Effect of Ethyl Acetate on the Number of Red Palm Weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae)

Captured in Dark Red and Yellow Aggregation Pheromone Traps

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Abstract

Aggregation pheromone traps, is the main element in the control program of the red palm weevil, *Rhynchophorus ferrugineus* Olivier, in most of its distribution sites in the world. A field trial was conducted in randomized complete block design at Al Rahba farms (UAE) during May 2009 to May 2010 to study the effect of ethyl acetate (EA) on the number of weevils captured in dark red and yellow pheromone traps. Results showed that, the red palm weevil was found all over the year, and the peak adult population trapped was during March–May. The highest catches (35.96±1.96 weevils/trap/month) were in the red traps that contains ethyl acetate, with significantly higher number of red palm weevil than yellow. The capture rates were 27.32 and 18.32 weevils/trap/month for red and yellow traps, respectively. The capture rates were 30.77 and 15.40 weevils/trap/month for traps with and without ethyl acetate, respectively. The sex ratio (male: female) was 1:2.11.

Key words: Aggregation pheromone, Ethyl Acetate, Trap color, *Rhynchophorus ferrugineus.*

Introduction:

Red palm weevil *Rhynchophorous ferrugineus* Olivier (Coleoptera: Curculionidae), has been reported as the most devastating insect pest and cause serious damage to date palm (*Phoenix dactylifera* L.) in the different growing area in the world (Ghosh, 1912; Abraham and Vidyasagar, 1992; Al-Saoud, 2004; Oehlschlager, 2005). It is difficult to detect the infection by red palm weevil in the early stages of attack, because it is an internal tissue borer (Vidyasagar and Keshava, 1991; Abraham *et al*., 1999; Faleiro, 2005). The pest is present all over the year, increasing its numbers and the damages (Faleiro and Chellapan, 1999; Abraham *et al*., 2002; El-Garhy 1996; Al-Saoud, 2009a). Red palm weevil (RPW) was managed in the Middle East countries with Integrated Pest Management Program (IPM), which dependeds on the aggregation pheromone trap as a corner stone (Faleiro and Satarkar, 2003; Al-Saoud 2010a; Al-Saoud, 2014). Trapping adult weevils with aggregation pheromone traps, which attracts both male and female weevils, has been widely practiced in surveillance and mass trapping programs in several countries where RPW is a problem (Abraham *et al*., 2000; Nair *et al*, 2000; Faleiro, 2006). In the Middle East as well as in India the sex ratio of weevil captures was reported to be female dominated in these traps (Abraham *et al*., 1998; Kalleshwaraswamy and Jagadish, 2006; Al-Saoud, 2011; Chakravarthy *et al*, 2014). Sujatha *et al*. (2010), reported that the use of pheromone trap for red palm weevil was found to effectively reduce the palm damage by 78% and the dead palm by 93% dead palm. Pheromone trap effectiveness is influenced by many factors, including color (Ajlan and Abdulsalam 2000; Abdallah and Al-Khatri, 2005; Al-Saoud *et al*., 2010), trap contents (Al-Saoud 2007; Al-Saoud , 2009b; Al-Saoud, 2012) and trap location (Hallett *et al*., 1999; Al-Saoud 2011). Ethyl acetate (EA) also appeared to have an important role on the effectiveness of the traps and increase the attraction of red palm weevils when used along with pheromone and food bait (Oehlschlager, 1998; El-Sebay, 2003; Abdallah *et al*, 2008; Guarin *et al*., 2010). The effectiveness of ethyl acetate is affected by many factors, such as: bite quantity (Al-Saoud 2009a; Al-Saoud, 2009b) and trap colors (Al-Saoud, 2010b; Al-Saoud 2012; Al-Saoud 2013). The purpose of the present study was to further evaluate the role of ethyl acetate on the number of red palm weevil captured in dark red trap color, which was recommended by Al-Saoud *et al*.,(2010) and yellow trap colors as control which is commonly used in date palm plantations in Al-Rahba area (Abu Dhabi) in UAE. .

Material and Methods:

1. Study sites:

The experiment was conducted at date farms at Al-Rahba, Abu Dhabi (Lat. 24º 28´ N; Long. 54º 22´ E), UAE, during the beginning of May, 2009 to the end of May 2010. Each farm contained at least 140 date palm trees of different ages (6- 30 years old).

