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Monitoring and Management of Date Palm Borers by Using Light Traps

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Abstract: Date palm borers become a serious threat to date palm plantations in Iraq, which required management program to suppress their population by using different methods; one of them is the light traps which disseminated in Basrah province. The objective of this trial is to evaluate the effectiveness of light traps as a part of pest management tool. In three years monitoring of coleopteran adults, rhinoceros beetles *Oryctes* spp. and longhorn date palm borer *Jebusaea hammerschmidtii* infesting the date palm *Phoenix dactylifera* were reported by using light traps in different regions of Basrah, Iraq. Due to the result of the abundance of the borers, *Oryctes* spp. were the most dominant and most important causing severe damage for the date palm. Four species of *Oryctes* (*O. agamemnon*, *O. elegans*, *O. sahariensis* and *O. sinaicus*) were recorded in Basrah date palm orchards; the seasonal activity of the species was between April and May, reaching the peaks during summer, and the populations decreased gradually till December. The overall sex ratios of all species of *Oryctes* spp. were male-biased except *O. elegans*, which had the sex ratio of 1.13 female: 1 male. Results revealed that the light traps exhibit an effective control method to suppress the adult borer's population and as a physical control and monitoring tool of date palm stem borers.

Keywords: Date palm, Coleoptera, Light traps, Monitoring *Oryctes* spp.

Introduction

Date Palm (*Phoenix dactylifera* L.) is considered one of the most economic fruit trees in Iraq and other countries of the Middle East and North Africa (Hazzouri *et al.*, 2015; Khierallah *et al.*, 2015). In Iraq, harvested area of dates was 168.86.000 ha in 2018 (Statista, 2020) with total date palms of 17036560 trees. The production of all cultivars was 639315 tons in a yield average of 63.7 Kg.palm^{-1} in 2019. In Basra province, the total palm trees were 1203121 with productivity per palm average of 41.2 Kg.palm^{-1} in 2019 (CSO, 2020). Palm trees are subjected to infest with different disease and pests (Alyouif and Mazeal, 2008; Al-Dosary, 2010; Elshafie *et al.*, 2017). Palm borers, the longhorn date palm stem borer *Jebusaea hammerschmidtii* (Coleoptera: Cerambycidae) and Rhinoceros beetle *Oryctes* spp. (Coleoptera: Scarabaeidae) have been recognized as serious palm pests (Rochat *et al.*, 2004; Al-Jboory , 2007; Ehsine *et al.*, 2014; Bedford *et al.*, 2015; Khalaf & Alrubiae, 2015; Khalaf *et al.*, 2017). *Oryctes* species are common in many countries of the

world (Bedford *et al.*, 2015). *Oryctes rhinoceros* is the most common palm borer species in Malaysia and many other countries of the world (Buxton, 1920; Bedford, 1980; Gnanasegaram *et al.*, 2011). *O. elegans* infest palms in Iran and Saudi Arabia (Rochat *et al.*, 2004; Al-Deghairi, 2007; Payandeh & Dehghan, 2010), while *O. agamemnon* was recorded in Tunisia (Soltani *et al.*, 2008; Ehsine *et al.*, 2014), and in UAE (Al-Deeb *et al.*, 2012).

