



Population fluctuations of oystershell scale insect, *Lepidosaphes ulmi* (L.) (Homoptera: Diaspididae) on certain olive varieties and the factors affecting its population

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Abstract

Oystershell scale, *Lepidosaphes ulmi* (L.) (Homoptera: Diaspididae) is one of the most common scale insects that attacks olive trees in Egypt. Therefore, the population density fluctuation of *L. ulmi* and its parasitoids, and their relations to some weather factors were investigated on three olive varieties (Picual, Coratina and Chemlali) at Faculty of Agriculture, Assiut University, Egypt, during 2017/2018 and 2018/2019 seasons. The results indicated that the pest population was concentrated during the period from April to September. The highest average of *L. ulmi* population was recorded on picual variety (7.81 and 8.96 insect/ 10 leaves) during 2017-2018 and 2018-2019 seasons, respectively. While the lowest population average was recorded on coratina (4.72 and 5.01 insect/ 10 leaves) during 2017-2018 and 2018-2019 seasons, respectively. During both seasons, there were significant differences in the average numbers of *L. ulmi* among the olive varieties, picual, coratina and chemlali. The results also showed that picual variety was more infested than other two varieties. Survey of *L. ulmi* parasitoids resulted in two species of parasitoids, *Aphytis chrysomphali* (Mercet) and *Aphytis disspidis* (Howard). The average percentage of parasitism was relatively high during, May, June, July and August on picual and chemlali varieties. While on coratina variety the average percentage of parasitism was relatively high during, April, May, September, December, and January during 2018-2019 season. Statistical analysis of the data indicates that, no significant differences among the percentage of the average annual parasitism on the three varieties (4.86 % on chemlali, 4.22 % on picual and 3.89 % on coratina variety). The effects of weather factors on the population of *L. ulmi* and its parasitoids and the effects of these parasitoids on the population of the pest were also studied. The results might be helpful in an IPM program to control the oystershell scale insect, *L. ulmi* and to settle the best time for pesticide application on olive varieties.

Keywords: *Lepidosaphes ulmi*, population fluctuation, *Aphytis* spp., weather factors, olive varieties.

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1. Introduction

The olive (*Olea europaea* L.), a long-lived evergreen, is one of the most economically horticultural crops in Egypt and worldwide. Most olive growing countries are localized in the Mediterranean basin which has more than 90% of the world's cultivated olive trees. Olive trees are subjected to attack by several insect pests that had a harmful effect on the quality and quantity of the olive yield. Oystershell scale, *Lepidosaphes ulmi* (L.) (Homoptera: Diaspididae) is one of the most important insect pests that causes severe damages to olive trees (Milek & Simala, 2012; Argyriou & Kourmadas, 1981). *L. ulmi* is a polyphagous species and having more than 150 hosts. It feeds on various fruit and forest trees, shrubs and ornamental plants, including olive trees (Milek et al., 2017; Alford, 2014; Milek & Simala, 2012; Mansour et al., 2011; Dminic et al., 2010; Katsoyannos & Stathas, 1995). It is a cosmopolitan species capable of living in different climatic regions. It infests numerous plant species from different families and is spread all over the Mediterranean basin (Ferris, 1937). *L. ulmi* infestation causes discoloration of the leaf and premature deterioration of the leaf; the infested fruit is unsightly, spotted and discolored, and may drop prematurely. This scale insect can kill branches and young trees, and if left unchecked, mature plants will seriously weaken and stunt (Gill, 1997). Even light infestations can cause great economic losses because of a zero tolerance policy for exported fruits (Helsen et al., 1996). The hymenopterous parasitoid *Aphytis* spp. was recorded as a natural enemy of *L. ulmi* (Stathas et al., 2005; Erol & Yaşar, 1999; Boulancer, 1965). Ozgokce et al. (2016) found that one of the main causes of *L. ulmi* mortality in apple trees was parasitization with the aphelinide,

Aphytis mytilaspidis (Le Baron), which mainly attacks the egg stage, but can also be found in adult females. Where, the percentage parasitism ranged between 22 and 36 % during the egg stage. The objectives of this study are to identify the seasonal changes in the population of oystershell scale, *L. ulmi* on different olive varieties in Assiut Governorate, Egypt to survey *L. ulmi* parasitoids on olives, to evaluate the rate of natural mortality of *L. ulmi* that caused by parasitoids, and to assess the effect of certain weather factors on the population fluctuation of *L. ulmi* and its associated parasitoids.

