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Monitoring and population characteristics of *Prays oleae* (Lepidoptera: Yponomeutidae) on different insecticidal treatments

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Monitoreo y características de la población de *Prays oleae* (Lepidoptera: Yponomeutidae) en diferentes tratamientos con insecticidas

RESUMEN. La presencia de la polilla del olivo (*Prays oleae* Bern.) y la efectividad de los diferentes tratamientos de control contra ella se han realizado en 160 olivos de la variedad Leccino en Istria, Croacia. Los tratamientos fueron: dimetoato, *Bacillus thuringiensis* var. *kurstaki* (Bt), piretrinas, consociación de olivo y piretro plantado y control. La polilla de oliva se ha monitoreado semanalmente utilizando trampas delta cebadas con feromonas y placas adhesivas de diferentes colores en 12 y ocho monitoreos. Las etapas de la vida de polilla (huevos no destruidos, huevos destruidos y larvas) se han contado en siete monitoreos. La actividad del depredador se ha determinado como la proporción de huevos destruidos en el número total de huevos observados en 50 muestras de flores y frutas elegidas al azar. En las trampas de feromonas, la captura máxima se determinó el 15 de mayo en el control, cuando el tiempo máximo de vuelo de la polilla en el control, los tratamientos con dimetoato y piretrinas coincidieron en el tiempo. Se detectaron más adultos en las trampas de feromonas que en las trampas adhesivas (16,8 veces más). En el tiempo, la primera preferencia de la polilla fue el rojo y luego las placas adhesivas azules. El mayor número de huevos (no destruidos y destruidos) se encontró en el dimetoato el 15 de mayo (2,8 ± 1,1 y 4,5 ± 1,6) y el 18 de junio (0,8 ± 0,5) como consecuencia de la alta tasa de ovoposición accidental en parcelas de dimetoato antes de las aplicaciones de tratamiento. El mayor número de larvas se detectó en el control el 2 de julio (2,0 ± 0,7).

PALABRAS CLAVE. *Bacillus thuringiensis* var. *kurstaki*. Barrenador del grano de oliva. Dimetoato. Piretrinas. *Tanacetum cinerariifolium*.

ABSTRACT. The presence of olive moth (*Prays oleae* Bern.) and effectiveness of different control treatment against it has been conducted on 160 olive trees of *Leccino* variety in Istria, Croatia. The treatments were: dimethoate, *Bacillus thuringiensis* var. *kurstaki* (Bt), pyrethrins, consociation of olive and planted pyrethrum and control. Olive moth has been monitored weekly using pheromone-baited delta traps and different coloured sticky plates in 12 and eight monitoring. Moth's life stages (non-destroyed, destroyed eggs and larvae) has been counted in seven monitoring. The predator activity has been determined as the ratio of destroyed eggs in the total number of observed eggs on 50 randomly chosen samples of flowers and fruits. On pheromone traps, the maximum catch has been determined on May 15th on control, when maximum of moth's flight on control, dimethoate and pyrethrins treatments coincided in time. There were more adults detected on pheromone traps then on sticky traps (16.8 times over). With time, moth's first preference was red and then blue sticky plates. The highest number of eggs (non-destroyed and destroyed) has been found on dimethoate on May 15th (2.8 ± 1.1 and 4.5 ± 1.6) and June 18th (0.8 ± 0.5) as a consequence of accidental high oviposition rate at dimethoate plots before treatment applications. The highest number of larvae were detected on control on July 2nd (2.0 ± 0.7).

KEYWORDS. *Bacillus thuringiensis* var. *kurstaki*. Dimethoate. Olive kernel borer. Pyrethrins. *Tanacetum cinerariifolium*.

INTRODUCTION

Olive moth, *Prays oleae* Bern. (Lepidoptera: Yponomeutidae) belongs to microleptidoptera and is one of the most important insect pests of olive tree (*Olea europaea* L.) in olive growing areas (EPPO, 2011). There are three generations of olive moth *per* year, each developing on different plant organs, but the most important and harmful are the first - antophagous (laying eggs on flower buds in April and feeding on flower) and the second - carpophagous (feeding in fruit and boring into stone of the fruit in early June, and causing fruit drop in July and September) (Kavallieratos et al., 2005; Nave et al., 2016). The economic losses due to that pest depend on the final infestation and olive yield of the year considered (Rosales et al., 2006). The anthophagous generation can cause yield losses up to 581 kg of fruit *per* ha whereas the following, carpophagous one up to 846 kg *per* ha (Bento et al., 2001).

Pheromone gland extracts from *P. oleae* females which contain major component, (Z)-7-tetradecenal (Z)-7-14:Ald has been used for monitoring olive moth population and for timing insecticide application (Champion et al., 1979; Mazomenos et al., 1999; Kumral et al., 2005).

