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Effect of insecticides on the intrinsic rate of natural increase of *Rhynocoris marginatus* (Fabricius)

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ABSTRACT: Sub-lethal concentrations of two commonly used insecticides methyl parathion (0.0009%) and endosulfan (0.0123%) on the life table parameters were evaluated in a reduviid *Rhynocoris marginatus* (Fabricius) in the laboratory. Both the insecticides reduced the gross as well as net reproductive rates to considerable levels. The study revealed that the values of intrinsic rate of natural increase (r_m) and finite rate of increase (λ) in control insects, namely, 0.043 and 1.044 were also drastically reduced by the insecticides (0.029 and 1.029, and 0.040 and 1.04 for methyl parathion and endosulfan, respectively). Between the two insecticides, methyl parathion caused the maximum reductions in weekly multiplication rate and annual rate of increase.

KEY WORDS: Effect, endosulfan, insecticides, life table, methyl parathion, *Rhynocoris marginatus*

INTRODUCTION

The continuous use of insecticides to manage the pests devastates natural enemy complexes and in turn encourages pest resurgence or secondary pest flares (Broadly and Thomas, 1995). The toxic effects of insecticide application occur through a continuum of events from direct exposure during application to contact with dry deposited residues (Croft, 1990). However, it is often the residual effects of insecticides that cause mortality and physiological disorders to populations of natural enemies for considerable lengths of time (Bellows *et al.*, 1992). In evaluating an insecticide for natural enemy selectivity, it may be more important to assess its potential impact relative to the application rate used in the cropping system than to compare its toxicity directly with other compounds. In continuation of these observations, the present study is aimed at understanding the effect of the sub-lethal doses of two commonly used insecticides (methyl parathion and endosulfan) on the life table in *Rhynocoris marginatus* (Fabricius). The life table studies in reduviids are very rare except the works of George (2000a, b, c) and George *et al.* (1998a, b, 2000) and there is limited report of the insecticidal effects on life tables of reduviids (George, 1996; George and Ambrose, 1998; Ambrose, 1999, 2001; Sahayaraj and Paulraj, 1999a,b; Sahayaraj and Karthikraja, 2003; Sahayaraj *et al.*, 2003). Moreover, there is no report of the insecticidal effects on the life table parameters of *R. marginatus*.

MATERIALS AND METHODS

Adults of *R. marginatus* were maintained on the larvae of flour moth *Corcyra cephalonica* (Stainton) in the year 2003 at Entomology Research Unit, St. Xavier's College, Palayankottai in plastic containers (250 ml) at 30 ± 2°C, relative humidity ranging from 75 – 80 per cent and photo period between 11- 13 h. Preliminary studies were conducted to find out LC_{50} for each insecticide for III instar nymphs at different exposure durations. LC_{50} of 48h duration was taken as one toxic unit and 1/10 value of the 48 h LC_{50} of each insecticide was considered as sub-lethal concentration (Croft, 1990). They were 0.0009 and 0.0123 per cent for methyl parathion and endosulfan, respectively. Twenty µl of the insecticide was applied topically on the thoracic region. Fifteen III instar nymphs were exposed to the sub-lethal dosage of each insecticide, separately.

A control set-up was maintained with fifteen III instar nymphs and they were treated with 20µl of water. The concentration of the insecticide was maintained continuously for 20 days with fresh application of insecticide every day. Insecticide treated nymphs were reared up to adults. Data on stadial period and age specific survival/mortality were recorded daily. The daily fecundity was recorded until all the females died.

The life tables were constructed by determining and recording the each age interval, the survival rate (l_x) and the mean number of female progeny per female (m_x) still alive at such age intervals. The intrinsic rates of increase of population were calculated. The studies were made by using Birch's (1948) formula elaborated by Watson (1964), Laughlin (1965), Southwood (1978) and Bellows *et al.* (1992).

