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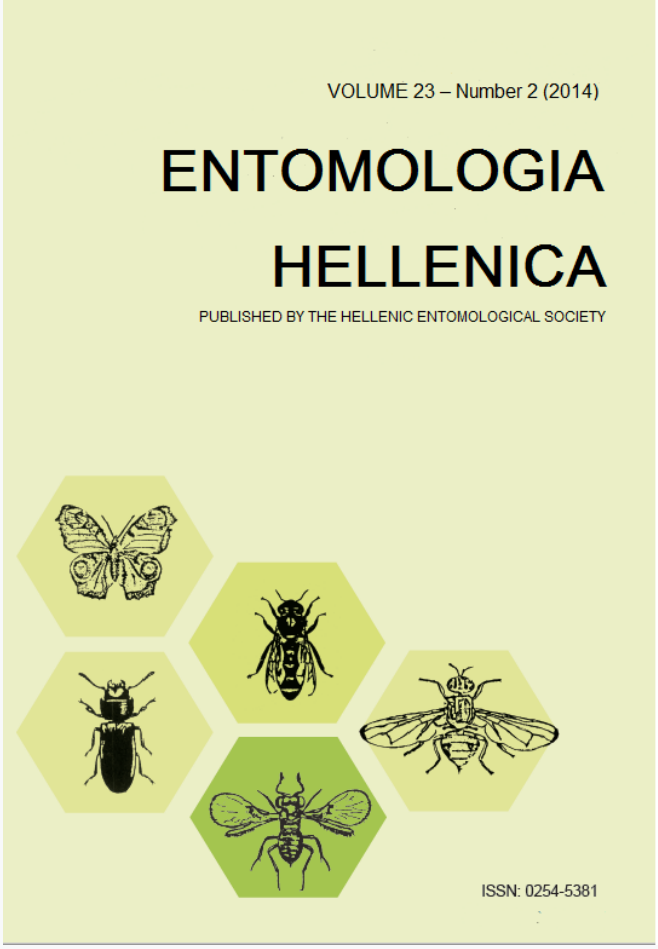

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Comparison of two types of pheromone traps for the capture of the red palm weevil (*Rhynchophorus ferrugineus*)

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ABSTRACT

This work presents the results of the comparison of two pheromone traps for the capture of the red palm weevil. Trap A was a yellow funnel trap with green top, while trap B was a yellow pitfall trap, both equipped with pheromone. The experiment took place at Sissi and Milatos villages of Lasithi prefecture, mid-North coastline of Crete, from March 2009 to February 2010. The total number of traps deployed at each sampling varied between 24 and 36 due to various disturbances (trap loss, dirt in traps etc.). In each location, always both trap types were present. A total of 3139 adults of red palm weevil were captured during the trials. Temporal variability shows similar pattern for both trap types, as well as for both sexes. Type A traps captured 1376 insects with a ratio of 1♂ to 3.40♀, while type "B" captured 1763 insects with a ratio of 1♂ to 3.15♀. ANOVA revealed significant differences between the two traps in the number of catches (Trap A: 38.22 insects per fortnight /trap, Traps B: 48.97 insects per fortnight /trap). Comparing females and males of both trap types as separate groups, the statistical significance is more profound. At Sissi on average 1.61 males and 5.32 females were captured per fortnight/trap, with an average male to female ratio of 1:3.30, being 1♂: 3.85♀ for type A traps and 1♂: 2.94♀ for type B traps. At Milatos 1.33 males and 4.04 females per trap were recorded and the male to female ratio was 1:3.04, this ratio being 1♂:2.36♀ and 1♂:3.86♀ for type A and B traps respectively. Impressively high captures (more than 150 up to almost 250 in traps of B type and from almost 150 up to more than 350 in traps of A type) were observed from September 2009 to January 2010 with a peak of 356 and 240 on January the 15th for both A and B type traps.

KEY WORDS: funnel trap, pheromone traps, pitfall trap, red palm weevil.

Introduction

The red palm weevil (RPW), *Rynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae), is probably the most serious pest of palms worldwide. The initial information about this species was published in 1891 in Indian Museum Notes (1891/3) and was later supplemented by Lefroy in 1906 (Vidyasagar 2007). It was described as a serious insect pest of coconut palm throughout India. By the mid-1980's, the pest had spread to the Middle East and then it moved more rapidly into northern Africa by 1992 and southern Europe by 1994, eventually reaching North America in 2009 (Fiaboe et al. 2012).

The larvae bore into the trunk causing significant damage that may result to plant

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necrosis. The insect was reported for the first time in Greece, during the winter of 2005 in Hersonissos (Heraklion prefecture) in Crete, in infested *Phoenix canariensis* Chabaud (Arecales: Arecaceae) (Kontodimas et al. 2007). In the beginning, the problem was located near the source of initial infestations, however now it has reached almost all parts of the island where palms grow.

