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RELEASE AND RECOVERY OF IMPORTED PARASITES OF THE CAROB MOTH, *SPECTROBATES CERATONIAE* (LEPIDOPTERA: PYRALIDAE), IN ISRAEL*

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ABSTRACT

The imported parasites *Goniozus legneri* Gordh, *Copidosomopsis (Pentalitomastix) plethorica* Caltagirone, and *Diadegma* sp. were reared and released in almond plantations in Israel to control the carob moth, *Spectrobates (= Ectomyelois) ceratoniae* (Zeller). About 32,000 *G. legneri* and 3.5 million *C. plethorica* were released at four locations in the north of the country (Lower Galilee) and at four locations in the south (Southern Coastal Plain), *Diadegma* sp. (*ca.* 1500 adults) were released only in the south. *G. legneri* were recovered in large numbers in all release plots 4 years after the last release. The highest percent of parasitization by this parasite (30.8%) was recorded at one location in the south. *C. plethorica* was recovered in the north at one location only, at a level of 2.6%. It was more abundant in the south but still at a lower rate of parasitism than *G. legneri. Diadegma* sp. was not recovered in any of the release plots 1 year after the release.

KEY WORDS: Goniozus legneri, Copidosomopsis plethorica, Diadegma sp., *Spectrobates (= Ectomyelois) ceratoniae*, parasite release, almonds.

INTRODUCTION

The carob moth, *Spectrobates (= Ectomyelois) ceratoniae* (Zeller) (Lepidoptera: Pyralidae), is a polyphagous fruit pest in the Mediterranean area (Bodenheimer, 1930; Heinrich, 1956). In Israel it is considered an important pest of grapefruit, carob and almond. The damage to grapefruit is caused by larvae hatching from eggs laid by invading females (Gothilf, 1970). Since all larvae are inevitably killed by gum exuded from the damaged fruits any control measure in this case should be directed against the immigrating adult moths. As far as biological control is concerned only egg parasites may be effective in this case. Several species of natural parasites are associated with the carob moth on carob, which is a major host of this pest (Gothilf, 1969). A new parasite, *Copidosomopsis (Pentalitomastix) plethorica* Caltagirone

(Hymenoptera: Encyrtidae) which was collected by Dr. L.E. Caltagirone in Mexico and released in nut orchards in California (Caltagirone, 1966) was imported from California to Israel and introduced into carob plantations in 1974 but was not recovered later (Gothilf, 1978). The occurrence of carob moth natural enemies is rare in almonds (Gothilf, 1984), even in regions where almonds are grown adjacent to carob trees. Insecticidal sprays are usually employed to control the pest in almond plantations, although sprays are not always efficient against the larvae which are found inside the fruits. In order to improve the natural control of the moth in almond, the parasite *C. plethorica* released in one almond growing area (Julis) in 1974. It was later found that the parasite established itself and the rate of natural parasitization increased significantly (Gothilf, 1978). Except for a single release of *C. plethorica* made in Niva in 1978, (described below), no additional releases were made until 1980 to 1982, when *C. plethorica*, together with two other new parasites from California, *Goniozus legneri* Gordh (Hymenoptera: Bethylidae) which originates from Uruguay and central Argentina (Legner and Silveira-Guido, 1983) and *Diadegma* sp. (Hymenoptera: Ichneumonidae) which originates from south Australia (Dr. E.F. Legner, personal communication), were reared in the laboratory and released in two major almond growing areas. This paper presents the result of such releases.

MATERIAL AND METHODS

Rearing the Parasites

All rearings were made indoors at an ambient temperature of 26 ± 1°C, 75 ± 5% R.H. The rearing procedure of the host, *S. ceratoniae*, was described by Gothilf (1968), and of *C. plethorica* by Gothilf (1978). *Goniozus legneri* was reared by introducing a single adult parasite into a glass tube, 4 cm long x 1 cm i.d., containing one last-instar host larva. About 50 such larvae were exposed to parasitization at a time. The parasite completed its egg laying on the host larva in less than one day. The same adult parasites were provided alternately with two or three larvae for parasitization All parasitized larvae were transferred to 10-cm-diam. petri dishes. Each larva yielded *ca.* ten adult *G. legneri*. The emerging parasites were supplied with honey until released in the field.

Diadegma sp. was reared as follows: open petri dishes (10 cm diam.), each containing 3rd- and 4th-instar *S. ceratoniae* larvae in food medium were exposed to about 30 adult *Diadegma* in a 45x35x30 cm wood-framed cloth cage. The parasites were supplied with honey. After 2-3 days the petri dishes were removed and covered. When parasites emerged they were transferred to 10x10x8 cm screened cages and fed with honey until released in the field.

Field Release and Recovery

Releases were made in two major almond growing areas in Israel, one in the north in the Lower Galilee (L.G.) and one in the south in the Southern Coastal Plain (S.C.P.). In each area releases were made in four 2-ha plots, each situated at different locations, 5-6 km apart. An exception is Sa'ad in the S.C.P. which is 20 km distant from the three other locations.

Goniozus legneri and *C. plethorica* were released in 1982 at the four locations in the L.G. The same parasites and *Diadegma* sp. were released at four locations in the S.C.P., mainly in 1981 and 1982 (Table 1). In each plot parasites were released once a month, in late May, June and July, when all developmental stages of the moth are present in the field. Before the first release a fruit sample was collected in each plot, kept in a cage in the laboratory, and observed for emerging parasites.

