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Population dynamics of *Palpita unionalis* and *Prays oleae* in relation to certain ecological factors in olive orchards

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Abstract
The olive leaf moth (jasmine moth), *Palpita unionalis* Hübner (Lepidoptera: Pyralidae) and the olive moth, *Prays oleae* Bern. (Lepidoptera: Praydidae) are of the major lepidopterous pests infesting olives in Egypt and other Mediterranean countries. The population dynamics of these pests in olive orchards at Dakahlia and Damietta governorates in addition to their responses to certain weather factors and the height of the olive trees were the purposes of the present study. The obtained results showed that populations of *P. unionalis* and *P. oleae* occurred all over the year. *P. unionalis* showed three distinct peaks of activity; while, *P. oleae* showed three and two peaks of activity at Dakahlia and Damietta governorates. The two pests exhibited relatively high activities during summer season in the two governorates. Statistical analysis showed that the effects of daily mean temperature and relative humidity on the seasonal activity of *P. unionalis* and *P. oleae* were relatively low. Populations of *P. unionalis* and *P. oleae* are significantly affected by the height on the olive trees which the samples were taken from it; where, the regression analysis showed that every increase on the height on trees increased *P. unionalis* and *P. oleae* larval populations by obvious numbers at Dakahlia and Damietta governorates.

Keywords: *Olea europaea*, lepidopterous pests, olive leaf moth, olive moth, weather factors, plant height

Introduction

Olive, *Olea europaea* L. is an ancient and one of the economically important crops in the Mediterranean Basin (which had about 98% of the world's olive production) and other parts of the world (Civantos, 2001 [7]; Herz *et al*., 2005 [18], Budia, 2012 [6] and Arenas-Castro *et al*., 2020) [4]. Olive trees are subjected to attack by several insect pests causing considerable yield losses in quality and quantity (Eid, 2003 and Spooner-Hart *et al*., 2007) [10, 33]. The olive leaf moth, *Palpita unionalis* Hübner (Lepidoptera: Pyralidae) and the olive moth, *Prays oleae* Bern. (Lepidoptera: Praydidae) are two well-known lepidopterous pests infesting olives in Egypt and other Mediterranean countries (Broumas *et al*., 2002 [5]; Shehata *et al*., 2003 [31]; Yilmaz & Genç, 2012 [36]; Mostafa *et al*., 2020 [25] and Ibrahim *et al*., 2023) [19].

The olive leaf moth, *P. unionalis* is an international pest originating in the Mediterranean Basin (Hegazi *et al*., 2012 [17] and Ghoneim, 2015) [14] It is one of the most dangerous pests of olives in Egypt and other Mediterranean countries (Broumas *et al*., 2002 [5]; Shehata *et al*., 2003 [31], Noori & Shirazi, 2012 [26] and Yilmaz & Genc, 2012) [36]. The most important damage by *P. unionalis* occurs on young trees, nurseries and shoots of old trees; where, feeding damage by larvae can reach up to 90% of the total leaf area; so, seriously affecting the development of the plant shoots and may also reduce the fruit yield by 30% (Pinto & Salemo, 1995 [28]; Solaiman, 1997 [32]; LopezVillalta, 1999 [22]; Grossley, 2000 [16]; Hegazi *et al*., 2012 [17] and Ghoneim, 2015) [14] In the high populations of *P. unionalis*, larvae attack olive fruits, especially table varieties, by creating irregular holes in the skin making them unsuitable for commercial marketing (Antonelli & Rossi, 2004 [3] and Mazomenos *et al*., 2002) [24].

The olive moth, *P. oleae* belongs to microleptidoptera and is one of the most economically important phytophagous of olive crop in Egypt as well as the Mediterranean Basin, the Black Sea, the Middle East and the Canary Islands and considered as a menace in olive growing areas (Tzanakakis, 2003 and EPPO, 2011) [12, 34]. *P. oleae* development stretches over three generations per year; when, larval stage of each generation is associated with different parts of the host. The first generation (philophagous), whose larvae attack leaves, the second generation (anthophagous), whose larvae feed on flowers, and the third generation (carpophagous), whose larvae feed on the fruit's monocarp. The emerged adults of the third generation oviposit on the olive leaves; where, the newly hatched larvae make mines inside the leaves (Kavallieratos *et al*., 2005) [20]. The damage caused by this insect can reduce the olive production by 49 to 63% (Ramos *et al*., 1998 [30] and Patanita & Mexia, 2004) [27].

