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Seasonal Activity of Red Palm Weevil (RPW), *Rhynchophorus ferrugineus* (Olivier) in Response to some Olfactory Stimulants

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ABSTRACT

Seasonal activity of *Rhynchophorus ferrugineus* adults had been studied during two successive years (2014 and 2015) in date palm orchards located at Mashtoul el- Souq district, Sharkia Governorate by using traps baited with different olfactory stimulants (aggregation pheromone, kairomone (Acetyl acetate) and their mixture). Red palm weevil population exhibited the highest activity in response to pheromone mixed with kairomone followed by pheromone alone with no significant between them in comparison with kairomone alone. Pheromone mixed with kairomone attracted the highest numbers of *R. ferrugineus* in the 1st and 2nd years (1.3 ± 1.1 and 1.6 ± 1.1 individuals/trap/week, respectively) followed by pheromone alone (1.2±0.9 and 1.3 ± 1.1 individuals/trap/week, respectively) with no significant difference, while, kairomone traps was less significant preferred (lured 0.1 ± 0.2 and 0.24 ± 0.2 individuals/trap/week, in the first and second years, respectively). *R. ferrugineus* population exhibited 3-4 peaks of abundance, and the highest occurrence was during July - August in both years of study. The efficiency of pheromone traps contained date fruits were significantly increased in comparison with traps without fruits. However combination of pheromone + kairomone + food bait recorded significantly higher mean cumulative RPW capture with 14.3, 19.5, 23.5 and 27.7 % of total capture of weevils in traps contained 02., 0.4, 0.7 and 1 kilogram of date fruit respectively. In the second year, these percent was 13.2, 15.0, 17.8, 23.9 and 24.6%, respectively. It could be concluded that co-attractants based on fermenting date fruits (0.7 Kg./trap) and ethyl acetate, are able to improve the attractant level of ferrugineol.

INTRODUCTION

The red palm weevil, *Rhynchophorus ferrugineus* (RPW) (Olivier) (Coleoptera: Curculionidae) is an economically important pest of palm trees in the different growing area in the world, Faliero (2006). *R. ferrugineus* is reported to attack 40 palm species worldwide (Anonymous 2013). According to Abd El-Kareim (1997 and 1998) pheromone trap not only used for detecting flight activity of insect pest population in the field but also could be incorporated in the management control program of this pest. Abraham *et al*. (1998) reported that mass trapping of *R. ferrugineus* is widely practiced in the Arabian Peninsula where it is a major problem in date palm. Management of *R. ferrugineus* relies on frequent inspection of palms to detect infestation, treatment of infested palms by injection of insecticide or removal, periodic spraying and trapping.

For the success of integrated pest control, early detection and monitoring of *R. ferrugineus* population are essential (Faleiro *et al*. 2011). According to Hallett *et al*.1999, the effectiveness of pheromone-based trapping for RPW has been demonstrated, in addition, mass trapping could serve as a tool for controlling RPW (Soroker *et al*. 2005).

Food bait should be used along with the synthetic pheromone lure to maintain the overall efficiency of the trapping system (Faleiro *et al*., 1999 Azmi *et al*., 2014). Hoddle and Hoddle (2011) recommended use of freshly cut coconut palm stumps with stacks of sectioned trunks and palm hearts was the most effective method to attract adult RPWs.

This study aims to evaluate the response of RPW to different olfactory stimulant lures in white plastic bucket traps baited with different types (aggregation pheromone alone, kairomone and their mixture. In addition to examine the efficacy of different weights of fresh date palm fruits with mixture of ferrugineol and acetyl acetate in attracting the RPW adults in field trappings

MATERIALS AND METHODS

1- Behavioral reaction of *R. ferrugineus* adults in response to some olfactory stimulants. (ferrugineol, ethyl acetate and their mixture).

Trap Design:

The trap consists of white plastic bucket (27 cm height x 28.5 cm diameters). The trap size about 10 L, and had four equidistant circular (4cm width) were cut at 12 cm height openings whose lower limits are tangent to the ground surface to allow *R. ferrugineus* entrance. For easily allowing weevil entry, four additional holes (4 cm width) in the bucket cover were done. Traps were inserted slightly in the soil surface.

The tested lures:

1- The commercial synthetic aggregation pheromone:
Trade name: Maxlure (ferrloure+700mg +lure)
Common name: ferrugineol.

