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Bioefficacy of the predatory reduviids *Rhynocoris kumarii* on the hemipteran pests of —cotton, *Dysdercus cingulatus*, and *Phenacoccus solenopis*

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Abstract

Mealy bugs and Red cotton bugs cause severe damage to cotton. Biological control may provide an affordable and sustainable option for the reduction of these losses. Functional response and stage preference are the tools employed to evaluate the efficiency of a predator. We studied the bioefficacy of 48 hours starved *Rhynocoris kumarii* third, fourth and fifth stadium and adult in petri dishes (9.5 cm X 1.3 cm) with cotton leaves. The stage preference was evaluated from the third instar to adult of *R. kumarii* on all the nymphal stages of *Dysdercus cingulatus* and *Phenacoccus solenopis*. Invariably, the third instar of *D. cingulatus* and *P. solenopis* were preferred by all the tested life stages of *R. kumarii*. The functional response of *R. kumarii* exhibited Holling's type II curvilinear decelerating response where a positive correlation was obtained between the prey density and the number of prey consumed by the predator. The number of *D. cingulatus* killed by *R. kumarii* were 37.4, 40.6, 39, 31.4 preys / predator / day, attack rate wasn0.63, 0.68, 0.65, 0.52 preys / predator, searching time was -2.675, -4.196, -1.535, -1.535 for the third, fourth, fifth and adult predators respectively. With reference to the consumption of *P. solenopis*, the third instar of *R. kumarii* consumed the maximum number of prey (5.0 prey / predator / day) than fourth instar (3.55 preys / predator / day) and fifth instar (3.50 preys / predator / day). The rate of attack of adult female predator was quite low (1.50 preys / predator / day) but fairly consistent. From laboratory observation, it can be concluded that the third to fifth nymphal instars of *R. kumarii* can be used for the management of both *P. solenopis* and *D. cingulatus* in cotton fields.

Keywords: Bioefficacy; *Dysdercus cingulatus*; Functional response; *Phenacoccus solenopis*; *Rhynocoris kumarii*; Stage preference

Introduction

Reduviidae constitute an important group of predatory insects in South India. It is the largest family of predatory land heteropterans and many of its members are found to be potential predators of a number of insect pests (Ambrose 1999; 2000; 2003). Since they are polyphagous, they are not effective on specific pests, but they are valuable predators in situations where a variety of insect pests occur (Ambrose et al. 2009). Predation upon a wide array of insects suppresses the efficacy of any organism which is a prerequisite for its utilization as a biological control agent. The description of a predator's instantaneous feeding rate or predatory impact, as a function of prey density is its functional response (Ghosh and Chandra 2011). The functional response of a predator is a key factor in regulating the population dynamics of predator prey systems in any ecosystem. It describes the rate at which a predator kills its prey at different prey densities and can thus determine the efficiency of a predator in controlling prey populations in biological control programmes in laboratory conditions or in field survey (Oaten and Murdoch 1975). The functional response of a natural enemy offers a good conceptual framework for understanding the action of agents in inundative releases in the field also (Waage and Greathead 1988). The functional response curves can be differentiated by evaluating the parameters such as attack rate and handling time. The attack rate estimates the steepness of the increase in the rate of predation with increasing prey density and handling time is very useful in estimating the satiation threshold. Arthropod predators generally display one of the three types of functional responses. The functional response curves may represent an increasing linear relationship (Type I), a decelerating curve (Type II) or a sigmoidal relationship (Type III) (Pervez and Omkar 2005).

Rhynocoris kumarii (Ambrose and Livingstone) is a harpactorine reduviid, whereas *Dysdercus cingulatus* and *Phenacoccus solenopis* are hemipteran pests. Both the predator and pest are widely distributed in tropical rain forest, scrub jungle and semi arid zone.

The present study was designed to evaluate the predatory efficiency through stage preference and functional response of *R. kumarii* on *D. cingulatus* and *P. solenopis* life stages with body weight of the prey and predator, because of the lack of literature and report available with respect to the specific distribution of *D. cingulatus* and *P. solenopis* in forest ecosystem and their control management.