In Iraq, *O. elegans* beetles were firstly recorded infesting date palms, and their rates reached 80-90% in some orchards (Hussain, 1963; Al-Kawaga, 1999; Khalaf & Alrubiae, 2015; Khierallah *et al.*, 2015). However, the other species *O. agamemnon*, *O. sinaicus* and *O. sahariensis* were recorded recently (Khalaf *et al.*, 2013; Al-Jamali & Al-Kariti, 2019; Augul & Al-Saffar, 2019). Many *Oryctes* species infest the coconut, oil and date palm trees worldwide causing economic losses (Bedford, 2013); for example, *O. rhinoceros* caused a loss of 10% of the 1.796 million hectares of coconut trees in India (Gopal *et al.*, 2001). Larvae and the adults of Rhinoceros beetles infest the date palm's stem and feed on dead and living tissues and they can cause severe damage when attacking the aerial root system leading to unexpected collapse of infested palms (Soltani *et al.*, 2008). The adults of fruit stalk borer *O. elegans* feed on the bases of frond and the fruit-stalk in fruitful palm trees (Al-Jboory, 2007; Khalaf & Naher, 2010); while Root borer *O. agamemnon* may change feeding behavior from a stem borer to a root borer due to egg laying activity, drought occurrence, or a food shortage, and the injury is mostly severe when the new short palms are infested (Soltani *et al.*, 2008).

Indirect damage of the adult and larval feeding is the attracting of the other pests such as Red Palm Weevil (RPW) to lay eggs on the in the bores in the area which occupied by RPW (Al-Ayedh & Al Dhafer, 2015). *Oryctes* spp. adults appear from May to October, with highest activity during August in Karbala Province, Iraq (Al-Jamali & Al-Kariti, 2019). The presence of a large number of females of the species *O. agamemnon* indicating of the laying of a large number of eggs and this leads to major damage by larvae and adults (Soltani *et al.*, 2008).

Light traps are common sampling technique for monitoring of the nocturnal insects (Sheikh *et al.*, 2016); Light trap has been used as physical control method and monitoring tool of date palm stem's borers (Al-Deeb *et al.*, 2012; Khalaf *et al.*, 2017; Al-Jamali & Al-Kariti, 2019). Understanding the population density of beetles is important for developing integrated management program (Wakil *et al.*, 2015). In this study, date palm borers were monitored for 3 years by using light traps to detect the population densities and seasonal abundances of *Oryctes* spp. and *Jebusaea hammerschmidtii* in Basrah province.

The main objective was to determine which species of the borers is the most dominant in different places of Basrah. The second objective focused on determining the efficacy of light traps grid on management of the population densities of *Oryctes* spp. in Basrah.

Materials & Methods

Site description

This study was conducted in Basrah province, Iraq. The plantation of Basrah varied based on the regions which have different ecosystems, the southern, eastern, and northern which separated into the desert and sedimentary ecosystems. The southern, the eastern and sedimentary area of the northern region are commercial plantations for date palm. More

than one million and two hundred thousand of palms are planted in the province which was selected for this study because large number of the trees are infested with different borers.

Date palm borers sampling procedure

Sampling and monitoring study were conducted to assess date palm borer's abundance from 2016 to 2018 in 18 randomly selected date palm orchards distributed across Basrah by using 18 light traps. The traps are part of light-traps-grid (120 Magna light traps, Russell IPM Company, UK, Fig. 1) which supplied with solar-energy lamp of wave's length 350-420 nm; the traps provided by Iraqi Ministry of Agriculture in 2015 were used to monitor date palms borers. In this study, the area of each selected orchard was at least 1 hectare composed of 140 to 160 palms. Each trap was checked biweekly and the number of beetles at each light trap per orchard were reported. Then, the adults were taken for identification and sexed based on the keys prepared by Al-Jassany & Al-Saedy (2019). The numbers of captured males and females of *Oryctes* spp. were counted at each sampling event. Some of the adult specimens were sent to the Natural History Museum, University of Baghdad for identification.

Statistical analysis

The geographical distribution, relative abundance and seasonal activity of the captured date palm borers (Rhinoceros beetles and longhorn date palm stem borers) and the most abundant borers (*Oryctes* spp.) infested date palms were analysed for the monitoring studies. In the second analysis, the study of efficacy of light traps grid disseminated across Basrah province was tested. For both analyses, the population densities of borers 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 *Oryctes* spp. was determined with χ^2 test by using R program (R Core Team, 2019).

Fig. (1): Light trap which used in the sampling and monitoring study of date palm borers in Basrah province, 2016-2018.

