

**BIOLOGICAL CONTROL OF THE JAPANESE BAYBERRY WHITEFLY,
PARABEMISIA MYRICA (KUWANA) (HOMOPTERA: ALEYRODIDAE), IN
ISRAEL***

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ABSTRACT

The Japanese bayberry whitefly, Parabemisia myricae (Kuwana), was first found in Israel in 1978, causing heavy damage to citrus and avocado trees. Local natural enemies, such as phytoseiid mites, lacewings, anthocorid bugs and parasitic wasps, were unable to curb the population of the pest. In 1982 the aphelinid parasite *Eretmocerus* sp. was introduced into Israel from California. It was reared in the laboratory and colonized in 61 localities. It became established very rapidly and spread to other infested areas; as a consequence of this there was a drastic reduction in the whitefly population throughout the country. High rates of parasitism (up to 77!) were recorded, and within 2 years of the parasite's introduction *P. myricae* had been successfully controlled.

INTRODUCTION

Parabemisia myricae (Kuwana) was discovered on citrus and avocado trees in Western Galilee in 1978 (Sternlicht, 1979), and has since spread to the Coastal Plain and other areas of Israel, causing heavy damage. During 1978-1983 broad-spectrum pesticides were often used in citrus groves in order to suppress the high populations of the pest (Golomb *et al.*, 1980; Israeli *et al.*, 1982). *P. myricae* was first described in Japan in 1927 (Kuwana, 1927) and later found in Taiwan, Malaya (Mound and Halsey, 1978), Hawaii, California (Cooperative Plant Pest Report, 1978-1979; Rose *et al.*, 1981), Cyprus and Turkey (CAB International Institute of Entomology, 1986).

The whitefly causes damage by withdrawing sap from young foliage, and by secreting vast quantities of honeydew, on which sooty mould fungi develop.

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Biological control methods only are adopted in the avocado orchards of Israel (Swirski *et al.*, 1986; Wysoki *et al.*, 1981); and chemical control in the citrus groves did not solve the problem of the pest. Since biological control of *P. myricae* on mulberry (*Morus* spp.) is very efficient in Japan (DeBach and Rose, 1982; Yasumatsu and Watanabe, 1965), attempts were made in California and Israel to import natural enemies of this whitefly.

This paper presents results of studies carried out in Israel during 1978-1986 on the impact of both local and imported natural enemies of *P. myricae*.

MATERIALS AND METHODS

Two-year-old potted citrus (soft-skinned varieties, Volkameriana, and Rough lemon) and avocado plants, which contained young foliar terminals, were used for the mass rearing of *P. myricae* (DeBach and Rose, 1982; Rose and DeBach, 1982; Rose *et al.*, 1981; Swirski *et al.*, 1980). The imported parasites were reared freely in separate insectaries under controlled temperature and humidity conditions ($23 \pm 3^{\circ}\text{C}$, 60-70% R.H.).

Inoculative releases of the imported parasites were made as follows: releases of adult wasps, transfers of potted plants and leaves carrying parasitised whiteflies to new colonization sites.

Two methods were used for counting eggs and larvae of *P. myricae*: i) Each leaf was scored in the following manner: no whiteflies — 0; 1 to 10 whiteflies — 1; 11 to 20 whiteflies — 2 and so on up to rating 5, which refers to leaves on which 41 or more whiteflies were found. ii) Eggs and larvae were counted on areas of 1 cm^2 , using a piece of celluloid which had a square hole of the desired size cut into it. Four squares were examined on each side of the leaf. The first method is unsatisfactory because it is not sensitive to small differences in infestation. The second method is preferable, but it is laborious and time consuming.

