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Effect of Weather Factors on Seasonal Population Fluctuation of Red Palm Weevil, *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculioinidae) Adults Attracted to Pheromone Traps at El-Sharkia Governorate, in Egypt

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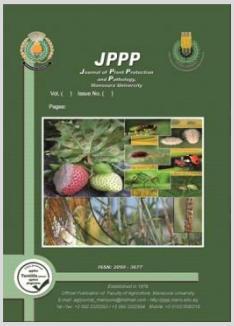

ABSTRACT

The Seasonal population fluctuation of red palm weevil, *Rhynchophorus ferrugineus* Olivier (RPW) (male and females) was estimated during two successive seasons (2017/2018 and 2018/2019) by using aggregation pheromone traps in date palm orchards located at Newly Salhea district, El-Sharkia Governorate, Egypt. The results obtained during the two successive seasons of study showed that, the average number of insects per year was different. Season, 2018/2019 was highest more than season, 2017/2018.The highest number adult stage of red palm weevil, RPW captured by pheromone traps was recorded in April. Four peaks of swarming activity on date palm trees throughout the two seasons April, November, March and May, respectively. In both seasons, the first peak occurred during April, while the second one occurred during November. Number of attracted female was considerable high than attracted males. Where the sex rstio % for male percentages were 1: 1.85% for male and female, respectively in season 2017/2018 while in season, 2018/2019 the male percentages were 1: 1.75 % for male and female, respectively. These results also revealed that effect of weather factors on capturing both simple correlation and regression values were insignificant positive effects for maximum, temperature and wind velocity on number of captured adults of RPW in the two seasons, while it was insignificant negative effects for mini Temp. , max, Mini relative humidity and the explained variance percentage (E.v. %) for the three weather factors on the number of captured adult was 7.88%.

Keyword: *Rhynchophorus ferrugineus* Olivier (RPW), Date palm, Aggregation pheromone Sex ratio, weather factors.

INTRODUCTION

The date palm, *Phoenix dactylifera* (Palmae) is the most common and widely cultivated plant in the arid regions of the Middle East and North Africa where, in many areas, its fruit has provided the carbohydrate food of local people, (Jones 1995). The red palm weevil (RPW) *Rhynchophorus. ferrugineus* (Olivier) (Coleoptera: Curculionidae) was first described in Egypt as a serious pest of date palm trees. During the last decade of the 20thcentury *R. ferrugineus* was firstly recorded in date palm plantations in Egypt (Saleh and Gouhar, 1993). The captured number of adults demonstrates the highest figures during the extended from April to June, which harbor the optimum weather factors. The valuable number of trapping adults was achieved during this period was probably due to the earlier simultaneous effect of micro climate factors that affecting the larval stage during summer months, (El-Garhy, 1996). Field experiment and stated that, *R. ferrugineus* had two main seasonal activities annually in Egypt. The first adult brood was during April and the second one was during November. It was found that there was no relationship between seasonal population fluctuation and weather factors. Female's density was more than males and represented 52.8 – 57.8 % of total population in the field, (El-Sebay, 2003).The use of pheromones in monitoring and controlling RPW populations has become an important effective tool (El-Ezaby *et al.*, 1998; Faleiro, 2005).

The aim of this study is based on field experiments to study the effect of weather factors on seasonal abundance and population trends of red palm weevil, *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculioinidae) adults attracted to pheromone traps.

MATERIALS AND METHODS

The experimental date palm orchard, an area of about 10 feddan was chosen at Newly Salhea district, El-Sharkia Governorate, Egypt. The field trials were carried out for two successive date palm growing seasons from May 2017 until April 2019.Standard Saudi bucket pheromone traps were used in the present study .The traps were placed tightly on soil surface. A number of round holes were made to allow adult weevils entry inside the trap safely and easily .The used traps commonly consists of plastic bucket (9 liter in size). The bucket was punctured around its wall with 4 holes each of 2.5 cm diameter at 15 cm from the bottom. Traps were with cover and buried in the ground down to the level of 15 cm to facilitate entrance of *R. ferrugineus* adults. Part-burying of the trap also prevented it from being over-turned by wind or animals or water of flooded irrigation. Each trap was 4 meter away from date palm trees (to avoid that any adult could miss the trap and lay eggs on the palm tree) in the shade to avoid evaporation.