Traps are mainly used for monitoring the insect, even though occasionally mass trapping has been employed to reduce adult populations (Soroker et al. 2005, El-Sayed et al. 2006). The trap design is important: sides of traps must be rough to allow weevils to crawl inside, while also entry holes must be near ground level to allow weevils to easily crawl inside. Usually, bucket and funnel traps are employed (Hallett et al. 1999), even though, recently, a pyramidal trap was found to be more effective compared to bucket traps (Vacas et al. 2013).

Pheromones, semiochemicals and food attractants may be used in the traps. Colour is also an integral part of an effective trap. Captures in black traps have been reported to be significantly higher than captures in red, yellow or white traps (Abuagla and Al-Deeb 2012). The combination of black colour and date baits (100gr) has also proved more effective, enhancing *R. ferrugineus* trap captures (Abuagla and Al-Deeb 2012). Recently, the combinations of black colour and ethyl acetate significantly increased the captures of pheromone traps (Al-Saoud 2013).

The aim of this work was to evaluate two types of traps used to monitor the red palm weevil as well as to monitor the insect population in the areas of Sissi and Milatos, mid-North coastline of Crete, Greece.

Materials and Methods

Two trap types were evaluated. Trap designated as 'A' was a yellow funnel type trap with green top from 'Charantonis' (http://www.charantonis.gr/etairia.htm). Trap designated as 'B' was a yellow pitfall trap from 'Novagrica' (http://www.novagrica.com/). Both traps were about the same size (15 cm high and 12 cm in diameter) while also equipped with pheromone Pherodis (Koppert).

The traps were placed in the villages of Sissi and Milatos, in the mid-North coastline of Crete, Greece, starting on March the 26th 2009 till February the 17th 2010. In that period the infestation level was high. These two villages are located almost in the middle between the initial infestation area and the palm forest of *P. theofrasti* in Vai, S. Crete, a species of major ecological interest.

The density of the palms was diverse, as they were located in hotels (high density) and houses (one or two palm trees), with no standard distance from one another. Traps were placed near infested or dead palms. An effort was made for the traps to be placed as close to the palms as possible (1-2 m), however in some cases they were a bit further (up to 10 m). In each location a pair of traps, one trap of each type, was placed at about the same distance from the palms. The distance between two pairs was very diverse as they followed the locations of the palms.

The collection of the trapped insects and renewal of the attractant was made in two wk intervals. The total number of traps used per sampling was 24 to 36, non stable throughout the experiment, due to different problems (destruction by weather, animals or human interventions). Wherever the trap of one type was destroyed we did not include the results of the corresponding trap of the other type.

The results were processed using SPSS 17.0 statistical package. In particular ANOVA (Analysis of Variance) and post hoc indexes of Tukey, Duncan and Scheffe were used.

Results and Discussion

In the beginning, 26 and 10 traps were placed at Sissi and Milatos respectively (a total of 36 traps); while at the end 17 and 7

correspondingly remained intact. In total, more than 3000 insects were captured. The overall sex ratio (females /males) was 3.25 which is significantly higher ratio than the ones found in the literature. This ratio is more than two-fold higher than that reported by certain researchers (Table 1). The highest one found in literature is the upper limit in Soroker et al. (2005) (♀/♂=3.8).

At the location of Sissi, an average of 6.93 insects per trap/fortnight were captured and the respective number for Milatos was 5.37. The sex ratio was higher at Sissi, ♀/♂=3.30, while in Milatos was 3.04.

TABLE 1. Females / Males (♀/♂) ratios of captured RPW according to the literature.

♀/♂ **ratio**	**Reference**
2.7	Abraham et al. (2001)
1.5-2.8	Kaakeh et al. (2001)
1.1	Abd-Allah and Al-Khatri (2005)
2.2-3.8	Soroker et al. (2005)
1.51	Abbas et al. (2006)

Type A traps captured 1376 insects (313♂ and 1063♀); ♀/♂=3.40. Type B traps captured 1763 insects (425♂ and 1338♀); ♀/♂=3.15. What was interesting is the different sex ratio in the two trap types with respect to the location. At Sissi, the ratio for A traps was 1:3.85 and for B traps 1:2.94, but in Milatos the results were reverse (2.36 vs. 3.86 for A and B traps respectively).

Type B traps captured significantly more insects than type A (traps A: 38.22 insects in total per fortnight /trap, traps B: 48.97 insects per fortnight /trap, F=6.46, d.f.=1, 44, P=0.015). Processing the data separating males and females, ANOVA showed significant differences among the four groups (F=5.036, d.f.=3, 68, P=0.003). Post hoc comparisons using Duncan test grouped females and males differently, while Tukey and Scheffe tests separated female captures from B trap from males and females of A trap.

