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P Khatua
Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

LN Mohapatra
Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

P Nayak
Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Dibyarani
Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Corresponding Author:
P Khatua
Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India

Feeding potential and functional response of syrphid fly, *Eumerus albifrons* Walker to cowpea aphid, *Aphis craccivora* Koch

P Khatua, LN Mohapatra, P Nayak and Dibyarani

Abstract
Laboratory experiments on feeding potential and functional response of syrphid fly, *Eumerus albifrons* Walker to cow pea aphid, *Aphis craccivora* Koch were conducted at Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar during 2018-19. Results showed a high degree of variation in feeding potential of different life stages of *E. albifrons* on *A. craccivora*. Higher predatory efficiency (88± 3.31aphids consumed per day) was exhibited by its third instar larva. During its entire larval period it consumed 156.34± 3.01 number of aphids. Functional response studies revealed that different larval stages of *E. albifrons* exhibited various types of functional responses to the offered prey of *A. craccivora*. Based on logistic regression analyses the first and second instar of *E. albifrons* exhibited a Holling's type II functional response characterized by a hyperbolic curve where as the third instar followed Holling's type III response curve represented by a sigmoid curve.

Keywords: *Aphis craccivora*, *Eumerus albifrons*, feeding potential, functional response

Introduction
Numerous insects visit blossoming plants, serving a significant natural part as pollinators while benefiting from pollen and nectar. Hoverflies (Diptera: Syrphidae) are notably important insects because they act as pollinators in adult stage (Blaauw & Isaacs, 2014) [2] and biological control agents in larval stage (Irshad, 2014) [8]. The larvae of hoverflies are specialized aphidophagous predators and have long been recognized as important natural enemies of aphids (Chambers, 1988) [4]. *Eumerus albifrons* Walker has been reported as an important predator in cowpea ecosystem. *Aphis craccivora* Koch commonly known as cowpea aphid or black legume aphid, is distributed worldwide, but particularly common in warm temperate and tropical regions. It is a very important polyphagous pest, feeding on over 80 plant families with preference for the family Fabaceae (Blackman and Eastop, 2000) [3]. Knowledge on functional response curves are highly essential, in order to evaluate the extent to which predatory activity is modified by prey density so that forecasting the suitability of a predator as a biological control agent will be more easier. It plays a critical role in the perspective of prey-predator interactions and their ecological and evolutionary consequences. Functional response curves refer to the change in the number of prey eaten per predator per time unit, as a function of prey density. When the number of prey killed is plotted against the number of prey available, a continuuam of pattern may emerge from which ecologist delimit three types of functional responses (Holling, 1966) [6]. The Type I response is characterized by a linear rise with a constant attack rate over all prey densities until satiation is reached. In the Type II response the attack rate decreases as prey density increases. Type III is represented by a sigmoid curve, where the attack rate increases with increasing prey density. Despite the potential of *E. albifrons* for cow pea aphid control, no information is available about its predator-prey interactions. Thus the main objective of this study were to evaluate the feeding potential of different life stages of *E. albifrons* and its functional responses to different densities of *Aphis craccivora* as prey.

Materials and Methods
Laboratory experiments on feeding potential of syrphid fly, *Eumerus albifrons* and its functional responses to different densities of *Aphis craccivora* were undertaken in Department of Entomology, Odisha University of Agriculture and Technology, Bhubaneswar during 2018-

2018-19. The rearing procedure adopted by Suja (2008) [12] was followed for the syrphid fly larva. Adult syrphid fly collected from the field failed to lay eggs under laboratory conditions due to absence of the hovering condition needed for egg laying and absence of necessary stimuli necessary to initiate mating. So eggs were directly collected from the field. Syrphid fly adults laid eggs on or near the aphid colonies which were white in colour and can be observed with the help of a magnifying hand lens of 10x power. After locating the eggs, the eggs along with the aphid colony were brought to the laboratory and kept in a petridish containing a wet blotting paper at the base. On hatching the emerging larva were collected and were kept individually in different petridishes and this procedure was followed till they come to pupation. For the feeding potential study, the syrphid larva of uniform instar were placed individually in different petridishes containing moist blotting paper at the base to maintain the optimum humidity conditions. They were provided with different densities of third and fourth instar nymphs of aphid. The number of aphids consumed were counted on next day at an interval of 24 hours to assess the feeding potential of each instar larvas. The left over aphids were removed and then provided with fresh supply of aphids each day. The procedure was followed till it comes to pupation. Prior to pupation they secrete white sticky substances which indicated that they will pupate. The feeding potential was computed for each instar of the syrphid fly (Mishra *et al*., 2013) [10].

