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Impact of insecticide Synergy-505 on the functional response of a non-target reduviid predator *Rhynocoris marginatus* (Fabricius) (Heteroptera: Reduviidae) feeding on *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)

DUNSTON P. AMBROSE, S. JESU RAJAN and A. GANESH KUMAR
Entomology Research Unit, St.Xavier's College (Autonomous),
Palayankottai 627 002, Tamil Nadu, India.
E-mail: eruxavier@sancharnet.in

ABSTRACT: Functional response studies in normal and Synergy-505 exposed adult males and females of *Rhynocoris marginatus* (Fabricius) feeding on *Spodoptera litura* (Fabricius) revealed Holling's type II curvilinear decelerating responses. However, Synergy-505 caused less pronounced type II functional response with reduced number of prey killed, attack rate and searching time and prolonged handling and recovery times in both adult males and females of *R. marginatus* reflecting reduced predatory potential.

KEY WORDS: Assassin bug, functional response, *Rhynocoris marginatus*, *Spodoptera litura*, Synergy-505.

INTRODUCTION

Biological control is a cornerstone of integrated pest management (IPM) and the contribution of predators such as assassin bugs in the regulation of insect pest populations is well recognized (Ambrose *et al.*, 2006; Grundy and Maelzer, 2000). Ambrose (2000) reported that the multivoltine voracious harpactorine reduviid predators could be effectively used in biological control programmes especially for lepidopteran caterpillars in cotton, castor and lady's finger. Generalist predators like them may consume virtually any arthropod they are able to capture, which allows them to establish and maintain high population densities and thereby suppress herbivore populations (Murdoch, 1985; Settle *et al.*, 1996; Cisneros and Rosenheim, 1997, 1998; Ambrose, 2000).

In IPM programmes, incorporation of natural enemies is possible only when they are protected from broad-spectrum biocides that have profound effects on non-target predators and parasites in agroecosystems (Croft, 1990). Hence, biorational insecticides that are comparatively safer and/or least toxic to beneficials but effective against target pests must be identified, promoted and incorporated in IPM programmes. Such screening of insecticides is imperative to safeguard the non-target beneficials such as reduviids from the hazardous effects of insecticides (Ambrose, 2001; Claver *et al.*, 2003; George and Ambrose, 2000 and 2004).

Although the dynamics of predator-prey

relationship are generally complex, the functional response or relationship between the number of prey consumed by the predator and the prey density is almost common (Solomon, 1949; Holling, 1959; Hassell, 1978). Functional response governs population biology, evolutionary biology, ethology and physiology because it links together different trophic levels in population biology and determines energy intake and mortality risk and thus influences evolutionary biology, animal behaviour and short as well as long-term physiological responses of individuals (Jeschke *et al.*, 2004). Natural enemies exhibit four types of functional responses (Holling, 1959; Hassell, 1978). The reduviids exhibit type II curvilinear decelerating functional response (Ambrose, 2000).

Since insecticides affect the functional response of reduviids (Claver *et al.*, 2003), an attempt was made to study the toxicological effects of Synergy-505 on the functional responses of adult males and females of *R. marginatus* feeding on the larvae of *S. litura* in the laboratory. Such baseline information will enable one to understand the specific type of functional response of this reduviid and the suitability of Synergy-505 in IPM against *S. litura* larvae where harpactorine reduviids like *R. marginatus* are utilized as biological control agents.

MATERIALS AND METHODS

Adults of *R. marginatus* were collected from Muthurmalai Scrub Jungle (altitude 125.33 ± 2.87 mts; latitude 77Ú21' and 8Ú7'N), Tirunelveli District, Tamil Nadu, South India. They were reared in the laboratory (28.34ÚC temperature; 12±1h photoperiod; 65-70% humidity) in plastic containers (16 x 7cm) separately on the larvae of rice moth, *Corcyra cephalonica* (Stainton). The larvae of *S. litura* were collected from castor fields and reared on castor leaves in plastic troughs (32 x 9cm) in the laboratory. The troughs were examined daily and the faecal matter was removed to prevent fungal attack on the larvae.