The commercially used pheromone "Ferrugineol" is a synthetic pheromone lures. It is a mixture of 4-methyl–5-

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nanol and 4–methyl–5- nanone (9:1). It is imported from Chem Tica Natural; Costa Rica was used for the present field study. Pheromone sac was placed underside trap top surface. The pheromone releases its active chemicals blames through a plastic membrane (3-10 mg/day) from 400 and 1500 N/tube, respectively under laboratory conditions of 27°C and 50 % R.H.

Selected Kairomone was used as a synergist to activate the potent ability of releasing ethyl acetate blooms. Ethyl acetate bags however were hanged from the underside surface of the trap top releasing chemicals through a fine plastic tube (as 100 and 128 mg /day).

Liquid soap was mixed with top water used in the inside bucket trap. To estimate the seasonal abundance of *R. ferrugineus* 9 traps were distribution in the experimental orchard, for one season , total 18 traps in two seasons, each traps were placed equally spaced and a part 100 m., as one in each block. The recommend bucket traps were distributed uniformly in the selected severely infested area. The changes in the population size were determined by numbers of captured RPW adults based on aggregation pheromone traps. Number of collected weevils caught in the pheromone traps was counted weekly; sexed. The mixture (water soap) was replaced weekly to keep sufficient moisture in each trap for avoid escaping of the adult and it help to kill the insects. Ethyl acetate kairomone and pheromone capsules within each trap were replaced by another new fresh one bi monthly.

The separate effect of three main weather factors namely; maximum daily temperature, minimum night temperature , mean relative humidity R.H.% and A.V.G.Wind (V.m/Sec.) speed in the experimental areas during the periods of study were obtained from the Central Laboratory for Agriculture Meteorology, Agricultural Research Center, Ministry of Agricultural , Giza was estimated and the relationships between changes in the population density , weekly number of the red palm weevil expressed as number of adults captured was worked out and the simple and multiple correlation (r) and regression values were calculated. These regression values are assumed to demonstrate the change in the population activity due to a unit change in any of the three corresponding factors .The partial regression values (b) and explained variance (E.v.%) indicate the average rate of changes in adult activity due to a unit change in any of the three factors. The partial regression methods used in this analysis to helpful in obtaining basic information about the amount of variability in the activity of the red palm weevil which could be attributed to all three weather factors combined (Explained variance).In the meantime, the significance levels of the partial regression values could be obtained through.

Plate 1. Trap design and related compounds

Fig. 1. Diagrammatic drawing of bucket pheromone trap

Statistical analysis:

Results were statistically analysed using a computer Costat programs where: analysis of variance, correlation, regression were Performa (Costat, software, 1990).

RESULTS AND DISCUSSION

1. Seasonal abundance and population trends of *R. ferrugineus*.

Data tabulated in Table (1and 2) and graphically illustrated in Figure (2,3and 4) showed theat monthly changes in the number of red palm weevil during the tested period from January to December and numbers were declined during January and February.in 2017/2018 and 2018/2019 seasons. It was noticed that the captures were more abundant in traps during the summer months than that during the winter. This result also may be due to that the flight activity; densities were more pronounced in warm weather during summer than in cold one.

