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AN EVALUATION OF INVASIVE PEST, RED PALM WEEVIL *RHYNCHOPHORUS FERRUGINEUS* (OLIVIER, 1790) (COLEOPTERA, CURCULIONIDAE) POPULATION IN IRAQ

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ABSTRACT

The Red Palm Weevil (RPW), *Rhynchophorus ferrugineus* (Olivier, 1790) is a devastating invasive pest of palm trees, invading the Iraqi date palm tree in 2015 for the first time in Safwan county, Basrah province. The Red Palm weevil has been categorized as a quarantine pest of date palm trees worldwide. In this study, a five years monitoring program has been achieved by scouting the invasive pest RPW population in Safwan county by using visual sampling and Pheromone baited traps.

The results indicated that the number of infested palms, increased from 12 trees in 2015 to 111 in 16 orchards in 2016. The number of the infested palms was minimized to 3 trees in the county in 2019 due to the management protocol of the Ministry of Agriculture. Furthermore, the results of RPW adults appeared monthly in the county with two activity peaks during the moderate-temperature-months.

In conclusion, the quarantine and management protocol of RPW decreased the population of the invasive pest which did not spread to other districts of Iraq.

Keywords: Date Palm, Iraq, Invasive pest, Red Palm Weevil, Monitoring.

INTRODUCTION

Red palm weevil (RPW) *Rhynchophorus ferrugineus* (Olivier, 1790) is considered one of the most destructive invasive pest attacking all types of palms trees including date palms worldwide (Cox, 1993; Faghih, 1996; Misra, 1998;Ju and Ajlan, 2011; Faleiro *et al*., 2012; Azmi *et al*., 2017; Manzoor *et al*., 2020); the first invasion of RPW in the Arabian Peninsula

was in UAE during 1985, then spread to other date palms producing countries in this region (Kehat, 1999; El-Mergawy and Ajlan, 2011; Al-Shawaf *et al.*, 2013); causing economic losses reaching $ 25.92 million for eradication protocol of RPW in the 5% infested date palms in the invaded countries in this region (El-Sabea *et al*., 2009). The regional trade of offshoots between and within different countries is one of many reasons for the successful invasion of RPW (Abraham *et al*., 1998). Furthermore, the behavioral and physiological characteristics of RPW increase the difficulties to stop the invasion in the new area; such as the RPW-clamped dispersal which causes highly infested orchards (Faleiro *et al.*, 2002), and the high potential of breeding that increases RPW population reaching the outbreak in various environmental conditions (Ajlan and Abdulsalam, 2000); as well as to the great flight potential for RPW that enable the adults to fly for long-distance, from 100 to 5000 m (Ávalos *et al*., 2014).

Red palm weevil is attracted to damaged and undamaged trees, and the severity of damage increased because the RPW-males produce an aggregation pheromone that attracts the female weevil on the infested palms (Gunawardena and Bandarage, 1995), resulting in tree death due to the larval and adult feeding inside the tree trunk; larvae can feed only in soft tissues, such as the palm crown, the top of the trunk and the bases of the petioles (Abraham *et al.*, 1998). They can also infest the small palm trunk and the decomposing tissues from dead palm trees (El-Mergawy and Ajlan, 2011). It is very difficult to early detect of the infestation, as the insect has its various stages inside the palm trunk, and symptoms appear late due to the tunnels on the bases or crowns of the trees, leaking of fermented scent brown secretions from the outer tunnels, and breaking the trunk or dropping the palm crown in the heavily infested palms (Bokhari and Abuzuhira, 1992; Abraham *et al*., 1998; Hussain *et al.*, 2013; Al-Dosary *et al.*, 2016). It is important to early detecting the infested palms; treat them effectively using chemical insecticides, while the late detection leads to tree death and insect wide-spreading (Hussain *et al*., 2013).