For an efficient control of economic pest, ecological studies on it should be done. According to Witzgall *et al*. (2010) [35], the first step in managing any pest begins with a proper monitoring program to determine the suitable method or time for controlling it. Therefore, population dynamics of *P. unionalis* and *P. oleae* in addition to their relations to certain weather factors and the height of the olive trees were the purposes of the present study.

Material and methods

The present investigation was conducted in the two governorates of Dakahlia and Damietta during the period from the 1st of June 2021 to the 31st of May 2022. In each governorate, an area of one feddan (which equal to 4200 m^2) cultivated with olive trees (approximately ten years old) was selected for the present study.

1. Population dynamics of *P. unionalis* and *P. oleae* in relation to the height on the trees

In a random selection, five trees (as replicates) approximately homogenous in age and size were marked in

each governorate for the present study. Ten branches of about 20 cm length were cut from each tree every two weeks. At the height of 1 meter from the ground, these twigs were taken as a rate of two branches from each cardinal direction (North, South, East & West) and middle of the tree. At the heights of 2 and 3 meters from the ground, the same action of sampling was done to estimate the effect of height on the pests' populations. Twigs of every height of each tree were put in paper bags, well tied and transported to laboratory for investigation. In the laboratory, numbers of *P. unionalis* and *P. oleae* larvae infested olive leaves of each branch were counted and recorded.

2. Effect of daily means of temperature degrees and relative humidity on the activity of *P. unionalis* and *P. oleae* populations

Daily means of temperature degrees and relative humidity were selected from the available meteorological data of Dakahlia and Damietta governorates during the period from the 1st of June 2021 to the 31st of May 2022. These means were obtained from the Central Laboratory for Agricultural Climate, Agricultural Research Center. Bi-weekly means of temperature degrees and relative humidity were calculated according to the sampling dates.

3. Statistical analysis

By using the computer program of CoHort Software (2004) [9], data were analyzed in one-way ANOVA followed by LSD (the least significant difference) at probability level of 0.05 by. Also, the bi-weekly mean numbers of *P. unionalis* and *P. oleae* larvae were correlated with each of temperature degrees and relative humidity means. In addition, the simple, multi regressions and explained variance were estimated.

Results

1. Population dynamics of *P. unionalis* and *P. oleae*

The obtained data showed that population of *P. unionalis* occurred all over the year and showing three distinct peaks of activity in the two governorates. At Dakahlia governorate, these peaks was recorded on the 27th of July (107.2 larvae/10 twigs), 2nd of November (57.5 larvae/10 twigs) and 8th of March (90.3 larvae/10 twigs). At Damietta governorate, the three peaks were recorded on the 29th of June, 5th of October and 22nd of February recording 89.9, 50.1 and 81.7 larvae/10 twigs, respectively (Figure, 1).

As shown in Figure (2), *P. unionalis* showed its highest abundance at the two governorates (Dakahlia and Damietta) during summer season in comparison with autumn, winter and spring seasons (which showed no signficant differences between them). Where, the mean numbers of larvae/10 twigs at Dakahlia governorate reached 54.0±11.1, 39.2±7.9, 38.9±6.6 and 38.5±4.0 during summer, autumn, winter and spring seasons, respectively; while, at Damieatta governorate, these means were recorded as 47.2± 14.8, 32.7±7.5, 38.3±7.6 and 29.8±3.8, respectively.

