JOURNAL OF ENTOMOLOGICAL SOCIETY OF IRAN
2020, 40 (2), 123–133
نامه انجمن حشره‌شناسی ایران ۱۳۹۹, ۴۰(۲), ۱۲۳–۱۳۳

JESI

DOI: 10.22117/JESI.2020.127118.1322

Determination of economic injury level of *Ommatissus lybicus* (Hemiptera: Tropiduchidae) on two commercial date cultivars in southern Iran

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Abstract
Dubas bug, *Ommatissus lybicus* Bergevin (1930), is one of the key pests of date palms in Iran, which drastically reduces the quality and quantity of dates produced. The Present study aimed to determine economic injury level of *O. lybicus* on two commercial date cultivars in three main date palm growing provinces of southern Iran. The economic injury level of dubas bug on date palm was estimated by Pedigo method. A date palm grove infested by dubas bug was chosen in Kerman (Bam), Fars (Farashband), and Bushehr (Tang-e Zard) provinces. The study was conducted in randomized complete block design with seven treatments replicated three times. Each experimental unit consisted of three identical trees in which the sampling was performed on the middle tree. We reached the intended densities of *O. lybicus* using natural and artificial infestation by using insecticides. The assessment was made based on the weekly recording the number of nymphs and honey droplets. In addition, the total weight of the harvested date was determined at harvesting. The results showed that EIL based on the number of nymphs/leaflet of date palm leaf on Zahedi cultivar were 1.06 and 0.34 nymphs for Farashband, respectively, and 0.28 and 0.88 nymphs for Tang-e Zard in studied years. The values for Bam on Mazafati cultivar in the three consecutive years of 2013, 2014 and, 2015 were 0.27, 0.25, and 0.10 nymphs, respectively.
Key words: date palm, dubas bug, EIL.

تعیین سطح زیان اقتصادی زنجرک خرما *Ommatissus lybicus* (Hemiptera: Tropiduchidae) در دو رقم تجاری خرما در جنوب ایران

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چکیده
زنجرک خرما، *Ommatissus lybicus* Bergevin (1930)، یکی از آفات کلیدی خرما در ایران است که باعث کاهش چشمگیر کیفیت و کمیت خرمای تولیدی می‌شود. مطالعه حاضر با هدف تعیین سطح زیان اقتصادی *O. lybicus* روی دو رقم تجاری خرما در سه استان خرماخیز جنوبی کشور انجام شد. تعیین سطح زیان اقتصادی زنجرک خرما با روش پدیگو انجام شد. برای این منظور، در هر یک از استان‌های کرمان (بم)، فارس (فراشبند) و بوشهر (تنگه زرد) یک نخلستان آلوده به

Received: 23 July 2019, *Accepted:* 21 June 2020
Subject Editor: Yaghoub Fathipour

زنجرک خرما انتخاب شد. آزمایش در قالب طرح بلوک کامل تصادفی با هفت تیمار و سه تکرار اجرا شد. هـر واحد آزمایشی شامل سه درخت هم‌سن بود که از درخت وسط نمونه‌برداری انجام شد. ما از دو روش آلودگی طبیعی و مصنوعی با استفاده از حشره‌کش‌ها به تراکم مورد نظر در *O. lybicus* رسیدیم. ارزیابی‌ها بر اساس ثبت هفتگی تعداد پوره‌ها و قطرات عسلک انجام شد. علاوه بر این، در پایان فصل و در زمان برداشت، وزن کل خرمای برداشت شده تعیین شد. نتایج نشان داد، سطح زیان اقتصادی در سال‌های مورد بررسی بر اساس تعداد پوره‌های زنجرک خرما در هر برگچه از برگ درخت خرما، روی رقم زاهدی ۱/۰۶ و ۰/۳٤ پوره در فراشبند و ۰/۲۸ و ۰/۸۸ پوره در تنگه زرد در سال‌های مورد بررسی بود. این مقادیر در بم روی رقم مضافتی در سه سال متوالی ۱۳۹۲، ۱۳۹۳ و ۱۳۹٤ به ترتیب ۰/۲۷، ۰/۲۵ و ۰/۱ پوره بود.

