Effects of imidacloprid, dichlorvos, pymetrozine and abamectin, on life table parameters of the predatory bug, *Orius albidipennis* (Hemiptera: Anthocoridae)

Q. Sabahi[1&*], Kh. Talebi[1], A. Kavousi[1&2] and A. Sheikhi Garjan[3]
1. Plant Protection Department, University College of Agriculture, University of Tehran, Karaj, Iran, 2. Department of Plant Protection, Faculty of Agriculture, Zanjan University, Zanjan 45371-38111, Iran, 3. Iranian Research Institute of Plant Protection, Tehran, Iran.
*Corresponding author, E-mail: qodratsabahi@gmail.com

Abstract

Effects of four pesticides (imidacloprid, dichlorvos, pymetrozine and abamectin) were evaluated on life table parameters of *Orius albidipennis* (Reuter). Pesticides were used at the concentrations recommended by the manufacturers. The bioassays were carried out using drum-cell method, in a growth chamber at 27 ± 1ºC, R.H. of 65 ± 5% and 16 h photo phase. The net reproductive rate (R_0) value for the populations treated with imidacloprid, dichlorvos, pymetrozine, abamectin and tap water as control was, 2.91 ± 0.48, 18.85 ± 2.55, 10.16 ± 1.21, 8.00 ± 1.05, 43.40 ± 7.64; the intrinsic rate of natural increase (r_m) was 0.040 ± 0.005, 0.097 ± 0.018, 0.086 ± 0.012, 0.078 ± 0.010, 0.148 ± 0.006: the mean generation time (T) was 25.60 ± 1.12, 25.94 ± 1.85, 26.37 ± 0.25, 25.61 ± 0.21, 25.20 ± 1.16; the doubling time (DT) was 18.04 ± 2.76, 7.72 ± 1.60, 8.23 ± 1.11, 9.24 ± 1.37, 4.68 ± 0.18, and the finite rate of increase (λ) was 1.041 ± 0.006, 1.102 ± 0.019, 1.090 ± 0.013, 1.081 ± 0.011, 1.160 ± 0.007, respectively. Imidacloprid and dichlorvos, which revealed the most and the least effects on the life table parameters, were the most and the least harmful among the chemicals tested.

Key words: *Orius albidipennis*, pesticides, side effects, life table parameters

چکیده

تأثیر چهار آفت‌کش (ایمیداکلوپرید، دیکلرووس، پیمتروزین و آبامکتین) بر آماره‌های جدول زیستی سن شکاری *Orius albidipennis* (Reuter) مورد بررسی قرار گرفت. آفت‌کش‌ها در دزهای توصیه‌شده‌ی سازندگان مورد آزمایش قرارگرفتند. زیست‌سنجی با استفاده از روش قفس در شرایط کنترل‌شده‌ی ٢٧ ± ١°C رطوبت نسبی ٦٥ ± ٥٪ و دوره‌ی نوری با ١٦ ساعت روشنایی در اتاقک رشد صورت گرفت. نرخ خالص باروری (R_o) در تیمار سن شکاری با آفت‌کش‌های ایمیداکلوپرید، دیکلرووس، پیمتروزین، آبامکتین و آب معمولی به عنوان شاهد به ترتیب، ٢/٩١ ± ٠/٤٨، ١٨/٨٥ ± ٢/٥٥، ١٠/١٦ ± ١/٢١، ٨/٠٠ ± ١/٠٥ و ٤٣/٤٠ ± ٧/٦٤؛ نرخ ذاتی افزایش جمعیت (r_m) به ترتیب ٠/٠٤٠ ± ٠/٠٠٥، ٠/٠٩٧ ± ٠/٠١٨، ٠/٠٨٦ ± ٠/٠١٢، ٠/٠٧٨ ± ٠/٠١٠ و ٠/١٤٨ ± ٠/٠٠٦؛ میانگین طول یک نسل (T) ٢٥/٦٠ ± ١/١٢، ٢٥/٩٤ ± ١/٨٥، ٢٦/٣٧ ± ٠/٢٥، ٢٥/٦١ ± ٠/٢١ و ٢٥/٢٠ ± ١/١٦؛ مدت زمان دوبرابرشدن جمعیت (DT) ١٨/٠٤ ± ٢/٧٦، ٧/٧٢ ± ١/٦٠، ٨/٢٣ ± ١/١١، ٩/٢٤ ± ١/٣٧ و ٤/٦٨ ± ٠/١٨ و نرخ افزایش متناهی جمعیت (λ) ١/٠٤١ ± ٠/٠٠٦، ١/١٠٢ ± ٠/٠١٩، ١/٠٩٠ ± ٠/٠١٣، ١/٠٨١ ± ٠/٠١١ و ١/١٦٠ ± ٠/٠٠٧ برآورد گردید. در بین ترکیبات مورد آزمایش ایمداکلوپرید و دیکلرووس به ترتیب بیشترین و کمترین تأثیر زیان‌بار را بر شکارگر نشان دادند.

