

THE INTRODUCTION OF *ENCARSIA LAHORENSIS* (HOWARD) (HYMENOPTERA: APHELINIDAE) INTO ISRAEL FOR THE CONTROL OF THE CITRUS WHITEFLY, *DIALEURODES CITRI* (ASHMEAD) (HOMOPTERA: ALEYRODIDAE)

Y. ARGOV and Y. ROSSLER

The "Israel Cohen" Institute for Biological Control, C.M.B.I. 27K.K.I. St., Rehovot, 76345, Israel

ABSTRACT

The citrus whitefly, *Dialeurodes citri* (Ashmead), was introduced into the northern coastal plain of Israel in 1975. A biological control project involving the introduction and direct field-releases of *Encarsia lahorensis* (Howard) was undertaken in 1980. Establishment and spread of the parasite were observed. The parasite is now present in all known citrus whitefly infestations in the country. **KEY WORDS:** Biological Control, *Dialeurodes citri*, *Encarsia lahorensis*, Israel.

INTRODUCTION

The citrus whitefly, *Dialeurodes citri* (Ashmead) (Homoptera: Aleyrodidae), is a polyphagous insect attacking plants belonging to 28 botanical families (Mound and Halsey, 1978), but is mainly a pest of citrus and some ornamental shrubs. It is native to south-east Asia and was introduced into Florida between 1858 and 1885, into California in 1907, into France in 1945-6, into Italy in 1967 and into Sicily in 1974 (Delrio et al., 1980; Ebeling, 1959; Porath, 1979). In Israel, in the Western Galilee the pest was first spotted in five commercial groves during 1975 (Sternlicht, 1979) and spread within five years to other localities in the same region, including the residential areas of Nahariyya and Acre (Israeli et al., 1983).

An intensive eradication program based on area-wide, massive application of insecticides, was conducted from 1975 to 1980 throughout the infested area. Although the pest was successfully contained for a few years, it was never eradicated. A few foci of infestation remained on *Citrus* spp., *Myrtus communis*, *Ligustrum* sp. and *Melia azedarach*, in the residential areas of Nahariyya and Acre. The introduction of natural enemies for the biological control of the pest was considered even during the eradication program, but was carried out extensively only since 1980, with the introduction of *Encarsia lahorensis* (Howard) (Hymenoptera: Aphelinidae).

MATERIAL AND METHODS

Encarsia lahorensis was first shipped to Israel as early as 1976 from Naples, Italy, by Prof. G. Viggiani of the University of Napoli in Portici. Attempts to rear the parasites on an alternative host, *Dialeurodes kirkaldyii* (Kontinsky), failed. Therefore, parasites emerging from later shipments were released directly in the field. Five such shipments, yielding a total of 77 females and 159 males, were received from 1978 to 1979. The adult parasites were all released in the infested area during the eradication program. None of these releases resulted in establishment, which was expected, considering the hostile environment the parasites encountered.

From March 1980 on, a small whitefly infestation was reserved for releases of *E. lahorensis* in a backyard located in the residential area of Nahariyya. The backyard comprised 8 citrus trees, including a lemon tree which was selected as the release site. Leaves bearing parasitized whiteflies were received during September and October 1980 from Naples, Italy, and all the emerging adult parasites were released on the lemon tree. A total of 77 females and numerous males were thus released during a 2 months period. Recovery was checked periodically on the lemon tree from December 1980, and on the adjacent citrus trees from July 1981, for a period of 2 years. A new focus of whitefly infestation was found in September 1981 in Acre (10 km south of Nahariyya), and parasitized whiteflies were transferred from Nahariyya to the new site on 5 different dates until April 1982. Recovery was checked in Acre from May 1982 to the end of the study in September 1983. We have counted and recorded live and parasitized 4th nymph instars of the whitefly on the citrus leaves, this being the susceptible stage to *E. lahorensis* attack.

During the study period we located additional foci of whitefly infestation in Nahariyya and neighbouring localities. We transferred to all these foci citrus leaves with parasitized whiteflies from the Nahariyya release site. Establishment of *E. lahorensis* in all these sites was obtained with no particular difficulties.

