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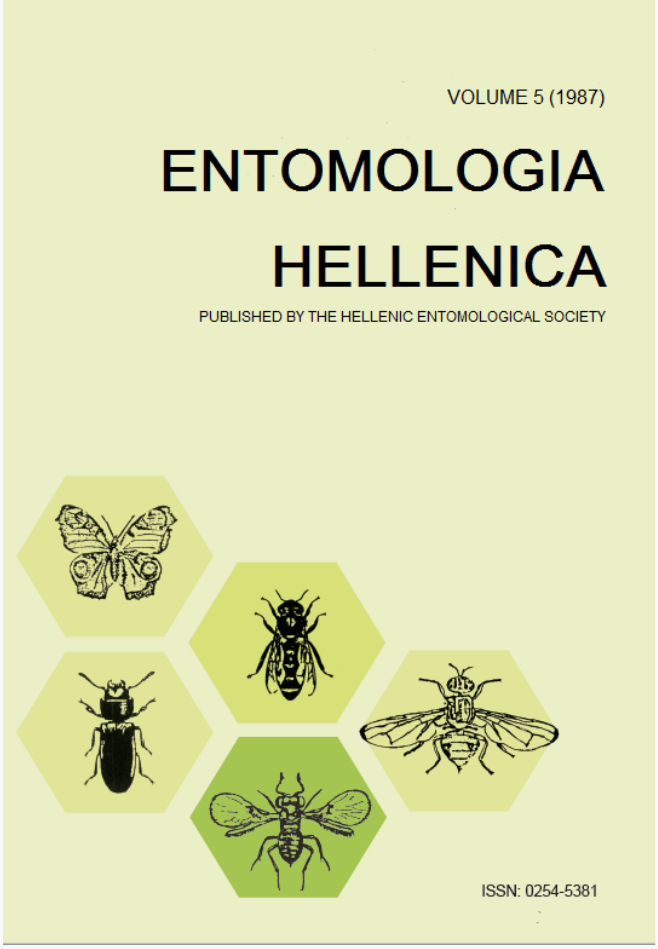

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The Occurrence of *Encarsia perniciosi* in Areas of Northern Greece as Assessed by Sex Pheromone Traps of its Host *Quadraspidiotus perniciosus*[1]

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ABSTRACT

During the 1982-1985 period the aphelinid endoparasite *Encarsia perniciosi* Tower was captured on synthetic pheromone traps of the San Jose scale (SJS), *Quadraspidiotus perniciosus* Comstock, in scale-infested insecticide treated and untreated orchards of Central and Western Macedonia (Northern Greece). It has expanded especially near the sites where it had been released, but also in areas 50-100 km from the point of release. The parasite in untreated orchards generally appeared from April to October, while in orchards treated with insecticides it was not caught after mid June. Spring flights of the parasite occurred on almost the same dates as the first captures of the male scale. Subsequent flights of *E. perniciosi* were not always synchronized with those of the male scale, and after the beginning of June the parasite showed a general decline throughout the remainder of each season.
The pheromone of the scale insect acts as a kairomone to the parasite and it can be used in trapping systems in scale-infested orchards for the confirmation of the presence and the distribution of *E. perniciosi*.

Introduction

Encarsia perniciosi Tower (Hymenoptera: Aphelinidae) is a monophagus, solitary endoparasite of the San Jose scale (SJS) *Quadraspidiotus perniciosus* Comstock (Homoptera: Diaspididae). It was first introduced into Greece from France in 1968 (Argyriou 1981). In the same year the SJS was first recorded in the area of Stavros, Imathia, Greece (Paloukis 1969). Releases of the parasite for the control of the scale were made from 1968 to 1981 in orchards of the districts of Imathia (Argyriou 1981, Katsoyannos and Argyriou 1985) and Pella (Argyriou, pers. comm.). Its establishment has been confirmed from the year of its introduction up to 1981 around the sites of release and sometimes as far as 20 km away from them, however, the rate of parasitism of the scale has been kept low 2-9% (Argyriou 1981, Katsoyannos and Argyriou 1985). In 1982, in a study on the flight of the SJS males by means of synthetic sex pheromone traps (Zoëcon's type «tent») we observed that besides SJS males, its parasite *E. perniciosi* was caught as well. Similar observations on sticky traps with natural and synthetic sex pheromones in 1974 and 1979, correspondingly, have been reported by Rice and Jones (1982). They also found that the parasite is using the SJS sex pheromone as a kairomone and that relatively small amounts of pheromone isomers may be important in the host-finding behavior of *E. perniciosi*. It is possible therefore, that the SJS sex pheromone can be used for the detection of the parasite in areas where the scale is present.

