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Full Length Research Paper

Functional response of *Exochomus flavipes* Thunberg (Coleoptera: Coccinellidae), a local predator of the cassava mealybug *Phenacoccus* manihoti Matile Ferrore,(Homoptera: Pseudococcidae)

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Functional response of first and fourth larval instars of *Exochomus flavipes,* as a predator of *Phenacoccus manihoti* was studied in the laboratory. Day old (24 hours) first and fourth instars *E. flavipes* were each fed on one day old eggs of *P.manihoti* at densities of 100, 200, 300, 400, 500, 600 and 700. This *was* replicated 10 times. Daily eggs consumption (functional response), was recorded. Functional response of fourth instar to different prey densities increased from 100 to a plateau between 500 and 700. For the first instar, eggs consumption was lower than that of fourth instar. There was a correlation between mean number of prey eggs consumed and the prey density, r = 0.982 and 0.995 for the first and fourth instars, respectively. Rate of discovery by predator was reduced with increase in prey density. There was a negative correlation between the rate of discovery and number of *P.manihoti* eggs consumed by the fourth instar (r = - 0.973). Functional response of *E flavipes* to increasing number of *P. manihoti* showed a density dependent action in this study. *E. flavipes* shows a potential to be exploited as a biocontrol agent of *P. manihoti.*

Keywords: Predator, prey, functional response, cassava mealybug, *Exochomus flavipes, larval instars, prey density.*

INTRODUCTION

The black lady bird beetle *E. flavipes* is an Ethiopian species, apparently occurring throughout Africa and has a very wide distribution in South Africa (Gayer, 1947). Like other entomophagous coccinellids, it feeds on soft bodied insects, and both the larvae and adults are predaceous in habit Hemchandra *et al., (*2010). In Egypt, *E. flavipes* is a potential natural enemy of green shield scale, *Pulvinaria psidii* (Abd- Rabou, 2011).

The life cycle of *E. flavipes* is holometabolous and the incubation period is influenced by temperature (Kiyindou, 1989). Mailu et al., (1980), working under laboratory constant temperature of 30^{o}C in Kenya recorded larval to adult period to last between 21-53 days, while adult life span was 50 days when fed on aphids. According to Everson (1980), many factors such as functional and numerical responses, reproductive rate, search capacity, the predator's life history in relation to that of the prey interact and ultimately determine the success of a predator in controlling its prey (Murdoch, 1973).

In a field survey in Ibadan, E. *flavipes* was noted as the predominant local predator collected from cassava fields in the area (personal observation). Both nymphs and adults fed on all stages of the cassava mealybug. Thus this study was designed to investigate the functional response of the larval stages of *E. flavipes* as a biological control agent of mealybugs.

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Table 1. Mean number (±S. D**)** of prey *Phenacoccus manihoti* (Homoptera: Pseudococcidae) eggs consumed by first and fourth larval instars of predator *Exochomus. flavipes* within a 24 hours period.

	Larval Instars	
Prey densities	**First**	**Fourth**
100	10.9 ± 4.48d	57.9 ± 6.70h
200	16.3 ± 3.77c	83.2 ± 9.92cg
300	19.1 ± 5.38c	93.0 ± 5. 91g
400	28.3 ± 6.6b	107.1± 20.59f
500	35.7 ± 5.27a	117.6± 23.22e
600	38.3 ± 5.03a	118.4 ± 25.96e
700	38.6 ± 5.68a	119.6 ± 22.33e

Mean followed by the same letter in the column are not significantly different at 5% level.

MATERIALS AND METHODS

Mealybug culture

Cassava mealybug (CMB: *Phenacoccus manihoti*) culture was established and maintained on potted cassava plants of the local variety "Odongbo", which has been found to be highly susceptible to *P.manihoti* (Akinlosotu *et al.,* 1987).Twenty to forty cassava cuttings were each planted in plastic pots containing field soil every two weeks until the study was finished. Two weeks after sprouting, some of the potted plants were artificially infested with egg masses of *P.manihoti* collected from the fields on alternate days. The potted plants were kept in the Green House of the Department of Crop Protection and Environmental Biology, Ibadan, Nigeria, and watered regularly. New clean potted plants were placed close to the already infested ones to maintain a continuous supply of the population of *P.manihoti* for all the experiments.

