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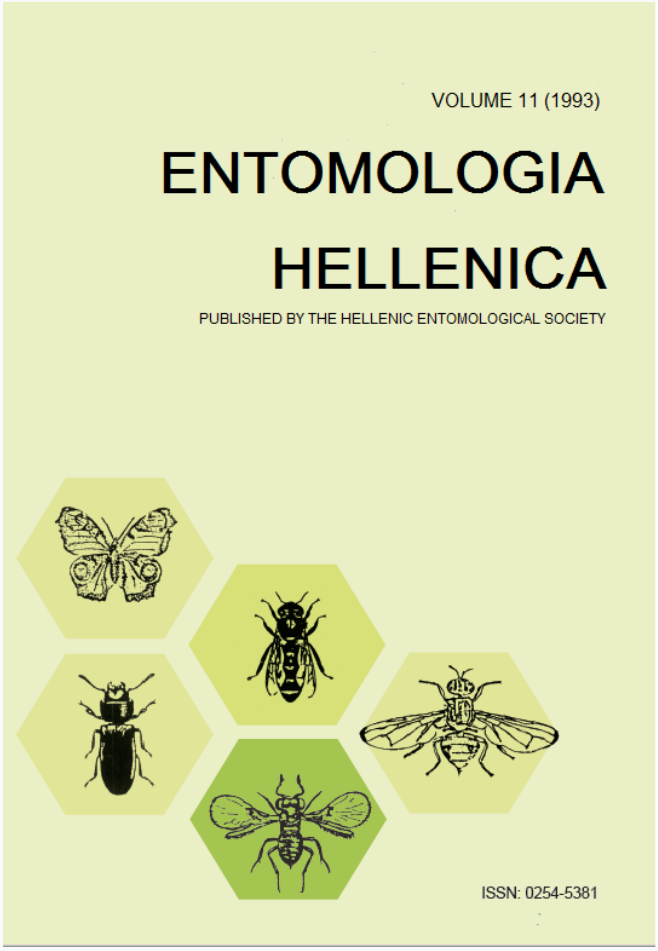

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Control of *Synanthedon (Aegeria) myopaeformis* by Mating Disruption Using Sex Pheromone Dispensers in Northern Greece[1]

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ABSTRACT

In 3 successive years (1990-1992) polyethylene tube dispensers, each containing 50.5 mg synthetic sex pheromone of the apple clearwing moth, *Synanthedon (Aegeria) myopaeformis* Borkh., were placed at a density of 680 per ha, once a year, in two adjacent commercial apple orchards each 1 ha in size. The degree of confusion reached almost 100% by releasing about 6 mg/ha/h, whereas the number of mated females decreased by 72.86%, compared with the untreated orchard. In 1993, after 3 years of experiments, a reduction of up to 91% of empty pupal skins per tree was attained. The encouraging results, especially when taking into account the relatively small size of the orchards, opens opportunities for the integrated control of this apple insect pest under the conditions of Northern Greece.

Introduction

The apple clearwing moth (ACM), *Synanthedon (Aegeria) myopaeformis* Borkh. (Lepidoptera: Sesiidae), is one of the key pests in apple orchards of Northern Greece (Kyparissoudas 1990). Conventional control of this pest is achieved by repeated applications usually during the flight period of the moths (Castellari 1986, Tremblay 1986), but controlling the larvae is extremely difficult, since they live between the bark and the wood of the apple trees. An alternative method of controlling the ACM is to apply mating disruption by using pheromones or the «sexual confusion» method (Voerman et al. 1983). Recently, studies have indicated that under specific circumstances mating disruption of apple clearwing moth is a feasible control method in commercial apple production (Stüber and Dickler 1987, 1988, Blommers and Freriks 1988, Codina et al. 1990).

This study collates and analyses the results of the experiments using synthetic sex pheromone dispensers, for control of the apple clearwing moth by the mating disruption method in commercial apple orchards of Central Macedonia (Northern Greece).

