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INSECTICIDAL IMPACT ON THE LIFE TABLE PARAMETERS OF A HARPACTORINE REDUVIID PREDATOR *Rhynocoris marginatus* (Fabricius), HETEROPTERA

P. J. Edward GEORGE & Dunston P. AMBROSE

Entomology Research Unit, St. Xavier's College, Palayankottai – 627 002, Tamil Nadu, India. E-mail: tvl_eruxaviers@sancharnet.in

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The effects of sublethal concentrations of three insecticides namely monocrotophos, dimethoate and quinalphos on the life table parameters were studied in a harpactorine reduviid predator *Rhynocoris marginatus* (Fabricius) in the laboratory (temp. 32 ± 2°C, Rh 75 – 80 %, photoperiod 11 – 13 hrs). Normal *R. marginatus* were multiplied 59.20 times per generation in a mean generation time of 110.37 days. The insecticides reduced the capacity of multiplication and enhanced the mean generation time. The intrinsic rate of natural increase (r_m) and finite rate of increase in control *R. marginatus* were 0.043 and 1.044, respectively, which decreased to 0.031 and 1.031, 0.035 and 1.036 and 0.038 and 1.038 in monocrotophos, dimethoate and quinalphos treated categories. Maximum reductions of weekly multiplications rate and annual rate of increase were observed in monocrotophos treated *R. marginatus*.

Heteroptera, Reduviidae, *Rhynocoris marginatus*, monocrotophos, dimethoate, quinalphos, life and fecundity table, India

GEORGE, E. P. J., AMBROSE, D. P., Utjecaj insekticida na biotički potencijal predatora *Rhynocoris marginatus* (Fabricius), Reduviidae: Harpactorinae, Entomology Research Unit, St. Xavier's College, Palayankottai – 627 002, Tamil Nadu, India. E-mail: tvl_eruxaviers@sancharnet.in - Entomol. Croat. 2004. Vol. 8. Num. 1-2: 13-23.

Učinak subletalnih koncentracija tri insekticida: monokrotofos, dimetoat i kvinalfos na biotički potencijal stjenice predatora *Rhynocoris marginatus* (Fabricius), istraživan je u laboratorijskim uvjetima (temperatura 32 ± 2°C, relativna vlaga 75 – 80%, fotoperiod 11:13 sati). Redovio se *R. marginatus* umnožava 59.20 puta po generaciji uz prosječno trajanje generacije od 110.37 dana. Insekticidi su skratili kapacitet umnožavanja i povećali dužinu razvoja generacije. Prava stopa prirodnog povećanja (r_m) i konačna stopa povećanja u kontroli *R. marginatus* bila je 0.043 i 1.044, odnosno, smanjena je na 0.031 i 1.031; 0.035 i 1.036 i 0.038 i 1.038 kod monokrotofosa, dimetoata i kvinalfosa u tretiranim kategorijama. Maksimalno smanjenje stope umnožavanja i godišnje stope porasta zapaženo je kod *R. marginatus* tretiranih monokrotofosom.

Heteroptera, Reduviidae, *Rhynocoris marginatus*, monokrotofos, dimetoat, kvinalfos, biotički potencijal, Indija

Introduction

Modern agriculture has come to rely extensively on synthetic chemical pesticides for pest control. Although these toxins are targeted at plant pests, many of them are broad spectrum biocides that have profound effects on non-target species in agroecosystems. Much less is known about the effects of chemical pesticides on predators and parasites than on herbivorous pests (CROFT & BROWN, 1975). Biological evaluations of pesticide impact have focused primarily on mortality assessments. However, it is well known that sub-lethal doses of these compounds can affect the physiology and behaviour of both target and non-target arthropod species (CROFT, 1990). One of the main goals of this paper is to highlight the study on pesticide/natural enemy relationships and to show how this type of study may improve IPM. We are recently entered into an exciting new era of research in which there will be a greater emphasis on selectivity to natural enemies over pests (AMBROSE, 2001). In continuation of this programme, the present study is aimed at understanding the impact of commonly used insecticides on a harpactorine reduviid, *Rhynocoris marginatus* (Fabricius). Reduviidae is the largest family of predaceous land Heteroptera with considerable potential to act as biological control agents. *R. marginatus* is predominantly found in agroecosystems and oraciously predates on various economically important insect pests such as *Anomis flava* Fabricius, *Achaea janata* Linnaeus, *Helicoverpa armigera* Hubner, *Spodoptera litura* (Fabricius) and *Mylabris pustulata* Thunberg and *Corcyra cephalonica* Stainton (AMBROSE, 2000, 2003). This study will be very useful in the development and greater use of physiologically selective insecticides in the agroecosystem where *R. marginatus* is commonly used for biocontrol programme.

