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Ecological Sound Control Strategies for Population Suppression of Date Palm Borers *Oryctes* spp.

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Abstract: Cultural practices, hand collection of larvae, light traps and entomopathogenic fungi were investigated to manage of palm borers *Oryctes* spp. in date palm orchards during the years 2010-2015. Cultural practices, such as sanitation and pruning frond bases, hand collection of larvae during regular annual service work and light traps with solar energy were practiced annually in one orchard for five years. In the second orchard, cultural practices were applied for two years, light trap for one year only, and no hand collection of larvae was done during the period. The third orchard was used as a control treatment. Results showed reduction in population density of larvae (91.6% and 53.0%) and adult (76.1% and 41.1%) of *Oryects* spp. in the 1st and 2nd orchard, respectively. The results also demonstrated the impact of moon light phases on the number of *Oryctes* spp. adults caught by light trap and the existence of an inverse relation between moon light and flight activity of adults. Biological experiments also revealed that entomopathogenic fungi can cause high mortality rate reaching 100% after 29 d. *Beauveria bassiana* scored higher mortality rate in short time, especially at concentration of 1×10^{11} conidia/mL with LT_{50} = 12.75 and LT_{90} = 20; while, *Metarhizium anisopliae* caused the higher percentage of malformed adults. The results depicted the effectiveness of some integrated ecological sound control methods for monitoring and population suppression of *Oryects* spp. in date palm orchards.

Key words: Integrated pest management, cultural practices, hand collection of larvae, light traps, moon light, entomopathogenic fungi, *Oryects* spp..

1. Introduction

Date palm tree, *Phoenix dactylifera* is one of the major crops in Iraq and most adapted to climatic conditions of the region [1, 2]. It suffers damages from several pests, especially borers, like palm frond borer—*Phonapate frontalis*, long horn palm stem (trunk) borer—*Jebusaea hammerschmidtii* and several *Oryctes* spp., fruit stalk (bunch) borer—*Oryctes elegans* and *Oryctes agamemnon*, Arabian rhinoceros beetle—*Oryctes agamemnon arabicus* and *Oryctes agamemnon matthisseni* which are widely spread in date palm orchards of Iraq and other countries [3-7].

Oryctes spp. complex caused severe damages to the bases of fronds and bunches, making long tunnels inside tissue, which acting as weakening and breaking factors for these parts [8-10]. By boring and feeding on plant tissue, it thus leads to infection with pathogens, and the associated plant weakness and low productivity [2, 11, 12]. Ecological beginning control measures play an important role as a solution responding to the economic, sanitary and environmental requirements. Such practices as a major component of integrated pest management (IPM) strategy can conserve the biodiversity by natural balance and minimizing and rationalizing to pesticide use [13].

The possibility of using light traps in management strategy of insect and date palm borers has been pointed out in many researches [14-16]. This study aimed to suppress population density of Arabian

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rhinoceros beetle—*Oryctes agamemnon arabicus* in Iraqi date palm orchards, through application some of ecological sound control methods.

2. Materials and Methods

Three integrated pest management techniques were administered in field to evaluate its efficacies to suppress the population density of *Oryects* spp. in date palm orchards (1 ha each) located in Almadain district according to global positioning system (GPS) with latitude 33°15′ north, longitude 44°56′ east (30 km south of Baghdad), where common date varieties (Barhee, Brem, Umrani, Khastawi and Zahdi) were contained, during the years 2010-2015. The control options were conducted as the following:

(1) In first orchard experience, cultural practices (pruning frond bases as annual regular service work in date palm orchards), hand collection of larvae and light trap were done for adults capture for five years period;

(2) In the second orchard experience, cultural practices were applied for two years 2010 and 2012, collecting adults by light trap for one year 2010 only, while no hand collection of larvae was practiced for in five years period;

(3) The third orchard was used as a control treatment, that is mean no cultural practices, no hand collection of larvae and no light trap were practiced in five years period. The *Oryctes* spp. larvae were collected and counted from the crown of palm tree during annual sanitation practices starting in January till March of each orchard. The numbers of Arabian rhinoceros beetle (ARB) adults were counted daily in each light trap during June and July to determine the population density of adults in each orchard. Meanwhile, Sony HD-R 50 camera was used to image the daily moon phases through the period from June 13-14 to July 12-13 in 2010, June 18-19 to July 17-18 in 2015 to measure the effect of moon light intensity on adults flight ability. In addition, two local entomopathogenic isolates were tested in laboratory for their pathogencity against *Oryctes* larvae, which are MARD 34 and MARD 46 (Table 1) selected from Entomopathogenic Fungal Isolates Bank at the Agricultural Research Directorate, Iraqi Ministry of Science and Technology [17].