واژگان کلیدی: *Orius albidipennis*، آفت‌کش‌ها، تأثیرات جانبی، آماره‌های جدول زیستی

Introduction

Most known species of genus *Orius* Wolff (Hemiptera: Anthocoridae) are major insect predators, which feed on thrips, mites, whiteflies, leafhoppers, eggs and early instars of lepidopterous insects. Both immature and adult stages are predators, that partially consume their prey, and in some cases they do not feed on prey that they have killed (Rajasekhara & Chatterji, 1970). The *Orius* species show facultative phytophagy, which is important in biological control as it allows for maintenance of predator populations during periods of prey scarcity (Coll, 1997). This fact makes *Orius* spp. a good option for biological control.

The *Orius albidipennis* (Reuter) is common to a wide range of natural and agricultural habitats throughout the world including Iran. The importance of this predator, have been emphasized by several investigators (Carnero *et al.*, 1993; Van de Veire & Degheele, 1995; Tommasini & Nicoli, 1996; Madadi, 1999; Ostovan & Mirhelli, 2005). Unfortunately the predator can be affected adversely by chemicals used in greenhouses for pest control.

The foliar applications of pesticides to crops are known to greatly reduce the population of *Orius* spp., however systemic applications can also reduce numbers because of its omnivorous feeding behavior (Brown & Shanks, 1976). To combine a biological agent with pesticides applications, chemicals used should have the least adverse effects on the agent. This requires information on chemicals, spray threshold, and times of application that are compatible with the natural control agents (De Cock *et al.*, 1996).

Several studies performed both in laboratories and fields have shown toxicity of different pesticides to various species of *Orius* (Trumble & Morse, 1993, Delbeke *et al*., 1997; Sclar *et al*., 1998; Al-Deeb *et al*., 2001; James & Vogele, 2001; Ghadamyari & Talebi, 2002; Liu & Sengonca, 2002; Studebaker & Kring, 2003; Angeli *et al*.; 2005, Ashley *et al*., 2006; Chang-Geum *et al*.; 2006, Rocha *et al*., 2006). Standard methods based on laboratory to field tests have been developed for some beneficial organisms including *Orius laevigatus* (Fieber) according to the requirements of the IOBC (Hassan, 1992; Van de Veire *et al*., 2002). Although the IOBC methods combine the acute mortality with reproductive performance as a total effect (Sterk *et al*., 1999) their shortage has been discussed and it has been concluded that the ecological relevance of IOBC methods are questionable (Stark *et al*., 2007).

Different methods used for studying the impacts of pesticides on biological control agents have been reviewed by Talebi *et al*. (2008). Studying the effects of pesticides on life table parameters have been discussed as the best approach to combine the lethal and sublethal effects (Daniels & Allan, 1981; Bechmann, 1994; Forbes & Calow, 1999; Stark & Banks, 2003; Stark *et al*., 2007; Talebi *et al*., 2008).

To our knowledge there is no published data on the effects of pesticides on life table parameters of *O. albidipennis*. In this study we tried to determine the side-effects of four pesticides on life table parameters of *O. albidipennis*.

Materials and methods

Rearing

The *O. albidipennis* was collected from corn fields near Karaj, Iran and reared in chambers at a temperature of 27 ± 1ºC, relative humidity of 65 ± 5% and 16 h photo phase. The predatory bug was reared in groups of 50 individuals in plastic container with a perforated paper for more than 20 generations. There were *Ephestia kuehniella* Zeller eggs and maize pollen as food, and green bean pod as the source of moisture and for oviposition bed in the container.