Materials and Methods

Lay-out of experiments (Fig. 1). The experiments were carried out in two adjacent (plots A and B) commercial apple orchards (cv. Starking Delicious, 15 years old), in total 1 ha in size, in the area of Arnissa about 100 km north-west of Thessaloniki. Orchard A, 0.7 ha in size, was surrounded at the north side by an apple orchard (15 years old) and wild vegetation, on the south side by experimental orchard B, on the east side by an apple orchard (1 year old), while on west side by peaches (1 year old). Orchard B, 0.3 ha in size, was surrounded on the south and west sides by wild vegetation, on the east side by an apple orchard (10 years old), while on the

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north side by peaches (1 year old), orchard A and apple orchard (1 year old).

Pheromone treatment. Both orchards (A and B) were treated with pheromone dispensers (Shin-Etsu Chemical Co, Ltd, Tokyo, Japan). These twisted-tie dispensers consist of a semi-permeable hollow polyethylene tube 1 mm in diameter, 20 cm long, and sealed at both ends. Embedded into one side of the tube is a thin aluminium wire to facilitate tying the dispensers into tree limbs or twigs. Dispensers, each containing 50.5 mg of pheromone (Z, Z-3, 15-18 : Ac), were placed at a rate of 680 units (approximately 3 per tree) per ha which is equivalent with 34.34 g pheromone per ha; sufficient to last for the entire summer season. In 1990 dispensers were installed in the orchards on May 11 and in 1991 and 1992 on May 25, prior to the first moth captures in the pheromone traps (Kyparissoudas 1991). They were tied at a height of about 1.70 m (Voerman et al. 1983, Blommers and Freriks 1988). Additionally, in orchard A four dispensers were placed from May 11 to August 24, 1990 (105 days) and May 25 - September 2, 1991 (100 days) to estimate the pheromone release rates by measuring weekly weight loss. The average release rates was expressed as mg/ha/h.

A zone of approximately 70 m (van Deventer and Blommers, unpublished data) of some adjacent (D) apple orchards, 1.5 ha (Fig. 1) were treated similarly to reduce the chance of insect moths migrating into the experimental orchards A and B.

The untreated (C) control apple orchard (0.5 ha, cv. Starking Delicious, 10 years old) was situated approximately 70 m from the south of the experimental orchard B.

In both experimental and untreated apple orchards growers were not taking any special measures against ACM. All orchards were sprayed with IGRs (diflubenzuron, fenoxycarb or triflumuron) on the upper part of the tree trunk against codling moth and leafminers.

Assessment of the effects of treatment. The effect of the pheromone treatment was measured by means of pheromone and juice traps and counds of empty pupal skins:

a. Pheromone traps. In each experimental orchard four Pherocon IC traps (Zoecon Palo Alto, California, USA) were placed about 1,6 m high in the north-east side of the trees, on May 11 1990 and in 1991 and 1992 on 25 May. Each trap contained an attractive cap (Shin-Etsu, Chemical Co, Japan). Traps were checked weekly and the attractive caps were replaced every 4 weeks. The same number of traps were placed in the untreated orchard (C).