The spore concentrations were determined using haemocytometer and adjusted to 1×10^5, 1×10^7, 1×10^9 and 1×10^{11} conidia/mL. The four concentrations were applied separately by direct spraying of each on the larvae and on their food. Three replicates (five larvae each) were used for each treatment. Borer larvae in each replicate were transferred into new sterilized cage 30 cm × 20 cm × 22.5 cm. Cages were kept under rearing room conditions (25 ± 2 °C and 70% relative humidity), and they were checked every 3 d, counting the dead larvae along with monitor their behavior and any noticeable morphological changes.

3. Results and Discussion

3.1 Cultural Practices and Hand Collection of Larvae as a Control Methods

The results in Table 2 indicated the efficacy of cultural practices (sanitation and pruning fronds bases) and hand collection of larvae during annual regular service work in date palm orchards in reducing the population density of *Oryctes* spp.. The number of collected larvae reduced from 9.5 to 0.8 and from 10.9 to 5.1 per tree crown in the 1st and 2nd orchards during

Table 1 Isolates of *Metarhizium anisopliae* and *Beauveria bassiana* used.

Isolate code	Species	Location	Longitude	Latitude	Isolation source
MARD 34	*Metarhizium anisopliae*	Basra province	47°77′ east	30°68′ north	Infected adult of *O. agamemnon arabicus* in date palm and citrus orchard
MARD 46	*Beauveria bassiana*	Thi Qar province, Nisria city	46°48′ east	31°13′ north	Date palm, orchard soil

Table 2 Effect of integrated control measures on population density of *Oryctes* spp. larvae on date palm orchards in five years period 2010-2015.

No. of tree	Larva per tree (in crown only) at year 2010-2015					
	Orchard No.1		Orchard No.2		Orchard No.3	
	2010	2015	2010	2015	2010	2015
1	7	0	13	5	10	12
2	4	1	12	4	9	29
3	12	0	11	3	13	31
4	15	0	12	5	14	19
5	10	2	15	2	14	28
6	13	0	9	6	12	22
7	12	2	12	2	13	18
8	14	1	6	7	14	16
9	8	1	9	8	9	17
10	9	1	10	9	10	25
Total	95	8	109	51	118	217
Mean	9.5	0.8	10.9	5.1	11.8	21.7
Reduction (%)	91.6%		53.0%		-	

2010 and 2015, respectively, in comparison with 11.8 to 21.7 in the 3rd orchard (control). Obviously, the control practices applied decreased the population density of larvae year after year from 2010 to 2015. Such reduction represents in values of 91.6% and 53.0% for the 1st and 2nd orchards, respectively, compared with the control orchard. The results of the control orchard showed the increase in larval number from total 118 larvae in 2010 to 217 larvae in 2015, which is almost two time higher. Such results clearly demonstrated the efficacy of the administered management practices, which could be applied routinely during annual services of date palm orchards. These results are in agreement with the finding of Khalaf et al. [18] on *Oryctes elegans* in Iraq date palm orchards.

3.2 Light Traps as a Control Method of Adults

The results in Table 3 showed that the total adults of *Oryctes* spp. caught during season of 2010 were 134, 157 and 139 adults per trap per month in the 1st, 2nd and 3rd orchards, respectively. While, after five years of using light traps to monitor and control, the numbers of adults caught reached 32, 93 and 237 adult per trap per month. These values represent a reduction in adults population of 71.1% in the 1st orchard after five years of annually cultural practices, hand collection of larvae and light trap during the whole period of experiment and 41.1% in the 2nd orchard (cultural practices each two years, 2010 and 2012 and light trap for one year 2010, without application of larval collection during the whole period of experiment), compared with the 3rd orchard (as a control treatment). It is obvious that management practices decreased the population density of *Oryctes* spp. adults after five years. It is worth mentioning that the number of captured adults decreased gradually till it reached the lowest number in mid of Islamic month (11-20) and increased gradually again from 21-30 in last final 10 d of Islamic month, which could be the effect of moon light on flight ability of adults. These results are in agreement with the finding by Khalaf et al. [2, 18], when they used light traps to monitor and control of *O. elegans* in Iraq date palm orchards.