Pesticide treatment

The pesticides used in this study were commercial preparations of imidacloprid (Bayer Agricultural Products, Germany) (350 SC, 40 mg/l), dichlorvos (Gyah Corporation, Iran) (50 EC, 150 mg/l), pymetrozine (Novartis Crop Protection, Switzerland) (25 WP, 150 mg/l), and abamectin (Gyah Corporation, Iran) (1.8 EC, 20 mg/l). Formulated pesticides were dissolved in tap water to produce concentration equivalent to field application rates.

Residual exposure

To evaluate the residual activity of pesticides glass plates (60 × 60 mm) were treated under the Potter precision spray tower (Burkard®) at 15 PSI pressure (Potter, 1952). The amount of solution deposit was 1.5 ± 0.01 mg/cm^2. Tap water was used in control treatment. Drum-cells (Van de Veire, 1992) were used as cage for exposure of individuals. Ventilation was provided through eight holes (1 cm diameter) covered with gauze, on the side of the cage. Treated glasses were left to dry before assembling the cells. The *E. kuehniella* eggs and maize pollen were placed in the cages. Ten individuals of the 1st instar nymphs were introduced to each cell. Four replicates, each consisted of 12 cells were used for treatments. The cells were maintained in an environmental chamber under the same conditions as rearing.

Life table analysis

A life table using age-specific survival rates (l_x) and fecundity (m_x) for every 24 hours period was constructed for calculating the life table parameters. Cohorts of *O. albidipennis* were followed over time and survivorship rates were recorded by life stage. The value of the intrinsic rate of increase (r_m) was obtained by the Euler equation and other life table parameters were calculated (Birch, 1948).

Statistical analysis

Significant treatments effects by residual exposure were tested using ANOVA and significant different treatments means were identified using Duncan's multiple range test (SAS Institute, 2001). Jackknife pseudo values for r_m, the mean generation time (T), the doubling time (DT), and the finite rate of increase (λ) for each treatment were subjected to ANOVA. The jackknife method removes one observation at a time from the original data set and recalculates the statistic of interest from the truncated data set. These new estimates, or pseudo values, form a set of numbers from which mean values and variances can be calculated and compared statistically (Meyer *et al*., 1986).

Results

The predator populations exposed to various pesticides show different net reproductive rates (R_0). The lowest value of R_0, was in populations treated with imidacloprid, while the highest related to dichlorvos treatment. There were significant differences among all treatments.

The r_m was significantly affected (F = 17.00, P < 0.002) among the populations that were exposed to different pesticides. This statistic reached maximal value in the population exposed to dichlorvos that significantly differed from the control, whereas minimal value was related to imidacloprid treated population. The r_m values related to abamectin and pymetrozine treated populations did not differ significantly (table 1).

The analysis revealed that there was no significant difference (F = 0.13, P > 0.9814) among the mean generation time (T) of the populations treated. The shortest T belonged to the population exposed to imidacloprid, and the highest was in population treated with pymetrozine (table 1).

Among the populations treated, DT was significantly affected (F = 12.50, P < 0.0008). The shortest duration for this statistic was recorded for the population exposed to dichlorvos, while the longest duration occurred after exposure to imidacloprid. In populations treated with abamectin and pymetrozine, DT was 9.24 ± 1.37 and 8.23 ± 1.11, respectively, which did not have any significant difference (table 1).

Table 1. Life table parameters (± Standard Error) of *O. albidipennis* exposed to field concentration of pesticides. Confidence limit = 95%. See text for abbreviations.