b. Juice traps. On June 2, 1992 two juice traps (yel-

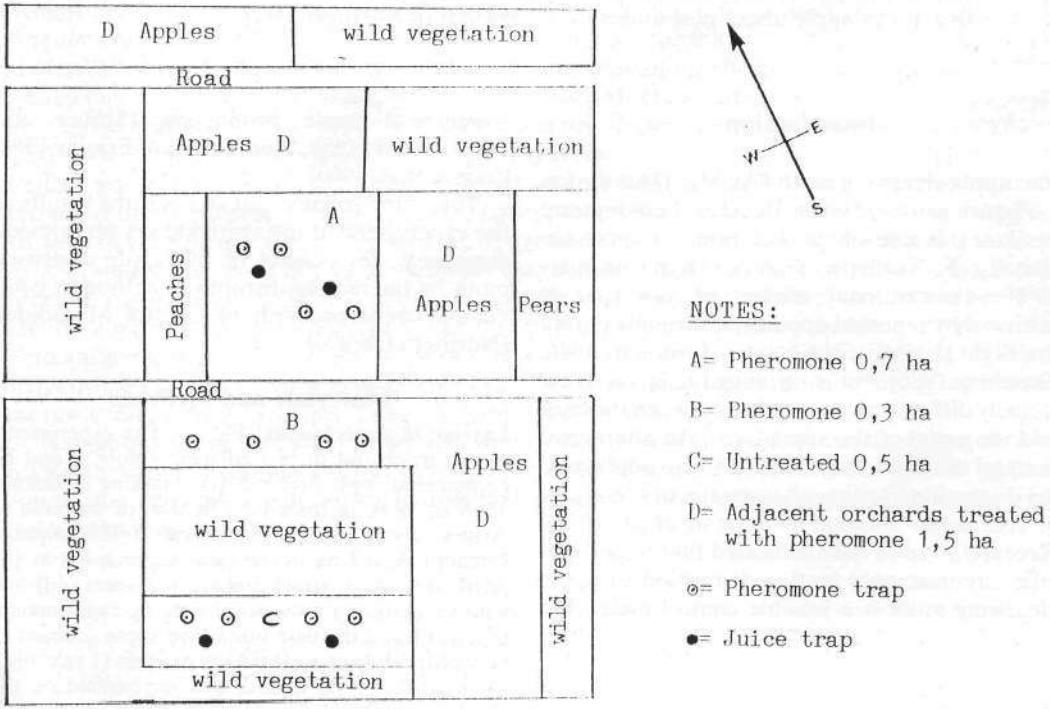

FIG. 1. Schematic plan of the test orchards.

low plastic pot, upper diameter 11 cm, depth 16 cm) were placed at a height of about 1.6 m in each pheromone-treated (A) and untreated orchard (C). Each juice trap contained a mixture of (pure) apple juice, molasse and apple vinegar at a ratio of 80:15:5, respectively. Traps were checked and refreshed once a week. Females from juice traps were transferred to the lab to be dissected for the presence of spermatophores. This method was evaluated only during 1992, because in 1990 and 1991 we tested the trap containing mixtures (Frankenhuyzen and Wijnen 1979, Blommers and Freriks 1988) and the colour of the plastic pots (Trematerra and Faccioli 1990) used.

c. Empty pupal skins. The number of empty pupal skins was counted and removed from the trunks (between 0-1,20 m high) of 20 selected trees four times a year (mid-June to mid-September) in both pheromone-treated and untreated orchards.

Results and Discussion

Pheromone trap catches. The flight curve of male moths, in the untreated orchards, as determined by means of the four pheromone traps, is shown in Fig. 2. In 1990 the first male was caught on May 12, whereas in 1991 and 1992 the first catches took place on June 2, that is respectively one and seven days after placement of the pheromone dispensers in the experimental apple orchard. The flight activity of ACM males continued until late August in all three years. Comparisons between the total male catches in pheromone-treated and untreated orchards indicated that there was almost 100% male disruption, in the treated orchards (Table 1).

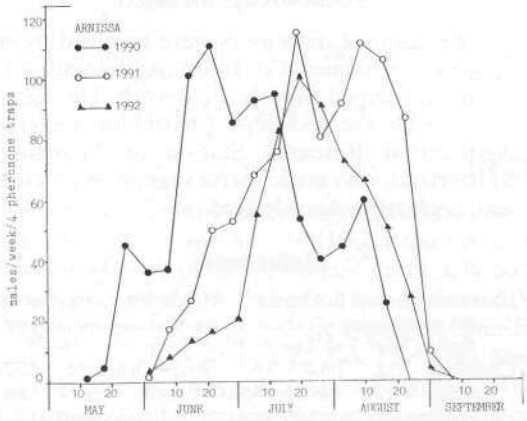

FIG. 2. Weekly captures of *Synanthedon myopaeformis* males in four pheromone traps in the untreated apple orchard (C). Arnissa in 1990-1992.