Exochomus flavipes culture

The initial stock of *E.* flavipes used to establish the mass culture was collected from cassava plots around the University of Ibadan, Nigeria. They were placed in cages containing some of the *P. manihoti* infested potted cassava plants described above. The *P. manihoti* infested plants were replaced regularly to maintain available food for *E. flavipes*. The egg masses of *P. manihoti* were collected daily, and observed under the microscope for *E. flavipes* eggs which were removed, and incubated. All the stages needed for subsequent experiments were collected from this stock.

Rearing Unit

A rearing unit for this experiment consisted of a plastic petri dish of about 8.5cm in diameter, with an opening of about 3cm in diameter on its lid. The opening was covered with fine nylon mesh for aeration. The floor of the petri dish was covered with Whatmann filter paper, 8.5cm in diameter.

Functional response of the larval stages 1 and 4

For this study, the first and fourth larval instars of *E. flavipes* were used. It was reasoned that, the first instar determines the survival of the later instars and food accumulated by the fourth instar is used at the pupal stage for the development of adult organ systems as no feeding takes place in the pupal stage. All the stages of *E. flavipes* needed for this experiment were collected from the stock described above. Day old (24 hours) first and fourth instars *E. flavipes* were each fed on one day old eggs of CMB at densities of 100, 200, 300, 400, 500, 600 and 700 per larva. Each prey density was replicated 10 times. The total number of eggs consumed during twenty four hour period was recorded. The data were subjected to Analysis of Variance (ANOVA) and Duncan's New Multiple Range test was used to compare the means.

The rate of discovery of the predator- larval- instar used was computed from basic functional response equation (Holling, 1965) as:

$$Y = \frac{Tax}{1 + abx}$$

Where Y = number of CMB eggs eaten over the chosen period of observation which was 24 hours.

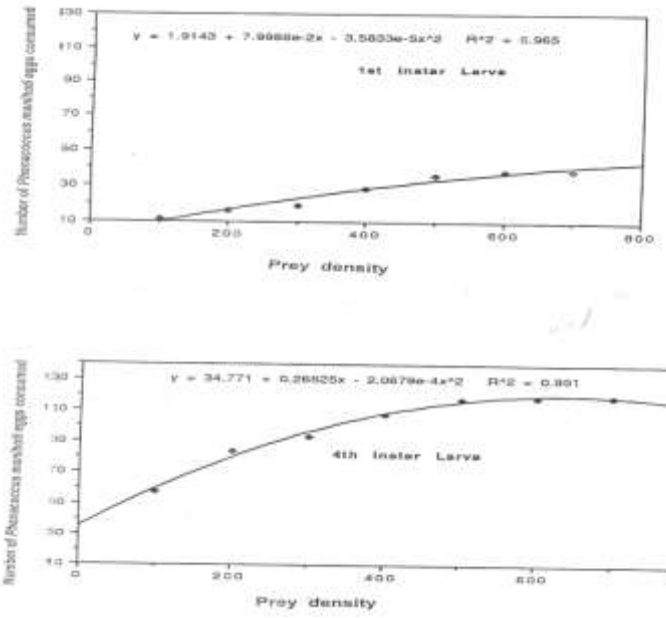
x = the density of CMB eggs (100 to 700) provided for the predator over the observational period which was 24 hours. .

T = the observational period which was 24 hours.

a = the rate of discovery (search rate)

b = the handling time which is the average time taken by

Figure 1. Functional response of the First and Fourth larvae of predator, *Exochomus flavipes* to change in the densities of prey, *Phenacoccus manihoti* eggs.



(a)

(b)

Table 2. Rate of discovery of prey *Phenacoccus manihoti* Matile Ferrore (Homoptera: Pseudococcidae) by first and fourth larval instars of the predator *Exochomus flavipes* Thunberg (Coleoptera : Coccinellidae) at the different densities of the prey in 24 hours period.

	Rate of discovery	
Prey densities	**First instar**	**Fourth instar**
100	18.02	90.14
200	14.19	65.86
300	11.40	49.40
400	13.97	43.07
500	15.36	38.11
600	14.19	31.99
700	12.30	27.72

Rate of discovery was obtained by solving the Holling's equation (Holling, 1965) using Visual Basic Programming Language.