Although there are different methods for managing olive moth control, the chemical one is widely applied, and the most commonly used insecticide is organophosphate dimethoate, which supress its second generation (Katalinić et al., 1999; Alvarado et al., 2005). Excessive applications leads to undesirable effects on natural enemies of the pest, environmental pollution and contamination of olives. Moreover, several studies have demonstrated that some olive pests like olive fruit fly are able to develop resistance to this insecticide (Hawkes et al., 2005; Skouras et al., 2007). For preventing and supressing olive moth population, several other "eco-friendly" insecticides have been used. Among them, *Bacillus thuringiensis* (Berliner) var. *kurstaki* (Bt), suppress the first, antophagous generation (Katalinić et al., 1999; Perez-Guerrero et al., 2012) causing insect larvae to starve. Besides Bt, botanical insecticides have been used in horticulture, like pyrethrum, which is obtained from dried flower head of the plant pyrethrum or daisy, *Tanacetum cinerariifolium* (Trevir.) Sch. Bip. Most of the pyrethrum crops are in Kenya, but it is native in Dalmatia (and in other locations on the coast of Croatia) and therefore the Croatian costal area is very suitable for its growing. Pyrethrins (six related insecticidal compounds of which the most abundant are pyrethrins I and II) are found predominantly in the ovaries of the flower (El-Wakeil, 2013) and its content can vary from 0.9 to 1.3% by weight of dried flowers in native populations (Casida & Quistad, 1995; Kolak et al., 1999). Ban et al. (2010) showed that content of pyrethrins from coast of Croatia reaches more than 1.2%. Natural pyrethrins act mainly by contact or ingestion on both central and peripheral nervous system, like neurotoxic action, blocking voltage-gated sodium channels in axons, thus causing immediate insect 'knockdown' paralysis (El-Wakeil, 2013). Pyrethrins are labile in presence of UV component of sunlight (half-lives of 2 h or less), which limit their use (El-Wakeil, 2013). Also, pyrethrins are oxygen, water and high-temperature sensitive (Casida & Quistad, 1995). In olive pest management, pyrethrins are used against olive fruit fly (*Bactrocera oleae* (Gmel.)) with a two-day pre-harvest interval (Simeone et al., 2009) while their effects on olive moth have not been formaly reported yet.

The purpose of this investigation was to determine and compare the effectiveness of different insecticidal treatments (*B. thuringiensis* var. *kurstaki* (Bt), dimethoate, pyrethrins, and consociation of olive and planted pyrethrum) against *P. oleae*, as well as to define pest ecology and biology in northernmost olive growing region of Croatia, as a contribution to its control management.

MATERIAL AND METHODS

Description of treatments

The experimental study about presence of *P. oleae* and effectiveness of different insecticidal treatments against it, has been set up in olive orchard of 15 ha (45° 31' N; 13° 66' E) in Istria, Croatia, during 2014. There were 20 blocks (consisting of eight *Leccino* variety olive trees each) set up in a randomized complete block design. The trees were 13 years-old and were planted at 5 x 6 m spacing. There were five treatments and four repetitions. Treatments were: 1) organophosphate insecticide dimethoate (Chromgor 40®, Chromos Agro d. d., Croatia) in a concentration of 0.15%; 2) biological insecticide Bt (Baturad®WP, Probelte S. A., Spain) in concentration of 0.1%; 3) botanical insecticide pyrethrum or 0.08% of natural pyrethrins (Kenyatox verde®, Copyr S. p. A., Italy) extracted from flowers of *T. cinerariifolium*; 4) consociation of olive and planted pyrethrum (*T. cinerariifolium*) and 5) control (unsprayed plots). Plants of two populations of pyrethrum *T. cinerariifolium* (B1 and B2) were planted at a distance of 30 x 50 cm in the treatment consociation olive-pyrethrum on April 30th, 2013.

In total, there were 160 olive trees (32 trees in each treatment). Cultivation has been uniform for all plots in the trial, whereas plant protection started before the beginning of the survey using only copper and without irrigation. Treatment applications were performed using 12 L motorized hand sprayer SOLO (3.0 kW at 5700 rpm; pressure 4 bar and nozzle type for circular spraying) and the volume of treatment for each plant/block were approximately 18 m^3. Applications for supressing the anthophagous generations were carried out when 5% of flowers have opened (phenophase 54-57; on May 15th) and for carpophagous generations when fruits were size similar of a grain of wheat (phenophase 71; on June 18th).

Meteorological conditions

Meteorological data (mean temperature, precipitation and relative humidity), which affect the quality and persistence of treatments, were obtained from a nearby weather station in Poreč (45° 22' N; 13° 60' E, aprox. 15 km distant from the olive orchard). All the data analysis were conducted using a proc GLM of the SAS software (SAS Institute, 1989). Data were recorded according to EPPO (1997).

***Prays oleae* flight dynamics/population density**

The presence of *P. oleae* was monitored and weekly assessed using pheromone-baited delta trap (RAG, Csalomon PAL, Hungary). Traps have been hanged on 1.7 m height on the external part of olive tree canopy at the beginning of April (one trap/ treatment; total: 12 monitorings). Pheromone dispenser was placed at the center of the sticky surface at the internal bottom and were replaced with new ones every six weeks. To estimate *P. oleae* flight dynamics/population density at diferent insecticidal treatments, the number of adult males was counted checking the sticky traps. Olive phenophases development was determined according to Meier (2001).