2. Traps:

Pheromone traps were fabricated from bucket treated with ULV, with a 10 Liter capacity, a cover, polypropylene with four rectangular (3 x 7 cm) windows cut equidistantly below the upper rim of the bucket. The distance between each window and the bottom of the bucket was 16 cm. The bucket was covered with a lid that had four windows similar to the ones on its sides. The outer surface of the bucket was rough with small projection (1-2 mm) to help the weevils to climb to the trap and enter. The upper surface of the lid had a small handle to ease opening the trap and the

lower side had a small knob on which a wire was fixed to hold the pheromone and ethyl acetate (EA) dispensers. Each trap contained the following materials: (i) dispenser of the RPW male aggregation pheromone (Ferrolure +) containing 700 mg Lure of the active ingredient (4-Methyl-5-Nonanol 90% + 4-Methyl-5-Nonanone 10%) at 95% purity manufactured by Chemtica International S.A. Costa Rica, (ii) 350 gram of fodder date fruits which was recommended by (Al-Saoud , 2009a), (iii) about 4-5 liters of water, with a water level inside of 4-5 cm, which was lower on the side of the opening of the bucket. The 4 treatments are described in Table 1.

Table 1. Four combinations of red palm weevil aggregation pheromone trap tested in the study at date palm plantations area at Al-Rahba (UAE) during May 2009 to May 2010

Treatment	Combinations of treatments
1	Red trap aggregation pheromone trap with Ethyl acetate
2	Red trap aggregation pheromone trap without Ethyl acetate
3	Yellow trap aggregation pheromone trap with Ethyl acetate
4	Yellow trap aggregation pheromone trap without Ethyl acetate

Dispenser of the Ethyl acetate (EA) (Weevil Magnet^{TM}) manufactured by Chemtica International S.A. Costa Rica, containing 40 ml of the active ingredient of EA at 98% purity. Dates fruits had been soaked in water for one day before added to the trap to soft and easy squeeze well with water, when added to the traps. Food bait (dates) was changed monthly. The new pheromone (Ferrolure+) was added every 45 days during, cold period (October -April) and every month during warm periods (May-September) and the new EA was added every 45 days. Water in the traps was replenished so as to keep sufficient moisture. The big perforated ladle was used to collect the trapped weevils and to shake the traps contents, to prevent growth of any fungi/mold. Captured weevils were removed from the traps at weekly intervals, and the numbers of : males and females were recorded in each treatments. The traps were rotated within each farm (Replicate) to next location after taking weekly results, to avoid location effect on collected insects as recommended by (Faleiro *et a*l, 2002; Al-Saoud, 2004, Al-Saoud 2010a). The maintenance of the traps was done weekly.

3. Trap Colors:

Dark red, which is superior in the effectiveness to the yellow and white traps and recommended by (Al-Saoud *et al*., 2010) and the yellow traps which are commonly used in United Arab Emirates and consider as control were used .

4. Experimental design and trap installation:

The experimental was a randomized complete block design with four treatments and four replicates. A total of 16 traps were installed for a trapping period from the beginning of May 2009 to the end of May 2010. The distance between traps was 50 m and each trap was fixed near the palm trunk on the ground level(near the old palms more than 20 years old) .

A monthly record of the number of weevils trapped in the 16 pheromone traps was maintained for the studying period to see the activity of red palm weevil during the different months of the year and to compare the efficacy of EA and trap color on the catches.

5. Statistical analysis:

The data were subjected to ANOVA and the means were compared by carrying out the Least Significant Difference test (LSD 5%) .

Results and Discussion:

1. Activity of red palm weevil, *R. ferruginous:*

The results in (Fig. 1) show that the red palm weevil is found all over the year in the date palm area in Al-Rahba, UAE. The number of captured weevils/trap was different from month to month. The results show that the rates of catches were 31.8, and 25.6 weevils/trap during May 2009 and May 2010 respectively.The highest catch was recorded in March 2010 with 57.3 weevils/trap, and the lowest catch was 10.5 weevils/trap during the months of January 2010.

