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Full Length Research Paper

A comparison of the toxicity of the botanical insecticide, Sirinol and two chemical insecticides, Mospilan and Consult, on two natural enemies of the pistachio psyllid, coccinellid predator (*Oenopia conglobata*) and parasitic wasp (*Psyllaephagus pistaciae*)

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The common pistachio psyllid, *Agonoscena pistaciae*, is one of the most important pests of pistachio tree. This pest has many natural enemies and some of the important ones are the coccinellid predator (CP) (*Oenopia conglobata*) and the parasitic wasp (PW) (*Psyllaephagus pistaciae*). In this research, the effect of three concentrations of Sirinol on the first and fourth instar larvae and the adult of *O. conglobata* and on the pupae and adult of *P. pistaciae* was tested and the toxicity of this insecticide was compared with that of two chemical insecticides, Consult and Mospilan. Topical bioassay was carried out in laboratory condition; however, to investigate the resistance stage of the parasitic wasp, a completely randomized experimental design was used in the field condition in 2010 and 2011. The results of these experiments show that the chemical pesticide, Mospilan, caused more mortality of all the stages of the two previously mentioned natural enemies than did Sirinol. The results show that Mospilan had a slightly harmful, moderately harmful, moderately harmful, and slightly harmful effect on the adult of the PW and the adult and the first and fourth instar larvae of the CP, respectively and Consult had a harmless, slightly harmful, slightly harmful, and moderately harmful effect on the named stages of the PW and CP respectively. On the other hand, Sirinol had a slightly harmful effect on the adult of PW, but a harmless effect on the other stages; consequently, it falls into the category of International Organisation for Biological Control (IOBC). The field experiments conducted in 2010 and 2011 showed that 15.79% Mospilan, 13.8% Consult, and 6.49% Sirinol caused the mortality of the larvae and pupae of the PW. This research showed that Sirinol which caused very low mortality of the natural enemies of pistachio psyllid can be used in Integrated Pest Management (IPM) program in pistachio orchards.

Key words: *Oenopia conglobata*, *Psyllaephagus pistaciae*, insecticide, Sirinol, Consult, Mospilan.

INTRODUCTION

The pistachio is one of the most important agricultural products with an ancient history. The domestic pistachio has many pests which feed on different parts of the plant, causing damage to the pistachio and severely decreasing its yield (Abrishami, 1994). The common psyllid of the pistachio, *Agonoscena pistaciae*, is one of the native

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pests of pistachio orchards in Iran and its neighboring countries. This pest is one of the key pests which damages all pistachio orchards and which damages other trees like Pistachio and the Kesour which are native trees as well as pistachios (Mehrnejad, 2002, 2003).

The common psyllid feeds on the sap of the leaves of the pistachio and damages the stability of the tree, defoliating the tree and inhibiting its growth by making the blooms to fall off (Samith et al., 2005). This pest has many natural enemies such as coccinellid predators (CP) and parasitic wasps (PW) (Mehrnejad, 2002). The coccinellid predator, *Oenopia conglobata*, which is known as spherical coccinellid beetle belongs to the coccinellidae family, cocinelinae subfamily, coccinellini tribe, and the genus Oenopia. This species live on the big and small trees (Hodek, 1973). This CP is known as aphid eater and it is used for controlling the Russian aphid, Diuraphis noxia, in southern America (Mehrnejad, 2002). Erler (2004) opined that this coccinellid is the predator of psyllid pyri. The study of Mojib et al. (2002) showed that this CP has a wide range of hosts and feeds on elm aphid, spruce aphid, and spruce bugs. CP is one of the important predators of the common psyllid of the pistachio in pistachio orchards; it plays the important role of decreasing the population of psyllids. This insect (*O. conglobata*) is found in all pistachio orchards in Kerman Province at all periods of the year. Its larvae and adult are found in psyllid colonies and they feed on the eggs and nymphs of the pistachio psyllids. The adult of *O. conglobata* can feed on 165 nymphs of psyllids daily, while its larvae can feed on 655 nymphs of psyllids, destroying them completely. The PW which belongs to the encyrtidae family is one of the important parasitic wasps of the pistachio psyllid. It can parasitize almost 80% of the nymphs of pistachio psyllids in some years. This PW can lay eggs on the nymph of the psyllids and feed directly on this nymph, thus, decreasing a large number of the psyllids (Mehnejad, 2002; Mehrnejad and Copland, 2005).