The present work aimed at studying the seasonal occurrence and the distribution of *E. perniciosi* in orchards of Central and Western Macedonia, Greece, by utilizing SJS sex pheromone traps.

Materials and Methods

During the period 1982-1985 traps were placed in 24

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apple, pear, peach and cherry orchards, each 0.3-0.4 ha, infested by the SJS. Some of the orchards were treated with insecticides (Table 1). In certain orchards (Table 1, marked with an asterisk) the seasonal flight of the SJS males as well as that of the parasite were studied. In the remainder, traps were checked for the confirmation of the existence of the parasite. In each experimental orchard, one, two or three «tent» traps (Zoëcon Corp., Palo Alto, CA 94304) were hung 1.5-2.0 m high in the north-east side of host trees. Traps in all areas were normally placed in early April. Observations were taken daily until the first appearance of the parasite and then, where the insect seasonal flight was studied, traps were checked weekly until the end of October - early November. Each trap contained a pheromone dispenser, charged with 300 mg 7-methyl-3-methylene-7-octen-1-yl propanoate (SJS-2, Zoëcon's) that was changed every four weeks. During the observations, traps were transferred to the laboratory where captured parasites and males SJS were counted under a dissecting microscope.

In 1982, sample twigs infested by scale were taken from two orchards (Table 2), in which the parasite was previously caught on pheromone traps, to test the existence of *E. perniciosi*. Samplings were made in June. Five to seven twigs older than one year, 30-75 cm long, were taken from different peach and apple trees (Morgan and Angle 1969). A total of 1,000 individuals of the scale were examined in the laboratory. In every sample, the existence of the parasite as well as the percentage of parasitism were recorded.

Results and Discussion

The parasite *E. perniciosi* was caught in 16 of the 24 orchards examined. It was captured in all 6 orchards where insecticides were not used and in only 10 of the 18 where insecticides were applied (Table 1). Fig. 1 shows the distribution of *E. perniciosi* in the areas where traps were set, and the areas where the parasite was released. It is seen that the parasite has expanded especially in the areas it was released, but also in areas at considerable distance from the release sites, namely at Velvendos and Tihio 50 and 100 km from the site of release. These areas are isolated from the points of release and hence one possible explanation is that the parasite was carried on infested tree stocks with the scale. There exist, however, areas in which the parasite was not caught in traps (Langadas, Goumenissa, Aridea, Arnissa, Perasma, Argos Orestico).

The seasonal flight of both species was studied in two treated and three untreated orchards (Figs. 2, 3). The first captures of *E. perniciosi* on the pheromone traps occurred on almost the same dates as the first captures of male scales. The initial flights

TABLE 1. Presence of *Encarsia perniciosi* during 1982-1985 in orchards of Central and Western Macedonia infested by *Quadraspidiotus perniciosus* treated (t) or untreated (unt) with insecticides.

Year	Observation area	Orchard	Chemical treatment	Presence of *E. perniciosi*
1982	Krya-Vryssi*	Peach	t	+
	Angelohori*	Apple	unt	+
1983	Krya-Vryssi	Apple	t	+
	Naussa	Peach	t	+
	Melissi*	Peach	t	+
	Skydra	Apple	t	+
	Rodohori	Apple	t	+
	Langadas	Apple	t	−
	Perasma	Apple	t	−
1984	Macrohori	Apple	t	+
	Langadas	Peach	t	−
	Aridea	Apple	t	−
	Gumenissa	Peach	t	−
	Polykarpi	Apple	unt	+
	Kolindros	Peach	t	−
1985	Krya-Vryssi*	Apple	unt	+
	Skydra	Cherry	unt	+
	Alexandria	Pear	t	+
	Rahi	Apple	unt	+
	Velvendos	Peach	t	+
	Tihio*	Apple	unt	+
	Argos Orestiko	Apple	t	−
	Arnissa	Apple	t	−
	Palaephyto	Apple	t	+

*Regular observation of traps for determination of scale and parasite flights.