Treatment	R_0 (female/female)	r_m (female/female /day)	T (day)	DT (day)	λ (female/female /day)
Control	43.40 ± 7.64a (34.23-52.57)	0.148 ± 0.006a (0.141-0.155)	25.20 ± 1.16a (23.84-26.56)	4.68 ± 0.18b (4.46-4.89)	1.160 ± 0.007a (1.153-1.167)
Dichlorvos	18.85 ± 2.55b (15.82-21.88)	0.097 ± 0.018b (0.076-0.118)	25.94 ± 1.85a (23.76-28.12)	7.72 ± 1.60b (4.80-9.64)	1.102 ± 0.019b (1.080-1.124)
Pymetrozine	10.16 ± 1.21c (8.64-11.68)	0.086 ± 0.012b (0.070-0.119)	26.37 ± 0.25a (26.05-26.69)	8.23 ± 1.11b (6.76-9.70)	1.090 ± 0.013bc (1.073-1.106)
Abamectin	8.00 ± 1.05c (6.74-9.26)	0.078 ± 0.010b (0.066-0.089)	25.61 ± 0.21a (25.36-25.86)	9.24 ± 1.37b (7.64-10.84)	1.081 ± 0.011bc (1.054-1.093)
Imidacloprid	2.91 ± 0.48d (2.33-3.49)	0.040 ± 0.005c (0.034-0.046)	25.60 ± 1.12a (24.27-26.93)	18.04 ± 2.76a (14.73-21.35)	1.041 ± 0.006c (1.033-1.055)
F	5.09	17.00	0.13	12.50	17.02
P	0.0172	0.0002	0.9814	0.0008	0.0002

Means within a column followed by the same letter are not significantly different at P ≥ 0.05.

A significant difference was observed in the finite rate of increase (λ) (F = 17.02, P < 0.0002) among populations treated. The highest λ was in the population exposed to dichlorvos, whereas the lowest one was in imidacloprid treated population. There were no significant differences between populations treated with abamectin and pymetrozine (table 1).

The age-specific survivorship (lx) of *O. albidipennis* populations, exposed to each pesticide, is presented separately in fig. 1. The total immature stages exposed to imidacloprid and dichlorvos had lower survivorship (21.0 and 40.2 %, respectively) than the average survival of 53.7 and 57.5 treated with pymetrozine and abamectin, respectively (F = 76.81, P < 0.0001).

The age-specific net fecundity (m_x) of *O. albidipennis* populations is presented separately for each pesticide in fig. 1. The maximum value of m_x was 9.09 females/day/ female. This value was observed on the population treated with dichlorvos. The maximum value of m_x for populations exposed to pymetrozine, imidacloprid and abamectin was 4.91, 3.45, and 3.45, respectively.

Discussion

The present study clearly demonstrates that the reproduction of the predator was affected significantly after exposure to the pesticides. This resulted in an overall reduced number of eggs laid by treated female during the oviposition period. Females treated with

