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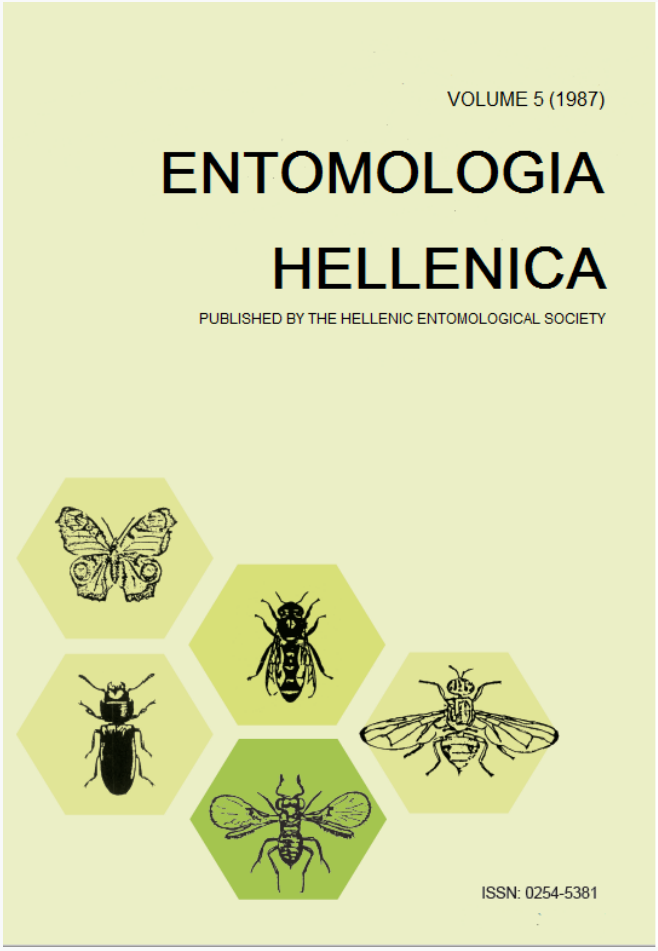

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Flight of San Jose Scale *Quadraspidiotus perniciosus* Males and Time of Crawler Appearance in Orchards of Northern Greece[1]

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ABSTRACT

The seasonal flight of San Jose scale (SJS), *Quadraspidiotus perniciosus* Comstock, males was studied during 1984-1987 in peach and nectarine orchards, under two different climatic conditions in Central Macedonia (Northern Greece), using sex pheromone traps. In late-season regions there were three periods of male flight activity (May, July-August, September-October), while in early-season regions there was also a partial fourth one (mid April-May, mid June-July, August-mid September and late September-early November). In the latter regions these flights can be correlated with the appearance of the scale crawlers during three periods (late May-early July, mid July-August, September-October) and a partial fourth one (November) in milder years, as determined using the sticky-tape trap technique. Pheromone traps and sticky-tape traps can be used for the study of phenology of San Jose scale, under conditions prevailing in Northern Greece.

Introduction

The San Jose scale (SJS), *Quadraspidiotus perniciosus* Comstock (Homoptera: Diaspididae), is a key pest in most deciduous fruit orchards of Northern Greece. It was first recorded in Greece in 1968 (Paloukis 1969), and since then it has been found in many locations throughout the country (Paloukis 1979, Kyparissoudas 1987). The phenology of the scale was studied in peach and almond orchards of Central Macedonia, using a sampling method and yellow sticky traps (Paloukis 1984, Katsoyannos and Argyriou 1985). The discovery (Rice 1974) and identification (Gieselmann et al. 1979) of a sex pheromone for SJS has resulted in the use of pheromone traps to detect and monitor adult flight activity. Male phenology has been determined by pheromone trapping studies (Rice and Jones 1977, Rice and Hoyt 1980). In the last years, sticky electrical-tape traps, a more sensitive, effective and practical technique, were used for monitoring seasonal activity and relative abundance of crawlers in commercial orchards (Mague and Reissig 1983). These techniques provide an effective and yet economic method of sampling this scale and were used recently for the study of the SJS phenology in apple orchards (Mague and Reissig 1983). A similar study was conducted in apple orchards in regions of Western Macedonia (Kyparissoudas et al. 1987). Further, this method was also utilized in the development of a forecast model to time sprays against all crawler generations (Reissig et al. 1985).

