Population dynamics of Red Palm Weevil, *Rhynchophorus ferrugineus* (Olivier, 1790) Infesting Date Palm Trees in the 10th of Ramadan district, one of the new reclamation areas in Egypt.

Olfat, E. Arafa[1]; Batt, M.A.[1] and El-Shafei, W.K.M.[2*]

[1]Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt
[2]Department of Date Palm Pests and Diseases, Central Laboratory for Date Palm Research and Development, Agricultural Research Center, Giza 12619, Egypt

Abstract

Seasonal abundance of red palm weevil (RPW) adult population along two consecutive years (2022 and 2023) in date palm farms located at 10th of Ramadan, Sharkia Governorate, Egypt, one of the new reclamation areas, was determined using Aggregation pheromone traps. Results indicated that the caught adults in the first year had high population of red palm weevil than those caught in the second year. In the two studied years, three peaks were noted and recorded at March (387, 122), April (574, 200), and November (507, 179) adults for 2022 and 2023 respectively. The highest numbers of RPW adults were recorded in April. There were much more attracted females than males. In the two tested years the proportion of males was 45.27 and 43.60%, while females were 54.73 and 56.40%, respectively which represented 1:1.21 and 1:1.29 in the two tested years 2022 and 2023 respectively. Additionally, these findings demonstrated that the impact of weather factors on RPW adults capturing through both simple correlation and regression values was insignificantly positive for maximum, minimum, and mean temperature, while it was highly significant for mean relative humidity in 2022, furthermore, the correlation was insignificantly negative for maximum, minimum, and mean temperature, while it was significant for relative humidity in 2023. From the obtained results, it can be recommended that if the decision is made for IPM of RPW in the studied area using chemical control by preventive spraying, it must be in conjunction with the timing of the occurrence of the insect peaks.

Keywords: *Rhynchophorus ferrugineus* Olivier (RPW), population dynamics, date palm, weather factors, pheromone trap

[*]**Corresponding author:** waelkamal27@yahoo.com

Introduction

Date palm trees are highly valued for their nutritional benefits and cultural significance, particularly in the Arab world (El-Shafei *et al*., 2018; El-Shafei *et al*., 2019), where their widespread cultivation and diverse growing conditions have contributed to the development of palm farming throughout the region (El-Shafei *et al*., 2020; El-Shafei *et al*., 2022; El-Shafei *et al*., 2024). Egypt ranks among the leading producers of dates globally, contributing around 20% to the world's total date production (FAO, 2022). However, numerous pests negatively impact all parts of the date palm, leading to significant reductions in both the quantity and quality of the fruit produced (Darwish *et al*., 2014; El-Shafei, 2015; Assous *et al*., 2022; Mahmoud *et al*., 2022; El-Shafei & Attia, 2023). One of the most significant and harmful pests affecting date palms worldwide is the red palm weevil (RPW), *Rhynchophorus ferrugineus* (Olivier) (Coleoptera: Curculionidae: Dryophthoridae) (El-Lakwah *et al*., 2011 a; El-Shafei, 2011; El-Shafei & Batt, 2024). The most commonly cultivated date palm varieties are susceptible to RPW infestations (Sallam *et al*., 2012). The widespread distribution of RPW has enabled it to expand into countries across Asia, Africa, Europe, and the Americas, causing significant damage to palm productivity (Giblin-Davis *et al*., 1996). RPW was initially identified as an invasive pest in date palm farms in Egypt's Sharqia and Ismailia governorates (Saleh, 1992; Saleh & Gouhar, 1993) before spreading to other regions of the country. Monitoring RPW population fluctuations in farms and governorates is considered one of the most crucial measures for protecting date palms. By tracking the population dynamics of the pest in a given area, it is possible to identify peak infestation periods, which are optimal for implementing control methods, as well as determine the best times for protecting date palms (El-Lakwah *et al*., 2012). There are also reclamation areas in Egypt where date palm cultivation has been introduced in the last two decades, and no information is available about the RPW population in these regions. Therefore, this research aims to study the seasonal population of the red palm weevil infesting palm cultivations in the 10th of Ramadan area as one of the newly reclamation areas in Egypt to help in developing integrated pest management programs and timing of prevention and control.

