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The population trend of *Palpita unionalis* in different olive varieties in Egypt

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Abstract Jasmine moth (JM), *Palpita unionalis* (Hübner) (Lepidoptera: Pyralidae) is a very important pest in the commercial, densely planted olive orchards in Egypt. In years of its highest population density, it can destroy a significant part of the crop. The objectives of this study were to determine the male flight trend and egg laying trend of the JM in three large plots of different olive varieties (two varieties/plot) in two successive fruiting seasons. Differences in male flight trend and egg laying trend of JM were observed among the different varieties ('Sennara', 'Toffahi', 'Shamy'). In 2003, more males were captured in traps placed in the Sennara/Toffahi plot than in the two Shamy/Toffahi plots. Egg densities were higher on Toffahi trees grown between Sennara trees than on Toffahi trees grown between Shamy ones. In 2004, in the plot where Toffahi and Sennara were grown together, JM females laid more eggs than in the olive plot where Toffahi rows alternated with Shamy rows. The results suggest that the Shamy variety discouraged gravid females from ovipositing, compared with Toffahi or Sennara varieties. In conclusion, olive variety, cropping system (mixed culture) and trapping season are among those characteristics that affect this pest.

Keywords Cropping season · Egg-laying trend · Jasmine moth · Male flight trend · *Olea europaea* · Sennara · Shamy · Toffahi

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Introduction

Host plant recognition and selection in Lepidoptera is primarily a function of the ovipositing female, and since newly emerged larvae are often limited in their dispersal abilities, oviposition is particularly crucial for survival of their progeny (Renwick & Chew 1994). Chemical stimuli have been suggested to play a role in ovipositional preference (Dominici *et al.* 1986; Neuenschwander *et al.* 1985). Kombargi *et al.* (1998) examined the possible role of surface waxes as chemical stimuli. They found that surface waxes vary greatly within and among varieties and also contain compounds that hinder oviposition. A generally accepted hypothesis for oviposition by a gravid female is that she lays eggs in or on host plants based on their quality and suitability for her offspring, referred to as the optimal oviposition theory or the preference–performance hypothesis (Jaenike 1978). Furthermore, according to this theory, when many hosts are simultaneously offered to a female, it is expected that she will follow a hierarchical order of host preference by laying eggs on the best larval diet first, and then on the second best diet, and so forth (Thompson 1988). Presence of optimal concentrations of stimulatory chemicals on the plant surface alone or in combination with physical stimuli such as shape, size and texture influences the female's oviposition decisions (Renwick & Chew 1994; Sambaraju & Phillips 2008; [Sambaraju 2007, thesis, Oklahoma State Univ., USA]).

Jasmine moth (JM), *Palpita unionalis* (Hübner) (Lepidoptera: Pyralidae), is a serious pest of *Olea europaea* L., *Jasminum* sp., *Ligustrum* sp., and *Phillyrea media* L., as its larvae attack leaves of these plant species, particularly those on terminal twigs. Newly hatched larvae usually feed on the parenchyma of the lower surface of the leaves–drying the upper epidermis, which turns brown. In nurseries, larvae may devour young leaves and apical buds, causing stunted growth of plants. Infested flower buds usually abscise before fruit setting. In heavy infestations, larvae attack the olive fruit, especially table varieties, by creating irregular holes in the skin, making them unacceptable for the commercial market (Badawi *et al.* 1976; Balachowsky 1972).

The available data on the phenology and biology of the jasmine moth in olive groves are few. In Italy, it has four to five generations (Martelli 1915), in Israel six (Avidov & Harpaz 1969), in Spain five (Fodale *et al.* 1988), in France two (Balachowsky 1972), in Turkey two to three (Kovanci *et al.* 2006) and in Greece three (Mazomenos *et al.* 2002). In Egypt, the moth completes ten generations per year (Badawi *et al.* 1976).

In Egypt, organophosphate insecticides have been used to control the population of *P. unionalis* for the past 35 years with two or three applications per growing season, depending on the harvest date of the olive crop (Foda *et al.* 1976). The dependence on chemical control constituted a major constraint in the development of IPM strategies, mainly because of resistance problems, disruptive effects on natural control of secondary pests, and pesticide residues in fruits.