The objective of this study was to determine the seasonal flight activity of SJS males by using sex pheromone traps, and to monitor seasonal crawler activity on sticky-tape traps, in peach and nectarine orchards of Central Macedonia (Northern Greece).

Materials and Methods

Data on the timing of male flights were collated for three years (1984-1986) from two untreated peach orchards infested by the scale: one 15 years old, covering an area of 0.4ha, and one 10 years old, 0.35ha in size, at Naoussa and Rahi, respectively. During 1986 and 1987 male flight activity and the appearance of crawlers was monitored in a 0.2ha untreated nectarine orchard, at Naoussa.

Male flight activity was monitored from April to mid-November with standard San Jose scale pheromone «tent» traps (Zoecon, Palo Alto, California). At each experimental orchard in early April,

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three pheromone traps were placed 1.8-2. Om above the ground in the north-east side of the trees (Rice et al. 1982). Each trap contained a pheromone dispenser charged with 300 μg of 7-methyl-3-methylene-7-octen-1-yl propanoate (SJS-2, Gieselmann et al. 1979). Trap catches were recorded 3 times each week and dispensers were replaced every 4 weeks. In 1986, in the peach orchard located in Naoussa the observations were taken daily. For SJS male counting the traps were transferred to the laboratory where captured males were counted under a dissecting microscope.

Seasonal crawler activity was measured on sticky-tape traps (Mague and Reissig 1983, Kyparissoudas et al. 1987) in four trees from mid-May (approximately twenty-five days after the onset of male flight) until mid-December. Four such traps were placed on branches 3-4cm in diameter in each of the four trees; the traps were checked daily until the first appearance of the crawlers and then at one week intervals. Crawlers on the traps were counted under a dissecting microscope in the laboratory. Since tape traps were of varying length due to differences in branch diameters, counts were expressed as number/cm^2 of tape (Mague and Reissig 1983).

Temperature data were collected daily from a recording thermograph and max-min thermometers from a weather station located near the observation orchards.

Results and Discussion

The seasonal flight of male San Jose scale during the study period, in both regions, is shown in Figs. 1, 2 and 4. In the late-season region (Rahi) there were annualy three periods of male flight activity (Fig. 1B). The first flight began in May, a second appeared early in July, while the third occurred late in August and continued until the second half of October. In the early-season region (Naoussa), in both orchards, there were three periods of SJS male flight activity and a partial fourth one (Figs. 1A, 2, 4). The appearance of overwintering generation males began in mid to late April and continued for 3-4 weeks. During spring the males fly for only a few days (Fig. 2). Similar observations have been reported by Rice and Hoyt (1980), Rice et al. (1982) and Kyparissoudas et al. (1987). The early flights were followed by a period of 5-6 weeks with no male activity. In mid to late June, first generation male flights started and following peak emergence during July, continued at declining levels into the second generation in early August-mid September. A partial fourth period of male flight activity occurred in mid to late September and continued until late October-early November. In contrast, Paloukis (1979) and Katsoyannos and Argyriou (1985), who studied the biology of SJS in