Functional response of *Eumerus albifrons* to cowpea aphid: For functional response study, five different densities of third and fourth instar nymphs of aphid *viz*., 20, 40, 60, 80 and 100 nos were taken in petridishes and one same day older larva of each instars of *E.albifrons* were kept in each of these petridishes. Then mean number of aphid consumed by *E. albifrons* in an interval of 24 hours was noted and this data was used to compute functional response to varying density of aphid population (Rizal *et al*., 2018) [11]. The type of the functional response was determined by working out the logistic regression analysis of the proportion of killed prey (Na) in relation to initial density of prey (N0) supplied (Trexler and Travis, 1993) [14]. The data were fitted to the logistic regression which describes the relationship between Na/N_0 and N_0 (Juliano, 2001) [8]

$$\frac{Na}{No} = \exp\left(\frac{P_0 + P_1N_0 + P_2N_0^2 + P_3N_0^3}{1 + \exp(P_0 + P_1N_0 + P_2N_0^2 + P_3N_0^3}\right)$$

where: P_0, P_1, P_2 and P_3 – the parameters to be estimated
If the linear parameter P1 is negative, a type II functional response is followed, whereas a positive linear parameter indicates predation is density dependent and followed a type III functional response (Juliano, 2001) [8].
Statistical analysis:
Data on the incidence of cowpea aphid along with its important predator syrphid fly were statistically analyzed for seasonal variation and then correlated through computation of correlation coefficients for the weather parameters. The significant correlation between incidence of cowpea aphid along with syrphid fly and weather parameters were further subjected for regression analysis in Opstat software. For the feeding potential of important predators on cowpea aphid, mean and standard deviation were calculated for various values.

Results and Discussion

(a) Feeding potential of *Eumerus albifrons:* Mean number of aphids consumed by first, second and third larval instars of *E.albifrons* were 19.33± 3.00, 38.66±3.24 and 88± 3.31, respectively. The percent consumption rate was 77.70 ±5.33, 86.06± 2.94 and 92.67± 1.75 for first, second and third instar of syrphid fly larva, respectively. In its entire larval period it consumed 156.34± 3.01 number of aphids (Table 1).

Table 1: Mean consumption rate and percent consumption by different instars of *Eumerus albifrons*

Instars	Mean no of aphids offered	Mean no of aphid consumed	Mean percent consumption of aphid
First instar(L1)	25	19.33± 3.00	77.70 ±5.33
Second instar (L2)	45	38.66±3.24	86.06± 2.94
Third instar(L3)	95	88± 3.31	92.67± 1.75
Total consumption during larval period	170	156.34± 3.01	91.96±1.77

Mishra *et al*. (2013) [10] also reported that maximum number of aphids was consumed by the third instar larva of *E.albifrons*. The present findings are in partial agreement with Rizal *et al*. (2018) [11] who reported that maximum number of aphids were consumed by the third instar larva of *Ischiodon scutellaris*

(b) Functional response of *Eumerus albifrons* to cowpea aphid, *A. craccivora:* Results on functional response of first instar of *E. albifrons* to varying aphid densities indicated that mean number of aphids consumed was found to be 10.22 ± 2.25, 17.98 ± 2.81, 19.89 ± 2.89, 23.56 ± 1.41 and 26.21 ± 2.03, respectively (Fig 1).While for the second instar the mean number of aphids consumed was 16.58 ± 2.79, 34.41 ± 2.07, 42.92 ± 2.96, 46.64 ± 2.33 and 47.01 ± 1.84, respectively (Fig 2). The third instar of *E. albifrons* when provided with varying aphid densities the mean number of aphids consumed was found to be 19.24 ± 1.03, 38.58 ± 1.58,58.72 ± 2.04,74.98 ± 2.96 and 84.34 ± 2.91, respectively (Fig.3). Data of proportion of aphids consumed by first and second instar of *E.albifrons* when analysed for various logistic regression coefficient, it was found that the linear coefficient value was negative (P_1= -2.98 and -1.81) as there was an initial reduction in the population of *A. craccivora* eaten with increasing prey offered which depicted a Holling's type II functional response characterized by a hyperbolic curve. This type of functional response with a decelerating predation rate has the potential to destabilize prey-predator dynamics due to inverse density dependent mortality of the prey. When the response of third instar of *E. albifrons* to varying aphid densities was worked out for logistic regression coefficients it was found that the value of the linear coefficient was more than zero (P_1= 0.46) showing density dependent predation, so it followed Holling's type III functional response represented by a sigmoid curve (Table 2). Such type of functional response incorporating density dependent prey mortality can regulate the target population.