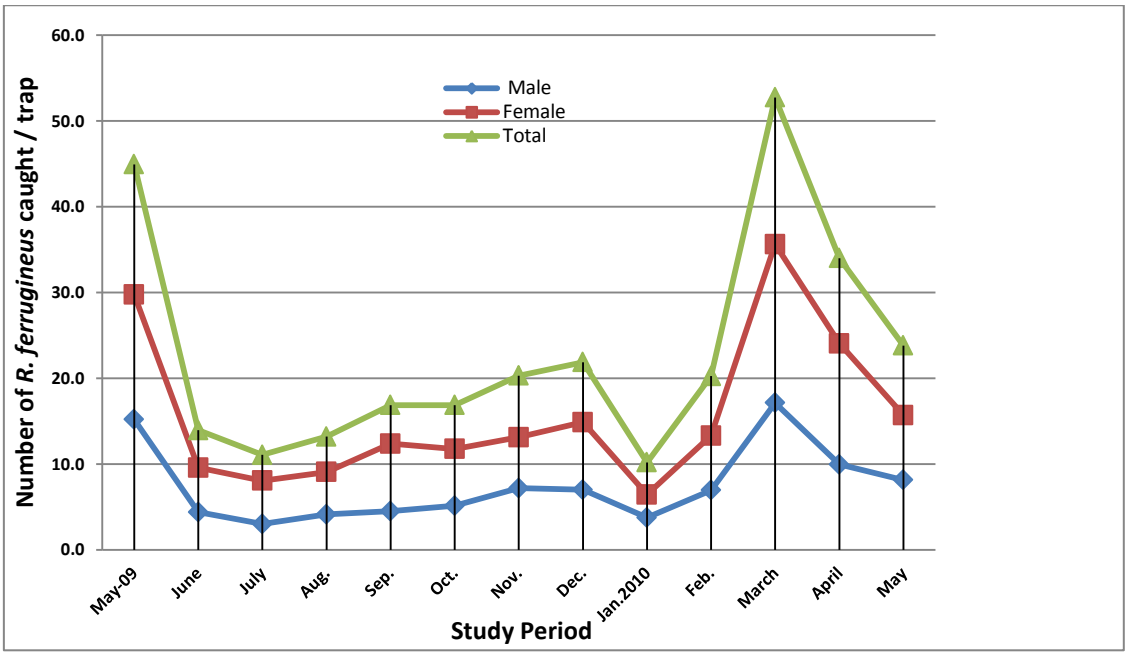

Figure 1. Average number *of R. ferrugineus* catches/trap in Al-Rahba (UAE) during May 2009 to May 2010

2. Effect of red palm weevil aggregation pheromone trap of colored traps on the number of caught weevils:

The results in (Fig.2) show that there were differences between the numbers of red palm weevils captured in the two traps colors. The traps captured 4801 weevils, with 2795 and 2006 weevils for dark red and yellow traps, respectively, with caught rates, 26.9 and 19.3 weevils/trap/month for the two traps colors, respectively. The percentages of collection weevils were 58.2% and 41.8% for the red and yellow traps, respectively. The rate of caught ranged between 13.4 to 65.8 weevils/trap/month for dark red traps compared with 7.6- 48.9 weevils/trap/month for yellow traps.