2. Materials and methods

Two seasons of study were conducted on three olive varieties, Picual, Coratina and Chemlali to determine the population density and fluctuation of *L. ulmi* on olive trees and its associated natural enemies as well effect of weather factors on the population of *L. ulmi* and its associated parasitoids. These experimental trials were conducted at the Faculty of Agriculture Experimental Farm, Assiut University, Assiut, Egypt during 2017-2018 and 2018-2019 seasons. This farm is a rather mosaic agro-ecosystem characterized by isolated areas of olive.

2.1 Survey and population fluctuations of oystershell scale insect and its associated natural enemies inhabiting olive trees

2.1.1 Experimental layout and population fluctuations of the scale insect pest

The experimental area was divided into three lines for three varieties, Picual,

Coratina and Chemlali. Each tree divided into three levels (bottom, middle and top level). From each tree level, Half-monthly samples of 10 leaves were taken at random and were kept in a polyethylene bag, then were transferred to the laboratory for examination. The numbers of *L. ulmi* (nymphs and adults) were counted on both sides (upper and lower surfaces) of leaves under a stereomicroscope for each inspection date.

2.1.2 Population fluctuations of oystershell scale insect parasitoids

Even as the *L. ulmi* numbers were recorded on the leaves; the parasitized oystershell scale insects were counted too. The scales, which have a minute hole because of the parasitoid emergence, were considered as parasitized ones. Also, samples of the three scale insect emerged parasitoid adults were kept in vials containing 75% ethyl alcohol for identification according to (Abou-Elhagag, 2004). The percentage of *L. ulmi* parasitism was calculated during 2018/2019 season based on the following formula:

$$\text{Parasitism \%} = \frac{n \text{ of parasitized scale insects}}{\text{Total } n \text{ of scale insects}} \times 100$$

2.2 Effect of three weather factors on population fluctuations of oystershell scale insect and associated parasitoids inhabiting olive trees

2.2.1 Meteorological data

The daily records of the day maximum temperature, minimum temperature and the daily mean relative humidity were obtained from the meteorological station located close to the experimental area at

the University of Assiut Experimental Farm during 2017-2018 and 2018-2019 seasons.

2.3 Statistical analysis

Data were analyzed as a one-way ANOVA and were presented as means $\pm$ SEM (Standard Error of Mean). Correlation coefficient values (r) were first estimated by SPSS software ver. 16. The counted populations of the pest or the parasitoids were considered as the dependent variate (Y), while the reading of corresponding weather factors represented the independent variate (X). Figures and statistical analysis were done using GraphPad Prism version 5.0.0 for Windows, GraphPad Software, San Diego, California USA, www.graphpad.com.

3. Results and Discussion

3.1 Population density and fluctuation of oystershell scale insect, *L. ulmi*

Data presented in Figures 1 and 2 shows the mean monthly population count of oystershell scale insect, *L. ulmi* (nymph and adult stages) on olive varieties picual, coratina and chemlali leaves during 2017-2018 and 2018-2019 seasons. During 2017-2018 season, the pest population started with an average number of 7.0 insects / 10 leaves on April (Max. temp. 33.2 °C, Min. temp. 14.4 °C and RH 25%) and progressively increased throughout January (10.28), February (13.72) and March (15.56) insect/ 10 leaves on picual variety. Whereas on coratina variety, the population started with an average number of 5.06 insect/ 10 leaves on April

and progressively increased throughout January (5.72), February (4.67) and March (8.28 insect/ 10 leaves). While on chemlali variety, the pest population started during the season with a

population level around 8.0 insect/ 10 leaves during April, December, January, and February then increased during March to be 11.67 insect/ 10 leaves (Figure 1).

