

Functional response, host stage preference and development of *Rhynocoris fuscipes* (Fab.) (Heteroptera: Reduviidae) for two cotton pests

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ABSTRACT

Considering the indispensable role of reduviid predators in ecofriendly pest management programme, the relationship between a predatory reduviid, *Rhynocoris fuscipes*, and three prey species viz., red cotton bug *Dysdercus koenigii* Fab. (Heteroptera: Pyrrhocoridae), cotton mealybug *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) and rice flour moth *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae), were scrutinized and studied to determine the influence of host species on biology, host stage preference and biological control efficiency under laboratory conditions. *Rhynocoris fuscipes* completed nymphal stage in 41 days when feeding on *C. cephalonica*, 45 on *D. koenigii*, and 50 days on *P. solenopsis*. Adult longevity, fecundity and egg viability were higher in *C. cephalonica* fed category and the lowest on *P. solenopsis*. Life table parameters were in favor of *C. cephalonica*. Third instars of *D. koenigii* were favored by third and fourth instars of the predator. Fifth instars and adults of the predator had chosen fourth and fifth instars of *D. koenigii*, respectively. All instars of predator preyed on adults of *P. solenopsis*. It is observed that the reduviid responded to increased *D. koenigii* and *P. solenopsis* density with type II functional response. Positive interactions distinctly imply that there is a salutary effect on the pest as well.

Keywords: Biocontrol; cotton pests; comparative biology, life table; *Rhynocoris fuscipes*, Functional response

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INTRODUCTION

One of the significant impediments ruining cotton cultivation is insect pest infestation. The red cotton bug, *Dysdercus koenigii* Fab. (Heteroptera: Pyrrhocoridae) (Arbind and Mayank, 1999), and *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) (Abbas *et al.*, 2010) specifically cause genuine harm by benefiting from developing cotton bolls and ripe cotton seeds, also by spreading fungi that develop on the lint and seeds. These pests are hard to control by insecticides due to the high mobility of red cotton bugs (Kohn and Bui Thi 2004) and the white waxy deposits of mealy bugs (Sunitha *et al.*, 2020). Therefore, the benefit of natural enemies to regulate these pests should be considered. Natural enemies can

be used in cotton fields as well as in vegetative stands containing wild host plants of these pests. It is observed that several insect predator species including reduviids have been feed on *Dysdercus cingulatus* Fab. (Heteroptera: Pyrrhocoridae) (Sahayaraj, 2014) and *P. solenopsis* (Tanwar *et al.*, 2007; David *et al.*, 2009) in India. *Rhynocoris fuscipes* is the most abundant reduviid predator in cotton agroecosystems (Sahayaraj, 2007; Kalidas and Sahayaraj, 2012) and is reported to feed on more than 40 insect pests of economical importance (Ambrose and Claver, 1999, Sahayaraj, 2007, Tomson *et al.*, 2017). Reproductive performance of this predator is low when reared on lepidopteran insects like *Spodoptera litura* Fab., and *Earias vittella* Fab. (George *et al.*, 2000). Remarkably, the

potential of the reduviid species as a biological control agent was evident under laboratory (Ambrose and Claver, 1997; Sahayaraj *et al.*, 2020) and field conditions (Tomson *et al.*, 2017).

The growth, advancement and proliferation of the reduviid predators vary in relation to preys (Bass and Shepard, 1974). The present study is really influential since it delves deep into the impeccable role of *D. koenigii* and *P. solenopsis* in various crops particularly the cotton. In order to understand the predator dynamics, construction of the life table for a predator species is relevant. Poignantly, the area regarding the vital role *D. koenigii* and *P. solenopsis* in curbing pests is almost untouched and currently, *no* information is available about the influence of *D. koenigii* and *P. solenopsis* on the life history, prey stage preference and bioefficacy of this predator. Hence, the biology, life table parameters, and bioefficacy were recorded for this predator under experimental environment.