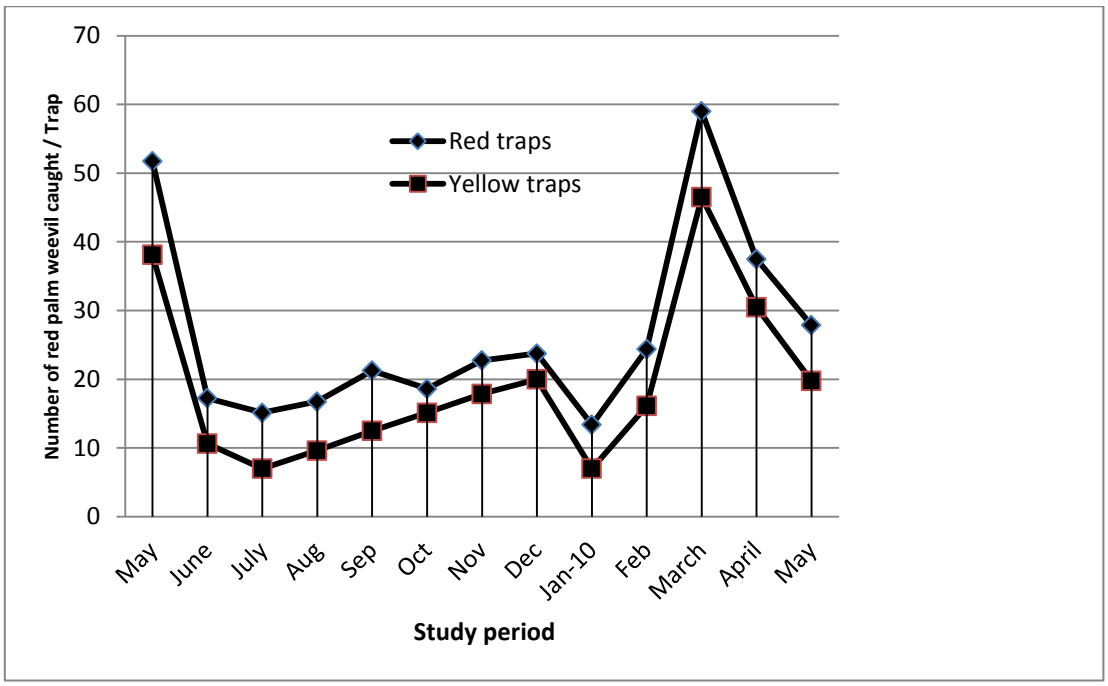

Figure 2. Effect of colors of R. *ferrugineus* aggregation pheromone trap on the number of caught weevils at Al-Rahba (UAE) from May 2009 to May 2010

3. Effect of ethyl acetate (EA) on the number of red palm weevil *R. ferrugineus* captured in pheromone traps:

The results in Fig (3) show that ethyl acetate was very essential factor in the attraction of red palm weevils. The highest capture was obtained in the traps charged with ethyl acetate compared with the numbers of the weevils captured in the traps without ethyl acetate during the different months of the study period. The numbers of weevils caught were 3186 and 1615 weevils for traps charged with ethyl acetate and traps without ethyl acetate, respectively. The percentages of caught were 66.36% and 33.64% for the traps with ethyl acetate and the traps without ethyl acetate, respectively. The averages of caught were 30.6 and 15.5 weevils/trap/month for these two treatments, respectively. The captured rates ranged between 14.1 – 73.6 weevils/trap/month in traps with ethyl acetate compared with 6.9- 41.0 weevils/trap/month for the traps without ethyl acetate.