The optimum toxicity level (40il) of the insecticide Synergy-505 (chlorpyrifos 50% and cypermethrin 5% E.C) derived from the LC_{50} values at 48 h duration was taken as one toxic unit and the 1/10 value was considered as sublethal concentration (Croft, 1990). Sublethal concentrations of the insecticide were applied with a micropipette on 1 x 1cm bits of absorbent paper which were placed in the rearing containers and the insecticide applied absorbent papers were replaced daily. Thirty III nymphal instars were exposed to the insecticide and thirty nymphs were maintained with water sprayed absorbent papers as control. Both the categories of the test individuals were allowed to grow up to adults separately.

The functional responses of both normal and Synergy-505 exposed adult males and females to the larvae of *S. litura* were studied in plastic containers (16 x 7 cm). The prey was first introduced into the container and allowed to settle. Thereafter, a predator was introduced into the container. The functional response was studied at 1, 2, 4, 8 and 16 prey densities. Eight replicates were maintained for each prey density. After 24 hr, the number of prey consumed or killed by the predator was evaluated. The prey number was maintained constant throughout the experiments by replacing the dead or consumed prey with fresh prey. In the present experiment, "disc" equation of Holling (1959) was used to describe the functional response of *R. marginatus*. The relationship between various parameters of functional response in the 'disc' equation such as prey density (x), total number of prey killed in a given period of time (y), the attack ratio (x/y), total time in days when prey was exposed to the predator (Tt), time taken for handling each prey by the predator (t), and rate of discovery per unit searching time (a) were statistically analyzed through regression analysis (Daniel, 1987) and compared among the normal and Synergy-505 exposed *R. marginatus*.

RESULTS AND DISCUSSION

Both normal and Synergy-505 exposed adult males and females of *R. marginatus* responded to increasing prey density by killing a greater number of prey than those at lower prey densities and thus exhibited type II curvilinear decelerating functional response (Holling, 1959) (Fig. 1 & 2) (Tables 1 & 2) as observed in *Acanthaspis pedestris* Stål (Claver *et al.*, 2003), *R. fuscipes* (Claver and Ambrose, 2002), *R. longifrons* (Stål) (Claver *et al.*, 2002) and *Coranus siva* Kirkaldy (Claver *et al.*, 2004).

But Synergy-505 exposed predators could attack less number of prey than the normal predator and thus exhibited a less pronounced type II functional response (Holling, 1959) (Fig. 1 & 2). For instance, at 16 prey density the normal male and female *R. marginatus* attacked 8.00 and 9.67 prey whereas Synergy-505 exposed male and female could attack 4.83 and 5.50 prey (Tables 1 & 2). Females killed more prey than males at all tested prey densities as reported for other reduviids (Ambrose, 2000). However, Perera (1982) observed a typical type II functional response curve (Holling, 1959) for *Encarsia formosa* Gahan parasitizing greenhouse whitefly *Trialeurodes vaporariorum* Westwood on potted lima bean plants (*Phaseolus lunatus* Linnaeus) was shifted to a sigmoid type III curve when synergized pyrethrin was applied as a

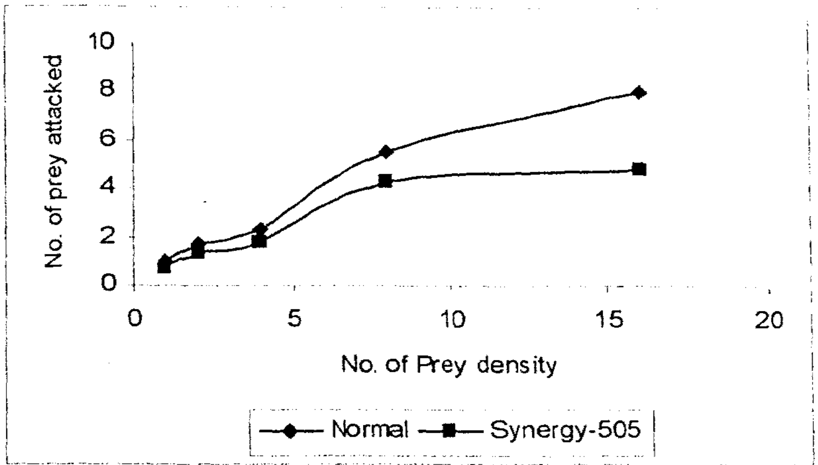

Fig. 1. Cumulative functional response curve of normal and Synergy-505 treated male *Rhynocoris marginatus* to *Spodoptera litura* larva