The Composition of the commercial synthetic pheromone is a mixture of 4-methyl-5-nonanol and 4-methyl-5-nonanone (9:1). Purity of both components > 95 %. Lure with release rate of (3-10 mg/day) and minimum 700 mg/lure total mixture, it imported from Chem. Tica International S.A., Costa Rica. Pheromone bag was hanged on the underside of trap top surface.

2- The synthetic Kairomone Trade name: Po 80 A weevil magnet 50ml/ lure.The synthetic kairomone is 50 ml of ethyl acetate 95% with release rate of (100-128 mg/day). , It imported from Chem Tica International S.A., Costa Rica. The kairomone was used as a synergist to activate the potent ability of releasing ethyl acetate blooms therefore, bags containing 50 ml each of kairomone at 95% active ingredient of ethyl acetate were hanged from the underside surface of the trap top releasing chemicals through a plastic (as 100 and 128 mg/day)

3- Mixture of pheromone and kairomone:

Each trap contained one pheromone bag and one kairomone capsule that were attached to the lower surface of the trap lid by a wire. The tested compounds were obtained from Plant Protection Institute, Doki, Egypt.

Experimental orchard:

All field experiments were carried out at a private date farm of area about 45 feddan at Mashtool el-Sook District, Sharkia Governorate during the period started from 1st of January 2014 till 31st December 2015. The chosen farm was cultivated with about 1000 date palm trees aged from 5 to 10 years of Hayani and Zaghlool cultivars.

Field bioassay:

1- Behavioral reaction of *R. ferrugineus* adults in response to ferrugineol, ethyl acetate and their mixture.

White plastic bucket traps baited with pheromone and kairomone as well as a set of traps (four traps for each set) with mixture of pheromone and kairomone, were placed at random in the previously mentioned date palm orchard. Trapped insects were counted weekly from during the period from 1st of January 2014 till 31st December 2015.

Concerning traps management, pheromone and kairomone were added regularly after one month. Water were added to each trap, and maintained at 5 liter/trap during the course of the experiment period. Finally, traps were regularly cleaned when it was needed. Traps were placed in shadow spots opposite to wind direction at least 100 meters between each to avoid insect confusion.

Statistical analysis was carried out for the bioassay and field experiments, by analysis of variance. Data were subjected to one way analysis of variance (ANOVA) and the means of separated using Duncan's Multiple Range Test (Costat, 1990). In addition, the correlation and simple regression were done.

2. The influence of date palm fruit (as food bait) on the overall efficiency of pheromone + kairomone traps:

To evaluate the influence of date palm fruit (as food bait) on the overall efficiency of pheromone + kairomone traps, an experiment was carried out as mentioned before.

Each trap contained a 700-mg ferrugineol, 50 ml of ethyl acetate and different weights of fresh date palm fruits, as olfactory attractants for RPW. Four weights of fresh date palm fruits (*i.e.*0, *0.2*, 0.4, 0.7 and 1 kg) were prepared. Each treatment was replicated four times (4 traps/weight). In addition a set of traps contained 1 Kg. date fruit without ferrugineol or ethyl acetate was used (as control).

Food baits (fresh date palm fruits and water were changed every 2 weeks to maintain sufficient moisture in each trap. Ethyl acetate, which acts as a kairomone, was placed in a bottle hung from the inside of the bucket and released at a rate of 200–400 mg d-1 (Abbas *et al*. 2006).

Further addition of ethyl acetate was done every week to enhance the efficiency of the food-baited pheromone trap. Each trap was far from each other for about 100 meters. The traps were inspected weekly from the first week of May till the last week of October during two years (2015 and 2016). Traps were set under the shade of the plant canopy and not exposed to direct sunlight in order to obtain a sustained and uniform release of the chemical lure into the environment.

RESULTS

1- Behavioral reaction of *R. ferrugineus* adults in response to ferrugineol, ethyl acetate and their mixture.

Flight activity of RPW adults had been studied during two successive years (2014 and 2015) in date palm orchards located at Mashtoul el- Souq district, Sharkia Governorate by using traps baited with different olfactory stimulants (aggregation pheromone, kairomone (Acetyl acetate) and their mixture). The obtained results are summarized and illustrated in Figures 1 and 2. As shown, there was a variation in time and abundance of the flight peak of RPW adults between the tested treatments. Red palm weevil population exhibited the highest abundance in response to pheromone and mixture of (pheromone and kairomone) with no significant between them in comparison with kairomone.