Biological and biochemical pesticides can be seen as biological and biochemical factors which are involved in the control of the pests and diseases of plants and which protect the future generation of plants. Most countries consider the non-chemical pest control as the formal way of pest management. Sometimes, biological pesticides, like chemical pesticides, can be used for protecting plants from pests and diseases and for weed control management. Different pesticides which can be used for controlling pistachio psyllids also kill large numbers of the CP and PW, eventually. Sirinol is a novel and highly active insecticide with broad-spectrum efficacy against sucking and biting insects (Amiri, 2009, 2010). Also, it is considered to have no acute toxicity on mammals and beneficial insects. Its mode of action is by interfering with ingestion and digestion in the gut of the insects; this is how the insecticide acts against pistachio psyllids (unpublished data). For this reason, this botanical pesticide has been selected to control the pistachio psyllids and cause a minimal damage to beneficial insects. The aim of this study was to investigate the effect of Sirinol and two chemical pesticides on the sensitive (adult) and resistant (larvae and pupae) stages of the PW and on the adult and first and fourth instar larvae stages of the CP. The data on the pesticides used in this study are shown in Table 1.

MATERIALS AND METHODS

Collection and rearing of the *O. conglobata*

Samples of the coccinellid beetle, *O. conglobata*, were collected from the urban area of Rafsanjan City; they were collected from pistachio orchards that had not been sprayed. After collecting the insects with an aspirator, they were brought to the laboratory in a plastic box. The fresh leaves with psyllids were collected to feed the CP. The insect box was checked daily and the eggs of the coccinellid with leaves were transferred to a new box which was kept at 22°C. The eggs were allowed to grow until the first instar larvae appeared, then some of them were chosen for bioassay, while some were grown until the adult coccinellid emerged; these were used for adult bioassay.

Collection of the parasitic wasp

The PWs were collected from one orchard near Rafsanjan city, where PWs were active and the nymph of the psyllid with parasitic wasp was abundant. The leaves with the PW were collected and transferred to the laboratory in a plastic bag. Then, they were put in a cylindrical glass and one side of this container was covered with cotton net. When the adult parasitic wasp emerged, they were collected with an aspirator and used for bioassay.

The effect of the insecticides on the first and fourth instar larvae and the adult of the coocinellid

In this test, three concentrations (field dose, half of the field dose, and 1/3 field dose which are equivalent to 2500, 1250 and 833 ppm) of Sirinol were used. The field dose of the Mospilan (250 g/1000 L of water) and Consult (500 ppm) was also used. All these concentrations were dissolved in acetone. After anesthetizing the first instar larvae at a temperature of 4°C, 1 µl of the solution formed by dissolving the insecticides in acetone was put in the first segment of the thorax of the test insects and the same acetone was used as control.

After carrying out the test, all the larvae were transferred to new Petri dishes with leaves bearing psyllid nymphs; all the Petri dishes were preserved at a temperature of 25±2°C and a relative humidity of 65±2%. The number of living and dead insects was counted 24, 48 and 72 h post treatment. The same process was repeated for the fourth instar larvae and adult of CP. These experiments were repeated four times.

Testing the insecticides on the adult of the parasitic wasp

The adult of one-day old PW was chosen for bioassay. The PW was transferred to a small glass tube with an aspirator, and put in a fridge at 4°C for 2 min for anesthetization. For each dose, 10 insects were used. All concentrations of the insecticides were dissolved in acetone and 1 µl of the solution was put in the first segment of the thorax of the PW. For the control, the same acetone

Table 1. Pesticides used in this research.

S/N	Common name	Trade name	Chemical group	Active ingredient	Formulation	Dose	LD_{50} (mg/kg)	Company
1	Insecticidial gel (IG)	Sirinol	Biorational insecticide	Garlic extract	EC	2500cc/1000 H_2O	> 5000	Kimia sabzavar Co.
2	Acetamiprid	Mospilan	Neonicotinoid	-	SP20%	250 g/1000 H_2O	146 to 217	Trustschen Co.
3	Hexaflumuron	Consult	Benzoy lurea	-	EC10%	500/1000 H_2O	> 5000	Arman sabz adineh Co.

was used. After assay, the wasps were separately put in 5 × 1 cm glass tubes.