The results in Fig. 1 showed that the relation between moon phase light intensity and flight ability of *Oryctes* spp. adults. Results showed that the numbers of adults caught in trap were affected negatively by the light intensity (full moon). Adults number caught were 19, 32 and 26 adult in the 1st, 2nd and 3rd orchards, respectively, compared with 39:76, 48:77 and 42:71 during the first (moon age 1-10

Table 3 No. of *Oryctes* spp. adults caught in light traps in date palm orchards at seasons of 2010-2015.

Observed date and moon phase				Number of *Oryctes* spp. adults					
				Orchard No.1		Orchard No.2		Orchard No.3	
Islamic month	Moon phase	2010 June/July	2015 June/July	2010	2015	2010	2015	2010	2015
1/2		13/14	18/19	6	2	7	5	6	13
2/3		15/15	19/20	5	1	6	4	5	13
3/4		15/16	20/21	4	2	6	3	6	12
4/5		16/17	21/22	4	1	5	4	6	12
5/6		17/18	22/23	5	1	4	3	2	10
6/7		18/19	23/24	2	0	4	3	2	6
7/8		19/20	24/25	4	1	6	3	5	7
8/9		20/21	25/26	3	0	4	2	5	4
9/10		21/22	26/27	3	1	3	2	2	3
10/11		22/23	27/28	3	1	3	2	3	3
11/12		23/24	28/29	3	0	2	0	2	1
12/13		24/25	29/30	0	1	2	1	2	3
13/14		25/26	30/1	2	0	4	3	3	5
14/15		26/26	1/2	2	0	5	3	3	3
15/16		27/28	2/3	1	1	3	2	2	0
16/17		28/29	3/4	0	0	2	0	2	3
17/18		29/30	4/5	2	0	3	1	2	3
18/19		30/1	5/6	2	1	3	0	2	4
19/20		1/2	6/7	3	1	3	2	3	0
20/21		2/3	7/8	4	1	5	1	5	3
21/22		3/4	8/9	3	0	5	2	4	6
22/23		4/5	9/10	3	0	7	3	6	8
23/24		5/6	10/11	6	1	7	4	7	12
24/25		6/7	11/12	6	1	8	5	6	14
25/26		7/8	12/13	7	2	6	6	5	14
26/27		8/9	13/14	8	2	8	4	8	13
27/28		9/10	14/15	10	3	8	5	9	17
28/29		10/11	15/16	11	2	9	5	8	14
29/30		11/12	16/17	12	3	9	7	8	16
30/1		12/13	17/18	10	3	10	8	10	15
Total				134	32	157	93	139	237
Mean				4.5	1.1	5.2	3.1	4.6	7.9
Reduction (%)				76.1%		41.1%		-	

