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INFLUENCE OF DIFFERENT PEST CONTROL AGENTS ON SOME BIOLOGICAL ASPECTS OF *Chrysoperla carnea* (Stephens)

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ABSTRACT: Four different pest control agents (*Beauveria bassiana* (Balsam), orange oil, neem oil, and pyriproxyfen) were evaluated at 0.5, 1 and 2 of field recommended concentrations (FRC) for their effectiveness on the biological aspects of the 2nd larval instar of *Chrysoperla carnea* (Stephens) under laboratory conditions of 26 ± 2°C and 65 ± 5% RH. Taking into consideration the relative potency at the LC_{25} and LC_{50} levels, the obtained results showed that the neem oil was the highest effective agent against 2nd larval instar of *C. carnea*, recording the LC_{50} value of 10.61 µg / ml solvent, while *B. bassiana* was the lowest effective agent recording the LC_{50} value of 396.99 µg /ml. The means of larval duration were 6.83, 7.33, 6.50, 5.51 and 6.60 days, for *B. bassiana*, neem oil, pyriproxyfen, orange oil at 0.5 FRC and control, consecutively. While the means of pupal duration were 8.33, 7.33, 8.00, 7.00 and 8.50 days, for the same pest control agents and control, respectively. The maximum percentage of cocooning (100.00%) was recorded when larvae of the predator were fed on treated aphid nymphs with *B. bassiana* at all tested concentrations, and fed on neem oil and pyriproxyfen at 0.5 and 1 FRC, as well as control larvae. Meanwhile, the minimum value of 75.00 % was noticed when the larvae were fed on treated aphid nymphs with neem oil or orange oil at 2 FRC. Obtained results cleared that the highest mean of adult emergence of *C. carnea* (60.00 %) was recorded for larvae fed on treated aphid nymphs with orange oil 0.5 or 1 FRC. Whereas, the lowest one (20.00 %) was noticed in the case of larvae reared on treated aphid nymphs with pyriproxyfen at 2 FRC. Generally, control larvae exceeded other tested pest control agents in adult emergence, showing 70.00%. The maximum of fecundity, fertility, and hatchability percentage (324 eggs, 86.04 and 91.22%, respectively) when the larvae of the predator were fed on untreated aphids. On the contrary, the 1 RFC pyriproxyfen resulted in the minimum of fecundity and fertility showing 12.00 eggs and 50.00 %, successively. On the basis of the obtained results, it was obvious that the tested pest control agents (*B. bassiana*, orange oil, neem oil, and pyriproxyfen) at the highest concentrations are not considered to have an environmental safety profile on *C. carnea*. We suggest that the use of the tested pest control agents might be useful in combination at the low concentrations with release of *C. carnea* larvae in integrated pest management (IPM) programs.

Key words: *Chrysoperla carnea, Beauveria bassiana,* orange oil, neem oil, pyriproxyfen, biological aspects, IPM.

INTRODUCTION

One of the commonly used strategies of IPM is the joint use of biological and chemical control, because at present, the complex of the pests attacking a crop cannot be controlled only with biological control. In this strategy, it is clear that the biological control and the chemical control of pests should not interfere. Therefore, the knowledge on the activity of insecticides toward the pests, the non-targets insects and the environment is a necessity **(Medina *et al.*, 2003 b)**.

Chrysoperla carnea (Stephens) is efficient biological control predator of economically important agricultural insect pests. Use of

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lacewings in IPM programs has increased in new years because, among others, this insect may have an advantage over other introduced or resident natural enemies: a relatively broad tolerance to many insecticides, particularly during the larval and cocoon stages **(Pree *et al.*, 1989; Medina *et al.*, 2001).** However, few studies have been performed on the impact of natural and chemical insecticides on it.

The International Organization of Biological and Integrated Control (IOBC/wprs) working group "Pesticides and beneficial arthropods" has examined the susceptibility of many predators and parasitoids to a high number of pesticides at maximum field rate **(Medina *et al.*, 2003 b)**.

Pyriproxyfen (an insect growth regulator), is a promising insecticide for IPM programs; Based on its selectivity against different beneficial insects or in the worst case, certain developmental stages of them. The juvenile hormone mimic, pyriproxyfen, interferes with the hormonal balance and induces a strong suppression of embryogenesis, metamorphosis, and adult formation **(Ishaaya *et al.*, 1994)**. The main response of insect adults to pyriproxyfen is hatching inhibition **(Abdallahi *et al.*, 2000)**.