In life table statistics the intrinsic rate of increase was determined by using the equation $\Sigma e^{-r_m x} l_x m_x$ 1

Where 'e' is the base of natural logarithm, 'x' is the age of the individual in days, l_x is the number of individuals alive at age 'x' as the proportion of 1, and 'm_x' is the number of female offspring produced per female in the age interval 'x'. The sum of products '$l_x m_x$' is the net reproductive rate (R_o). The rate of multiplication of population for each generation was measured in terms of females produced per generation. The precise value of cohort generation was calculated as follows.

$$T_c = \frac{\Sigma l_x m_x}{R_o}$$

The arbitrary value of innate capacity for increase 'r_c' was calculated from the equation

$$r_c = \frac{\log_e R_o}{T_c}$$

This is an appropriate 'r_m' value. The values of negative exponent of $e^{-r_m x}$ ascertained from this experiment often lay outside the range. For this reason both sides of the equation were multiplied by a factor of $\Sigma e^{7-r_m x} l_x m_x$ 1096.6 (Deevy, 1947; Birch, 1948; Watson, 1964). The two values of $\Sigma e^{7-r_m x} l_x m_x$ were then plotted on the horizontal axis against their respective arbitrary 'r_m' on the vertical axis. Two points were then joined to give a line, which was intersected by a vertical line drawn from the desired value of $e^{7-r_m x} l_x m_x$ (1096.6).

The point of intersection gives the value of 'r_m' accurate to three decimal places. The precise generation time (T) was then calculated from equation

$$T = \frac{\log_e R_o}{r_m}$$

The finite rate of increase (λ) was calculated as e^{r_m}. This λ represents the number of individuals added to the population per female per day. The weekly multiplication of predator population was calculated as $(e^{r_m})^7$. The doubling time was calculated as log2/logλ.

RESULTS AND DISCUSSION

The normal *R. marginatus* attained maturity on the 80th day following hatching (Table 1) whereas

Table 1. Life and age specific fecundity table of control *R. marginatus*

x	l_x	m_x	$l_x m_x$	$l_x m_x x$	Trial r_m	
					0.026	0.046
0–79 immature						
90	0.80	20.0	16.00	1400.00	1690.176	279.384
100	0.80	14.0	11.20	1120.00	912.249	123.459
110	0.75	17.0	12.75	1402.50	800.736	88.724
120	0.65	9.0	5.85	702.00	283.282	25.699
130	0.60	7.0	4.20	546.00	156.818	11.647
140	0.50	10.0	5.00	700.00	143.946	8.753
150	0.45	5.0	2.25	337.50	49.945	2.486
160	0.35	3.0	1.05	168.00	17.972	0.732
170	0.25	2.0	0.50	85.00	6.599	0.220
180	0.15	2.0	0.30	54.00	3.053	0.083
190	0.10	1.0	0.10	19.00	0.785	0.010
200	0.10	0.0	0.00	0.00	0.000	0.000
		90.0	59.20	6534.00	4065.561	541.205

the methyl parathion and endosulfan treated insects attained maturity on the 102nd day and 84th day, respectively (Table 2, 3). The normal individuals survived for 120 days and reduction in their survival was noticed in the insects treated with insecticides (72 days and 101 days for methyl parathion and endosulfan, respectively). The first adult mortality of normal *R. marginatus* occurred on the 20th day of the reproductive period (30th day from hatching) and the last occurred on 200 days after hatching. Nevertheless, the life table for methyl parathion and endosulfan treated categories showed the first adult mortality on the 10th day of the reproductive period and the last occurred on the 180th day and 185th day after hatching, respectively. This may be due to the short nymphal period in normal categories (Tables 1, 2, 3).

The total number of female births amounted to a net reproductive rate (R_0) of 59.2 females/ female/ generation in normal individuals was reduced to 22.8 females/ female/ generation in methyl parathion treated insects, whereas, it was 52.0 females/ female/ generation in endosulfan treated category. The mean length of generation (T_c) increased from 110.37 days in normal to 131.73 and 114.44 days in methyl parathion and endosulfan treated categories, respectively. Thus, the intrinsic rate of increase in numbers (r_c) decreased from 0.036 in normal to 0.023 and 0.034 in methyl parathion and endosulfan exposed categories, respectively. The higher reduction in the net reproductive rate observed in methyl parathion treated category indicates the greater negative effect exerted by methyl parathion on the capacity of *R. marginatus* to multiply in a generation. This is similar to the observation of George (1996) when three harpactorine reduviids were exposed to topical treatments of five insecticides *viz*., monocrotophos, dimethoate, methyl parathion and endosulfan. These insecticides interfere with the hydroxylation process of some steroids and subsequently reduce the availability of ecdysone that leads to

