Effect of Three Insecticides on the Biology of Green Lacewing, *Chrysoperla carnea* (Neuroptera: Chrysopidae)

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Abstract

Chrysoperla carnea Stephens **(Neuroptera: Chrysopidae)** is predator which has the potential to be used along with insecticides in an integrated crop management strategy. Experiments were carried out to study the effect of endosulfan (0.07%), imidacloprid (0.01%) and neem seed kernel extract (NSKE) (5%) on some biological aspects of *C. carnea*. At the rates tested, larval mortality was 32.45%, 26.41%, 10.20%, and 7.20% for endosulfan, imidacloprid, and control, respectively. Larvae fed on *Corcyra cephalonica* eggs treated with NSKE and imidacloprid pupated early, i.e. the larval period shortened by 4–5 days as compared to that of larvae fed on endosulfan treated and non–treated (control) eggs. In addition, 13.89% of predator larvae feed on Imidacloprid treated prey failed to pupate. The oviposition period of surviving adults was significantly ($P < 0.05$) affected in the following order: NSKE< imidacloprid< Endosulfan, when compared with the untreated check. The mean fecundity and productive age of adult females varied significantly ($P < 0.05$) according to the insecticide treatment. The sex ratio of the adults, pre-oviposition and post-oviposition periods and female longevity were not significantly ($P < 0.05$) affected by the insecticide treatment applied to the larvae. NSKE was the most biologically compatible natural pesticide with biological control (predation) as compared to endosulfan 35EC and Imidacloprid 17.8SC.

Key words: Biology, green lacewing, insecticide
Running title: Effect of some insecticides on green lacewing

Introduction

Over the past 50 years, there has been a steady increase in the use of chemical pesticides both in developed and developing countries for managing crop pests. However, the use of chemical pesticides has stimulated widespread concerns about their impacts particularly on human health and the environment. The use of broad-spectrum chemical pesticides adversely affects beneficial insects like parasitoids and predators. Until recently, the value of conserving poragrfoils and predators was not well understood and the role in the natural regulation of many crop pests is appreciated only recently. In order to conserve natural enemies present in the agro-ecosystems, the use of safer insecticides and / or alternative methods of application that minimizes damage to natural enemies are essential. The green lacewing, *C carnea* is common to many agro-ecosystems and plays a major role in the regulation of soft-bodied and lepidopterous insects.,

Green lacewings have been used in integrated pest management (IPM) programmes in conjunction with pesticides; and different insecticides have been evaluated for their compatibility with *C. carnea*. For instance, DDT, nicotine, rotenone, ryania, pirimicarb, endosulfan, lindane, primicarb, thiram, nitenpyran, imidacloprid and acetamiprid demonstrated low toxicity to *C. carnea* (Bartlett 1964, Babrikova, 1979, Hassan, et al. 1987,

Balasubramani & Swamiappan 1997 & Toda & Kashio 1997). Sirinivasan & Babu (2000a, & b) reported that endosulfan and neem seed kernel extract (NSKE) were less toxic than other insecticides for *C. carnea*. Kaethner (1991), Schmutterer (1996) & Sarode & Sonalk (1999) reported that neem seed kernel extract (NSKE) is safe against *C. carnea*. This study was conducted to assess effects of three frequently used insecticides on larval development period, pupation rate, length of the pupal period, larval ability of spinning pupal case, total fecundity throughout the adult female life span, and the peak productive age of adult female *C. Carnea*.

Materials and Methods

Three commonly used insecticides i.e. endosulfan 35 EC containing 0.07% active ingredient, imidacloprid (confidor) 17.8 SC containing 0.01% active ingredient and neem seed kernel extract (NSKE) (5% weight by volume) were tested in the laboratory against the first instar larvae of *C. carnea*. The effects of these products were compared with those treated with water (control). NSKE was prepared from neem seeds collected after ripening. The seeds were air-dried in shad and crushed into powder. Five gram neem seed powder was soaked in water for 4 hours after which the supernatant was filtered off to form a solution of NSKE (5%W/V).

The required concentrations of the insecticides were prepared by dilution using tap water and sprayed on to frozen eggs of rice moth, *Corcyra cephalonica* Stainton, using a hand atomizer. Control eggs were sprayed with tap water only. Approximately 50–200 sprayed eggs were dried for ten minutes and placed in each glass tube. First-instar larvae of *C. carnea* were transferred to the tubes containing the treated eggs, one larva per tube. Each treatment was replicated five times with ten tubes per replication. After the green lacewing larvae had completely consumed the treated eggs, untreated *C. cephalonica* eggs were provided additionally as food on alternate days until pupation. Observations were made daily on larval mortality starting from 24 hrs after replication until pupation; on larval and pupal period; percent pupation; percent adult emergence and appearance (normal/abnormal); pre-oviposition, ovipostion and post-oviposition periods; total number of eggs each female laid per day; fecundity and longevity of adults (Srinivasan & Babu 2000a, b).

