Functional response of *Exochomus nigromaculatus* (Col.: Coccinellidae) to different densities of *Aphis nerii* and *Aphis craccivora*

ALIREZA NAZARI
Faculty of Agriculture, Arak Islamic Azad University
Daneshgah Ave. Arak, Iran. P.O. Box: 38135-567

JALIL HADJI-ZADEH & AHAD SAHRAGARD
Faculty of Agriculture, Guilan University
Km. 10 of Rasht- Qazvin Road, Tehran, Iran. P.O. Box: 41335-3179

BAHRAM TAFAGHODINIA
Iranian Research Organization for Science and Technology
#71, Forsat St., Engelab Ave., Tehran, Iran. P.O. Box: 15815-3538
http://www.interyet.com

Abstract: - The functional response of the Ladybird beetle, *Exochomus nigromaculatus*, was examined at different densities of *Aphis nerii* and *Aphis craccivora* under laboratory condition (30 ±1 °C and 65 ±5% RH, with a 14-10 L/D photoperiod). For each experiment, a piece of host plant and a given density of prey and one predator were placed in a Petridis. After 24 hours, the total numbers of prey attacked was counted and experiments conducted in 5 replicates. The results revealed that, 4th instar larvae an adult of e. nigromaculatus exhibited a type II functional response to density levels of 4, 8, 16, 32, 64, 96, and 128 aphid preys. A non-linear regression analysis (Least squares procedure) was used to estimate searching efficiency and handling time of predator. Searching efficiency and handling time of four instar larvae of the predator reared on *A. nerii* were 1.24 and 0.006, and for those reared on *A. craccivora* were 1.17 and 0.009, respectively. Searching efficiency and handling time of Adult predators reared on *A. nerii* were 1.12 and 0.007, and for those reared on *A. craccivora* were 1.01 and 0.008, respectively. The difference in prey species seems to have a contributing factor in determining the rate of predation, whereas searching efficiency in both stages of predator with prey of *A. nerii* was higher than *A. craccivora*.

.

Key-Words: Functional response, predator, prey, *Exochomus nigromaculatus*, *Aphis nerii*, *Aphis craccivora*

1- Introduction

The number of prey attacked by predators is often a function of prey density [12] and [4]. The functional response has been defined as a change in the number of prey attacked as prey density changes. Several types of such functional responses have been recorded: Linear increase (type I); an increase decelerating to a plateau (type II); sigmoid increase (type III) and a dome shaped response (type IV) [4] [13] [2] and [8].

When behavioral components of predator-prey interactions are interpreted with respect to some quantitative model, the resultant descriptive parameters of the model can be applied to predictions about the dynamics of predator-prey associations [2]. An important element of such association is the "Functional

response," the short-term dependence of the predator's feeding rate on prey density. Functional response curves can be used to infer basic mechanisms underlying the interactions of predator-prey behavior, to clarify co evolutionary relationships, and to enhance practical predictive powers for biological control [6].

Predaceous coccinellids are a major factor in the natural control of the orchard aphids. *Exochomus nigromaculatus* Goeze, is one of the prevalent seasonally in orchard plots as well as other agro-ecosystems in Guilan, and is often seen feeding on the *Aphis nerii* B.D.F. and *Aphis craccivora* Koch [10].

2- Materials and Methods

Adult male and female of *E. nigromaculatus* were collected from Oleander planting at the around of Guilan agricultural experiment Station, Rasht, Iran, in May, 1999. The beetles were removed to the laboratory, and reared by natural prey, (*Aphis nerii* and *Aphis craccivora*). The aphids had been freshly collected at the same field site as the beetles were introduced so as to provide densities.

Adults of coccinellid that held for 24 h without feeding after emerging, and 4th instar larvae were used. Treatment included 4th instar of *A. nerii* and *A. craccivora*. Coccinellids were reared by *A. nerii*, were used in first treatment, and coccinellids were reared by *A. craccivora*, were used in second treatment.

Experiments were conducted in a growth chamber at temperature 30 ±1 °C and relative humidity 65 ±5% and a light regimen of 14:10 (L:D). For each experiment, predators were placed singly in Petri dishes (10 cm) with 4, 8, 16, 32, 64, 96, and 128 preys, which was the same range of prey. Five replicates of each prey density were run simultaneously. After 24 h, the total number of prey attacked was counted. Preys

that were not moving were isolated and examined after several hours to see if each occurred. No direct measure of handling time was made. Attacked preys were not replaced.

Holling's type II response [4] was used for assessment of functional response:

$$N_t = aTN_t/(1+aT_hN_t)$$

Here, N_a is the number of prey eaten per predator per day; a is the instantaneous attack rate; T is the total time predators and prey are exposed to each other; T_h is the "handling time" associated with each prey eaten; T is the total time predators and prey are exposed to each other, and N is the density of prey.