To assess the establishment of the new parasites, a sample of approximately 500 fruits was collected in each plot either at the end of the first release season or up to 5 years later. The samples were collected in late December and brought to the laboratory. At this time of the year the moth population is composed of grown larvae only. The fruits were opened and larvae were transferred, individually, to cotton plugged glass vials, supplied with almond kernels as food. Emergence of moths or parasites was recorded. Infestation of the fruit sample by carob moth larvae varied from one plot to another, averaging 40 larvae per 100 fruits.

RESULTS AND DISCUSSION

The number of emerging parasites from nut samples collected before release was low, *ca.* 1% of total emergence, and consisted mainly of *Phanerotoma flavitestacea* Fisher. None was of the released species. However, emergence of *C. plethorica* was recorded in a sample collected at Niva, where one release of this parasite was made in 1978.

Recovery checks were made in the L.G. 3 years after release. *G. legneri* was the most abundant – up to 25.3% at Kadoorie (Table 2). A much lower rate of parasitization was found in Yavne'el, which is located farther east than the other locations, close to the Jordan Valley, which has a warm and dry climate. Apparently these conditions are less favorable for the parasites. On the other hand *C. plethorica* was recovered in small numbers and only at Kefar Tavor. None was found at the three other locations.

TABLE 1. NUMBER OF PARASITES RELEASED IN ALMOND PLANTATIONS

Location	Year	*Goniozus legneri*	*Copidosomopsis plethorica* x10^3	*Diadegma* sp.
Lower Galilee	1982	3500	1500	0
Kefar Tavor	1982	2000	500	0
Kadoorie	1982	2250	500	0
Sharona	1982	2250	45	0
Yavne'el				
Southern Coastal Plain				
Luzit	1980	3400	350	875
	1981	7500	1050	420
Niva	1981	1000	0[a]	75
Helez	1982	4500	700	60
Sa'ad	1981	1000	0	75
	1982	4500	800	0

[a]Approximately 50,000 *C.plethorica* were released at this location once in 1978.

TABLE 2. RECOVERY RESULTS FORM NUT SAMPLES[a] COLLECTED IN ALMOND PLANTATIONS AFTER RELEASE OF PARASITES

Location	Year	Adult emergence (%)					
		Larval mortality (%)	Carob moth	*Goniozus legneri*	*Copidoso-mopsis plethorica*	*Diadegma* sp.	Other para-sites
Lower Galilee							
Kefar Tavor	1985	14.5	60.3	22.6	2.6	0	0
Kadoorie	1985	19.0	55.7	25.3	0	0	0
Sharona	1985	13.6	79.0	7.4	0	0	0
Yavne'el	1985	20.0	76.7	3.3	0	0	0
Southern Coastal Plain							
Luzit	1980	24.3	70.0	2.4	0.5	2.8	0
	1981	8.1	57.6	27.2	2.0	2.9	2.2
	1982	14.6	56.1	26.8	2.5	0	0
	1985	16.0	62.1	21.0	0.9	0	0
Niva	1981	11.4	79.5	0	9.1	0	0
	1982	19.2	40.4	30.8	9.6	0	0
	1985	8.3	71.0	17.9	2.8	0	0
Helez	1985	17.1	69.2	13.7	0	0	0
Sa'ad	1982	6.7	93.3	0	0	0	0

[a]Samples were of *ca.* 500 fruits per plot per year. On the average, nuts were infested by 40 carob moth larvae per 100 fruits.

Establishment of *C. plethorica* was more pronounced in the S.C.P. but the rate of parasitism was still low in comparison with that recorded in a previous study (Gothilf, 1978). The highest rate of parasitism was found in Niva in 1981 and 1982 (9.1% and 9.6%, respectively). One release of *C. plethorica* was done in Niva in 1978 but the results have not been recorded until this study. It is not clear why *C. plethorica* was not recovered from samples collected at Helez, where climatic conditions are similar to those of Luzit and Niva. As for the plantation in Sa'ad, actually no establishment of parasites was expected in this plot because although chemical sprays against the carob moth have of late been almost discontinued in most plantations, due to the poor economic situation of the almond industry, in the Sa'ad plantation almond pests are still controlled by routine preventive spray of broad spectrum insecticides and fungicides. Only $<7\%$ of the nuts from this plantation were found by us to be infested by the carob moth, compared with $\sim$ 40% infestation usually found in other plantations. Of the two other parasites released in the S.C.P. *G. legneri* was clearly established and reached rates of up to 30.8% parasitism. *Diadegma* sp., on the other hand, was recovered only in Luzit, at the end of the first and second release years, but subsequently was not found.

The results of this work show that the conditions in the main almond growing areas of Israel are favorable for the survival of *G. legneri* and it is expected that this parasite will be partially effective in regulating the carob moth population and

reducing the damage to almond nuts. *G. legneri* was found to perform best at high summer temperatures and was successfully established in almond plantations in California following its introduction for the control of the navel orangeworm (Legner & Silveira-Guido, 1983). *C. plethorica* seems to be less successful than *G. legneri*, although it is too early to exclude a regulative effect of this parasite on the pest population in the south of the country. *Diadegma* sp. is known as a natural enemy of *S. ceratoniae* at low densities in almonds in Australia (Dr. E.F. Legner, personal communication). Nevertheless, it failed to survive in Israel following the present releases. However, it should be mentioned that we were not successful in producing large numbers of this parasite in our laboratory rearing, and hence only relatively small numbers were released (Table 1).

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