Nucleus culture of *C. cephalonica* was obtained from the laboratory stock culture of Entomology Division of Indian Agricultural Research Institute, New Delhi. The culture was maintained on ground grains of maize placed in a plastic rearing jar (20cm x 15cm). In each cylinderical plastic jar, disinfested broken maize grains were kept with $1/4^{th}$ space of the jar volume. In each jar, half kilogram crushed maize grains was added and 0.1cc of *C. cephalonica* fresh eggs sprinkled. The culture was maintained at temperature of 28 ± 2 °C. *C. cephalonica* adults were collected every day and transferred into oviposition jar (20cm x 15cm) for egg laying. Eggs were collected from the jars after 24 hours, cleaned, and used for the studies daily as suggested by Gautam (1994).

C. carnea adults collected from farmers' fields were also maintained for oviposition by providing food supplements, i.e. 50% honey solution and bakers' yeast granules in the laboratory at 27 ± 2 °C. The cotton containing honey solution and bakers' yeast granules was replaced separately every two days. The females laid eggs mostly on black muslin cloth with few on

inner sides or bottom of the jars (4cm x 7.5cm). The stalked eggs were collected with forceps and maintained for hatching. Newly hatched larvae were kept in separate vials with the required amount of C. *cephalonica* eggs and used to evaluate the effects of insecticide on the biology of *C. carnea.*

Pre-oviposition, oviposition and post-oviposition period

The time from emergence of adult females to the start of oviposition was considered as the pre-ovipositional period. The number of eggs laid by individual females on black muslin cloth and on the inner sides of the rearing tubes was recorded every day. After emergence, the adults were transferred to different rearing jars. The period over which eggs were laid was considered as the oviposition period. The post-oviposition period was the time between the end of egg laying and death of the adult female.

Longevity, fecundity and length of egg production period

The biology of newly emerged adults was studied by providing them with a diet of 50% honey solution and baker's yeast granules; adults were held in rearing jars (4 x 7.5 cm) at a temperature of 27 $\pm$ 2°C. Male and female survival was recorded daily to determine effects of the treatments on longevity (days). The daily, weekly and total numbers of eggs laid by each female during its oviposition period were recorded to assess treatment effects on fecundity and to determine the length of time over which females continued to produce eggs according to the treatments applied. Each treatment and the control was replicated five times.

Data collected were subjected to analysis of variance (ANOVA) and treatment means were compared using Duncan's Multiple Range Test (Gomez and Gomez, 1984). Data on percent mortality were subjected to angular transformation before analysis.

Results

Larval mortality

Endosulfan 35 EC caused the highest larval mortality (32.5 %), whereas NSKE caused the least (10.2 %) one-day after insecticide application. Data on percent mortality showed that larval sensitivity to endosufan was the highest followed by imidacloprid and NSKE. Although toxicity level of the insecticide was in the safe range, the results revealed that larval mortalities due to endosulfan and imidacloprid were significantly higher ($P < 0.05$) than that of NSKE up to the fourth day after the application. Mean daily mortalities in endousfan and imidacloprid were 11.30% and 11.56%, respectively, and was significantly higher ($P < 0.05$) than that of NSKE. The mean daily mortality in the NSKE treatment was significantly higher ($P < 0.05$) than the daily mortality in the control (Table 1).

Larval period

Effect of the different insecticides on the mean larval period varied considerably (Fig. 1). Larvae fed on eggs prey treated with NSKE and imidacloprid pupated in 5–9 days while those treated with endosulfan 35 EC pupated in 7–11 days. Larvae treated with pupated in 6–10 days. Of the predator larvae fed on imidacloprid treated prey, 13.89% failed to pupate whereas the larvae exposed to endosulfan and NSKE pupated normally.

Table 1. Effect of different insecticides on mortality of *C. carnea* larva

Insecticide	Mortality (%) days after insecticide application								
	1 day	2 day	3 day	4 day	5 day	6 day	7 day	Total within 7 days	Mean/ day
Endosulfan (0.07%)	32.45[a]	18.00[a]	16.33[a]	8.00	5.00[ab]	0.00	0.00	79.78a	11.38[a]
Imidacloprid (0.01%)	26.41[a]	14.00[a]	10.20[a]	4.00	14.29[a]	6.00	6.00	80.90a	11.56[a]
NSKE (5%)	10.20[b]	0.00[b]	8.16[a]	4.00	14.29[a]	0.00	2.00	38.65b	5.23[b]
Control	7.26[b]	0.00[b]	2.00[b]	0.00	2.00[b]	0.00	0.00	11.26b	1.81[c]
LSD Value	7.11	6.06	8.35	NS	10.68	NS	NS	39.27	2.98
S.E.M	1.31	1.11	1.53	2.48	1.96	1.58	1.92	10.34	0.55