To compare the attractiveness of different coloured sticky plates to the moth, yellow, blue, red, white, green and transparent-sticky plates were tested. The plates were installed in orchard in three repetitions arrangement, and eight monitorings were done. Plates were 24 x 17 cm in size, soaked with non-drying glue and hanged at 1.7 m. The distance between two adjacent traps was ≈ 70 m. Each check date, traps were cleaned and the number of captured adults *per* plate was registered.

Predatory effect of native predatory fauna on *P. oleae* eggs

From each experimental block, 50 samples (olive flowers and fruits) has been chosen randomly and number of *P. oleae* eggs (both destroyed by natural enemies (predators and parasitoids) and non destroyed ones) was counted every week [thereafter in seven monitorings from May 15th to July 2nd]. Flowers and fruits were examined under a stereo binocular microscope (Carl Zeiss, Oberkochen, Germany). The variable *predator activity* (PA%) has been determined according to Rosales et al. (2006, 2008) and Sabouni et al. (2008), *i.e.* the presence of predatory fauna of Chrysopidae were indirectly measured as the percentage of predation (ratio of destroyed eggs in the total number of observed eggs).

Larval density of antophagous and carphophagous generations

Related to antophagous generation, in the time of larval activity the number of larvae was counted in orchard as mentioned above. To determine the larval density of carphophagous generation (damage caused on the fruits), under the trees of each block of the treatments, rugs dimensions of 1 m^2 were set up. The number of falling fruits on each treatment caused by moth carpophagous infestation were determined on three monitorings along July (14th, 21st and 25th) while yield *per* treatment was determined on November 4th, 2014.

RESULTS

Meteorological conditions

The climate in Istria during 2014 was extremely warm, and very / extremely wet, depending on locations (Meteorological and Hydrological Service of Croatia, 2015). Data obtained from Poreč showed a total rainfall of 1221.6 mm with a mean value of 101.8 ± 51.7 mm (Fig. 1). Mean annual temperature was 15.1 ± 5.2 °C and relative humidity (RH) 74.8 ± 7.3%.

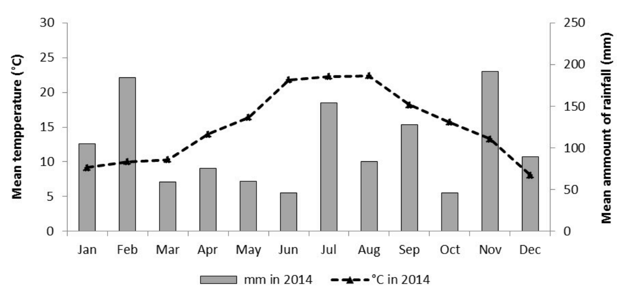

Fig. 1. Mean temperature (°C) and amount of rainfall (mm) in Poreč (Istria, Croatia) in 2014.

During the monitoring period of olive moth (from April 10th to July 11th) the mean air temperature ranged from 12.2 to 24.5 °C (min: 7.0 - 17.8 °C; max: 16.9 - 29.2 °C) and the mean relative humidity was 57.1 - 82.4%. The temperature (average, maximum and minimum), mean relative humidity and precipitation on the day of applications against anthophagous generation (May 15th) were as follows: 15.8 (18.5 - 6.7) °C; 46%; 2.1 mm (the first precipitation has been recorded on May 26th), while against carpophagous generation (June 18th) were 21.4 (26.5 - 11.6) °C; 44%; 17.6 mm, recorded on June 26th.

Monitoring of *P. oleae* flight dynamics using pheromone traps

Twelve trap-check assessments on olive moth males presence were done, based on pheromone-baited delta traps observing from April 10th to July 11th, or from phenophases 9-79 (Fig. 2). The cumulative number of captured moth ranged from 17 (May 28th) to 717 (May 15th). The total catched olive moth *per* treatments during monitoring period on dimethoate was 350, on pyrethrins 364, on control 414, on Bt treatment 434, and on consociation 625. The flight of the first generation was more intense in general than that of the second one, while the maximum number for control, dimethoate and pyrethrins coincided in time. The first generation started emerging on pheromone traps on April 10th (phenophase 9). The maximum catching on pheromone traps has been recorded from April 23th to May 22nd (phenophases 15-53 and 55-60) and lasted four weeks. The flight duration of the first generation was up to May 28th. The carpophagous generation started to emerging on May 28th, with maximum from June 12th to 18th (phenophases 69-71).