Neem tree (*Azadirchta indica* L.) holds great promise providing an effective means for suppressing insect pests. Azadirachtin, a natural and bioproducts, derived from Neem seed kernels, is an active ingredient of Neem Azal caused disturbance to growth and molting (**Hermann *et al.*, 1997**). Neem Azal T/S is a formulation contains azadirachtin. It can be used as an environmentally safe insecticide (**Schulz *et al.*, 1997**). Many authors studied the effect of neem Azal formulations against predators and parasitoids **(Atalla *et al.*, 2009)**. Laboratory studies revealed that some Neem products showed harmful effects on larvae of *C. carnea* **(Jacob and Vogt, 1993; Hermann *et al.*, 1995).**

Beauveria bassiana (Balsam) cause white muscardine disease in a wide range of insects. *B. bassiana* is now exploited in greenhouse and outdoor crops as a tool for the control of many agricultural arthropod pests including whiteflies, aphids, thrips, psyllids, mealybugs and weevils (**Shah and Goettel, 1999).** In cases of entomopathogens, the lethal and sub-lethal effects at the pathogen on beneficial insects (predators and parasitoids) with regard to fecundity, longevity and survivorship-among others, are worth evaluating (**Fazal, 2004**). However, the success of fungal entomopathogens as biological control agents depends not only on high efficacy against insect pests, but also on low virulence against non-target insects **(Thungrabeab and Tongma, 2007).**

One of the important botanicals is orange oil whose products are derived from the orange tree, *Citrus simensis* L. the principal active compound in orange oil is (sodium tetraborohydrate decahydrate). The orange oil has been found very effective in causing aphid mortality and hence can be used for the management of aphids in different crops (**Edson *et al.*, 2018)**. Our goal is to provide data about the impact of different pest control agents (plant extract oils, *B. bassiana* and Pyriproxyfen) on some biological aspects of *C. carnea.*

MATERIALS AND METHODS

The present study was carried out in Plant Protection Department, Faculty of Agriculture, Zagazig University, Egypt under the laboratory conditions of 26 ±2 °C and 65±5% RH.

Tested Materials

Four different pest control agents (*Beauveria bassiana* (Balsam), orange oil, neem oil and pyriproxyfen) with three concentrations (0.5, 1 and 2 field recommended concentration (FRC)) for each treatment were used to evaluate the effects of treated aphid with previous materials on some biological aspects of the 2nd instar larvae of *Chrysoperla carnea* (Stephens) (Table 1).

Stock Cultures

Prey culture

Faba bean, *Vicia faba* Linnaeus, seeds were sown in plastic pots number 10, 20 cm diameter and 17 cm height. The pots were kept under standard laboratory conditions at means of 26±2ºC and 65 ±5% RH. Thereafter, the pots were caged and the growing seedlings were artificially infested with the cowpea aphid, *Aphis craccivora* Koch nymphs.

Predator culture

Adults of *C. carnea* were collected from faba bean fields infested with *A. craccivora.* They were placed in glass chimney cage measured 17cm height, 7 cm top diameter and 8.5 cm bottom diameter. Each chimney cage was placed on a 9 cm diameter Petri dish. Filter paper was placed on the bottom of the Petri dishes, and the upper open end of the glass chimney was covered with black muslin cloth tightened with rubber band. The adults were continually provided with food consisted of 1 g honey + 1 ml distilled water + 1 g pollen which was provided on a food card, 2 x 3 cm. The laid eggs were collected daily and the newly hatched larvae were reared on *A. craccivora* individuals until they reached the beginning of the second instar and were used in the experiments.

Experimental Design

Effect of pest control agents on the 2nd instar larvae of *Chrysoperla carnea* (Stephens) when fed on sprayed aphid nymphs

Experiments were carried out to evaluate the effects of treated aphid with four different pest control agents on some biological aspects of *C. carnea*. Newly molted 2nd instar larvae of *C. carnea* were used. Three dilutions of each agent (0.5, 1 and 2 FRC) were prepared in distilled water. Each larva was confined in cylindrical plastic vials (4 cm diameter and 7 cm height), with tightly fitting lids containing leaflets harbored 50 *A. craccivora* nymphs sprayed with tested concentrations for 24 hours. Thereafter, the larvae transferred to new cylindrical plastic vials and were provided daily by fresh leaflets harbored untreated nymphs of the aphid to complete their development. Thirty newly molted 2nd instar larvae of *C. carnea* in three groups, ten each, were used for each concentration and the control as well. Biological aspects such as mortality percentage, larval duration, pupal duration, percentage of pupation, pupal weight, adult emergence, male and female longevity, percentage of malformed adults, fecundity, fertility, and hatchability were recorded. The percentage of mortality as a result of fungi infection was calculated. The cadavers were removed from the cylindrical plastic vials, then surface sterilized in 5% sodium hydrochloride and 75% ethanol solution and rinsed in plenty of sterile water, then left to dry for 48 hr **(Dourou- Kpindou *et al.,* 1995).** After drying, they were kept in humid conditions in clean desiccators at room temperature to examine whether they died because of fungus infection or not according to **Luz and Fargues (1998)**

Statistical Analysis

Obtained data were analyzed using one-way analysis of variance completely randomized (ANOVA) and means compared using Duncan's multiple range test at $P \leq 0.05$ probability. Lethal and sub-lethal concentrates at 50% and 25% (LC_{50} and LC_{25}) were calculated with Probit analysis (**Finney, 1972**) using program BioStat 5.8.4.3.