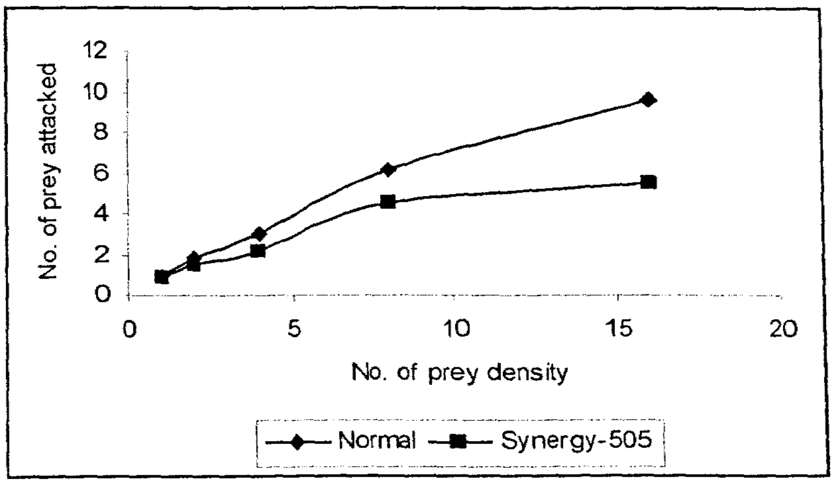

Fig. 2. Cumulative functional response curve of normal and Synergy-505 treated female *Rhynocoris marginatus* to *Spodoptera litura* larva

Table 1. Functional response values for normal and Synergy-505 exposed male *Rhynocoris marginatus* to *Spodoptera litura* larva (n=8) for 6 days

Condition	Prey density (x)	Prey attacked (y)	Attack ratio y/x	Days/y $b = Tt / k$	Days all y's (by)	Days searching $Ts = Tt - by$	Rate of discovery $y/x/T_s = (a)$	Discovery equation $y' = a(Tt - by)x$
Normal	1	1.00	1.0		0.75	5.25	0.190	
	2	1.67	0.835		1.25	4.75	0.176	
	4	2.33	0.583	0.75	1.75	4.25	0.137	$y' = 0.22(6-0.75y)x$
	8	5.50	0.688		4.12	1.87	0.367	
	16	8.00	0.50		6.00	-	-	
Synergy -505	1	0.67	0.670		0.83	5.17	0.130	
	2	1.33	0.665		1.65	4.35	0.153	
	4	1.83	0.458	1.24	2.27	3.73	0.123	$y' = 0.32(6-1.24y)x$
	8	4.33	0.541		5.37	0.63	0.859	
	16	4.83	0.302		6.00	-	-	

Table 2. Functional response values for normal and Synergy-505 exposed female *Rhynocoris marginatus* to *Spodoptera litura* larva (n=8) for 6 days

Condition	Prey density (x)	Prey attacked (y)	Attack ratio y/x	Days/y $b = Tt / k$	Days all y's (by)	Days searching $Ts = Tt - by$	Rate of discovery $y/x/T_s = (a)$	Discovery equation $y' = a(Tt - by)x$
Normal	1	1.00	1.0		0.620	5.380	0.186	$y' = 0.23(6-0.62y)x$
	2	1.83	0.91		1.135	4.865	0.188	
	4	3.00	0.75	0.620	1.860	4.140	0.181	
	8	6.17	0.77		3.825	2.175	0.354	
	16	9.67	0.60		6.0	-	-	
Synergy -505	1	0.83	0.83		0.906	5.094	0.163	$y' = 0.25(6-1.091y)x$
	2	1.50	0.75		1.637	4.363	0.172	
	4	2.17	0.54	1.091	2.367	3.633	0.149	
	8	4.50	0.56		4.909	1.091	0.513	
	16	5.50	0.34		6.0	-	-	

uniform cover spray on the bean leaves.