واژگان کلیدی: خرما، زنجرک خرما، EIL

دریافت: ۱۳۹۸/۰۵/۰۱، پذیرش: ۱۳۹۹/۰٤/۰۱.

Introduction

Date is one of the main horticultural products of Iran, which plays an important role in the national economy, food security, export, and foreign exchange. There are 253679 hectares under cultivation with a production level of 1223142 tons in Iran (Ahmadi *et al*., 2017). *Ommatissus lybicus* Bergevin (1930) (Hem: Tropiduchidae) also known as dubas bug (Thalhouk, 1977), is one of the most important pests of date palm, which is currently under more than 15,000 hectares of chemical control. It was reported from Iraq, Egypt, North Africa, Libya, and Spain (Thacker *et al.*, 2003). Ecological niche modeling demonstrated that northwest of Sistan and Baluchestan; east, south and southeast of Kerman, northeast and northwest of Hormozgan, and small districts of Bushehr provinces are hot spot habitats for *O. lybicus* in Iran (Bagheri *et al*., 2018b). Infestation level and chemical pest control are not the same in different provinces (Bagheri *et al*., 2018b). Their nymphs and adults cause important damage to date palm directly and indirectly. Direct damage is caused by sucking the sap, to the weakness of the trees. Indirect damage is caused by excreting honeydew that acts as a trophic resource for saprophytic fungi, especially sooty molds (Thacker *et al*., 2003). The late ripened fruits on infested palms are smaller and less sweet. Due to honeydew and dust on fruits, their price will be decreased in the market (Hussain, 1963). *Ommatissus lybicus* has two distinct generations per year which causes more damage at first generation in most areas (Arbabtafti *et al*., 2016) and high potential to cause economic damage if it is not managed properly (Bagheri *et al*., 2016).

Economic injury level is the smallest number of insects that will cause yield losses equal to the insect management costs (Stern *et al*., 1959) and control is necessary before reaching that level. Investigating the economic injury level of pest and determining the relationship between population density and yield reduction is one of the most important tools in integrated pest management programs. Chemical control of *O. lybicus* was recommended when 75% of eggs hatched (Hussain, 1963). Hussein (1963) divided dubas bug infestation into three levels: low infestation (average 0-5 eggs per leaflet), moderate (5-10 eggs per leaflet), and severe (more than 10 eggs per leaflet). However, Pezhman (2007) believed that the date when 30-40% of the eggs have hatched is important in timing insecticide applications (depending on the area and the severity of egg infestation on the leaves). In general, the damage is increasing in high-density date palm groves hence; planting intervals are important (Damghani, 1992). A recent study revealed a considerable variation between *O. lybicus* populations under intensive chemical strategies (Bagheri *et al*., 2018a). Therefore, determination of economic injury level according to conditions of different regions avoid mismanagement in the pest control strategy. The purpose of the present study was EIL estimation of *O. lybicus* in three main date producing provinces of Iran.

Materials and methods

Study location

This study was carried out in Kerman (Bam) (29° 06' 21.60" North, 58° 21' 25.20" East, 1050 m Height), Fars (Farashband) (28° 51' 0.00" North, 52° 04' 59.88" East, 800 m Height) and Bushehr Provinces (Tang-e Zard) (29° 06' 41" North, 51° 33' 24" East, 481 m Height) from 2013 to 2015. The main variety were Mazafati in Kerman and Zahedi in Fars and Bushehr.

In each region, about 5000 m^2 of an infested 8-10 year old date palm grove without any chemical control was chosen. All operations were carried out in accordance with the custom of the area. A randomized complete block design was performed with seven treatments and three replications and each experimental unit consisted of three trees that samples were taken from the middle tree. Selected trees were in the same age and other operations, such as irrigation practices, irrigation intervals, fertilizer rates, pruning time, etc. were the same.