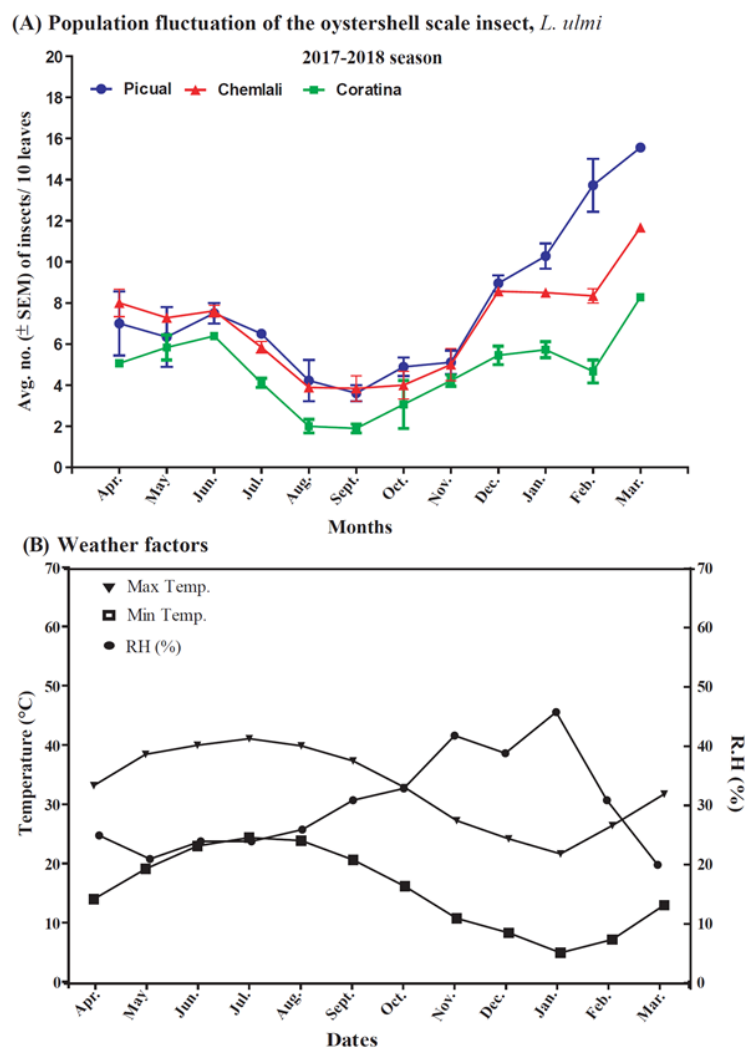


Figure 1: Population fluctuations of the oystershell scale insect, *L. ulmi* on the leaves of certain olive varieties and some prevailing weather factors during 2017-2018 season.

During 2018-2019 season, the population of oystershell scale insect, *L. ulmi* started with high monthly mean in April (12.78 insect/ 10 leaves) and in June with an average of 14.61 insect/ 10 leaves for picual variety. Thereafter, the population decreased slightly during December, January, and February and in March

reached its lowest level, where it was 5.78, 3.37, 4.78, and 3.84 insect/ 10 leaves, respectively. In coratina variety, the maximum population recorded during May, June, July and November; the population ranged from 7.11 to 7.39 insects / 10 leaves, whereas the lowest population recorded during December