Materials and method

The pests *D. cingulatus* and *P. solenopis* were collected from the forest ecosystem in Tirunelveli (8.7300° N, 77.7000° E) and Kanyakumari (8.0780° N, 77.5410° E) districts of Tamilnadu and were maintained under laboratory conditions (Temperature 31-32ºC; RH 75-80%; Photoperiod 11-13 hours) in a plastic trough (22x10x14 cm) on soaked cotton seed. The nymphs and adults of *R. kumarii* were also collected from forest ecosystems in Tirunelveli and Kanyakumarii districts of Tamil Nadu and were reared in the laboratory (Temperature 31-32ºC; RH 75-80%; photoperiod 11-13 hours) in separate plastic containers (8x6x4 cm) on *Corcyra cephalonica* (stainton) larvae (Sahayaraj 2007; Sahayaraj and Asha 2010) and *Spodoptera litura*.

The Stage preference of both the pests was studied by exposing all the stages (1^{st} to adult) of prey separately in the petri dish to the predator. Observations were made for 24 hours on the successful predation and the stages of prey preferred. This experiment was repeated five times.

The functional response of predator was assessed separately at six densities viz, 1, 5, 10, 20, 40 and 60 prey / predator. The prey was introduced into the petri dish (9.5 cm dia x 1.3 cm height) with cotton leaf. After selection of the prey the predators were released. Approaching time and handling time were observed. After 24 hours, the numbers of prey consumed or killed were counted. In the present study the disk equation of Holling (1959) was used to describe the functional response of *R. kumarii*. Prey density (x), total number of prey killed in the given period of time (y), and the maximum prey consumed (k) were recorded. Prey attack ratio (y/x), rate of discovery per unit of searching time (a=y/x/Ts), time spent by the predator in searching prey (Ts), total time when prey was exposed to the predator (Tt), the maximum number of prey consumption (k), and the time spent for handling each prey by the predator (b=Tt/k) were calculated using disc equation (Sahayaraj and Asha 2010). Mean number of prey killed by a predator as a function of prey density was subjected to correlation in SPSS software and significance was expressed at 0.05% level.

Result

Third, fourth, fifth and adults of *R. kumarii* responded to the increasing prey density by killing higher number of prey (R) than it killed at lower prey density. This was confirmed by positive correlation recorded between the prey density and the number of prey killed during 24 hours (r=0.09, 0.99, 0.97, 0.75 for third, fourth, fifth and adult of *D. cingulatus* and r=0.97, 0.98, 0.94, 0.98 for *P. solenopis* respectively as seen in **table 1 and 2**). Functional response revealed that prey consumption by *R. kumarii* increased with increase in prey density, which exemplifies Hollings type II functional response. This was further confirmed by the positive correlation, obtained between the prey density and prey killed irrespective of the predator life stages (third, fourth, fifth instars and adults) tested. The maximum predation expressed by 'K' value was always found restricted to high prey density. The weight of the predator and the prey weight were considered for functional response and stage preference. The weight of the third, fourth and fifth instar and adult of *R. kumarii* were 6.63 mg, 14.18 mg, 32.71 mg and 21 mg respectively. All these predator stages preferred the third instar of *D. cingulatus* (11.32 mg) and *P. solenopis* (000). This is due to the high amount of haemolymph and easy handling of the prey helped in killing and feeding. Time spent by the predator for searching (ys) and handling (b) the prey was found to increase gradually as the predator grew older. The same trend was observed for rate of discovery (a). From the life stages observed, maximum and minimum attack ratios were observed in fourth nymphal instar and adult of *R. kumarii* respectively. It can be seen from **Table 1** that the predator spent less time for searching its prey at maximum density. The fifth instar of *R. kumarii* shows highest rate of discovery (9.067) at 40 prey density.