Different densities of *O. lybicus* were determined based on two methods, natural infestation and artificial density (by using insecticide). In natural infestation, existing densities of *O. lybicus* in date palm groves were used for sampling and control was considered (it was done in Kerman and Bushehr provinces) and in artificial infestation, densities were determined based on different concentrations of an insecticide and control was considered too (Pedigo & Hagley, 1992). In Fars, diazinon (60% EC, Golsam) (0.5, 1, 1.5, and 2 ml/l) and oil of two companies, Partonar and Aria Chemistry (1.5%), were used.

Sampling method

Four leaflets/frond from four main geographical direction (16 leaflets) of each tree (a replication) were sampled to record the number of nymphs (Hussein, 1963) after study initiation every week. Numbers of honeydew droplets, as a feeding index, were recorded as well. For this purpose, transparent glass plates (12×12 cm^2) were used. Each glass was divided into 64 frames of 1.5×1.5 cm^2. Four plates per tree were placed under the canopy on the soil surface for 12 hours (19:00 h -07:00 h local time) after study initiation. The number of honeydew droplets was counted in three randomly chosen frames/glass plate (This method was selected based on the Thacker *et al*. (2003) to estimate the number of honeydew droplets and nutritional activity tracking using water-sensitive paper. We used glass plate instead of water-sensitive paper because of the greater accessibility and the lack of movement and drift).

Data Analysis

Data were analyzed using the SAS Var. 9.1 (SAS Institute Inc., Cary, NC). The correlation between the nymph population and honeydew droplets was estimated using PROC UNIVARIATE, PROC CORR. The relationship between the nymph density and honeydew droplets and date yield was determined by applying PROC REG and the detection of outliers was made by COOK D coefficient.

According to Pedigo (1999), because it is difficult to calculate the damage of sucking insects (decrease in photosynthesis) (I) and its relationship with yield reduction (D), a coefficient representing yield loss/ insect was used: $b = I \times D$

The coefficient b was obtained from the linear regression equation of the experiment. In this way, by setting different densities of the insect, the yield loss was measured: $Y = a + bX$

Y is date palm yield (kg/ha), a is the constant value (intercept), b is the slope that shows the yield loss/insect, and X is pest density (nymph/leaflet or honeydew/cm^2). So EIL was estimated based on the Pedigo *et al.* (1986) formula as follows:

$$EIL = C / (V \times b \times K)$$

Where C is the control cost ($/ha), V is the market value of the crop ($/kg), b is the slope of the regression of yield loss/insect and K is the reduction of injury due to treatment (proportion 0.6 for 60% mortality to 1 for no loss). Here, 0.6 was considered for 60% of mortality by the current control method.

At first, the mean density and yield loss were estimated and then the yield loss for each nymph or honeydew droplets was calculated.

To estimate EIL, the gain threshold should be estimated too as a yield increase required the compensating cost of management (Stone & Pedigo, 1972). It is used to express the beginning of economic damage and as a measure of marketable yield per special area (Pedigo, 1999).

$$GT = C/V$$

Results

Relationship between the nymph density and honeydew droplets

A three-year study in Bam, Tang-e Zard, & Farashband showed that only the mean of honeydew droplets in Bam was normal. Therefore, the Spearman method was used to determine the correlation coefficient. As Table 1 shows, there was a direct correlation between the average density of nymphs and honeydew droplets in Bam & Tang-e Zard, while this correlation was not observed in Farashband.

Table 1. Determination of the correlation coefficient between the mean populations of nymph with honeydew droplets of *O. lybicus* by Spearman method in studied areas.

