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Rhynchjel and Rinocab Pheromones as Attractants for the Red Palm Weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionoidea: Dryophthoridae) under Field Conditions

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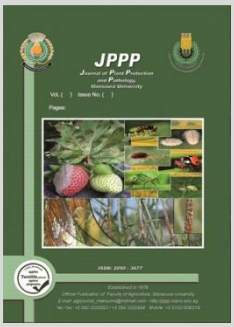

ABSTRACT

The objectives of this work were detection the role of two pheromones types, Rhynchjel and Rinocab, in limitation and control on the infestation with red palm weevil (RPW), *Rhynchophorus ferrugineus* Olivier, (Coleoptera: Curculionoidea: Dryophthoridae). The obtained results from 5traps for Rhynchjel pheromone and 30 traps for Rinocab pheromone at various locations of Belbeis district (Sharkia Governorate) and Ashmoun district (Menoufia Governorate) indicated that each of two types of pheromones obviously attracted different number of RPW adults throughout the year. The results also showed each of population density of catching adults, average population per trap and monthly percentages of attracted adults from annual population. Activity and emergences of RPW adults clearly appeared each of definition of adult emergence time at various geographical regions, peaks of population emergence, sexual percentage of annual adult population and emphasize the role of pheromones in the protection from infestation with RPW where numerous numbers from adult are attracted to pheromone traps which act preventive factor against infestation. The annual population of attracted adults reached 553 &1160 adults for Rhynchjel while attained to 3011 and 4324 adults for Rinocab at the locations of Sharkia and Menoufia Governorates, respectively. This study detected the role of pheromones in restriction of the infestation chance and also minimize of occasion to egg ovipostition where the annual sexual percentage of females recorded 41.59 and 44.9% at Sharkia Governorate, while, it recorded 78.97 and 32.47% at Menoufia Governorate for each Rhynchjel and Rinocab pheromones, respectively.

Keywords: Red palm weevil, *Rhynchophorus ferrugineus*, pheromones taps.

INTRODUCTION

The red palm weevil (RPW) *Rhynchophorus ferrugineus* Olivier, consider one of invasive insects which severely infest different species of palm tress. This weevil seriously cause deterioration the state of infested palm trees and then the death of tress and reduce to production of date crop, Soroker, V. *et al*. (2005).

Varieties studies were carried out in several countries of various regions of the world, aims to the control of this dangerous weevil by different methods in IPM program. Pheromone types are an important component of the program, different designs of traps used worldwide, the inverted bucket and upright traps are commonly used in Saudi Arabia, while the fabricated plastic traps are used in United Arab Emirates, whereas the inverted bucket traps are mostly used in India (Foleiro *et al*., 1998 and Floeiro, 2006).

The previous studies by many researchers showed various results concerning each of different designs of traps, the food bait, lure (pheromone) longevity, insecticide solution, release of chemical into environment , time of year, sex ratio of trapped weevils, trapping efficiency, number of traps according to size of farm and pheromone traps color.

The important investigators of this field were Oehlschlager, (1994), Faleiro *et al*., (1998), Faleiro and Chellapan, (1999), Abraham *et al*., (2001), Kaekeh *et al*., (2001), Faleiro and Satarkar, (2002), Muthiah *et al*., (2002), Faleiro *et al*., (2003), Duoyang *et al*., (2004), Soroker *et al*. (2005), Faleiro, (2006), Muthiah and Nair, (2006), Oehlschlager, (2007), Al-Saoud, (2008); Abbas and Al-Nasser, (2012) and Vacas *et al*., (2013). The purpose of the current work is to realization and detections the effectual role of pheromones in the infestation with R.P.W.

MATERIALS AND METHODS

1- Used pheromones : The chosen tested pheromones clarified in Table (1).

2. The chosen farms of each pheromone:

Two infested palm orchards with RPW were chosen at two locations, each with 12.5 feddans, divided to 5 areas, 2.5 feddans were determined for each tested pheromone for each location. The number of used traps and their distribution in palm farms were carried out according to agriculture ministry protocol.