Monitoring of *P. oleae* flight dynamics using different coloured sticky plates

Moths were observed on a different colour sticky plates in eight monitorings between April 10th to June 26th (Fig. 3). A significant moth preferences to red colour plates was observed on April 30th and to blue plates on June 12th and 18th compared to other tested plates. The maximum of total captured moths depending on date and independent of coloured trap, has been recorded on May 15th (n = 58) and on April 30th (n = 57) (data not shown). The anthophagous generation started to emerging on coloured sticky traps on April 23rd (data not shown). The first catch of the carpophagous generation has been recorded on June 12th and lasted until June 26th. A total of 2,317 adult moths was captured from April 10th to July 11th, *i.e.* on pheromone traps (2,187) plus coloured sticky plates (130).

Moth's population characteristics on insecticidal treatments

Native predatory fauna on *P. oleae* eggs

In the period from May 15th to July 2nd, the number of destroyed and non-destroyed eggs of olive moth has been determined on olive flowers and fruits at different treatment plots (Figs. 4 and 5). Based on assessments before the first insecticide aplication (May 15th), number of non-destroyed eggs found on dimethoate was higher than number of eggs on control (2.8 ± 1.1 and 0.5 ± 0.3), and before the second application (June 18th) the highest number has been also found on dimethoate (0.8 ± 0.5 and eggs absence) (Fig. 4).

The number of destroyed eggs on May 15th and May 22nd were significantly higher compared to the number of eggs on May 29th and June 12th (Fig. 5). The number of destroyed eggs, before insecticide application (May 15th) was higher on dimethoate (4.5 ± 1.6) compared to Bt, pyrethrins and control (1.0 ± 0.6, 1.3 ± 0.5 and 1.8 ± 1.0) (Fig. 5). On the second application (June 18th), there were no statistical difference between number of destroyed eggs on different dates.

Total predator activity (PA) was 70.6%. On dimethoate treatment PA was 63.3%, whereas on *T. cinerariifolium* was 82.0%, 55.9% on pyrethrins, 75.7% on Bt and 73.2% on control.

Larval density of antophagous and carphophagous generations

The larval density was assessed after the first and second applications counting the total number of larvae on both flowers and fruits. The presence of larvae was noted but there was not statistically difference between treatments on May 22nd (Fig. 6). During the period of carpophagous generation, after second treatment application, number of larvae on June 18th and 26th were lower than the number on July 2nd. The assessment on July 2nd showed that the highest number of larvae in the fruits was on control (2.0 ± 0.7).

The cumulative ratio of non-destroyed eggs and larvae was almost the same (62:57), while the ratio of destroyed:non-destroyed eggs was 149:62, which is a difference of 2.4 times over.

The number of fallen fruits has been recorded in three monitorings in July (14th, 21st and 25th), but there were no statistical differences between treatments. The mean number of fruits *per* treatment were from 16.6 (Bt) to 19.2 (pyrethrins) (data not shown). The different treatments had no significant effects on the number of fallen fruits.

The harvest of olive trees was carried out on November 4th, 2014. Mean yield *per* treatment has been determined, being significantly higher on dimethoate (11.9 ± 3.4 kg/tree) compared to all other treatments (consociation 5.6 ± 1.4, control 5.9 ± 1.1, pyrethrins 6.6 ± 2.6 and Bt 7.9 ± 1.0 kg/tree) (data not shown).