Life Stages	Prey Density	No of prey consumed	Consumed ratio (y/x)	Handling (by)	Days searching (Ts=1-by)	Prey Y'=a(1-by)	Predicted attack Y'/x	Max (Y)	B=by/y	Rate of discovery (a=y/x/Ts)
	1	01	1.0	0.09	0.37	0.99	0.99		0.09	1.098

Third instar	5	3.8	0.76	0.281	0.719	0.75	0.15		0.0739	1.057
	10	5.6	0.56	0.347	0.653	0.56	0.056		0.0619	0.857
	20	14.2	0.71	1.448	-0.448	0.71	0.035		0.1019	-1.584
	40	24	0.6	3.024	-2.024	0.59	0.0147		0.126	-0.296
	60	37.5	0.625	3.675	-2.675	0.623	0.0104	37.5	0.098	-0.233
Fourth instar	1	1	1	0.048	0.952	0.99	0.99		0.048	1.0504
	5	3	0.6	0.342	0.658	0.59	0.12		0.114	0.9118
	10	6	0.6	0.516	0.484	0.59	0.06		0.086	1.2396
	20	14.4	0.72	1.238	-0.238	0.12	0.0006		0.085	0.4911
	40	27.4	0.685	2.466	-1.466	0.68	0.017		0.09	-0.4672
	60	40.6	0.677	5.196	-4.196	0.676	0.112	40.6	0.13	-0.1613
Fifth instar	1	1	1	0.07	0.93	0.99	0.99		0.07	1.0752
	5	3.8	0.76	0.220	0.78	0.759	0.151		0.0578	0.9743
	10	6.8	0.68	0.462	0.538	0.679	0.067		0.0679	1.2639
	20	13.6	0.68	0.925	0.075	0.679	0.034		0.680	9.0666
	40	30.4	0.76	2.188	-1.188	0.759	0.018		0.0719	-0.6397
	60	39	0.65	2.535	-1.535	0.649	0.010	39	0.065	-0.4234
Adult	1	1	1	0.05	0.95	1.000	1		0.05	1.053
	5	3.6	0.72	0.55	0.45	0.72	0.144		0.153	1.6
	10	7.8	0.78	0.067	0.933	0.056	0.0005		0.0008	0.836
	20	14	0.7	0.091	0.91	0.699	0.0349		0.0006	0.769
	40	25.8	0.645	0.0542	0.95	0.644	0.0161		0.0210	0.678
	60	31.4	0.523	0.039	0.961	0.522	0.0008	31.4	0.0001	0.544

Table 1: Functional response of *Rhynocoris kumarii* on *Dysdercus cingulatus.*

Life Stages	Prey Density	No of prey consumed	Consumed ratio (y/x)	Handling (by)	Days searching (Ts=1-by)	Prey Y'=a(1-by)	Predicted attack Y'/x	Max (Y)	B=by/y	Rate of discovery (a=y/x/Ts)
Third instar	1	0.50	0.50	0.72	0.28	0.49	0.49			1.78
	2	1.50	0.75	3.56	-2.56	1.48	0.74			0.29
	4	2.30	0.57	1.76	-0.76	2.28	0.57			0.75
	6	2.70	0.45	2.77	-1.77	2.65	0.44			0.25
	8	4.90	0.61	3.35	-2.35	4.70	0.58			0.25
	10	**5.00**	0.50	2.91	-1.91	4.90	0.49	5.00	0.58	0.26
Fourth instar	1	0.75	0.75	1.94	-0.94	0.75	0.75			1.08
	2	1.60	0.80	2.57	-1.57	1.59	0.79			0.52
	4	2.25	0.56	2.42	-2.84	2.20	0.55			0.47
	6	2.60	0.43	1.27	0.51	2.57	0.42			1.10
	8	3.45	0.35	2.27	-1.27	3.34	0.33			4.07
	10	**3.55**	0.44	2.01	-1.12	3.39	0.43	3.55	0.57	2.35
Fifth instar	1	0.60	0.60	0.18	0.82	0.59	0.59			0.73
	2	1.80	0.90	2.59	-1.59	1.78	0.89			0.56
	4	2.20	0.55	0.32	0.68	2.17	0.54			0.80
	6	2.50	0.41	1.21	-0.21	2.45	0.40			1.95
	8	3.30	0.41	1.45	-0.45	1.52	0.19			0.91
	10	**5.50**	0.55	2.82	-1.82	5.46	0.54	5.50	0.51	0.30
Adult	1	0.40	0.40	0.26	0.74	0.39	0.39			0.58
	2	0.95	0.47	0.51	0.48	0.94	0.46			1.07
	4	1.15	0.28	0.56	0.43	1.13	0.27			0.78
	6	1.60	0.26	0.67	0.33	1.57	0.26			0.86
	8	1.35	0.16	0.58	0.41	1.30	0.16			0.78
	10	1.60	0.16	0.63	0.36	1.58	0.15	1.90	0.38	0.89