MATERIALS AND METHODS

Collection and maintenance of predator and pests Cotton seedlings (SVPR variety 2) were individually maintained in 25 cm diameter cement pots in a screen house at St. Xavier's College Campus until they were about 25 cm tall and apposite for rearing red cotton bug and cotton mealy bugs. The seedlings were irrigated twice a week, and followed local practices. Separate cultures of the red cotton bug and the cotton mealy bug were reared on 20 potted cotton plants. *Dysdercus koenigii* and *P. solenopsis* originated from specimens collected on cottons at Vallanadu (Latitude: 8.7177N, Longitude: 77.8491E). Laboratory reared *Corcyra cephalonica* (CCL) were utilized in these tests.

Rhynocoris fuscipes nymphs and adults were collected from cotton crops cultivated in and around Tirunelveli and Kanyakumari districts, Tamil Nadu, India. They were sustained in rearing under experimental conditions [temperature of $28 \pm 2^\circ\text{C}$, 60-70% RH and photoperiod of 11: 13 (L:D) hrs] in transparent plastic containers (15cm wide/width and 8cm long) while been fed with immature stages of *C. cephalonica*, *D. koenigii* (DKN) and *P. soleno*

psis (PSN) in equal numbers (3 each/day).

Developmental Biology and life table of predator

The study comprised of three experiments. First and foremost, the experiment assessed the impact of common and factitious preys on the developmental biology of the reduviid predator. In this study, freshly hatched (≤ 24 h old) *R. fuscipes* nymphs were used. Third-instar *D. koenigii* and *P. solenopsis* nymphs [colonies maintained at Crop Protection Research Centre (CPRC)], were offered to each nymph. One reduviid nymph was placed in a 300-ml transparent plastic container. For each prey, 50 replications were maintained. Based on trail basis two or three prey (nymphs or larvae or adult) per day were provided for each predator nymphs all through the experiment. Moreover, Consumed preys and predator exuviae were removed and replaced every 24 h. The duration of nymphal development and mortality of the predator on each pest species was noted until adult eclosion. The emerged adults were sexed, and weighed using mono-pan Balance (Dhona, India). Sex ratio of the emerged adults was calculated (number of females emerged /total number of adults emerged).

After the appearance of adult insects, each *R. fuscipes* male and female pair was released into a 500-mL plastic cup for mating. For the duration of pre-oviposition period, adults were reared on the same prey species from which they had been reared. Each *R. fuscipes* pair received three to four *D. koenigii* (DKN) and *P. solenopsis* (PSN) or *C. cephalonica* (CCL) per day. Recordings were completed on the length of the pre-oviposition period, the number of egg groups, the number of eggs in a group, the total number of eggs laid over the life-time, the oviposition time, oviposition index and the post-oviposition time (last egg laying day to till the end of the death).

Different batches of reduviid eggs were allowed to hatch in 1-L plastic containers sheltered with netted lids. The newly emerged nymphs were reared under laboratory conditions as specified above. The life table of the predator was constructed as per Southwood *et al.* (2009).

The rate of increase was determined by using the following formula:

$$\sum e^{-rmx} l_{mx} = 1 \text{ (or) } \sum e^{-rmx} l_{mx} = 1096.6 \text{ (constant)}$$

Gross Reproductive Rate (GRR)

Net reproductive rate, ($R_0=l_{mx}$), the rate of multiplication of the population in each age group was calculated in terms of the numbers of females produced per generation. The approximate mean length of generation time (T_c) was calculated as, $T_c = \sum l_{mx}/R_0$

The arbitrary value of innate capacity for increase (rc) was calculated (Laughlin 1965) using the formula: $rc = \log e R_0 / T_c$

It was the arbitrary value of 'rm'. Since the value of e^{-rmx} obtained from experiments often lay outside the range, both sides equation were multiplied by a factor of $\sum e^{-rmx} l_{mx} = 1096.6$. The innate rate of increase (λ) was intended as $\lambda = \text{antilog } e^{rm} / \text{female/day}$. The weekly multiplication of the predator was calculated as ($\text{antilog } e^{rm}$). The doubling time (DT) was calculated as $DT = \ln 2 / rm$.