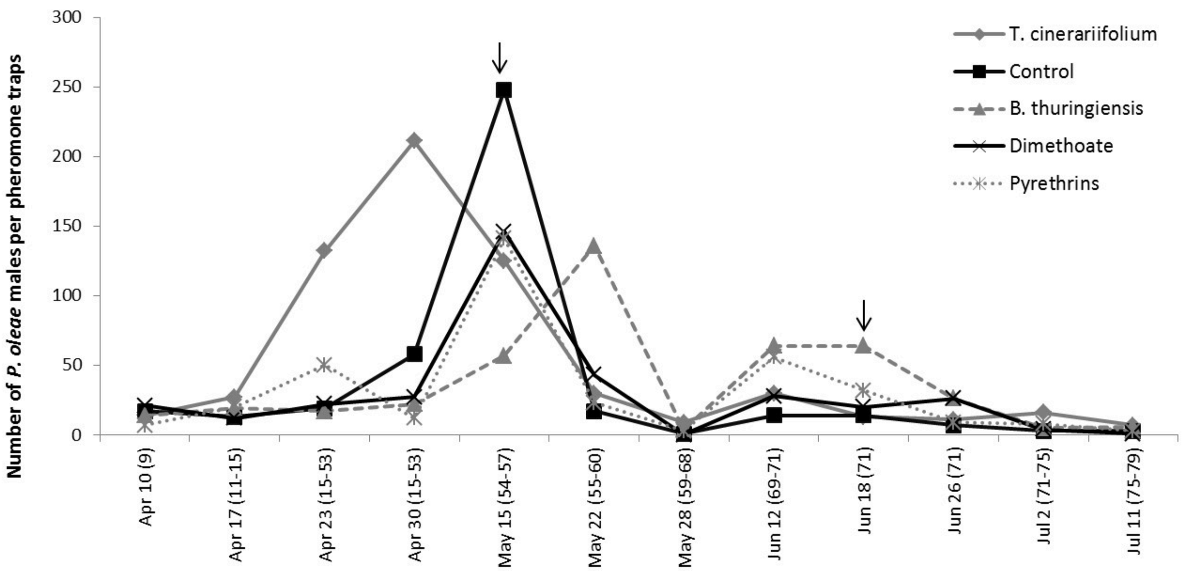

Fig. 2. Fluctuation (flight) of *Prays oleae* males on pheromone traps between April 10th and July 11th, 2014. Arrows indicate spraying dates (numbers in parenthesis represent olive phenophases labeled as BBCH scale: 9) External small leaves opening further with their tips inter crossing; 11) First leaves completely separated. Grey-greenish coloured; 15) The leaves are more separated without reaching their final size; 52) Inflorescence buds open. Flower cluster development starts; 54) Flower cluster growing; 55) Flower cluster totally expanded. Floral buds start to open; 57) Corolla, green-coloured, is longer than calyx; 59) Corolla changes from green to white coloured; 60) First flowers open; 68) Majority of petals fallen or faded; 69) End of flowering, fruit set, non-fertilized ovaries fallen; 71) Fruit size about 10% of final size; 75) Fruit size about 50% of final size. Stone starts to lignificate (it shows cutting resistance) and 79) Fruit size about 90% of final size. Fruit suitable for picking green olives).

DISCUSSION

Regarding *P. oleae* monitoring, there were more adults detected on pheromone traps (16.8 times over) then moths on colour sticky plates. Presence of Chrisopidae species as one of the main predators of *P. oleae* eggs has been observed, predominantly on transparent, followed by white and blue sticky traps (pers. observation). According to Kavallieratos et al. (2005), significantly more males of *P. oleae* were captured in the wing-style trap Pherocon 1C and Delta traps than in other trap types. The authors found that Delta traps were more efficient than the Pherocon 1C within antophagous pest generation. Other study showed that sticky delta style traps or milk carton traps with sticky lining, caught more males of *Prays nephelomima* (Meirick) than funnel traps or milk carton traps with insecticide strips (Jamieson et al., 2008).

There are unsuficient data on effect of colour on capture of lepidopterous pests, althought most of the insects respond to wavelenght extending from UV to red (360-650 nm) (Athanassiou et al., 2004). In our study, early in the season, red sticky plates were more effective to capture *P. oleae* (about 14 times) than yellow, white, green and transparent ones. There is a noticeable potential of red, but also blue sticky plates in *P. oleae* flight monitoring (first and second generations), which could be an interesting topic for future studies. Athanassiou et al. (2004) proved that white traps caught more males of *Palpita unionalis* Hübner (Lepidoptera: Pyralidae) compared with yellow, green and brown traps, but significant differences were noted only between white and brown traps; also more males were found in traps baited with red dispenser in comparision with white ones. The authors pointed that combination of red septa and white funnel traps were the most eficient, based on 2.3 times more captured moths than on other combinations.

Thus, trap design, type of dispenser, trap colour, and also trapping location (more effective on edge zone of orchards than inside), are characteristics that strongly affect the response of *P. unionalis* males to pheromone-baited traps (Athanassiou et al., 2004). Trap design and trapping side on the olive tree canopy strongly affect *P. oleae* captures, whereas dispenser age or trap height have little or no influence (Kavallieratos et al., 2005). In our survey, there was congruence beetween moth captures on red and blue sticky plates and maximum flight of both antophagous and carpophagous pest generations, which confirmed the data gained using pheromone traps. The maximum of moth flight on control, dimethoate and pyrethrins treatments coincided in time. Generally, the maximum flight coincided with the beginning of flowering (first pest generation activity) and with the fruit size suitable for oviposition (second moth's generation activity) (Fig. 2). Aditionally, at first