Results & Discussion

In 2016-2018, a total of 1512 Rhinoceros beetles *Oryctes* spp. belonging to four species and 147 longhorn date palm stem borers *J. hammerschmidtii* were captured by the light traps in all the regions of province of Basrah. The results of distribution of the date palm borers indicated that there were no significant

differences in the population densities *Oryctes* spp. and *J. hammerschmidtii* among the regions ($F = 0.373$, $P < 0.69$; $F = 3.091$ and $P < 0.0506$ respectively; Table 1); *Oryctes* spp. were the most dominant with approximately 91% of entire abundance compared with *J. hammerschmidtii* with approximately 9% of the entire abundance ($F = 35.53$, $P < 0.00000$, Fig. 2). Rhinoceros beetles were active from April to November with peak activity from July to September; however, *J. hammerschmidtii* were active from May to September with peak activity in July ($F = 4.836$, $P < 0.000137$; $F = 3.521$, $P < 0.00238$; Table 2). The results of the number of date palm borers trapped by the light traps varied among the years (Table 3); the highest population of *Oryctes* spp. was 22.35 beetles.trap^{-1} in 2017, then the population reduced to 7.81 beetles.trap^{-1} in 2018 ($F = 2.093$, $P < 0.152$). There was no significant differences among the populations of longhorn date palm stem borer during the 3-years of monitoring program; the highest population was 2.65 borers trap in 2017, and the densities decreased to 0.00 borers in 2018 ($F = 0.824$, $P < 0.366$).

Table (1): Distribution of the date palm borers in Basrah during 2016-2018.

Region	No. of date palm borers per light trap, 2016-2018					
	J. hammerschmidtii			*Oryctes* spp.		
	Total	Mean	(SE)	Total	Mean	(SE)
Southern	88	4.89[a]	1.79	231	12.83[a]	3.58
Eastern	12	0.88[a]	0.26	236	16.79[a]	4.33
Northern	47	0.82[a]	0.48	1041	18.33[a]	3.10

Each population was separately statically analyzed; Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05); SE = Standard Error.

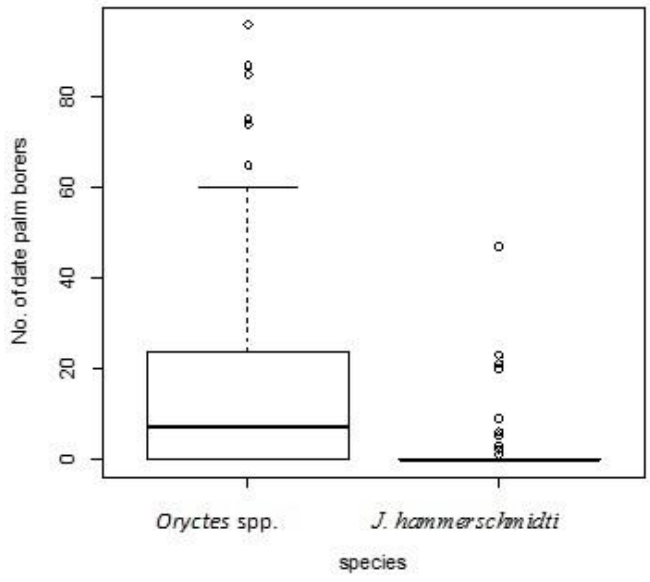

Fig. (2): The relative abundance of the date palm borers in Basrah during 2016-2018.

Table (2): Seasonal activity of the date palm borers in Basrah during 2016-2018.

Month	No. of date palm borers per light trap			
	J. hammerschmidtii		*Oryctes* spp.	
	Mean	(SE)	Mean	(SE)
April	0.00[b]	0.00	0.50[b]	0.33
May	0.90[b]	0.67	18.20[ab]	4.81
June	2.46[ab]	1.51	13.00[ab]	2.94
July	10.33[a]	3.82	33.33[a]	7.56
August	1.67[ab]	0.61	33.50[a]	6.84
September	0.30[b]	0.16	32.40[a]	8.32
October	0.00[b]	0.00	24.25[a]	4.10
November	0.00[b]	0.00	1.91[b]	1.20

Each population was separately statically analysed; Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05); SE =standard Error.