Table 2: Functional response of *Rhynocoris kumarii* on *Phenacoccus solenopis.*

Discussion

Rhynocoris kumarii (Ambrose and Livingstone) is an important hunter reduviid. Research on reduviids show that they are distributed in Marunthuvalmalai (Vennison and Ambrose 1990) Sungankadai (Kumar 1993), Godayan (Ambrose and Sahayaraj 1991) Courtallam (Edwin and Ambrose 1996), Azhagarmalai (Kumarasami and Ambrose 1991-1992), Kalakad, Petchiparai, Papanasam and Sivagiri. But in Kalakad, Petchiparai, Papanasam, Sivagiri ecosyatems, they haven't been recorded before.

Rhynocoris kumarii is found to predate on *C. compressus, H. armigera*, (Ambrose 1980, 1987), *P. succinta* (Ambrose and Livingstone, 1987), *M. pustulata* (Kumaraswami 1991), *D. cingulatus* (Ambrose 1995), *M. indica, P. gossypiella, S. lilana, E. scintillians* (Ambrose and Claver 1995a, 1995b), *P. solenopis, E. merinone, C. cephalonica, E. insulana, E. vitella, O. hyalinipennis, E. mollifera, Tribolium confusum Duv, Papillo demoleus Linn., R. clavatus, C. gibbosa, D. indicus, E. atomosa* (Ambrose 1999). The above mentioned reports have mentioned only the preference of the pest. In this present study, the density of the prey was high when compared with the previous studies. The weight of the prey and predator was considered.

Dysdercus cingulatus and *Phenococcus solenopis* are hemipteran pests. They have the following natural enemies namely, *R. marginatus* (Ambrose 1999), *Corianus nodulosus* (Sahayaraj 1997), *Endochus umbrinus* (Sahyaraj 1991), *R. kumarii* (Ambrose 1995), *Ectomocoris tibialis* (Ambrose 1999), *Neara vividula parasitoid, Antilochus coquebertii* (Yunus and Ho 1980; Zaidi and Zaheer 1985), Mite *Hemipterotarseius sp*. and the nematode *Stenesnema carcocapsae*.

D. cingulatus and *P. solenopis* infest many of the forest plants. So, we investigated the control strategies of these pests in *R. kumarii*, because *R. kumarii* was found to be present in all the plants where *D. cingulatus* and *P. solenopis* were present. These predators are polyphagus bugs that feed mainly on leaf feeding larvae of Lepidoptera, Isoptera, Coleoptera and Hemiptera. Numerous studies have been reported on the predatory potential of reduviids (Sahayaraj 1994a; 1994b; 1995; 2000; 2006; Sahayaraj and Sivakumar 1995; Sahayaraj and Ambrose 1994), but information regarding the predatory potential against *D. cingulatus* and *P. solenopis* has been minimum. Predatory efficiency of these reduviids exhibited type II functional response in *A. cranivora* and also other reduviids (Sahayaraj 1991; Sahayaraj and Raju 2006). Here, the results show the inversely proportional relationship between attack and prey level. It is presumed that the predator required less time to search the prey and more time on non-searching activities at higher prey densities, which in turn might have caused perceptive decline in the attack rate until hunger was established. Moreover, higher prey density also result in reduction in unsuccessful attacks of a predator on a prey, as there are less chances of escape when compared to those in scarce prey density, where there are more chances for the prey to escape from the predator (Sahayaraj 2006). Hunger and time spent by the predator in searching and handling the prey can affect the prey consumption and eventual preparation of the predator for further search.