Prey life stage preference

To evaluate whether *R. fuscipes* nymphs and adults shown an inclination for different life stages of *D. koenigii* and *P. solenopsis*, and whether preference varied among predator life stages. In Choice tests, a reduviid nymph from one of the three nymphal instars or a adult was supplied with four prey of each of the following life stages: first, second, and third nymphal instar and adult *P. solenopsis* or all life stages of *D. cingulatus* (first, second, third, fourth and fifth nymphal instar and adults) for 16 and 24 total prey per test respectively. Prior to each test, prey insects were reassigned to a piece of cotton leaf (64 mm²) in a Petri dish (9-cm diameter) with the lower surface of the leaf looking up. One *R. fuscipes* nymph was then established onto the leaf. Remarkably, this method limited the reduviid and the prey on the leaf all through the experiment. Reduviids used for this test in the second day of each instar and adult were fed the meat-based artificial diet until tests began to evade probable consequences on prey preference due to hunger.

Functional response

Test fields comprised of glass Petri dishes (9.0-cm in diameter). A cotton leaf was placed in each arena in order to mimic a natural environment. To evaluate the functional response, 10 newly hatched predators were used in each one of the densities of *D. koenigii* third instar nymphs (1, 2, 4, 8, and 10) and *P. solenopsis* adults (1, 2, 4, 8 and 16). The different life stages of *R. fuscipes* (third, fourth and fifth instar nymphs and adults) were evaluated on various pest species at various densities. Firstly, the prey was brought into the compartment and was permitted to agree to 15 min. It was followed by the entry of a predator and the quantity of prey devoured or slaughtered after 24 h was examined. All the functional response parameters were investigated independently for the two bug species and prey life stages. The trials were recreated 10 times for each prey species.

Statistical analysis

The modified "Holling disc equation" (Holling, 1959), i.e. the 'random predator equation' (Rogers, 1972), was utilized to decide the functional response of *R. fuscipes* on *D. koenigii* and *P. solenopsis*. Prey density (N_0), total number of prey killed in a given period of time (N_e), and the maximum prey consumed (k) were confirmed. Prey attack ratio ($E = N_e / N_0$), rate of discovery per unit of searching time [$a = (N_e / N_0) / T_s$], time spent by the predator in searching for the prey (T_s), and time spent for handling each prey by the predator ($b = T_h / k$) were calculated using 'random predator equation'. Data of prey attack ratio (N_e / N_0) was converted in to prey attacking efficiency (PAE) by multiplying with 100 ($PAE = N_e / N_0 \times 100$). Correlation was carried out between the number of prey provided (N_0) and prey consumed (N_e) and also between observed prey consumed (N_e) and calculated prey consumed (y') by the predator. Mean number of prey attacked by a predator in relation to prey density was subjected to ANOVA and the significance was expressed at 5% level. Developmental time and adult weight of the reduviid reared on DCN and PSN were evaluated using analysis of variance (ANOVAs) with CCL as fixed variables. The influence of the feeding regime on