The average number of insects per year was different. Season, 2018/2019 was highest more than season, 2017/2018.The highest number adult stage of red palm weevil, the highest numbers were recorded in April .Four peaks were recorded in each of the two seasons. These peaks were recorded during April (99), November (88), March (79) and May (72) adults/traps, respectively in season 2017/2018 while in season 2018/2019 were April (109), November (105), March (100) and May (88) adults/traps, respectively. The highest peaks of adult numbers were recorded during two times, the first was on April and the second one was on November. These higher captures rates were probably due to the highly adult emergence occurred from broods completed their developmental period during winter months. Results agree with those recorded by (Gunnawardena and Bandarage, 1995; El- Garhy, 1996 and El -Ezaby, *et al*. 1998) they reported very low number of RPW being captured in December and January, maximum catches in March, April, May and June. Abbas (2000) who reported five peaks for adult capture of RPW during mid-March, end of April, end of June, mid-September and the end of October were recorded during the first season 1995. Six peaks of activity mid-March, end of April, mid of June, mid-July, the end of September and mid-November were recorded during 1996 season. Muralidharan*et al.* (2000) who found that in India the highest population density of the red palm weevil was observed in May (29.6/trap), March (16/trap) and December (4.6/trap). Vidyasagar, *et al.* (2000) in Saudi Arabia showed that the peak adult population of

RPW trapped during April and May. A much lower second peak was observed during October and November months just before winter. El-Sebaey (2003) indicated that *R. ferrugineus* had two main active seasons annually. The first adult brood was observed in April and the second one was in November. Qin *et al.*, (2004) who found that, the population monitoring of red palm weevil occurred in four peaks a year in the area of Wenchang, Hainan Province. The adult population abundance of RPW according to the previously mentioned data is not exactly existed all over the year in two years of study. Abbas *et al.* (2005) indicated that the insect population of red palm weevil increased gradually from January to reach its peak in March, April, or May. Abdallah and Al-Khatri (2005), who observed that RPW adults emerging continually throughout the year. Abbas, *et al.* (2006) population of RPW increased gradually from January and peaks in March, April or May and Sujatha *et al.* (2010) recorded that RPW higher catches of weevils in March, April, May, June and July. El-Sebay,*et al.*, (2010) studied that the highest level of occurrence expressed as adults of red palm weevil caught in aggregating pheromone traps during early spring months i.e. March, April, and May. and EL-Lakwah *et al.* (2011). Average of *R. ferrugineus* adults captured by aggregation pheromone was different during the two years of study.

Table 1. Monthly mean numbers of *Rhynchophorus ferrugineus* (Olivier.) adults captured by nine pheromone traps placed in date palm orchard at Newly Salhea district, El-Sharkia Governorate, during season, 2017/2018.

2017/2018										
Date	No. of captured adult					Weather factors				
	Male	Female	Total	Mean /9 trap	Males %	Temp .C.º		R.H.%		Wind velocity (V.m/se)
						Max. Temp.	Mini. Temp	Max.R.H.%	Mini. R.H.%	Average
May2017	28	44	72	8	38.89	34.3	19.3	76.44	19.86	0.28
Jun.2017	21	41	62	6.89	33.87	36.6	22.5	76.39	21.77	0.21
Jul.2017	16	27	43	4.78	37.21	38.36	24.4	83.65	25.25	0.2
Aug.2017	5	12	17	1.89	29.41	37.5	24.8	83.85	30.47	0.12
Sep.2017	1	8	9	1	11.11	35.95	22.6	83.88	30.35	0.11
Oct.2017	13	21	34	3.78	38.24	31.86	18.5	83.02	30.41	0.13
Nov.2017	32	56	88	9.78	36.36	26.12	13.6	90.25	37.87	0.09
Dec.2017	7	17	24	2.67	29.17	23.01	12.2	90.54	42.89	0.1
Jan.2018	1	5	6	0.67	16.67	18.49	9.04	79.48	37.35	0.38
Feb.2018	3	8	11	1.22	27.27	24.2	11.1	93.35	32.95	0.09
Mar.2018	30	49	79	8.78	37.97	28.77	14.2	79.47	21.53	0.22
Apr.2018	34	65	99	11	34.34	30.46	16.3	77.76	23.31	0.22
Total	191	353	544	60.44	35.11					
Mean	15.92	29.42	45.33							
S.E. ±	3.67	5.99	9.64							
Sex ratio %	35.11	64.89	100							

No. =number %=percentage C. =temperature Max.Temp. =maximum temperature
Mini.Temp. = minimum temperature
Max. R.H. %= maximum relative humidity percentage
Mini. R.H. %= minimum relative humidity percentage
V. m/Sec.=wind velocity meter/second S.E. ± =stander error

Table 2. Monthly mean numbers of *Rhynchophorus ferrugineus* (Olivier.) adults captured by nine pheromone traps placed in date palm orchard at Newly Salhea district, El-Sharkia Governorate during season, 2018/2019.