(3.39 insect/ 10 leaves), January (2.84 insect/ 10 leaves), February (4.45 insect/ 10 leaves), and March (3.84 insect/ 10 leaves). The population of the pest was on the chemlali variety started on April with an average of 6.73 insect/ 10 leaves and reached the highest number during May (8.52 insect/ 10 leaves), June (9.06 insect/ 10 leaves), July (9.12 insect/ 10 leaves), August (9.67 insect/ 10 leaves) and September (8.05 insect/ 10 leaves), whereas the lowest population recorded on December (4.39), January (3.56), February (4.33) and March (4.11 insect/ 10 leaves) (Figure 2). Data of both

seasons clearly indicated that, the pest population was reached its peak during the period from April to September. The highest average of oystershell scale insect, *L. ulmi* population was recorded on picual variety (7.81 and 8.96 insect/ 10 leaves) compared to the other varieties coratina (4.72 and 5.01 insect/ 10 leaves) and chemlali (6.88 and 6.73 insect/ 10 leaves) during 2017-2018 and 2018-2019 seasons, respectively. Cavalloro (1984) stated that, oystershell scale insect, *L. ulmi* population are lost during winter owing to the harvest or to the falling of olives.

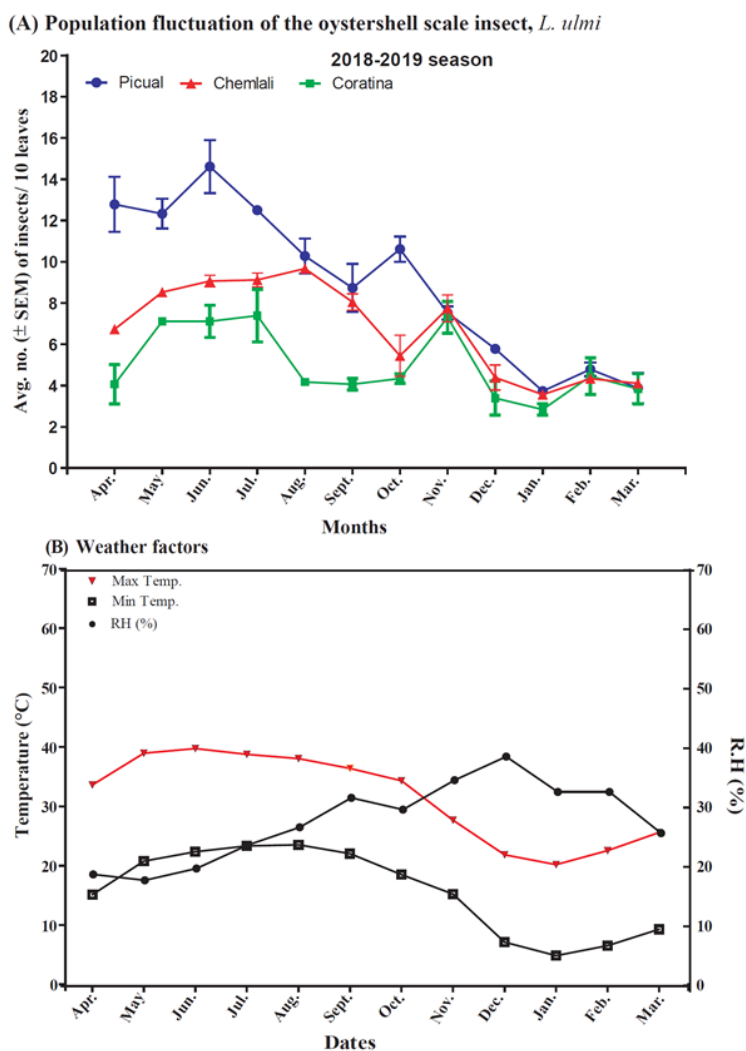


Figure 2: Population fluctuations of the oystershell scale insect, *L. ulmi* on the leaves of certain olive varieties and some prevailing weather factors during 2018-2019 season.