Field tests were carried out in 2002–2004 to evaluate the mating disruption method for the control of JM on olive trees (Hegazi *et al.* 2007). During that work, it was observed that traps installed in certain varieties consistently captured more insects than those in plots of other varieties. So, in an attempt to understand parameters affecting the population dynamics of JM on a large commercial olive orchard (240 ha), the male flight trend and egg laying trend of JM were investigated in three large isolated plots of different varieties. Two aspects were studied: (i) JM males captured in pheromone-baited traps in different olive varieties, and (ii) density of JM eggs in the same varieties in different plots for two consecutive years.

Materials and methods

Experimental fields The study was conducted during 2003–2004 in a densely planted commercial olive farm (240 ha) located in the arid olive growing area between Alexandria and Cairo, 177 km south of Alexandria (E 30°51' 2"; N 30°08' 27"). The farm is divided into 88 isolated plots (two varieties/plot) by windbreak hedges and is not situated near any ornamental plantations or any other known host plants of *P. unionalis*. Three lines (30 trees/line) of one variety were alternated by three lines of the second variety and so on. 'Dolce', 'Sennara', 'Shamy', 'Manzanillo', 'Toffahi', 'Hamedy', 'Kalamata', 'Bicual' and 'Aks' are the principal varieties of table olives, constituting approximately 5.3%, 5.8%, 4.2%, 26.1%, 12.4%, 4.7%, 8.1%, 27.2% and 6.2%, respectively, of the total 61,774 olive trees. Three large plots (3.5 ha each) that had a history of heavy JM infestation and were situated 150 m apart from each other were chosen. Varieties of the first two plots (Plot 1 and 2) consisted of Toffahi and Shamy, while those of the third one (Plot 3) were Toffahi and Sennara. The varieties Toffahi and Sennara suffer high infestation levels by both JM and the olive moth (*Prays oleae*). Olive trees were 7–8 years old, 3–4 m tall and 5–6 m apart; tree density was 336 trees ha^{-1}. Trees were drip irrigated. Plots were kept spray-free during the

