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Ecological Studies on *Lepidosaphes ulmi* (L.) (Hemiptera: Diaspididae) and its Parasitoids on Olive Trees in Middle Egypt

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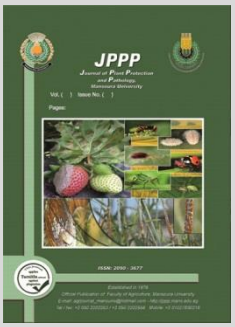

ABSTRACT

The oystershell scale insect, *Lepidosaphes ulmi* (L.) is considered one of the serious pests attacking olive trees in Egypt. The present study was carried out in Naser region, Beni-Suef Governorate during two successive years (2021 and 2022). The population fluctuation of the oystershell scale showed two to three peaks that were recorded during the spring, summer and autumn seasons during the years of study. The highest population peak was recorded in summer (11 and 15.6 insects/leaf, through 2021 and 2022, respectively). While the percentage of The factors of minimum and maximum temperatures, relative humidity, and annually. parasitism showed 4-5 peaks parasitism had non-significant effect on population density of *L. ulmi* in 2021 season, but had highly significant parasitism rates in both years effect in 2022 season. However, these ecological factors had significant effects on the of study. The parasitoids, *Aphytis chrysomphali* and *A. diaspidis* (Hymenoptera: Aphelinidae) were collected from *L. ulmi* scales.

Keywords: Population fluctuation, *Lepidosaphes ulmi*, parasitoids, weather factors.

INTRODUCTION

The long-lived olive tree, *Olea europaea* L. is considered one of the most economical horticultural crops in Egypt and world (Abd-Ella et al., 2020). It is believed that, Since 4800 B.C., it has been cultivated in the Mediterranean region. This evergreen perennial tree has a great socioeconomic importance for many Southern European countries (Arenas-Castro et al., 2020).

There is no doubt that the quantity and quality of the olive crop are seriously affected by several numbers of insect pests. One of the most important insect pests that seriously damage olive trees is the oystershell scale, *Lepidosaphes ulmi* (L.) (Hemiptera: Diaspididae), particularly in Egypt (Abd-Ella et al., 2020). It is a polyphagous species that attacks for more than 150 host of plant species of different families. It infests various fruit, ornamental trees, forest trees, shrubs and olive trees (Milek and Simala, 2012; Alford, 2014; Dminic et al., 2010; Mansour et al., 2011; Milek et al., 2017). It is classified as a cosmopolitan species because it is able to live in different climatic regions (Abd-Ella et al.,2020). The infestation by *L. ulmi* causes discoloration and premature deterioration of the leaf, while the infested fruit is spotted, unsightly, discolored, and may drop prematurely. This scale insect can kill twigs and young trees, so if it left unchecked, the mature plants will become seriously weaken (Gill, 1997). Minor infestations might result in huge economic losses because of the zero tolerance policy of the exported fruit, (Helsen et al., 1996)

The hymenopterrous parasitoids, *Aphytis* spp. (Hymenoptera: Aphelinidae) have been recorded as one of the main causes in reducing populations of *L. ulmi* in many countries (Stathas et al., 2005; Ozgokce et al., 2016).

The aim of this study is 1) to monitor the seasonal changes in the population density of the oystershell scale, *L. ulmi* on olive trees in Beni-Suef Governorate, Egypt, 2) to estimate the rate of parasitism on this scale insect, and 3) to examine the effect of some biotic and abiotic factors on population density of *L. ulmi* and its parasitism.

MATERIALS AND METHODS

The experiments were conducted in Naser region, Beni-Suef Governorate, Egypt during two successive years started from 15th January 2021 to 31st December 2022. An area of two feddans cultivated with olive trees (variety Picual) about 5 years-old and homogenous in shape was selected and divided into four groups as replicates.

Regular traditional farming practices (agricultural methods, irrigation, fertilization, and weeds removal) were implemented annually according to the recommendations of the Ministry of Agriculture of Egypt. No chemical insecticides were used during the period of study.