Figure 1 presents the total captures for each sampling date. The higher number was found on January the 15th, 2010 (596 insects). The numbers of insects captured from September to January are impressive. This pattern has been observed before at the north coast of Crete (Aggelakopoulos et al. 2010).

Figure 2 shows the captures for each trap type and gender throughout the sampling period. It general, fluctuation of captures is synchronized for both trap types and gender.

According to the literature, RPW is most active in the costal State of Goa in Western India between October and November and least active during the summer (Faleiro 2006), which is similar to the flight pattern recorded in the area of our observations.

In other cases, RPW is reported to be more active during spring, rather than autumn, as in the cases of Saudi Arabia (Vidyasagar et al. 2000) and Israel (Soroker et al. 2005). Also, in United Arabic Emirates captures followed similar patterns, with a major peak in spring and a smaller one during the autumn (Kaakeh et al. 2001, Al-Saoud et al. 2010). These patterns are related to climatic conditions as weevils would fly when relative humidity is high and temperatures are moderate (Faleiro 2006).

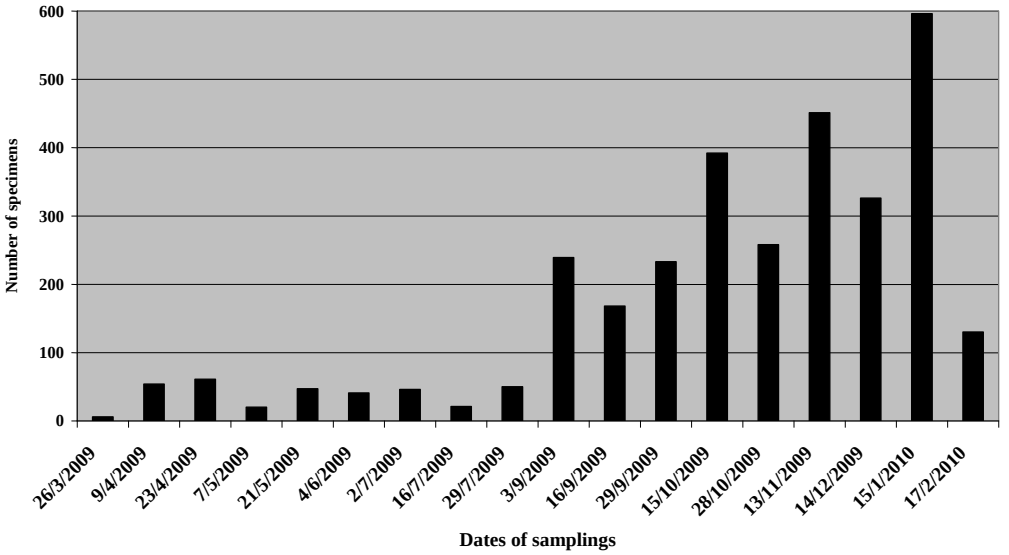

FIG. 1. Total number of captures in both trap types for each sampling date.

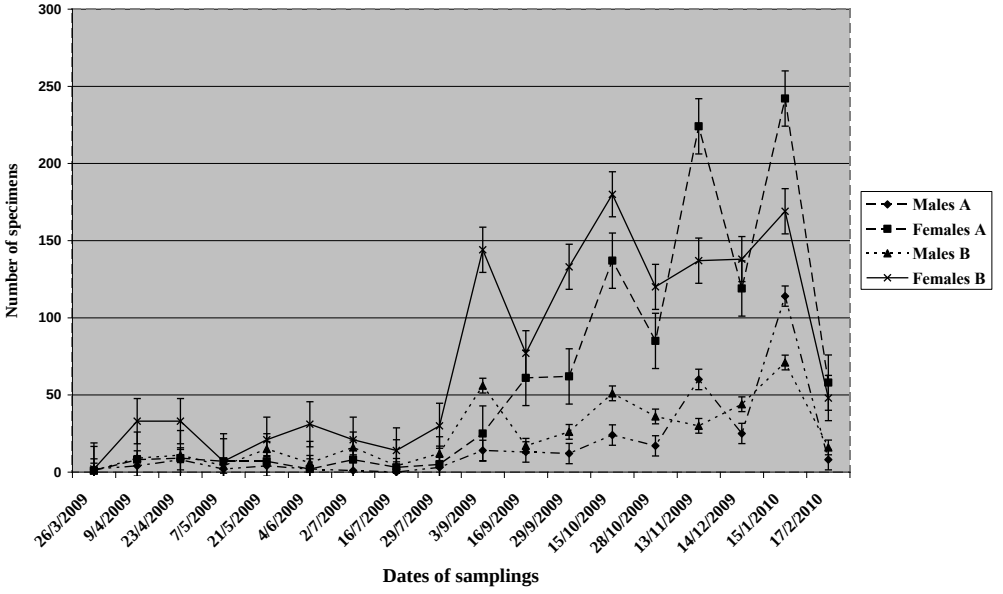

FIG. 2. Trap captures per trap type and gender at Sissi and Milatos locations in Crete, at each sampling date.