Area		Nymph/leaflet		Honeydew droplet/1.5×1.5cm^2	
		p	r_s^*	*p*	r_s
Farashband	Nymph/ leaflet			<0.5349	-0.12240
	Honeydew droplet/1.5×1.5cm^2	<0.5349	-0.12240		
Bam	Nymph/ leaflet			<0.0001	0.83707
	Honeydew droplet/1.5×1.5cm^2	<0.0001	0.83707		
Tang-e Zard	Nymph/ leaflet			<0.0001	0.66429
	Honeydew droplet/1.5×1.5cm^2	<0.0001	0.66429		

*Pearson correlation coefficient

Data analysis of variance revealed that there was a linear relationship between the mean number of nymph and honeydew droplets of *O. lybicus* in Farashband, Bam, & Tang- e Zard (Table 2).

Table 2. Linear relationships between mean number of nymph and honeydew droplets of *O. lybicus* in studied areas**.**

Area	Equation	r^2	P_{reg}	*F*
Farashband	Y= 0.4441X + 0.9131	0.531	<0.0002	21.56
Bam	Y = 0.1995X + 0.5921	0.948	<0.0001	437.3
Tang-e Zard	Y = 0.1098X+ 0.6828	0.8447	<0.0001	168.61

EIL calculation

Linear regression revealed an inverse relationship between the nymph densities and honeydew droplets of *O. lybicus* and yield in each area and year (Table 3). Thus, higher nymph density or honeydew reduced more date yield.

The values of EIL for *O. lybicus* in different regions and years are depicted in Table 4. Furthermore, insecticide application costs ($/ha) for *O. lybicus* management and the market value of date palm product ($/kg) are shown in Table 4.

Loss per insect was calculated by linear regression in where loss per insect was estimated from the slope of the yield function (Tables 3 & 4).

Table 3. Linear relationships between different densities of nymph and honeydew droplet of *O. lybicus* and yield loss in studied areas in 2013- 2015.

Year	Area	Parameter	Equation	$^{*}P_{reg}$	r^2	Loss (kg/ha) per insect (plant)
2013**	Farashband	N. nymph	-	<0.3205	-	157
		N. honeydew droplet	Y= 105.58-2.5264X	<0.0441	0.789	-
	Bam	N. nymph	-	<0.3901	-	626
		N. honeydew droplet	-	<0.3372	-	-
2014***	Bam	N. nymph	Y= 79.721-7.041X	<0.0005	0.9299	704
		N. honeydew droplet	Y=88.175-2.7381X	<0.0001	0.9598	-
	Tang-e Zard	N. nymph	Y=89.819-5.9338X	<0.0010	0.5789	593
		N. honeydew droplet	Y=80.002-0.564X	<0.0044	0.4767	-
2015	Farashband	N. nymph	-	<0.5164	-	437.78
		N. honeydew droplet	-	<0.6703	-	-
	Bam	N. nymph	Y=1011.2-16.504X	<0.0001	0.9845	1594
		N. honeydew droplet	Y=982.07-3.5966X	<0.0073	0.959	-
	Tang-e Zard	N. nymph	Y=54.885-13.003X	<0.0094	0.4161	1300.3
		N. honeydew droplet	Y=55.689-22.699X	<0.0173	0.3639	-

* In case P_{reg} was not significant, the EIL was calculated manually. N = Number
** It was not done in Bushehr due to the low population of *O. lybicus*.
*** Fars data was not use due to the low population of *O. lybicus.*

Discussion

A host's ability to tolerate pest damage depends not only on its inherent resistance but also on its general conditions. Thus, a healthy plant is usually more tolerant to pest damage. Proper crop management can increase the tolerance of pest infestation by improving the general conditions of the host (Mahmoudi *et al*., 2014). The development and use of EIL values for managing the population of pests lead to the superior yield (Hutchins, 1996). The efficiency of plant protection practices in pest management should be estimated by crop loss assessment (Oerke & Dehne, 2004). Such information can provide insight into the economic and food planning policies and affect the price of agricultural products (Ghaderi *et al*., 2019).