Table 1. The tested pest control agents

Trade name	Active ingredient	FRC*	Manufacturer
Analytical standard Pyriproxyfen (98 %)	Pyriproxyfen	0.5 cm^3/L.	Sumitomo chemical Australia pty limited
Biover 10% wp ($32x10^6$ viable spore / mg)	*Beauveria bassiana*	2 gm/L.	Bioinsecticides production unit, Plant Protection Institute, ARC, Giza, Egypt.
Neemforce 0.15 %EC	Azadirachtin + neem oil	10 cm^3/L.	Arab. Company (Egypt)
Prev-AM 6% SL	Orange oil (d-limonene)	4 cm^3/L.	AAKo BV (Holland)

* field recommended concentration.

RESULTS AND DISCUSSION

Effect of Pest Control Agents on the Larvae of *Chrysoperla carnea* (Stephens) When Fed on Sprayed Aphid, Aphis *craccivora Kock*

Concentration mortality responses of larvae to the tested pest control gents

The obtained results in Table 2 and Fig. 1 represented LC_{25} and LC_{50} values of pyriproxyfen, *B. bassiana*, neem oil and orange oil. The LC_{25} values were 36.37, 66.73, 8.84 and 99.14 ppm of pyriproxyfen, *B. bassiana*, neem oil and orange oil, respectively. The corresponding LC_{50} values were 179.03, 396.99, 10.61 and 327.99 ppm for the same pest control agents, respectively. These results revealed that neem oil was more toxic than the other control agents at both LC_{25} and LC_{50} levels, unlike orange oil.

These results are in agreement with those of **Srinivasan and Babu (2000)** who reported that the neem oil was found harmful to larvae of the predator, *C. carnea* causing mortality. Also, these results are in agreement with the findings of **Medina *et al.* (2003 b)** who found that azadirachtin was highly toxic, where The LD_{50}-value of this non-oily EC-formulation of azadirachtin (Align) was calculated to be 11.7 ng AI/insect. **Ahmad *et al.* (2003)** stated that the 2nd larval instar of *C. carnea* showed a very high mortality when feeding on aphids sprayed with neem oil whereas the total mortality was 27.4%. **Filotas *et al.* (2004) and Ugine *et al.* (2007)** gave a report about the effects of the entomopathogenic fungi *viz.*, Biofly, Biovar and Bioranza formulations against the pests and the larvae of aphidophagous predators. Bioranza caused a higher percentage of mortality to larvae of aphidophagous predators than Biovar.

Table 2. Concentration mortality responses of *Chrysoperla carnea* (Stephens) larvae to the tested pest control agents

Active ingredient	LC_{25}	LC_{50}	Slope
Pyriproxyfen	36.37	179.03	0.97
B. bassiana	66.73	396.99	0.87
Neem oil	8.84	10.61	8.52
Orange oil	99.14	327.99	1.30

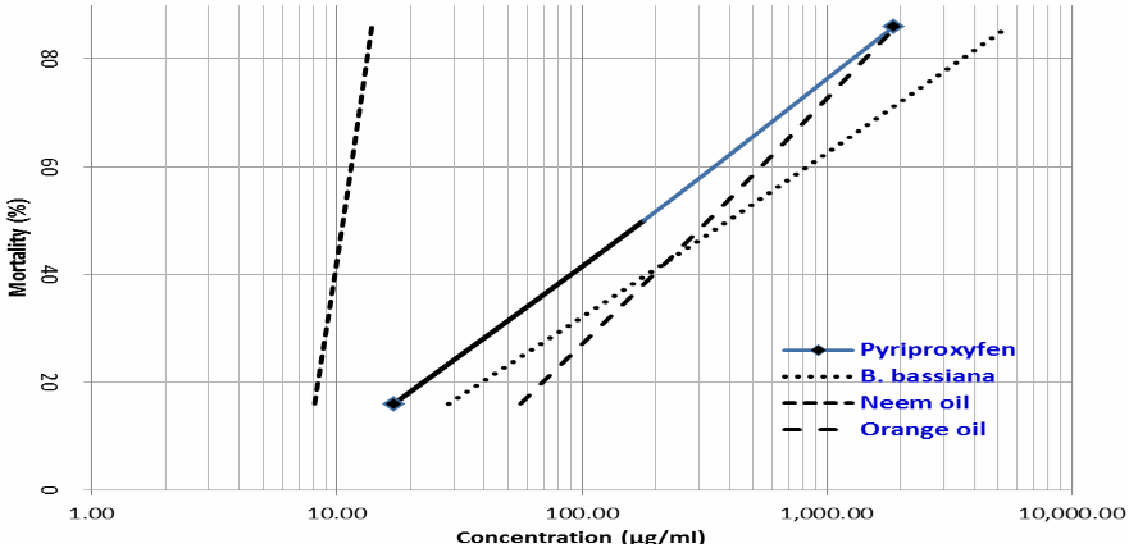


Fig. 1. Effects of the tested pest control agents on the larvae of *Chrysoperla carnea* (Stephens)

