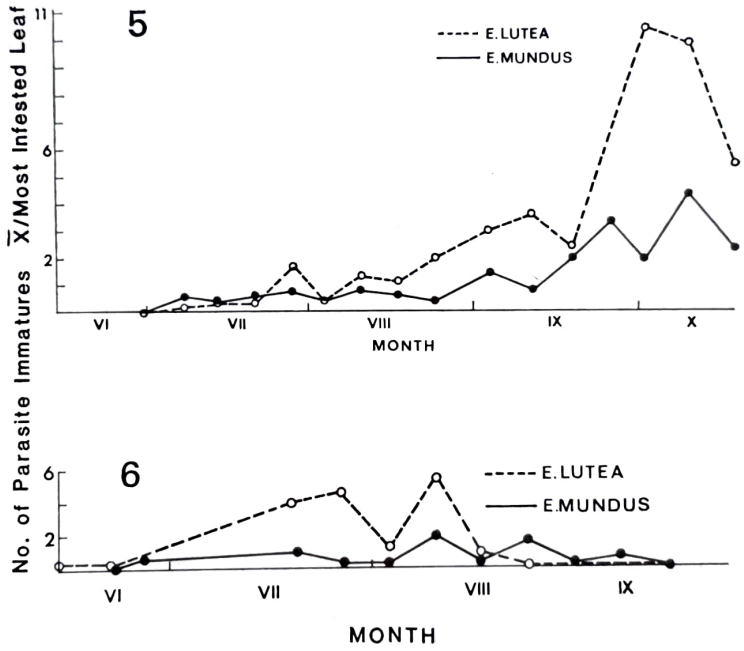

Fig. 5–6.—Populations of *Eretmocerus mundus* and *Encarsia lutea*; 5, in untreated cotton at Kfar Aza in 1978; 6, in treated cotton at Habonim (HC 7) in 1977.

and parasite populations (Fig. 2 & 6), at Nachshon (NS 7) larger populations of the host and of its parasites were found (Fig. 2 & 7). Parasitism there oscillated, reaching over 10% and dropping at the end of August.

Distribution of whitefly pupae upon the cotton plant

Infestation of the cotton plant by *B. tabaci* was not uniform. The pest established foci on the plant. These are the result of the oviposition preferences of the adult whiteflies, of the growth pattern of the cotton plant, and of the population density of the insects upon the plants. In treated plots, the whitefly distribution was also affected by the penetrating capacity of the insecticide through the cotton foliage. In order to

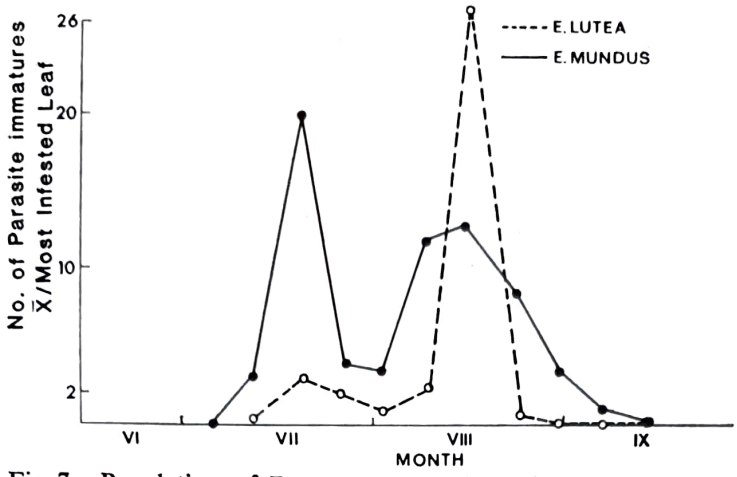

Fig. 7.—Populations of *Eretmocerus mundus* and *Encarsia lutea* in treated cotton at Nachshon, (NC 7) in 1977.

test the distribution of the whiteflies upon the cotton plant, weekly whitefly counts on leaves 0, +2 and −2 were compared at Habonim.

Since our observations confirmed the results of Melamed-Madjar & Cohen (1978) that up to the middle of July the maximal population of whitefly 'pupae' in an untreated field existed on about the sixth leaf, counts were started on 14 July. The position of the leaf with the maximal whitefly population varied greatly but was always much closer to the top on the side branches than on the central branches (Table I).

TABLE I. *The location of the leaf with the maximal population of* B. tabaci *on cotton plants at Habonim*

Date	Central stem	Side branches
14.vii.77	6·4 ± 1·6*	2·3 ± 0·3*
20.vii.77	3·7 ± 0·7	3·1 ± 0·5
27.vii.77	3·8 ± 0·6	3·5 ± 1·3
3.viii.77	9·0 ± 1·3	3·9 ± 0·8
10.viii.77	8·3 ± 2·4	3·1 ± 0·6
17.viii.77	11·7 ± 1·6	3·1 ± 0·5
24.viii.77	11·8 ± 2·1	3·1 ± 0·3
31.viii.77	5·4 ± 1·2	1·6 ± 0·1

*Mean ± standard error of the location of the most infested leaf as counted from the top of the branch or stem.