Both in normal and Synergy-505 treated male *R. marginatus*, the highest attack ratios (1 and 0.67) were found at 1 prey/predator density and the lowest attack ratios (0.5 and 0.302) at 16 prey/predator density ($y = 0.882 - 0.026x$; $r = -0.79$ and $y = 0.667 - 0.023x$; $r = -0.891$ for normal and Synergy-505 exposed predators), but the attack ratios were reduced by Synergy-505, irrespective of prey densities in both male and female. Such prey density dependent attack ratios ($y = 0.949 - 0.023x$; $r = -0.902$ and $y = 0.783 - 0.029x$; $r = -0.917$ at 1 and 16 prey densities for normal and Synergy-505 exposed predators) were also observed in other reduviids (Ambrose, 2000; Ambrose *et al.*, 2000; Claver *et al.*, 2003). The attack ratios were greater in females than in males (Ambrose, 2000). It is presumed that the predators spent less time on searching activities that in turn might have caused a perceptive decline in their attack rate until hunger was established. Similar insecticides-affected attack ratios were recorded in cypermethrin (Ambrose *et al.*, 2005) and in deltamethrin (Ambrose *et al.*, 2006) exposed *R. marginatus*.

The maximum predation represented by 'k' value was restricted to the higher prey density (16) for both normal and Synergy-505 exposed male (8.0 and 4.83) and female (9.67 and 5.50) *R. marginatus* (Tables 1 & 2). It is due to the fact that at higher prey density the predator spent less time on searching its prey and utilized all its time in attacking and consuming. The 'k' values were uniformly higher in females than in males. But Synergy-505 reduced the rate of predation as evidenced by showing almost half of the normal 'k' values. Croft (1990) reported that insecticide-exposed natural enemies exhibited a decreased feeding rate or altered food preference. Similar decreased feeding rates were also observed in cypermethrin (6.53 to 2.60) (Ambrose *et al.*, 2005) and deltamethrin (6.53 to 3.03) (Ambrose *et al.*, 2006) treated *R. marginatus* and cypermethrin treated *A. pedestris* (5.80 to 1.73) (Claver *et al.*, 2003).

The searching time decreased as the prey density increased in both normal and Synergy-505 exposed male ($y = 5.443 - 0.358x$; $r = -0.983$ and $y = 4.952 - 0.351x$; $r = -0.925$, respectively) and female ($y = 5.545 - 0.360x$; $r = -0.992$ and $y = 4.955 - 0.342x$; $r = -0.952$, respectively) *R. marginatus*. The males more quickly searched the prey than females. Synergy-505 did not significantly alter the searching time of this predator as observed in cypermethrin (Ambrose *et al.*, 2005) and deltamethrin (Ambrose *et al.*, 2006) exposed *R. marginatus*. However, *A. pedestris* exposed to cypermethrin took longer time to search the prey (Claver *et al.*, 2003). Endosulfan and permethrin repelled the hymenopteran parasitoid *Trichogramma pretiosum* Riley (Jacobs *et al.*, 1984) from searching its prey. Such insecticide repellency affecting the searching behaviour was also reported for natural enemies belonging to Aphelinidae, Syrphidae and Trichogrammatidae (Ambrose, 2001).

The handling time decreased as the prey density increased in both normal and Synergy-505 treated *R. marginatus* because the resting time of the predator at lower prey density was much longer than that at higher prey density. Females quickly handled the prey than males as observed in several other reduviids (Ambrose, 2000). However, Synergy-505 prolonged the handling time from 0.75 to 1.24 days in male and from 0.620 to 1.091 days in female *R. marginatus*.

Though sex as well as prey densities do not significantly influence the rate of discovery (a), it was affected by Synergy-505. For instance, at 8 prey density, it was shifted from 0.367 (normal) to 0.859 (Synergy-505) and from 0.354 to 0.513 in male and female predators (Tables 1 & 2). The altered attack ratio, handling time and rate of discovery observed in Synergy-505 exposed *R. marginatus* were due to its decreased feeding rate or altered food preference. Similar effects were reported in cypermethrin (Ambrose *et al.*, 2005) and deltamethrin (Ambrose *et al.*, 2006) exposed *R. marginatus* and in cypermethrin exposed *A. pedestris* (Claver *et al.*, 2003).

From the foregoing account, it is clear that Synergy-505 negatively affected the functional response events. It reduced the number of prey killed, the attack rate and searching time and prolonged handling and recovery times. Thus, Synergy-505 affected the predatory potential of *R. marginatus* feeding on *S. litura* larvae. Hence, it is advisable not to incorporate Synergy-505 along with *R. marginatus* in integrated pest management programme against *S. litura* and to avoid this insecticide in ecosystems where beneficials such as *R. marginatus* live.

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