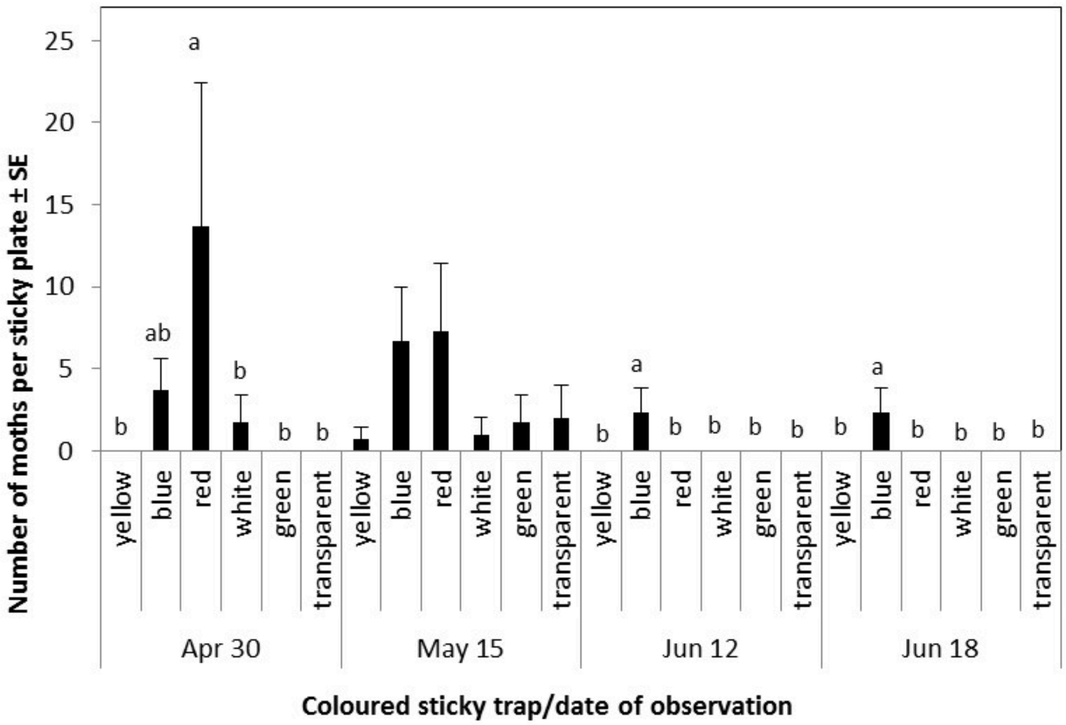

Fig. 3. Mean ± SE capture of *Prays oleae* males and females on different coloured sticky plates in four of eight monitorings (April 10th to June 26th, 2014). Marked differences labelled by different letters are significant at $p < 0.05$ by LSD test (n=3). Data without statistical differences are not shown (Apr 10th, Apr 17th, Apr 23rd and June 26th).

assesment (May 15th), the number of non-destroyed eggs was higher compared to number detected on May 22nd and 29th (Fig. 4). This initially indicates the effectiveness of insecticide treatments and, later, the egg development into larval stage. A similar trend was observed related to carpophagous generation, where no presence of alive eggs was recorded only at dimethoate on June 26th (Fig. 4). Further, at July 2nd no alive eggs were recorded at all treatments related to new hatched larvae boring into fruits.

Considering the complexity of the results achieved in this research, one can hardly draw simple conclusions. When comparing all the monitoring period, it seems that the highest efficiency in pest reduction was achieved using dimethoate, which was confirmed with the highest yield, and the lowest cumulative number of moth caught on pheromone traps; but on the other side, the density of non-destroyed and destroyed eggs on flowers and fruits was the highest on the same plots (Figs. 4 and 5). We can explain this as a consequence of an accidental high oviposition rate at dimethoate plots, before treatment application.

Based on yield achieved with Bt, which was just below to dimethoate, this biological treatment also gained good results. Like that, the densities of non-destroyed and destroyed eggs were the lowest on June 18th and May 15th (Figs. 4 and 5). Related to number of larvae of the most damaging carpophagous generation, in all treatments values were lower comparing to the control. Although, there was no difference between the treatments, the percentage of infested fruits by larvae was the lowest at Bt plots (5.3%, while the number of larvae was three) (data not shown). The appearence of *P. oleae* larvae has been detected on May 22nd, related to duration of embrional development of antophagous generation, which was also the same date of maximim number of larvae and destroyed eggs in total. According to Varlez et al. (1993), Bt treatments against *P. oleae* can affect parasitoid populations of *Chelonus elaeaphilus* Silvestri (Hymenoptera: Braconidae) adversely by killing parasitized hosts directly, as well as by increasing the mortality of parasitoids which have survived Bt treatment and by reducing the body size (and therefore probably the fecundity) of adult parasitoids.

When comparing yield in this investigation, it seems that there are not so much differences between consociation (olive-pyrethrum) and control. Pyrethrum treatment had the highest cumulative number of moths on pheromone traps (625 vs. 414 on control), while the highest number of larvae have been found on control on