The intensive chemical control of RPW currently is applied by growers and governments to reduce the spreading of this pest in the invasive area (Abozuhairah *et al*., 1996; Aldawood *et al*., 2012).The choice of promising insecticides to control RPW in the orchards usually is evaluated depending on laboratory tests, for instance, Shawir *et al.* (2014) evaluated the toxicity of eight insecticides from various chemical groups and reported that imidacloprid was the most effective insecticide against larvae and adults of RPW. Also, beta-cyfluthrin was recommended against RPW-stages depending on the laboratory-experimental findings (Abo-El-Saad *et al*., 2012). In the fields, the chemical control application has been varied; imidacloprid and a nematode formulation of (*Steinernema carpocapse* /chitosan WG) have been evaluated by spraying the trunks (Dembilio *et al*., 2010). Whereas, Abdel-Salam *et al*. (2014) have evaluated the efficacy of six chemical insecticides and biological insecticides, Biovar and Avermectin by injection into palm's trunks, and found that the chemical insecticides were more toxic than Biovar and Avermectin. The pheromone traps usually are used for monitoring the population density of RPW (Faleiro *et al*., 2003; Faleiro, 2006; Kaakeh, 2006). Mass trapping by applying artificial male aggregation pheromones also are adopted for RPW control in the IPM worldwide (Faleiro, 2006; Al-Dosary *et al.*, 2016). Vidyasagar *et al.* (2016) recommended using two traps per hectare to minimize the weevil population in Saudi Arabia; whereasAbraham *et al.*(2000) involved the pheromone traps decreasing the infestation rates of RPW in date palm`s orchards of Al-Hassa, Saudi Arabia.

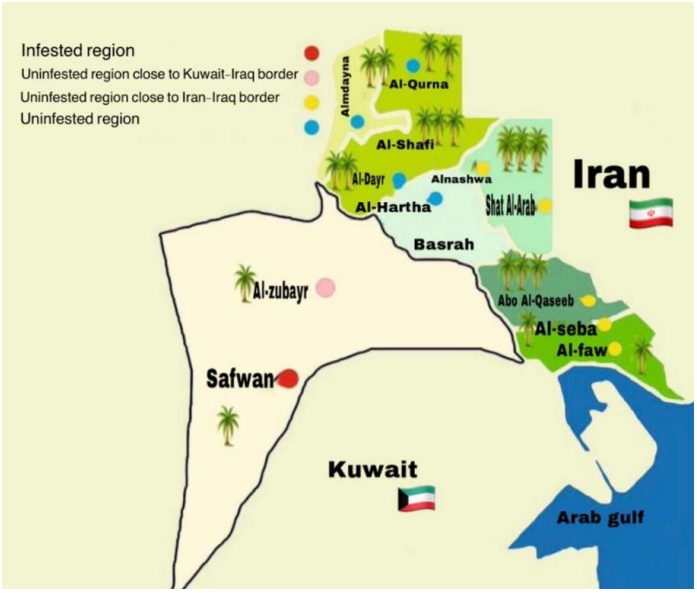
In Iraq, the date palms of Safwan county/Basrah province were firstly invaded by RPW in December 2015 (Anonymous, 2015; Aletby, 2016); since the visual symptoms of the invasive pest are difficult to detect, the legislation related to taking effective quarantine protocol has been taken to prevent the invasive pest spread to other counties of Basrah. Usually, the date palm trees are propagated by planting the offshoots which are perhaps being infested with the developmental stages of RPW if transported for invasive acreages; and depending on the quarantine, the government has restricted the transporting of the offshoots and other planting materials within and between the provinces of Iraq. The invasive pest has not spread to the other regions of Basrah province, depending on the results of the scouting program of RPW (FAO, 2019; Alyousuf and Nikpay, 2020).

In the current study, the infestation of Red Palm Weevil invading the date palm orchards of Safwan has been monitored from 2015 to 2019. The main objective of the study focused on monitoring the adults of RPW by using pheromone traps.