Also, the obtained findings are in agreement with those of **Atalla *et al*. (2009)** who stated that the 3rd instar larvae of *C. carnea* fed on treated aphid nymphs sprays with the three different concentrations of neem oil, *i.e.* 50, 100 and 200 ppm showed different biological responses. Larval mortality percentages were under 50% against all the three concentrations used of neem oil formulation for one, two and three days post-treatment. The concentrations of 100 and 200 ppm showed 35.9 and 43.4% mortality after 2 days of treatment, respectively. **Maroufpoor *et al.* (2010)** reported that the use of selective insecticides could increase conservation of natural enemies and therefore contribute to the success of IPM programs. In their study, the toxicity of one selective insecticide (Spinosad) to *C. carnea* larvae was evaluated under laboratory conditions. In implementation of 250 ppm of Spinosad on second and third instar larvae showed a negligible mortality rate after 3 days, whereas the first instar larvae suffered 33 percent mortality. They concluded that spinosad is not to be considered to have an environmental safety profile on *C. carnea* similarly to well established biological insecticides. **Rashid *et al*. (2016)** reported that the neem oil concentrations (2, 2.5, and 3%) had different impacts on prey preference and prey consumption. Neem oil at higher concentrations had an antifeedant effect on larvae of *C. carnea*.

Larval duration

Obtained results showed that the highest mean larval duration of *C. carnea* (8.00 ± 0.52 days) was recorded for larvae fed on treated aphid nymphs with 2 FRC neem oil whereas, the lowest one (5.50 ± 0.22 days) was in case of larvae fed on treated aphid nymphs with 0.5 FRC orange oil (Table 3). Analysis of data revealed that the differences between means were significant (F=2.34*).

These results are in agreement with these of **Ahmad *et al.* (2003)** who reported that the total larval period of *C. carnea* was prolonged significantly when larvae were fed on neem oil treated aphids.

Pupal duration

Results in Table 3 indicate that the tested pest control agents (orange oil and pyriproxyfen at 2 FRC) caused a significant elongation in the pupal duration over other treatments, showing 9.83 ± 0.65 and 9.00 ± 0.00 days, respectively. Meanwhile, the shortest mean was recorded when the 2nd larval instar of *C. carnea* fed on treated aphid nymphs with orange oil 0.5 FRC, recording 7.0 ± 0.37 days. Analysis of data revealed that the differences between means were highly significant (F=5.56*).

These results are in agreement with these of **Ahmad *et al.* (2003)** who stated that the pupal duration of *C. carnea* was prolonged significantly when larvae were fed on treated aphids with neem oil.

Cocooning percentage

As shown in Table 3, the maximum cocooning (100.00%) was recorded when larvae of the predator were fed on treated aphid nymphs with each of *B. bassiana* at all tested concentrations, neem oil and pyriproxyfen at 0.5 and 1 FRC, as well as control larvae. Meanwhile, the minimum value of 75.00% was noticed when larvae were fed on treated aphid nymphs with neem oil or orange oil at 2 FRC.

These results are in accordance with those of **Atalla *et al*. (2009)** who reported that 94.1% of larvae surviving at 50 ppm, neem oil treatment developed to pupae. Pupation percentage of treated larvae at 100 and 200 ppm concentrations were 87.5 and 84.6%, respectively.

Weight of cocoon

Results in Table 3 indicate that all tested pest control agents affected negatively the weight of cocoon over the control, except pyriproxyfen at 1 FRC which manifested a mean of 6.80±0.50 mg. *B. bassiana*, neem oil, and orange oil at 0.5 FRC recorded the highest means showing 6.20± 0.12, 5.50±0.06 and 5.50±0.50 mg, respectively. Meanwhile, neem oil or orange oil at 2 FRC resulted in the lowest means of 4.20 mg.

Statistical analysis assured that there were highly significant differences among the means of the four tested pest control agents at 0.05 level of probability (F= 9.31*).