Materials and methods

1. Location of the experiments

Field experiments were conducted over two consecutive seasons (2022 and 2023) in a farm located in the 10th of Ramadan region, Sharkia Governorate, Egypt. Aggregation pheromone traps were placed throughout the study area to monitor changes in the red palm weevil (RPW) population activity, measured by the number of adults captured. The date palm farm where the experiments were carried out spans an area of 20 feddans (1 feddan = 4200 m^2). A total of 15 pheromone traps (15 replicates) were distributed, with each trap placed 100 meters apart.

2. Trap design

In this study, traditional bucket traps (standard Saudi bucket pheromone traps) were used. These traps were designed to attract and capture RPW adults. The traps were partially buried to ensure stability and prevent displacement by wind, animals, or flooding irrigation. Each trap was placed in the shade to minimize water evaporation and positioned 4 meters from the date palm trees to prevent adults from bypassing the traps and laying eggs on the palms. Several spherical holes were created on each trap to facilitate easy access for the adult weevils. The traps were made from 10-liter plastic buckets with four 5 cm diameter holes spaced 15 cm from the bottom of the bucket.

3. Trap components

3.1 Synthetic aggregation pheromone lures

The synthetic pheromone used in the traps was "PO28 Ferrolure+" (a commercial blend of 4-methyl-5-nonanol and 4-methyl-5-nonanone in a 9:1 ratio), both of which are more than 95% pure. These components were provided by ChemTica International S.A., Costa Rica. A pheromone sac was suspended from the underside of the trap top, releasing the active components through a plastic barrier at a release rate of 3–10 mg/day. Each lure contained a minimum of 700 mg of the total mixture, packaged in a bubble formulation.

3.2 Ethyl acetate (kairomone)

Ethyl acetate, a kairomone, was used in combination with the pheromone to enhance trap attraction. This kairomone was supplied by ChemTica International S.A. as "Weevil Magnet" 45 mL lures (trade name PO80A), which released 100–128 mg/day of ethyl acetate through a small plastic tube suspended from the trap top.

3.3 Water and poisoned material

Each bucket trap contained 5 liters of water mixed with liquid soap to immobilize and kill the captured weevils.

4. Component renewal timing

To ensure continuous effectiveness, the water-soap mixture was replenished weekly to maintain moisture levels, preventing weevils from escaping and assisting in their death. Additionally, new pheromone and kairomone lures were replaced every three months to ensure consistent release rates.

5. Monitoring RPW adult population fluctuations

RPW population changes were monitored by collecting and counting the number of adults trapped in the aggregation pheromone traps. The trapped adults were removed, sexed, and counted weekly.

6. Weather data and meteorological factors

The Central Laboratory for Agricultural Meteorology, Agricultural Research Center, Ministry of Agriculture, and the reclamation land for the experimental location provided data on the primary meteorological factors during the study periods, including mean relative humidity (R.H.%), minimum nighttime temperature, and maximum daily temperature. Regression analysis and simple and multiple correlation (r) were used to determine the relationships between population fluctuations and the meteorological data. The explained variance (E.v.%) and partial regression values (b) were calculated to quantify the impact of each meteorological factor on RPW population activity.

7. Statistical analysis

Data were analyzed using the Costat statistical software (Costat, 1990). Regression, correlation, and analysis of variance (ANOVA) were performed, following the methods of Fisher (1950), Duncan (1955), Little and Hills (1975), and SAS (1988).

Results and discussion

Population Patterns and Seasonal Abundance of *R. ferrugineus*

The monthly variations in the number of red palm weevil (RPW) adults during the testing period from January to December in the two consecutive seasons of 2022 and 2023 are shown in Figure (1) and reported in Tables (1 & 2). The results indicated three peak periods in each season, occurring in March (387 and 122 RPW adults), April (574 and 200 RPW adults), and November (507 and 179 RPW adults). April and November recorded the highest numbers of adults, with 574 and 200 in 2022 and 507 and 179 in 2023, respectively. In contrast, the numbers of RPW adults were lowest in January and February of both seasons. It was observed that the number of RPW adults captured in the first season (2022) was higher than in the second season (2023). Additionally, more RPW adults were captured during the summer months than during the winter months. This could be attributed to increased flying activity, density, and mating behavior during the warmer summer months. RPW adults captured in the spring and fall months (March, April, October, and November) showed the highest occurrence, with the peak in April likely due to the emergence of broods that had completed their winter development. These findings align with previous studies by El-Garhy (1996), Abbass (2000), and El-Sebay (2003), who observed that RPW populations peak in April, May, and June, with another peak in November. El-Lakwah *et al*. (2011 b) and El-Shafei (2011) also noted that RPW adults are present year-round, with the lowest populations in December and January. Additionally, Saleh *et al*. (2012) reported two annual population maxima, typically in March, April, and November, while Osman (2015) observed four population peaks throughout the year. Similarly, Olfat and Barakatt (2021) found the highest RPW captures in April, with swarming activity peaking in April and November.