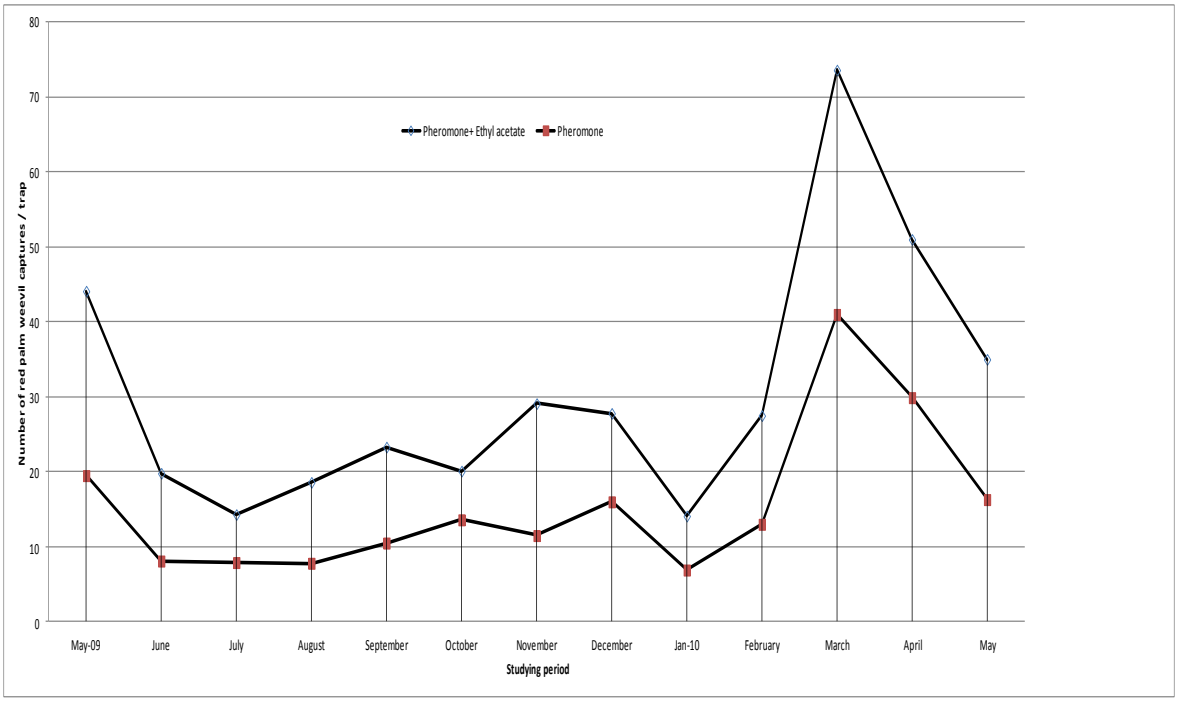

Figure 3. Effect of ethyl acetate on the number of red palm weevil catches on aggregation pheromone traps at Al-Rahba (UAE) during May 2009- May 2010

4. Sex ratio of *R. ferrugineus* caught in aggregation pheromone traps:

The results reveal that the total numbers of captured weevils were 4801, where as male is 1542 and female is 3259. The results show that the numbers of cached females dominated on the number of cached males all over the period of study, and the sex ratio (Males: Females) ranged between 1: 1.82 to 1: 2.76, with the overall of 1: 2.11 .

5. Effect of ethyl acetate (EA) on the number of *R. ferrugineus* males caught in red and yellow pheromone traps:

The traps captured 1542 males. A total of 600, 432, 317 and 193 weevils caught in red traps with EA, yellow traps with EA, red traps without EA and yellow traps without EA, respectively. The statistical analysis shows that the number of weevils caught is significantly affected by the trap colors and EA ($F=104.17$; $df=3$; $p<0.005$) (Table 2). All treatments are superior to the yellow traps colors without EA and the red traps with EA is superior to other two treatments, while yellow traps with EA dominated on red traps without EA. Red traps with EA recorded the highest average number of caught (11.54±0.95) compared with other three treatments, which caught an average of 08.31±0.45, 06.10±0.28 and 03.71±0.60 weevils/trap/month, for yellow traps with EA, red traps without EA and yellow traps without EA, respectively. The average of captured rates was 9.88 and 4.91 weevils/trap/month for traps charged with EA and traps without EA, respectively. The percentage of total numbers of weevils caught in traps were 38.9 %, 28.0 %, 20.6% and 12.5% for these four treatments, respectively.

Table 2. Effect of ethyl acetate and traps colors on the mean monthly captures of *R. ferrugineus* males in food baited pheromone (Ferrolure+) traps at Al-Rahba, UAE, (May 2010 to May 2011)

Trap color	Mean of male of red palm weevil captures/trap[1]		
	With EA	Without EA	Mean[2]
Red	11.54±0.95a	06.10±0.28c	08.82 (89.18)
Yellow	08.31±0.45b	03.71±0.60 d	06.01(123.99)
Mean	09.88	04.91	(101.23)
LSD 5%	0.52		F = 104.17

[1]**Means with similar letters are not significant different (p≥0.05, LSD 5%).**
[2]**Values in parentheses represents the increase percentage in captures weevil over the trap without EA.**

6. Effect of ethyl acetate (EA) on the e number of *R. ferrugineus* females caught in red and yellow pheromone traps:

The traps captured 3259 females weevils. A total of 1270, 898, 654 and 437 weevils caught in red traps with EA, yellow traps with EA, red traps without EA and yellow traps without EA, respectively. The results in Table (3) indicate that there is a significant effect of the trap colors and EA (F=164.91; df=3; p<0.005). All treatments were superior the yellow traps color without EA. The an averages of captured weevils were (24.42±1.05, 17.27±0.45, 12.58±0.33 and 08.40±0.58 females/trap/month) for the red traps with EA, yellow traps with EA, red traps, and yellow traps, respectively. The averages of captured rates were 20.85 and 10.49 weevils/trap/month for traps charged with EA, and traps without EA, respectively. The percentage of total numbers of weevils caught in traps was 39.0%, 27.6%, 20.1% and 13.4 for these four treatments respectively.