Table 2: Coefficients from logistic regression of proportion of aphid consumed as a function of aphid densities by larval instars of *E. albifrons*

Instars	Parameters	Coefficients	Standard error	t_{stat}	Pvalue
First instar	Intercept	26.79	24.32	1.01	0.39
	Linear (P_1)	-2.98	2.85	-1.04	0.40
	Quadratic (P_2)	0.22	0.07	2.82	0.11
Second instar	Intercept	31.90	48.21	0.66	0.57
	Linear (P_1)	-1.81	3.26	-0.55	0.63
	Quadratic (P_2)	0.07	0.05	1.29	0.32
Third instar	Intercept	9.29	10.34	0.898	0.46
	Linear (P_1)	0.46	0.47	0.974	0.43
	Quadratic (P_2)	0.007	0.004	1.54	0.26

t_{stat} = coefficient /standard error, P value =probability level

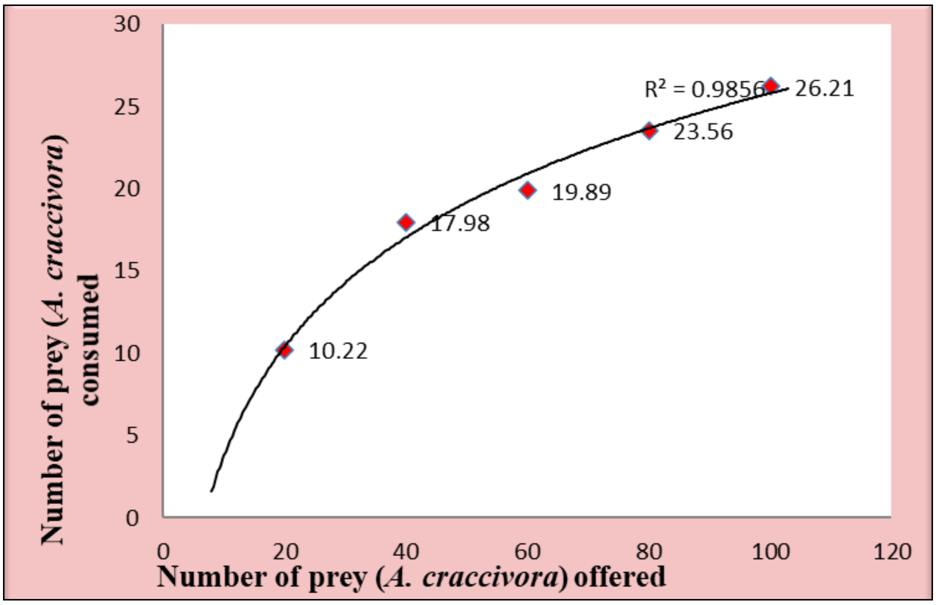

Fig 1: Functional response of first instar of *Eumerus albifrons* to *Aphis craccivora*