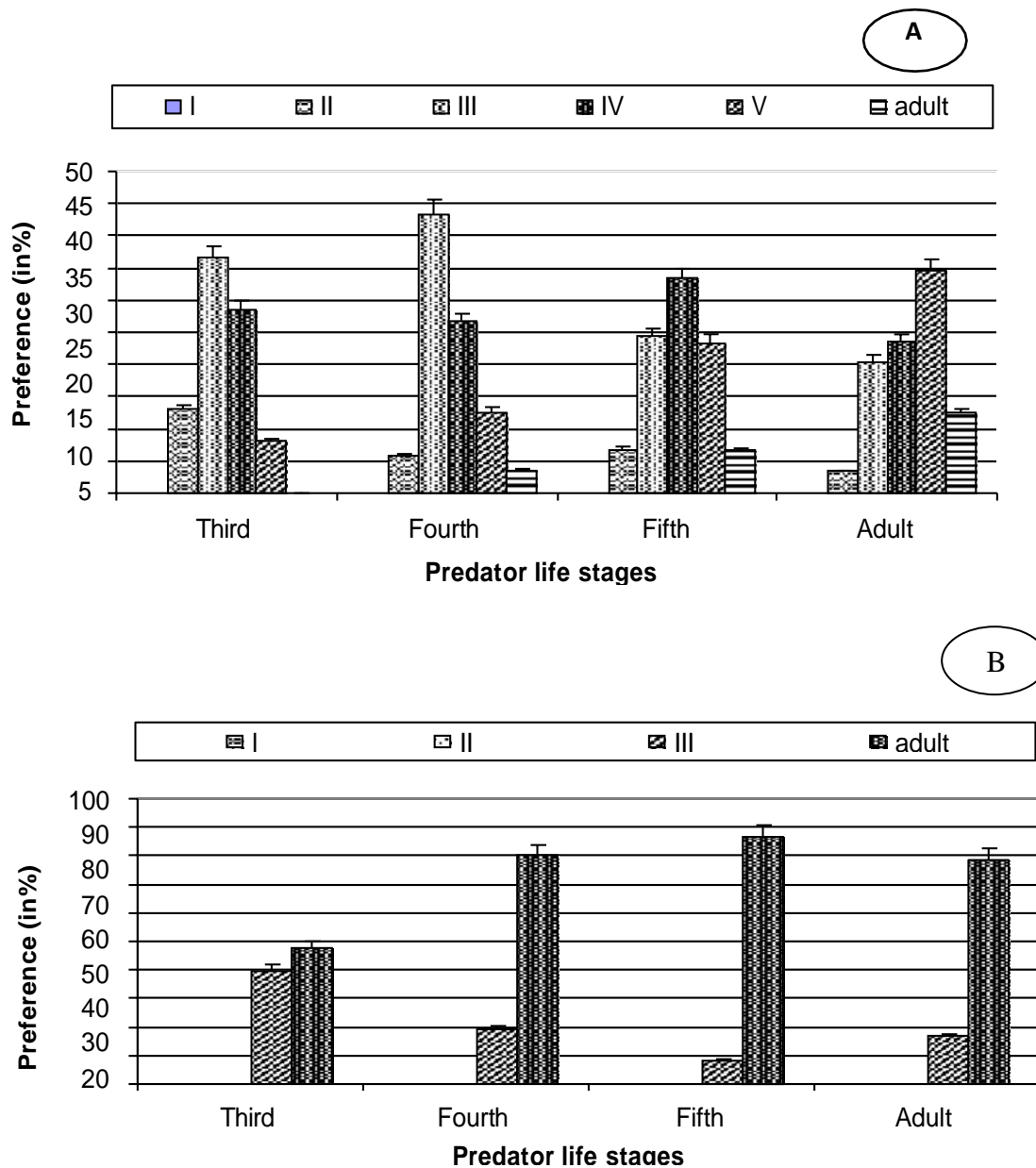


Figure 1. Stage preference of *R. fuscipes* life stages on the nymphs (first -I, second -II, third -III, fourth - IV and fifth - V instar) and adults life stages of *D. koenigii* (A) and *P. solenopsis* (B)

nymphal survival was analyzed using one-way ANOVA and Tukey test. Correlation was recorded between the attack ratios (N_e/N_o) and predicted attack ratio (Y'/N_o). All analyses were performed using the SPSS statistical software (Version 11.5) and all statistical tests were carried out at 5% level of significance ($\alpha = 0.05$).

RESULTS

Nymphal development and survival

The duration of incubation period of the predatory reduviids was slightly more prolonged when it fed on the DCN ($F = 3.399$, $df = 4, 176$,

$P = 0.01$) and PSN ($F = 3.432$, $df = 4, 155$, $P = 0.01$) when compared to feeding on CCL (Table 1). It is observed that the nymphal period was shortened when reared on *C. cephalonica* when compared to feeding on *D. koenigii* ($F = 2.550$, $df = 14, 48$, $P = 0.008$) or *P. solenopsis* ($F = 4.125$, $df = 11, 51$, $P = 0.005$). The nymphal survival rate decreased while the predator grew older. The total nymphal survival was significantly lower in DCN ($P = 0.03$) and PSN ($P = 0.02$) when compared to the CCL (58.8%) using Tukey test.