Table (3): Effect of light traps on the population densities of date palm bores.

Year	No. of date palm borers per light trap			
	J. hammerschmidtii		*Oryctes* spp.	
	Mean	(SE)	Mean	(SE)
2016	0.82[a]	0.39	13.27[ab]	2.64
2017	2.65[a]	1.17	22.35[a]	3.88
2018	0.00[a]	0.00	7.81[b]	2.05

Each population was separately statically analysed; Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05); SE = Standard Error.

Four species of *Oryctes* spp. (*O. agamemnon*, *O. elegans*, *O. sahariensis* and *O. sinaicus*; Fig. 3) were recorded associated with date palms in Basra, the results of table 4 showed that all the species of *Oryctes* spp. equally (non-significantly) distributed over the Basrah regions (northern, eastern and southern) (F = 1.394, P < 0.254; F = 0.095, P < 0.91; F = 0.331, P < 0.719; F = 3.919, P < 0.0509 respectively). Numerically, the population densities varied among the species; *O. agamemnon* was the most dominant (approximately 0.34 % of entire abundance), and *O. elegans* was the most second abundant (approximately 0.24 % of entire abundance); whereas *O. sinaicus* had the less abundance (approximately 19% of the entire abundance) (F = 1.636, P < 0.181; Fig. 4).

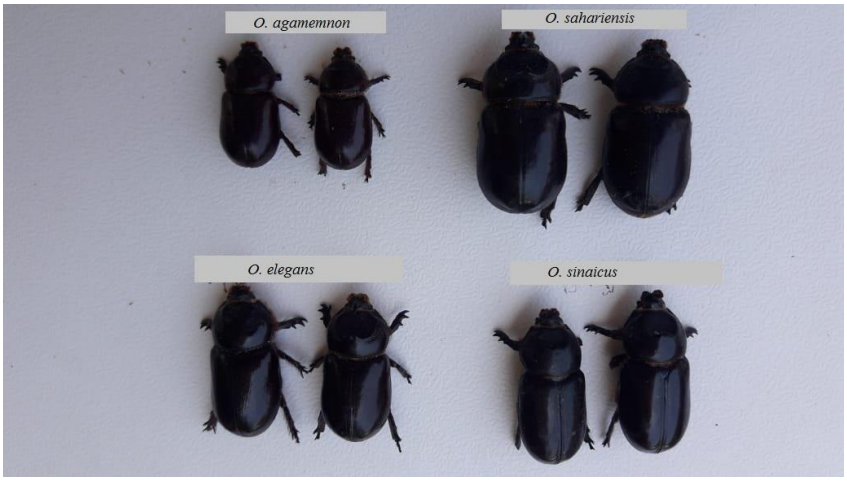

Fig. (3): *Oryctes* spp. collected from in Basrah between 2016-2018.

Table (4): Distribution of *Oryctes* spp. in Basrah, 2016-2018.

Region	No. *Oryctes* spp. per light trap, 2016-2018							
	O. agamemnon		*O. elegans*		*O. sahariensis*		*O. sinaicus*	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Southern	2.22[a]	0.72	4.56[a]	1.17	1.43[a]	0.75	1.30[a]	0.63
Eastern	5.79[a]	2.11	3.57[a]	0.82	2.88[a]	1.24	1.12[a]	0.01
Northern	6.89[a]	1.50	3.95[a]	0.91	2.62[a]	0.82	2.46[a]	0.90

Each species population was separately statically analysed; Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05); SE = Standard Error