MATERIALS AND METHODS

Study site

This study has been conducted in Safwan county, Basrah (Map 1); more than sixty-one thousand date palm trees planted in the county are subjected to be invaded by RPW *R. ferrugineus*; the first date palm`s orchard was invaded in 2015 that was located (30° 07` 30.73" N, 47° 42` 53.81" E) about three kilometers from the Iraqi-Kuwaiti borders (Map 2). In this study, the area of each orchard was at least 1 ha planting at an approximate density of 140 to 160 trees per ha.



Map (1): Infested region (Safwan county) about three kilometers from Iraq- Kuwait border. (Map was provided by Basrah Department of Plant Protection, Ministry of Agriculture, Basrah, Iraq)

Map (2): The first patch of infestation in Safwan county about three kilometers from Iraq- Kuwait border (Map was provided by Basrah Department of Plant Protection, Ministry of Agriculture, Basrah, Iraq).

Monitoring program of the invasive pest Red Palm Weevil

Due to the threat of Red Palm weevil, the ministry of Agriculture in Iraq has categorized RPW as a quarantine pest of date palm trees and restricted the transporting of offshoots and whole date palm materials in all counties of Basrah and other Provinces. Depending on the sampling visually and looking for symptoms of infection in palm orchards (Pl.1and 2), the infested orchards of Safwan county were determined during 2015-2019. Monitoring of red palm weevil in Safwan`s date palms has been scheduled biweekly by using Pheromone baited traps (Pls.3and 4), 2017-2019. The pheromone (RHYFER; Red Palm Weevil, Alpha Scents, Inc.) was used in the bait traps including pieces of date palm trunks with water which have been changed biweekly and the pheromone have been replaced monthly. The pieces of date palm trunk were used to increase the efficiency of the traps. Exactly, 28, 28, and 34 pheromone traps were set up in 19, 24, 30 date palm orchards in the county in 2017, 2018, and 2019, respectively. The pheromones were provided by the Department of Plant Protection, Ministry of Agriculture for monitoring, and management of the RPW. A sampling study was

conducted to assess RPW abundance from 2017 to 2019 by using the pheromone traps. The traps were checked and emptied biweekly. At each sampling effort, the number of weevils at each pheromone trap/ orchard and the number of collected males and females of RPW were recorded.

Specimens' identification:

The weevil was identified depending on the morphological identification (Hallett *et al*., 2004; Aletby, 2016), and the molecular diagnosis study which was done in the department of Plant Protection, University of Basrah (Al-Saad and Aletby, 2018). The weevils were sexed by checking the brown hairs on half rostrum of male and absent in female (Aletby, 2016).

Statistical analysis

The infested palms in the infested fields of Safwan county were determined from2015 to 2019. Due to obtaining few data of the first year (2015, one infested orchard) and last year (2019, two infested orchards), so the statistical analysis included the data of 2016-2018. The seasonal activity of the captured RPW by the pheromone traps was analyzed for the monitoring studies. The population densities of WPR were tested using analysis of variance (ANOVA), and means were compared using a Least Significant Difference (LSD) test at $P \leq 0.05$. The analysis of the sex ratio of RPW was determined with χ^2 test by using the R program (R Development Core Team, 2019).

Plate (1): Symptoms of infection of RPW in date palms; (A) The hole in the trunk, (B) The damage inside the trunk.

Plate (2): *Rhynchophorus ferrugineus*; (A) Larva, (B) Adult, which sampled visually from date palm orchards.

Plate (3): Adult of RPW captured by pheromone traps in date palm orchards.

Plate (4): Checking of the pheromone traps of RPW in the date palms orchards.

RESULTS

Monitoring program of the invasive pest, RPW population in Safwan County

Five years monitoring of invasive RPW has been carried out in Safwan by sampling visually and looking for symptoms of infection in palm orchards. There were no significant differences among the infested date palms ($F = 1.632$, $P < 0.205$) in the infested orchards ($F = 2.72$, $P < 0.0744$) in the county between 2016 and 2018. Numerically, 12 trees of 660 date palm trees in a private date palm orchard were invaded by RPW in 2015.