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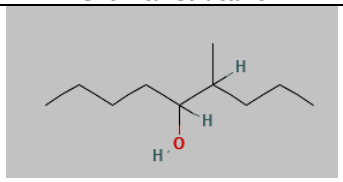
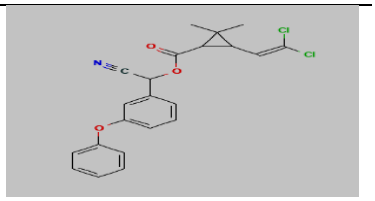
Table 1. Used tested Pheromones against Red Palm Weevil *Rhynchophorus ferrugineus* Olivier.

Common name	Chemical name	Molecular Formula	Molecular Weight	Chemical Structure
Rhynchjel	4-Methule-5nonanol	C10 H22 O	158.28	
Rinocab	Cypermethrin	C22H19Cl2NO3	416.3	

Rhynchjel pheromone.

The infested farms 2.5 feddans of palm trees determined for the tested pheromone **(**Rhynchjel pheromone), at each of Adliya village, Belbeis district (Sharkia Governorate) and AL-Ghanamiya village, Ashmoun district (Menoufia Governorate). Five-traps baited with Rhynchjel pheromones were distributed (in the middle July 2021) in experimental area, at centre of previous divided areas, where each pheromone covered 2.5 feddans almost. Pheromone Lure traps were bimonthly examined, the attracted adults were sexed and counted. The numbers were recorded beginning from the first August 2021 to last week of July 2022.

Rinocab pheromone (attractive pheromone Killer).

Another of infested farms 2.5 feddans of palm trees were determined for the tested pheromone (Rinocab pheromone), were chosen at each of Adliya village, Belbeis district (Sharkia Governorate) and AL-Ghanamiya village, Ashmoun locations (Menoufia Governorate). 30-traps with covers, each trap was provided by attractive pheromone Killer (Rinocab pheromone), were distributed beside palm trees (in the middle July 2021). The traps were bimonthly examined; the attracted and killed adults were sexed and counted during the period from 1st August 2021 to end of July 2022.

The average of attracted and killed adults of each trap, monthly percentage and sexual percentage of attracted annual numbers were estimated as follow:

$$\text{Average of attracted adults/trap} = \frac{\text{Monthly number of attracted adults}}{\text{Number of traps (5 or 30 traps)}}$$

$$\text{Monthly percentage} = \frac{\text{Monthly number of attracted adults}}{\text{Annual number of attracted adults}} \times 100$$

$$\text{Sexual percentage} = \frac{\text{Annual number of males or females}}{\text{Annual number of attracted adults}} \times 100$$

RESULTS AND DISCUSSION

1- Population densities of attracted RPW adults by Rhynchjel pheromone lures.

At Sharkia Governorate:

Population density of catching adults:

Number of RPW adults catching by Rhynchjel pheromone lures during different months of the period from early August 2021 to last July 2022 at Belbeis location, Sharkia Governorate (Table, 2) detected that the highest number of attracted adults (85) recorded during April followed by January (71adults), July (61 adults), February (45 adults), May (43 adults) and November (42adults). While, the lesser numbers of attracted adults observed during the other months of study period, the minimum numbers recorded during June (34 adults), March (32 adults and December (30adults).

Monthly percentages of catching adults:

Monthly percentages from the annual attracted adult cleared that high percentages recorded 15.37%, 12.84% and 11.03% during April, January and July 2022, respectively, while the minimum percentages observed during March 2022(5.79%) and December 2021 (5.42%), whereas the other percentages ranged between 6.15% during June to 8.14% during February 2022, (Table, 2).

Average population per trap:

Averages of catching population by Rhynchjel pheromone lures during the study period showed that the highest average of attracted population of each trap recorded 9.8 adults during 2nd half April 2022 decreased to 6.8, 7.4, 6.75 and 6.4 adults during the 1st half of January, the 2nd half of January, the 1st half of July and 2nd half July 2022, while the lowest average recorded 2.8 adults during the 2nd half of September, the 1st half of October 2021 and the 1st half of June2022, Fig(1).