Adult emergence

Obtained results revealed that the highest mean adult emergence of *C. carnea* (60.00%)

Table 3. Effect of pest control agents on larval and pupal durations, cocooning and cocoon weight producing from the 2nd larval instar of *Chrysoperla carnea* (Stephens) fed on treated aphid nymphs under laboratory conditions

Treatment \ Biological aspect		Larval duration (day)	Pupal duration (day)	Cocooning (%)	Cocoon weight (mg)
B.bassiana	**0.5 FRC**	6.83 ± 0.40^{b}	8.33 ± 0.21^{bc}	100.00	6.20±0.12^{abc}
	1 FRC	7.00 ± 0.73^{ab}	7.83 ± 0.31^{cde}	100.00	6.20±0.06^{abc}
	2 FRC	6.67 ± 0.33^{b}	8.17 ± 0.17^{bcd}	100.00	5.40±0.06^{def}
Neem oil	**0.5 FRC**	7.33 ± 0.21^{ab}	7.33 ± 0.42^{bc}	100.00	5.50±0.06^{cdef}
	1 FRC	7.00 ± 0.00^{ab}	7.83 ± 0.17^{bc}	100.00	5.20±0.23^{ef}
	2 FRC	8.00 ± 0.52^{a}	8.33 ± 0.21^{bc}	75.00	4.20±0.12^{g}
Pyriproxyfen	**0.5 FRC**	6.50 ± 0.34^{bc}	8.00 ± 0.00^{cd}	100.00	5.80±0.42^{cde}
	1 FRC	7.33 ± 0.61^{b}	8.00 ± 0.00^{cd}	100.00	6.80±0.50^{a}
	2 FRC	6.33 ± 0.42^{b}	9.00 ± 0.00^{ab}	83.33	6.00±0.12^{bcd}
Orange oil	**0.5 FRC**	5.50 ± 0.22^{c}	7.00 ± 0.37^{e}	85.71	5.50±0.50^{cdef}
	1 FRC	7.17 ± 0.31^{ab}	8.67 ± 0.42^{bc}	83.33	4.90±0.10^{fg}
	2 FRC	7.33 ± 0.33^{ab}	9.83 ± 0.65^{a}	75.00	4.20±0.15^{g}
Control		6.50 ± 0.22^{bc}	8.50 ± 0.22^{bc}	100.00	6.70±0.38^{ab}
F. value		2.34*	5.56*		9.31*

Data are expressed as means ± SE. Within the same column, data followed by the same letter are not significantly different ($P \geq 0.05$)

FRC: field recommended concentration.

was recorded for larvae fed on treated aphid nymphs with orange oil 0.5 or 1 FRC. Whereas, the lowest ones (28.57 and 20.00%) were noticed in cases of larvae fed on treated aphid nymphs with pyriproxyfen at 1 and 2 FRC, respectively (Table 4). Generally, control larvae exceeded other tested pest control agents in adult emergence, showing 70.00%.

Bull and Meola (1993) found that the insecticide pyriproxyfen had no effect except on oviposition period of *C. carnea*. These results are in conformity with those of **Medina *et al.* (2003 b)** who stated that pyriproxyfen had no significant effect on the percentages of normal pupal formation, adult emergence, oviposition period and egg fertility. However, azadirachtin was harmful at higher doses. These results are in agreement with those of **Ahmad *et al.* (2003) and Atalla *et al*. (2009).**

Deformation

All tested pest control agents with investigated concentrations didn't result in any malformed adults except at 2 FRC in all treatments which showing 100.00% malformed adults Fig. 2.

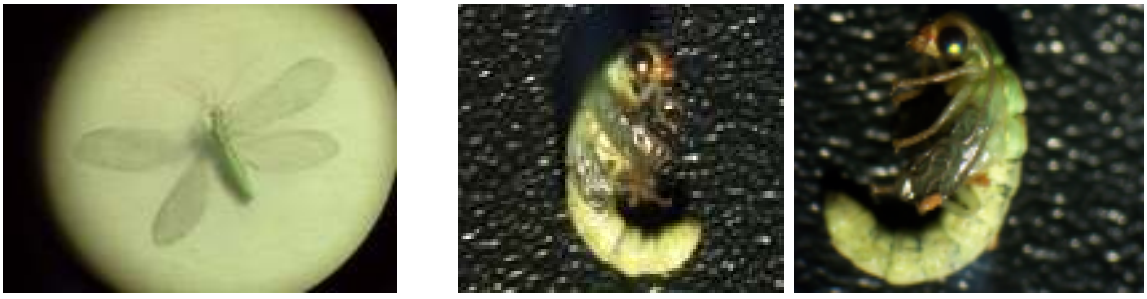
Ahmad *et al.* (2003) mentioned that the percentage of adults deformed amounted to

Table 4. Effect of pest control agents on emergence and longevity of adults producing from the 2nd larval instar of *Chrysoperla carnea* (Stephens) fed on treated aphid nymphs under laboratory conditions