In this study, third, fourth, fifth instars and adult prefer the third instar of *D. cingulatus* and *P. solenopis*. It may be due to the haemolymph content of the pest and its mobility. From this study, the predator and prey ratio of third, fourth, fifth instar and adult of *R. kumarii* was 1:38, 1:41, 1:39, and 1:31 for *D. cingulatus* and 1:5, 1:3.55, 1:3.5 and 1:2.3 for *P. solenopis* respectively. According to our study, the fourth instar and the third instar of *R. kumarii* have the potential to suppress the population of *D. cingulatus* and *P. solenopis* respectively. The correlations between third, fourth, fifth and adult of *R. kumarii* with four instars of *D. cingulatus* are 0.999, 1, 0.995, and 0.989 and with *P. solenopis* are 0.97, 0.98, 0.94, and 0.98. This is significant at 0.01 levels. Multiple comparisons show that the lowest predensity having significant values at 0.05 levels, density 1 has 0.504. The pests *D. cingulatus* and *P. solenopis* are distributed worldwide and they damage cotton crops. In our study we collected these pests in *Cordispermum helicabum* (Scorbularaceae), *Pavonia odarata* (Malvaceae), *Leucus aspera* (Lamiaceae). These plants have considerable medicinal value. *D. cingulatus* and *P. solenopis* are polyphagous. Thus, they are found to shift to other plants when one host plant gets washed out. Hence the control of these pests becomes indispensable in order to protect the medicinal plants.

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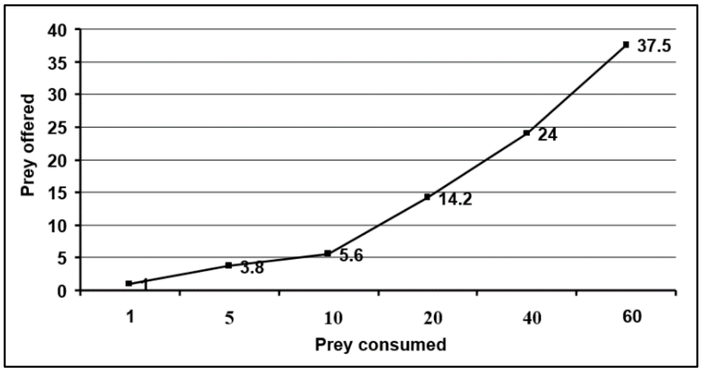

Figure 1. Bioefficacy of *Rhynocoris kumarii* third instar on *D. cingulatus* third instar.

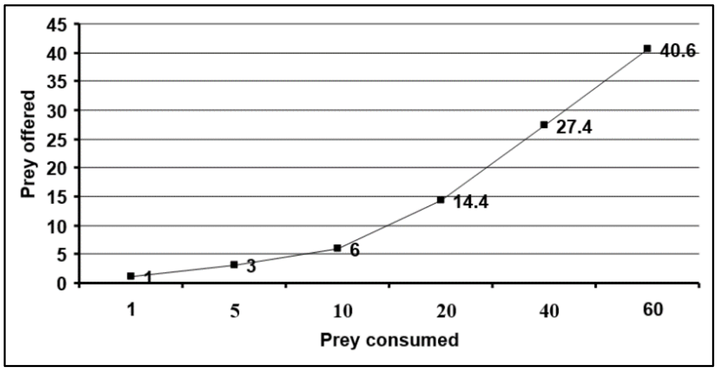

Figure 2: Bioefficacy of *Rhynocoris kumarii* fourth instar on *D. cingulatus* third instar.