In the first year (2014):

As shown in Figure (1), the date palm weevil started to appear in both traps baited with mixture of (PH. + K.) or pheromone alone early at the 2nd and 3rd weeks of March and exhibited four peaks of abundance. The first and second peaks occurred at the last week of April and May by using pheromone alone or mixed with acetyl acetate traps, represented by 1.25 and 2. 25 individuals/ trap, respectively. The third peak (the highest one) was recorded at the second week of August, represented by 3.25 and 3.75 individuals/ trap, respectively. The fourth one occurred at the last week of September by using pheromone alone or mixed with acetyl acetate traps, represented by 2.0 and 1.25 individuals/ trap, respectively. On the contrary, red palm weevil population showed the lowest preference to acetyl acetate (kairomone) and it started to appears later with very few individuals at the last week of May, with a slight peak of activity at the last week of July, represented by 1.0 individuals/trap. So, it could be concluded that pheromone alone or mixed with acetyl acetate more suitable to express population changes of red palm weevil, *R. ferrugineus* in comparison with acetyl acetate.

In the second year (2015):

R. ferrugineus population exhibited different trend of population changes by using the different lures. However, it started to appear earlier at the second week of March by using pheromone mixed with kairomone and showed three periods of seasonal abundance with three distinct peaks (Figure, 2). The first period occurred from the second week of March to the fourth week of April with highest abundance represented by 1.25 individuals /trap on the 2nd week of April. The second period was observed from the fourth week of April to the 2nd week of June; with the highest peak of 2.5 individuals/ trap on the 4th week of May. The third period occurred from the 3rd week of June to the 4th week of October with the highest peak of 4.5 individuals/ trap on the 4th week of August 2015. By using pheromone alone, RPW started to appear later at the last week of March and showed three peaks of seasonal activity on the 2nd week of April, 4th week of May and on the 3rd week of August, represented by 0.5 and 1.75 and 3.5 individuals/trap, respectively. While, *R. ferrugineus* population recorded with few individuals all over the season.

As a conclusion, the obtained data indicated that *R. ferrugineus* population was active all over the year, except in winter months (January, February and December). The highest occurrence of *R. ferrugineus* was during July - August in the first and second seasons of study.

As mentioned above for ferrugineol treatment, RPW captures was in general strongly affected by the time (date), and the addition of the synthetic kairomone ethyl acetate to ferrugineol-baited traps also had slight effects on RPW captures.

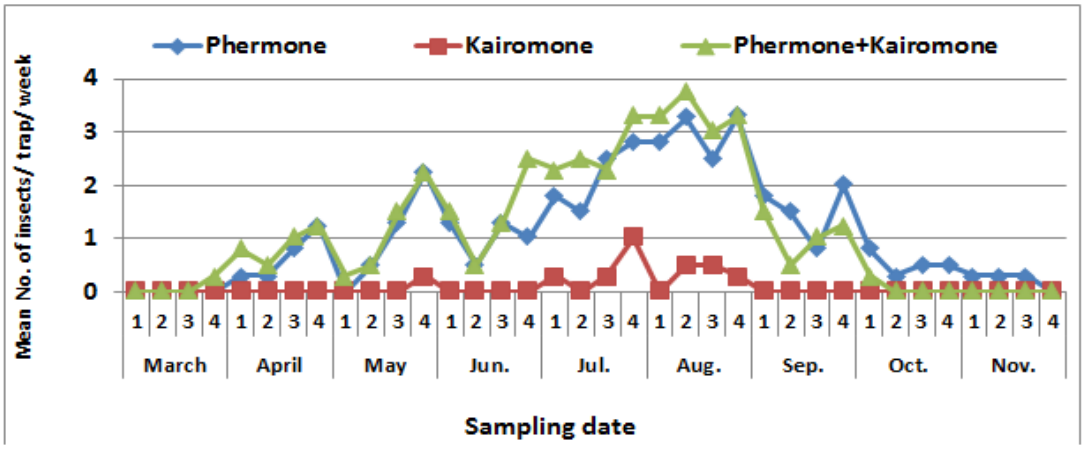

Figure 1. Seasonal activity of *Rhynchophorus ferrugineus* adults at Mashtool el-Sook District during 2014 in response to different lures (aggregation pheromone, synthetic kairomone and their mixture).