SEM = Standard error of mean; LSD = Least significant difference test at 0.05 alpha level; percent mortality, within a column followed by unlike letter is significantly different at P= 0.05 (DMRT)

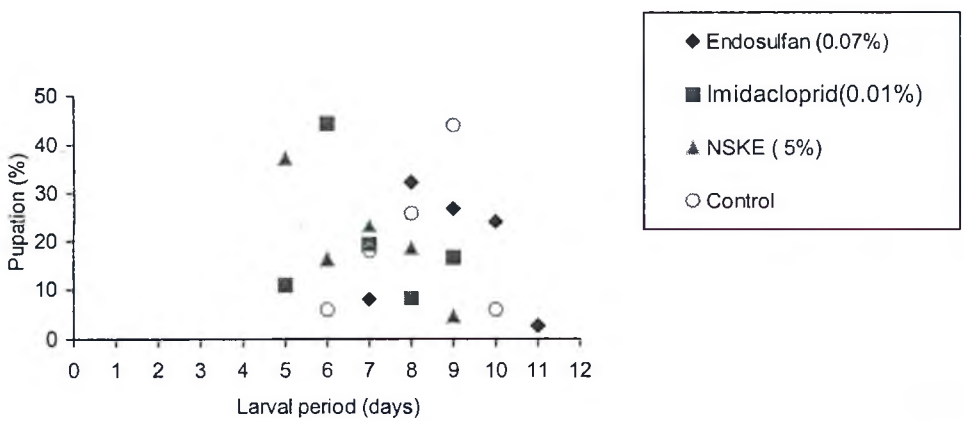

Fig.1. Effect of insecticides on mean larval period and pupation (%) of *C. carnea*

Pupal period and adult emergence

Average pupal period in all treatments including the control ranged from 7.01 to 7.87 days (Table 2). The pupal period was similar for all treatments except NSKE (Table 2). Adult emergence (normal, abnormal and total adult) were not significantly (P > 0/05) different among the treatments. Total emergence ranged from 82–90%.

Reproductive attributes

The length of pre-oviposition period of adults that emerged from treated with imidacloprid, endosulfan, NSK and water was 3.2, 4.4 days 5.4 and 3.6 days, respectively (Table 3). Compared with the control, the oviposition period was significantly affected only by NSKE, although imidacloprid and endosulfan also negatively affected the egg laying period. The number of eggs laid per day per female and the total number of eggs laid per female (fecundity) were significantly lower (P<0.05) in all insecticide treatments than the control. Daily and total oviposition was the lowest in the endosulfan treatment compared to the other insecticides tested (imidalcoprid and NSKE). Differences between post-oviposition periods and the sex ratio were not significant (P > 0.05).

Longevity

Adult males lived for 30 days in the imidacloprid treatment, 33.8 days in the endosulfan 29.4 days in the NSKE and 48.4 days in the control treatments. Adult females survived up to 47.4 days in the imidacloprid, 47.8 days in the endosulfan, 38.6 days in the NSKE treatments and 58 days in the control, (Table 3). For both males and females, adult longevity was significantly ($P<0.05$) shorter in the imidacloprid and NSKE treatments than in the control. The longevity of adult females that had emerged from larvae treated with the three insecticides was specifically shorter ($P=0.05$) than that had emerged from those treated with water (control).

Table 2. Effect of insecticides on mean pupal period and percent adult emergence of *C. carnea*

Insecticide	Pupal period (Days)	Normal emergence (%)	Abnormal emergence (%)	Total emergence (%)
Endosulfan (0.07%)	7.01^{b}	68	16	84
Imidacloprid (0.01%)	7.30^{b}	72	10	82
NSKE (5%)	7.87^{a}	70	20	90
Control	7.35^{b}	78	10	88
LSD Value	0.403	NS	NS	NS
S.E,M	0.056	1.513	2.907	3.124

SEM = Standard error of mean; LSD = Least significant difference test at 0.05 alpha level; percent mortality, within a column followed by unlike letter is significantly different at P= 0.05 (DMRT)

Table 3. Effect of insecticides on reproductive attributes of *C. carnea*.