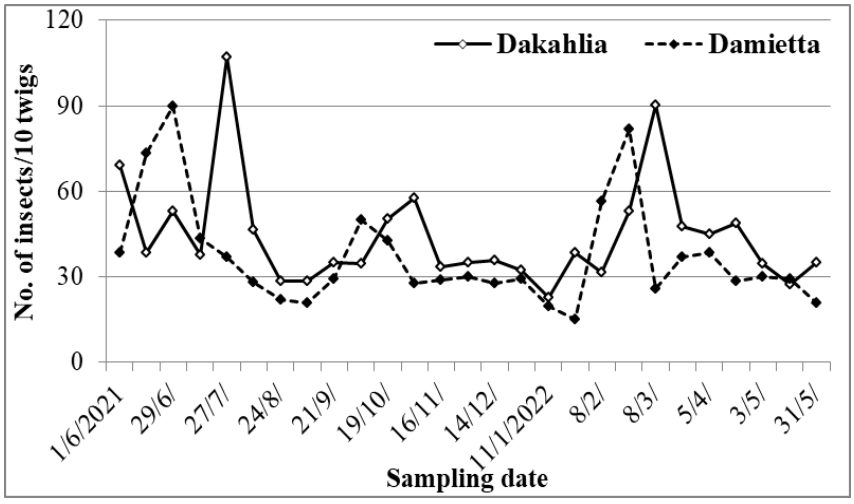

Fig 1: Population dynamics of *P. unionalis* in olive orchards at Dakahlia and Damietta governorates during the year of 2021/22.

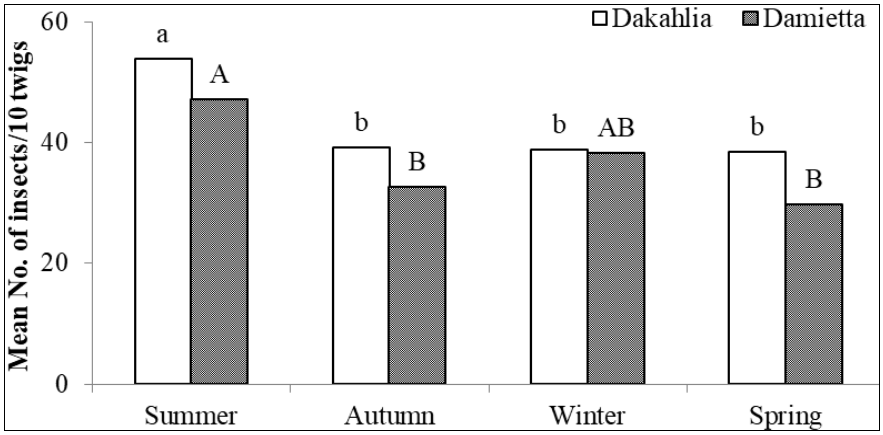

Fig 2: Relative abundance of *P. unionalis* on olive orchards at Dakahlia and Damietta governorates during summer, autumn, winter and spring seasons of 2021/22. (Note: In each governorate, colomns had the same letter did not differe at a significant of 5%)

With respect to *P. oleae*, it was recorded all over the year in the two governorates with obviously low population in comparison with *P. unionalis*. *P. oleae* exhibited three peaks of activity at Dakahlia governorate and two peaks of activity at Damietta governorate. At Dakahlia governorate, the peaks was recorded on the 29th of June (29.1 larvae/10 twigs), 2nd of November (6.7 insects/20 twigs), 22nd of February (11.9 insects/20 twigs) and 5th of April (13.8 insects/20 twigs). At Damietta district, the peaks were recorded on the 15th of Jone, 21st of September, 22nd of February and 3rd of May reaching 21.6, 6.9, 13.3 and 9.9 insects/20 twigs, respectively (Fig 3).