Captured RPW adults sex ratio

In both 2022 and 2023, the male percentage of RPW adults was 45.27% in 2022 and 43.60% in 2023, while the female percentage was 54.73% and 56.40%, respectively (see Tables 1 & 2 and Figure 1). This corresponds to male-to-female ratios of 1:1.21 in 2022 and 1:1.29 in 2023. Over the two years, females were more frequently captured in the traps than males. This trend increased from the beginning of the season, peaking in July 2022 (47.51%) and March 2023 (46.72%). There were two primary periods of increased male captures: the first from March to July (45.22–47.51% of the total) and the second from October to December (41.67–43.02%) in 2022. In 2023, the first period was from January to April (30–46.72%), and the second from May to August (43.93–45.45%), with a third from September to December (38.46–37.21%). These findings are consistent with Al-Saoud (2004), who reported a male-to-female ratio of 1:1.33 and 1:1.44 in 2003 and 2004, respectively. Females are often more attracted to the aggregation pheromone than males, likely due to their greater tendency to disperse in search of food sources for their offspring (Faleiro, 2006). Studies by Abd El-Wahab *et al*. (2021) and Olfat and Barakatt (2021) in Egypt have similarly shown that female RPWs are more frequently captured than males.

Relationship between population and weather factors

The data in Table (3) and Figure (1) illustrate how weather factors affected the number of captured RPW adults. The explained variance percentage (E.v.%) for weather factors on the number of captured adults was 0.70% in 2022 and 53% in 2023. Simple correlation and regression analysis revealed insignificant positive effects of maximum, minimum, and mean temperature on the number of captured RPW adults. However, mean relative humidity had a highly significant positive effect on the number of captured adults in 2022, while temperature factors (maximum, minimum, and mean) showed insignificant negative effects on capture rates. These findings align with Faleiro & Satarkar (2005) and Aldryhim & Al Ayedh (2015), while El-Lakwah *et al*. (2011 b) and El-Shafei (2011) found a positive correlation between RPW captures and average temperature. Some studies, such as Mozib & El-Shafie (2013), have found a negative association between temperature and capture rates. Olfat and Barakatt (2021) also reported that maximum temperature and wind velocity had an insignificant positive impact on RPW captures, while minimum temperature and relative humidity had a negative effect. In contrast, Al Ansi *et al*. (2022) noted that pheromone trap effectiveness was greatest at moderate air temperatures (22–33°C), where capture rates were negatively correlated with temperature.

Table (1): The total number of *R. ferrugineus* adults captured each month throughout 2022

Months	2022							
	No. of captured adult				Weather factors			
					Temp. (°C)			R.H.%
	Male	Female	Total	Males %	Max. Temp	Mini. Temp	Mean Temp	Mean R.H.%
Jan.	11	16	27	40.74	17.05	9.57	13.31	58.56
Feb.	18	27	45	40.00	19.48	11.59	15.54	60.15
Mar.	175	212	387	45.22	22.88	13.74	18.31	54.25
Apr.	261	313	574	45.47	27.03	16.28	21.66	49.42
May	162	187	349	46.42	32.14	19.80	25.97	42.88
Jun.	140	164	304	46.05	34.24	22.05	28.15	44.36
Jul.	124	137	261	47.51	34.60	24.19	29.39	56.16
Aug.	92	108	200	46.00	35.34	24.85	30.09	55.67
Sep.	50	70	120	41.67	35.33	24.61	29.97	59.75
Oct.	88	122	210	41.90	31.06	21.58	26.32	60.41
Nov.	234	273	507	46.15	23.52	16.41	19.96	62.07
Dec.	77	102	179	43.02	21.74	12.83	17.28	62.60
Total	1432	1731	3163					
Mean	119.3	144.3	263.6					
S.E. ±	22.85	26.29	40.1					
Sex ratio %	45.27	54.73	100					