Life table analysis is one of the most effective means of studying population density, which is also altered by the sub lethal doses of insecticides by affecting the physiology of the insect. Longevity, age specific fecundity, sex ratio and generation time can be examined as they relate to the intrinsic rate of increase. It is from this standpoint that the present investigation has been undertaken and the information incorporated in this paper examine these issues with respect to *R. marginatus* exposed to the sub lethal dose of monocrotophos, dimethoate and quinalphos.

Materials and Methods

Adults of *R. marginatus* were maintained in the laboratory at Entomology Research Unit, St. Xavier's College, Palayankottai in plastic containers (250 ml) at 30 ± 2^o, relative humidity ranging from 75 – 80% and photo period between 11- 13 hrs on

the larvae of *Corcyra cephalonica* Stainton. Preliminary studies were conducted to determine the LC_{50} concentration for each insecticide for III instar nymphs at different exposure durations (Table 1). LC_{50} concentrations of 48 h duration was taken as one toxic unit and 1/10 values of the 48h LC_{50} of each insecticide was considered as sublethal concentration. They were 0.002, 0.004 1, 0.0044 % for monocrotophos, dimethoate and quinalphos, respectively. Twenty µl of the insecticide were applied topically on the thoracic region. Fifteen III instar nymphs were exposed to the sub lethal dosage of each insecticide, separately.

Table 1. Relative toxicity of three insecticides on *R. marginatus*.

Insecticide	Duration (hours)	LC_{50}	Regression Equitation	'r'	Fiducial Limit	P
Monocrotophos	24	0.029	1.949x + 2.15	0.987	0.022-0.039	<0.01
	48	0.020	2.056x + 2.33	0.979	0.016-0.025	<0.01
	72	0.015	2.448x + 2.10	0.989	0.012-0.019	<0.01
	96	0.013	3.129x + 1.52	0.949	0.010-0.016	<0.05
Dimethoate	24	0.073	1.890x + 1.46	0.929	0.051-0.104	<0.05
	48	0.041	2.033x + 1.72	0.948	0.032-0.052	<0.05
	72	0.031	2.227x + 1.68	0.948	0.024-0.039	<0.05
	96	0.025	3.351x + 0.29	0.885	0.020-0.032	<0.05
Quinalphos	24	0.049	4.490x – 2.58	0.995	0.042-0.057	<0.001
	48	0.044	4.644x – 2.64	0.995	0.039-0.050	<0.001
	72	0.039	4.928x – 2.86	0.986	0.036-0.043	<0.01
	96	0.036	5.613x – 3.74	0.972	0.033-0.040	<0.01

A control set up was maintained with fifteen III instar nymphs and they were treated with 201 of water. The experimental, as well as control individuals, were maintained at room temperature (30 ± 2^{o}C). The concentration of the insecticide was maintained continuously for 20 days with fresh application of insecticide everyday and were fed daily. Insecticide treated categories of nymphs were reared to adults. Data on stadial period and age specific survival/mortality were recorded daily. The daily fecundity was recorded until all the females died.

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 in different morphs 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 (SIDDIQUI et al.1973). The weekly multiplication of predator population was calculated as $(e^{r_m})^7$. The doubling time was calculated as log2/logλ.

Results and Discussion

Life table studies indicated that the longevity of ovipositing females of normal *R. marginatus* ranged from 80 – 200 days. The mortality during the nymphal stages is 20%. The first adult mortality within the cohort occurred on the 20th day of oviposition and mortality gradually increased thereafter (Table 2). The duration of immature stages lasted for 80 days. The adults attained maximum mean progeny production per day (m_x) of 20 female per female on the 1st day of oviposition and production ceased on the 100th day after oviposition. In contrast to the above analysis, the life table analysis of insecticide treated *R. marginatus* females showed that the longevity of the ovipositing females ranged from 60 – 185 days, 70 – 200 days and 75 – 185 days in monocrotophos, dimethoate and quinalphos treated categories, respectively. Insecticides also altered the nymphal mortality. It was 40, 30 and 25% in the monocrotophos, dimethoate and quinalphos treated categories. The adult mortality caused within the cohort was also varied by the insecticides. The first adult mortality within the cohort occurred on the 10th, day of oviposition in all the insecticide-treated insects (Tables 3, 4, 5). Insecticides also altered the duration of immature stages. They were 92, 88 and 85 days for the insecticides monocrotophos, dimethoate and quinalphos, respectively. Alterations in the maximum mean progeny production was also noticed by the application of insecticides. The maximum mean progeny production was noticed on the first day of oviposition and is 12, 15 and 16 female per female per day.