The values of EIL estimated by converting the number of droplets of honeydew to nymphs, had a high differences with those estimated by direct calculation (4 to 5 folds of calculated EIL based on nymphs except for the first year of Farashband as Table 5 shows), showing high discrepancies between these two approaches for calculating EIL. Generally, despite the significant regression relationship confirmed for all three regions based on yield loss/ insect, we believe that direct population estimates are better than indirect methods and population indices (honey droplets). In spite of this study, Tucker *et al*. (2003) believed that honeydew droplets recording provided a better estimate of pest population than direct counting of nymphs because of animation and easily dispersion of nymphs on the leaves. They believed that this method is much easier and more accurate in palm trees.

Table 4. Economic injury level of *O. lybicus* in studied areas in 2013- 2015.

Year	Components of EIL calculation		Area		
			Farashband	Bam	Tang-e Zard
2013*	Control Cost ($/ha)	Insecticide	40.625	40.625	-
		Labor + Sprayer	34.375	46.875	-
		Possibility of respraying	25%	25%	-
		Total cost	93.75	109.375	-
	Value of crop ($/Kg)		0.937	1.094	-
	Gain Threshold (Kg/ha)		100.053	99.977	-
	Control efficacy		0.6	0.6	-
	Loss (Kg/ha) per insect (plant)		157	626	-
	EIL (Nymph/leaflet)		1.06	0.27	-
2014**	Control Cost ($/ha)	Insecticide	-	39.39	39.394
		Labor + Sprayer	-	36.36	33.33
		Possibility of respraying	-	50%	20%
		Total cost	-	113.64	90.91
	Value of crop ($/kg)		-	1.061	0.91
	Gain Threshold (Kg/ha)		-	107.11	99.91
	Control efficacy		-	0.6	0.6
	Loss (Kg/ha) per insect (plant)		-	704	593
	EIL (Nymph/leaflet)		-	0.253	0.281
2015	Control Cost ($/ha)	Insecticide	46.377	46.377	46.377
		Labor + Sprayer	40.58	40.58	40.58
		Possibility of respraying	20%	50%	20%
		Total cost	104.348	130.435	104.348
	Value of crop ($/kg)		1.16	1.304	0.869
	Gain Threshold (Kg/ha)		89.955	100.027	120.078
	Control efficacy		0.6	0.6	0.6
	Loss (Kg/ha) per insect (plant)		437.78	1594	1300.3
	EIL (Nymph/leaflet)		0.34	0.1045	0.1538

* It was not done in Bushehr due to the low population of *O. lybicus*.
** Fars data was not use due to the low population of *O. lybicus.*

Table 5. EIL estimation of *O. lybicus* based on the regression relationship of each region in three years by different measures.

Year	Area								
	Farashband			Bam			Tang-e Zard		
	Nymph /leaflet	Honeydew droplet/ 1.5×1.5cm^2	Convert honeydew to nymph/ leaflet	Nymph /leaflet	Honeydew droplet/ 1.5×1.5cm^2	Convert honeydew to nymph/ leaflet	Nymph /leaflet	Honeydew droplet/ 1.5×1.5cm^2	Convert honeydew to nymph/ leaflet
2013*	1.06	0.66	1.2	0.27	2.38	1.07	-	-	-
2014**	-	-	-	0.25	0.65	0.72	0.28	2.95	1
2015	0.34	0.59	1.17	0.1	0.92	0.77	0.15	0.88	0.78

* It was not done in Bushehr due to the low population of *O. lybicus*.
** Fars data was not use due to the low population of *O. lybicus.*

Analysis of variance on data indicated that there was a correlation between the number of nymphs/ honeydew droplets and yield. The regression relationship of the mean number of nymphs/ honeydew droplets by yields revealed that when the number of nymphs was lower, the yield would be higher (Table 6). Ogunlana & Pedigo (1974) obtained similar results on potato leafhopper. As the number of potato leafhopper increased from zero to 300 per plant, the yield decreased by half.