For feeding the PW, pure honey was used; the honey was put on 3 × 0.2 cm filter papers which were put in the glass tubes. One insect was put in each tube. In each concentration, 10 PWs were used. After assay, the tubes with the insects were transferred to a germinator with a temperature of 25°C and relative humidity (RH) of 75%. The number of dead and living insects was counted 24, 48 and 72 h post treatment. The mortality in the control was corrected with Abbott formula (Abbott, 1925).

The effect of the insecticides on the resistant stage of *P. pistaciae* (larvae and pupae inside of the nymph)

For this experiment, one non-sprayed pistachio orchard was selected where PW was active. This orchard was randomly divided into four parts. Each part was sprayed with the following insecticides: 1) Sirinol with 2500 cc in 1000 L of water; 2) Mospilan with 250 g in 1000 L of water; 3) Consult 500 cc in 100 L of water; and 4) control just with water. These treatments were sprayed with a 100 L-volume sprayer. After spraying, the next morning, 100 nymphs with PW larvae and pupae were selected; after one month, the number of living PWs was counted and the percentage of mortality was corrected with Abbott formula (Abbott, 1925).

The first experiment

This experiment was done in August, 2010 in Jafarabad Village in Rafsanjan. The trees were planted in the right order and were 25 years old. The spraying was done early morning when the weather was fair (not windy).

The second experiment

This test was done in September, 2011 in Akbarabad village in Rafsanjan. The trees were planted in the right order and were 18 years old. The spray was done at 6 o'clock, early in the morning and finished at 8: 30 am; the weather was calm (not windy).

Statistical analysis

According to the principles of International Organization of Biological Control (IOBC), four evaluation categories (% mortality or reduction in beneficial capacity) were used: 1 = harmless (< 25%); 2 = slightly harmful (25 to 50%); 3 = moderately harmful (51 to 75%); and 4 = harmful (>75%) (Hassan, 1994). The mortality of the PW and CP calculated as well as mean numbers per leaf was calculated and statistically evaluated by analysis of variance. Means were compared with SPSS program (SPSS 11.0).

RESULTS

The effect of the insecticides on adult *O. conglobata*

The results of the experiments showed that at 24 h post treatment, the highest mortality (39.9%) of the insects was caused by Mospilan followed by Consult (8.56%). The mortality caused by three concentrations of the botanical insecticide, Sirinol, was significantly different from that caused by the chemical insecticides; the highest dose of Sirinol caused only 3.3% mortality of CP. 48 h post treatment, the highest mortality (46.6%) was caused by Mospilan. There were significant differences in the insect mortality caused by the three concentrations of Sirinol. These doses were divided into two groups: the 2500 and 1250 ppm doses which, respectively, caused 3.33 and 6.66% mortality were in one group, while the 833 ppm dose which caused 1.66% mortality was in another group. 72 h post treatment, Mospilan caused the highest mortality (57.49%), while the mortality caused by Sirinol at the dose of 2500 ppm, 72 h post treatment, was not different from the mortality rate observed at 48 h post treatment (Figure 1). The mortality caused by Consult at 72 h post treatment was 16.90%. With reference to the IOBC evaluation category used for assessing the effect of toxins on beneficial insects, Sirinol and Consult are harmless toxins, while Mospilan is a moderately harmful toxin (Table 2).