RESULTS AND DISCUSSION

The first parasitized whiteflies were observed in the Nahariyya release site in December 1980, 2-3 months after the onset of releases. Very few parasitized individuals were then found in a very large whitefly population. In the following spring (March 1981), the release site was surveyed and 16 parasitized individuals were found in a dense whitefly population. Evidently, the introduced parasite was able to survive the winter and start reproducing in the following spring. During the study period, *E. lahorensis* was established in both release sites and reached substantial population levels. The advance of parasitization in Nahariyya was rather slow, reaching levels above 10% only in September 1981, one year after the releases were terminated. Establishment in Acre was much more rapid, reaching levels of 80% and more as early as one month after the termination of releases (in May, 1982).

The level of parasitization remained higher in the Acre release site throughout the study period. We observed a gradual decrease in the pest population in the two release sites during the study period. That trend was partially reflected in the density of the 4th nymphs of *D. citri* on the same months in consecutive years (Tables 1 and 2).

TABLE 1. PARASITIZATION OF *DIALEURODES CITRI* (ASHMEAD) BY *ENCARSIA LAHORENSIS* IN THE NAHARIYYA RELEASE SITE

Date	Leaves inspected	<i>D. citri</i> nymphs per leaf \pm S.D.	% nymphs parasitized
July 27, '81	20	47.75 \pm 54.20	5.5
Sept. 21, '81	20	17.75 \pm 18.78	14.9
Oct. 26, '81	45	23.02 \pm 21.83	22.3
Dec. 22, '81	39	40.00 \pm 36.71	5.6
March 8, '82	39	39.35 \pm 45.71	13.4
Apr. 18, '82	34	35.08 \pm 33.11	13.3
May 18, '82	28	9.10 \pm 6.10	59.1
June 28, '82	35	0.11 \pm 0.40	66.6
Sept. 14, '82	very low population of <i>D. citri</i>		
May 1, '83	63	12.67 \pm 11.13	6.0
June 22, '83	94	6.12 \pm 13.24	10.3
July 14, '83	100	10.64 \pm 9.28	19.1
Sept. 12, '83	100	4.67 \pm 6.28	35.6

TABLE 2. PARASITIZATION OF *DIALEURODES CITRI* BY *ENCARSIA LAHORENSIS* IN THE ACRE RELEASE SITE

Date	Leaves inspected	<i>D. citri</i> nymphs per leaf \pm S.D.	% nymphs parasitized
May 18, '82	19	2.37 \pm 2.65	83.9
July 14, '82	46	14.59 \pm 18.13	30.9
Sept. 14, '82	65	1.37 \pm 2.23	53.4
Oct. 19, '82	50	15.12 \pm 17.75	12.1
May 1, '83	61	11.54 \pm 12.62	20.63
June 22, '83	125	7.44 \pm 9.41	12.5
July 14, '83	119	9.18 \pm 9.24	23.5
Sept. 12, '83	120	0.10 \pm 0.35	85.4

The highest levels of parasitization were reached in both release sites during May-June and September. This coincided with a decline in the density of the 4th nymphs of whitefly. The inverse relation between host density and % parasitism by *E. lahorensis* did not reflect, at that present stage of colonization, the density dependence of the parasite. It seemed, though, that *E. lahorensis* had no difficulty in searching and locating hosts even when they were present at a very low density. It also seemed that, during the initial colonization period, *E. lahorensis* was unable to respond successfully and quickly to the increase in the host population, leaving a high proportion of unparasitized host.

Israel is the seventh country into which *E. lahorensis* has been introduced for the control of the citrus whitefly. The original introduction of the parasitic wasp was into California in 1966 from India and Pakistan. From there it was further introduced into Texas, Florida, Italy (Sicily, Sardinia, Naples), Greece (Corfu), France, Turkey and Russia. In all these countries (except for Turkey and Russia) records of recovery and establishment are available (Rose and DeBach, 1981; Viggiani and Mazzone, 1978).

The biology of *E. lahorensis* was not studied in Israel. It was, however, studied extensively in relation to citrus whitefly control by Viggiani and Mazzone (1978) in Italy. They showed the pest to have 2-3 annual generations in southern Italy, with adults appearing in April, August and October. *E. lahorensis* had 4-6 annual generations, with adults appearing in April-May, August-September and October-November. Our observations as well as those of Chen et al. (1979) were similar. The peak of adult emergence of whiteflies was observed in April. The second generation appeared during the summer, and a third generation in October.