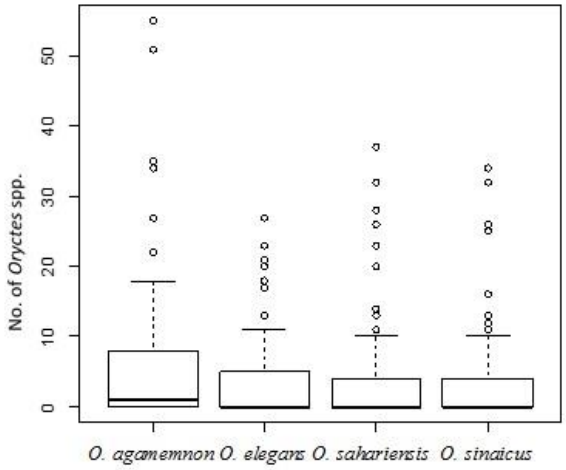

Fig. (4): The relative abundance of *Oryctes* spp. in Basrah during 2016-2018.

The monthly catches of *Oryctes* spp. (Table 5) showed that *O. agamemnon* beetles appeared in May (8.40 beetles.trap^{-1} monthly) and the population increased reaching the peak (14.20 beetles/ trap/ month) in September (F = 3.663, P < 0.00175). Also, *O. elegans*, the second dominant population, emerged in May (6.00 beetles.trap^{-1} monthly) with peak activity (7.00 and 7.42 beetles.trap^{-1} monthly) in September and October respectively (F = 2.554, P < 0.0199).

Table (5): Seasonal activity of *Oryctes* spp. in Basrah during 2016-2018.

Month	No. *Oryctes* spp. per light trap							
	O. agamemnon		*O. elegans*		*O. sahariensis*		*O. sinaicus*	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Apr	0.00[b]	0.00	0.00[b]	0.00	0.25[ab]	0.17	0.25[ab]	0.71
May	8.40[ab]	2.13	6.00[a]	2.18	1.60[ab]	0.58	2.20[ab]	0.48
June	3.46[ab]	1.11	2.92[ab]	0.55	3.077[ab]	1.02	3.54[ab]	1.70
Jul	10.67[ab]	3.89	6.78[a]	1.80	7.00[ab]	2.02	8.89[a]	2.87
Aug	13.67[ab]	2.88	3.17[ab]	1.61	10.67[a]	3.31	6.00[ab]	1.55
Sep	14.20[a]	4.17	7.00[a]	2.21	10.20[a]	0.73	1.00[ab]	0.75
Oct	4.33[ab]	1.35	7.42[a]	1.39	5.08[ab]	1.58	7.42[a]	2.10
Nov	0.62[b]	0.62	0.95[b]	1.03	0.19[b]	0.20	0.14[b]	0.15

Each species population was separately statically analyzed; Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05); SE = Standard Error.

Both *O. sahariensis* and *O. sinaicus* emerged in April with average of population densities 0.25 beetles.trap^{-1} monthly and the densities increased to 10.67 beetles.trap^{-1} on August and 8.89 beetles.trap^{-1} on July respectively (F = 3.655, P < 0.0017, F = 3.337, P < 0.00357 respectively).

The numbers of annual captured males of *Oryctes s*pp. were greater than that of the trapped females except *O. elegans* (Table 6). The overall sex ratio of the captured of *O. sahariensis*, *O. sinaicus* and *O. gamemnon* were male-biased which were 1:1.46 (143 females: 209 males; χ^2= 578.79, p < 0.0000), 1:1.32 (124 females: 164 males; χ^2 = 508.51, p < 0.0000) and 1:1.3 (223 females: 291 males; χ^2= 657.02, p < 0.0000) respectively, however, the sex ratio of *O. elegans* was close to the predictive sex ratio 1:1 which was 1.13:1 (190 females:168 males; χ^2 = 381.35, p < 0.0000).

Table (6): Sex ratio of *Oryctes* spp. in Basrah during 2016-2018.