Table 2. 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
0-80 immature						
90	0.80	20.0	16.0	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	154.818	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	0.35	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	0	0
		90.0	59.20	6534.00	4065.561	541.205

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

x	l_x	mx	l_xm_x	l_xm_xx	Trial r_m	
					0.026	0.046
0-92 immature						
105	0.60	12.0	7.20	756.00	1634.481	200.153
115	0.55	10.0	5.50	632.00	1074.648	107.743
125	0.50	8.0	4.00	500.00	672.697	55. 218
135	0.40	5.0	2.00	270.00	289.498	19.456
145	0.30	5.0	1.50	217.50	186.880	10.282
155	0.25	4.0	1.00	155.00	107.233	4.831
165	0.20	3.0	0.60	99.00	55.378	2.043
175	0.15	3.0	0.45	78.75	35.748	1.079
185	0.15	1.0	0.10	18.50	6.837	0.169
		51.0	22.35	2727.25	4063.400	400.974

Table 4. Life and age specific fecundity table of dimethoate exposed *R. marginatus*.

x	l_x	m_x	l_xm_x	l_xm_xx	Trial r_m	
					0.026	0.046
0-88 immature						
100	0.70	15.0	10.50	1050.00	1722.230	233.078
110	0.60	12.0	7.20	792.00	976.604	108.211
120	0.55	10.0	5.50	600.00	616.925	55.966
130	0.50	10.0	5.00	650.00	463.793	34.44
140	0.40	4.0	1.60	224.00	122.732	7.463
150	0.30	5.0	1.50	225.00	95.151	4.737
160	0.25	3.0	0.75	120.00	39.343	1.604
170	0.20	2.0	0.40	62.00	17.352	0.579
180	0.15	2.0	0.30	54.00	10.762	0.274
190	0.10	1.0	0.10	19.00	2.967	0.066
200	0.10	0	0	0	0	0
		64.0	32.85	3862.00	4067.859	446.446

Insecticides reduced the multiplication per generation (net reproductive rate) from 59.20 (control) to 22.35, 32.85 and 34.20 in monocrotophos, dimethoate and quinalphos treated categorie, respectively. Maximum reduction was observed in the monocrotophos treated category followed by dimethoate and quinalphos indicating that monocrotophos had the highest negative impact on the capacity to multiply in a generation in *R. marginatus* (Table 6). This might be due to the hydroxylation processes of the insecticides (CONNEY et al. 1966). The hydroxylation processes of some steroids subsequently reduce the availability of ecdysone by which insecticides increased

the stadial period (AMBROSE, 1999). GEORGE (1996) also reported similar slower developmental rate in three harpactorine reduviids when exposed to topical treatments of insecticides.The values of innate capacity for increase (r_m) also revealed that insecticides reduced the rate of multiplication (0.043 in control was reduced to 0.031, 0.035 and 0.038, respectively, in monocrotophos, dimethoate and quinalphos treated categories). The intrinsic rate of natural increase(r_c) and finite rate of increase (λ) were determined as 0.036 and 1.044, 0.025 and 1.031, 0.029 and 1.036 and 0.032 and 1.038 females/ female/day respectively in untreated and those treated with monocrotophos, dimethoate and quinalphos, respectively. The fecundity rate (m_x) and the reproductive rate (l_xm_x) showed decreasing trends with increasing age in all the categories. However, these rates of increase were attainable only under favourable conditions and also by the sufficient supply of prey larvae *C. cephalonica*. At this rate the population of *R. marginatus* are capable of multiplying 1.351, 1.242, 1.278 and 1.305 times per week and 6.5 x 10^6, 8.2 x 10^4, 3.5 x 10^5 and 1.0 x 10^6 times per annum, respectively. Time required to double the population was calculated as 15.84, 23.154, 20.067 and 18.813 days for normal *R. marginatus* and those treated with monocrotophos, dimethoate and quinalphos, respectively.