The effect of the insecticides on the adult of P. picatacia

The highest mortality (87.5%) was caused by Mospilan at 24 h post treatment followed by Consult which caused 42.5% mortality, and Sirinol which caused 30.5, 12.5 and 5% mortality at 2500, 1250, and 833 ppm concentrations, respectively (Table 3). There were significant differences in the insect mortality caused by the different doses (2500, 1250, and 833 ppm) of Sirinol (Table 3). The mortality caused by Mospilan was 90% at 48 h post treatment, while the mortality caused by the highest dose of Sirinol was 33.02%. There were significant differences in the effect of the different insecticides: Mospilan caused the highest mortality (92.5%) followed

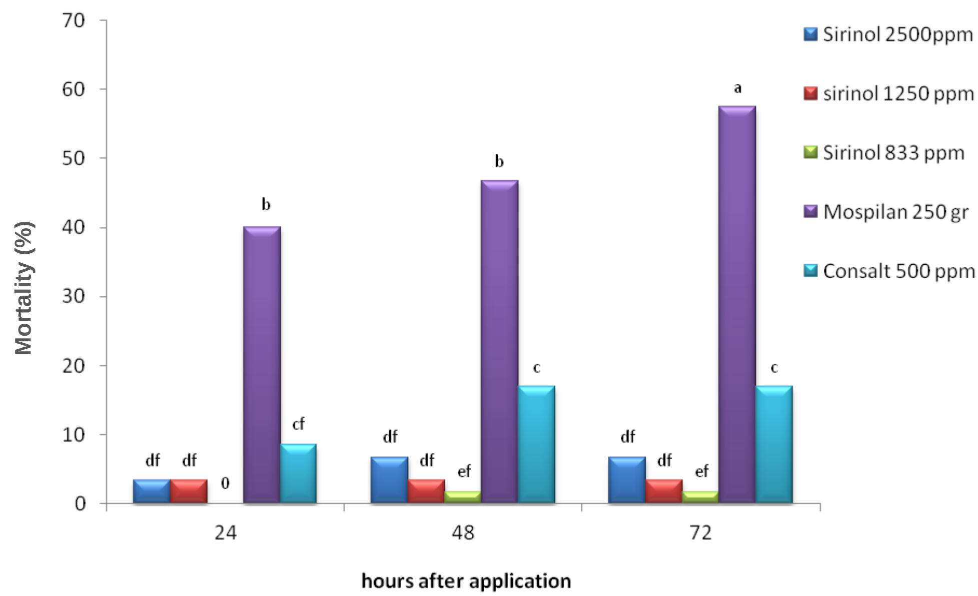

Figure 1. Percentage mortality of the adult of *O. conglobata* at different times.

Table 2. Mean comparison of percentage mortality of the adult of *O. conglobata* in different insecticides and times.

Insecticide	Dose/1000 L of H_2O	Mean percentage of mortality		
		24 h	48 h	72 h
Sirinol	2500 cc	3.33^{1**df*}	6.66^{1df}	6.66^{1df}
Sirinol	1250 cc	3.33^{1df}	3.33^{1df}	3.33^{1df}
Sirinol	833 cc	0^{1}	1.66^{1ef}	1.66^{1ef}
Mospilan	250 g	39.99^{2b}	46.66^{2b}	57.49^{2a}
Consult	500 cc	$8.56^{1c\text{-}f}$	16.90^{1c}	16.901^{c}

*The different letters show significant difference (p<5%). **According to the principles of IOBC, four evaluation categories (% mortality or reduction in beneficial capacity) were used: 1 = harmless (< 25%); 2 = slightly harmful (25 to 50%); 3 = moderately harmful (51 to 75%); and 4 = harmful (>75%) (Hassan, 1994).

Table 3. Mean comparison of percentage mortality of the adult of *P. picatacia* in different insecticides and at times.

Insecticide	Dose/1000 L of H_2O	Mean percentage of mortality		
		24 h	48 h	72 h
Sirinol	2500 cc	$30.52^{*1\ c\text{-}g}$	$33.02^{2c\text{-}f}$	$33.02^{2c\text{-}f}$
Sirinol	1250 cc	$12.50^{1g\text{-}h}$	$12.77^{1g\text{-}h}$	$15.27^{1f\text{-}h}$
Sirinol	833 cc	5^{1h}	5^{1}h	7.50^{1h}
Mospilan	250 g	87.50^{3a}	90^{3a}	92.50^{3a}
Consult	500 cc	$42.50^{2c\text{-}f}$	45^{2bc}	45^{2bc}