Table 6. The Mean of yield (kg/ ha) for different densities of nymph/leaflet of *O. lybicus* in studied areas in 2015.

Nymph/ leaflet	Yield* (Kg/ ha)		
	Farashband	Bam	Tang-e Zard
0	127.96	968.04	54.88
1	127.64	952.1	41.88
2	127.32	936.16	28.88
3	127	920.22	15.88
4	126.69	904.28	2.87
5	126.37	888.34	
10	124.79	808.64	
15	123.20	728.94	
20	121.62	649.24	
25	120.03	569.54	
30	118.44	489.84	

* The calculation is computed by putting different densities in equations of each region.

The damage of an insect pest species can vary depending on the density, population distribution, cultivar, and climate (Chiaxg, 1964; Price, 1997). Here, this point was very clear in comparing the mean of date yield in Bam and Farashband in Table 6. For example, the density of 30 nymph/ leaflet reduced the yield almost half in Bam, while the process of this change is very slow and insignificant in Farashband.

Chemical control of *O. lybicus* was recommended when 75% of eggs hatched (Hussain, 1963). Hussein (1963) divided dubas bug infestation into three levels: low infestation (average 0-5 eggs per leaflet), moderate (5-10 eggs per leaflet), and severe (more than 10 eggs per leaflet). However, Pezhman (2007) believed that the date when 30-40% of the eggs have hatched is important in timing insecticide applications (depending on the area and the severity of egg infestation on the leaves).

The spatial distribution pattern of pests is an important factor in plant damage and crop loss. When the same number of pests is dispersed over the crop area, it usually has much less impact than when the pest is highly aggregated, which may cause severe plant damage in the area of aggregation (Chiaxg, 1964; Cocco *et al*., 2015; Martins *et al*., 2017; Smith, 1969). Arbabtafti *et al.* (2012) verified that adults and eggs of *O. lybicus* had an aggregated pattern in Kerman and Bushehr provinces in Iran.

Our results indicated that if there was 1.06 nymph/ leaflet on Zahedi cultivar in Farashband in 2013 it is necessary to use chemical control but this value reached 0.34 nymph/ leaflet in 2015. The value was an average of 0.28 and 0.15 nymph/ leaflet On Zahedi cultivar in Tang-e Zard in 2014 and 2015, respectively. The result of this study was almost near to each other on Mazafati cultivar in Bam every three years so that the estimated economic injury level was 0.27, 0.25, and 0.1 nymph/ leaflet in 2013, 2014, & 2015, respectively.

We found that the values of EIL were different either based on the sampling area or year of the study. This issue may stem from the difference in the genetic profile of the hosts and dubas bug or variation in the bioclimatic variables, affecting the biology of *O. lybicus* (Arbabtafti *et al*., 2016; Bagheri *et al*., 2016, 2018b). For instance, the demographic parameters of three geographically distinct populations of *O. lybicus* (Bam, Jiroft, & Tezerj) on two date palm cultivars (Berhi & Khunizi) revealed that Bam is an aggressive population with higher infestation rate compared with the other populations due to its higher *r* and *λ* values as well as shorter mean generation time on both host cultivars (Bagheri *et al*., 2016). This population experiences repeated exposure to heavy pesticide applications, which may accelerate its genetic divergence (Bagheri *et al*., 2017). In addition to the above-mentioned variables, *O. lybicus* may fluctuate in response to changes in the type of irrigation (effective in irrigation cycle) and horticultural management (age and height of date palms and interplanting distance) (Mahmoudi *et al*., 2014). All of these studies confirmed our results well, as in Bam we have the least EIL in comparison with the other regions. The effect of cultivar on EIL value has been shown in findings of Ghaderi *et al*. (2019) too. They found high variation in EIL of *T. absoluta* on different cultivars (4.15, 4.47, 4.70 and 5.04 larvae/plant on "Petomech," "CalJN3," "Rio Grande" and "Early Urbana Y" cultivars, respectively, under natural conditions and 4.75 and 5.44 larvae/plant on "Cal JN3" and "Early Urbana Y", respectively, under artificial conditions). Furthermore, Shipp *et al*. (2000) revealed that various factors, including cultivar, the strain of pest species and, climatic conditions could affect the values of EIL.