Biological aspect / Treatment		Adult emergence (%)	Longevity (in days)				
			Male	Female			
				Pre-oviposition	Oviposition	Post - oviposition	Total
B. bassiana	**0.5 FRC**	57.14	9.00 ±0.00b^{c}	3.33±0.33^{e}	12.67±1.45^{d}	6.33±0.33^{ab}	22.33±1.67^{c}
	1 FRC	50.00	5.00±0.00^{e}	4.50±0.29^{d}	13.00±1.73^{cd}	5.50±0.29^{bc}	23.00±1.15^{c}
	2 FRC	40.00	-	-	-	-	-
Neem oil	**0.5 FRC**	55.56	7.50±1.44^{cd}	5.67±0.33^{c}	12.67±1.20^{d}	7.00±1.00^{a}	25.33±0.67^{bc}
	1 FRC	50.00	7.00±0.00^{d}	5.50±0.29^{cd}	8.50±0.29^{ef}	3.50±0.29^{de}	17.50±0.87^{d}
	2 FRC	33.33	-	-	-	-	-
Pyriproxyfen	**0.5 FRC**	50.00	12.00±0.00^{a}	7.00±0.58^{b}	11.50±1.44^{de}	6.00±0.58^{ab}	24.50±1.44^{c}
	1 FRC	28.57	9.00±0.00^{bc}	9.00±0.00^{a}	5.00±0.00^{f}	3.00±0.00^{e}	17.00±0.00^{d}
	2 FRC	20.00	-	-	-	-	-
Orange oil	**0.5 FRC**	60.00	10.00±0.00^{b}	6.50±0.87^{bc}	23.50±2.02^{b}	4.50±0.29^{cd}	34.50±2.60^{a}
	1 FRC	60.00	7.00±0.00^{d}	8.50±0.29^{a}	16.50±0.87^{c}	3.50±0.29^{de}	28.50±1.44^{b}
	2 FRC	33.33	-	-	-	-	-
Control		70.00	10.67±0.88^{ab}	2.67±0.67^{e}	28.33±2.60^{a}	4.33±0.33^{d}	35.33±0.88^{a}
F. value			74.31*	55.43*	49.81*	32.75*	126.156*

Data are expressed as means ± SE. Within the same column, data followed by the same letter are not significantly different (P ≥ 0.05)

FRC: field recommended concentration



(A) Normal (untreated) (B) Deformed (treated)

Fig. 2. Adult of *Chrysoperla carnea*

13.2% when larvae were fed on neem oil treated aphids. **Atalla *et al.* (2009)** reported that the larvae of *C. carnea* fed on aphid nymphs treated with 100 and 200 ppm neem oil showed 12.5 and 23% deformity, respectively. The low concentration (50 ppm) showed the lowest effect on the deformation of larvae (5.88 %).

Male longevity

Results in Table 4 show that the mean of male longevity of the predator was clearly affected by feeding the 2nd larval instars on the treated aphid with the tested pest control agents. The maximum mean of male longevities were 12.00, 10.67 and 10.00 days, recorded when the larvae were fed on treated aphid nymphs with pyriproxyfen 0.5 FRC, control and orange oil 0.5 FRC, respectively. While the minimum ones were 5.00 and 7.00 days after feeding on treated aphid nymphs with *B. bassiana* and neem oil or orange oil at 1 FRC, respectively. Analysis of data revealed that the differences between means were highly significant (f = 74.31*).

Unlike these findings, **Schuster and Stansly (2000)** tested Azatin EC on two species of chrysopids and found neem product nontoxic to male longevities of the predator.

Female Longevity

As shown in Table 4, all tested pest control agents with investigated concentrations prolonged pre-oviposition period with means ranging between 3.33 ± 0.33 and 9.00 ± 0.00 days over the control (2.67± 0.67 days).

Regarding the oviposition period, control larvae exceeded the experimented pest control agents, recording 28.33 ± 2.60 days. Feeding 2*nd* larval instar of *C. carnea* on treated aphid nymphs with neem oil at 0.5 FRC, resulted in the highest mean of post-oviposition period (7.00 ± 1.00 days), while the lowest one (3.00 ± 0.00 days) was observed with pyriproxyfen 1 FRC. Analysis of data revealed that the differences between means were highly significant. As indicated in Table (4), control larvae attained the highest mean adult female longevity (35.33 ± 0.88 days), followed by larvae fed on treated aphid nymphs with orange oil at 0.5 FRC recording 34.50 ± 2.60 days. The lowest ones (17.50 ± 0.87 and 17.00 ± 0.00 days) were observed when larvae fed on treated aphid nymphs with neem oil and pyriproxyfen 1 FRC, respectively. The differences between means were highly significant.

Unlike these findings, **Schuster and Stansly (2000)** tested Azatin EC on two species of chrysopids and found neem product nontoxic to female longevities of the predator. The obtained results are in agreement with the findings of **Ahmad *et al.* (2003)** who mentioned that a significant reduction of the adult life span could be stated after feeding of neem oil treated aphids by larvae of *C. carnea*. **Roy *et al.* (2008)**, in their results about the adverse effects of *B. bassiana* towards three species of predators, mentioned the negative effects towards these predators.