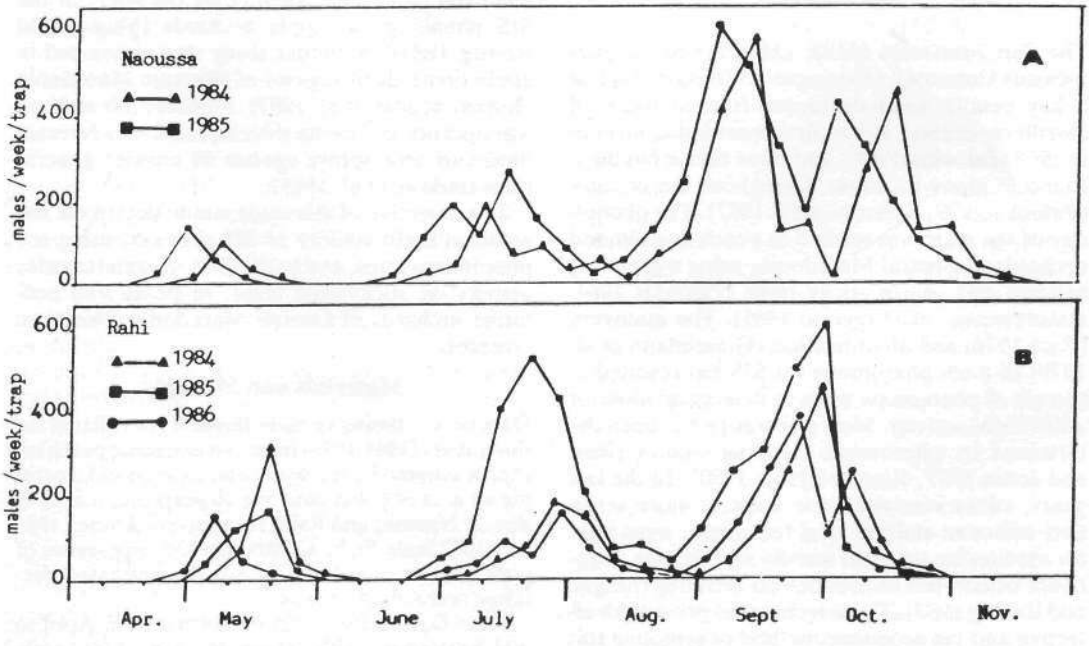


FIG. 1. Seasonal captures of San Jose scale males on pheromone traps in peach orchards. A: Naoussa, B: Rahi, northern Greece.

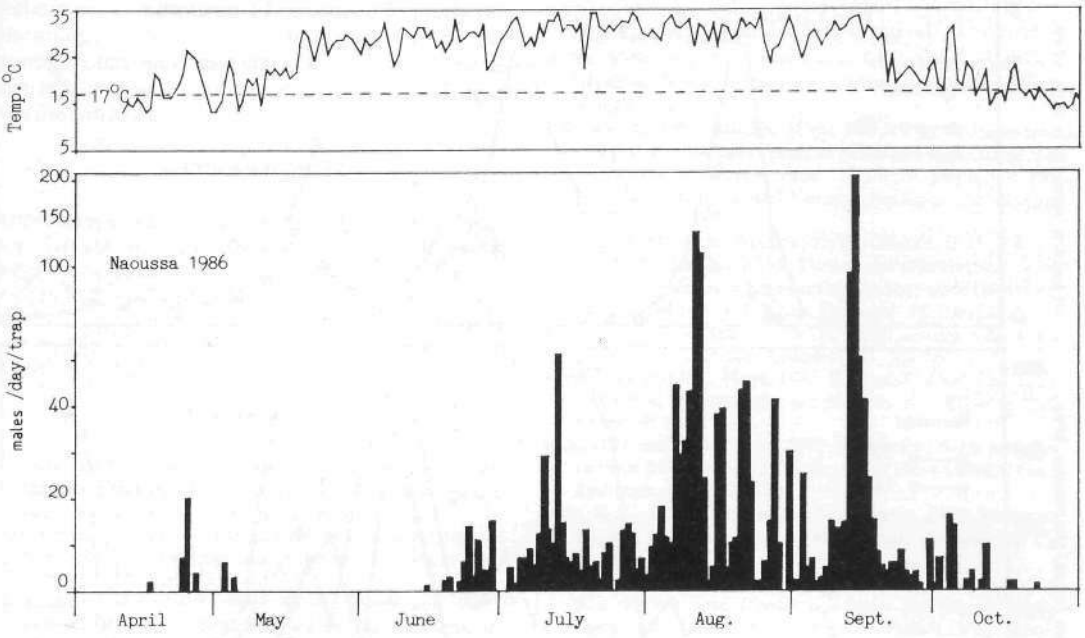
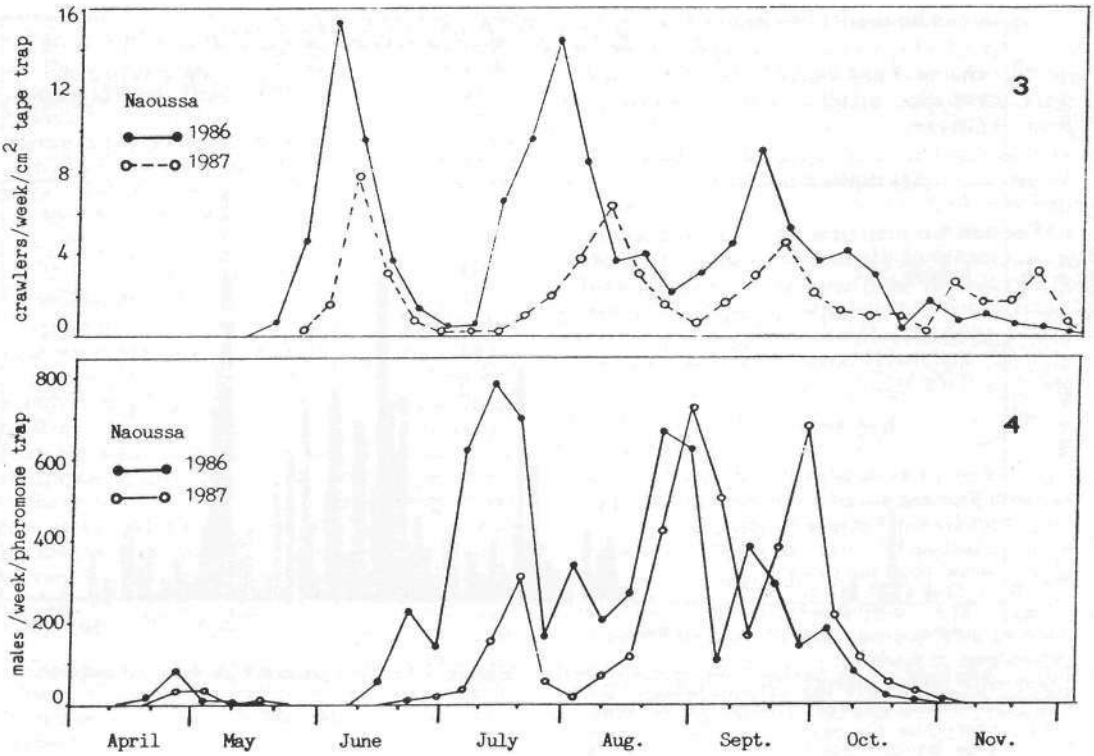