Year	No. *Oryctes* spp. per light trap							
	O. sahariensis		*O. sinaicus*		*O. elegans*		*O. gamemnon*	
	Female	Male	Female	Male	Female	Male	Female	Male
2016	26	21	15	13	23	13	24	11
2017	109	177	75	113	124	120	183	261
2018	8	11	34	38	43	35	16	19
Total	143	209	124	164	190	168	223	291
F:M	1:1.46		1:1.32		1.13:1		1:1.3	

The efficiency of the light traps on the population of the *Oryctes* spp. (Table 7) indicated the densities of the beetles were decreased over the years, and the results showed that there were significant differences among the populations of the *O. agamemnon* and *O. sahariensis* captured by the light traps throughout the period of monitoring program; their highest population were 8.54 and 5.50 beetles.trap^{-1} in 2017 respectively, then decreased to 1.35 and 0.73 beetles.trap^{-1} in 2018 respectively (F = 2.037, P < 0.0157, F = 3.919, P < 0.0509 respectively). However, the populations of *O. elegans* and *O. sinaicus* were 4.69 and 3.63 beetles per trap in 2017 respectively, then their densities have been decreased to 2.96 and 2.77 beetles.trap^{-1} in 2018 respectively (F = 0.247, P < 0.621, F = 0.013, P < 0.909 respectively).

Three years monitoring of borers pests infesting the commercial plantations for date palm by using light traps grid disseminated across different regions of Basrah province showed many coleopteran adults were captured from April to November annually. Rhinoceros beetles *Oryctes* spp. and longhorn date palm stem borers *J. hammerschmidtii* were the most common dangerous borers reported.

The results of distribution of the date palm borers indicated that both of the borers have been distributed in all regions where date palm plantation are grown. *Oryctes* spp. were very high abundance compared to *J. hammerschmidtii*, and depending on these results, it thought that *Oryctes* spp. are responsible for the severe damage on the date palms of Basrah.

Table (7): Effect of light traps on the population densities of *Oryctes* spp.

Year	No. *Oryctes* spp. per light trap							
	O. gamemnon		*O. elegans*		*O. sahariensis*		*O.sinaicus*	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
2016	3.18^{ab}	0.70	3.27^{a}	1.00	4.27^{ab}	1.07	2.55^{a}	0.44
2017	8.54^{a}	1.80	4.69^{a}	1.03	5.50^{a}	1.30	3.62^{a}	1.03
2018	1.35^{b}	0.58	2.96^{a}	0.74	0.73^{b}	0.20	2.77^{a}	1.01

Each species population was separately statically analysed; Mean values followed by different lowercase letters are significantly different (LSD test, P≤0.05); SE = Standard Error

The results of management of the date palm borers showed that the light traps were effective methods to control of Rhinoceros beetles due to the decreasing of high population densities of the *Oryctes* spp. between 2016 and 2018, compared to the non-significant effect on the numbers of longhorn stem borers which were very low during the studying period. For that reason, the study focused on the monitoring and management of *Oryctes* spp.

In this part of the study, four species of Rhinoceros beetle (*O. agamemnon*, *O. elegans*, *O. sahariensis* and *O. sinaicus*) were recorded in all the regions of Basrah. Also, *O. sahriensis* de Miŕe was recorded for the first time in Basrah province. All *Oryctes* spp., which recorded in Basrah were found in southern and eastern Iraq (Al-Jassany & Al-Saedy, 2019). Also, it was noticed that *O. agamemnon* was the most dominant and *O. elegans* was the most second abundant, while the population densities of *O. elegans* was the highest in the other provinces (Al-Jassany & Al-Saedy, 2019).