Fecundity, fertility and hatchability percentage

As cleared in Table 5, all above mentioned tested pest control agents with investigated concentrations affected negatively female fecundity, recording means ranging between 12.00 ± 0.00 to 123.67 ± 12.67 eggs, compared to the control (324.67±12.98 eggs). Statistical analysis revealed highly significant differences between the tested pest control agents.

These results are in disagreement with these of **Hermann *et al.* (1997)** who reported that no negative effect of neem oil on *C. carnea* efficacy was found. **Medina *et al.* (2003 a)** found that the pyriproxyfen was harmless to *C. carnea* adults, whereas fecundity was not affected irrespective of the insecticide or the time of application (before or after the onset of oviposition).

Concerning fertility and hatchability percentages, the same trend was observed. The highest means of 86.04 ± 1.25 and 91.21± 0.23% were recorded for control, respectively. Meanwhile, the lowest means of 50.00 ± 0.00 and 56.34 ± 0.46 % were noticed when larvae were fed on treated aphid nymphs with pyriproxyfen and neem oil 1 FRC, respectively. Analysis of data revealed that the differences between means were highly significant.

These results are in disagreement with these of **Medina *et al.* (2004)** who revealed that no effect on fertility of the adult green Lacewings, *C. carnea*, when provided with azadirachtin treated water. **Medina *et al.* (2003 a)** stated that

Table 5. Effect of pest control agents on fecundity, fertility, hatchability and incubation period of adults producing from the 2nd larval instar of *Chrysoperla carnea* (Stephens) treated aphid nymphs under laboratory conditions.

Treatment \ Biological aspects		Fecundity	Fertility (%)	Hatchability (%)	Incubation period (in days)
B. bassiana	**0.5 FRC**	123.67±12.67^{b}	65.18±3.53^{bc}	75.79±5.51^{b}	4.50±0.33^{d}
	1 FRC	91.50±6.64^{c}	57.95±2.63^{d}	67.37±3.10^{cd}	5.40±0.58^{c}
	2 FRC	-	-	-	-
Neem oil	**0.5 FRC**	80.67±12.60^{c}	69.80±1.01^{b}	73.04±3.26^{bc}	7.40 ±1.15^{a}
	1 FRC	30.00±2.31^{de}	69.62±0.22^{b}	56.34±0.46^{e}	4.40±0.67^{d}
	2 FRC	-	-	-	-
Pyriproxyfen	**0.5 FRC**	30.50±2.60^{de}	58.35±2.60^{d}	63.96±0.19^{de}	4.10 ±0.33^{d}
	1 FRC	12.00±0.00^{ef}	50.00±0.00^{e}	66.67±0.00^{cd}	5.40±0.63^{c}
	2 FRC	-	-	-	-
Orange oil	**0.5 FRC**	37.50±1.44^{d}	60.18±1.55^{cd}	58.00±5.87^{e}	5.60±0.58^{bc}
	1 FRC	42.50±1.44^{d}	59.72±2.73^{d}	61.76±4.16^{de}	6.10±0.67^{b}
	2 FRC	-	-	-	-
Control		324.67±12.98^{a}	86.04±1.25^{a}	91.21±0.23^{a}	3.90±0.58^{d}
F. value		186.48*	333.48*	141.67*	96.83*

Data are expressed as means ± SE. Within the same column, data followed by the same letter are not significantly different ($P \geq 0.05$)

FRC: field recommended concentration

pyriproxyfen exerted showed a negative effect on hatching and fertility, when the eggs were laid by females treated at the highest concentration assessed (2 × maximum field recommended concentration).

Incubation period

Results presented in Table 5, indicate that the incubation period of laid eggs by the adults of predator was highly significant differed owing to the tested pest control agents during the 2nd larval stage. The maximum mean (7.40±1. 50 days) was attained by feeding 2nd larval instars of *C. carnea* on neem oil at 0.5 FRC, whereas, the minimum mean (3.90 ± 0. 58 days) was noticed for control larvae. Statistical analysis showed that there were highly significant differences among the means of the four tested pest control agents at 0.05 level of probability (F= 96.83*).

These results are in conformity with these of **Schuster and Stansly (2000)** who tested Azatin EC on two species of green lacewings and found neem product nontoxic to eggs. **Isman (2006**) reported that the pest control agents *viz*., neem oil were harmless to *C. carnea* larvae in the laboratory at low concentrations. These novel compounds can be recommended for use in IPM programs at low concentrations where the population of the lacewing is involved.

Conclusion

Four different pest control agents (*B. bassiana*, neem oil, pyriproxyfen, and orange oil) were evaluated for their effectiveness against 2nd larval instars of *C. carnea* under laboratory conditions at 26 ± 1 °C and 65 ± 5% RH. The obtained results revealed that neem oil was more toxic than the other control agents at both the LC_{25} and LC_{50} levels, unlike orange oil. The highest percentage of adult emergence

(70.00%) was found with the control, while the lowest one (20.00%) was recorded in case of pyriproxyfen at 2 FRC. The highest mean of fecundity (324 eggs) when the larvae of predator fed on untreated aphids (control). On the contrary, the pyriproxyfen at 1 FRC resulted in the lowest mean of fecundity (12.00 eggs).