Table 3. Effect of ethyl acetate and trap colours on the mean monthly captured of *R. ferrugineus* females in food baited pheromone (Ferrolure +) traps at Al-Rahba, UAE.(May 2010 to May 2011)

Trap color	Mean of male of red palm weevil captures / trap[1]		
	With EA	Without EA	Mean[2]
Red	24.42±1.05a	12.58±0.33c	18.50 (94.12)
Yellow	17.27±0.45b	08.40±0.58 d	12.84(100.06)
Mean	20.85	10.49	(98.76)
LSD 5%	0.59		F = 164.91

[1]**Means with similar letters are not different significantly (p≥0.05, LSD 5%).**
[2]**Values in parentheses represents the increase percentage in captured weevil over the traps without EA.**

7. Effect of ethyl acetate (EA) on the total number of *R. ferrugineus* weevils caught in red and yellow pheromone traps:

The traps captured 4801 weevils. A total of 1870, 1330, 971 and 630 weevils caught in red traps with EA, yellow traps with EA, red traps without EA, and yellow traps without EA, respectively. The statistical analysis showed that the number of weevils caught significantly affected by the trap colors and EA (F= 181.80; df=3; p<0.005) (Table 4). Red traps baited with EA recorded the highest average number of caught (35.96±1.96 weevils/trap/month), which was superior the other three treatments. The yellow traps with EA and red trap without EA caught an average of 25.58±1.11, 18.67±0.54 weevils/trap/month, respectively. The lowest number of captured (12.12±1.05 weevils/trap/month) was recorded in the yellow traps without EA. The averages of captured rates were 30.77 and 15.40 weevils/trap/month for traps charged with EA and traps without EA,

respectively. The percentage of total number of weevils caught in traps were 39.0%, 27.7%, 20.2% and 13.1 for these four treatments, respectively.

Table 4. Effect of ethyl acetate and trap colors on the mean captures of *R. ferrugineus* monthly in food baited pheromone (Ferrolure +) traps at Al-Rahba, UAE, (May 2010 to May 2011)

Trap color	Mean of male of red palm weevil captures / trap[1]		
	With EA	Without EA	Mean[2]
Red	35.96±1.96a	18.67±0.54c	27.32(92.60)
Yellow	25.58±1.11b	12.12±1.05 d	18.85 (111.06)
Mean	30.77	15.40	(99.80)
LSD 5%	1.2		F = 181.80

[1]**Means with similar letters are not different significantly (p≥0.05, LSD 5%).**

[2]**Values in parentheses represents the increase percentage in captured weevil over the trap without EA.**

Discussion

The white and yellow colors bucket traps are commonly used in IPM program of red palm weevil for a long time in the UAE. Recently, Al-Saoud *et al*., (2010) and Al-Saoud, (2013) found that the use of dark colors pheromone traps can significantly enhance red palm weevil capture. Results of Sansano *et al*., (2008) showed that the brown-reddish colored traps recorded the highest numbers of red palm weevils. These results confirm that the RPW adults prefer dark colors. The red traps caught highest number of weevils, compared with the number weevils captured in yellow traps. Kalleshwaraswamy and Jagadish, (2006) reported, that the color of the trap is not an important factor in influencing the weevil attraction, which is not true as appear in the present study. The results show that the ethyl acetate increase the percentage of captured weevils with 92.60% and 111.06% in red and yellow traps, respectively. Guarino *et al*., (2010), reported that the ethyl propionate alone or in combination with EA was found to be a better synergist in food baited red palm weevil pheromone traps than EA alone.