*The different letters show significant difference (p<5%). **According to the principles of IOBC, four evaluation categories (% mortality or reduction in beneficial capacity) were used: 1 = harmless (< 25%); 2 = slightly harmful (25 to 50%); 3 = moderately harmful (51 to 75%); and 4 = harmful (>75%) (Hassan, 1994).

by Consult which caused 45% mortality. Among the different doses of Sirinol, the highest mortality (33.2%) was caused by 2500 ppm at 72 h post treatments (Figure 2). With reference to the IOBC evaluation category used

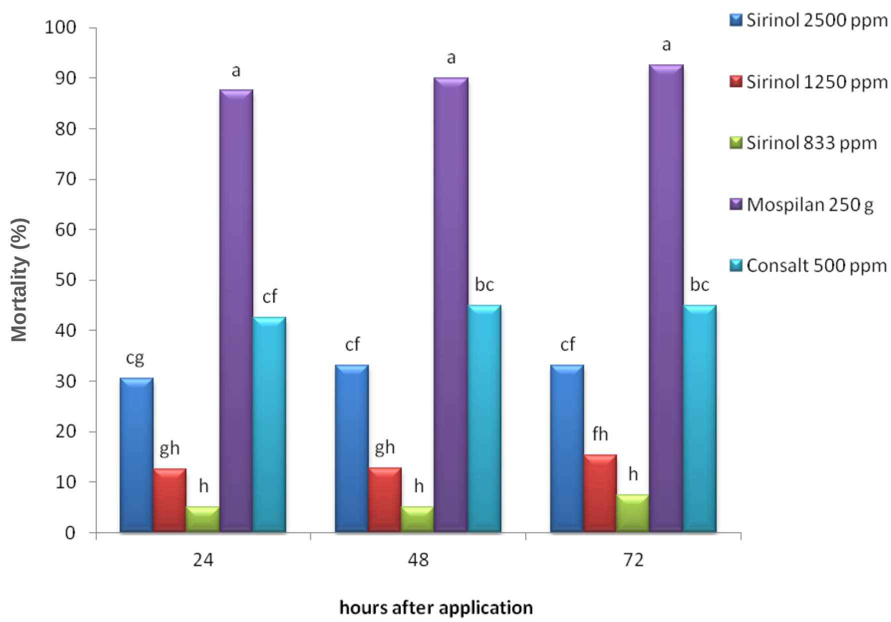

Figure 2. Percentage mortality of the adult of *P. picatacia* at different times.

Table 4. Mean comparison of percentage mortality of the first instar larvae of *O. conglobata* in different insecticides and times.

Insecticide	Dose/1000 L of H_2O	Mean percentage of mortality		
		24 h	48 h	72 h
Sirinol	2500 cc	8.16^{1e-i}	11.89^{1di}	18.80^{1c-e}
Sirinol	1250 cc	5.16^{1f}	10.23^{1ei}	13.68^{1c-h}
Sirinol	833 cc	0.16^{1i}	8.56^{1e-i}	8.56^{1e-i}
Mospilan	250 g	86.54^{3a}	91.30^{3a}	93.09^{3a}
Consult	500 cc	17.26^{1c-f}	24.16^{1c}	36.18^{2bc}

*The different letters show significant difference (p<5%). **According to the principles of IOBC, four evaluation categories (% mortality or reduction in beneficial capacity) were used: 1 = harmless (< 25%); 2 = slightly harmful (25 to 50%); 3 = moderately harmful (51 to 75%); and 4 = harmful (>75%) (Hassan, 1994).

for assessing the effect of toxins on beneficial insects, the highest dose (2500 ppm) of Sirinol and Consult were slightly harmful toxins, while the two doses of Sirinol (1250 and 833 ppm) were harmless toxins; Mospilan, on the other hand, is a moderately harmful toxin (Table 3).

The effect of the insecticides on the first instar larvae of the coccinellid predator

The results of this study showed that 2500, 1250, and 833 ppm concentrations of Sirinol caused 8.16, 5.16 and 0.16% mortality to the insects, respectively, while Mospilan and Consult, respectively, caused 86.54 and 17.26% mortality at 24 h post treatment. Mospilan had the highest mortality (91.30%), while Sirinol had the lowest mortality (8.56%) at the dose of 833 ppm, 48 h post treatment. There were significant differences in the insect mortality caused by the different concentrations of Sirinol at 72 h post treatment. The lowest mortality (8.56%) was caused by 833 ppm of Sirinol, while the highest mortality (93.09%) was caused by Mospilan (Table 4 and Figure 3). With reference to the IOBC evaluation category used for assessing the effect of toxins on beneficial insects, all the doses of Sirinol are harmless toxins; Consult is a slightly harmful toxin, while Mospilan is a harmful toxin (Table 4).