RESULTS AND DISCUSSION

Local natural enemies

Four species of phytoseiid mites were found associated with *P. myricae* in avocado and citrus orchards: *Euseius rubini* (Swirski and Amitai), *Amblyseius swirskii* Athias-Henriot, *Typhlodromus athiasae* Porath and Swirski and *Iphiseius degenerans* (Berlese). *E. rubini* was the most common phytoseiid in avocado orchards, *A. swirskii* and *T. athiasae* in citrus orchards, while *I. degenerans* was found only once preying upon a larva of *P. myricae*. In laboratory trials, adults of *E. rubini* and *A. swirskii* preyed on all stages of *P. myricae*. Larvae attained adulthood when fed eggs and larvae of the whitefly, but reached only nymphal stages on 2nd and 3rd larval stages of the prey. Females of both species of phytoseiids laid eggs when preying upon the pest (Wysoki and Cohen, 1983).

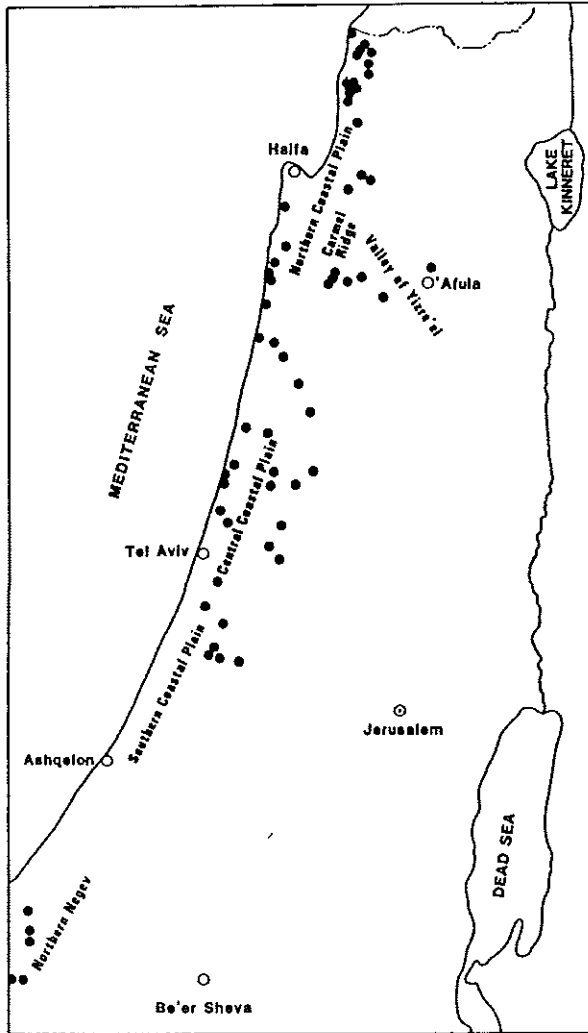
Larvae of the green lacewing, *Chrysoperla carnea* (Stephens), and to a lesser extent those of the brown mealybug lacewing, *Symphorobius sanctus* Tjeder, as well as

undetermined anthocorid bugs, were often seen preying upon larvae of the whitefly on avocado and citrus trees.

In Israel, local parasites were scarce and the predators were unable to curb outbreaks of *P. myricae* (Swirski *et al.*, 1985). Therefore endeavours were made to import natural enemies from other countries.

Imported natural enemies

The fungus *Aschersonia aleyrodidis* Webber was imported from Florida and Colombia, via the Netherlands. It was distributed in many citrus and avocado orchards, but never recovered (in cooperation with R. Kenneth, Hebrew University of Jerusalem, Faculty of Agriculture, Rehovot, Israel).



Map 1. Colonization sites.

The coccinellid *Nephaspis amnicola* Wingo provided successful control of the spiraling whitefly, *Aleurodicus dispersus* Russell, in Hawaii (Lai and Funasaki, 1983). This species and another coccinellid, *Delphastus pusillus* (Le Conte), were introduced into Israel from Hawaii. They were reared in our laboratory on *P. myricae* and on the tobacco whitefly, *Bemisia tabaci* (Gennadius), released in spring 1981 in avocado and citrus orchards at Bet Dagan (Coastal Plain), but have not yet been recovered.