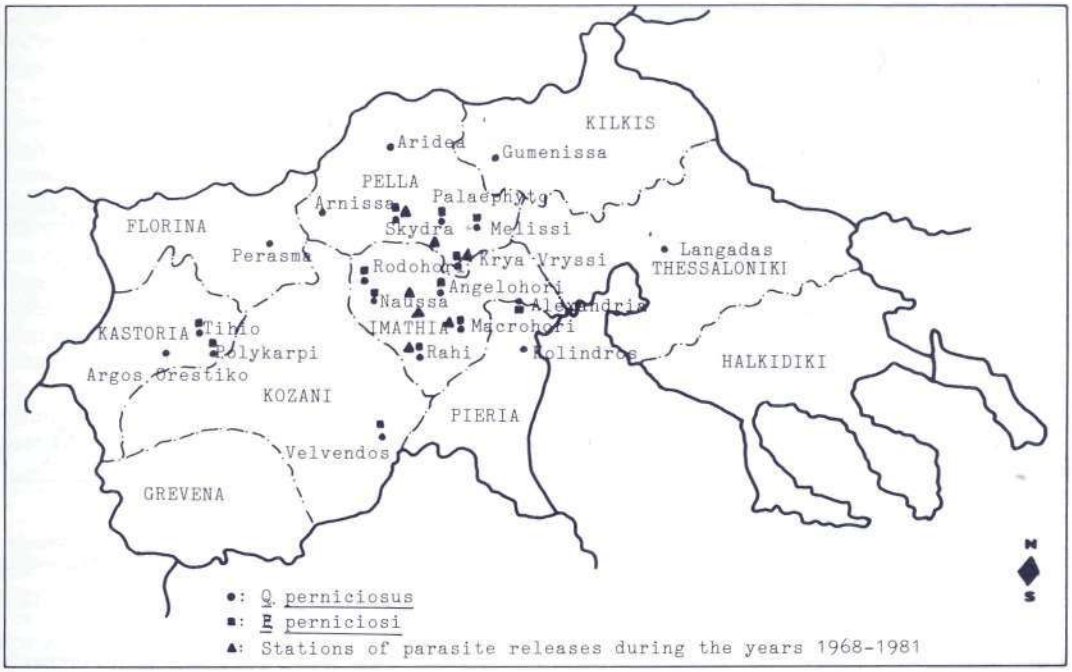

FIG. 1. Areas where *Encarsia perniciosi* adults and *Quadraspidiotus perniciosus* males were captured on pheromone traps in Northern Greece during the years 1982-1985.

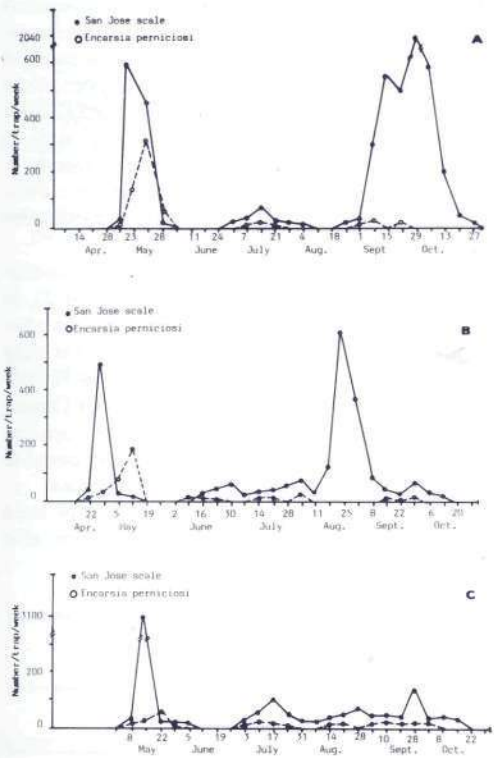

FIG. 2. Seasonal captures of SJS males and *Encarsia perniciosi* on pheromone traps in untreated apple orchards. A: Angelohori 1982, B: Krya Vryssi 1985, C: Tihio 1985.

of parasite and male scales usually occurred in early season regions in mid to late April, while in late season regions (Fig. 2C) early in May. In both regions the flight of parasite and host continued to late May. A second flight of the parasite was recorded only in untreated orchards (Fig. 2). The one exception in the parasite captures is that seen in Melissi (Fig. 3B), where the orchard was treated with insecticides. The first captures of parasite and male scales in this flight in the area of Tihio (Fig. 2C) occurred on the same dates. In the area of Krya Vryssi (Fig. 2B) the parasite appeared only one week prior to the host scale, while in the area Angelohori (Fig. 2A) the parasite appeared one week after the onset. The flight of the parasite continued until the beginning of October, but only in unsprayed orchards, while the appearance of the male scale continued, in treated and untreated orchards, until the end of October.