However, despite the early detection of RPW, the numbers of infested palms were largely increased to 111 trees in 16 orchards in 2016. Then, the number of the infested orchards was almost duplicated to 25 orchards, while the number of infested trees was minimized to 51 trees in 2017, 34 trees (in 17 infested orchards) in 2018, and 3 trees (in 2 infested orchards) in 2019 (Diag.1 and 2), after the trapping programs were implemented. Mass trapping of RPW by using synthetic aggregation pheromone traps showed that 146, 306, and 248 adults were caught in 2017, 2018, and 2019 respectively (Tab.1); interestingly, most of the collected weevils were captured in the orchards which were close to the Iraqi- Kuwaiti borders. The results of the monitoring study indicated that RPW was active during the whole year, with two activity peaks; the first peak was from March to May (0.32, 0.37, and 0.46 weevil/ trap/ month, respectively) and the population increased reaching the second peak in October and November (0.34 and 0.32 weevil/ trap/ month, respectively; $F = 12.32$, $P < 0.0000$, see Table (2)). The overall sex ratio of RPW (Tab.3) were female-biased; the proportion of female were 0.72 in 2017 ($\chi^2 = 1208.2$, $p < 0.0000$), 0.59 in 2018 ($\chi^2 = 2344.8$, $p < 0.0000$) and 0.50 in 2019 ($\chi^2 = 916.11$, $p < 0.0000$).

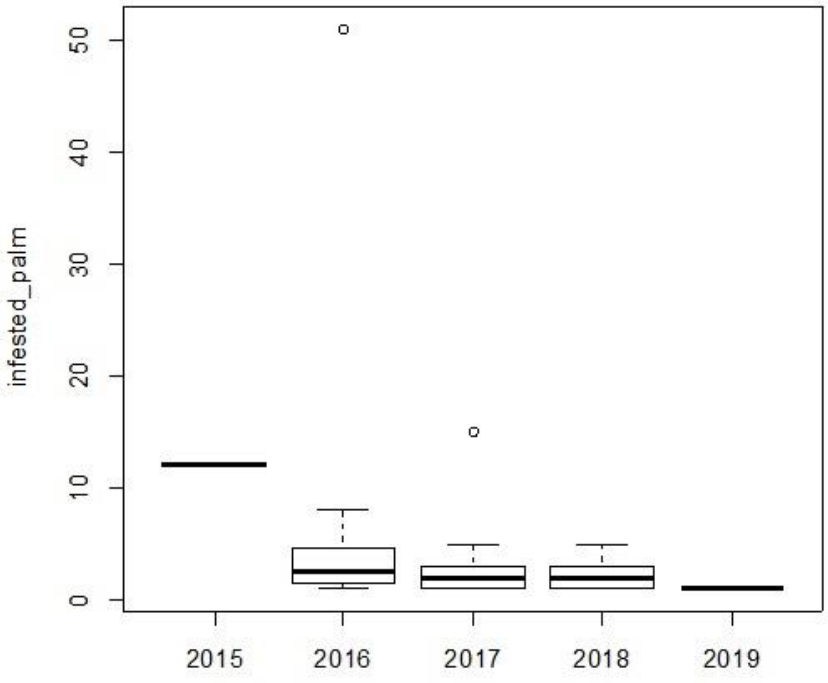


Diagram (1): The total number of infested date palms in Sawfan county, 2015-2019.