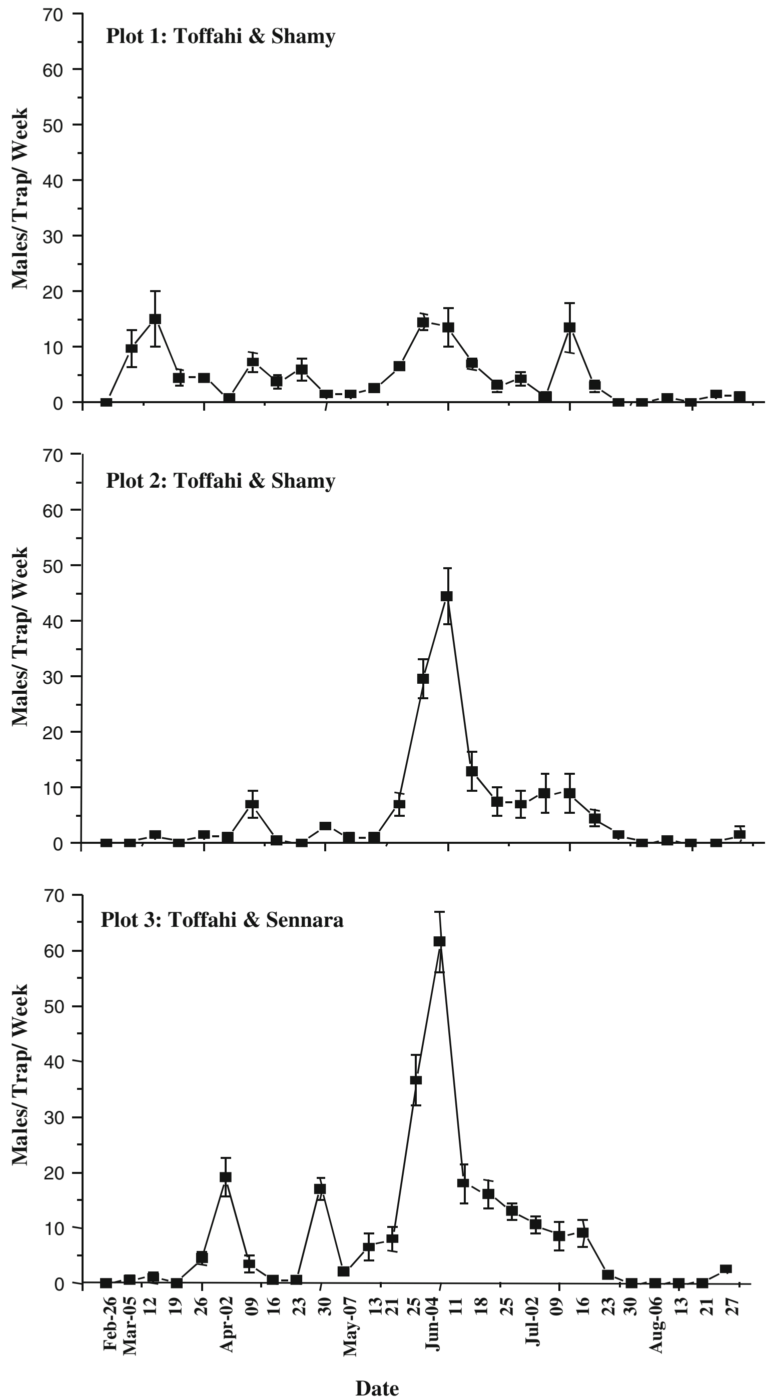


Fig. 1 Captures of *Palpita unionalis* males in pheromone traps installed in three large plots of different olive varieties, during 2003. Mean of three replicates (± SD)

experimental period. In 2003, male moth captures and oviposited eggs were recorded weekly on Toffahi trees, present in the different plots, to investigate JM population fluctuation in plots comprising different varieties. In 2004, plot 1 (Toffahi/Shamy) and plot 3 (Toffahi/Sennara) were selected to study the male flight trend and egg-laying trend of JM on olive trees of plots that combine preferred and non-preferred varieties (plot 1) and two preferred varieties (plot 3).

During 2003–2004, the mean annual rainfall was 9.2 mm. Rainy seasons occurred from November–December to January–February. Mean monthly

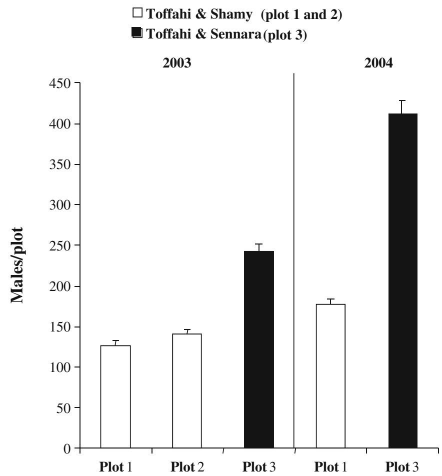


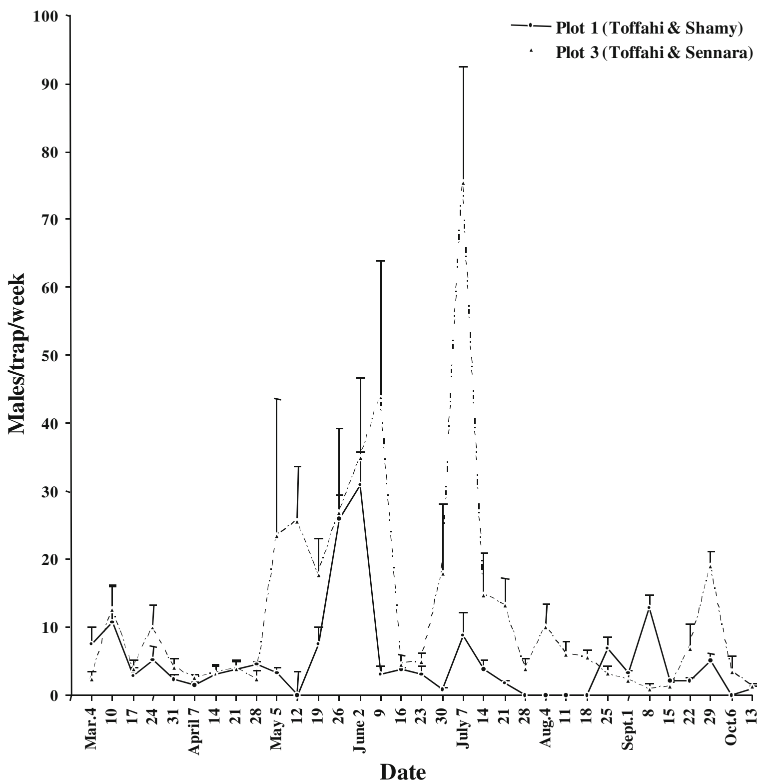
Fig. 2 Mean number of *Palpita unionalis* males in pheromone traps installed in plots of different olive varieties during 2003–2004. Mean of three replicates (± SD)