The number of SJS males during the whole trapping period, as indicated by pheromone trap captures, was always higher than that of the parasite, except in the case of Melissi (Fig. 3B), where the parasite was captured in higher numbers than those of the host. After the first flight, in each

year, the population of the scale occurred at a low level during the summer, except in the case of Melissi (Fig. 3B), where the populations were high, but increased greatly as the season progressed. Conversely, in all cases, in untreated orchards, there was every year a decline of the numbers of the parasite after the beginning of June (second flight of the SJS). These data agree with those of Rice and Jones (1982).

The reasons for the general seasonal decline of *E. perniciosi* populations are not known. Rice and Jones (1982) attribute this decline during the summer to the asynchronization between the appearance of the parasite population and the mature scale population after the first flight. In our case, examining the population trends of the host-parasite system, it is apparent that there is generally a synchronization in their occurrence (Figs. 2, 3). Also, the second flight of the parasite would correlate with maturity of most female scales in the population. Studies on the SJS biology made in Central Macedonia (Paloukis 1979, 1984, Katsoyannos and Argyriou 1985), have shown that during mid June to July there are high populations of mature scales. Further, Rice and Jones (1982) reported that possible reasons for the reduction of the parasite captures were the higher temperatures (34.5-36°C) and low relative humidities (25-30%) which occurred during the summer, while Mathys and Guignard (1967) maintained that the parasite can tolerate extremes of temperature, but it is more susceptible than its host to low relative humidities. In Northern Greece, the average relative humidity during June to August is 52.5-60.5%, levels required for parasite emergence (Mathys and Guignard 1967), while the average maximum temperature during the summer is somewhat lower in the range of 30.5-32.6° C. One plausible explanation for the mid-season decline in parasite captures could be attributed to the inability of the parasite to respond to the scale pheromone, an idea put forward by Rice and Jones (1982).

In orchards treated with insecticides the parasite did not appear after the end of May (Fig. 3A) or end of July (Fig. 3B). It may be that a detrimental effect of chemicals to the parasite occurred. Indeed, the apple, pear, peach and cherry orchards receive several sprays from May throughout August mainly to control the scales *Quadraspidiotus perniciosus* Comstock, *Pseudaulacaspis pentagona* Targioni-Tozzetti, *Cydia pomonella* L., *Cydia molesta* Busck, *Anarsia lineatella* Zeller and *Rhagoletis cerasi* L. with insecticides such as Azinphos methyl, Carbaryl, Diazinon, Dimethoate, Methidathion, Mevinphos, Phosalone, Phosphamidon, which are either harmful or moderately toxic to the parasite (Bénassy 1974).

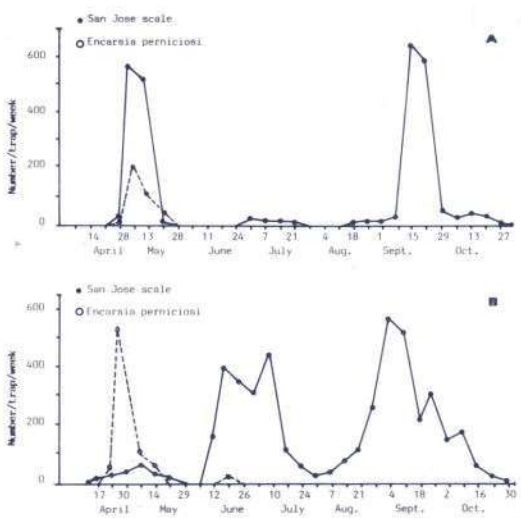

FIG. 3. Seasonal captures of SJS males and *Encarsia perniciosi* on pheromone traps in peach orchards treated with insecticides. A: Krya Vryssi, B: Melissi 1983.