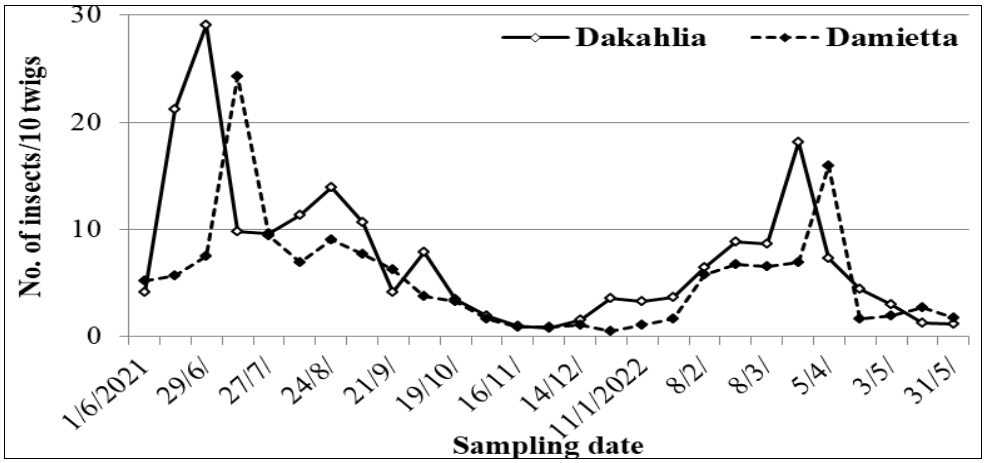

Fig 3: Population dynamics of *P. oleae* in olive orchards at Dakahlia and Damietta governorates during the year of 2021/22.

The olive moth, *P. oleae* showed its highest abundance at Dakahlia and Damietta governorates during summer season (with means of 12.4±1.3 and 9.5±1.0 larvae/10 twigs) followed by spring season (6.2±1.4 and 5.3±0.7 larvae/10 twigs). During autumn and spring seasons (which had no sigficant differences between them), the mean number of larvae/10 twigs was 4.2±0.2 and 3.9±0.7 at Dakahlia governorate, and was 3.5±0.3 and 2.8±0.4 at Damietta governorate, respectively (Fig 4).

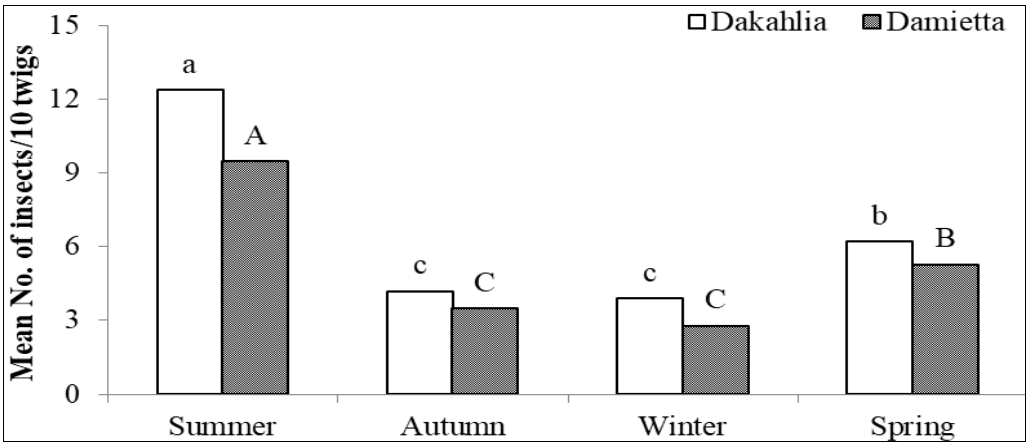

Fig 4: Relative abundance of *P. oleae* on olive orchards at Dakahlia and Damietta governorates during summer, autumn, winter and spring seasons of 2021/22. (Note: In each governorate, colomns had the same letter did not differe at a significant of 5%)

2. Effect of certain weather factors on the activity of *P. unionalis* and *P. oleae* populations

Statistical analysis showed that the effects of daily mean temperature and relative humidty on the seasonal activty of *P. unionalis* and *P. oleae* were relatively low; where, the correlation coefficient values between mean temperature & relative humidty and the two pests were insignificant (Table, 1). Even in spite of the low effects of these weather factors, relative humidity was relatively more effective on *P. unionalis* than temperature degrees; in contrary, temperature degrees was relatively more effective on *P. oleae* than relative humidity. On another hand, the combined effect of daily mean temperature degrees and relative humidity was higher on *P. oleae* (E.V.=9.7%) in comparison with their combined effect on *P. unionalis* (E.V.= 0.1%).

Table 1: Effect means of daily temperature degrees and relative humidity on the activity of *P. unionalis* and *P. oleae* populations in olive orchards at Dakahlia and Damietta governorates during the year of 2021/2022.