1. Population fluctuation of *L. ulmi* :

Biweekly samples consisted of 50 leaves were taken from five trees in each group. Ten leaves were collected randomly from the different directions of each tree plus the middle ones. The chosen samples were kept in paper bags and transferred to the laboratory for examination. Under a stereomicroscope the numbers of nymphs and adult of *L. ulmi* on both leaf surfaces were counted and recorded.

2. Survey of parasitoid species on *L. ulmi* and their percentages:

Olive leaves infested with *L. ulmi* were randomly collected in a paper bag from each replicate then placed in plastic jars (2 L capacity), covered with white muslin, and the neck of jar closed by a rubber band in the laboratory until

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emergence of parasitoids. The emerged parasitoid species were collected daily and preserved in vials containing 70% ethanol + 5% glycerin. The parasitoid species were identified in the Biological Control Research Dept., Plant Protection Research Inst., A. R. C., Giza, Egypt.

To estimate the parasitism rates, olive leaves infested with *L. ulmi* were examined carefully by a fine needle to dissect 200 adult and nymphs of *L. ulmi*.

Each specimen was placed on a slide and covered with a water film for examination under a stereo-microscope. The parasitized scale insects were examined, determined and counted. Then parasitism percentage on *L. ulmi* was calculated based on the following formula:

Parasitism% = (No. of parasitized scale insects /Total no. of scale insects)× 100

٣. Effect of some factors on population density of *L. ulmi* and its parasitoids:

The daily weather data (maximum, minimum temperatures and the mean relative humidity) of Beni-Suef Governorate during both years, 2021 and 2022, were obtained from the Meteorological Station of Sids Research Centre, Beni-Suef Governorate.

Correlation and regression coefficient values were determined between the population density of *L. ulmi* (dependent variable YL) and each of the four factors (maximum and minimum temperatures, relative humidity, and parasitoids) (independent variable X) during the two years of study.

Likewise, the rates of parasitism (Yp) were correlated with each factor of weather factors (X).

Generally, factors data can be used to predict occurrence and possibly population dynamics by using the following regression equation in case of the significance coefficient.

($Y_L = a_1 + bX_1 + bX_2 + bX_3 + bX_4$) for *L. ulmi*

($Y_p = a_2 + bX_1 + bX_2 + bX_3$) for the parasitism of *L. ulmi*

a=constant, b= coefficient value of each factor, X_1= maximum temperature (max. T.), X_2= minimum temperature(min. T.), X_3= relative humidity (R. H. %), X_4= percentage of parasitism.

Correlation coefficient, partial regression and the analysis of variance were analyzed by using the statistical program SPSS software ver. 20.

The explained variance E.V.% = r2 × 100 (r = correlation value).

The higher percentages of the explained variance indicate to a stronger association and better prediction (Rosenthal and Rosenthal, 2011).

RESULTS AND DISCUSSION

1. Population fluctuation of *Lepidosaphes ulmi*:

Data presented in Figure (1) show the biweekly means of maximum, minimum temperatures (°C) and relative humidity (R.H.%), while those in Figure (2) show the seasonal population fluctuation of different stages of *L. ulmi* (nymphs and adult) on olive leaves. The insect population had 2-3 peaks. In the first year (2021), the insect population density had two peaks during the first week of March (9.3 insects/ leaf with Max. T. 18.5 °C, Min. T. 9.9 °C and R. H. 46.5%) and the first week of June (7.9 insects/ leaf with Max. T. 33.6 °C, Min. T. 20.3 °C and R. H. 33.2%). Whereas in (2022), the insect population density had three peaks during the first week of March (15.6 insects/ leaf with Max. T. 21.1 °C, Min. T. 7.6 °C and R. H. 47.9%), the first week of June (15.2 insects/ leaf with Max. T. 35.1 °C, Min. T. 18.9 °C and R. H. 35%), and the first week of October (10.1 insects/ leaf with Max. T. 35.9 °C, Min. T. 22.3 °C and R. H. 40.7%).

The population of *L. ulmi* ranged from 3 to 11 insects/ leaf in the first year to 4.4 to 15.6 insects/ leaf in the second year.