The number of prey attacked as a function of density was plotted, and an iterative nonlinear least-squares regression [11] was fitted to the means using the Holling (1959).

3- Results and Discussion

Logistic regression analysis (table1) showed that prey consumption by 4th instar larvae and adults of *E. nigromaculatus* were significantly positively correlated with the density of *A. nerii* and *A. craccivora*. Positive correlation between food consumption and the population densities of prey have been reported for some other coccinellid species predaceous on aphids [3]. The density responsiveness exhibited by both larvae and adults of *E. nigromaculatus* to varying densities of *A. nerii* and *A. craccivora* exemplifies the type II functional response described by Holling (1959). The number of prey consumed daily per predator increased rapidly with initial increase in prey density, and thereafter increased at a decreasing rate (fig1).

The increase in the number of aphid killed by coccinellids at high aphid density may be the result of several factors operating simultaneously.

The rate of successful search, the time available for searching, the time spent in handling prey and the hunger level of the predator were proposed by Holling(1966) as the major factors affecting the functional response of a predator [5]. The increase in the number of aphids killed with increasing density may then be explained by the fact that at lower densities, aphids are more widely spaced out and therefore it takes more time and longer search for a predator to come across a prey [3]. At higher prey densities, encounters are more frequent; a predator stays in an area where prey aggregates and continues to feed until satiation or even beyond [1].

Laing and Osborn (1974) also found that disturbance of the predator during feeding by another prey can result in killing more prey individuals than otherwise might be expected [7]. In this study, interference with predation at higher prey densities and predation satiation may have resulted in the response shown by *E. nigromaculatus*.

Searching efficiency of the 4th instar larvae of predator was higher than Adult predators and handling time of the 4th instar larvae of predator was less than those adults. Also comparison between searching efficiency and handling time of 4th instar larvae by two species of prey *A. nerii* and *A. craccivora*, showed that searching efficiency of the 4th instar larvae of predator fed on *A. nerii* was higher than searching efficiency of the 4th instar fed on
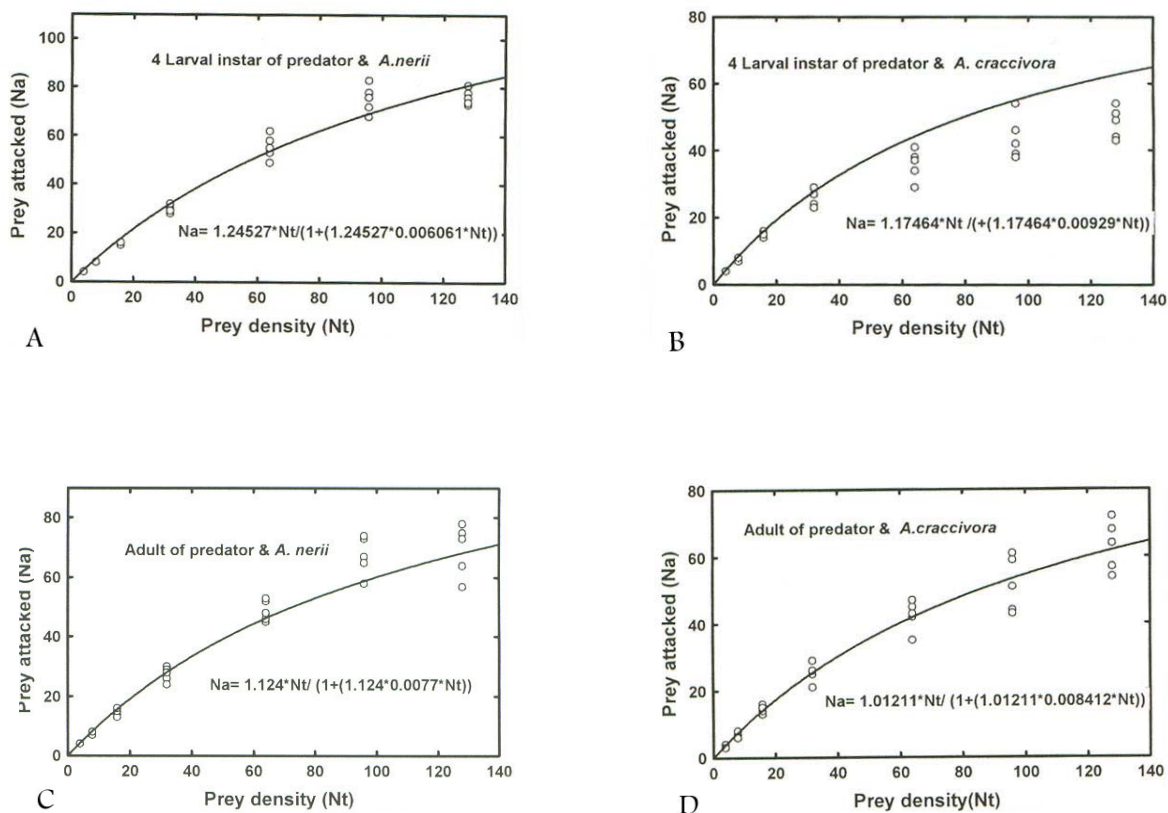