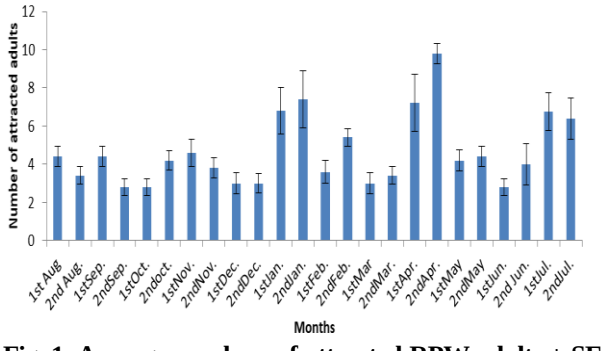


Fig. 1. Average numbers of attracted RPW adults ± SE. by Rhynchjel pheromone traps at Sharkia Governorate during the period from the 1st half of August 2021 to the 2nd half of July 2022.

At Menoufia Governorate:

Population density of catching adults:

Number of RPW adults catching by traps of Rhynchjel pheromone Lures during different months of the period from early August 2021 to last July 2022 at Asmoun

location, Menoufia Governorate (Table, 2) showed that the largest numbers of RPW adults attracted to traps appeared during each of May2022 (201adults), November2021 (134 adults), June2022 (122adults), September 2021 (113adults), April2022 (111adults) then October2021 (105 adults), while the lowest number observed during March2022 (34 adults).

Monthly percentages of catching adults:

The highest monthly percentages of catching adults from annual attracted adults recorded 17.33%, 11.55% and 10.52% adults appeared during May 2022, November2021 and June2022, respectively. The minimum percentages recorded 5.6%, 5.43%, 5%, 5.09% and 2.93% during the months for August2021, December 2021, January2022, February 2022 and March 2022, respectively. The other percentages ranged between 8.19% during July 2022 to 9.74% during September 2021(Table, 2).

Average population per trap:

High values for average population of RPW adults catching by Rhynchjel pheromone lures were remarkable during different months of study period, the highest average recorded 21.6 adults during the 1st half of May 2022followed by the 2nd half of April 2022(19.6 adults) and the 2nd half of May2022(18.6 adults). The moderate values observed during the 2nd half of September 2021 (13.2adults), the 1st half of November2021 (13.4 adults), the 2nd half of November2021 (13.4 adults) and the 1st half of June 2022 (10.4adults), whereas the lowest averages recorded 3.6, 3.2 and 2.6 adults during the 1st half of March2022**,** the 2nd half of March 2022 and the 1st of half April2022 (Fig., 2).

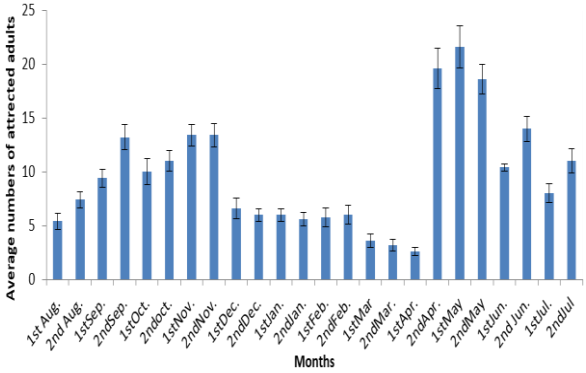


Fig. 2. Average numbers of attracted RPW adults± SE. by Rhynchjel pheromone traps at Menoufia Governorate during the period from the 1st half of August 2021 to the 2nd half of July 2022.

Table 2. Number of RPW adults caught by Rhynchjel pheromone lures during different months of the period first August 2021 to last July 2022 at Sharkia and Menoufia Governorates.

Months	Sharkia Governorate					Menoufia Governorate				
	No. of attracted adults			Monthly	Monthly	No. of attracted adults			Monthly	Monthly
	M.	F.	Total	Cu./(5traps)	%	M.	F.	Total	Cu./(5traps)	%
Aug.	23	16	39	39	7.05	20	45	65	65	5.6
Sep.	20	16	36	75	6.51	35	78	113	178	9.74
Oct.	15	20	35	110	6.33	25	80	105	283	9.05
Nov.	31	11	42	152	7.59	18	116	134	417	11.55
Dec.	17	13	30	182	5.42	11	52	63	480	5.43
Jan.	34	37	71	253	12.84	15	43	58	538	5.00
Feb.	25	20	45	298	8.14	14	45	59	597	5.09
Mar.	18	14	32	330	5.79	8	26	34	631	2.93
Apr.	51	34	85	415	15.37	21	90	111	742	9.57
May	28	15	43	458	7.78	16	185	201	943	17.33
Jun.	16	18	34	492	6.15	26	96	122	1070	10.52
Jul.	41	20	61	553	11.03	35	60	95	1160	8.19
Total	323	230	553	553	100	244	916	1160	1160	100
Sex ratio %	58.41	41.59	----------			21.03	78.97	----------		