2018/2019										
Date	No. of captured adult					Weather factors				
	Male	Female	Total	Mean /9 trap	Males %	Temp .C.º		R.H.%		Wind velocity(V.m/se)
						Max.Temp.	Mini.Temp	Max.R.H.%	Mini.R.H.%	Average
May.2018	34	54	88	9.78	38.64	35.2	21.4	35.2	22.08	0.25
Jun.2018	24	46	70	7.78	34.29	36.95	23.4	36.95	21.921	0.26
Jul.2018	21	33	54	6	38.89	37.37	24.6	37.37	28.732	0.26
Aug.2018	7	14	21	2.33	33.33	36.93	24.8	36.93	29.251	0.13
Sep.2018	8	10	18	2	44.44	35.27	23.6	35.27	30.186	0.09
Oct.2018	19	32	51	5.67	37.25	31.65	20.3	31.65	33.254	0.11
Nov.2018	39	66	105	11.67	37.14	27.5	15.5	27.5	34.529	0.04
Dec.2018	12	25	37	4.11	32.43	22.29	12	22.29	40.2	0.15
Jan.2019	1	5	6	0.67	16.67	19.34	8.23	19.34	32.654	0.32
Feb.2019	2	10	12	1.33	16.67	21.1	8.53	21.1	30.296	0.21
Mar.2019	36	64	100	11.11	36	24.09	12.2	24.09	28.846	0.34
Apr.2019	41	68	109	12.11	37.61	26.92	14.4	26.92	24.529	0.33
Total	244	427	671	74.56	36.36					
Mean	20.33	35.58	55.92							
S.E. ±	4.20	6.78	10.96							
Sex ratio %	36.36	63.64	100							

No. =number %=percentage C. =temperature Max. Temp. =maximum temperature Mini. Temp. = minimum temperature
Max. R.H. %= maximum relative humidity percentage
Mini. R.H. %= minimum relative humidity percentage
V. m/Sec.=wind velocity meter/second S.E. ±=stander error

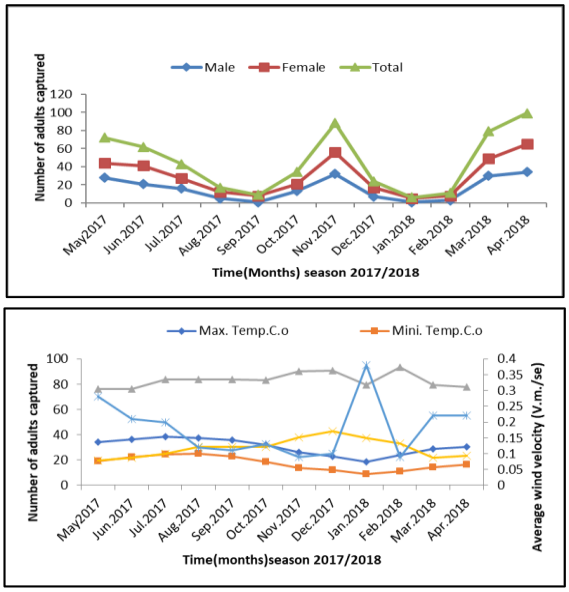

Fig. 2. Seasonal fluctuations of *Rhynchophorus ferrugineus* (Olivier.) adults captured by aggregation pheromone traps placed in date palm orchards at, Newly Salhea district, El-Sharkia Governorate during, 2017/2018 season.