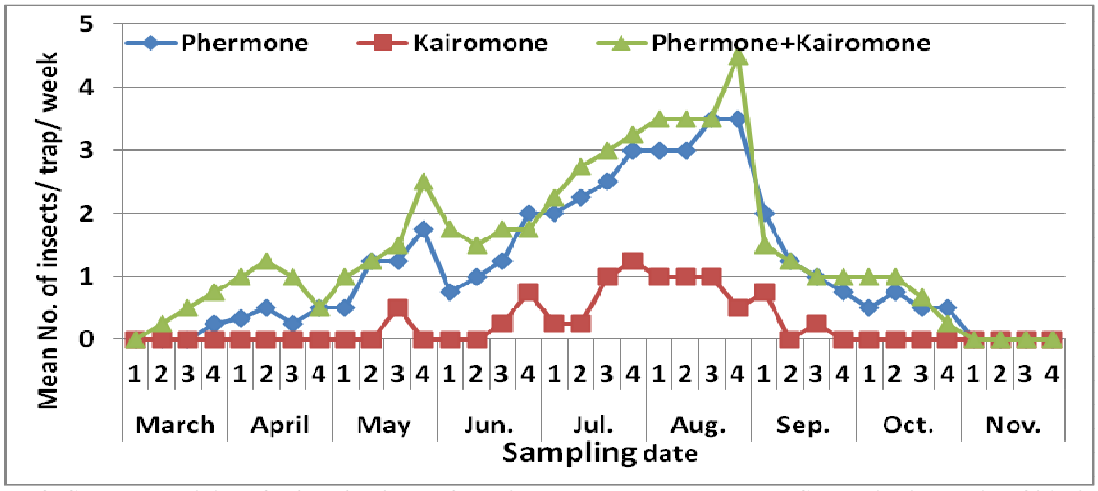

Figure 2. Seasonal activity of *Rhynchophorus ferrugineus* adults at Mashtool el-Sook District during 2015 in response to different lures (aggregation pheromone, synthetic kairomone and their mixture).

Data illustrated in Figure (3) showed the general mean numbers of *R. ferrugineus* adults during the first and second seasons of study (2014 and 2015).

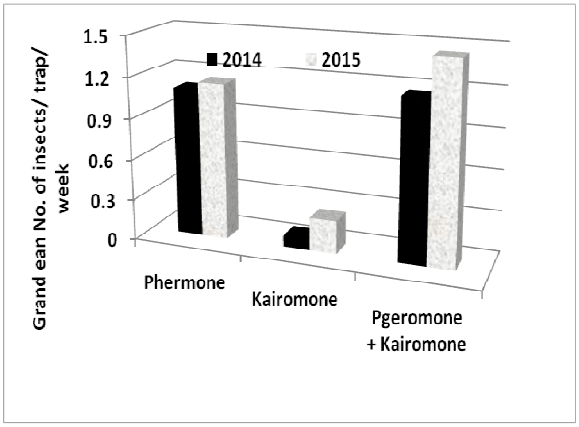

Figure 3. Grand mean number of attracted *Rhynchophorus ferrugineus* adults/ trap to traps baited with acetyl acetate (kairomone) ; aggregation pheromone and their mixture in date palm orchards located Mashtool el-Sook District during 2014 and 2015 (L.S.D.(p=5%)=0.42 and 0.45 for the two successive years.

Statistical analysis indicated that, *R. ferrugineus* adults showed differences in their responses towards the tested lures. However, pheromone alone (1.2±0.9 and 1.3 ± 1.1 individuals/trap) or mixed with kairomone (1.3 ± 1.1 and 1.6 ± 1.1 individuals/trap) exhibited the highest attractiveness for the RPW adults with no significant differences, in the 1st and 2nd years, respectively. While, kairomone alone traps lured relatively low numbers of *R. ferrugineus* adults (0.1 ± 0.2 and 0.24 ± 0.2, in the first and second years, respectively), and represented the second group that was less significant preferred (Figure, 3).

The influence of date palm fruit on the overall efficiency of pheromone + kairomone traps:

The response of RPW, *R. ferrugineus*, to food-baited pheromone traps contained different weights of date palm fruits have been evaluated in two years (2015 and 2016). The obtained results are summarized and illustrated in Table(1) and Figure (4).