Table 1. Egg and nymphal developmental period (days, mean \pm SE) of *R. fuscipes* when reared on a factitious (*C. cephalonica*) and two hemipteran cotton pests *D. koenigii* and *P. solanopsis*.

Life stage	Prey		
	<i>C. cephalonica</i>	<i>D. cingulatus</i>	<i>P. solanopsis</i>
Egg	6.3 \pm 0.1 ^a	6.8 \pm 0.1 ^a	6.5 \pm 0.1 ^a
First instar	7.7 \pm 0.1 ^b	7.9 \pm 0.1 ^a	8.4 \pm 0.1 ^a
Second instar	6.3 \pm 0.1 ^b	7.1 \pm 0.1 ^a	7.4 \pm 0.1 ^a
Third instar	7.9 \pm 0.1 ^b	8.3 \pm 0.2 ^a	8.8 \pm 0.1 ^a
Fourth instar	6.2 \pm 0.2 ^b	7.4 \pm 0.1 ^a	7.8 \pm 0.2 ^a
Fifth instar	7.4 \pm 0.2 ^c	8.3 \pm 0.2 ^b	9.8 \pm 0.2 ^a
Total	41.1 \pm 0.4 ^c	45.6 \pm 0.4 ^b	48.9 \pm 0.3 ^a

Comparison was made among the prey's and significance is expressed at 5% level

Adult mass, longevity and sex ratio

In contrast to those fed with CCL, DCN fed male and female *R. fuscipes* adults were significantly heavier ($F=5.624$, $df=2, 7$, $P=0.026$) than those fed with PSN ($P=0.054$) tested with Tukey test. Highly female biased sex ratio was examined in all the three tested preys [(Female: Male) 1:0.43, 1:0.37 and 1:0.37 for *C. cephalonica*, *D. koenigii* and *P. solenopsis*, respectively]. In general, female predators lived longer than the male predators (Table 2). The male and female adult longevity was significantly shorter for DCN ($P=0.05$ for male) and PSN ($F=3.738$, $df=9, 10$, $P=0.026$ for female) offered predators when compared to the factitious prey, *C. cephalonica* (Table 2).

Fecundity and hatchability

Table 2. Mean survival (days \pm SE), oviposition periods (days \pm SE), fecundity (eggs/female) and hatchability (%) of *R. fuscipes* reared on *C. cephalonica*, *D. koenigii* and *P. solanopsis*

Life stages of predator	Prey		
	<i>C. cephalonica</i>	<i>D. cingulatus</i>	<i>P. solanopsis</i>
Male longevity	40.9 \pm 0.7 ^a	37.6 \pm 0.43 ^b	28.7 \pm 0.5 ^c
Female longevity	46.0 \pm 0.4 ^a	40.5 \pm 0.4 ^b	32.33 \pm 0.5 ^c
Preoviposition	12.7 \pm 0.1 ^c	15.2 \pm 0.2 ^b	16.3 \pm 0.2 ^a
Oviposition	20.4 \pm 0.2 ^a	14.7 \pm 0.17 ^b	10.6 \pm 0.2 ^c
Post-oviposition	11.8 \pm 0.3 ^a	9.4 \pm 0.13 ^b	5.6 \pm 0.3 ^c
Oviposition index	0.082	0.068	0.053
Fecundity	132.6 \pm 0.3 ^a	127.4 \pm 0.1 ^b	121.6 \pm 0.2 ^c
Minimum number of eggs/group/female	4.3 \pm 1.2 ^a	3.8 \pm 1.8 ^a	3.96 \pm 1.3 ^a
Maximum number of eggs/group/female	33.6 \pm 1.2 ^a	28.3 \pm 1.68 ^b	22.4 \pm 1.3 ^c
Hatchability	97.7 \pm 1.5 ^a	97.6 \pm 1.4 ^a	94.4 \pm 2.8 ^b