Table 2. Life and age specific fecundity table of methyl parathion exposed *R. marginatus*

x	l_x	m_x	l_xm_x	l_xm_xx	Trial r_m	
					0.013	0.033
0–101 days immature	-	-	-	-	-	-
120	0.70	13.0	9.10	1092.00	2097.024	190.237
130	0.65	9.0	5.85	760.50	1183.749	79.554
140	0.65	7.0	4.55	637.00	88.457	49.162
150	0.50	4.0	2.00	300.00	312.045	15.536
160	0.40	2.0	0.80	128.00	109.602	4.467
170	0.20	2.0	0.40	68.00	48.120	1.606
180	0.10	1.0	0.10	18.00	10.564	0.289
		38.0	22.80	3003.50	4569.561	340.851

Table 3. Life and age specific fecundity table of endosulfan exposed *R. marginatus*

x	l_x	m_x	l_xm_x	l_xm_xx	Trial r_m	
					0.024	0.044
0–83 days immature	-	-	-	-	-	-
95	0.80	18.0	14.40	1368.00	1615.22	241.59
105	0.80	12.0	9.60	1008.00	847.05	103.73
115	0.75	14.0	10.50	1207.50	728.78	73.06
125	0.70	10.0	7.00	875.00	382.18	31.37
135	0.60	10.0	6.00	810.00	257.69	17.32
145	0.50	5.0	2.50	362.50	84.46	4.65
155	0.40	3.0	1.20	186.00	31.89	1.44
165	0.20	3.0	0.60	99.00	12.54	0.46
175	0.10	2.0	0.20	35.00	3.29	0.10
185	0.10	0.0	0.00	0.00	0.00	0.00
		77.0	52.00	5951.00	3963.10	473.72

prolongation of stadial period (Ambrose, 1999, 2001).

The true intrinsic rate of natural increase (r_m) was 0.043, 0.029 and 0.040 females/ female/ day in normal, methyl parathion and endosulfan treated categories, respectively (Table 4). The superiority of r_m as an index of population increase signifies that the number of individuals added to the population will multiply per unit time, designated

Table 4. Effect of methyl parathion and endosulfan on the life table parameters of *R. marginatus*

Parameters	Control	Methyl parathion	Endosulfan
Gross reproductive rate (Σm_x)	90.00	38.00	77.00
Net reproductive rate ($R_o = \Sigma l_x m_x$)	59.20	22.80	52.00
Mean length of generation ($T_c = \Sigma l_x m_x X / R_o$)	110.37	131.73	114.44
Estimated value of intrinsic rate of increase in numbers (r_c)	0.036	0.023	0.034
Corrected r_m ($e^{7-r_m X} l_x m_x = 1096.6$) (female/female/day)	0.043	0.029	0.040
True generation time ($T = \log_e R_o / r_m$)	94.905	107.82	98.78
Finite rate of increase in numbers (λ= anti $\log_e r_m$)	1.044	1.029	1.041
Doubling time (days) (log 2/log λ)	15.84	25.08	17.71
Weekly multiplication rate	1.351	1.225	1.323
Annual rate of increase	6.5×10^6	3.9×10^4	2.1×10^6

as finite rate of increase (λ). The values were 1.044, 1.029 and 1.041 females/ female/ day for control, methyl parathion and endosulfan treated, respectively. At this rate, the normal *R. marginatus* was capable of multiplying 1.351 times per week and 6.5×10^6 times per annum under prevailing laboratory conditions. But this was reduced to 1.225 and 1.323 times per week and 3.9×10^4 and 2.1×10^6 times per annum by methyl parathion and endosulfan, respectively. Further, the time required to double the population computed as 15.84 day in normal individuals was prolonged to 25.08 and 17.71 days by methyl parathion and endosulfan (Table 4).

Fecundity seems to be one of the most sensitive biological characteristics to sub-lethal effects and is the most important in terms of population dynamics. Similar reduced fecundity was shown by Parker *et al.* (1976) in the coccinellid, *Chilomenes sexmaculata* (Fabricius) when it was topically treated with sub-lethal doses of malathion. The reduction in fecundity observed in the present study by the insecticides was correlated with a reduction in longevity and a reduction in the proportion of the life span during which eggs were laid. This might be the reason for the reduced gross as well as net reproductive rates, innate capacity for natural increase, finite rate of increase and weekly multiplication rate.

Life table parameters of *R. marginatus* treated with the insecticides revealed that insecticides reduced the reproductive capacity, longevity and prolonged the developmental time. These observations further suggest that the endosulfan would be less harmful to *R. marginatus* when compare to methyl parathion and safer to the existence and multiplication of *R. marginatus*. Such findings have considerable implications for the growers who are selecting insecticides for use in an Integrated Pest Management Programme where *R. marginatus* is present as a biocontrol constituent.

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