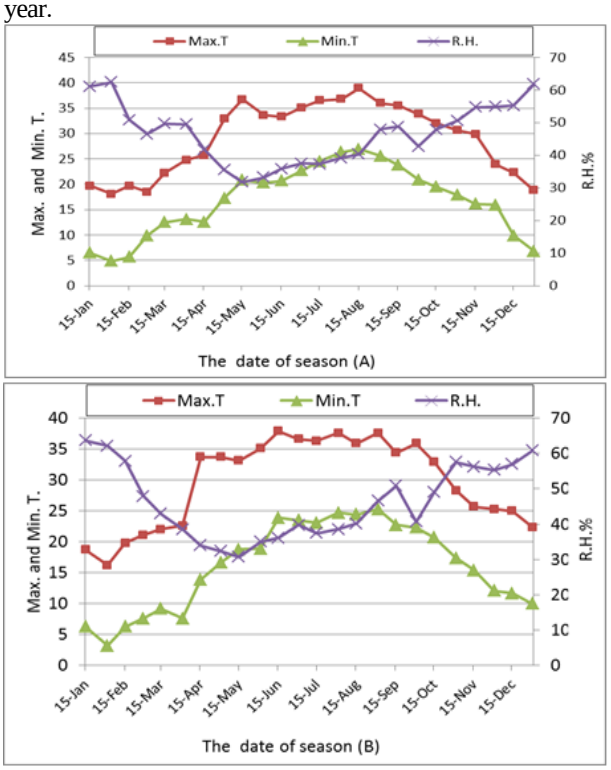

Fig. 1. Biweekly means of maximum (Max. T.) and minimum (Min. T.) temperatures (°C), and relative humidity (R.H.%) in Naser region, Beni-Suef Governorate, Egypt during 2021 (A) and 2022 (B) years.

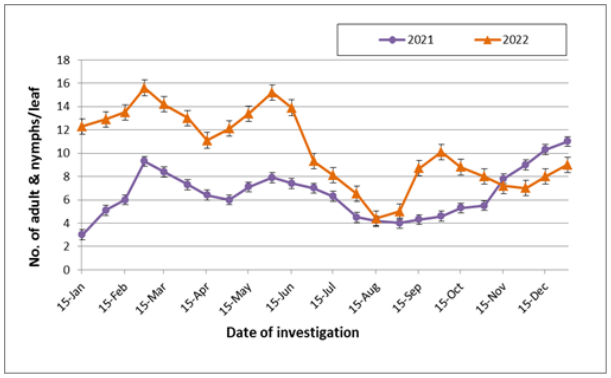

Fig. 2. Population density of *Lepidosaphes ulmi* / leaf of olive trees in Naser region, Beni-Suef Governorate, Egypt during 2021 and 2022.

These results are agree with those of Fountain et al (2012) who found that *L. ulmi* had two peaks in apple orchards during three successive years, 2007–2009 in Kent, UK. Also, Abd-Ella et al. (2020) mentioned that, the highest average of population density of *L. ulmi* was recorded on picual variety (7.81 and 8.96 insect/ 10 leaves) during 2017-2018 and 2018-2019 seasons, respectively in Assiut, Egypt.

2. Survey of parasitoids on *Lepidosaphes ulmi* and their percentages:

Two species of primary parasitoids, *Aphytis chrysomphali* (Mercet) and *A. diaspidis* (Howared)

(Hymenoptera: Aphelinidae) were collected from *L. ulmi.* in olive orchard in Naser region, Beni Suef Governorate, Egypt during both years of the study.

This result is in complete agreement with Abd-Ella et al. (2020) who reported the same parasitoid species on *L. ulmi* in Assiut governorate, Egypt.

Data presented in Fig. (3) show the seasonal parasitism on *L. ulmi* stages in Naser region, Beni Suef Governorate during 2021 and 2022 years. The percentage of parasitism had 4-5 peaks in the two years of investigation. There were four peaks in the first year on 15th May, 1st July, 15th August and 1st December with 5.5, 7.5, 8, and 3.5% respectively. While in the second year, it had five peaks on 1st May, 15th June, 1st August, 1st September and 1st October with 6.5, 7, 6.5, 5 and 5.5% respectively.

Population fluctuation of *L. ulmi* was relatively high that may be due to the low percentage of parasitism that ranged from 1.5 to 8% and from 1to 7.5% in the first and second years, respectively.