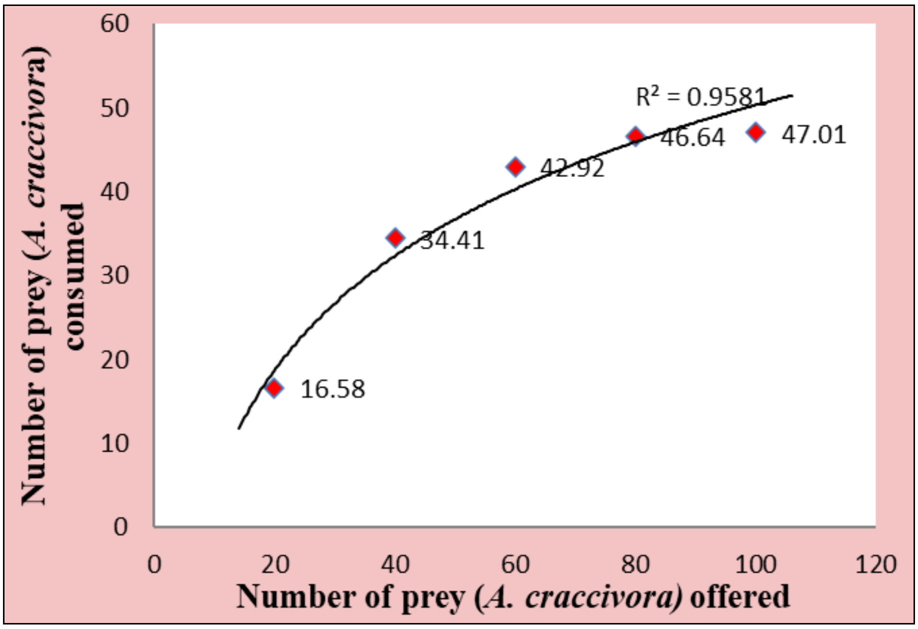

Fig 2: Functional response of second instar of *Eumerus albifrons* to *Aphis craccivora*

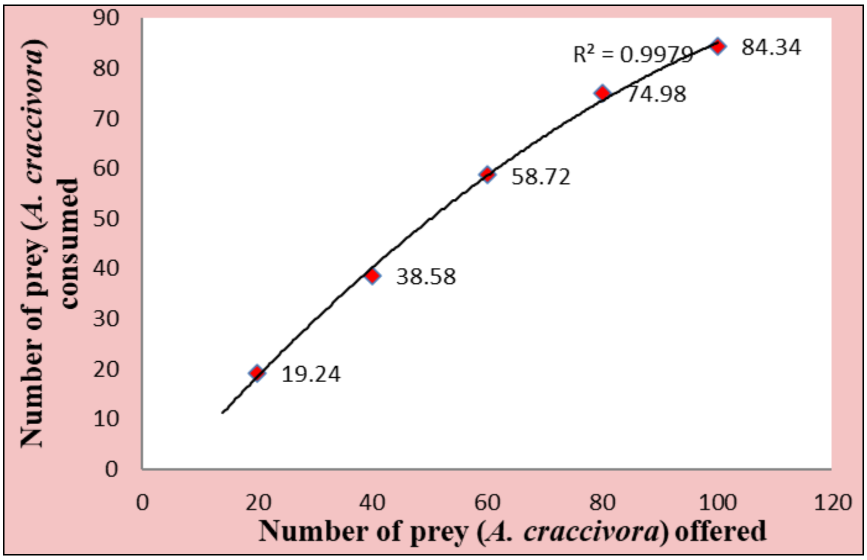

Fig 3: Functional response of third instar of *Eumerus albifrons* to *Aphis craccivora*

Information on the functional response of *E.albifrons* to *A. craccivora* could not be traced out in literature however the present findings were partially supported by the reports of Arcaya *et al*. (2017) [1] who obtained the type II functional response while studying the feeding potential of *Allograpta exotica* on cowpea aphid. Julian *et al*. (2011) [9] reported that the functional response type II was the most common for *E. balteatus* on *Myzus persicae* though functional response of Holling's type I, type II and type III have been reported for syrphids. Type III functional response was also detected by (Tenhumberg, 1995) [13] for *E. balteatus* feeding on *Sitobionavena* and *Metapolophium dirhodum*. The sigmoidal Type III functional response is density dependent up to a threshold of resource density and can contribute to the stability if the average density of resource is below this threshold (Hassell *et al*., 1977) [5].

Conclusion

The regression analysis of functional response of *E. albifrons* on *A. craccivora* showed a linear relationship between log number of prey density and log number of prey consumption during first and second instar following Holling's type II functional response while third instar followed Holling's type III reponse curve. There was high degree of variation in feeding potential of different life stages of *E. albifrons* on *A. craccivora*. The first, second and third instar of *E. albifrons* consumed on an average 19.33± 3.00,38.66±3.24 and 88± 3.31 number of aphids, respectively. During its entire larval period it consumed 156.34 ± 3.01 number of aphids. Highest predatory potential (88± 3.31 aphids) was observed in third instar larva. So from above studies it may be inferred that syrphid fly is a common natural predator and can control the cowpea aphid population especially during its peak infestation. This aphidophagous syrphid can suppress the aphid population at early colony development.

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