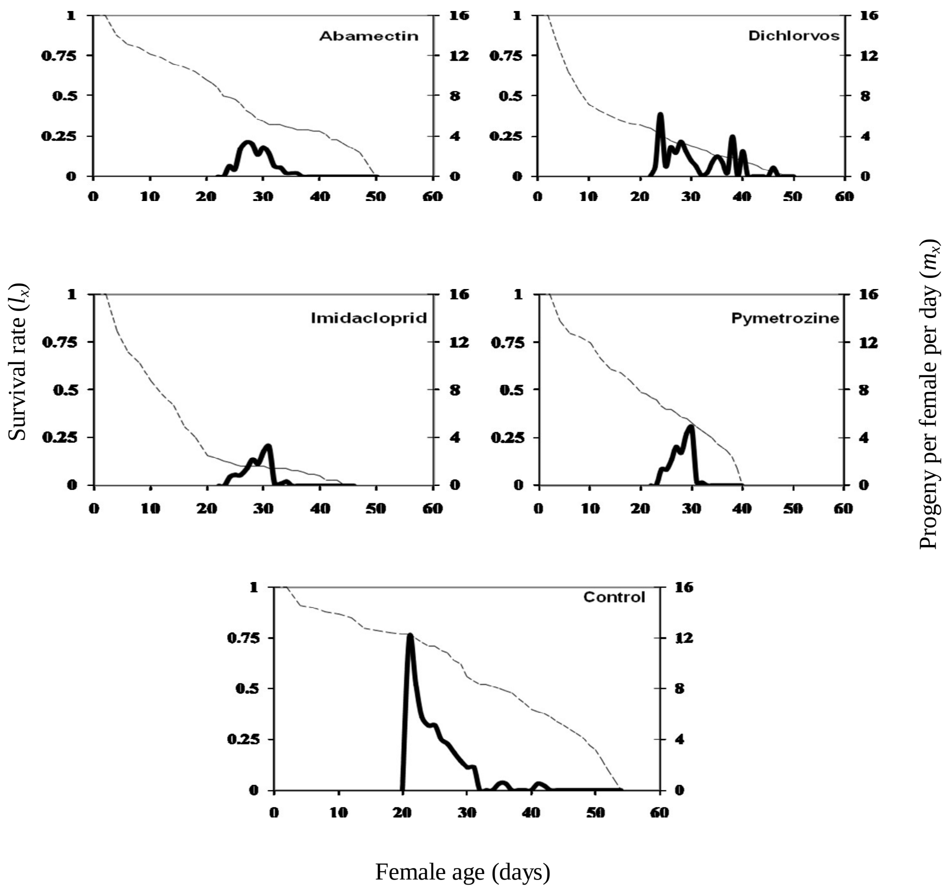

Figure 1. Age-specific survivorship, l_x, (dashed line) and fecundity, m_x, (solid line) of *O. albidipennis* population exposed to abamectin, dichlorvos, imidaclopird, and pymetrozine at N1 stage, compared with the control.

dichlorvos, similar to the untreated females, began oviposition within 4 days of adult emergence; however, the rate of oviposition yielded from the control was the highest. The rate of oviposition was also varied due to insecticides tested and the age of females. The longest oviposition period was found in dichlorvos treated population, whereas the shortest period occurred in pymetrozine and imidacloprid treatments. Similar result was obtained by Tran *et al.* (2004) who found imidacloprid reduced the oviposition of *Neochrysocharis formosa*

(Westwood) (Hym.: Eulophidae), a parasitoid of *Liriomyza trifolii* (Burgess) (Dip.: Agromyzidae). They argued imidacloprid reduced wasp host searching efficiency.

Our findings showed that imidacloprid and abamectin have serious adverse effects while pymetrozine has fewer effects on *O. albidipennis*. This result agrees with that of Van de Veire *et al*. (2002) who classified imidacloprid and abamectin as harmful and pymetrozine as harmless for *O. laevigatus*.

The r_m values of *O. albidipennis* ranged from 0.040 ± 0.005 to 0.097 ± 018 female/female/day in different pesticides treatments. Although small differences in r_m values can make remarkable differences in expected population growth during the test period, this value in population exposed to dichlorvos was more than twice as high as that of imidacloprid, resulted from faster development, higher survivorship, and higher reproductive rate than imidacloprid treated population. The value of r_m for control was 0.148 ± 0.006 female/female/day.

The mean generation time, a critical life table parameter that may have a great impact on the intrinsic rate of increase than total fecundity (Mackauer, 1986), showed a slight difference among treated populations. We found similar values for this parameter, ranging from 25.20 ± 1.16 days for control to 26.37 ± 0.25 days for pymetrozine treated populations. This low difference denotes none of the pesticides could significantly affect the mean time from eclosion of parents to eclosion of offspring. Therefore, there isn't any phonological asynchrony between predator and prey.

Doubling time, which is a function of rate of increase, is another index revealing the predator ability to increase population. This parameter, which varied from 4.68 ± 0.18 days in control to 18.04 ± 2.76 days in population exposed to imidacloprid, showed a significant adverse effect of this insecticide on the predator population.

The effects of imidacloprid residues on overall life table parameters of *O. albidipennis,* indicated that the application of this insecticide as foliar spray must be considered carefully in integrated pest management programs, although other means of application including seed treatment also cause mortality in similar predators (Al-Deeb *et al*., 2001), due to systemic translocation of imidacloprid in plant and feeding behavior of predator which feed on plant nectar. However, Angeli *et al*. (2005) who examined the residual effects of imidacloprid on the predatory bug *O. laevigatus* noted that this insecticide was very toxic by contact but only slightly toxic toxicity when ingested.

The results indicated that the maximum R_0, the shortest *DT*, the highest l_x, r_m and λ were obtained in population treated with dichlorvos. These results showed low residual effects of the compound in a well-ventilated test chamber. In closed environments, such as greenhouses, this compound may be harmful for the predator; at least during the early days after application. In fact, high vapour pressure of dichlorvos led to high fumigation toxicity of compound for adult *Orius strigicollis* (Poppius) (Chang-Geum *et al.*, 2006).

Pymetrozine and abamectin were in the mid range of above extremes and therefore should be used carefully in an integrated control approach; however, as these data obtained under laboratory conditions, the effects of pesticides on *O. albidipennis* should be confirmed by further tests under semi-field and field conditions.

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