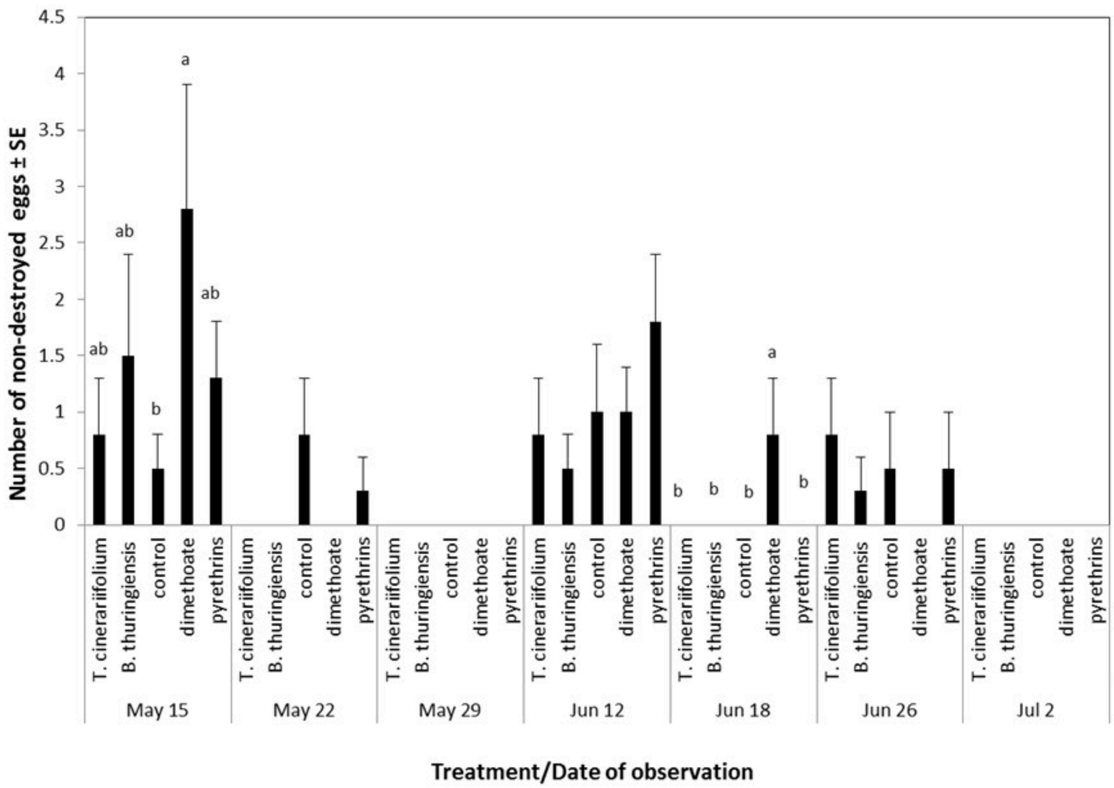

Fig. 4. Mean number of non-destroyed eggs ± SE of anthophagous and carpophagous generations of *Prays oleae* under different treatments (seven monitorings from May 15th to July 2nd, 2014). Treatments were carried out on May 15th and June 18th. Mean values, labelled by different letters are significantly different at $p < 0.05$ by LSD test (n=4).

July 2nd. Thus, consociation and pyrethrins reduced the pest larval density of carpophagous generation equally like the other treatments. Considering that the pyrethrum flowers were just one-year old, for a better major impact on this pest more years of cultivation and investigation would be necessary. On the other side, synthetic pyrethrins are photolabile and their period of protection are reduced by the appearance of sun (and also temperature, oxygen and water). Treatments with pyrethrins showed very similar results to consociation comparing infestation and yield. The difference between them relied in the cumulative number of catched moth on pheromone traps. Similarly, Andersen et al. (2006) reported that pyrethrins did not protect treated plants of *Brassica rapa* L. from other insects as flea beetles (*Phyllotreta cruciferae* (Goeze) and *P. striolata* (F.) (Chrysomelidae: Alticinae). On the other side, pyrethrins proved to be readily degradable so they could be applied close to harvest, if neccessary (Simeone et al., 2009).

Different characteristics of *P. oleae* have been investigated in our study or by other authors. Shehata et al. (2003) showed that the lower threshold temperature (LTT) for total larval development was found to be 10.9 °C, registered in our study between April 10th and 23rd, and on May15th, 2014. The variable predator activity in this survey and that of Rosales et al. (2008) was similar; *i.e.*: in our investigation, PA on dimethoate treatment were 63.3% and 73.2% on control plots, *versus* 60.9% and 72.7% respectively. Hegazi et al. (2011) stated that mean number of alive eggs/week was 37.2 ± 7.9, while we recorded on average 30.2 eggs/week including 7.0 eggs/week on dimethoate, 7.1 on consociation, 4.9 on pyrethrins, 5.3 on Bt treatment, and 5.9 on control/week.

Results show several *P. oleae* life traits at different insecticidal treatments, from organic to conventional, increasing the knowledge about its monitoring, biology and control. In order to determine the efficiency of treatments, it should also consider that *Leccino* (olive variety predominant in Istria peninsula) is moderate attractive to olive moth in general. Furthermore, 2014 in Istria was a very/extremely wet and extremely warm year, with lower moths infestation levels than previous ones. These variables could affect life cycle and population density of olive moth as well.

Since conventional production shows negative effects on both environment and human health, the using of organic plant protection products as well as integrated pest managements (IPM) are encouraged. Similar and longtime surveys will be necessary in order to assess the efficiency of alternative control agents against olive pests and their impact on nature and humans.