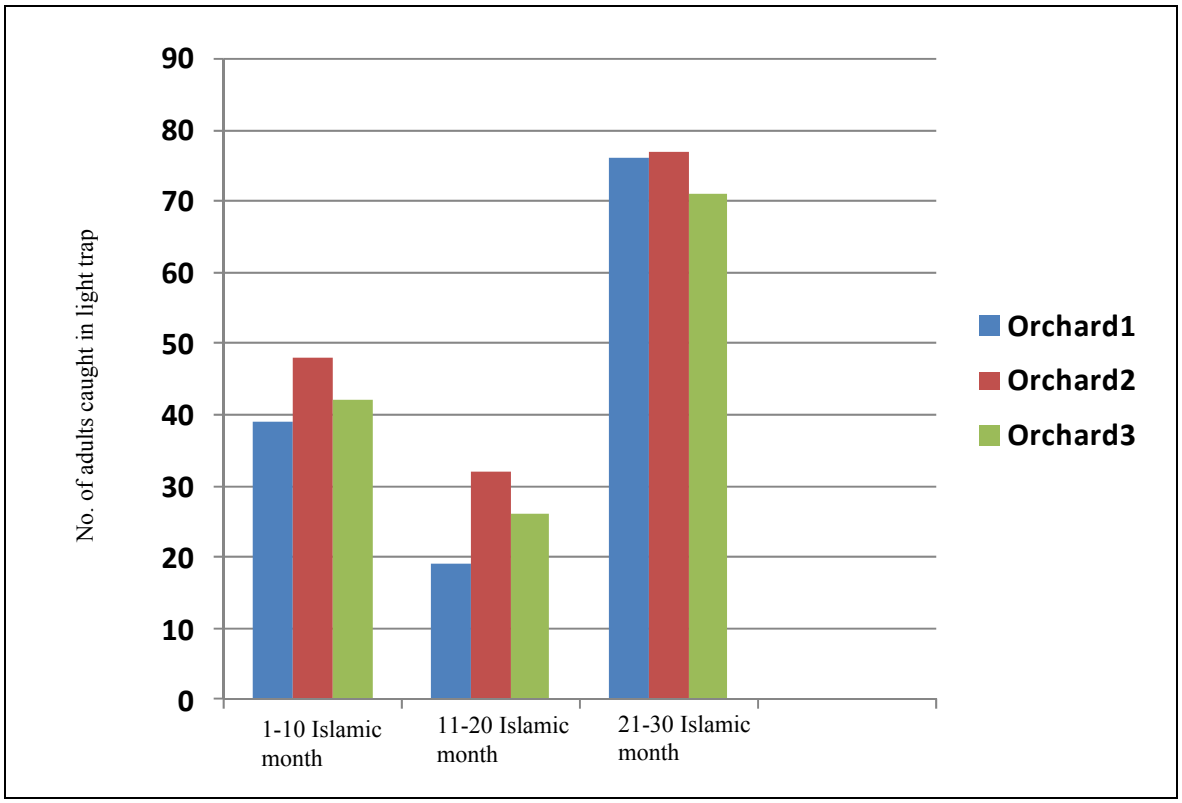

Fig. 1 Effect of moon light on flight ability of *Oryctes* spp. in date palm orchards.

day):last 10 day (moon age 21-30 day) in the 1st, 2nd and 3rd orchards, respectively (Fig. 1). These results indicated a relation between the flight ability of *Oryctes* spp. adults and moon light intensity. These result matches with those found by Khalaf et al. [2], Steibaner [15] and Morton et al. [19] about impact of brightness of the moon light on *Oryctes elegans*, *Heliothis armigera* and *Mnesampela privata* caught in light traps.

3.3 Efficacy of Entomopathogenic Fungi on Oryctes spp. Larvae

Survival percentages of *Oryctes* spp. larvae after treating them with entomopathogenic fungal isolate *B. bassiana* MARD 46 spore suspensions revealed that the concentration 1×10^{11} conidia/mL inflicted the highest mortality among larvae, reaching 93.33% after 19 d, followed by the concentration 1×10^{9} conidia/mL that recorded mortality of 66.66% at the same time (Fig. 2). In addition, mortality reached 53.33% after 19 d using concentration of 1×10^{7} conidia/mL and the lowest mortality was 40% at the concentration 1×10^{5} conidia/mL after the same period. All concentrations used decreased larval survivals with time progression, reaching 0% at the end of the experiment (29 d).

Fig. 3 illustrates survival percentages of date palm borers' larvae during experiment duration (29 d) following treatment with different spore suspension concentrations of *M. anisopliae* (MARD 34). The result revealed that the highest mortality after 19 d was 66.66% at concentration 1×10^{11} conidia/mL, followed by the concentration 1×10^{9} conidia/mL with 53.33% at the same time. The lowest mortality scored at the concentrations 1×10^{5} conidia/mL and 1×10^{7} conidia/mL, reaching 46.66% after 19 d of the treatment. All concentration recorded decrease of survival with time progression, reaching 0% at the end of the experiment.