Insect species	Weather factor	Simple regression				Multi regression	
		r	b	P	R^2	b	E.V.
Dakahlia							
P. unionalis	Temperature	-0.01	-0.01	0.90	0.0%	-0.03	0.1%
	Relative humidity	0.03	0.01	0.87	0.1%	0.08	
P. oleae	Temperature	0.28	0.24	0.14	8.3%	0.30	9.7

	Relative humidity	-0.19	-0.19	0.34	3.6%	-0.12	
Damietta							
P. unionalis	Temperature	-0.02	-0.01	0.91	0.0%	-0.05	0.1%
	Relative humidity	0.02	0.01	0.89	0.1%	0.06	
P. oleae	Temperature	0.29	0.33	0.13	8.9%	0.23	11.2
	Relative humidity	-0.22	-0.29	0.26	4.9%	-0.12	

3. Effect of height of the tree on relative abundance of *P. unionalis* and *P. oleae* populations

As shown in Figure (5), relative abundance of *P. unionalis* affected significantly by the height on the tree which the samples were taken from it. *P. unionalis* was sgnficantly higher on the height of 3 meters from the ground which contributed with 44.8 and 43.5% of the total collected larval population at Dakahlia and Damietta governorates. The height of 2 meters contributed with the second rank (32.0 and 32.5%) of the total collected population at Dakahlia and Damietta governorates. The least height which contributed with 23.2 and 24.0% of the total collected *P. unionalis* population at Dakahlia and Damietta governorates was that of 1 meter from the ground.