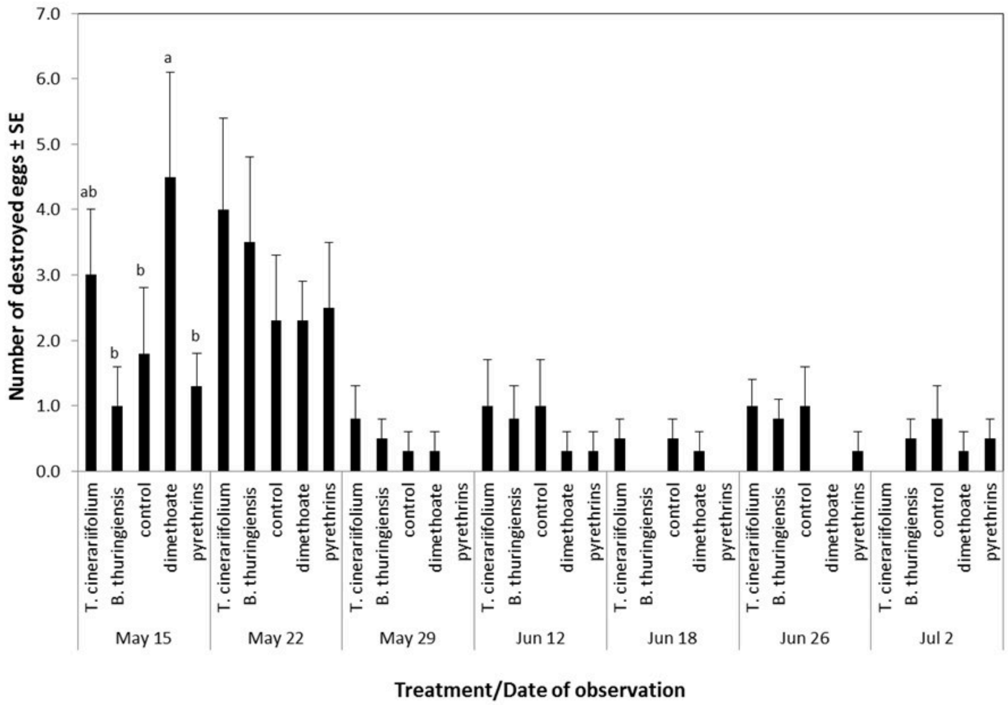

Fig. 5. Mean number of destroyed eggs ± SE of anthophagous and carpophagous generations of *Prays oleae* under different treatments (seven monitorings from May 15th to July 2nd, 2014). Treatments were carried out on May 15th and June 18th. The means, labelled by different letters are significantly different at $p < 0.05$ by LSD test (n=4).

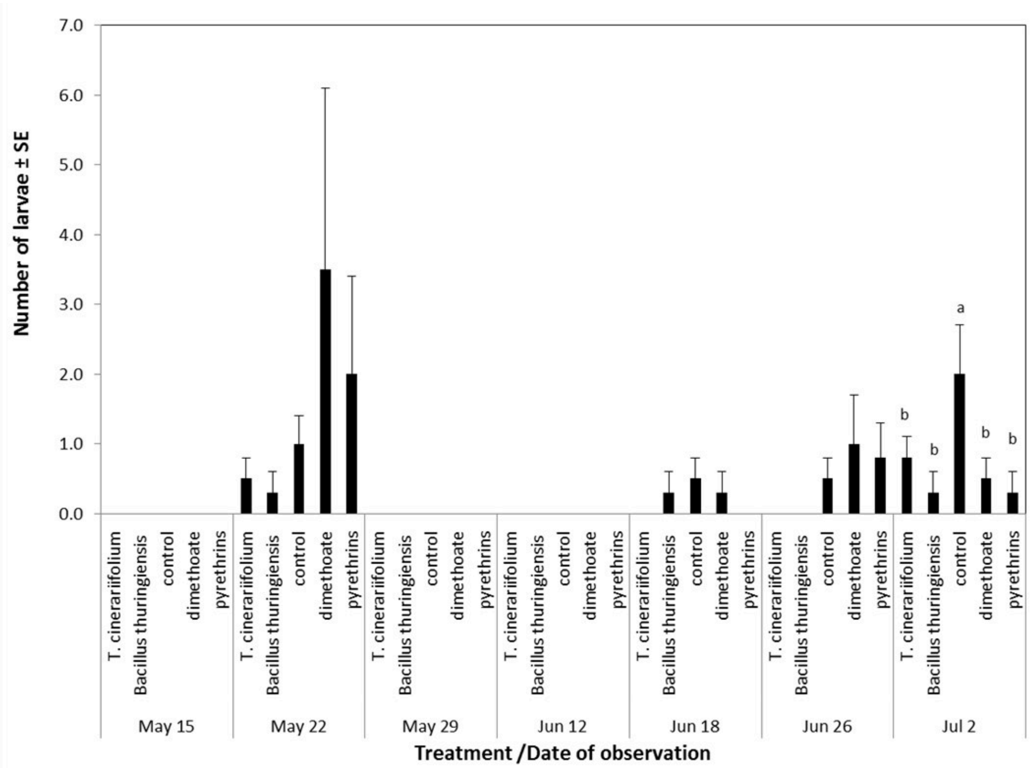

Fig. 6. Mean number of larvae ± SE of anthophagous and carpophagous generations of *Prays oleae* under different treatments (seven monitorings from May 15th to July 2nd, 2014). Treatments were carried out on May 15th and June 18th. The means, labelled by different letters are significantly different at $p < 0.05$ by LSD test (n=4).

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