M.= Male, F.= Female, Cu = cumulative

2. Population densities of attracted RPW adults by Rinocab pheromone.

At Sharkia Governorate:

Population density of attracted adults:

Obtained data on population density of attracted RPW adults by Rinocab pheromone (A killer attractant pheromone) at Belbeis location, Sharkia Governorate during the different months of the period from first August 2021 to last July 2022 are illustrated in Table(3). The results clearly showed that the highest number of attracted and killing RPW adult inside pheromone traps was recorded during March2022(412 adults) followed by February 2022 (386 adults), November 2021 (353adults), December 2021 (252adults), while the lowest numbers observed during each of October2021 (197adults), August2021 (187adults) then September 2021 (173adults).

Monthly percentages of attracted adults:

Monthly percentages of attracted adults from annual attraction were high during March 2022 (13.68%), February 2022(12.82) and November 2021(11.72%) whereas, the minimum percentages were ranged between 5.75% observed during September 2021 to 8.37% recorded during December 2021, Table (3).

Average population per trap:

The average numbers of attracted RPW adults to Rinncab pheromone traps at Belbeis location was ranged between 2.03adults recorded during 1st half of September 2021 to 7.63 adults observed during the 1st half of March 2022 which followed with 6.8, 6.63, 6.23 and 6.1 adults during the 2ndhalf of November2021, the 2nd half of February2022, the 1st half of February2022 and the 2nd half of March 2022, respectively. While the minimum averages of attracted adults to trap recorded during the 1st half of September2021 (2.46adults) , the 1st half of January2022 (2.1adults) and the 1st half of August2021 (2.03 adults), Fig. (3).

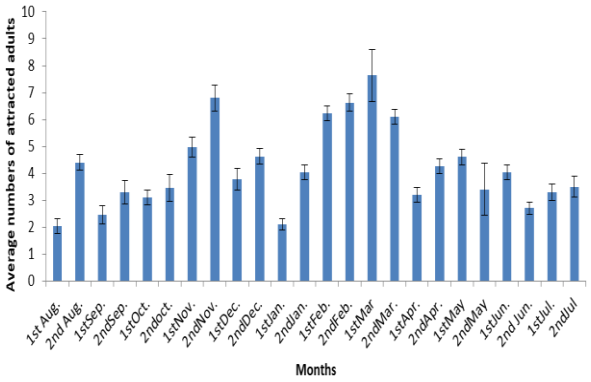


Fig. 3.Average numbers of attracted RPW adults ± SE. by Rinocab pheromone traps at Sharkia Governorate during the period from the 1st half of August 2021 to the 2nd half of July 2022.

At Menoufia Governorate:

Population density of catching adult:

Rinocab pheromone traps which placed in palm tree orchards at Ashmoun location, Menoufia Governorate during the period from the first August 2021 to last July2022 (Table 3) appeared that large number of RPW adults were attracted to traps during October2021 (553adults), May2022 (465adults), April 2022 (428adults), June 2022(373adults) Then November2021 (370adults), while, the minimum numbers were recorded during January 2022(253 adults), December 2021 (207adults) and February 2022(135adults).

Monthly percentages of attracted adults:

Highest monthly percentages of annual attraction by Rinocab pheromone were recorded 12.79% during October 2021 followed by 10.75% during May2022, while the minimum percentages arrived to 5.85% and 4.79% during January2022 and December2021, respectively (Table, 3).

Average population per trap:

The average of attracted RPW adults of each Rinocab pheromone trap ranged from 2.3 adults/trap recorded during 1st half of December2021to 9.8adults /trap collected during 1st half of October2021. The highest averages of attracted adults found during May2022 (9.57adults/trap), 1st half of April 2022(8.87adults/trap), 2nd half of October 2021 (8.6adults /trap), 2nd half of Novenber2021 (8adults/trap), 2nd half of September 2021 (6.8adults/trap) and 2nd half of February 2022 (6.3adults/trap). While the minimum averages of attracted adults for each trap observed during the 2nd half of July2022 (3.57adults), the 2nd half of January2022 (3.3adults) and the 1st half of December2021 (2.3adults), Fig. (4).