3.2 Factors affecting the oystershell scale insect, *L. ulmi*, population

3.2.1 The parasitoids, *Aphytis* spp.

Survey of *L. ulmi* parasitoids resulted in two species of parasitoids, *Aphytis chrysomphali* (Mercet) and *Aphytis disppidis* (Howard) (Hymenoptera: Aphelinidae) in the Faculty of Agriculture Experimental Farm, Assiut University, Egypt. Seasonal variation of the percentage of parasitism by *Aphytis* spp. in the oystershell scale insect, *L. ulmi* on three olive varieties picual, coratina and chemlali during 2018-2019 season showed in Figure (3 A and B). Data presented in Figure (3 A and B) indicated that, the average percentage of parasitism was relatively high during April, May, June, July, August and September with an average of 4.79, 5.29, 4.74, 7.10, 6.52 and 5.76 % on picual variety, respectively. Meanwhile, the lowest average percentage of parasitism was recorded on October, November, December, January and March with an average of 0.50, 3.45, 3.85, 1.47 and 2.44%.

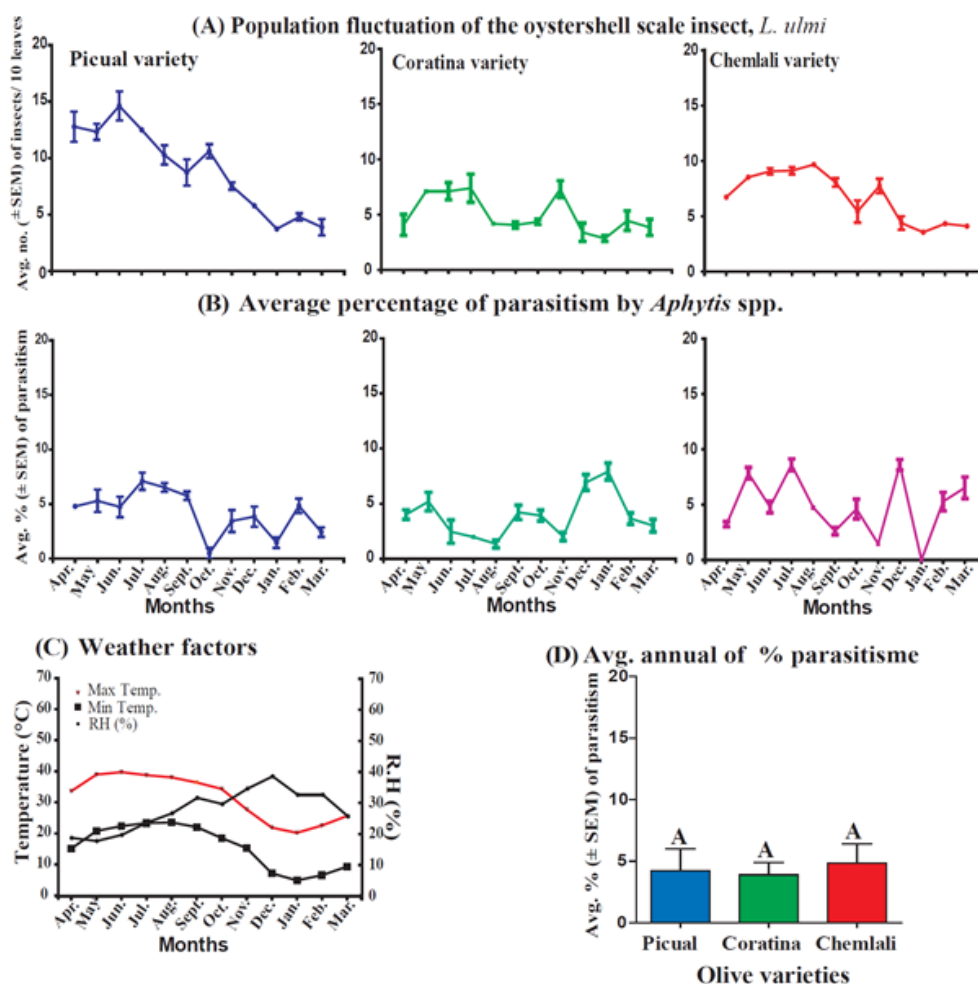


Figure 3: Population fluctuations of the oystershell scale insect, *L. ulmi* and monthly average parasitism by *Aphytis* spp. on olive varieties picual, coratina and chemlali and some prevailing weather factors during 2018-2019 season.