The effect of the insecticides on the fourth instar larvae of the coccinellid predator

The results of the study showed that 2500, 1250, and 833 ppm concentrations of Sirinol, respectively, caused 8.33, 6.66 and 3.33% mortality on the fourth instar larvae. However, the highest mortality (38.33%) was caused by

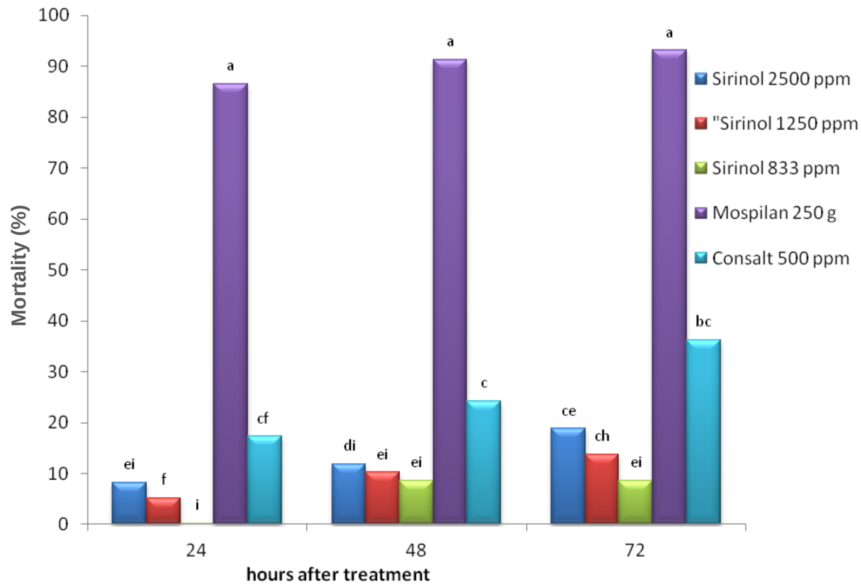

Figure 3. Percentage mortality of the first instar larvae of *O. conglobata* at different times.

Table 5. Mean comparison of percentage mortality of the fourth instar larvae of *O. conglobata* in different insecticides and at times.

Insecticide	Dose/1000 L of H_2O	Mean percentage of mortality		
		24 h	48 h	72 h
Sirinol	2500 cc	8.38^{1bd}	9.99^{1bd}	9.99^{1bd}
Sirinol	1250 cc	6.66^{1bd}	6.66^{1bd}	6.66^{1bd}
Sirinol	833 cc	3.33^{1d}	4.99^{1cd}	4.99^{1cd}
Mospilan	250_g	38.33^{2a}	38.33^{2a}	39.99^{2a}
Consult	500 cc	8.56^{1bd}	15.23^{1bc}	16.90^{1b}

*The different letters show significant difference (p<5%). **According to the principles of IOBC, four evaluation categories (% mortality or reduction in beneficial capacity) were used: 1 = harmless (< 25%); 2 = slightly harmful (25 to 50%); 3 = moderately harmful (51 to 75%); and 4 = harmful (>75%) (Hassan, 1994).

Mospilan followed by Consult which caused 8.56% mortality at 24 h post treatment. The highest mortality (38.33%) was caused by Mospilan, while the lowest mortality (4.99%) was caused by 833 ppm concentration of Sirinol at 48 h post treatment. A mean comparison of the results showed that there were significant differences in the effects of the botanical and chemical insecticides on the insects. These insecticides were divided into three groups: 2500 and 1250 ppm doses of Sirinol were in the first group; 833 ppm dose of Sirinol was in the second group; and the two chemical insecticides (Mospilan and Consult) were in the third group. The highest mortality (39.9%) was caused by Mospilan at 72 h post treatment (Table 5 and Figure 4). With reference to the IOBC evaluation category used for assessing the effect of toxins on beneficial insects, all the doses of Sirinol and the Consult were harmless toxins and they were categorized in one group while the Mospilan was a slightly harmful toxin in it was categorized in different group (Table 5).