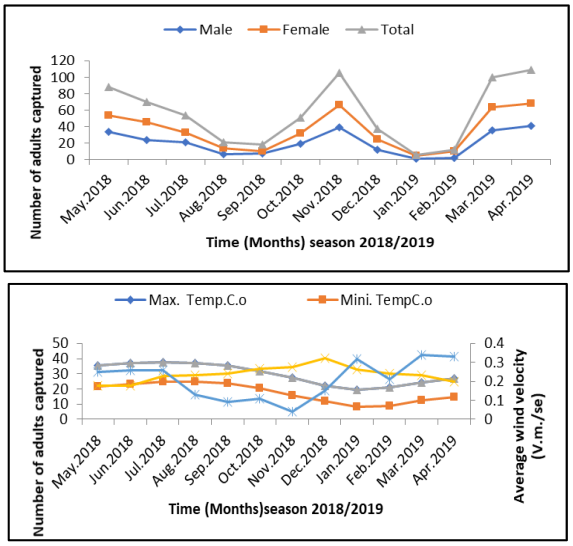

Fig. 3. Seasonal fluctuations of *Rhynchophorus ferrugineus* (Olivier.) adults captured by aggregation pheromone traps placed in date palm orchards at Newly Salhea district, El-Sharkia Governorate during, 2018/2019 season.

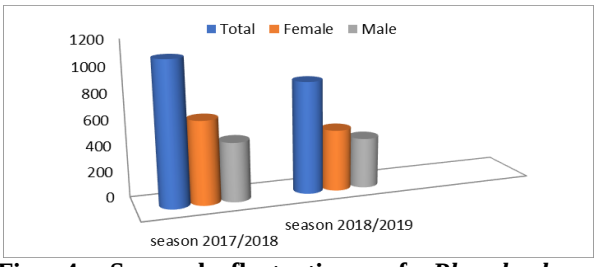

Fig. 4. Seasonal fluctuations of *Rhynchophorus ferrugineus* (Olivier.) adults captured by aggregation pheromone traps placed in date palm orchards at Newly Salhea district, El-Sharkia Governorate during, two successive seasons, 2017/ 2018 and2018/2019 season.

Sex ratio.

As indicated from Table (1 and 2) and Fig. (2 and 3) the male % reached 35.11% and female% 64.89 % which represented 1:1.85. Occurrence of females in traps was higher than males all over the year, 2017/2018 it was increased gradually at the beginning of season and reached its maximum in May 2017 (38.89%). Three mainly period for increasing male captures were recorded, the first during (May2017 until August2017) representing (38.89-29.41% percentages while the second was recorded in (October2017 until December2017) representing (38.24- 29.17%),the third was recorded in (Feb 2018 until Apr.2018) representing (27.27- 34.34 %) while in year, 2018/2019 out the male % reached 36.36 % and female% 63.64 % which represented 1:1.75. Occurrence of females in traps was higher than males all over the year; it was increased gradually at the beginning of season and reached its maximum in Sept 2018 (44.44%). Three mainly period for increasing male captures were recorded, the first during (May 2018 until July 2018) representing (38.64-38.89% percentages while the second was recorded in (Sept.2018 until Nov.2018) representing (44.44- 37.14%), the third was recorded in (Feb 2019 until Apr.2019) representing (16.67-37.61%) such results are agree with. Abbas (2000) who reported the sex ratios of male to female were 33.67 and 33.7: 66.3 during the two successive seasons, respectively .The sex ratios of males was increased to its maximum ratios at the end of November El-Sebay (2003) determined that female density was higher than male density and constituted 52.8-57.8% of the total population in the field. Al-Saoud (2004) found that the sex ratio (males: females) of RPW was 1: 1.75 and 1:2 during the period from July 2003 to February 2004, respectively. Faleiro (2005) found that the weevil captures were female dominated and for every male trapped two female weevils were captured El-Sebay,*et al*., (2010) studied that number of attracted female was considerable high than attracted males

Effect of weather factors:

The statistical analysis of the interaction between maximum temperature and number of captured adults in Table (3) and Figure (2 and 3) revealed that effect of weather factors on capturing both simple correlation and regression values were insignificant positive effects for maximum, temperature in 2017/2018 and 2018/2019 seasons where r value r=0.0764, 0.0604 and b= 0.0228, 0.016 on the numbers of captures, respectively and wind velocity where r value r= 0.0500 , 0.0856 and b=2.203e-4, 4.23e-4 on number of captured adults of RPW in two seasons, while it was insignificant negative effects for mini Temp.in season ,2017/2018 where r value = -0.007, and b=-0.002 while it was insignificant positive effects where r value =0.0278 and b= 0.006 on the numbers of captures, respectively in season,2018/2019, max, relative humidity where r value r=-0.144, -0.0593 and b=-0.090, -0.015 on the numbers of captures, respectively in two seasons, Mini relative humidity where r value r=-0.240, -0.1890 and b=-0.1890, -0.0470 on the numbers of captures, respectively in two seasons and the explained variance percentage (E.v. %) for the three weather factors on the number of captured adult was 7.88 % .The results agree with Weissling *et al.* (1992) and El-Garhy (1996) in Egypt, recorded that the threshold zero for RPW development rank within the range of 12-14

Cº. scare numbers of adult weevils were accordingly captured in December and January, when low temperature were prevailed. The highest numbers during the period extended from April to June, may reflect the optimum weather factors suitable conditions. It may be probably due to an earlier effect of micro climate factors (minimum temperature, relative humidity and wind velocity) ,Faleiro (2005) who found that maximum temperature had a significant impact on the weevil activity in India, the maximum temperature was positively correlated (r =0.51) with weevil captures. Also the data are in agreement with. Osman (2015) showed that there was non-significant positive correlation between daily mean temperature and the population abundance of RPW, while the correlation between means of daily relative humidity and the population abundance of the RPW adults was non-significant negative correlation during the same tested year 2011. Also the results showed that there was significant positive correlation between daily mean temperature and the population abundance of RPW, while the correlation between means of daily relative humidity and the population abundance of the RPW adults was significant negative correlation during the same tested year 2012. Hussain, *et al.*, (2016) found that there were different effects of daily mean temperature and relative humidity on the population activity of *R. ferrugineous* . Hamouda, *et al., (*2020) studied that the effect of relative humidity factor on the population of male and females was negative effect in both tested traps.

Table 3. Simple correlation of different population parameter affected by Max., Mini., Temp.ºC., Max.,Mini.R.H. % and Wind velocity m/sec. values number of *Rhynchophorus ferrugineus* (Olivier.) captured by nine pheromone traps placed in date palm orchard at Newly Salhea district, El-Sharkia Governorate during the two successive seasons ,2017/2018 and 2018/2019.

No. of captured Adult	Weather factors	2017/2018				2018/2019				General mean of E.v.%
		Simple correlation		Regression		Simple correlation		Regression		
				Simple	Multiple			Simple	Multiple	
		r.	p.	b.	E.v.% (R^2x 100)	r.	p.	b.	E.v.% (R^2 × 100)	
Male	Max. Tempºc.	0.0782	0.5389 ns	0.06351	11.02%	0.0828	0.5152 ns	0.0593	5.59%	8.31%
	Mini. Tempºc.	-0.0114	0.928 ns	-0.0078		0.0525	0.6799 ns	0.0344		
	Max. R.H. %	-0.1463	0.2485 ns	-0.1231		-0.0672	0.5974 ns	-0.0453		
	Mini. R.H. %	-0.2553	0.0417 *	-0.2589		-0.1908	0.1309 ns	-0.1257		
	Average wind velocity (m/sec)	0.0559	0.6605 ns	6.6810		0.0777	0.5415 ns	0.0010		
Female	Max. Tempºc.	0.0750	0.5555 ns	0.0354	9.16%	0.0467	0.7136 ns	0.0202	6.15%	7.66%
	Mini. Tempºc.	-0.0058	0.9632 ns	-0.0023		0.0128	0.9197 ns	0.0050		
	Max. R.H.%	-0.1422	0.2622 ns	-0.0695		-0.0542	0.6702 ns	-0.0220		
	Mini. R.H.%	-0.2310	0.0662 ns	-0.1360		-0.1872	0.1385 ns	-0.0744		
	Average wind velocity (m/sec)	0.0463	0.7161 ns	3.2144		0.0900	0.4792 ns	7.1225		
Total	Max. Tempºc.	0.0764	0.548 ns	0.0228	9.88%	0.0604	0.634 ns	0.016	5.88%	7.88%
	Mini. Tempºc.	-0.007	0.950 ns	-0.002		0.0278	0.827 ns	0.006		
	Max.R.H. %	-0.144	0.255 ns	-0.090		-0.0593	0.641 ns	-0.015		
	Mini. R.H.%	-0.240	0.055 ns	-0.090		-0.1890	0.134 ns	-0.0470		
	Average wind velocity (m/sec)	0.0500	0.6945 ns	2.203e-4		0.0856	0.501 ns	4.23e-4		