In conclusion, type B traps were more effective than type A for monitoring RPW populations at the locations this experiment took place. Slightly more insects were captured at Sissi (107.7 insects per trap and fortnight) compared to Milatos (94.3 insects per trap and fortnight). The lowest and highest sex ratios were 1♂: 2.36♀ and 1♂: 3.86♀ respectively. The insect population

showed very high flight activity from September to January.

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Σύγκριση δυο τύπων παγίδων κόκκινου ρυγχωτού κάνθαρου (*Rhynchophorus ferrugineus*) των φοινικοειδών

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ΠΕΡΙΛΗΨΗ

Σε αυτή την εργασία συγκρίνονται τα αποτελέσματα από τη χρησιμοποίηση δύο τύπων φερομονικών παγίδων για τη σύλληψη του κόκκινου ρυγχωτού κανθάρου (ρυγχοφόρου) των φοινικοειδών, αμφότερες εφοδιασμένες με τη φερομόνη Pherodis (Koppert). Οι συγκρινόμενες παγίδες είναι δύο τύπων. Η παγίδα Α (προμηθευτής: Δ. Χαραντώνης) είναι τύπου χοάνης, με κίτρινο σώμα και πράσινο στέγαστρο, ενώ η Β (προμηθευτής: Novagrica) είναι παγίδα παρεμβολής με εξολοκλήρου κίτρινο χρώμα. Οι διαστάσεις και των δύο είναι 15 cm ύψος και 12 cm διάμετρος. Οι παγίδες αξιολογήθηκαν στις τοποθεσίες Σίσι και Μίλατος του νομού Λασιθίου, από 26 Μαρτίου 2009 έως 17 Φεβρουαρίου 2010. Συνελήφθησαν, συνολικά και από τους δύο τύπους παγίδων, περισσότερα από 3000 έντομα. Σε κάθε σύλληψη αρσενικού αντιστοιχούσαν περισσότερα από τρία θηλυκά. Ο αριθμός των παγίδων που χρησιμοποιήθηκαν κατά τη διάρκεια της μελέτης κυμάνθηκε από 24 έως 36. Ο αριθμός δεν ήταν σταθερός λόγω απωλειών παγίδων εξαιτίας καιρικών συνθηκών ή ανθρώπινης παρέμβασης. Σε κάθε τοποθεσία υπήρχε ένα ζεύγος από μία Α και μία Β παγίδα. Στην περιοχή Σίσι λειτούργησαν από 17 έως 26 παγίδες και στην Μίλατο 10 παγίδες, με μείωση στις τρεις τελευταίες δειγματοληψίες. Στις παγίδες τύπου Α συνελήφθησαν συνολικά 1376 έντομα με αναλογία 1♂ προς 3,40 ♀. Στις παγίδες τύπου Β συνελήφθησαν συνολικά 1763 έντομα με αναλογία 1♂ προς 3,15 ♀. Η διαφορά στις συλλήψεις μεταξύ των δύο τύπων παγίδων ήταν στατιστικά σημαντική (τύπου Α: 38,22 έντομα ανά παγίδα και δεκαπενθήμερο, τύπου Β: 48,97 έντομα ανά παγίδα και δεκαπενθήμερο). Στο Σίσι συνελήφθησαν 1,61♂ και 5,32♀ ανά παγίδα, με αναλογία 1♂: 3,30♀, που αναλύεται περαιτέρω σε 1♂: 3,85♀ για τις παγίδες τύπου Α και 1♂: 2,94♀ για τις παγίδες τύπου Β, ενώ στη Μίλατο 1,33♂ και 4,04♀ ανά παγίδα, με αναλογία 1♂: 3,04♀, που αναλύεται περαιτέρω σε 1♂: 2,36♀ για τις παγίδες τύπου Α και 1♂: 3,86♀ για τις παγίδες τύπου Β. Σε ότι αφορά στη χρονική διακύμανση, σε γενικές γραμμές εμφανίζεται συγχρονισμός στις αυξομειώσεις των συλλήψεων, τόσο των δύο τύπων παγίδων, όσο και των δύο φύλων. Εντυπωσιακός είναι ο αριθμός των συλλήψεων από το Σεπτέμβριο του 2009 έως και τον Ιανουάριο του 2010. Η παγίδα Α έδειξε πιο αποτελεσματική για την παρακολούθηση του πληθυσμού του ρυγχοφόρου στις περιοχές που έγιναν οι δειγματοληψίες.