Comparison was made among the prey's and significance expressed at 5% level

Life table

The life table analysis showed that the gross reproductive rate (GRR) was higher in all the categories than the net reproductive rate (Ro). (Table 3) *Corcyra cephalonica* fed predators exhibited the highest GRR and Ro. The mean length of generation (Tc) was higher in PSN (57

days) than in DCN (55 days) and CCL (53 days) fed predators. Higher innate capacity was recorded in *C. cephalonica* (0.080) followed by *D. koenigii* (0.074). In general, all the life table parameters were in favor of the *C. cephalonica* fed *R. fuscipes* (Table 3).

Table 3. Life table parameters of *Rhynocoris fuscipes* reared on caterpillars of *C. cephalonica*, nymphs of *D. koenigii* and *P. solanopsis*.

Life table parameter	Host insect		
	<i>C. cephalonica</i>	<i>D. koenigii</i>	<i>P. solanopsis</i>
Gross reproductive rate (GRR)	94.32	85.24	67.02
Net reproductive rate (NRR) Ro	72.03	57.97	33.48
Length of generation (Tc)	53	55	57
Innate capacity for increase (rc)	0.080	0.074	0.063
Corrected (rm)	0.084	0.073	0.064
Finite rate of increase (λ)	1.08	1.075	1.07
Weekly multiplication	1.71	1.66	1.56
Doubling time (in days)	8.25	9.49	10.83
Hypothetical female in F2 generation	5188.32	3360.52	1120.9

Stage preference

The third, fourth and fifth nymphal instars and adults of *R. fuscipes* favored third, fourth and fifth nymphal instars of *D. koenigii*, respectively (Fig. 1A). However, consistently all the tested life forms of reduviid preferred *P. solenopsis* adults (Fig. 1B).

Functional response

The functional responses of third, fourth, fifth and adult of *R. fuscipes* were recorded, and the results revealed that the attack ratios decreased with increases in *D. koenigii* and *P. solenopsis* densities. The predators exposed a type II functional curve. The maximum and minimum attack ratio was observed in prey 1 and 10 prey/predator respectively (P=0.039 and P=0.046 for fifth instar nymphs and adult predator respectively) analyzed by Tukey test. Similar trends were observed in *D. koenigii* (P=0.046 and P=0.054 for fourth instar nymphs and adult predator respectively). The attack ratio 'E' and the predicted attack ratio (Y^1/No) were positively correlated for the various stages of the predator ($r=0.99$) and different types of the preys encountered ($r=0.99$). The rate of discover 'a' values were decreased while the prey density considerably increased both for *P. solenopsis* and *D. koenigii*. The observed greatest number of prey eaten (Ne) was great in adult predator at 24

h when *D. koenigii* and *P. solenopsis* were offered as a prey.

DISCUSSION

The biology of predators was affected by a variety of external and internal aspects. Among them, nutrition seems to be the most crucial single factor in distressing the growth and reproduction. For a prey animals groups to be reasonable, it must give exceedingly significant supplements, for example, proteins, sugars, lipids, nutrients and minerals, in adjusted extents and focuses to meet a predator's metabolic necessities (House, 1977). For example, George (2000) found that among several species of lepidopteran prey of the reduviid *R. marginatus*, *Spodoptera litura* Fab. and *Helicoverpa armigera* Hubner (Lepidoptera : Noctuidae) were the most suitable for development. Non-nutritional factors such as sequestered secondary plant metabolites, odor, texture, and mobility of prey additionally assume a large role in prey suitability. For example, instars of *R. marginatus* are probably going to experience trouble when feeding on prey having mandibles (Ambrose *et al.*, 1990), very large and active preys (elusive behavior) and prey with impenetrable integuments (Sahayaraj, 2014). Reduviids fed with *C. cephalonica* larvae had reduced predator total nymphal developmental period and nymphal mortality, shorter pre-oviposition period, and high fecundity,

hatchability and oviposition index. Furthermore, in the majority cases the adults gained more weight (51.4 mg) when sustained on this prey. The adult female body size is often influenced by the nymphal nutrition, which in turn affects the fecundity of the insect.