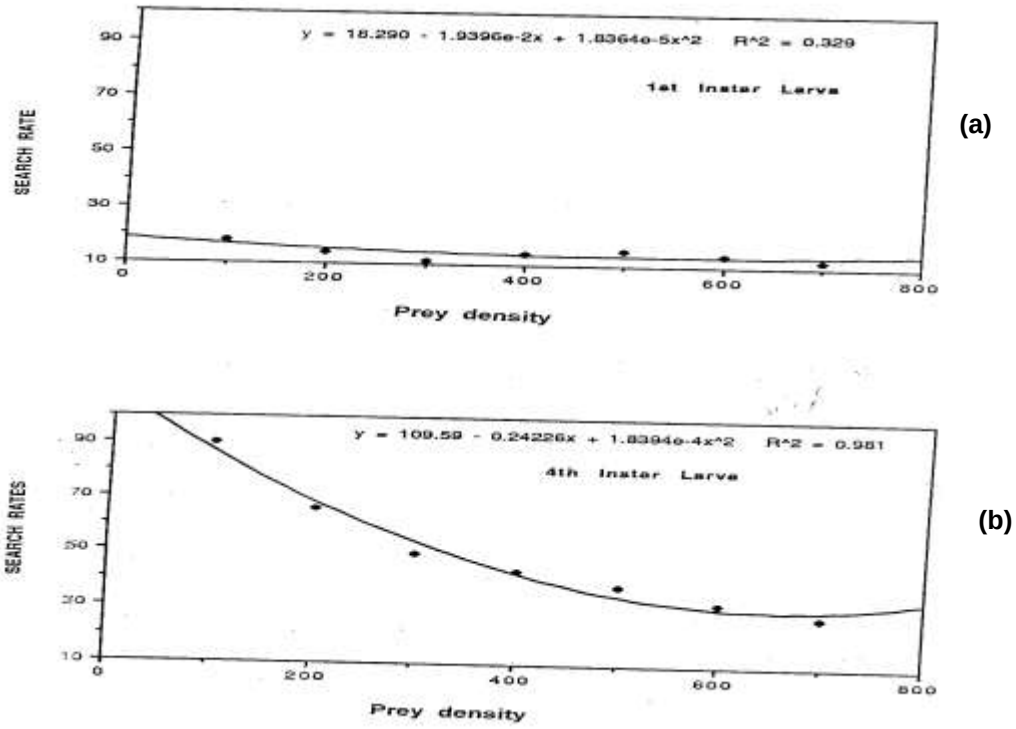
an average first or fourth instar larva to consume one egg.

The computation of 'a' was done by solving the Holling's equation using Visual Basic programming language (Nsiama - She, 1985). The handling time 'b' was derived by transposing the Holling's basic functional equation and using an average of two sample points each to derive two simultaneous equations from it. The two simultaneous equations were solved for the value of 'b'. After determining the search rate or the rate of discovery of the first and fourth instars of *E. flavipes,* a second power polynomial function was used to determine the maximum search rate, i.e. the Y- axis intercept (Akpokodje *et al*., 1990).

RESULT

The functional response of the first and fourth instars of *E. flavipes* to different densities of *P.manihoti* eggs rose from prey density of 100 to 700.With the first instar, the rise was gradual from 100 to 700 prey eggs (Fig. 1a), while

Figure 2. Relationship between the search rate of predator, *Exochomus flavipes* at different densities of prey, *Phenacoccus manihoti* eggs



the curve showing the fourth instar response was steep and ended with a plateau between prey densities of 500 to 700 (Fig.1b). The functional response curve obtained for both instars were of the Holling's type II curve, which showed for the fourth instar, a declining prey mortality with prey density to a plateau representing predator saturation (Holling,1965). At a prey density of 100, the first instar larva of the predator fed on about 11 eggs within 24 hours which was about one fifth (58) the number of eggs consumed by the fourth instar larva at the same prey density (Table 1).Considering each larvae type separately, there were no differences in the number of prey eggs consumed by the first and fourth instar larvae, between prey densities of 200 to 300 and also between 500 to 700 (Table1).

The relationship between the mean number of *P.manihoti* eggs consumed per larva and the prey density was significant ($p < 0.05$) with an r- value of 0.982 and 0.995 for the first and fourth in stars, respectively (Fig.1a - b)