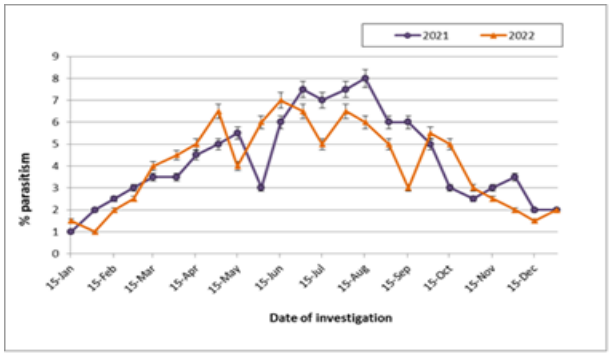

Fig. 3. Parasitism percentages on *L. ulmi* in Naser region, Beni-Suef Governorate, Egypt during 2021 and 2022 years.

These results are in agreement with those of Abd-Ella et al. (2020) who found that the percentages of parasitism on *L. ulmi* had 4 peaks annually that ranged from 1.47to 7.1%.

٣. Effect of some weather factors on *L. ulmi* and its parasitim:

On population density of *L. ulmi*:

Data illustrated in Table (1) present the multiple correlation coefficients between the population density of *L. ulmi* and the corresponding of maximum and minimum temperatures, relative humidity and rate of parasitism that were 0.58 and 0.76 in the first and years, respectively. Statistical analysis of the data showed that these factors had non-significant effect on *L. ulmi* in 2021, but had significant effect on *L. ulmi* population in 2022.

The prediction regression model between population of *L. ulmi* and other factors in the second year was as follows:

$$Y_L = 25.3٢ - ٠,٠٦X_1 - ٠,٣٩X_2 - ٠,١٨X_3 + ٠,٣٤X_4$$

However, the calculated percentages of explained variance values of the combined effect of these four factors were 33.9% and 57.7%, while the F-tests were 2.43 and 6.48 in the two years, respectively.

The remaining unexplained variance is may be due to the effect of other unaccounted factors, such as the total amount of rainfall or wind speed, in addition to the experimental error which affecting on the *L. ulmi* population density during the two years of investigation.

Table 1.Multiple correlation coefficient and multiple regression between population of *Lepidosaphes ulmi* (Y) and maximum and minimum temperatures, relative humidity (R.H.%) and parasitism percentages during 2021 and 2022 years in Naser region, Beni-Suef Governorate, Egypt.

Year	X factors	Analysis of partial regression				Analysis of variance	
		r	B	SE	t	F	E.V. %
2021	Max. T. (X1)	0.58	-0.46	±0.23	-1.98	2.43ns	33.9%
	Min. T. (X2)		0.31	±0.24	1.27		
	R.H.% (X3)		-0.13	±0.07	-1.94		
	Parasitism (X4)		-0.39	±0.39	-0.99		
2022	Max. T. (X1)	0.76	-0.06	±0.39	-0.16	6.48*	57.7%
	Min. T. (X2)		-0.39	±0.33	-1.19		
	R.H.% (X3)		-0.18	±0.11	-1.58		
	Parasitism (X4)		0.34	±0.66	0.52		

Correlation (r), coefficient value (B), standard error (SE), t-values (t), F-test (F) and percentage of explained variance E.V. %).
ns= not significant, *Highly significant at probability level 0.01

These results are consistent with Abd-Ella et al (2020) who found that maximum and minimum temperatures and relative humidity had significant effect on *L. ulmi* in the two years of investigation.

On the parasitoids of *L. ulmi*:

The data in Table (2) show the correlation coefficients between the parasitoids of *L. ulmi* and the corresponding of maximum, minimum temperatures and relative humidity that were 0.87 and 0.92 for the two years respectively. Statistical analysis of the data showed that these factors had highly significant effect (at probability level 0.01) on the parasitoids of *L. ulmi* population density in the two years. Maximum temperature and relative humidity showed positive effect while minimum temperature had negative effect on the parasitoids in 2021. While in 2022 maximum and minimum temperatures showed positive effect while relative humidity had negative effect on the parasitoids in 2022.