Stewart *et al.* (1991) pointed out the diet association between female body size and number of ovarioles. This generalization is supported by the results of the present study, wherein the fecundity was higher in *R. fuscipes* reared on *C. cephalonica*, which were heavier as compared to the smaller *R. fuscipes* females reared on *P. solenopsis* (41.2 mg) and *D. koenigii* (48.7 mg). This is in accordance with the results of Phoofolo and Obrycki (1997) that confirms the fact that female body size may be an excellent marker of potential fecundity. The idea of the prey species devoured by the predator majorly affects the fertility of the predators as stated by Enkegaard *et al.* (1997), Hansen *et al.* (1999), Sahayaraj and Selvaraj (2003). Thus the higher fecundity of *R. fuscipes* females reared on *C. cephalonica* may be due to the higher primary nutrients in the latter.

The longevity of female predators fed at different preys did vary due to their nutritional contents as reported by Ambrose *et al.* (1990). The longest nymphal developmental duration was noticed among insects fed with *P. solenopsis*, which might be due to the insufficient nutrients derived from the small size of the prey. Though they are smaller in size and their waxy coating on the surfaces, the predator constrained to catch a higher number of preys to satisfy itself which thusly built up a feeding stress. Similar type of results was reported by Ambrose and Claver (1999). The present study indicates that *C. cephalonica* is the most suitable prey for rearing the reduviid predator considered. Because, *R. fuscipes* nymphs and adults used *C. cephalonica* and *D. koenigii* larvae as efficient prey which shows that they give every essential supplement in sufficient fixation and extent and have a vulnerable integument, texture and *C. cephalonica* scent doesn't present a boundary against larval feeding (George, 2000). The lepidopteron pests have a suitable pest range for the growth of reduviid predators (George, 2000). The most immediate manner by which sustenance can impact the predator biology is on its nymphal

developmental period and nymphal mortality. The results of this investigation show that when fed on *C. cephalonica*, the development of *R. fuscipes* into adult was a little faster than feeding on *D. koenigii* and *P. solenopsis*.

The life table statistics of *R. fuscipes* varied with *P. solenopsis* and *D. koenigii* compared to *C. cephalonica*. The gross and net reproductive rate was higher for *C. cephalonica* reared *R. fuscipes* as compared to *P. solenopsis* and *D. koenigii* fed *R. fuscipes*. This is as per the consequences of George *et al.* (2000), who have attributed such finding to the sharp decrease in the survivorship estimation of parent females. However, the gross and net reproductive rates, innate capacity for increase, intrinsic rate of increase and weekly multiplication declined in the case of *Alloeocranum biannulipes* Montrouzier and Signoret (Hemiptera: Reduviidae) (Loko, 2019). The gross reproductive rate was 43.0, 37.5 and 32.5 on *S. litura*, *E. vittella* and *C. cephalonica* respectively (George *et al.*, 2000). In contrast, the result of the current study explicates that helipteran pests enhanced *R. fuscipes* reproduction (Table 3) and these preys can be used for small scale laboratory production. The values of the intrinsic rate of increase (r), the finite rate of increase (λ) and the population doubling time (DT), which reflect the general impact of prey type on immature development, survival and fecundity, were greater for individuals of *R. fuscipes* fed on larvae of *C. cephalonica*. Greater values for these parameters were due to the quicker immature development time, lower immature mortality, higher daily rate of progeny production and an earlier peak in oviposition. Results obtained during this study are helpful for the further study of population dynamics. Therefore the development of management techniques for the management of *P. solenopsis* and *D. koenigii* pests, as controlled laboratory studies offer insights into the event and population dynamics of insects.