No. = Number; % = Percentage; Temp. (°C) = Temperature; Max. Temp. = Maximum Temperature; Min. Temp. = Minimum Temperature; Mean Temp. = Mean Temperature; R.H. % = Relative Humidity (%); S.E. = Standard Error (±)

Table (2): The total number of *R. ferrugineus* adults captured each month throughout 2023

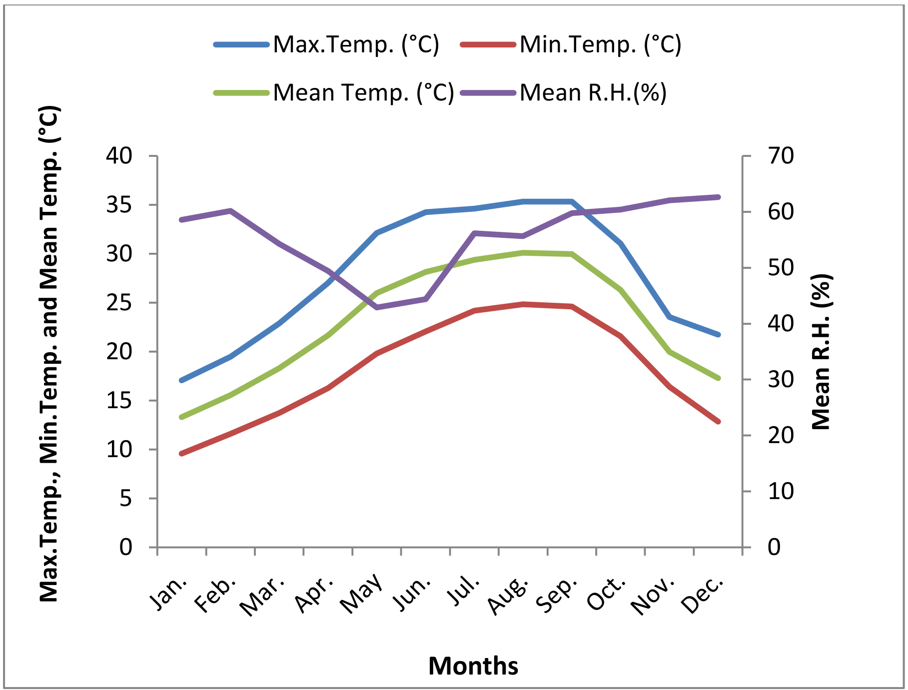
Months	2023							
	No. of captured adult				Weather factors			
					Temp. (°C)			R.H.%
	Male	Female	Total	Males %	Max. Temp	Mini. Temp	Mean Temp	Mean R.H.%
Jan.	3	7	10	30.0	20.74	12.28	16.51	59.92
Feb.	8	12	20	40.0	21.97	12.59	17.28	60.65
Mar.	57	65	122	46.72	26.17	15.17	20.67	55.25
Apr.	92	108	200	46.0	27.49	16.61	22.05	52.39
May	47	62	109	43.93	27.17	18.52	22.85	46.88
Jun.	38	52	90	42.22	34.15	22.96	28.55	48.11
Jul.	30	36	66	45.45	43.88	30.54	37.21	58.46
Aug.	16	24	40	45.45	34.68	25.51	30.09	59.39
Sep.	5	9	14	38.46	33.41	24.59	29.00	61.40
Oct.	18	36	54	31.58	30.59	21.54	26.06	62.19
Nov.	82	97	179	45.81	26.85	18.79	22.82	60.57
Dec.	16	27	43	37.21	22.15	14.97	18.66	60.59
Total	412	533	945					
Mean	34.3	44.42	78.75					
S.E. ±	8.61	9.62	18.18					
Sex ratio %	43.6	56.40	100					

No. = Number; % = Percentage; Temp. (°C) = Temperature; Max. Temp. = Maximum Temperature; Min. Temp. = Minimum Temperature; Mean Temp. = Mean Temperature; R.H. % = Relative Humidity (%); S.E. = Standard Error (±)