Data presented in Table (1) and Figure (4) showed the mean number of *R. ferrugineus* adults attracted to the different food- baited pheromone traps. Traps contained date fruits captured more weevils than traps without fruits. Moreover, higher rates of fruit weight improve captures up to the highest rate tested of 1 Kg.

Table 1. Efficacy of traps using different weights of date fruits with or without ferrugineol in trapping *Rhynchophorus ferrugineus* adults in the field during two successive years (2015 and 2016) from June to September.

Treatments	Mean No. of insects/trap.		% of total capture	
	2015	2016	2015	2016
Ph.+ K.	3.1 ± 1.3 cd	5.2 ± 3.3 bc	10.1	13.2
Ph.+k+0.2 Kg date	4.4 ± 2.2 bc	5.9 ± 2.6 b	14.3	15.0
Ph+k+0.4 Kg date	6.0 ± 2.1 ab	7.0 ± 2.0 ab	19.5	17.8
Ph+k+0.7 Kg date	7.2 ± 1.9 a	9.4 ± 2.7 a	23.5	23.9
Ph+k+1 kg date	8.5 ±1.7 a	9.7 ±2.0 a	27.7	24.6
(control)1 kg date	1.5 ± 0.9 d	2.2 ± 0.8 d	4.9	5.5
L.S.D.(P= 5%)	2.6	3.5	100	100

Data illustrated in Figure (4) indicated that *R. ferrugineus* adults show differences in their responses towards date palm fruit weights. However, traps contained 1Kg date fruits exhibited the highest attractiveness for RPW adults, while the lowest potentiality was recorded at 0.2 Kg. The obtained data obviously indicated that date palm fruits had a positive relationship between captured RPW adults and date fruit weights. However, the attractant insects increased significantly as the weights increased (Table,1). With respect to statistical analysis, there was significant difference between the efficiency of traps contained date fruits and no fruits. However combination of pheromone + kairomone + food bait recorded significantly higher mean cumulative RPW capture with 14.3, 19.5, 23.5 and 27.7 % of total capture of weevils in traps contained 02., 0.4, 0.7 and 1 kilogram of date fruit respectively. In the second year, these percent was 13.2, 15.0, 17.8, 23.9 and 24.6%, respectively.

In general, it could be concluded that co-attractants based on fermenting date fruits and ethyl acetate, are able to improve the attractant level of ferrugineol.

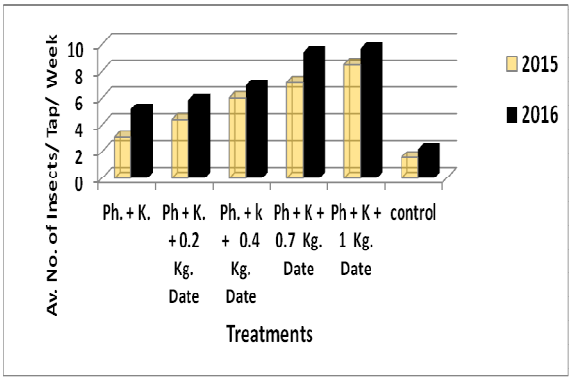

Figure 4. Grand mean number of attracted *Rhynchophorus ferrugineus* adults/trap to traps using different weights of date fruits with or without (ferrugineol + Kairomone) in the field during two successive years (2015 and 2016) from June to September.

DISCUSSION

1- Behavioral reaction of *R. ferrugineus* adults in response to ferrugineol, ethyl acetate and their mixture.

The swarming activity of the adult of red palm weevil, *R. ferrugineus* was studied in response to pheromone, kairomone and their mixture at Mashtool el-Sook District, Sharkia Governorate during two successive years. The obtained results indicated that *R. ferrugineus* population was active throughout the year, except in winter (in both years). In Egypt several authors came to similar conclusions (El-Deeb *et al*.2015), the lowest activity was recorded in winter months at Abo-Nagi, EL-Kassassien district, Ismailia Governorate and at Sharkia Governorate (Abd El- Fattah,S.M, 2010). In Oman, Abdallah and Al-Khatri (2005) reported that the adult emerging continually throughout the year. The minimum number of insects was recorded during December and January.