On coratina variety, the average percentage of parasitism was relatively high during April, May, September, December, and January with an average of 4.01, 5.20, 4.22, 6.98 and 7.92 %, and the lowest record was on June, July, August, October and November with an average of 2.46, 1.98, 1.35, 3.93 and 2.01%, respectively. While, on chemlali variety, the highest average percentage of parasitism was recorded during May, June, July, August December, February, and March with an average of 7.84, 4.80, 8.60, 4.74, 8.60, 5.28 and 6.53 %, respectively. Statistical analysis of the data indicates that, no significant differences among the averages of the annual percentages of the parasitism within the three varieties (4.86 %, 4.22 % and 3.89 % on chemlali, picual and coratina varieties, respectively) during 2018-2019 season (Fig. 3 D). These results showed that, the population of the parasitoids, *Aphytis* sp. was approximately synchronized with the pest population. The lowest percentage of parasitism was recorded on the pest might be owing to the lowest population numbers of the pest and the weather

factors. It is known that, most *Aphytis* species are facultative gregarious. The degree of gregariousness depends on host size but there are some differences between species (Luck et al., 1982). In Egypt, Abd-Rabou (1997) and Abou-Elhagag (2004) studied the role of *Aphytis* sp. in regulating the olive scale insects. Statistical analysis of the data in Table (1) indicates that, the correlation between the monthly average parasitism by *Aphytis* spp. and the weather factors (max. and min. temperatures) were highly significant positive on picual variety ($r = 0.550$ and 0.561), whereas, the relative humidity showed highly significant negative correlation ($r = -0.349$). On coratina variety, the correlation was highly significant and negative between the max. and min. temperature ($r = -0.595$ and -0.617) and highly significant positive correlation with RH (%) ($r = 0.334$). On chemlali variety, the correlations between the monthly average parasitism by *Aphytis* spp and both maximum and minimum temperatures ($r = 0.299$ and 0.168) were insignificantly positive and negative with RH (%) (-0.231).

Table 1: Correlation coefficient between the parasitoid, *Aphytis* spp. populations and maximum and minimum temperatures, and relative humidity on certain olive varieties during 2018-2019 seasons.

Varieties	Correlation coefficient values "r"		
	Maximum Temperature (°C)	Minimum Temperature (°C)	RH (%)
Picual	0.550**	0.561**	-0.349**
Coratina	-0.595**	-0.617**	0.334**
Chemlali	0.299ns	0.168ns	-0.231ns

ns: non-significant $p > 0.05$, * $p < 0.05$, ** $p < 0.01$.

Temperature and humidity have strong effect on *Aphytis* survival. Extreme temperatures are considered the main factor of mortality for *Aphytis* in the field

(Rosen & DeBach, 1978). In a laboratory experiment, Kfir and Luck (1984) found that the combination of high temperatures with low humidity

negatively affected *Aphytis* adult survival.

3.2.2. Weather factors

Data in Table (2) showed the simple correlations between the population of the oystershell scale insect, *L. ulmi* and the maximum, minimum temperature, relative humidity and the monthly average parasitism by *Aphytis* spp. on certain olive varieties (picual, coratina and chemlali) during 2017-2018 and 2018-2019 seasons. During 2017-2018 season, statistical analysis of the data indicates that the correlation between the oystershell scale insect, *L. ulmi* population and the maximum ($r = -0.488$) and minimum temperatures ($r = -0.578$) were highly significant negative correlation and insignificantly negative with RH (%) ($r = -0.074$) on picual variety. Whereas, on coratina variety the maximum ($r = -0.273$) and minimum ($r = -0.393$) temperatures, and the relative humidity ($r = -0.109$) showed insignificant negative correlations. Also, statistical analysis on chemlali variety showed that the maximum ($r = -0.408$) and minimum ($r = -0.506$) temperatures showed highly