minimum temperature varied from 10.2°C in January to 23.9°C in August and the mean monthly maximum temperature varied from 18.9°C in January to 35.6°C in July. Mean relative humidity varied from 47.8% in April to 63.8% in January.

Trap catches On each plot, three funnel traps were hung on poles at a height of 1.5–2 m close to the external south part of the tree canopy, only on Toffahi trees. Each trap was baited with a red rubber septum no. Z124354-100EA (Aldrich Chem. Co., St. Louis, MO, USA), loaded with 3 mg of the two pheromone components, (*E*)-11-hexadecenyl acetate (E11-16:Ac) and (*E*)-11-hexadecenal (E11-16:Ald). The ratio of the two components in the blend was adjusted to 70:30 (Athanassiou *et al.* 2004; Mazomenos *et al.* 1994). The distance between traps was about 60 m. Traps were serviced weekly and lures were replaced every 4–5 weeks. In 2003, the experiment started on February 26th and ended on August 27th in all three plots. In 2004, trap catches were recorded only in plots 1 and 3 from March 4th to October 13th. The position of each trap was changed weekly in a clockwise manner.

Egg counts The effect of olive variety on number of eggs was assessed by recording egg densities in different olive varieties grown together. In 2003, the number of JM eggs present on shoots, leaves and fruits

Fig. 3 Captures of *Palpita unionalis* males in pheromone traps installed in two plots of different olive varieties, during 2004. Mean of three replicates (± SD)



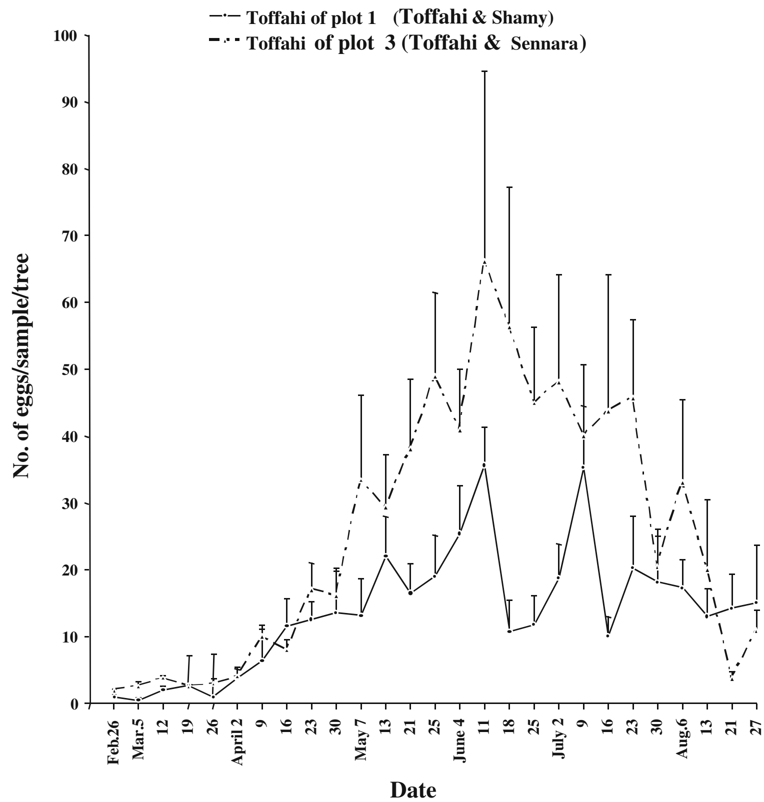


Fig. 4 Egg laying activity (mean ± SD) of *Palpita unionalis* on Toffahi trees in two plots of different olive varieties, during 2003

on Toffahi trees grown in plots of varieties 1 and 3 was determined once a week for 27 weeks. In 2004, the same procedure was applied on each variety of both plots 1 and 3. Three sampling points/variety were randomly chosen in each plot, avoiding the border areas of the plot. On each sampling point, three neighboring trees were sampled. From each tree, ten olive shoots (*ca* 30 cm long) were removed in each direction. In the laboratory, the number of un-hatched eggs per sample was recorded. The eggs of JM are larger than those of olive moth. JM eggs are flattened oval (1 mm long and 0.6–0.7 mm wide), yellowish-white and finely reticulated. The eggs are deposited singly or most commonly in groups of two to eight eggs close to each other on both sides of the tender olive leaves, flowers and fruits and even on olive branches.