Reduviids are non-specific predators, however some species are legendary to exhibit preference for specific prey once at the same time offered with completely different species. Changes in prey preference related to the age of the predator are well documented among invertebrates,

together with reduviid (Sahayaraj, 2007). It has additionally been accounted for that mean prey size of the predator (Cisneros and Rosenheim, 1997). However, the present findings have shown that the size of the *R. fuscipes* instar did not affect prey selection. For instance, third instar reduviid did not accept adult *D. koenigii*, this inclination decreased and was lost as predators expanded in age. The biological control potential of *R. fuscipes* was previously studied against *Spodoptera litura* (Ambrose and Claver, 1997). However, there are no reports against the two economically important cotton pests considered in the present study. In this study, *R. fuscipes* presented a Type II functional response (Holling 1959), like a few reports on the functional response in *Ectomocoris tibialis* (Sahayaraj 2014), *Antilochus coqueberti* (Kohno *et al.*, 2004) and *Neohamatorrhophus therasii* (Sahayaraj 2014). The proportion of red cotton bug and cotton mealybug preyed by the reduviid life stages increased at a decreasing rate in case of *D. koenigii* and *P. solenopsis* densities, and the proportion of preys fed was not constant (Table 4 and 5). The Type II functional response was more evident at 24 h, conceivably on the grounds that they are insatiable feeders, a level of predator satiation was not reached at 24 h with 10 and 16 red cotton bug and cotton mealybug density, respectively.

Maturing has been considered as a declining change from development to senescence and is broadly concentrated in insects (Rothstein 1982). In any case, past investigations in reduviids concentrated fundamentally on the impacts of maternal and paternal age, age-explicit fertility, and foraging behavior (Sahayaraj, 2014), and barely any examinations with respect to the impacts of maturing on the functional response of predatory insect have been distributed up to this point (Ambrose *et al.*, 1990). This study reveals that the type of functional response shown and the degree of predation by *R. fuscipes* against *D. koenigii* and *P. solenopsis* could be harmfully affected by ageing. *R. fuscipes* exhibited Type II responses at various ages tested, and the degrees of functional response in adults were significantly greater than nymphal life stages. This could be credited to truth that conceptive arrangement began at adult stage and their capacity to react to

expanding prey density indicated that physiological senescence in adults was faster than in nymphs.

The handling time against the prey species diminished after some time and the attack coefficient expanded at 24 h (Table 4 and 5). The maximum attack ratio was observed in prey density 1 and minimum at the higher density might be due to lesser time required to find each prey and more time spent in non searching activities at higher densities. These results can be due to the predators setting aside effort to adapt to the new test field and to another sort of prey. *R. fuscipes* showed attacking of maximum number of *P. solenopsis* (k) than *D. koenigii*, although the calculated handling time was almost the same ($b = 0.03$). Be that as it may, research facility proportion of the functional response provides a biased perspective on the efficiency of predators in the field because, in lab preliminaries, the prey density is falsely high with low inquiry prerequisites and a nonappearance of elective prey (O'Neil, 1997). Field preliminaries of functional response are Field important to comprehend the predatory level of *R. fuscipes* and its adequacy as a biological control agent.

Corcyra cephalonica larvae can be used for the laboratory rearing of *R. fuscipes*. The results confirmed that *P. solenopsis* is a lower quality feed than *D. koenigii* and *C. cephalonica*. The nymphs fed with the former took significantly longer period to develop into adults (50 days), body weight was less (40.4 mg) and laid minimum eggs (22 eggs/female). These differences translated into a significantly lower fitness index ($r = 0.028$) for *D. koenigii* ($r = 0.031$) and for *C. cephalonica* ($r = 0.037$). In general, *R. fuscipes* fed on *P. solenopsis* had extended developmental time but with low reproductive performance. The laboratory results of functional response study recommend that *R. fuscipes* could be considered as a planned possibility for use as a commercial biocontrol agent for *P. solenopsis* and *D. koenigii* in India.

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