The effect of the insecticides on the larvae and pupae of the PW in psyllid nymph

The results of the field experiment show that Mospilan caused the highest percentage mortality (15.79%) of the larvae and pupae of the PW followed by Sirinol and Consult which caused 6.49% and 1.38% mortality respectively. With reference to the IOBC evaluation category used for assessing the effect of toxins on beneficial insects, all the insecticides (Sirinol, Mospilan and Consult) were harmless toxins; they were all harmless to the resistant stage of the PW in psyllid nymph (Table 6).

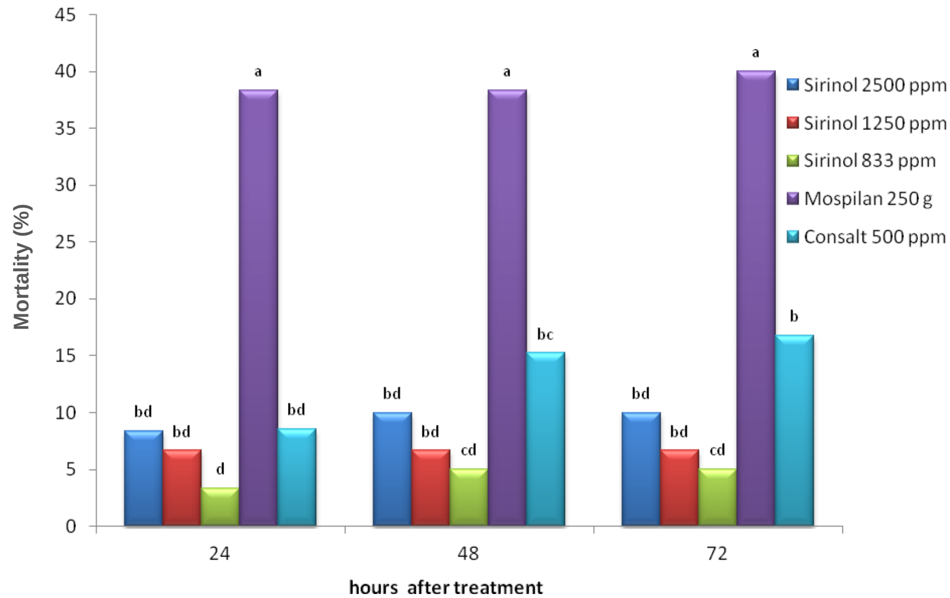

Figure 4. Percentage mortality of the fourth instar larvae of *O. conglobata* at different times.

DISCUSSION

This is the first research on the effect of Sirinol (the garlic extract) on pistachio psyllids and two of its natural enemies (CPs and PWs). This study shows very good and promising results which may be very helpful in an IPM program. Different plant materials have been used against pests. For instance, garlic extract was tested on two insects of the order Diptera like Musca domestica and Delia radicum and was found to control these two agricultural pests (Gared et al., 2006). Different toxins have been tested on the common pistachio psyllid. Basirat (2006) tested Actara (Thiametoxam), a neonicotinoid insecticide, and Mitac (Amitraz), a triazapentadiene insecticide, on PW and CP, and found out that the effect of Actara on the adult of PW, the resistant stage of PW, the sensitive stage of CP (larvae), and the resistant stage of CP was, respectively, harmful, slightly harmful, slightly harmful, and moderately harmful, while the effect of Mitac insecticide on the aforenamed stages of the PW and CP was moderately harmful, slightly harmful, harmless, and harmless. On the whole, the toxicity of Actara on beneficial insects was higher than that of Mitac (Basirat, 2006). The results of this experiment showed that the effect of the botanical insecticide, Sirinol, which caused 33.2% mortality of PW was less than that of the chemical pesticides, Mospilan and Consult which, respectively, caused 92.5% and 45% mortality of PW at 72 h post treatments. The mortality of the larvae and adult of CP which was caused by the chemical insecticides such as Mospilan and Consult was much higher than that caused by the botanical insecticide. For example, the mortality of the first and fourth instar larvae and adult of CP, which was caused by Mospilan at 72 h post treatment was 93.09, 39.99 and 57.49%, respectively, while the mortality of the afore-named stages of CP, which was caused by the highest dose of Sirinol was 18.8, 9.99 and 6.66%, respectively, at 72 h post treatment.