FIG. 2. Daily flight of male San Jose scale on pheromone traps in peach orchard, in relation to flight threshold temperatures, Naoussa, northern Greece, 1986. ° C= sunset temp.

similar regions, reported only three periods of adult male activity for three generations of the species. The average daily catches in relation to flight threshold temperatures at Naoussa is shown in Fig. 2. It is seen that the flights begin when the temperatures at sunset are above 17° C, but decline rapidly or cease at temperatures below 17° C, resulting in only low captures for these days. These data agree with those of Rice and Hoyt (1980).

The seasonal crawler appearance in the region of Naoussa during 1986 and 1987 is shown in Fig. 3. It is seen that there were three distinct periods of crawler appearance, and a partial fourth one. Emergence of first generation crawlers began in late May or 30-32 days after the first males had been captured in pheromone traps, and peaked within 10-12 days. A second generation started in mid July or approximately 25 days after the beginning of the second male flight and continued until the end of August. In early September the third generation of crawlers appeared, followed by a partial fourth generation from late October until the end of November. The first two periods of seasonal crawler activity, and in most part the third appearance as shown by tape traps (Fig. 3), coincide to a large degree with crawler appearance observed in similar regions by Katsoyannos and Argyriou (1985). These workers reported that for the year 1978 there were only three periods where crawlers were present and that all larvae of the 3rd generation stopped development at the 1st instar and hibernated. Only a small number of reproducing females, as well as a few crawlers generated by them were observed during the winter period. Baskerville and Emin (1969) and Anonymous (1978) reported a lower threshold of scale development, 10.5° C and 7.3° C, respectively, while Vasseur and Schvester (1957) showed that the threshold of development of SJS crawlers kept at various temperatures from mid-August to mid-December was 9.0 to 10° C. This information, in relation with the data of Table 1, confirms that the field development of SJS crawlers as well as the number of generations per year depend mainly on weather conditions, especially temperature (November - December). Hence, in cool years, such as 1978 the insect might complete three generations (Katsoyannos and Argyriou 1985), while in milder years (1986-1987) in some regions a partial fourth one might also appear (Table 1).

In the region of Rahi the three major periods of male flight activity as shown by Fig. 1B (May, July-August, September-October), coincide quite closely with male appearance observed during 1983 to 1986 in late-season regions of Western Macedonia by Kyparissoudas et al. (1987). They also found that these flights correlated with the presence of the scale crawlers which were ob-



FIGS. 3-4. 3, San Jose scale crawler appearance, 1986-1987; 4, male San Jose scale flight activity, 1986-1987; Naoussa, northern Greece.

served during June, August and October. This suggests that in the region of Rahi, there must also be three similar periods of crawler appearance.