In 1982, the existence of the parasite was confirmed with samplings in two orchards (Table 2), in which the parasite was previously caught on pheromone traps (Figs. 2A, 3A). These orchards were near to the areas where in 1981 releases of the parasite were made (Argyriou, pers. comm.) This information shows that the SJS pheromone traps can be used to determine the presence of the parasite and to confirm its establishment after release.

The ascertainment that pheromone traps used for monitoring *Q. perniciosus* populations also

TABLE 2. Presence and percent parasitism by *Encarsia perniciosi* in treated (t) and untreated (unt) with insecticides orchards during 1982.

Area	Number of scales	*Encarsia perniciosi* Number	%
Krya-Vryssi (t)	1000	15	1.2
Angelohori (unt)	1000	63	5.3

caught a considerable number of the scale parasite, leads to the conclusion that the use of these traps in areas where the parasite is present should be done in a way that will endanger it the least possible. In case there is no interest in following the flight of the scale by pheromone traps, but just in monitoring the presence of the parasite, traps should be used as little as possible to avoid a significant reduction to the parasite population. This can be achieved by: a) using a minimal number of traps, b) placing the traps at periods of reduced parasite activity, c) removing the traps immediately after confirmation of the parasite existence. In orchards treated with insecticides, the application of the scale pheromone can be used only during spring, because the parasite does not seem to appear after the beginning of June.

Acknowledgment

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KEY WORDS: *Quadraspidiotus perniciosus, Encarsia perniciosi*, Pheromone traps, Kairomone

Χρησιμοποίηση Παγίδων Φερομόνης του *Quadraspidiotus perniciosus* για τη Διαπίστωση της Παρουσίας του Παράσιτου του *Encarsia perniciosi* σε Οπωρώνες της Βόρειας Ελλάδας

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ΠΕΡΙΛΗΨΗ

Κατά την περίοδο 1982-1985 το παράσιτο *Encarsia perniciosi* συλλήφθηκε σε παγίδες συνθετικής φερομόνης του *Quadraspidiotus perniciosus* που είχαν τοποθετηθεί σε ψεκαζόμενους και αψέκαστους οπωρώνες της Κεντροδυτικής Μακεδονίας προσβεβλημένους από το κοκκοειδές. Το παράσιτο συλλαμβανόταν κυρίως σε οπωρώνες που βρίσκονταν κοντά σε περιοχές όπου τα προηγούμε-

να χρόνια είχαν γίνει ελευθερώσεις του (Ημαθία, Πέλλα). Η παρουσία του όμως διαπιστώθηκε και σε περιοχές (Βελβεντός, Καστοριά) που απείχαν 50-100 χλμ. από τα κέντρα των ελευθερώσεων. Στους αψέκαστους οπωρώνες το παράσιτο εμφανιζόταν από τον Απρίλιο μέχρι τον Οκτώβριο, ενώ στους οπωρώνες που δέχονταν χημικές επεμβάσεις αυτό δε συλλαμβανόταν μετά τα μέσα Ιουνίου. Η πρώτη πτήση του άρχισε σχεδόν ταυτόχρονα με την εμφάνιση των αρσενικών του κοκκοειδούς, ενώ στις επόμενες πτήσεις δεν υπήρχε πάντοτε συγχρονισμός στην εμφάνιση παράσιτου και ξενιστή. Από τον Ιούνιο και μετά παρατηρήθηκε μια γενική μείωση στους πληθυσμούς του παράσιτου, σε αντίθεση με τους πληθυσμούς των αρσενικών του κοκκοειδούς που παρουσίασαν σημαντική αύξηση μετά τον Αύγουστο.

Η φερομόνη αυτή του κοκκοειδούς, η οποία δρα στο παράσιτο ως καϊρομόνη, φαίνεται ότι μπορεί να χρησιμοποιηθεί σε συστήματα παγίδευσης τύπου «tent-trap» για την ευχερή διαπίστωση της παρουσίας του παράσιτου σε οπωρώνες προσβεβλημένους από το κοκκοειδές. Η εφαρμογή της όμως πρέπει να γίνεται σε περιόδους μειωμένης δραστηριότητας του παράσιτου, ώστε αυτό να ζημιώνεται κατά το δυνατόν λιγότερο.