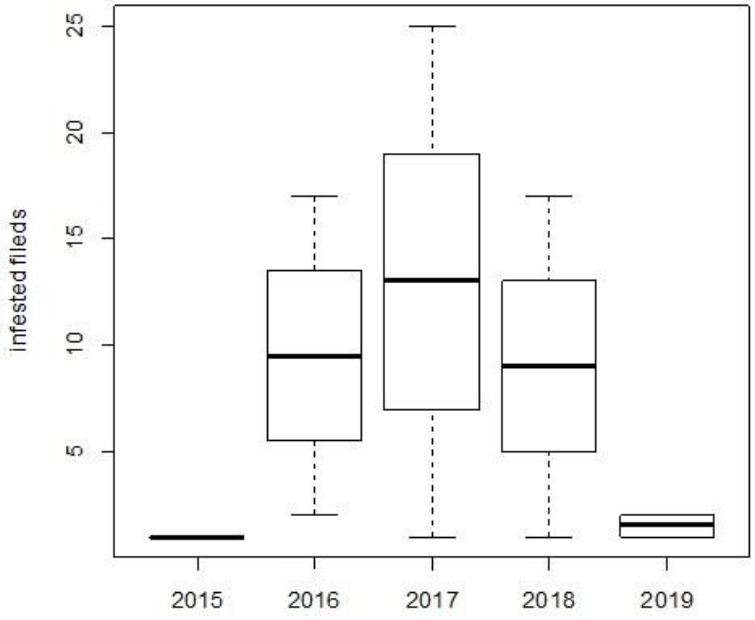


Diagram (2): The total number of infested orchards in Sawfan county, 2015-2019.

Table (1): Average of RPW adults captured per pheromone trap across Sawfan county annually, 2017-2019.

Year	RPW population (weevil/trap/ year)	
	Total	Mean (SE)
2017	146	0.1600877[b] (0.030)
2018	306	0.2743056[a] (0.031)
2019	248	0.2326389[a] (0.029)

Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05)

Table (2): Average of captured adults per pheromone trap across Sawfan county monthly, 2017-2019.

Month	RPW population (weevil/trap/ year)
	Mean (SE)
1	0.09[cd] (0.053)
2	0.11[cd] (0.056)
3	0.32[b] (0.141)
4	0.37[ab] (0.139)
5	0.46[a] (0.155)
6	0.17[c] (0.069)
7	0.16[c] (0.071)
8	0.17[c] (0.086)
9	0.17[c] (0.084)
10	0.34[b] (0.110)
11	0.32[b] (0.142)
12	0.05[d] (0.034)

Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05)

Table (3): Sex ratio of RPW in Basrah, 2016-2018.

Year	No. of weevils/ trap		Sex ratio	
	Male	Female	Proportion of female	χ^2
2017	35	111	0.72	1208.2, $p< 0.000$
2018	130	186	0.59	2344.8, $p< 0.000$
2019	167	168	0.50	916.11, $p< 0.000$
mean	332	465	0.58	

DISCUSSION

It is thought that Red Palm Weevils *Rhynchophorus ferrugineus* were originally introduced into southern Iraq from Kuwait since the first patch of infestation in Safwan county, Basrah located about three kilometers from the Iraqi-Kuwait border (Map 2). Iraqi date palm trees had not been invaded by RPW before 2015, while the pest was listed as a quarantine pest in the Arabian Peninsula since 1985, then spread to other date palms producing countries in this region including Kuwait in 1993 (Kehat, 1999; El-Mergawy and Ajlan, 2011; Al-Shawaf *et al*., 2013); there are two reasons for that, firstly, the external quarantine of the date palms has

been issued by the Ministry of Agriculture in Iraq since 1974 (Iraqi Laws and Legislation, 1974); next, the agricultural system of Basrah diverse based on the regions which have varied environments, the southern, eastern, and northern which have some desert. Commercial plantations of date palm trees were planted only in the southern and eastern regions of Basrah; in the last few years, date palm trees have been planted in the desert area of Basrah that extended to the Iraqi-Kuwaiti borders (Alyousuf and Nikpay, 2020).