Ricano et al. [20] found that using more than one formula of *B. bassiana* can remarkably reduce survival and increase mortality rate among red palm

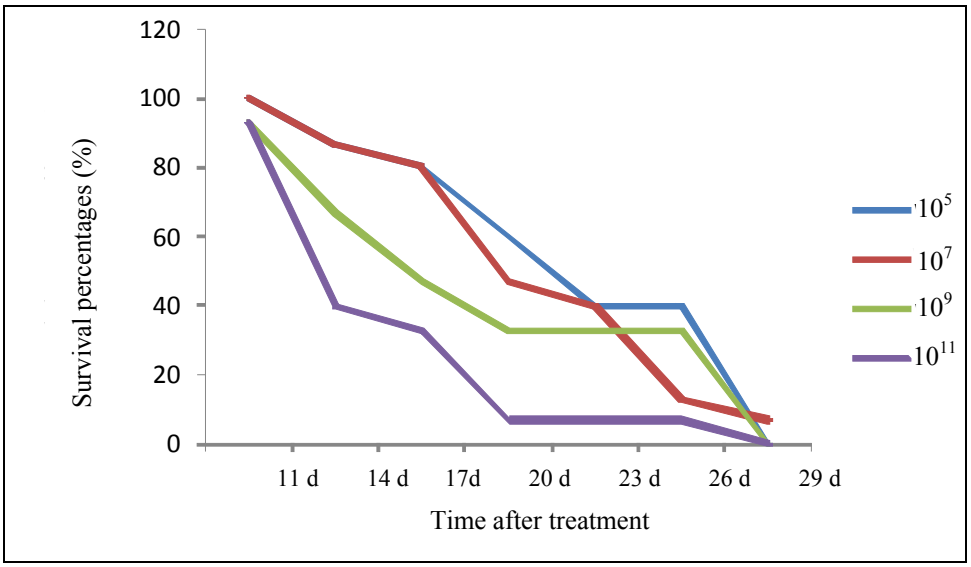

Fig. 2 Survival percentages among date palm borer larvae *Oryctes* spp. treated with the *Beauveria bassiana* isolate (MARD46).

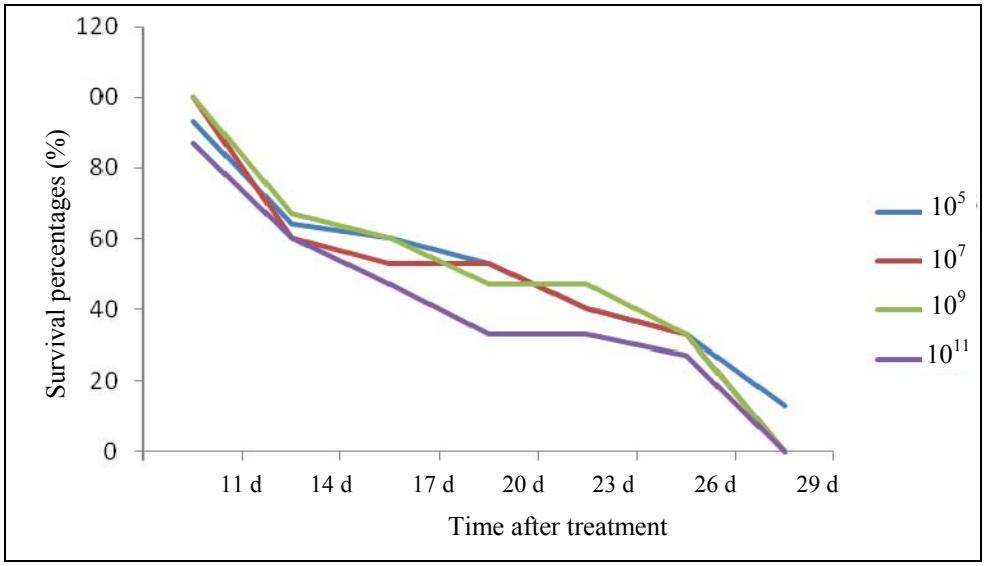

Fig. 3 Survival percentages among date palm borer larvae *Oryctes spp.* treated with the *Metarhizium anisopliae* isolate (MARD34).

weevil larvae and adults. *B. bassiana* can increase mortality rate of *Helicoverpa armigera* larvae as well as mentioned by Ritu et al. [21]. Such practice, using entomopathogenic fungi infested of conventional insecticides which failed in achieving acceptable control level, could be effective alternative and sound method from ecological and health view points.

4. Conclusions

In conclusion, the results demonstrated the high infestation rates of *Oryctes* spp. to date palm trees. Application of cultural practices, hand collection of larvae, light traps for adults and entomopathogenic fungi as ecological sound pest management practices showed clearly the efficacies of such practices to control of *Oryctes* spp. (especially *Oryctes agamemnon arabicus* as a dominant species in Iraq) in date palm orchards. Therefore, the approach of these practices is recommended to manage and control palm borer annually.

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