The seasonal activity of *Oryctes* spp. revealed to the variation of the population densities of captured beetles monthly, and showed that the adults of *Oryctes* spp. appeared between April and May and reached their peaks during the summer, and their populations decreased gradually reaching lower population levels in December. (Khalaf *et al.*, 2010) found that the density of *O. elegans* trapped by light traps (Russel IPM Company) was 28.5 beetles.trap^{-1} from July to October, while the population peak was 37 beetles / traps during September. The sexual ratios of the species of Oryctes were male-biased except *O. elegans*. Al-Jassany & Al-Saedy (2019) found that sexual ratio of *O. elegans*, and *O. sinaicus* were female-biased (1 male: 1.44 females and 1 male: 1.49 females) respectively in the middle of Iraq; Soltani (2014) indicated that the sexual ratio of the *O. agamemnon arabicus* was (1 male: 2 female) in Tunisia.

The light traps can be considered as one of the effective means to control the insect in palm due to the high efficiency of attracting a large number of *Oryctes* spp. beetles. The descending of population densities of the borers were shown over the monitoring years since the light traps were settled in Basrah province due to the sequential trapping of beetles over the years across the regions; Khalaf *et al*. (2012) indicated that the population density was reduced from 6 to 1.8 larvae / palm trees because of the trapping of their adults in the middle of Iraq. The

successful IPM programs are effectively developed depending on ecological-friendly techniques for reliable monitoring plans; light traps is one of the most important techniques in the palm pest management program that used to reduce the population density of borers on palm trees (Al-Deeb *et al.*, 2012; Khalaf *et al.*, 2012).

Conclusion

To conclude to my results, Rhinoceros beetles *Oryctes* spp., are responsible for the severe damage of date palms in Basrah showing high abundance compared to *J. hammerschmidtii*. The populations of the borers (*O. agamemnon*, *O. elegans*, *O. sahariensis* and *O. sinaicus*), which were active between April and May, descended over the monitoring years since the light traps were settled in Basrah province due to the sequential trapping of beetles over the years. Depending on management record, light traps (ecological-friendly technique) are effective method as one of the physical control tactics.

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Conflicts of interest

The authors declare that they have no conflict of interests.

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مراقبة ومقاومة حفارات نخيل التمر باستعمال المصائد الضوئية

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المستخلص: تم مراقبة أنواع بالغات حفارات عذوق النخيل وحيدة القرن .*Oryctes* spp وحفارات ساق نخيل ذو القرون الطويلة *Jebusaea hammerschmidtii* التي تصيب أشجار النخيل باستخدام المصائد الضوئية ولمدة ثلاث سنوات بين 2016-2018في مناطق مختلفة من محافظة البصرة، العراق. بينت النتائج ان .*Oryctes* spp كانت الأكثر وفرة وغزاره عددية في منطقة الدراسة واستدل منها بأن هذا الجنس هو الأكثر أهمية مسبباً أضراراً شديدة لنخيل التمر. تم تسجيل أربعة أنواع من حفارات عذق النخيل وحيدة القرن *O. agamemnon* و *O. elegans* و *O. sahariensis* و *O. sinaicus* في بساتين نخيل البصرة. سجل النشاط الموسمي للأنواع بين شهر نيسان وآيار ووصلت كثافاتها العددية إلى قمتها خلال اشهرفصل الصيف، وانخفضت أعدادها تدريجياً حتى كانون الثاني. واظهرت النتائج ان نسب الذكور الى الاناث ولجميع أنواع .*Oryctes* sppكانت هي الاعلى باستثناء *O. elegans* ، التي كانت فيها النسبة الجنسية 1.13 أنثى: 1 ذكر. اعتمادًا على نتائج الدراسة، فقد سجلت الكثافة السكانية لهذه الحفارات انخفاظاً بين سنوات الدراسة وبشكل ملحوظ في محافظة البصرة بسبب شبكة المصائد الضوئية (التقنية الصديقة للبيئة) التي توزعت على مناطق مختلفة في المحافظة.

الكلمات المفتاحية: نخيل التمر ، *Oryctes* spp، Coleoptera، مراقبة ، المصائد الضوئية.