No phytotoxic effects on pistachio due to particle film application were observed. On the contrary, however, kaolin-sprayed trees, throughout the two years of the trials, were healthier and more vigorous than the insecticide-sprayed trees and their controls. These results provide comparative data on the effectiveness of kaolin particle film and support the potential of using this pesticide as an alternative pest management tool against pistachio psyllid (Saour, 2005). There were no phytotoxic effects observed when Sirinol was used against the pistachio psyllids and their natural enemies; consequently, Sirinol could also be taken as an alternative way for controlling the common pistachio psyllid.

From the results of this research, it is suggested that a botanical insecticide such as Sirinol be used to replace chemical insecticides because of the fact that it caused low mortality of natural enemies, whereas the chemical insecticides were hazardous to beneficial insects and the environment.

From a pest management perspective, the current study provides a good understanding of the efficacy of Sirinol under pistachio orchard conditions and reveals its potential for use against pistachio psyllid infestations. Moreover, the widespread adoption of Sirinol is unlikely to cause resistance since this technology provides a physical mechanism for preventing pest attack as well as toxic chemical selection pressure. As it has been recognized in this research, Sirinol is known to disrupt natural enemies, but its effect on the biological balance could vary among pests and their predators and

Table 6. Mean comparison of percentage mortality of the larvae and pupae of the parasitic wasp in different insecticides and times.

Replicate	Mospilan (250 g)		Consult (500 ppm)		Sirinol (2500 ppm)		Control	
	Number of dead PW	Efficacy of toxin (%)	Number of dead PW	Efficacy of toxin (%)	Number of dead PW	Efficacy of toxin (%)	Number of dead PW	Efficacy of toxin (%)
1	33	8.33	35	2.77	33	8.33	36	−
2	33	23.25	43	0	41	4.65	43	−
Mean % efficacy of toxin	−	15.79[1]	−	1.38[1]	−	6.49*[1]	−	−

In this field experiment, the number of living and dead parasitic wasps was counted after one month. *The different letters show significant difference (p<5%). [1]According to the principles of IOBC, four evaluation categories (% mortality or reduction in beneficial capacity) were used: 1 = harmless (< 25%); 2 = slightly harmful (25 to 50%); 3 = moderately harmful (51 to 75%); and 4 = harmful (>75%) (Hassan, 1994).

parasitoids. For example, despite two seasons of Sirinol applications, no resurgence of secondary pests that are regulated by parasitoids or predators has been detected. In contrast, the most important endoparasite of pistachio psyllid, *Psyllaephagus pistaciae* Ferrie`re (Hymenoptera: Encyrtidae) (Souliotis et al., 2002), detected by the presence of parasitized psyllid nymphs mummies and other beneficial insects like lady-beetles and common green lacewing were often observed in the experimental orchard. Although several of these pesticides are efficacious, the potential for resistance may limit their efficacy; also, they are not effective against the adults of the psyllids, which transmit Liberi-bacter solanacearum. Further combinations with broad-spectrum insecticides can have deleterious effects on beneficial insects, including predators and parasitoids of the psyllids, leading to high populations of potato psyllids. The integration of insect pathogens into these botanical insecticides in the IPM strategy for control of psyllids could reduce reliance on synthetic insecticides and increase the levels of control, especially against early season psyllids. The effect of some botanical insecticides and mineral oils on Citrus leafminer has been investigated; the investigation revealed that a combination of mineral oils with *Bacillus thuringiensis* and Sirinol and Palizin and Tonexir can increase the toxicity of the named insecticides (Amiri-Besheli, 2007, 2008, 2009, 2010). Therefore, in future research, mineral oils which are non-toxic can be combined with Sirinol in order to obtain good results in the control of the common pistachio psyllid.

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