The predacious beetle *Cybocephalus binotatus* Grouvelle, imported from Japan, was reared in the laboratory on the two above-mentioned whiteflies. Field releases were made in 1980 and 1981 in citrus and avocado orchards in Western Galilee, but this beetle has not yet been recovered.

Several undescribed species of aphelinid parasites were introduced into Israel from Japan and the U.S.A. *Encarsia* sp., collected in Japan in 1980 on *Morus* spp., *Myrica rubra*, *Myrsine seguina* and *Dioscorea japonica* at Hagi (Honshu Island), Fukuoka, Kuchinotsu, Saga and Kagoshima (Kyushu Island), was reared in our laboratory. It was released in the avocado orchard at Bet Dagan, but apparently did not become established.

Three parasite species were imported into Israel in 1982 from southern California: (i) *Eretmocerus* sp. (Japan), (ii) *Encarsia* sp. (Japan), and (iii) another *Eretmocerus* sp. (California) (Blumberg, 1983).

(i) A uniparental *Eretmocerus* sp. introduced from Japan into California, became established there (DeBach and Rose, 1982). Adult wasps were released on avocado trees at Bet Dagan, Rishon leZiyyon (Coastal Plain) and Mazzuva (Western Galilee), but the recovery attempts have been unsuccessful. (ii) In Japan the biparental *Encarsia* sp. is the dominant parasite of *P. myricae* on *Morus* spp., curbing the reproduction of the pest efficiently. It was imported into California and became established at various sites (DeBach and Rose, 1982; Rose and DeBach, 1982). *Encarsia* sp. established a generation in Israel under quarantine conditions but the culture was lost. (iii) *Eretmocerus* sp. (California) was discovered in April 1982 in Los Angeles and San Diego counties. It was mass-reared and released in various parts of southern California, which resulted in very successful suppression of the pest (Rose and DeBach, 1982). This species was mass-reared at Bet Dagan and released during 1982-1984 at 61 locations, from Rosh Haniqra in the north to Mivtahim in the south and Merhavaya in the east (see Map 1). It was first recovered at Mazzuva in October 1982, when one parasitized larva was found during a search of one hour (Table 1). Later a few parasitized whiteflies were recorded also at other colonization sites. However the breakthrough occurred in October 1983, when in certain orchards the parasitism rate reached high levels (up to 64.1% and a year later up to 77%).

Tables 2-4, giving the rates of infestation of avocado leaves with *P. myricae* in various localities, prior to and after the importation of the California *Eretmocerus*, show a great reduction of the pest's population following the releases of the parasite. Moreover, whereas in 1979-1983 many citrus plots were treated chemically against *P. myricae* (Golomb *et al.*, 1980; Israeli *et al.*, 1982), no interference is needed nowadays on this crop. Thus *Eretmocerus* sp. proves to be a very efficient biocontrol agent against *P. myricae* on avocado and citrus.

TABLE 1. PARASITISM (%) OF *PARABEMISIA MYRICAE* BY *ERETMOCERUS* SP. FROM CALIFORNIA

Year	Month	Plant host	Colonization site	Parasitism (%)
1982	X	avocado	Mazzuva (N)	<1
1983	II	citrus	Nahalat Yehuda (S)	<1
		avocado	Gan Shelomo (S)	<1
	V		" "	<1
		citrus	Kabri (N)	<1
			Nahalat Yehuda	<1
	VI	avocado	Bet Dagan (S)	<1
	VII		Nahalat Yehuda	<1
			Bet Dagan	<1
		grapevine	" "	<1
	VIII	avocado	Mazzuva	<1
			Bet Dagan	<1
	X		Nezer Sereni (S)	<1
			Rosh haNiqra (N)	<1
			Kabri	<1
			Regba (N)	30.6
			Gan Shelomo	19.3
			Bet Dagan	43.4
			Mazzuva	9.3
			Kefar Bilu (S)	61.4
		citrus	Gan Shemuel (C)	41.5
			Kabri	64.1
			Mazzuva	16.7
		<i>Morus</i> sp.	Gan Shelomo	34.1
1984	III	avocado	Regba	75.0
			Mazzuva	77.0
			Gan Shelomo	66.7
	IV		Nezer Sereni	12.5
	VII		Regba	28.6
			Mazzuva	52.5
			Kabri	37.5
			Bet Dagan	43.8
			Gesher haZiv (N)	44.4
			Bet ha'Emeq (N)	33.3
			Lohame haGetaot (N)	42.9
		citrus	Mazzuva	42.5
	VIII	avocado	Bet Dagan	42.8
1985	IX		" "	46.8
1986	X		Regba	63.5