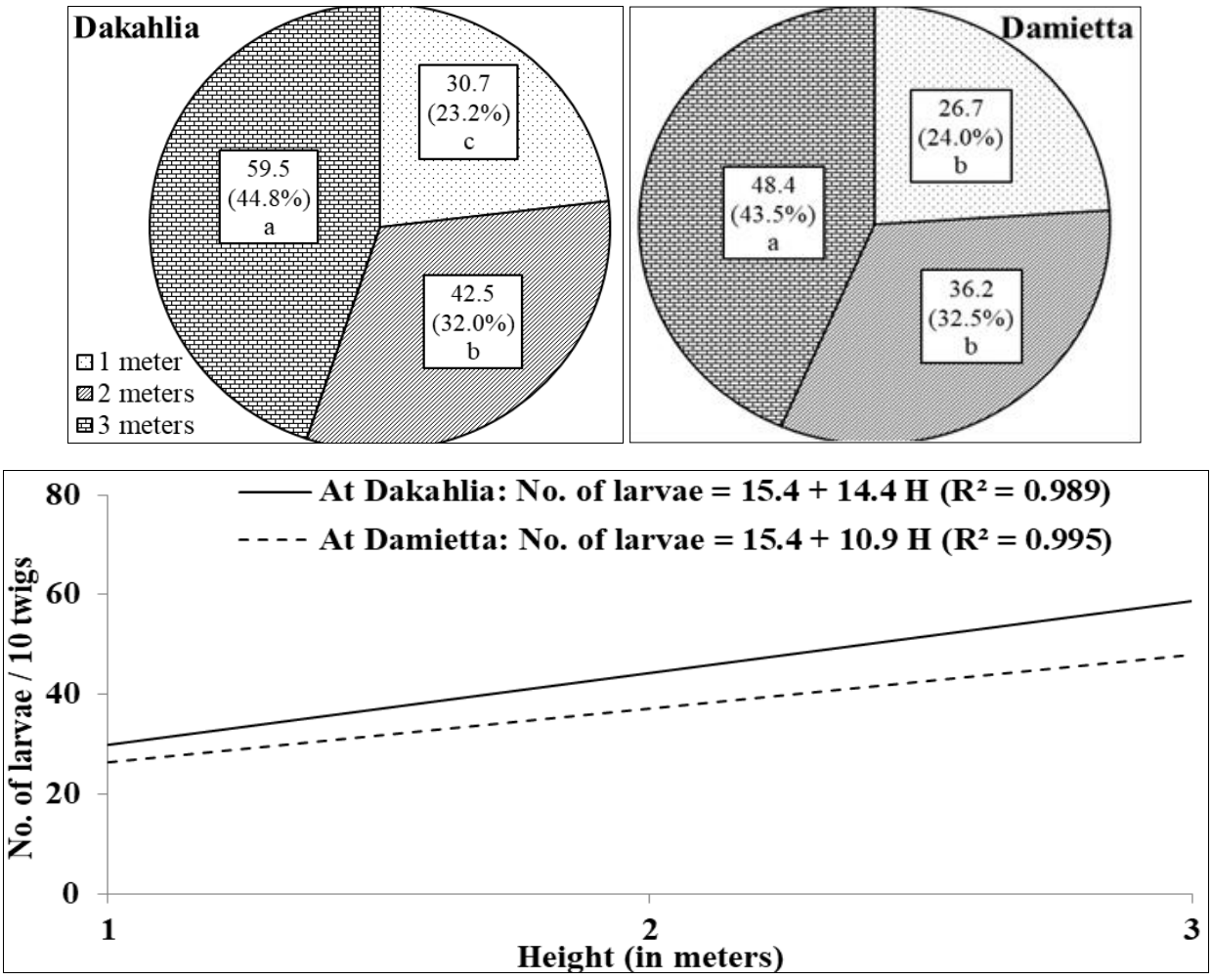

Fig 5: Effect of height of the olive tree on relative abundance of *P. unionalis* larval population at Dakahlia and Damietta governorates during the year of 2021/2022. (Notice: Heights had the same letter in the same governorate did not differe at significant of 5%)

On another hand, regression anaysis showed that every increase on the height of trees by 1 meter increased *P. unionalis* larval poulation by 14.4 and 10.9 larvae/10 twigs at Dakahlia and Damietta governorates (Figure, 5). Also, regression anaysis revealed that height on the trees had a relatively high effect on *P. unionalis* larval population; where, the calculated R^2 reached 0.989 and 0.995 at Dakahlia and Damietta governorates.

As it was recorded on *P. unionalis*, relative abundance of *P. oleae* affected significantly by the height on the tree which the samples were taken from it. Where, larval population of *P. oleae* was sgnficantly higher on the height of 3 meters from the ground which contributed with 48.8 and 46.3% of the total collected population at Dakahlia and Damietta governorates. The heights of 2 and 1 meters contributed with the second (30.6 and 32.1%) and third (20.6 and 21.6%) ranks of the total collected population at Dakahlia and Damietta governorates, respectively. Statistical analysis showed that there were signficant differences between the collected populations from different heights (Figure, 6).

Regression anaysis showed that every increase on the height of trees by 1 meter increased the larval population of *P. oleae* by 2.9 and 2.0 larvae/10 twigs at Dakahlia and Damietta governorates. Regression anaysis explained that the height on the trees had a relatively high effect on larval population of *P. oleae*; where, the calculated R^2-values were 0.973 and 0.993 at Dakahlia and Damietta governorates (Fig 6).