r = correlation coefficient. P = probability Max. Temp. ºC. = maximum temperature. Mini. Temp. ºC. =minimum temperature. Max.R.H. %= maximum relative humidity percentage. Mini. R.H. %= minimum relative humidity percentage. No=number V.m/Sec.=wind velocity meter/second n.s. = non- significant *=significant -=negative

CONCLUSION

Finally, used mass pheromone traps in IPM to control RPW which considerate dangerous pest in Egypt.

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تأثيرالعوامل الجويه على التقلبات الموسميه لمجموع الحشرات الكامله لسوسه النخيل الحمراء المنجذبه للمصائد الفرمونيه فى محافظه الشرقيه مصر

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أوضحت الدراسة التي أجريت لرصد التغيرات في الكثافة العددية باستخدام المصائد الفرمونية التجميعية لسوسة النخيل الحمراء(الذكوروالاناث) فى مزارع النخيل بمركز الصالحيه الجديده بمحافظة الشرقيه مصرخلال٢٠١٧/٢٠١٨،٢٠١٨/٢٠١٩وجد ا ن معدل تعدادالحشرات لكل سنه مختلف فكان اعلى فى موسم ٢٠١٨ /٢٠١٩عن موسم ٢٠١٧/ ٢٠١٨وأعلى تعداد لطورالحشره الكامله لسوسه النخيل الحمراء التى تم جمعها المصادة بالمصائد الفيرومونية فى أبريل فى كلا الموسيمين وسجلت أربعة ذروات لهذه الحشره على أشجارنخيل البلح خلال الموسم فى ابريل ونوفمبر ومارس ومايو على الترتيب.وفى كلا الموسيمين وجد فترتي نشاط للحشره الاولى فى ابريل والثانيه فى نوفمبركما وجد أن عدد الإناث المنجذبة للمصائد مرتفعا مقارنا بعدد الذكورحيث كانت النسبه الجنسيه للذكور بنسبه ١ للذكور: ٨٥و١ للاناث على الترتيب فى موسم ٢٠١٧/ ٢٠١٨بينما فى موسم ٢٠١٨/٢٠١٩كانت بنسبه١ للذكور: ٧٥و١ للاناث على الترتيب فى موسم ٢٠١٨/ ٢٠١٩ ٠كما أوضحت النتائج ايضا أن قيم الارتباط البسيط والانحداركانت موجبة وغيرمعنوية لدرجة الحرارة العظمى وسرعه الرياح على تعداد الحشرات الكاملة لسوسة النخيل الحمراء المصادة فى الموسمين بينما كانت غيرمعنوية وسالبة لدرجه الحراره الصغرى والرطوبة النسبية العظمى والصغرى فى الموسمين ومعامل الاختلاف للعوامل الثلاثة ٨٨و٧% على تعداد الحشرات الكاملة لسوسة النخيل الحمراء لكلا الموسمين.عموما لابد من استخدام المصائد الفرمونيه التجميعيه فى المكافحه المتكامله لسوسه النخيل الحمراء والحصول على أعلى تأثيرللاصطياد فى مزارع النخيل فى مصر ٠