Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2024; 12(2): 162-165

Received: 28-02-2024
Accepted: 15-04-2024

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Biocontrol efficiency of *Rhynocoris fuscipes* (Hemiptera: Reduviidea) against *Dysdercus koenigii* (Hemiptera: Pyrrhocoridae), a severe pest of *Abelmuschus esculents*

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DOI: https://doi.org/10.22271/j.ento.2024.v12.i2b.9309

Abstract
An attempt was made under laboratory condition to estimate the functional response of fourth instar of *R. fuscipes* to different prey densities (1, 2, 4, 8 and 16) of *D. koenigii*. Fourth instar of this predator showed a curve linear functional response against first nymph of *D. koenigii*. The prey consumed ratio (y) of *R. fuscipes* was increased as the *D. koenigii* densities(x) increases from *one D. koenigii/ R. fuscipes* to 16 *D. koenigii / R. fuscipes*. The maximum predation rate was restricted to the maximum *D. koenigii* number (3.9). The predation attack ratio (y/x) at less prey density categories was highest. Searching time (Ts) and attack ratio (y/x) were decreased with the increasing prey density. The fourth instar of *R. fuscipes* showed curve linear functional response curve when offered with different prey densities. The killing efficiency was higher at nymphal stage.

Keywords: Ecofriendly, pest management, *Dysdercus koenigii*, *Abelmuschus esculentus*, *Rhynocoris fusipes,* Functional response

Introduction
Two species of red cotton bugs are generally occur in Gorakhpur, Uttar Pradesh, namely *D. koenigii* and *D. cingulatus* (Hemiptera: Pyrrhocoridae). They have always been source of serious damage to crop by feeding on developing cotton balls, and ripened cotton seeds. Both nymph and adults of the genus *Dysdercus* have strong proboscis, a needle like stylet meant for piercing and sucking of plant sap [1, 2, 3]. They are the destructive pest of cotton due to severe lint staining problem [4, 5, 6, 7, 8, 9, 10]. Alternate host plant of *D. koenigii* includes Okra, *Abelmuschus esculentus* (Malvaceae), hollyhock [11] and plant of family Bombacaceae [12]. Okra, *A. esculentus* is the most important vegetable crop of the tropical and subtropical regions of the world. Synthetic insecticides have played an important role in the management of insect pests in order to reduce losses caused by pests and to meet the demand of increasing pest population [13]. However, insects have evolved resistance to all types of insecticides including inorganic, DDT, cyclodienes, organophosphate, carbamates, pyrethroids, juvenile hormone analogs, chitin synthesis inhibitors, neonicotinoids and microbials [14]. Hence, it is necessary to adopt a diversified approach to control *D. koenigii* by increasing the availability of biological control agents. Many invertebrate predators, are available in Okra field, among the predators reduviids are also give an important role in food chain and insect pest managements. Concerning Indian reduviid fauna, there are about 464 species belonging to 144 genera and 14 sub-families [15]. Reduviid predators are resistance to major pesticides [16, 17, 18]. Reduviids are polyphagous assassin bugs being natural predators more than 44 pests of agro-ecosystem without harming human being and other natural enemies [19]. In general reduviid predators are the most abundant natural enemies in annual agroeco-system. *R. fuscipes* are predominantly and potential predators in crops like Okra, soyabean, chilli, maize, cotton and Cowpea [20].
Prey Stage preference was evaluated in both choice and non-choice tests. Second, third, and fourth nymphal instars of *D. cingulatus* were preferred by third, fourth and fifth nymphal instar and adults of *R. fuscipes* [20]. The first nymph of *D. koenigii* was light orange which turns into blood red colour within one day [21]. Similarly, first nymph of *D. koenigii* was more preferred by third instar of *R. fuscipes* as compared to adult of *D. koenigii*.

Both nymph as well as adult of red cotton bug was vigorously suck plant sap especially sap of mature pod and causes low yields, their number is also maximum. In general, reduviid predator was preferred *Dysdercus* species [22] along with other six pest species studied. Stage preference of reduviids such as *R. marginatus* was apparently determined by their size in relation to their prey size [23].