The prediction regression equations of parasitoids population density in the two years were:

$$Y_{p1} = 4.97 - ٠,٠9X_1 + .٠28X_2 - .٠06X_3 \text{ for the first year, 2021.}$$

$$Y_{p2} = 6.38 + ٠,٠5X_1 + 0.07X_2 - 0.11X_3 \text{ for the second year, 2022}$$

On the other hand, the calculated percentage of explained variance values of the combined effect of these four factors were 75.7% and 84.8% while; the F-tests were 20.75 and 37.13in the two years, respectively.

The remaining unexplained variance may be due to the effect of other unaccounted factors in addition to the experimental error affecting *L. ulmi*' parasitoids density during the two years of investigation.

Table 2. Multiple correlation and regression coefficients between parasitism percentages on *Lepidosaphes ulmi* and maximum and minimum temperatures, relative humidity (R.H.%) during 2021 and 2022 (in Naser region, Beni-Suef Governorate, Egypt.

Year	X factors	Analysis of partial regression				Analysis of variance	
		r	B	SE	t	F	E.V. %
2021	Max. T.	0.87	-0.09	±0.13	-0.685	20.75*	75.7%
	Min. T.		0.28	±0.12	2.282		
	R.H.%		-0.06	±0.04	-1.600		
2022	Max. T.	0.92	0.05	±0.13	0.39	37.13*	84.8%
	Min. T.		0.07	±0.11	0.6		
	R.H.%		-0.11	±0.03	-3.48		

Correlation (r), coefficient value (B), standard error (SE), t-values (t), F-test (F) and percentage of explained variance E.V. %). *Highly significant at probability level 0.01

These results in agreement with those of Abd-Ella et al. (2020) who found that maximum and minimum temperatures, and relative humidity had highly significant effect on the parasitoids of *L. ulmi*.

CONCLUSION

These results indicated that, the oystershell scale insect, *L. ulmi* had 2-3 peaks with two ectoparasitoid species (*A. chrysomphali* and *A. diaspidis*) were recorded. Percentage of parasitism had 4-5 peaks annually and ranged from 1.5% to 8% and from 1% to 7.5% in the two years respectively. The weather factors and parasitoids had non-significant effects on the population of *L. ulmi* in (2021) but had significant effects in (2022). Furthermore, the weather factors had significant effects on parasitism rates in both years of the study. These results may be helpful in the IPM program to detect the best time for control *L. ulmi* on olive trees. However it needs more investigation in Egypt.

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دراسات بيئية على حشرة الزيتون المحارية (L.) *Lepidosaphes ulmi* على أشجار الزيتون وطفيلياتها في منطقة مصر الوسطى

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الملخص

تعتبر حشرة الزيتون المحارية (*Lepidosaphes ulmi*) واحدة من الآفات الخطيرة التي تصيب أوراق الزيتون في مصر. ولذلك أجريت هذه الدراسة بمركز ناصر بمحافظة بني سويف خلال سنتين متتاليتين (٢٠٢١ و ٢٠٢٢). تم تسجيل التقلبات الموسمية لهذه الآفة ووجد أن لها من قمتين إلى ثلاث قمم خلال مواسم الربيع والصيف والخريف خلال سنوات الدراسة. وقد تم تسجيل أعلى ذروة في الصيف ١١ و ١٥,٦ حشرة/ورقة خلال عامي ٢٠٢١ و ٢٠٢٢ علي التوالي. وجد أن لنسبة التطفل من ٤ إلي ٥ قمم سنويا. وكان لدرجات الحرارة العظمي الصغري والرطوبة النسبية ونسبة التطفل تأثيرغير معنوي على الكثافة العددية للأفة في عام (٢٠٢١) ولكن كان هذا التأثير عالي المعنوية في عام (٢٠٢٢). كما كان لهذه العوامل البيئية تأثير عالي المعنوية على معدل التطفل خلال عامي الدراسة. وقد تم جمع الطفيليات *Aphytis chrysomphali* و *A. dispidis* من علي حشرة الزيتون المحارية *L. ulmi*. الكلمات الدالة: التجمعات الموسمية, *Lepidosaphes ulmi*, الطفيليات, عوامل الطقس