The results of the infestation rates of RPW indicated that the eradication efforts (chopping, burning, and burying all palm trees of the first infested patch of RPW in Safwan in 2015),which were done by the Ministry of Agriculture, did not prevent spreading the insect to other date palm trees in Safwan County in the next few years. The findings also indicated the continuing of infestation of date palm trees in the county due to the neighborhood to the infested Kuwaiti date palm orchards (El-Mergawy and Ajlan, 2011). Moreover, the higher flight potential of RPW adults enables them to fly for long-distances (Ávalos *et al*., 2014) and cross the border invading the Iraqi date palm trees. Whereas, the promising results indicated that the constant quarantine and management program of RPW minimized the infested palms to 3 trees in the county in 2019.

The monitoring results of the seasonal activity of RPW by using the pheromone traps showed the variation of the population densities of captured weevils monthly and showed that the adults appeared in all the months with two activity peaks during the moderate temperature months. Hashim *et al*. (2013) evolved pheromone traps to monitor RPW and indicated that there were two activity peaks in March and September of the growing season of 2007/2008.

In addition to the important role of the pheromone traps in the monitoring protocol, it can be considered as one of the effective means to control the insect infesting the palm trees due to the high efficiency of attracting a large number of the RPW. Mass aggregation pheromone traps are adopted for RPW control in the IPM worldwide (Paraj Shukla, 2017); for instance, in Saudi Arabia, more than 2,250 traps were involved in the mass trapping of RPW disseminated in more than 10,000 ha of Al-Qatif region (Vidyasagar *et al*., 2000); and in Al-Hassa where IPM based on pheromone traps were adopted in date palm orchards (Abraham *et al*., 2000) leading to the decrease of the infestation rates of RPW from 1994 to 1997.

CONCLUSION

In the study, the population of the invasive Red Palm Weevil *Rhynchophorus ferrugineus* was monitored for five years; despite all efforts which have been taken by the staff of the department of plant protection to eradicate the invasive pest in the county, it was a difficult task for the staff to control RPW. For that reason, continuous monitoring of the RPW is essential to prevent the spreading of RPW in Iraq. Also, more extensive efforts are required to all Basrah's counties, meeting with the growers and owners of date palm orchards throughout the province of Basrah, and explaining the dangerous, severity, symptoms, and injury of the RPW.

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تقييم الكثافة السكانية للافة الغازية سوسة النخيل الحمراء *Rhynchophorus ferrugineus* (Olivier, 1790) (Coleoptera, Curculionidae) في العراق

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الخلاصة

تعد الافة الدخيلة، سوسة النخيل الحمراء (RPW) *Rhynchophorus ferrugineus* (Olivier, 1790) من الافات المدمرة لأشجارالنخيل، و قد غزت هذه الافة اشجارالنخيل لأول مرة في مدينة سفوان بمحافظة البصرة- العراق في عام 2015؛ اذ صنفت سوسة النخيل الحمراءعلى أنها آفة تحت الحجر الزراعي على أشجارالنخيل.

وفق هذه الدراسة، تم وضع برنامج لمراقبة الافة مدته خمس سنوات عن طريق التحري البصري عن سوسة النخيل الحمراء الغازية في قضاء سفوان فضلا عن استخدام مصائد الطعم الفرمونية في مراقبة الحشرة؛ حيث أشارت النتائج إلى ارتفاع عدد أشجارالنخيل المصابة من 12 شجرة في بستان واحد عام 2015 إلى 111 شجرة في 16 بستاناً في عام 2016، بينماانخفض عدد أشجارالنخيل المصابة إلى 3 أشجارفي المحافظة في عام 2019 بسبب بروتوكول ادارة الافة المتبع من قبل وزارة الزراعة؛ علاوة على ذلك، بينت

نتائج المصائد الفرمونية للدور البالغ لسوسة النخيل الحمراء شهريًا الى وجود ذروتين للنشاط خلال أشهر درجات الحرارة المعتدلة.

اخيراً بينت النتائج ان برنامج الحجر الزراعي و إدارة سوسة النخيل الحمراء أدت الى خفض أعداد الآفة الغازية ، إذ إنها لم تنتشر إلى مناطق اخرى من العراق.