TABLE 1. Captures of *S. myopaeformis* males in pheromone-treated (A and B) and untreated (C) orchards, Arnissa 1990-1992.

	Catches in 4 pheromone traps			% reduction in male catch	
	Untreated	Pheromone			
Year	C	A	B	A	B
1990	828	3	0	99.5	100.0
1991	882	4	1	99.6	99.9
1992	593	0	0	100.0	100.0

The evaporation rates in 1990 and 1991 were 6.06 mg/ha/h (mean temperature 21°C) and 6.15 mg/ha/h for periods of 105 and 100 days, respectively (Fig. 3).

This information showed that the captures of ACM males in pheromone traps were almost totally inhibited, by a release of pheromone from the twisted-tie dispensers at a rate of approximately 6 mg/ha/h. This result was obtained with a lower quantity of pheromone (34.34 g/ha) compared with the experimental results given by Stüber and Dickler (1987), Blommers a Freriks (1988) and Codina et al. (1990).

Juice traps and unmated females. Table 2 summarizes the number of captured moths in juice traps as well as the dissections of females in the pheromone-treated (A) and the untreated orchard. In 1992 72.86% of the females were found to be unmated in orchard A, compared to 23.28% in the untreated orchard. The high number of unmated females caught in the juice traps in the pheromone-treated orchard provide more supporting evidence of the success of mating disruption of *S. myopaeformis* as was reported earlier by Stüber and Dickler (1988).

Empty pupal skins. In table 3 the results of the empty pupal skin counts are summarized. In both experimental orchards (A and B) a considerable reduction of the mean number of empty pupal skins per tree was found. In detail, the reduction in orchard A ranged from 34.3 to 11.5 in 1991, 3.9 in 1992 and 2.9 in 1993, while it ranged in orchard B from 13.1 to 3.4, 0.7 and 0.5 in the same years, respectively. In 1992, after 2 years of applying pheromone dispensers, in both experimental orchards decrease of infestation was satisfactory, because up to 88% reduction of empty pupal skins per tree was attained in the pheromone-treated orchard. This reduction reached 88.6% and 94.4% per tree in the experimental orchards A and B, respectively. However, there was a statistically significant difference in the reduction of

TABLE 2. Number of *S. myopaeformis* (males and females) captured in juice traps and the percentage of unmated females in pheromone-treated (A) and untreated (C) orchards, Arnissa 1992.

Treatment	Juice traps	Capture total	Captures males	Captures females	Female mated	Female unmated	% Unmated females
Pheromone	2	435	155	280	76	204	72.86
Untreated	2	484	222	262	201	61	23.28

TABLE 3. Number of empty pupal skins of *S. myopaeformis* (collected from tree trunks between 0-1.20 m high) in pheromone-treated (A and B) and untreated (C) orchards, Arnissa 1990-1993.

	Empty pupal skins per tree[1]				
	Untreated	Pheromone		% reduction in pheromone	
Year	C	A	B	A	B
1990	27.0	34.3	13.1	–	–
1991	32.6a	11.5b	3.4c	66.5	74.0
1992	32.8a	3.9b	0.7c	88.6	94.4
1993	-	2.9	0.5	91.9	96.3

1. Figures not followed by same letter across the table are significantly different ($P < 0,05$, Student's t-test).

empty pupal skins between both experimental orchards. We could show that the mating disruption method gave more satisfactory and faster results when the initial infestation level of ACM moths was low (orchard B) as has also been described by Charmillot and Vickers (1991). In 1993, after 3 years of tests, damage reduction was 91,9% and 96,3% per tree in the experimental orchards A and B, respectively.

The results (high level of disruption, significantly lower number of mated females and empty pupal skins in pheromone-treated than in the untreated orchard) indicate that mating disruption of ACM is a technically feasible control method in small size apple orchards in the area of Arnissa (Northern Greece).