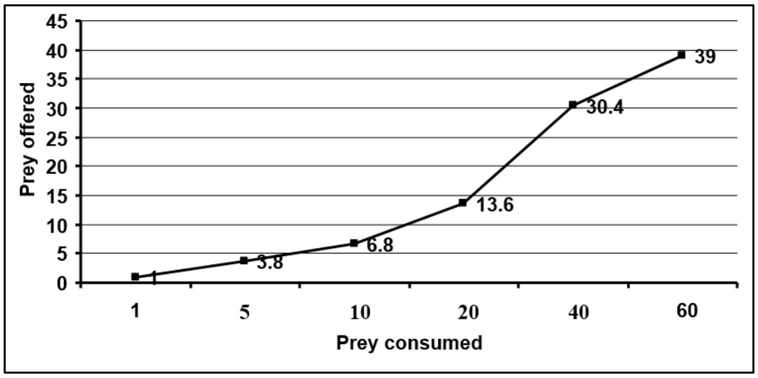

Figure 3: Bioefficacy of *Rhynocoris kumarii* fifth instar on *D. cingulatus* third instar.

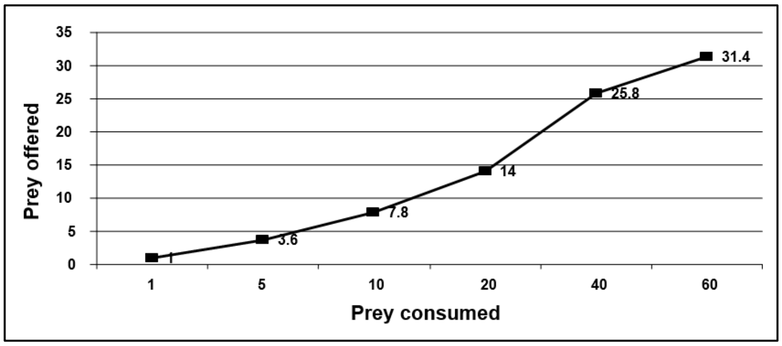

Figure 4: Bioefficacy of *Rhynocoris kumarii* adult *on D. cingulatus* third instar.

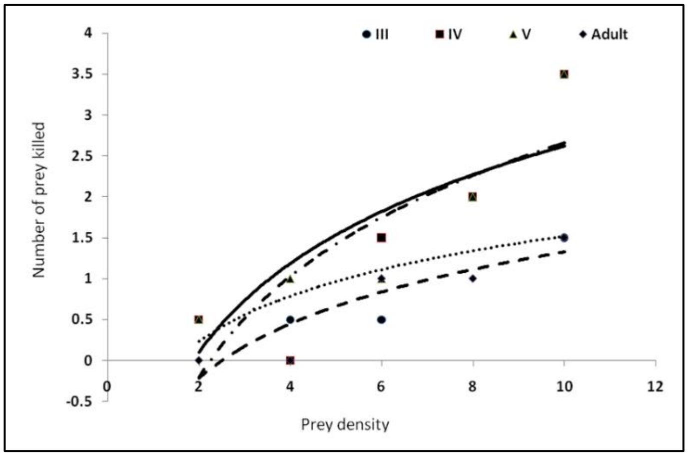

Figure 5: Type II functional response curve of *Rhynocoris kumarii* third, fourth and fifth nymphal instar and adults preying upon different densities of *Phenacoccus solenopsis*.

Citation: *Muthupandi M, Kapilan M, Manimaran A (2025); Bioefficacy of the predatory reduviids Rhynocoris kumarii on the hemipteran pests of —cotton, Dysdercus cingulatus, and Phenacoccus solenopis, Enviro Sci Poll Res and Mang: ESPRM-161*