(N) Northern Coastal Plain; (C) Central Coastal Plain; (S) Southern Coastal Plain.

TABLE 2. INFESTATION OF YOUNG LEAVES OF AVOCADO WITH *PARABEMISIA MYRICAE* AT BET DAGAN IN SEPTEMBER 1982, 1983 AND 1986 (THE CALIFORNIA *ERETMOCERUS* SP. INTRODUCED IN 1982) (NUMBER OF EGGS AND LARVAE ON 1 CM²) (NUMBER OF EXAMINED TREES - 10; NUMBER OF EXAMINED LEAVES - 100)

Variety	Side	1982		1983		1986	
		Eggs	Larvae	Eggs	Larvae	Eggs	Larvae
Ettinger	Upper	0.22	0.18	0.62	0.31	0.07	0.01
	Lower	0.07	1.36	0.21	2.10	0.02	0.15
Fuerte	Upper	2.23	0.58	2.25	0.79	0.16	0.07
	Lower	0.35	2.16	0.40	2.66	0.13	0.34
Nabal	Upper	0.73	0.24	0.58	0.21	0.08	0.01
	Lower	0.15	0.74	0.19	0.69	0.01	0.07
Hass	Upper	0.51	0.26	0.84	0.65	0.10	0.01
	Lower	0.10	1.73	0.14	2.51	0.01	0.09

TABLE 3. RATE OF INFESTATION (%) OF YOUNG AVOCADO LEAVES WITH EGGS AND LARVAE OF *PARABEMISIA MYRICAE* AT REGBA (NORTHERN COASTAL PLAIN) IN NOVEMBER PRIOR TO (1979) AND AFTER (1986) INTRODUCTION OF THE CALIFORNIA *ERETMOCERUS* SP. IN 1982 (NUMBER OF EXAMINED LEAVES - 300 ON 15 TREES)

Year/Variety	Infestation rate*					
	I	II	III	IV	V	Total
1979						
Fuerte	2.7	4.3	3.3	8.0	81.7	100.0
Hass	7.0	4.7	11.7	5.6	71.0	100.0
Ettinger	7.0	7.7	16.7	7.3	61.0	99.7
1986						
Fuerte	17.0	0	0	0	0	17.0
Hass	9.7	0	0	0	0	9.7
Ettinger	7.7	0	0	0	0	7.7

*I-0 - 10 whiteflies; II - 11-20; III - 21-30; IV - 31-40; V - above 41 whiteflies.

TABLE 4. INFESTATION OF YOUNG AVOCADO LEAVES (%) WITH EGGS AND LARVAE OF *PARABEMISIA MYRICAE* IN VARIOUS REGIONS OF ISRAEL PRIOR TO (1979) AND AFTER (1985, 1986) INTRODUCTION OF THE CALIFORNIA *ERETMOCERUS* SP. IN 1982 (IN EACH SITE VARIOUS AVOCADO VARIETIES WERE EXAMINED)

Region	1979		1985		1986	
	Number of sites	Rate of infestation	Number of sites	Rate of infestation	Number of sites	Rate of infestation
Upper Galilee			2	<1		
Lower Galilee			1	<1		
Valley of Yizre'el			1	<1		
Northern Coastal Plain	5	97-100	6	0-1	8	0-1
					1	<10
Central Coastal Plain			5	0-1	10	0-1

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