Table 5. Life and age specific fecundity table of quinalphos exposed *R. marginatus*.

x	l_x	m_x	l_xm_x	l_xm_xx	Trial r_m	
					0.026	0.046
0-85 immature						
95	0.75	16.0	12.0	1140.00	1627.673	243.449
105	0.70	14.0	9.8	1029.00	1066.761	130.632
115	0.60	10.0	6.0	690.00	524.140	52.549
125	0.50	7.0	3.5	437.50	245.369	20.141
135	0.40	3.0	1.2	162.00	67.513	4.537
145	0.30	3.0	0.9	130.00	40.635	2.236
155	0.20	2.0	0.4	62.00	14.494	0.653
165	0.15	2.0	0.3	49.50	8.724	0.322
175	0.10	1.0	0.1	17.50	2.334	0.070
185	0.10	0	0	0	0	0
		58.0	34.2	3718.00	3597.643	454.589

As mentioned above, life table analysis is the best method to examine pesticide sublethal effects on the population responses of natural enemies. Pesticides can alter every parameter of population growth . The net reproductive rate is much reduced by insecticides. In fact, fecundity seems to be one of the most sensitive biological characteristics to sublethal effects and is the most important in terms of population dynamics.

Similar reduced fecundity was shown by PARKER et al., (1976) in the coccinellid *Menochilus sexmaculatus* Fab. when it was topically treated with sublethal doses of malathion. The reduction in fecundity observed in the present study was correlated with a reduction in longevity and a reduction in the proportion of the life span during which eggs were laid. GROSCH (1975) and PRESS et al., (1981) also reported that adult female of *Bracon hebetor* Say laid a significantly low number of eggs when they were topically treated with carbaryl and permethrin. GEORGE (1996), GEORGE & AMBROSE (1996), MUTHUPANDI (2001) and NAMBIRAJAN (2003) also reported reduced fecundity in insecticides exposed harpactorine reduviids. Maximum reduction in egg output by monocrotophos treated category was attributed due to its higher toxicity. The reduced fecundity by insecticides was caused by the disruption of parental reproductive physiology or it might be due to the lower food intake (AMBROSE, 1999).

Table 6. Insecticidal impact on the life table parameters of *Rhynocoris marginatus*

Parameters	Control	Monocrotophos	Dimethoate	Quinalphos
Gross reproductive rate (Σm_x)	90.00	51.00	64,00	58,00
Net reproductive rate ($R_o = \Sigma l_x m_x$)	59.20	22.35	32.85	34.20
Mean length of generation ($T_c = \Sigma l_x m_x X/R_o$)	110.37	122.02	117.55	108.71
Estimated value of intrinsic rate of increase in numbers (r_c)	0.036	0.025	0.029	0.032
Corrected r_m ($e^{7-r_m} X\ l_x m_x$ = 1096.6) (female/female/day))	0.043	0.031	0.35	0.038
True generation time (T = loge R_o/r_m)	94.91	100.22	99.77	92.95
Finite rate of increase in numbers (λ= anti log er_m)	1.044	1.031	1.036	1.038
Doubling time (days) (log 2/log λ)	15.84	23.15	20.07	18.81
Weekly multiplication rate	1.351	1.242	1.278	1.305
Annual rate of increase	6.5×10^6	8.2 x 104	3.5×10^5	1.0 x 106

Sublethal doses of insecticides also reduced the longevity of an individual as observed by KOT & PLEWKA (1970), PLEWKA et al., (1975) and SINGH et al., (1979) on the egg parasitoid *Trichogramma evanescens* Westwood and GROSCH & HOFFMAN (1973) in *B. hebetor*. Similar observations were reported by PARKER et al., (1976) in *M. sexmaculatus*, SHOUR & CROWDER (1980) in *Chrysopa carnea* Stephens and GEORGE & AMBROSE (1998, 1999 a, b, 2000) on three harpactorine reduviids. The developmental rate was also influenced by the insecticides. ADAMS (1960) was one of the first to note developmental rate differences in a natural enemy species exposed to sublethal doses of a pesticide. He observed an increase in the mean time to pupate when the coccinellid *Coccinella transversoguttata* was treated with the herbicide. LAWRENCE et al., (1973) also observed slower developmental rate in the pupae of *Chrysoperla carnea* exposed to topical treatments of carbaryl. The lowest longevity and the highest developmental time observed in monocrotophos treated category might be due to its higher toxicity. Similar enhanced developmental rate was recorded by GEORGE & AMBROSE (1998, 1999a, b) on three harpactorine reduviids, MUTHUPANDI (2001) on *R. kumarii* and NAMBIRAJAN (2003) on *R. marginatus*.

The variation in the life table parameters of *R. marginatus* treated with the insecticides clearly revealed that insecticides reduced the reproductive capacity, longevity and enhanced the developmental time. These studies suggest that these three commonly used insecticides monocrotophos, dimethoate and quinalphos in the agroecosystems could affect the physiology of non-target reduviid biocontrol agents such as *R. marginatus*. Hence, screening of insecticide is imperative to safeguard the non-target beneficials such as *R. marginatus* which is an excellent ecofriendly biological control agent predating upon various insect pests.

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