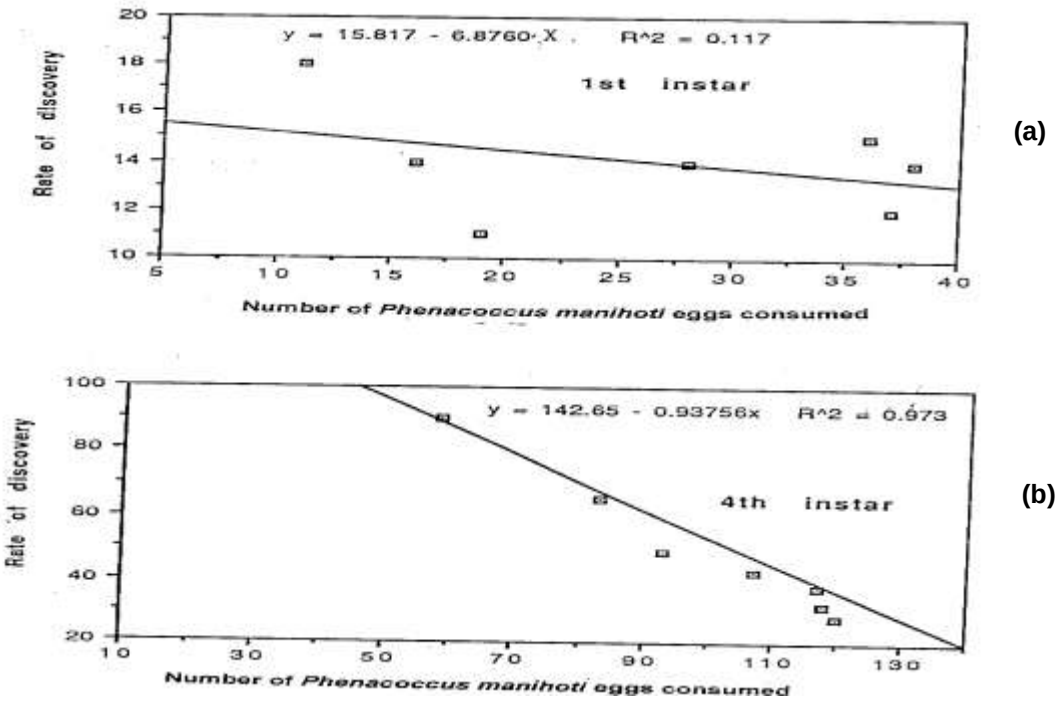
The influence of prey density on the rate of discovery is presented in Table 2. In general, the rates of discovery decreased with increase in the prey density in the first and fourth larval instars of the predator. The fourth instar had a higher rate of discovery than the first instar at all prey densities. A plot of the search rate (area of discovery) against the prey densities showed a slight curve for the first instar (Fig. 2a), while it showed a pronounced convex curve by the fourth instar (Fig.2b). Also, there was a non linear negative correlation with r - values of -0.574 and -0.991 for the first and fourth instars, respectively.

There was a non significant negative correlation between the rate of discovery and the number of *P.manihoti* eggs consumed by the first instar (r= - 0117: Fig.3a) and a negative correlation between the rate of discovery and the number of *P.manihoti* eggs consumed by the fourth instar (r =- 0.973: Fig. 3b).

DISCUSSION AND CONCLUSION

The density of prey is one of the factors influencing the searching efficiency of a predator (Holling, 1959). When the larval instars of *E. flavipes w*ere provided with increasing density of *P.manihoti* eggs, the number of consumed increased. The increase in the rate of feeding could be attributed to less time spent in searching for the prey as prey density increase. Murdoch (1973), showed that a predator given varying densities of a single prey species eats more prey at higher prey densities, but does so at a decreasing rate so that the response causes prey mortality that is inversely dependent, i.e. Hollings' type 11

Figure 3. Relationship between the rate of discovery and the number prey, *Phenacoccus manihoti* eggs consumed by the first and fourth instar larvae of predator, *Exochomus flavipes*.



response. This result, which agrees with the findings of Holling (1965), (Sandness and Mc - Murthry (1970), showed a density dependent action, as the number of the prey consumed by the predator, increased with prey density.

The consumption by the fourth instar iarva was higher at all prey densities than that of the first instar. Similar results were reported by Tanigoshi and Mc Murthry (1977) and Nsiama – She (1985). The increasing ability of the older predator larvae to consume more prey could be a result of increase in the size and structure of the mouthparts, and familiarity of the older larvae with the prey, thereby spending less time for searching and handling the prey (Price, 1975). The search rate of the first instar larva was lower than that of fourth instar. The search rate was found to decrease with increase in prey density. This result agrees with Akpokodje *et al*. (1990), and Holling (1965),

The handling time ('b') recorded for the larval instars of *E. flavipes* were constant at all prey densities, although it was much higher in the first instar than in the fourth instar. Murdoch (1973) reported that either or both parameters of search rate (a) and handling time (b) could change with predator experience. He further stated that only (a) may change while (b) remained constant. Holling (1959b) and Nsiama-She (1985) also reported a constant handling time.

The results of this study suggest that the larval stages of *E. flavipes* could serve as a control agent of *P. manihoti*.

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