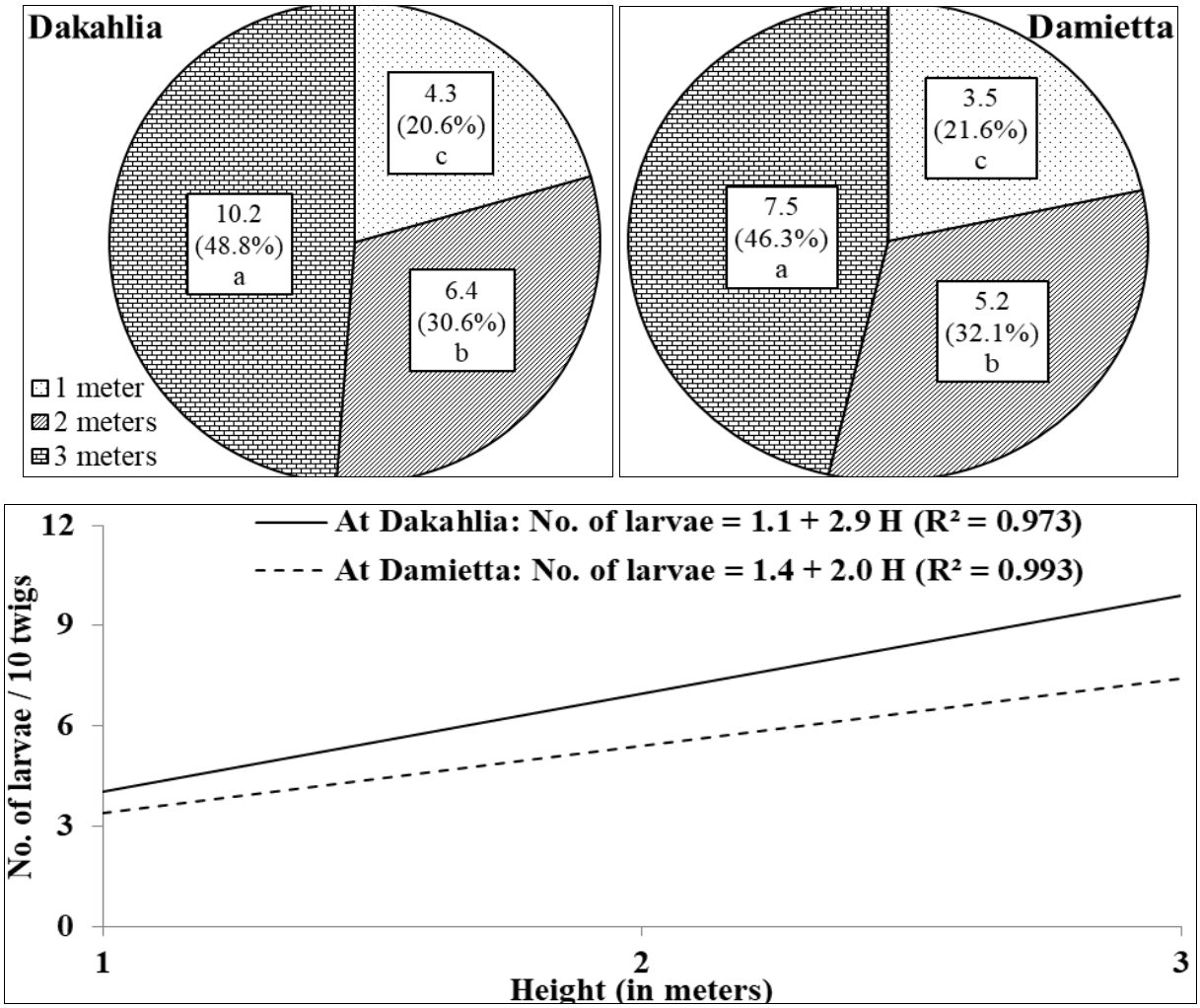

Fig 6: Effect of height of the olive tree on relative abundance of *P. oleae* larval population at Dakahlia and Damietta governorates during the year of 2021/2022. (Notice: Heights had the same letter in the same governorate did not differe at significant of 5%)

Discussion

The present results showed that *P. unionalis* occurred all over the year infesting olive leaves, exhibited three peaks of activity and showed its highest population during summer season at the two governorates of Dakahlia and Damietta. These results are in agreement with those obtained by Hegazi *et al*. (2012) [17] and Ibrahim *et al.* (2023) [19]; they recorded that *P. unionalis* occurred all over the year recording three peaks of activity. Ghoneim (2015) [14] mentioned that *P. unionalis* is a multivoltine species with several overlapping generations per year and the number of generations depending on many factors such as the host plant and seasonal conditions. So, Grossley (2000) [16] reported that this pest has 2-3 generations in cold to mild regions and more than 5-6 generations in mid-tropical and tropical regions. Mostafa *et al*. (2020) [25] found four to five peaks of *P. unionalis* activity on olive orchard at Dakahlia governorate. In Spain it has five generations per year in (Fodale & Mule, 1990) [13]; while, in Italy it has four to five generations (Fodale & Mule, 1990) [13]. On an other hand, Hegazi *et al*. (2012) [17] mentioned that the highest activity of *P. unionalis* was recorded during the summer season at Alexandria governorate. While, El-Kenawy (2012) [11] and Mostafa *et al*. (2020) [25] recorded the highest populations of this pest during spring and autumn seasons in the coastal region, Middle Egypt and Dakahlia governorate. The differences between the present results and others may be attributed to the variation of the host plant, seasonal temperature and other environmental conditions (Ghoneim, 2015) [14]