Materials and Methods

Insect collection and rearing

Adults of *R. fuscipes* were collected from twig of Okra during copulation in Mahayogi Gorakhnath Krishi Vigyan Kendra Chuakmafi (Lat: 26.93012 N 26º55'48.42588", Longi: 83.23686 E 83º14'12.70212"). After copulation period the female individual were separated and kept in a transparent plastic trough (30cm L×24.5cm W×6cm H), along with wet cotton bud to maintain humidity, stone, dry twig and green leaves (replace after 24 hours), to mimic natural environmental condition and that serve as substrate for egg laying under laboratory (Temperature 25±1 ºC - 27±1 ºC, relative humidity 70%-80%, and photoperiod of 11L: 13D hours) condition. Both adult female and nymph were maintained on factitious host, fourth instar of *Corcyra cephalonica.*

Functional response studies: The 36 hours starved fourth nymphal instars from stock culture were randomly selected for functional response experiment. The prey, first nymph of *D. koenigii* collected from Okra plant was first introduced into the trough (9.5cm diameter and 4.5cm height), with a small piece of host leaf and pod to mimic natural environment and was allowed to settle. After 20 minutes fourth instar of predator were introduced into each container. Ten replicates were maintained for each category. The number of prey consumed was counted after 24 hours and the prey densities was maintained constant by replacing prey consumed with live ones throughout the study period. Eight day observation was made. Hollings' [24] disc equation [y'(Tt-by)x] was used to describe the functional response of *R. fuscipes* to *D. koenigii*.

Where,
X = prey density, y=Total number of prey killed in given period of time (Tt).
Tt = Total time in days for which prey was exposed to the predators b= Handling time in days.
a= Rate of discovery per unit of searching time (y/x/Ts), y/x= Attack ratio, Ts= Searching time in days.

Results and Discussion

The curve linear functional response curve was obtained for the functional response experiment of *R. fuscipes*, They exhibited positive functional response (Fig.: 1). According to Table 1 which stated that the prey consumed ratio (y) of *R. fuscipes* was increases as the *D. koenigii* densities (x) increased from one *D. koenigii / R. fuscipes* to 16 *D. koenigii / R. fuscipes.* Similar result were also observed in *R. longifrons* (Stål) to *Clavigrolla gibbosa* Spinola and in *Coranus spinicutis* (Reuter) to tomato insect pest [25, 26]. The maximum predation rate of *R. fuscipes* was denoted by 'k' and its value was restricted to the maximum *D. koenigii* consumed (y') can be expressed in Hollings' disc equation [24].

$$Y' = 0.19\ (8-2.0\ y)\ x$$

The predator attack ratio (y/x) at less prey density category was highest that is similar at one and two prey/predator level. Hence, the predator attacked ratio decreased as the prey density was increased. In Regression Statistics (multiple R= 0.8985, R square = 0.8073, Adjusted R square = 0.7431 and Standard Error = 0.5650 in five observation). In ANOVA the regression significance F= 0.0382, intercept and X variable 1 P value was 0.0274, 0.0382, respectively. The rate of discovery 'a' defined as the proportion of the prey attacked by predator per unit of searching time. Similarly the parameter searching time (Ts) and attack ratio (y/x) was decreased with the increasing prey density. Also, rate of discovery decreased with increasing prey densities. Hence, a negative correlation obtained between the prey density and the searching time of the predator at all prey density. In recent laboratory, study of *R. fuscipes* against *D. koenigii* was estimated as biological pest control agents. The fourth instar of *R. fuscipes* showed curvelinear functional response when offered with different prey densities. The killing efficiency of the predator was higher during nymphal stage of the prey, rather than adult or egg stage of prey. Hence, reduviid will utilize as promising biological control agent against pest in IPM.