Data analysis Data are presented as means of male catches per trap and mean number of eggs deposited per sample. Means were normalized using the log(X+0.5) transformation to increase variance homogeneity.

Results

Seasonal flight trend In 2003, the mean weekly catches per trap in each plot (1–3), is shown in Fig. 1. The moth appeared on March 5th in plot 1 (Toffahi/Shamy) and plot 3 (Toffahi/Sennara) and on March 12th in plot 2 (Toffahi/Shamy). There were obvious peaks and dips in the number of JM males trapped in plots of different olive varieties, and differences in the total trap catches among the three plots. The moth developed low population densities in plots 1 and 2 compared with plot 3. The total season-long trap capture (27 weeks) of plot 3 was 1.9- and 1.7-fold greater than trap captures in plots 1 and 2, respectively. Mean male captures were most abundant in plot 3 compared with plots 1 or 2, with 9.0, 4.6 and 5.2 male captures per week, respectively (plot 1: 126±7.2, plot 2: 141±5.8, plot 3: 243±8.8 males per plot) (Fig. 2). Although mean JM catches were highest in plot 3, similar population fluctuation patterns were recorded in all experimental plots. Overall, a distinct peak of JM was observed on May 25th for plot 1 (14.5±1.5 males/trap) and on June 4th for both plot 2 (44.5±5.0 males/trap) and plot 3 (61.5±5.5 males/trap). The majority of

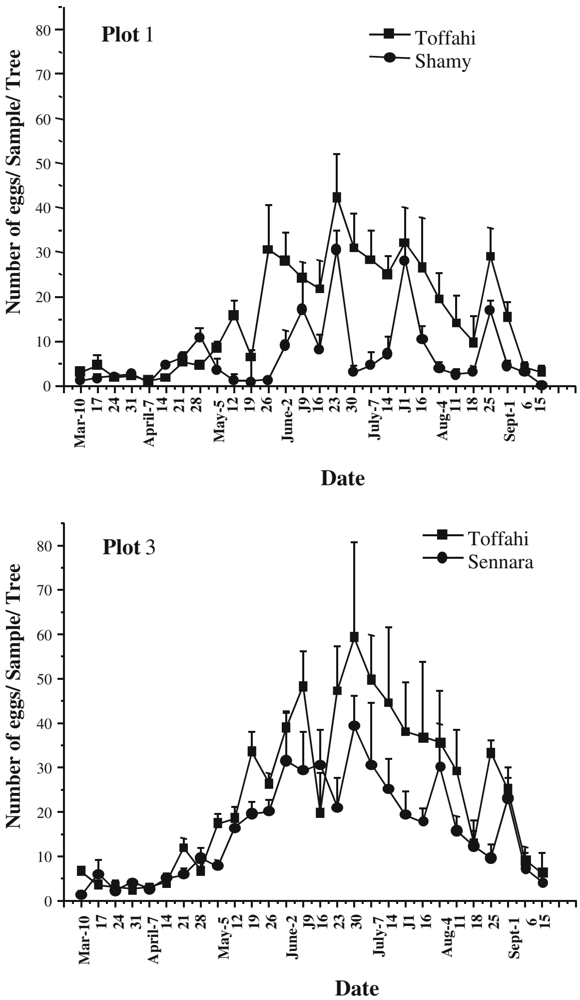


Fig. 5 Egg laying activity (mean ± SD) of *Palpita unionalis* on olive trees in two plots of different olive varieties, during 2004

JM males, 41.8%, 76.2% and 66.5% of the seasonal total, were caught during May–June on plots 1, 2 and 3, respectively, which represent the first distinct flight (Fig. 1); the second distinct flight occurred in September–November.