The intensity and number of *P. oleae* generations are depending on the climatic conditions and host phenology (Mansour *et al*., 2017) [23]. The present results showed that *P. oleae* occurred all over the year infesting olive leaves (with relatively low population in comparison with *P. unionalis*) and exhibited two to three peaks of activity with highest activty during summer season at Dakahlia and Damietta governorates. These results are in agreement with those obtained by Mansour *et al*. (2017) [23]; they reported that this pest exhibted two to three peaks of adult activity in olive orchards Morocco. Also, Kumral *et al*. (2005) [21] and Andreadis *et al*. (2011) [2] mentioned that adults of *P. oleae* showed three main flight activties in olive orchardds in Turkey and Greece. Godena *et al*. (2019) [15] reported that *P. oleae* showed two peaks of activity on olive trees in Croatia during the period from April to July. Also, the present study came in the same line of Pralavorio *et al*. (1981) [29] and Amor (1994) [1] who explained that the favorable climatic conditions and availability of buds and flowers of olive trees increasing densities of different developmental stages of *P. oleae* during summer season.

The obtained data from the two studied governorates explained that daily temperature degrees had insignficantly negative and positive effects on *P. unionalis* and *P. oleae*

populations, respectively. In contrary, relative humidity had insignficantly postive and negative effects on *P. unionalis* and *P. oleae* populations, respectively. These results are nealy in agreement with those obtained by Mostafa *et al*. (2020) [25]; they reported that temperature degrees had insignificant effects on *P. unionalis* population in olive orchard. Also, Ibrahim *et al*. (2023) [19] reported that *P. unionalis* exhibited negative response to the increase of minimum temperature and relative humidity. The insignficant effects of temperature degrees and relative humidity on *P. oleae* population may be explaned by the study of Godena *et al*. (2019) [15]; who mentioed that the maximum flight coincided with the occurrence of olive flowers (first generation) and suitable fruit size for oviposition (second generation). Also, Pralavorio *et al*. (1981) [29] and Amor (1994) [1] mentioned that the availability of the host organs (buds and flowers) is of the main reasons for increasing *P. oleae* population. According to Mansour *et al*. (2017) [23], the intensity and number of *P. oleae* generations are depending on the climatic conditions and host phenology; where, areas with mild temperatures and suitable humidity show high *P. oleae* population; while, warmer areas and less humidity decreased its population.

Mansour *et al*. (2017) [23] and Godena *et al*. (2019) [15] mentioned that populations of *P. oleae* and *P. unionalis* are depending mainly on the host phenology. These findings are explain the present results; which showed that *P. unionalis* and *P. oleae* populations are signficantly affected by the heights on the olive trees which the samples were taken from it; where, the regression anaysis showed that every increase on the height of trees increased *P. unionalis* and *P. oleae* larval poulations by obvious numbers at Dakahlia and Damietta governorates. These findings may be attributed the relatively high numbers of the young leaves on the height levels of the trees; which is where most of terminal twigs. This explain can be supported by Hegazi *et al*. (2012) [17]; they mentioned that larvae of *P. unionalis* attack leaves of olive trees, particularly those on terminal twigs. Also, Pinto & Salemo (1995) [28], Grossley (2000) [16] and Eid (2003) [10] added that *P. unionalis* preferred the young leaves of olive trees for infest the young trees, nurseries and shoots of old trees. With respect to *P. oleae*, Ramos *et al*. (1998) [30], Patanita & Mexia (2004) [27], Kavallieratos *et al*. (2005) [20], Mansour *et al*. (2017) [23] and Civantos-Ruiz *et al*. (2022) [8] reported that its larvae make mines in the olive leaves; where it is easier in the young leaves (in the terminal twigs) more than old leaves.

Conclusion

At Dakahlia and Damietta governorates, both of *P. unionalis* and *P. oleae* infested olive leaves with three peaks of activity with obviously high population of *P. unionalis* in comparison with *P. oleae*. The highest activity of the two pests was recorded during summer season. Larval populations of *P. unionalis* and *P. oleae* increased as the height on the trees increased; so, control treatments should be concentrsted at the high levels of the olive trees.

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