Conclusion

The study underscores the significant agricultural threat posed by *Dysdercus* species, particularly *D. koenigii* and *D. cingulatus*, in Gorakhpur, Uttar Pradesh. These red cotton bugs inflict substantial damage to cotton crops, affecting yield and quality due to lint staining. Synthetic insecticides have been traditionally relied upon for pest management, but the evolution of insecticide resistance necessitates a diversified approach. Reduviid predators, such as *R. fuscipes*, emerge as promising biological control agents, exhibiting a preference for nymphal stages of *D. koenigii*. The functional response experiments reveal the efficacy of *R. fuscipes* in controlling *D. koenigii* populations, especially during its nymphal stage. This highlights the potential of Reduviids in integrated pest management strategies.

Table 1: Functional response of *Rhynocoris fuscipes* against *Dysdercus koenigii* during 8 day observation

Prey density (x)	Prey attack (y)	Max (k)	Days/y b=Tt/k	Days ally's (by)	Days searching Ts=Tt-by	Attack ratio y/x	Rate of Discovery y/x/Ts=a	Disc equation Y'=a(Tt-by)
1	1.0			2.05	5.95	1.0	0.16	
2	2.0			4.1	3.9	1.0	0.25	
4	2.7	3.9	2.05	5.33	2.47	0.67	0.271	Y'=0.19(8-2.05y)x
8	3.2			6.56	1.44	0.4	0.277	
16	3.9			7.99	0.00	0.24	00	

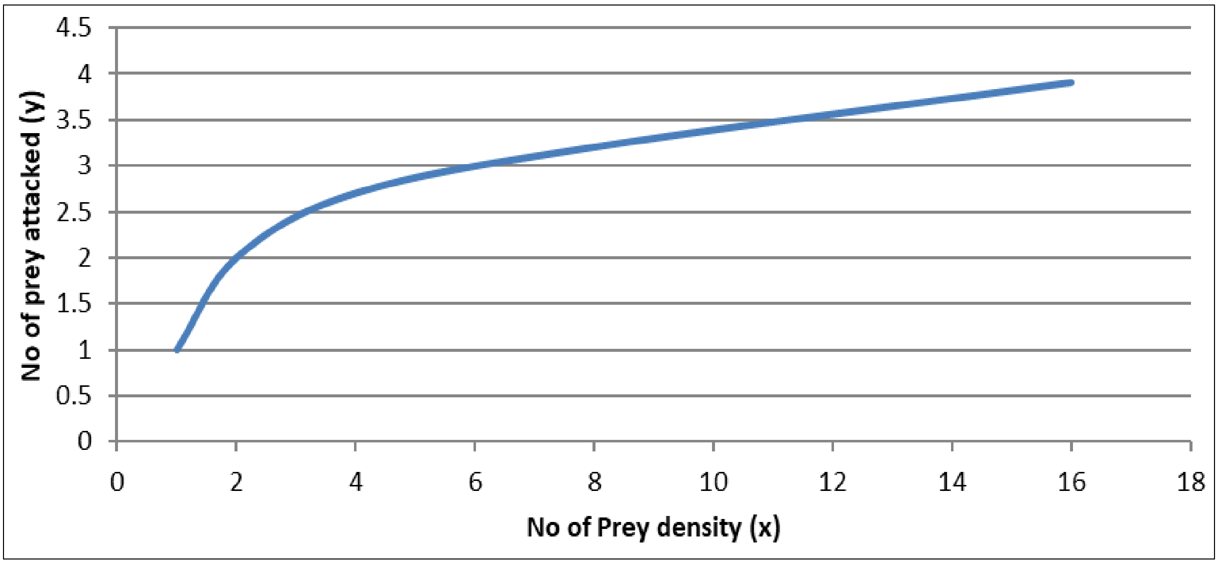

Fig 1: Curve linear function response curve of *Rhynocoris fuscpes* on *Dysdercus koenigii*

Acknowledgements

The authors are thankful to Prof. CO Samuel, Principal and Secretary, St. Andrew's College for providing laboratory facilities and encouragement. The junior author is acknowledged to his Ph.D. advisory committee members Prof. Veena Batra Kuswaha and Prof. Keshav Singh for their great concern and monitoring.

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