There are controversial reports on the dispersal rate of *E. lahorensis* from the release site. In Florida, the parasite population spread 200 meters from the release site within 3 months (Ru and Sailer, 1979). In California, movement of only 6 meters was observed in a year (Rose, cited by Ru and Sailer, 1979). In Naples, Italy, dispersal was rapid, and the parasite's population spread 3-4 km within 1-2 years (Viggiani and Mazzone, 1978). In Israel, parasitized whiteflies were found ca. 20 meters from the initial release tree in Nahariyya 8 months after the initial releases (a period that included also 4 months of winter). In Acre, we found in January 1984 parasitized whiteflies in foci a few hundred meters from the release site. The parasite covered that distance within 21-28 months. In May 1984 we found parasitized whiteflies on *Ligustrum* shrubs in the suburbs of Haifa, ca. 9 km from the Acre release site. Thus, although we have no definite information on the exact rate of spread of the parasite population, we nevertheless can conclude that it is able to spread from the release site.

Currently, *E. lahorensis* appears to be present in all the known *D. citri* infestations in the Western Galilee. In April 1984 we found few new whitefly infestations in the central coastal plain, near Tel-Aviv. These foci were promptly provided with *E. lahorensis* adults and parasitized whiteflies, transferred from the Nahariyya and Acre sites. Rapid establishment was observed as well.

ACKNOWLEDGMENTS

We thank Prof. G. Viggiani of the University of Naples, Italy, for collecting and sending *E. lahorensis*. Thanks are due to Mr. C. Chen and the entomological team of the Plant Protection, Ministry of Agriculture, Bet-Dagan; Mr. E. Israeli and Dr. A.

Golomb of the Extension Service, Ministry of Agriculture, Acre, for their assistance. We gratefully acknowledge Mrs. M. Tsamry and Mrs. W. Domaretski of the "Israel Cohen" Institute for Biological Control, Rehovot, for their technical help during the study, and Drs. B. Peleg and Y. Nitzan for help and advice.

REFERENCES

- Chen, C., Klein, Z.I. and Shabtai, Y. 1979. A new citrus pest in Israel, the citrus whitefly, *Dialeurodes citri*. Prevention of its expansion and the eradication program. *Alon haNorea* 33:673-680. (in Hebrew)
- Delrio, G., Ortu, S. and Prota, R. 1980. Fitofagi di recente introduzione nelle colture agrumicole della Sardegna. *Studi Ssassaresi*, 28/29:57-64.
- Ebeling, W. 1959. Subtropical Fruit Pests. University of California Press, 436 pp.
- Israeli, E., Golomb, A., Chen, C. and Klein, Z.I. 1983. The citrus whitefly (*Dialeurodes citri*) a new pest of citrus in Israel. *Phytoparasitica* 11:125. (Abstract)
- Mound, L.A. and Halsey, S.H. 1978. Whitefly of the World. British Museum (Natural History) and J. Wiley and Sons, 340 pp.
- Porath, A. 1979. Whiteflies (Aleyrodidae) attacking citrus in the world. *Israel Ministry of Agriculture, Extension Service Citriculture Department*, 28 pp. (Mimeograph, in Hebrew)
- Rose, M. and DeBach, P. 1981. Citrus whitefly parasites established in California. *California Agriculture*, 35:21-23.
- Ru, N. and Sailer, R.I. 1979. Colonization of a citrus whitefly parasite, *Prospaltella lahorensis*, in Gainesville, Florida. *Florida Entomologist* 62:59-65.
- Sternlicht, M. 1979. The yellow whitefly species, *Parabemisia myricae* (Kuwana) (Aleyrodidae, Homoptera) new in Israel. *Hassadeh* 59:1830-1831. (in Hebrew)
- Viggiani, G. and Mazzone, P. 1978. Morfologia, biologia e utilizzazzionie di *Prospaltella lahorensis* How. (Hym: Aphelinidae) parassita esotico introdotto in Italia per la lotta biological al *Dialeurodes citri* (Asmead). *Bolletino del laboratorio di Entomologia Agraria "Filippo Silvestri" di Portici* 35:99-161.