Taking into account that pest control agents tested are harmless to *C. carnea* larvae in the laboratory at low concentrations, in contrast to high concentrations and also to adults, these pest control agents might be recommended for use in IPM programs at low concentrations where the population of the lacewing is involved.

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تأثير مواد مكافحة مختلفة للآفات على بعض الخصائص البيولوجية لأسد المن الأخضر *Chrysoperla carnea* (Stephens)

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تم تقييم تأثير أربعة مواد مختلفة لمكافحة الآفات وهي البوفاريا باسيانا (Balsam) *Beauveria bassiana*، زيت البرتقال، زيت النيم وبيروبروكسفين عند التركيز الموصى به حقلياً، نصفه وضعفه على المعايير البيولوجية لأسد المَّن الأخضر عند تغذية يرقات المفترس فى العمر الثانى على مَّن اللوبيا المعامل بالمواد سالفة الذكر لفترة ٢٤ ساعة تحت الظروف المعملية علي درجة حرارة ٢٦ ± ٢ درجة مئوية ورطوبة نسبية ٦٥ ± ٥%، عند حساب التركيزين المميتين لربع ونصف اليرقات المعاملة (LC_{50} و LC_{25})، أظهرت النتائج التي تم الحصول عليها أن زيت النيم كان أعلاهم سمية، حيث سجلت قيمة LC_{50} 10.61ميكروجرام/مل من المذيب، بينما كانت أقل سمية لفطر البوفاريا باسيانا ٣٩٦,٩٩ ميكروجرام / مل من المذيب، سجلت متوسطات فترة الطور اليرقى لأسد المَّن الأخضر ٦,٨٣، ٧,٣٣، ٦,٥٠، ٥,٥١ و ٦,٦٠ يوماً عند نصف التركيز الموصي به حقلياً لكل من البوفاريا باسيانا، زيت النيم، بيروبروكسفين، زيت البرتقال والكنترول على التوالى، فى حين تراوحت فترة طور العذراء ٨,٣٣، ٧,٣٣، ٨,٠٠، ٧,٠٠ و ٨,٥٠ يوماً لنفس عوامل مكافحة الآفات سالفة الذكر على التوالى، سجلت أقصى نسبة للتشرنق (١٠٠%) بتغذية العمر اليرقى الثانى لأسد المَّن الأخضر على مَّن معامل بفطر بوفاريا باسيانا تحت جميع التركيزات المختبرة، زيت النيم وبيروبروكسفين عند التركيزين الموصي به حقلياً ونصفه، إضافة إلى يرقات الكنترول، بينما لوحظت أقل نسبة للتشرنق (٧٥%) بتغذية يرقات العمر الثانى للمفترس على مَّن معامل بكل من زيت النيم أو زيت البرتقال بضعف التركيز الموصي به، أظهرت النتائج أن أعلى متوسط لنسبة خروج الحشرات الكاملة لأسد المَّن (٦٠%) كانت بتغذية اليرقات على مَّن معامل بزيت البرتقال بالتركيز الموصي به حقلياً ونصفه. فى حين لوحظت أقل نسبة خروج للمفترس (٢٠%) كانت عند التربية على مَّن معامل بالبيروبروكسفين بضعف التركيز الموصي به حقلياً، وبصفة عامة فقد تفوقت يرقات الكنترول على جميع عوامل مكافحة الآفات المختبرة معطية ٧٠% نسبة خروج، سجلت أعلى متوسطات لكل من نسبة الخصوبة ونسبة الفقس (٣٢٤ بيضة، ٨٦,٠٤ و ٩١,٢٢% على الترتيب) عند تغذية اليرقات على مَّن غير معامل، على العكس فقد نتج عن تغذية يرقات المفترس على مَّن معامل بالبيروبروكسفين بالتركيز الموصي به حقلياً أقل متوسطات لكل من عدد البيض الموضوع ونسبة الخصوبة (١٢ بيضة و ٥٠% على التوالى)، فى ضوء النتائج المتحصل عليها فقد لوحظ أن عوامل مكافحة الآفات (البوفاريا باسيانا، زيت البرتقال، زيت النيم وبيروبروكسفين عند التركيزات العالية غير آمنة على أسد المَّن الأخضر، حيث يفضل استخدام عوامل مكافحة الآفات المختبرة سالفة الذكر بتركيزات منخفضة بحيث تكون متوافقة مع إطلاق يرقات أسد المَّن الأخضر فى برامج المكافحة المتكاملة للآفات.

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