significant negative correlation, whereas the relative humidity ($r = -0.157$) showed insignificant negative correlation. During 2018-2019 season, the effect of maximum ($r = 0.907$) and minimum ($r = 0.804$) temperatures were highly significant positive correlation with the oystershell scale insect, *L. ulmi* population, whereas, the relative humidity showed highly significant negative correlation ($r = -0.737$) on picual variety. On coratina variety, the correlation was highly significant positive correlation between max. ($r = 0.574$) and min. temperatures ($r = 0.587$), and highly significant negative correlation with RH (%) ($r = -0.443$) and the population pest. Whereas on variety chemlali, the max. and min. temperatures showed highly significant positive correlation ($r = 0.891$ and 0.931), meanwhile, the relative humidity showed highly significant negative correlation ($r = -0.523$) with oystershell scale insect, *L. ulmi* population. The correlation between the pest and the parasitoid, *Aphytis* spp. was highly significant positive on picual ($r = 0.466$), coratina ($r = 0.412$) and chemlali ($r = 0.725$) varieties.

Table 2: Correlation coefficient between the parasitoid, *Aphytis* spp., weather factors (maximum, minimum temperatures, and relative humidity) and the population of the oystershell scale insect, *L. ulmi* on certain olive varieties (picual, coratina and chemlali) during 2017-2018 and 2018-2019 seasons.

Seasons	Varieties	Correlation coefficient values "r"			
		<i>Aphytis</i> spp. (%)	Maximum Temperature (°C)	Minimum Temperature (°C)	RH (%)
2017-2018	Picual	-	-0.488 **	-0.578 **	-0.074ns
	Coratina	-	-0.273ns	-0.393ns	-0.109ns
	Chemlali	-	-0.408**	-0.506**	-0.157ns
2018-2019	Picual	0.466**	0.907**	0.804**	-0.737**
	Coratina	0.412**	0.574**	0.587**	-0.443**
	Chemlali	0.725**	0.891**	0.931**	-0.523**

ns: non-significant $p > 0.05$, * $p < 0.05$, ** $p < 0.01$.

It is clear that the climate and the natural enemies affects both spatial and temporal distribution, as well as reproduction and

dissemination of plant pests since temperature, relative humidity, light and water are major factors influencing their

population, growth and development (Landa, 2019). Consequently, climate change is expected to affect the incidence and severity of pest attacks in olive. However, it is difficult to predict such consequences, as they are the results of complex interactions between the specific pest, the olive genotype, and the specific environment (climate, agronomic practices, etc.). Thus, the life cycle (survival, reproduction, dispersal, infection) of a given pest, and their specific relations with the host can be affected in very different ways, and cannot be generalized (Landa, 2019). In conclusions, the obtained results indicated that, *L. ulmi* is the most common scale insects attacks the olive varieties (Picual, Coratina and Chemlali) during both seasons. The highest average of *L. ulmi* population was recorded on picual variety, while the lowest average was recorded on coratina variety. Also, the results stated that picual variety was more infested by *L. ulmi* than other varieties. In addition, survey of *L. ulmi* parasitoids resulted in two species of parasitoids, *A. chrysomphali* and *A. dispididis* in the Faculty of Agriculture Experimental Farm, Assiut University, Egypt. Moreover, the results indicated that the weather factors affect the population of *L. ulmi* and its parasitoids. These results might be helpful in an IPM program to control the oystershell scale insect, *L. ulmi* and to settle the best time for pesticide application on olive varieties.

Acknowledgements

The authors wish to thank the Plant Protection Department, Faculty of Agriculture, Assiut University, Egypt, for

providing a partial funding support for this study. Also, sincere thanks are extended to anonymous reviewers who gave constructive criticisms to the earlier version of this manuscript.

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