The present study indicates that pheromone traps can be used to accurately monitor flight activity of male SJS, and to identify discrete generations of scale under field conditions. Further, it shows that the sticky-tape traps are an effective and practical technique of monitoring seasonal crawler activity in commercial orchards. These

TABLE 1. Average temperatures ° C in the region of Naoussa during the years 1978-1987 (months divided into 10 day intervals a, b and c).

Year	September			October			November			December		
	a	b	c	a	b	c	a	b	c	a	b	c
1978	20.0	19.0	16.8	18.0	16.0	10.0	9.0	6.0	6.5	4.0	10.0	8.5
1979	20.2	19.5	21.0	20.8	21.2	12.0	10.5	12.5	10.0	9.5	4.8	6.5
1980	19.8	20.5	19.8	16.7	17.2	15.5	13.5	11.5	10.0	7.5	7.3	5.5
1981	21.0	19.5	21.5	20.0	17.5	15.3	11.5	5.2	8.0	7.5	8.0	6.0
1982	22.5	21.5	21.7	15.0	16.0	15.0	9.0	9.5	7.7	6.2	8.7	6.3
1983	20.2	20.5	18.2	18.5	14.0	10.7	12.2	6.0	6.2	3.5	5.0	8.5
1984	22.0	21.0	19.5	21.0	16.0	16.5	13.0	9.5	10.0	8.0	6.0	5.5
1985	21.0	19.0	20.5	18.0	13.0	11.0	11.5	10.0	10.0	8.5	10.0	6.0
1986	20.0	23.5	19.5	18.0	13.8	14.2	9.2	9.0	8.5	6.0	4.0	2.0
1987	22.0	25.0	21.5	15.0	16.5	12.0	9.0	11.0	11.0	7.5	4.5	7.0
Average	20.9	20.9	20.0	18.1	16.1	13.2	10.8	9.0	8.8	6.8	6.8	6.2

techniques can be used as a method to study the phenology of SJS, and to determine the proper timing of chemical application against the immature stages of scale, under conditions prevailing in Northern Greece.

Acknowledgment

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KEY WORDS: *Quadraspidiotus perniciosus*, Pheromone traps, Sticky-tape traps

Πτήση των Αρσενικών και Εμφάνιση των Κινητών Προνυμφών του *Quadraspidiotus perniciosus* σε Οπωρώνες της Βόρειας Ελλάδας

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ΠΕΡΙΛΗΨΗ

Μελέτες που έγιναν από το 1984 μέχρι το 1987 με παγίδες φερομόνης σε οπωρώνες ροδακινιάς και νεκταρινιάς της Κεντρικής Μακεδονίας έδειξαν ότι στις όψιμες περιοχές (Ράχη) υπάρχουν κάθε

χρόνο τρεις περίοδοι (Μάιος, Ιούλιος-Αύγουστος, Σεπτέμβριος-Οκτώβριος) πτήσης των αρσενικών του *Quadraspidiotus perniciosus* Comstock, ενώ στις πρώιμες περιοχές (Νάουσσα) υπάρχουν τρεις περίοδοι (μέσα Απριλίου-Μάιος, μέσα Ιουνίου-Ιούλιος, Αύγουστος-μέσα Σεπτεμβρίου) και μία τέταρτη μερική (τέλος Σεπτεμβρίου-αρχές Νοεμβρίου). Στις πρώιμες περιοχές οι τρεις πρώτες πτήσεις συσχετίζονται με την ύπαρξη τριών περιόδων (τέλος Μαίου-αρχές Ιουλίου, μέσα Ιουλίου-Αύγουστος, Σεπτέμβριος-Οκτώβριος) εμφάνισης των κινητών μορφών του κοκκοειδούς, όπως αυτές προσδιορίστηκαν με τη χρήση κολλητικών-παγίδων ταινιών, ενώ η τέταρτη μερική πτήση συσχετίζεται με μία αντίστοιχη περίοδο εμφάνισης κινητών μορφών κατά τη διάρκεια του Νοεμβρίου, μόνο όμως σε χρονιές που κατά τη διάρκεια του φθινοπώρου επικρατούν συνθήκες ευνοϊκές για την ανάπτυξή τους. Οι παγίδες φερομόνης και οι κολλητικές-ταινίες παγίδες φαίνεται ότι μπορούν να χρησιμοποιηθούν ως μέθοδος για τη μελέτη της βιολογίας του *Q. perniciosus* στις κλιματικές συνθήκες της Βόρειας Ελλάδας.