Some non-target insects (Coleoptera, Diptera, Hymenoptera, Lepidoptera) were also trapped and their numbers peaked in May (data not shown).

Monitoring of JM males in plot 3 suggested that moth density in 2004 was higher than on the same plot, in 2003 (Fig. 2). Capture of JM moths in 2004 occurred constantly from March 4th throughout the growing season and into autumn during the beginning of harvest, *i.e.*, moths were present all during the season (Fig. 3). More moths were recorded in traps installed in the Toffahi/Sennara plot 3 (heavily infested area) than in those in the Toffahi/Shamy plot 1 (moderately infested area) (Figs. 3 and 4). The total numbers of captured moths were 441.1±17.9 and 177.1±6.9 per trap in plots 1 and 3, during 2004 (Fig. 2).

Egg laying trend The effect of olive variety on egg laying trend of JM is shown in Figs. 4 and 5. This was assessed by recording egg densities on olive flowers, fruits and leaves/sample/tree on olive trees of the test plots. The most striking feature in our findings was that JM eggs were constantly present from late February until the last sampling (August/September). Weekly records of JM eggs revealed an uneven temporal distribution of fertile females during the monitoring period. Figure 4 shows weekly means of JM eggs per tree found on only Toffahi trees grown in plot 1 (Toffahi/Shamy) and plot 3 (Toffahi/Sennara), in 2003. There were apparent peaks and dips in numbers of JM eggs throughout the study period. However, egg numbers were higher on Toffahi trees in plot 3 (694±41.1) than on the same variety grown in plot 1 (Toffahi and Shamy trees) (440±40.4). The mean number of egg counts per week was 13.9±1.8 and 25.7±3.8 eggs on Toffahi tree samples of plots 1 and 3, respectively.

The egg laying activity of JM females on olive trees in all varieties of plots 1 and 3 in 2004 is shown in Fig. 5. There were noticeable peaks and dips in number of JM eggs laid on plots of different olive varieties. The JM females laid more eggs in June–July and in September. However, in plot 1, the total number of JM

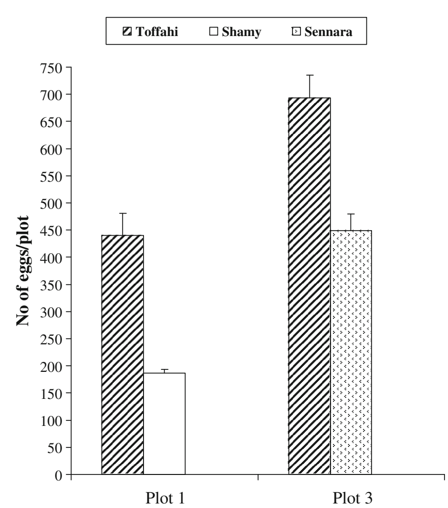


Fig. 6 Total number of *Palpita unionalis* eggs in two large plots with different olive tree varieties

eggs was lower on Shamy trees (187.3±6.4 eggs/tree) than on Toffahi trees (440.3±40.4 eggs/tree) (Fig. 5). On the other hand, comparison between number of eggs laid during the whole test period on each of the Toffahi and Sennara trees grown on the same plot 3 (Fig. 5) revealed more eggs laid on Toffahi trees (694.6±41.1 eggs/tree) than on Sennara trees (449.3±30.6 eggs/tree). Also, there was a difference between total eggs laid on Toffahi and Sennara trees. Toffahi trees were intensively visited, as indicated by an increasing amount of eggs laid per week compared with on other tree varieties. In plot 1, the mean number of eggs counted per week was 15.7±2.3 and 6.7±1.6 eggs on Toffahi and Shamy trees, respectively. In plot 3, these counts were 24.8±3.4 eggs on Toffahi trees *vs.* 16.0±2.1 eggs on Sennara trees. These results suggested that Toffahi trees in plot 1 were less visited by JM females when compared with Toffahi trees in plot 3 (Fig. 6).

Discussion

In Egypt, lepidopterous pests are important constraints for olive production, especially in recently established, intensively managed olive plantations.

We monitored the season-long presence of both JM males and egg number on three large isolated olive plots of diverse varieties in which the Toffahi variety was grown in all plots. Differences were observed in either weekly JM male captures or JM egg counts among olive plots. In 2003, there were no differences in moth densities among plots where the same olive varieties, Toffahi and Shamy, were grown. However, densities of both JM males and eggs were each nearly double the figures when Sennara was combined with Toffahi compared with plots containing Toffahi and Shamy varieties.