Annual changes in the value of EIL can be related to factors such as the market value of crop and pest management costs, which play a decisive role. Therefore, it is not possible to expand the EIL of a region or a cultivar to other areas or varieties and it is necessary to estimate the EIL for each region and each cultivar separately.

Acknowledgments

The financial and technical support of this research by Iran national Science foundation and Iranian Research Institute of Plant Protection is greatly appreciated.

References

Ahmadi, K., Ebadzadeh, H. R., Hatami, F., Hosseinpoor, R. & Abdeshah, H. (2017) Agricultural statistics of of Iran. *Information and Communication Technology Center, Planing and Economic Affair, Ministry of Agriculture-Jahad 3*, 239.

Arbabtafti, R., Damghani, R., Fassihi, M. T. & Khajehzadeh, Y. (2016) Study on population fluctuations of Dubas bug, *Ommatissus lybicus* Bergevin (Hem: Tropiduchidae) in Iran. *Applied Entomology and Phytopathology* 83(2), 133-147.

Arbabtafti, R., Damghani & R., Fassihi. (2012) A study on spatial distribution pattern and the sample size of different stages of *Ommatissus lybicus* Bergevin (Hem: Tropiduchidae). *20th Iranian Plant Protection Congress*, 26-29 August, Shiraz, Iran.

Bagheri, A., Fathipour, Y., Askari-Seyahooei, M. & Zeinolabedini, M. (2016) How different populations and host plant cultivars affect two-sex life table parameters of the date palm hopper, *Ommatissus lybicus* (Hemiptera: Tropiduchidae). *Journal of Agricultural Science and Technology* 18, 1619-1606.

Bagheri, A., Fathipour, Y., Askari-Seyahooei, M. & Zeinolabedini, M. (2017) Reproductive isolation among allopatric populations of date palm hopper, *Ommatissus lybicus* (Hemiptera: Tropiduchidae). *Annals of the Entomological Society of America* 110, 337–343.

Bagheri, A., Fathipour, Y., Askari-Seyahooei, M. & Zeinalabedini, M. (2018a) *Ommatissus lybicus* (Hemiptera: Tropiduchidae), an economically important pest of date palm (Arecaceae) with highly divergent *populations. Canadian Entomologist* 1–15.

Bagheri, A., Fathipour, Y., Askari-Seyahooei, M. & Zeinalabedini, M. (2018b) Ecological Niche Modeling of *Ommatissus Lybicus* (Hemiptera: Tropiduchidae) De Bergevin. *Annals of the Entomological Society of America* 111(3), 114–121.

Chiaxg, H. C. (1964) The effects of feeding site on the interaction of the European corn borer, *Ostrinia nubilalis*, and its host, the field corn, *Zea mays*. *Entomologia Experimentalis Et Applicata* 7, 144–148.

Cocco, A., Serra, G., Lentini, A., Deliperi, S., & Delrio, G. (2015) Spatial distribution and sequential sampling plans for *Tuta absoluta* (Lepidoptera: Gelechiidae) in greenhouse tomato crops. *Pest Management Science* 71, 1311–1323.

Damghani, R. (1992) Study of the Biology of *Omatissus lybicus* in Bam. Final report of the research project. *Agricultural Organization of Bam* 12 pp.

Ghaderi, S., Fathipour, Y., Asgari, S. & Reddy G. V. P. (2019) Economic injury level and crop loss assessment for *Tuta absoluta* (Lepidoptera: Gelechiidae) on different tomato cultivars. *Journal Applied Entomolology* 143, 493-507.