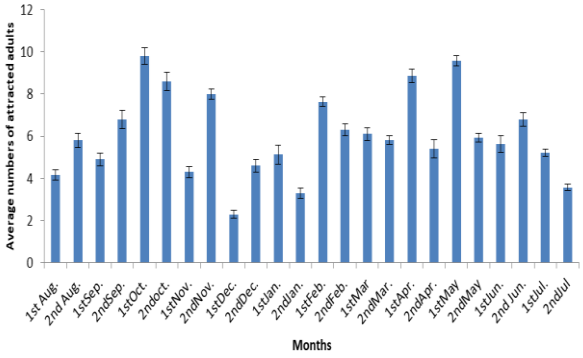


Fig. 4. Average numbers of attracted RPW adults ± SE. by Rinocab pheromone traps at Menoufia Governorate during the period from the 1st half of August 2021 to the 2nd half of July 2022.

Table 3. Number of attracted and killing adults of RPW by Rinocab pheromone traps during different months of the period from first August 2021 to last July 2022 at Sharkia and Menoufia Governorates.

Months	Sharkia Governorate					Menoufia Governorate				
	No. of attracted adults			Monthly	Monthly	No. of attracted adults			Monthly	Monthly
	M.	F.	Total	Cu./ (5traps)	%	M.	F.	Total	Cu./ (5traps)	%
Aug.	91	96	187	187	6.21	161	123	284	284	6.57%
Sep.	83	90	173	360	5.75	203	149	352	636	8.14
Oct.	123	74	147	557	6.54	348	205	553	1189	12.79
Nov.	216	137	353	910	11.72	250	120	370	1559	8.56
Dec.	138	114	252	1162	8.37	140	67	207	1766	4.79
Jan.	107	77	184	1346	6.11	167	86	253	2019	5.85
Feb.	207	179	386	1732	12.82	283	135	418	2437	9.67
Mar.	211	201	412	2144	13.68	270	88	358	2795	8.28
Apr.	120	104	224	2368	7.44	321	107	428	3223	9.90
May	136	100	236	2604	7.84	347	118	465	3688	10.75
Jun.	107	95	202	2806	6.71	284	89	373	4061	8.63
Jul.	120	85	205	3011	6.81	146	117	263	4324	6.02
Total	1659	1352	3011	3011		2920	1404	4324	4324	
Sex ratio%	55.1	44.9	----------		100	67.53	32.47	----------		100

M.= Male, F.= Female, Cu = cumulative

3. Pheromones as indicator on activity and emergence of RPW adults

Attracted adults to pheromone traps indicate to the emergence time of RPW adults during the annual activity period and detected the collected numbers of each males and females from different pheromone traps, baited by Rhynchjel and Rinocab pheromones, at half monthly periods, from the 1st half of August 2021 until the 2nd half of July 2022. The obtained results are illustrated by figures 5 & 6 for Rhynchjel pheromone at different locations of Sharkia and Menoufia Governorates, respectively and figures 7 & 8 for Rinocab pheromones at some locations of pervious Governorates. The fore mentioned figures also obviously showed the population peaks of attracted RPW females and males at study regions.

Peaks of emergence population

The illustrated data on attracted adults showed that the activity and emergence of RPW adults were continued during a whole year in different locations at various geographical regions (Sharkia and Menoufia Governorates) and revealed that the differences in population fluctuation during different seasons.

Results on population density of attacked RPW adults, during the period from the 1st half of August2021 to the 2nd half of July2022 (Table1&2), attracted to pheromone traps placed in palm orchards at Sharkia and Menoufia Governorates, at Belbeis, Sharkia Governorate showed that Rhynchjel pheromone discovered 3peaks of population (85, 71 and 61adults) observed at April, January and July whereas, Rhynchjel pheromone revealed 2peaks of population (201& 134 adults) for May and November at Menoufia Governorate. While Rinocab pheromone detected 3 peaks (412, 386 and 353 adults for March, February and November) at Belbeis, Sharkia Governorate whereas, Rinocab pheromone at Ashmoun, Menoufia Governorate showed also 3 peaks of population (553, 465 and 428 adults) recorded during October, May and April.