Reproductive attribute	Imidacloprid (0.01%)	Endosulfan (0.07%)	NSKE (5%)	Control	LSD value	S.E.M
Pre- oviposition period (days)	3.2	4.4	5.4	3.6	NS	0.1
Oviposition period (days)	34.0^{ab}	35.4^{ab}	26.0^{b}	48.0^{a}	1.3	0.2
No. of eggs laid/ day/female	19.8^{b}	10.2^{c}	17.0^{b}	27.1^{a}	0.7	0.1
Post-oviposition Period (days)	12.2	8.0	7.2	7.6	NS	0.2
Sex-ratio (M/F)	0.9	0.53	0.7	0.73	NS	0.1
Longevity (days):						
Male	30.0^{b}	33.8^{ab}	29.4^{b}	48.4^{a}	1.3	0.2
Female	47.4b	47.8b	38.6c	58.0a	1.4	0.2
Fecundity (total No. of eggs/ female)	673.0^{b}	362.9^{c}	435.6^{bc}	1126^{a}	61.3	0.7

SEM = Standard error of mean; LSD = Least significant difference test at 0.05 alpha level; percent mortality, within a column followed by unlike letter is significantly different at P= 0.05 (DMRT)

Fecundity and productive age

The mean fecundity of *C. carnea* was significantly ($p < 0.05$) higher (1126) in the control than in the imidacloprid (673), NSKE (435.6) and endosulfan (362.9) treatments (Table 3). Fecundity of the endosulfan treated females was also significantly lower ($P < 0.05$) than the imidacloprid treated females. The average number of eggs each female laid per day was 27.1 for the control, 19. 8 in the

imidacloprid, 10.2 in the endosulfan and 17.0 in the NSKE treatment (Table 3).

Egg production continued up to 6 weeks of age in the imidacloprid and NSKE treated females, 7 weeks of age in the endosulfan treated female and 9 weeks of age in the water treated (control) (Fig. 2).

In the first week, the number of eggs produced in each treatment was not significantly different ($P > 0.05$). However, from the second week to the ninth week, egg production by all the insecticide treated females was lower than those produced by water-treated females. The highest number of eggs was produced by imidacloprid-treated females during the 2nd week, while for females treated with water (control), egg production peaked during the 3rd week (Fig 2).

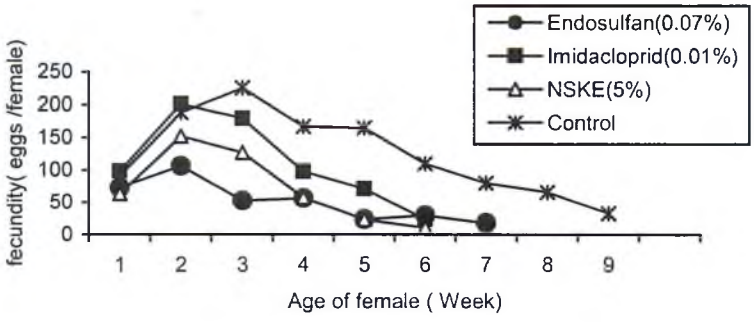

Fig. 2. Influence of insecticides on fecundity and productive age of female *C. carnea*.

Discussion

Although the insecticides evaluated in this study negatively affected various aspects of *C. carnea* biology, they were considerably less toxic than many other pesticides. Barlett (1964), Palpp & Bull (1978), Hassan et al. (1987), Kapadia & Puri (1991) and Balsubramani & Swamiappan (1997) reported that *C. carnea* was tolerant or resistant against endosulfan. Srinivasan & Babu (2000a), however, reported that endosulfan (0.07%) significantly ($P < 0.05$) affected adult longevity and fecundity compared with the control. Toda & Kashio (1997) revealed that imidacloprid showed low toxicity following topical application to *C. Carnea,* but had high residual activity. Elbert et al. (1998) similarly reported that imidacloprid which does not readily penetrate the insect cuticle has only low levels of insecticidal activity when applied topically contrary to when injected into the cuticle. These results suggest poor efficiency of imidacloprid against biting or chewing insects as compared to piercing or sucking hemipteran pests. In addition, Drinkwater & Groenewald (1994) reported on antifeedant effect of imidacloprid against aphids, black maize beetle (*Heteronychus arator*) and false wireworms (*Somaticus* sp.). Kaethner (1991) indicated that neem seed extract with or without oil was harmless to the eggs, larvae or adults of *C. carnea* and *C. septempunctata*. Results of the present study indicated that NSKE has less side effects than endosulfan and imidacloprid. Abdul Kareem et al. (1993) reported the harmless effect of NSKE (5%) on natural enemies in cotton. Saleem & Matter (1991), Yadav & Patel (1993) and Srinivasan & Babu (2000b) reported that NSKE had a temporary repellent effect on *C. carnea*. Results on female fecundity

obtained in this study agree with the findings of Srinivasan Babu (2000a, b). Furthermore the reductions in mean fecundity and the productive age of females reported in the current study concurs with observations of Srinivasan Babu (2000a, b).

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