Hussain, A. (1963) Biology and Control of the Dubas Bug, *Omatissus lybicus* (Hom: Tropiduchidae) infesting Date palm in Iraq. *Commenwelth Agriculture Bureaux* 737-745.

Hutchins, S. H. (1996) Economic thresholds for insect management. in Higley, L. G. & Pedigo L. P. (Eds) *Economic thresholds for integrated pest management*. pp. 275–290. Lincoln, University of Nebraska Press.

Mahmoudi, M., Sahragard, A., Pezhman, H. & Ghadamyari, M. (2014) Effect of climatic and management factors on the abundance of dubas bug, *Ommatissus lybicus* Bergevin (Hem.: Tropiduchidae) in northern Hormozgan and southern Fars Provinces. *Plant Pests Research* 3(4), 63-76.

Martins, J. C., Picanço, M. C., Silva, R. S., Gonring, A. H., Galdino, T. V. & Guedes, R. N. (2017) Assessing the spatial distribution of *Tuta absoluta* (Lepidoptera: Gelechiidae) eggs in open field tomato cultivation through geostatistical analysis. *Pest Management Science* 74(1), 30-6.

Oerke, E. C. & Dehne, H. W. (2004) Safe guarding production losses in major crops and the role of crop protection. *Crop Protection* 23, 275–285.

Ogunlana, M. O. & Pedigo, L. P. (1974) Economic-Injury Levels of the potato leafhopper on soybeans in Iowa. *Journal of Economic Entomology* 67, 29-32.

Pedigo, L. P., Hutchins, S. H. & Higley, L. G. (1986) Economic injury levels in theory and practice. *Annual Review Entomology* 31, 341- 368.

Pedigo, L. P. (1999) *Entomology and pest management*. 3th ed. Prentice- hall. Englewood Cliffs, NJ. 691 pp.

Pedigo, L. & Higley L. (1992) The economic injury level concept and environmental quality. A New Perspective. *American Entomologist* 38, 12–18.

Pezhman, H. (2002) A view on date palm and its research program in Iran. *Proceeding of Date palm Global Network Establishment. Alain-University*. 07-09 April, 71-80.

Pezhman, H. (2007) Date palm guide (plantation, cultivation, harvesting). 226 pp. *Educational Technology Services Bureau* [In Farsi]

Price, P. W. (1997) *Insect ecology*. New York, John Willey & Sons.

Shipp, J. L., Wang, K. & Binns, M. R. (2000) Economic injury levels for western flower thrips (Thysanoptera: Thripidae) on greenhouse cucumber. *Journal of Economic Entomology* 93, 1732-1740.

Smith, R. F. (1969) The importance of economic injury levels in the development of integrated pest control programs. *Qualitas Plantarum Et Materiae Vegetabiles* 2, 81–92.

Stern, V. M., Smith, R. F., van den Bosch, R. & Hagen, K. S. (1959) The integrated control concept. *Hilgardia* 29, 81-101.

Stone, J. D. & Pedigo, L. P. (1972) Development and economic injury level of the green clover worm on soybean in Iowa. *Journal of Economic Entomology* 65, 197–201.

Thalhouk, A. S. (1977) Family Tropiduchidae, *Ommatissus binotatus* Fieb. Var. *lybicus* De Berg, pp. 304–305. In J. Kranz H. Schmutterer and W. Koch (eds.), *Diseases, pests and weeds in tropical crops.* John Wiley & Sons, Chichester, United Kingdom.

Thacker J. R. M., Al Mahmooli I. H. S. & Deadman M. L. (2003) Population dynamics and control of the Dubas bug, *Ommatissus lybicus* in the Sultanate of Oman. p. 987- 992. In: *The BCPC International Congress- Crop Science and Technology. Procceding.* An International Congress, Glasgow, Scotland, UK, 10-12 November 2003.