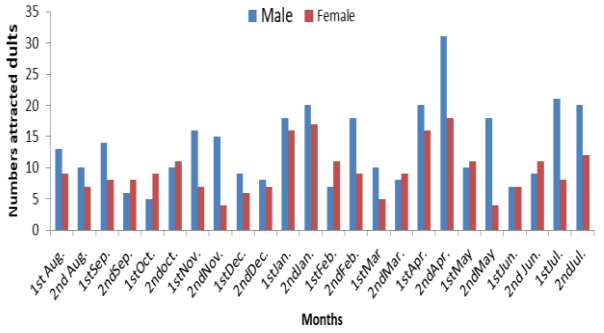


Fig. 5. Number of captured red palm weevils, *R. ferrugineus* adults by Rhynchjel pheromone traps in date palm orchard at Belbeis, Sharkia Governorate.

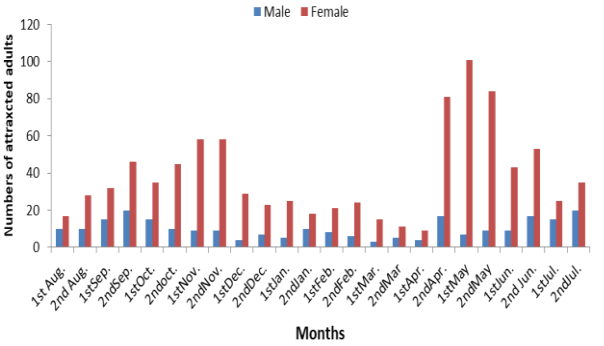


Fig. 6. Number of captured red palm weevils, *R. ferrugineus* adults by Rhynchjel pheromone traps in date palm orchard at Ashmoun, Menoufia Governorate.

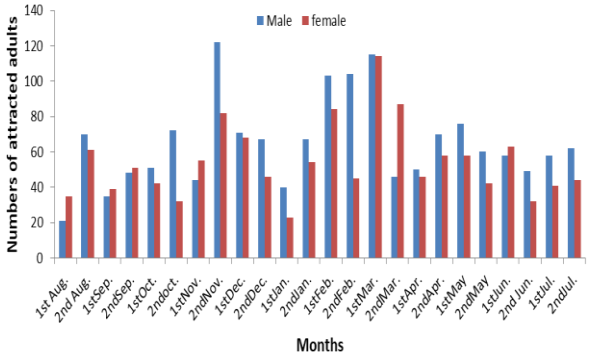


Fig. 7. Number of captured red palm weevils, *R. ferrugineus* adults by Rinocab pheromone traps in date palm orchard at Belbeis, Sharkia Governorate.

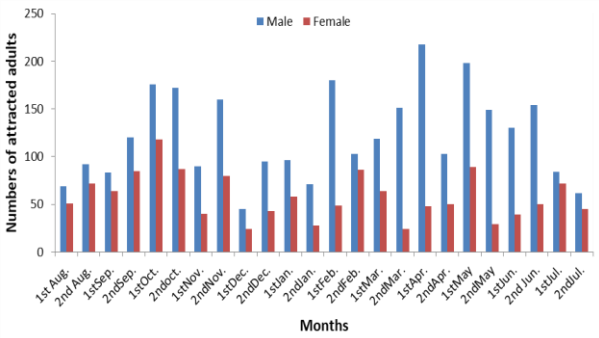


Fig. 8. Number of captured red palm weevils, *R. ferrugineus* adults by Rinocab pheromone traps in date palm orchard at Ashmoun, Menoufia Governorate.

Sexual percentage of annual adult population

Annual number of catching adults by pheromone traps (Tables, 2 & 3) showed the annual percentage of each females and males collected by Rhynchjel and Rinocab pheromones from palm tree orchards showed that the percentages of males and females recorded 58.41% and 41.59% in Sharkia Governorate by Rhynchjel pheromone, while Rinocab at the same Governorate recorded 55.1 and 44.90% of each males and females. Whereas the percentages appeared 21.03 and 78.97% for Rhynchjel at Menoufia Governorate, while this percentage recorded 67.53 and 32.47% for Rinocab pheromone at Menoufia Governorate.