These results indicated that red palm weevil was presented all over the year, and increases the damage, infestation severity and spread the pest to other date palm plantation areas. The rate of caught differed from month to month, the highest captures were recorded during the months of March and April (the flowering period of date palm trees and favorable the environmental conditions, especially the temperature). The rates of captured were 31.8 and 25.6 weevils/trap during May 2009 and May 2010, respectively, this is may be because the different factors as such as environmental conditions, and the distribution the pheromone traps during May in those two years, and the distribution of the pheromone traps during these months. While the lowest caught was recorded during January. The seasonality of this population change corresponds with the findings of other studies (Abraham *et al.* 1998; Vidyasagar *et al*. 2000b; Al-Saoud 2007; Al-Saoud, 2011). The result indicates that the RPW reproduction occurs all over the year. The behavior of the insect (all stages inside the infested trunks), making control of this pest difficult to achieve, especially using pesticides which is stop using in UAE during the pollination period (mid-January- end of March), and during the beginning of crop formation (Rutab stage) until the harvest of the fruits (June-September). Difficulty of chemical control of RPW makes the implementation and refinement of an effective Integrated Pest Management Plan (IPM) an important step in reducing the red palm weevil population. The overall sex ratio (male:female) of red palm weevils captured in the pheromone traps was 1:2.1, this result differs from the results found by Abraham *et al.*,(1999), who recorded the sex ratio ranging from 1:2.35 to 1:3.06, with an overall average of 1;2.68 in favor of females. Al-Saoud (2007, 2009a, 2009b) reported a sex ratio ranging from 1:1.33 to 1:2.28, male:

female. As the captures were female dominated, pheromone trapping along with other components of the IPM strategy contributed in suppressing the buildup of the pest population.

Pheromone trapping of red palm weevil is an ecologically safe and environmentally friendly tool in the IPM strategy currently adopted worldwide for red palm weevil management in date palm plantations and one that can be implemented on large scale either by the state or by farmers on a collective basis.

Conclusion:

The results of this study revealed that must be use of dark red traps for improve the efficacy of red palm weevil aggregation pheromone traps, all over the year, all date palm plantation areas, supplement of the traps with: pheromone, EA, 350 g date fruit as a bait, and the water, will be the best recommended contains . These traps should be maintained regularly and replenished the water allows, adding new pheromone and EA according the required. More deep study must be done to improve effectiveness of this important technique

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تأثير خلات الإيتيل على أعداد سوسة النخيل الحمراء *Rhynchophorus ferrugineus* Olivier (Coleoptera : Curculionidae) الملتقطة في المصائد الفيرمونية الحمراء الداكنة والصفراء

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الملخص:

المصائد الفيرمونية التجميعية هي العنصر الأساسي في برنامج مكافحة سوسة النخيل الحمراء *Rhynchophorus ferrugineus* Olivier في معظم أماكن انتشارها في العالم . أجريت تجربة حقلية بتصميم القطع العشوائية الكاملة في مزارع النخيل في منطقة الرحبة (الإمارات العربية المتحدة) خلال الفترة، أيار/مايو 2009 وحتى أيار/مايو2010 لتحديد تأثير خلات الإيتيل على أعداد الحشرات التي تلتقطها المصائد الحمراء الداكنة والصفراء. بينت النتائج تواجد الحشرة على مدار السنة، وبلغت أوج نشاطها خلال الفترة آذار/مارس و نيسان/أبريل. بلغت أعلى معدلات للصيد 35.96 ± 1.96 حشرة/ مصيدة/شهر في المصائد الحمراء التي احتوت على خلات الإيتيل وبلغت النسبة الجنسية (ذكور: إناث) 1: 2.1. بلغت معدلات الصيد 30.77 و 15.40 حشرة/مصيدة /شهر للمصائد التي احتوت على خلات الإيتيل التي تفوقت على بقية المعاملات بفروق معنوية عالية على المصائد الصفراء. بلغت معدلات الصيد 27.32 و18.85 حشرة/مصيدة/شهر للمصائد الحمراء والصفراء على التوالي. بلغت معدلات الصيد 30.77 و15.40 حشرة/مصيدة/شهر للمصائد التي أضيف إليها خلات الإيتيل والمصائد التي لم يضاف اليها خلات الإيتيل على التوالي. كانت النسبة الجنسية (ذكور : إناث) 1: 2.11.

كلمات مفتاحية: فيرمون تجميعي، خلات الإيتيل، لون المصيدة، *Rhynchophorus ferrugineus* .