TABLE II. *The relative rate of infestation with* B. tabaci *'pupae' of leaves + 2 and − 2 compared with the most infested leaf (0) at Habonim in 1977*

Leaf	Relative infestation (%) During the whole season	At times of low populations	At times of high populations
+2	29·0 ± 2·6	22·8 ± 3·7	32·9 ± 3·4
−2	30·1 ± 2·3	26·0 ± 3·9	32·6 ± 2·7

The relative level of infestation of leaves +2 and −2 is higher during high infestation than during low infestations ($P < 0{\cdot}005$ for leaf +2; $0{\cdot}05 < P < 0{\cdot}10$ for leaf −2).

The leaves that were younger or older than the leaf with the highest infestation, had, on the average, about 30% of its whitefly population. This percentage was about 33 when the pest population was high and only 23–26 when it was low (Table II).

Discussion

B. tabaci is known as a thermophilic insect (Avidov, 1956). It appears to be well-adapted to develop in cotton, where it is able to build up very high populations during the summer. The whiteflies established themselves until mid-July on the upper parts of the plant, and the maximal population of 'pupae' occurred on the sixth or seventh leaf. This was due to the tendency of the females to oviposit on the young foliage at the top of the plant. After mid-July, the foliage of the cotton plant ceased growing at the terminals of the main branches, but the side branches continued to grow and small groups of young leaves sprouted out in various places along the branches. The whitefly females oviposited upon these young leaves, and the leaf with the maximal population could occur at various levels or locations upon the plant but was usually closer to the ground on the main branches than on side branches (Table I). The whiteflies seemed to concentrate upon a few leaves on each branch, with one leaf bearing the maximal population, and the population on leaves on each side of it being markedly lower (Table II). The fact that leaf +2 and leaf −2 had a relative higher whitefly population whenever the population on leaf 0 was high than when the latter was low, indicated that the latter served as a 'centre' from which the former received the 'overflow'.

Only two species of natural enemies were found in noticeable numbers during our work. *Eretmocerus mundus* appears to be present in most of the Mediterranean countries and the Sudan. It was recorded from Spain and Italy (Viggiani, 1965) and was found in the Sudan (Gameel, 1969). The *E. masii* Silvestri or *E. diversiciliatus* Silvestri of El Helali et al. (1971) is probably also *E. mundus*, since *E. masii* is a nomen nudum and a synonym of *E. mundus* (Viggiani, 1965), and *E. diversiciliatus* is a parasite from Lagos, Nigeria (Silvestri, 1934), and has never been recorded from the Mediterranean region. All known records of *E. mundus* are from *B. tabaci.*

The distribution of *Encarsia lutea* seems to be similar to that of *Eretmocerus mundus.* However, records are still more scanty than for the latter. Moreover, this species has also been reported from Arizona (Stoner & Butler, 1965).

The pattern of occurrence for both parasite species differs at Kfar Aza from the more northern locations of Nachshon and Habonim. In the latter, they reached their peak populations in August. Thereafter, their populations dropped rapidly in spite of the high host populations still present. At Kfar Aza, their populations rose slowly at first, but instead of declining they continued to rise towards the end of the season. The higher level of *E. mundus* in 1977 was replaced by a higher level of *Encarsia lutea* in 1978.

These differences between the occurrence of the two parasite species in two geographic sub-regions were neither correlated with host densities, nor did they result from cultural practices, all of which were performed under our supervision. It is possible that the generally more humid conditions and cooler nights at the end of the summer at Kfar Aza favoured the build-up of the parasite populations.

The percentage parasitism showed a trend commensurate with the existence of the parasites, and with the host population trend. At Nachshon and Habonim, there was a general decline in parasitism during the season. The decline started about the middle of July, at the same time as the rise in the host population. The percentage parasitism at Kfar Aza, both in 1977 and 1978, increased about the end of August and continued thereafter. This late rise was due to the numbers of both parasite species increasing at the end of the season there.

No rise in percentage parasitism was observed with increase in host population size in both treated and untreated fields. This was also true at Kfar Aza, where no natural decline of the parasite populations occurred at the end of the season. At Habonim, the natural decline of the parasites was so marked that percentage parasitism was identical in an untreated cotton field and in an adjacent plot that had received 14 insecticide applications.

Cotton growers have difficulties in controlling *B. tabaci* through the commonly practised method of aerial spraying of insecticides. Part of their difficulties can be explained through the distribution of the older larvae and pupae on the plant, which was shown to be non-uniform, but these stages tended to occupy the lower parts of the canopy, into which insecticides are not able to penetrate effectively. By the same token, the parasite populations, although affected by the insecticide treatments, are not eliminated.

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