In 2004, the number of JM moths was generally higher than in the previous year. In the Toffahi/Shamy plot, JM females laid fewer eggs on Shamy trees compared with the number of eggs counted on Toffahi trees in the same plot. The results suggested that Shamy trees were less visited, as indicated by a decreasing number of eggs on Shamy trees compared with those on Toffahi trees. This allows us to suggest that the Shamy variety is probably not preferred by JM females. Thus, a varied plant composition may both reduce immigration of pests into a field and also accelerate their withdrawal from the area (Osman *et al.* 2001). The scenario was different on the Toffahi/Sennara plot (plot 3): intensities of both adults and eggs of JM were higher in this plot compared with those recorded in the Toffahi/Shamy plot (plot 1). In the Toffahi/Sennara plot, more intensive egg-laying was recorded on olive trees of both varieties, *i.e.*, both were susceptible varieties. The results suggest that the presence of another susceptible variety, *i.e.*, Sennara possibly enhanced the preference of JM to the Toffahi/Sennara plot.

The experimental plots are three of 88 olive plots of monoculture, 240 ha. Spreading of pests is fastest in a monoculture, especially on plants sown or planted in rows (Metspalu *et al.* 2003). Jasmine moth is a highly mobile moth and is known to disperse even to northern Europe (Tremewan 2002). So, it is highly probable that in the Toffahi/Sennara plot there was a large immigration of JM from neighboring plots, increasing the number of eggs in this plot. Cole (1976) reported that volatile compounds of host plants are most likely responsible for the oviposition site selection of insect pests.

The exact reason for the low pest densities in Toffahi/Shamy plots is not known. The data suggest a strong effect in preference of JM when Sennara was present along with Toffahi on the same plot. This further indicates that JM was preferentially attracted to the Toffahi/Sennara plot than to the Toffahi/Shamy plot. The results indicate that deciding when to apply control measures against JM may differ among orchards of different varieties. The results give an answer to why Toffahi/Sennara plots represent the pinpoint locations of high infestation level by JM among the 88 plots of the farm. The study shows that trapping season, olive variety and cropping system are among the characteristics that affect the target pests. These findings should be taken into account when developing a pest management system. Trapping in olive plots of different varieties would be useful in providing orchard-specific information and correct estimates of adult emergence and proper timing for control measures. Burrack and Zalom (2008) have reported that in mixed variety plantings, small oil varieties may suffer less damage, suggesting that diversified olive production may help mitigate effects of olive fruit fly damage.

It is known that female olive fruit flies, *Bactrocera oleae*, exhibited a strong ovipositional preference when presented with a choice of olive varieties in the field (Burrack & Zalom 2008). The olive moth, *Prays oleae*, another destructive lepidopterous pest, is known to prefer the most nutritional oviposition substrate, in terms of nitrogen content (Petrakis 2000). Kumral *et al.* (2007) have reported different life table parameters for *Palpita unionalis* on several host plants.

Although there were considerable differences in weekly captures of JM males among olive plots, similar information on JM flight trend was obtained from the experimental sites. However, there was no apparent concordance between the number of egg counts and the number of males captured in pheromone traps. The results suggest high levels of female presence/egg laying activity even when no JM males were found in pheromone traps.

Some moths other than JM were attracted to the baited traps. This is not surprising because some of these non-target moths may use similar or identical pheromone components (Adams *et al.* 1989; Weber & Ferro 1991). The present results suggest that chemical compounds from the JM pheromone (Lepidoptera: Pyralidae) may be involved in the attraction of the scarabs (Coleoptera: Scarabaeidae). Several studies have documented the phenomenon in which baited traps attract non-target and even beneficial insects (Gauthier *et al.* 1991; Gross & Carpenter 1991; Meagher & Mitchell 1999).

Although the present results are preliminary and cover only two seasons, some important indications can be derived from the finding that growing olive varieties together in the same area, may influence egg laying and reduce the abundance of JM in olive trees and may partially protect the sensitive variety from insect infestation. The above results showed how important it is to consider—when control of a certain pest is intended—the choice of varieties for founding an olive orchard with diverse varieties.

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