In the present study, *R. ferrugineus* exhibited the highest abundance during July, August and September in the first and second years at Sharkyia Governorate, Egypt. While, in Tunisia the highest catch by pheromone traps was recorded during September- October (Dhouibi *et al*., 2017). This variation may be due to the differences in weather factors. However, prevailing climatic conditions influence weevil activity. In the Middle East peak weevil activity is recorded between March and May while a second peak in captures occurs during October and November (Abraham *et al*., 1998; Vidyasagar *et al*., 2000; Soroker *et al*., 2005).

The present study cleared that *R. ferrugineus* adults showed differences in their responses towards the tested lures. However, pheromone alone or mixed with kairomone exhibited the highest attractiveness for the RPW adults with no significant differences. While, kairomone (acetyl ether) alone traps lured relatively low numbers of *R. ferrugineus* adults, and represented the third group that was less significant preferred. Similar conclusion was obtained by Vacas *et al*., 2014.

2. The influence of date palm fruit on the overall efficiency of pheromone + kairomone traps:

The obtained data cleared that co-attractants based on fermenting date fruits and ethyl acetate, are able to improve the attractant level of ferrugineol. The obtained data agree with Gries *et al*.(1994) that palm tissue was significantly more effective in enhancing pheromone attraction. Hallett *et al*. (1993) concluded that inclusion of food baits in traps is crucially important as host volatiles have a striking synergistic effect on RPW response to pheromones. Also, Zagatti *et al*,(1997) reported that RPW adults are attracted by allelochemicals released by the fermenting tissues of wounded host-plants. Similar conclusion was obtained by Vacas *et al*.(2014). Also, Oehlschlager *et al.* (1993) reported that volatiles produced from fermented date and coconut palms (e.g., ethyl propionate and ethyl butyrate) strongly enhance the attractiveness of pheromone traps of *R. ferrugineus*. Tokitomo *et al.* (2005) and Azmi *et al* (2014) demonstrated volatiles or esters and some active compounds produced by the food baits during the fermentation process can trigger the primary attraction of RPWs to the traps. According to Zada *et al*. (2002) and Abdallah and Al-Khatri, (2005) this enhancement is due to palm tissues that develop the fermentation processes that produce volatiles, which are synergistic to weevil aggregation pheromones. According to Hallett (1996); Faleiro and Kumar (2008); Al-Saoud *et al.* (2010) and Azmi *et al* (2014) volatiles associated with fermented sugarcane, date, coconut petioles and pineapple have been reported as an attractant to *R. ferrugineus*.

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النشاط الموسمي لحشرة سوسة النخيل تجاه بعض المنبهات الشمية

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تم دراسة النشاط الموسمي لسوسة النخيل الحمراء خلال عامي 2014 و 2015 بمزارع النخيل بمنطقة مشتول السوق بمحافظة الشرقية باستخدام مصائد تحتوي على بعض الجاذبات الشمية [فرمون التجمع، الكيرومون (اسيتيل اسيتات) والخليط منهما]. وقد اظهر تعداد الحشرة أعلى استجابة تجاه خليط الفرمون والكيرومون تلاه الفرمون منفرداً (بدون اختلافات معنوية بينهما) وأقل استجابة كانت تجاه الكيرومون منفرداً. وقد بلغ متوسط الجذب الاسبوعي لخليط الفرمون والكيرومون خلال عامي الدراسة 1.3±1.1 و 1.6±1.1 حشرة/مصيدة على التوالى، أما في حالة الفرمون منفردا فقد بلغ المتوسط الاسبوعي 1.2±0.9 و1.3±1.1 حشرة/مصيدة، وفي حالة الكيرومون منفرداً بلغ المتوسط 0.1±0.2 و0.24±0.2 حشرة/مصيدة/اسبوع خلال عامي 2014 و2015 على التوالي. من ناحية اخرى اظهر تعداد سوسة النخيل الحمراء 3-4 ذروات للنشاط وكان أعلى نشاط للحشرة خلال شهري يوليو واغسطس من كلا العامين. وقد اوضحت النتائج ان المصائد المحتوية على خليط من الفرمون والكيرومون والطعم الغذائي (ثمار البلح) سجلت أعلى معدل جذب للحشرة حيث سجلت 14.3و 19.5 و 23.5و 27.7 % من اجمالى عدد الحشرات على التوالى وذلك خلال العام الاول ، أما فى العام الثانى فسجلت تلك المصائد 13.2و 15 و 17.8و 23.9 و 24.6% من اجمالى عدد الحشرات على التوالى.