Fig1. the curves of functional response of *E. nigromaculatus* to the variable densities of preys. A) 4th instar larvae of coccinellid with *A. nerii* B) 4th instar larvae with *A. craccivora* C) Adult of coccinellid with *A. nerii* D) Adult of coccinellid with *A. craccivora*

A. craccivora. We know size of 4th instar of *A. nerii* is larger than 4th instar of *A. craccivora.* These observations showed that both stages (4th instar and adult) of *E. nigromaculatus* prefer *A. nerii* than *A. craccivora.*

Table 1- parameters estimated by Holling indicating functional response of *E. nigromaculatus* at different experiments

Type of experiment	Searching efficiency a^{-1} (h)	Handling time (h)	F	R^2	T/T_h
L4 of predator and *A. nerii*	1.24	0.006	1991.5	0.98	166.7
L4 of predator and *A. craccivora*	1.17	0.009	1375.5	0.95	111.1
Adult of predator and *A. nerii*	1.12	0.007	345.3	0.97	142
Adult of predator and *A. craccivora*	1.01	0.008.	1167.4	0.98	125

The maximum number of attack is limited by an upper asymptote defined by the ratio T/T_h [2]. Na_{max} in 4th instar larvae of predator with *A. nerii*, 4th instar larvae with *A. craccivora*, adult coccinellid with *A. nerii*, and adult with *A. craccivora*, were 166.7, 111.1, 142, and 125 preys respectively. As prey density increases, attack rates increase, more time is spent handling prey, and less time is available to search for prey, resulting in the deceleration in the number of attacks [2]. Low attack rate in 4th instar larvae and adult of predator with *A. craccivora* were related on those higher estimating handling time.

References:

1. S. FIREMPONG, and R. KUMAR, Natural enemies of Toxoptrea aurantii (Bog.) (Homoptera:Aphididae) on cocoa in Ghana. Biol. J. Linn. Soc., 7, 261-292. (1975)

2. M. P. HASSELL, The dynamics of arthropod predator-prey systems. Princeton Univ. Press, Princeton, New Jersey, (1978)

3. I. Hodek, Bionomics and ecology of predaceous Coccinellidae. Annu. Rev. Entomol., 18. 79-104. (1967)

4. C. S. HOLLING, Some characteristics of simple types of predation and parasitism. Can. Entomol. 91: 385-398. (1959)

5. C. S. HOLLING, The functional response of invertebrate predators to prey density. Soc. Can., 48, 1-86. (1966)

6. M. A. HOUCK, and R. E. Strauss, The comparative study of functional responses: Experimental design and statistical interpretation. Can. Ent. 117: 617-629. (1985)

7. J. E. LAING, and A. L. OSBORN, The effect of prey density on the functional and numerical responses of three spesies of predaceous mites. Entomophaga., 19, 267-277. (1974)

8. R. F. LOUCK, Principles of arthropod predation pages 497-530. In C. B. Huffaker and R. L. Rabb [eds.]. Ecol. Ent. Wiley, New york. (1985)

9. T. I. OFULA, Predation by *Cheilomenes vicina* (Col.: Coccinellidae) on the cow pea aphid *Aphis craccivora* (Hom.: Aphididae): Effect of prey stage and density. Entomophaga. 31 (4). 331-335.(1986)

10. H. Peyrovi, A faunestic survey of Coccinellidae (Coleoptera) in Guilan Region. Msc. Thesis, University of Guilan, Iran, 100 pp. (1997)

11. SAS Institute, User's guide: Statistics. SAS Institute, Cary, N.C. (1985)

12. M. E. Solomon, The natural control of animal populations. J. Anim. Ecol. 18: 1-35, (1949)

13. W. Tostowaryk, The effect of prey detense on functional response of *Podisus modestus* (Hem.: Pentatomidae) to densities of the sawflies *Neodiprion swainei* and N. pratti (Hym.: Neodiprionidae). Can. Entomol. 104: 61-69. (1972)