Table (3): Simple correlation and both simple and multiple regression analyses of various population parameters affected by Max. Temp., Min. Temp., Mean Temp. (°C), Mean R.H. (%), and the number of *R. ferrugineus* captured by pheromone traps during the two consecutive seasons of 2022 and 2023

No. of captured Adult	Weather factors	2022				2023			
		Simple correlation		Regression		Simple correlation		Regression	
				Simple	Multiple			Simple	Multiple
		r.	p.	b.	E.v.% (R^2x 100)	r.	p.	b.	E.v.% ($R^2 \times 100$)
Male	Max. Temp. (°C)	0.18	0.18 ns	0.54		-0.03	0.85ns	-0.031	
	Min. Temp. (°C)	0.15	0.27 ns	0.55	0.69	-0.05	0.71 ns	-0.046	0.51
	Mean Temp. (°C)	0.17	0.21 ns	0.55		-0.04	0.77ns	-0.04	
	Mean R.H. (%)	-0.34	0.012 *	-0.72		-0.29	0.04 *	-0.29	
Female	Max. Temp. (°C)	0.19	0.18 ns	0.61		-0.04	0.75 ns	-0.05	
	Min. Temp. (°C)	0.15	0.27 ns	0.61	0.72	-0.05	0.74 ns	-0.06	0.55
	Mean Temp. (°C)	0.17	0.21 ns	0.63		-0.04	0.73 ns	-0.06	
	Mean R.H. (%)	-0.36	0.01 **	-0.85		-0.32	0.02 *	-0.38	
Total	Max. Temp. (°C)	0.19	0.18 ns	1.15		-0.04	0.79 ns	-0.07	
	Min. Temp. (°C)	0.15	0.27 ns	1.16	0.70	-0.05	0.72 ns	-0.12	0.53
	Mean Temp. (°C)	0.17	0.21 ns	1.18		-0.04	0.75 ns	-0.09	
	Mean R.H. (%)	-0.35	0.01**	-1.56		-0.31	0.02*	-0.67	

r = correlation coefficient; b = regression coefficient; R^2 = Explained variance (E.v. %); P = probability; max. temp. (°C) = maximum temperature; min. temp. (°C) = minimum temperature; mean temp. (°C) = mean temperature; R.H. % = relative humidity percentage; No = number; ns = non-significant; - = negative.