This method could also be used in larger plantations. However, more experiments are required to confirm this opportunity which are in progress. Concerving the cost of this method, it could be said that it is commercially acceptable taking into account that it is a) very effective against the target insect, b) environmentally safer c) the only effective method compared to the other available methods used.

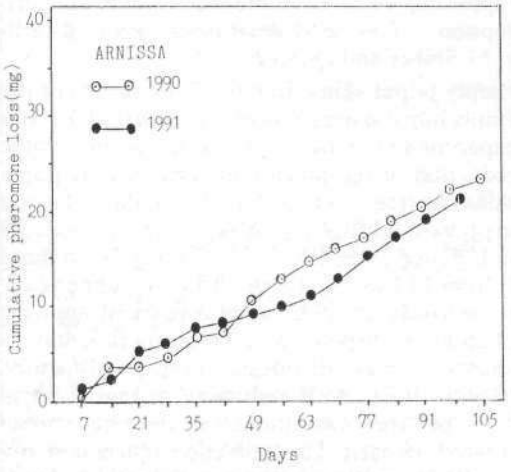

FIG. 3. Weight loss of pheromone from polyethylene twisted-tie dispensers (containing 50.5 mg of pheromone) in Arnissa 1990 and 1991.

Acknowledgements

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KEY WORDS: *Synanthedon (Aegeria) myopaeformis,* Apple clearwing moth, Pheromone dispensers, Mating disruption.

Αντιμετώπιση του Εντόμου *Synanthedon myopaeformis* (Borkh) με Συνθετική Φερομόνη Φύλου σε Οπωρώνες της Βόρειας Ελλάδας

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ΠΕΡΙΛΗΨΗ

Την περίοδο 1990-1993 διενεργήθηκαν δοκιμές σε δύο όμορους μηλεώνες έκτασης 10 στρεμμάτων στην περιοχή Άρνισσας - Ν. Πέλλας για την αντιμετώπιση του εντόμου *Synanthedon myopaeformis,* Borkh. (Lepidoptera: Sessiidae) με τη μέθοδο «παρεμπόδιση της συνάντησης και σύζευξης των δύο φύλλων (mating distuption ή confusion)». Χρησιμοποιήθηκαν εξατμιστήρες (dispensers) από σωλήνες πολυαιθυλενίου, της εταιρείας Shin-Etsu Ιαπωνίας, καθένας των οποίων περιείχε 50.5 mg συνθετική φερομόνη Z, Z-3, 15-18 Ac. Με μία εφαρμογή 68 εξατμιστήρων ανά στρέμμα το χρόνο και επί 3 συνεχή χρόνια (1990, 1991, 1992) πριν την έναρξη της πτήσης του εντόμου, επιτεύχθηκαν στους οπωρώνες των δοκιμών, συγκριτικά με το μάρτυρα, τα ακόλουθα αποτελέσματα: α) η παρεμπόδιση των συλλήψεων των αρσενικών ατόμων σε φερομονικές παγίδες, με σταθερό ρυθμό αποδέσμευσης της φερομόνης περίπου 6 mg/h/ha, ήταν του επιπέδου 99.5-100% β) το ποσοστό των αγονιμοποιήτων θηλυκών ατόμων, από συλλήψεις σε τροφοπαγίδες, έφθασε το

72.86% γ) η μείωση της προσβολής (αριθμός νυμφικών εκδυμάτων του εντόμου ανά δέντρο), τρία χρόνια μετά την πρώτη εφαρμογή της φερομόνης (1993), κυμάνθηκε από 91.9-96.3%. Τα ενθαρρυντικά αυτά αποτελέσματα, υπό ορισμένες προϋποθέσεις, ανοίγουν νέες προοπτικές για την αποτελεσματική αντιμετώπιση του επιζήμιου αυτού εχθρού της μηλιάς, με συνθετικές φερομόνες φύλου, στις συνθήκες της Βόρειας Ελλάδας.