Most previous and varieties studies on several pheromone of red palm weevil were interest with at attracting adults of red palm weevil to the different designs traps including shapes, colors, heights and different types of pheromones as well as food bait, number of traps relative to area of the farm.

Data are in agreement with that obtained by Chakravarthy A K, *et al.* (2014). The study was conducted in Bangalore, South India to know the attractiveness of red palm weevil to aggregation pheromone. The result obtained indicated that, the aggregation pheromone of red palm weevil attracted significantly more number of weevils (13.4 females and 7.6 male weevils) than control. Similarly, field studies found that both 750 and 1000mg pheromone dosage lures of red palm weevil trapped significantly higher numbers of weevils (695.80 females and 789 male weevils,). On an average 80-85% red palm weevil population got trapped. Observations indicated activity of red palm weevil throughout the year. Pheromone traps for red palm weevil can be placed in fields from June to August. Population reductions of pest by pheromone traps are compatible with mechanical and cultural management tools with cumulative effects.

From researchers interested in this filed Faleiro *et al*., (1998); Muthiah *et al*., (2002); Duoyang *et al*., (2004); Muthiah and Nair, (2006); Al-Saoud, (2008); Abbas and Al-Nasser, (2012) and Vacas *et al*., (2013) who carried out studies on ecology, evaluations of some aggregations pheromones types, several attractants, evaluations of food baits. The current work is to realization and detection the effect role of pheromones limitation and control on the infestation with red palm weevil.

CONCLUSION

The current works appeared the following information:- population densities of attracted RPW, monthly percentage of catching adults, population per trap, activity and emergence of RPW, definition of adult time emergence population, sexual percentage of annual adult population and Role of pheromone in the protection from infestation with RPW. The obtained results from this work on each of Rhynchjel pheromone (attractive pheromone) and Rinocab pheromone (attractive pheromone Killer) detected important pheromones as limiting factors and control palm trees infestation by RPW.

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الفرمونات Rhynchjel و Rinocab كجاذبات لسوسة النخيل الحمراء *Rhynchophorus ferrugineus* (Coleoptera: Curculionoidea: Dryophthoridae)Olivier تحت الظروف الحقلية

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الملخص

تهدف هذه الدراسة تقييم دور نوعين من الفيرمونات رينوكاب و رينكوجل فى السيطرة على الاصابة بسوسة النخيل الحمراء *Rhynchophorus ferrugineus* Olivier . وقد أظهرت النتائج المتحصل عليها من خمس مصائد لفيرمون رينكوجل و30 مصيدة لفيرمون رينوكاب فى مواقع مختلفة بمركز بلبيس (محافظة الشرقية) و مركز أشمون (محافظة المنوفية) أن كل من النموذجين من الفيرمونات جذبت بوضوح أعداد مختلفة للحشرات الكاملة لسوسة النخيل الحمراء خلال العام . كذلك أوضحت النتائج كلا من كثافة تعداد المصائد ، متوسط التعداد لكل مصيدة والنسبة المئوية للحشرات المنجذبة من التعداد السنوى ، ونشاط خروج حشرات سوسة النخيل الحمراء ، وقد تم تحديد وقت خروج الحشرات فى المناطق الجغرافية المختلفة ، وقمم خروج التعداد ، والنسبة المئوية الجنسية لتعداد الحشرات ، كما أكدت النتائج دور الفيرمونات فى جذب أعداد وفيرة من الحشرات الكاملة والتى تعمل على الوقاية من الاصابة بسوسة النخيل الحمراء . وأثبتت النتائج أن التعداد السنوى للحشرات المنجذبة بلغت 533 و1160 حشرة لفيرمون رينكوجل بينما وصلت إلى 3011 و 4324 حشرة لفيرمون رينوكاب عند مواقع محافظات الشرقية والمنوفية على التوالى . وقد أثبتت هذة الدراسة دور الفيرمونات فى الحد من الاصابة وفرصة وضع البيض حيث سجلت النسبة المئوية الجنسية للإناث 44.9 و 41.59٪ فى محافظة الشرقية ، بينما كانت النسبة 78.97 و 32.47٪ فى محافظة المنوفية لكل من فيرمون رينكوجل و رينوكاب على التوالى .