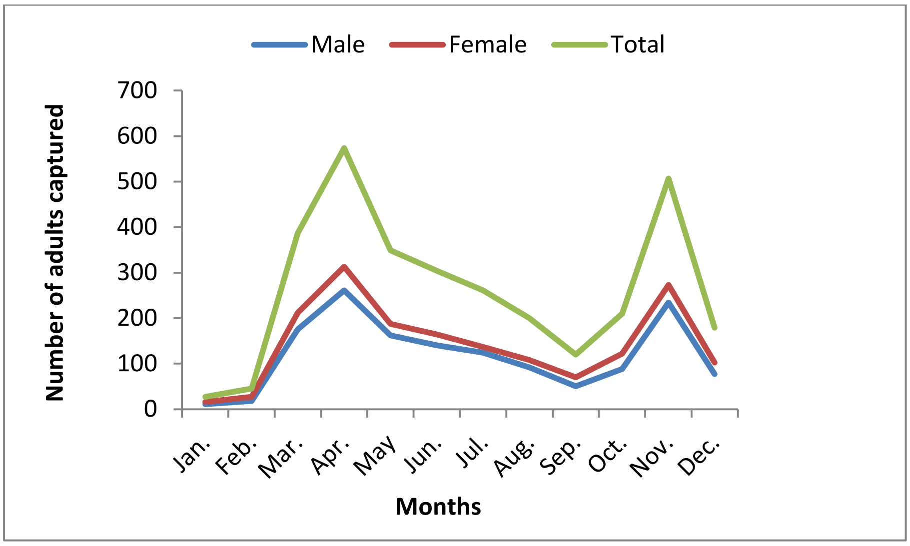
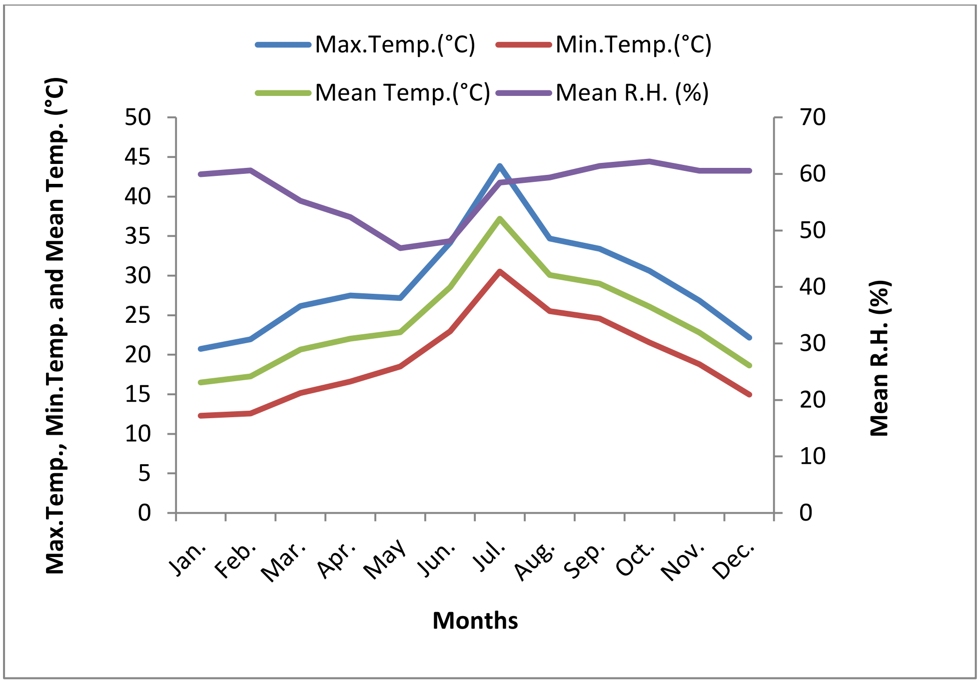


Fig. (1): Seasonal fluctuations of *Rhynchophorus ferrugineus* adults captured by aggregation pheromone along 2022 months



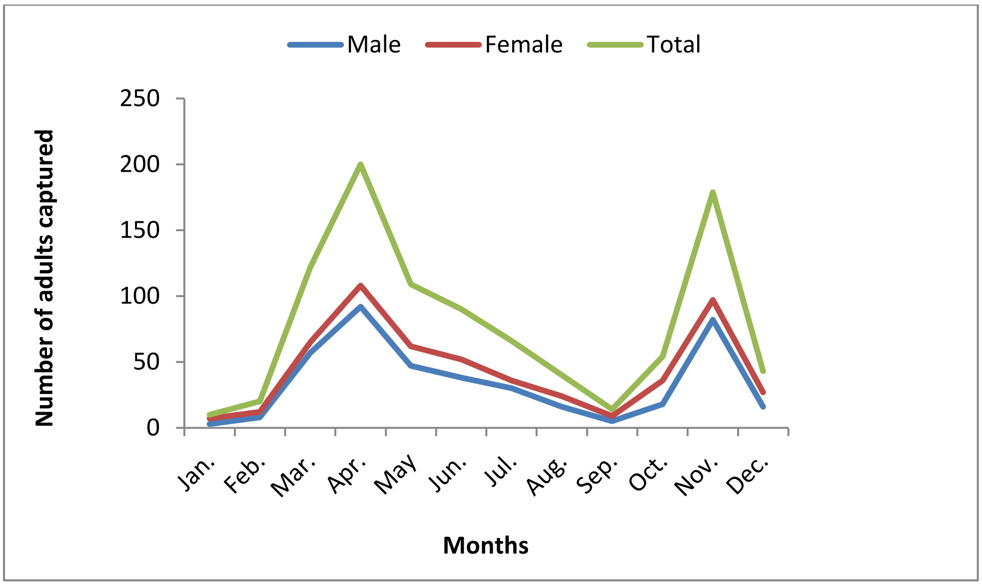


Fig. (2): Seasonal fluctuations of *R. ferrugineus* adults captured by aggregation pheromone along 2023 months

Conclusions

Summarizing the results obtained in this study, we find that the fluctuations RPW population in the 10th of Ramadan area in Sharkia Governorate, one of the new reclamation areas during the years 2022 and 2023. The results showed that RPW has three peaks per year in March, April and November during the two years of the study. The highest insect population was in April and the lowest in January in both years of the study. Also, the numbers of female adults were more than the male adults attracted to the pheromone traps. Therefore, we recommend that if a decision is made to spray preventively against RPW in the studied area within the integrated management program for this pest, it should be in conjunction with the RPW peaks explained in this research.

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ديناميكية تعداد سوسة النخيل الحمراء (Olivier) *Rhynchophorus ferrugineus* التي تصيب أشجار نخيل البلح في مركز العاشر من رمضان، إحدى مناطق الاستصلاح الحديثة في مصر.

الفت السيد عرفة[١]، محمد عبالغنى بط[١]، وائل كمال محمد الشافعى[٢]

[١]معهد بحوث وقاية النباتات – مركز البحوث الزراعية – وزارة الزراعة – الدقى – جيزة – مصر

[٢]قسم آفات وامراض النخيل – المعمل المركزي للأبحاث وتطوير نخيل البلح – مركز البحوث الزراعية- مصر

الملخص العربي

تم تقدير التعداد الموسمي للحشرات الكاملة لسوسة النخيل الحمراء (Oliver) *Rhynchophorus ferrugineus* خلال عامين متتاليين (٢٠٢٢ و٢٠٢٣) باستخدام المصائد الفرمونية التجميعية في مزارع أشجار نخيل التمر بمنطقة العاشر من رمضان، محافظة الشرقية، مصر، وهي إحدى مناطق الاستصلاح الحديثة في مصر. أوضحت النتائج المتحصلة أن تعداد حشرات سوسة النخيل الحمراء المجمعة خلال عام ٢٠٢٢ كان أعلى من تعداد الحشرات المجمعة في عام ٢٠٢٣. تم تسجيل ثلاثة قمم (فترات نشاط) للتعداد خلال عامي الدراسة في مارس (٣٨٧ و ١٢٢ حشرة كاملة)، وأبريل (٥٧٤ و ٢٠٠ حشرة كاملة)، ونوفمبر (٥٠٧ و ١٧٩ حشرة كاملة) في عامي ٢٠٢٢ و٢٠٢٣ على التوالي. سجل أعلى تعداد للحشرة خلال العامين في شهر أبريل. كما كانت أعداد الإناث المنجذبة للمصائد أعلى من الذكور خلال الدراسة. خلال عامي الدراسة، كانت النسبة المئوية للذكور ٤٥,٢٧% في ٢٠٢٢ و ٤٣% في ٢٠٢٣، بينما كانت النسبة المئوية للإناث ٥٤,٧٣% في ٢٠٢٢ و ٥٦,٤% في ٢٠٢٣، مما يعكس نسبة (ذكور: إناث) تساوي ١:١,٢١ في ٢٠٢٢ و ١:١,٢٩ في ٢٠٢٣. أوضحت النتائج أيضًا أن تأثير عوامل المناخ مثل درجات الحرارة العظمى والصغرى والمتوسطة كانت إيجابية وغير معنوية بالنسبة لقيم الارتباط البسيط والانحدار على اصطياد الحشرات الكاملة لسوسة النخيل الحمراء في كلا العامين. أما متوسط الرطوبة النسبية، فقد كان له تأثير إيجابي وعالي المعنوية في موسم ٢٠٢٢، بينما كان تأثير درجات الحرارة العظمى والصغرى والمتوسطة غير معنوي، وكان تأثير متوسط الرطوبة النسبية في موسم ٢٠٢٣ سالبًا ومعنويًا. من خلال النتائج المتحصلة، يمكن التوصية بأنه إذا تم اتخاذ القرار بشأن إدارة متكاملة لسوسة النخيل الحمراء في المنطقة المدروسة باستخدام المكافحة الكيميائية بالرش الوقائي، فيجب أن يكون ذلك بالتزامن مع توقيت حدوث قمم نشاط الحشرات المسجلة.

الكلمات الدالة: سوسة النخيل الحمراء، ديناميكية التعداد، عوامل الطقس، المصائد الفرمونية، نخيل التمر.