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PREDATION BY *CHEILOMENES VICINA* [*COLEOPTERA : COCCINELLIDAE*] ON THE COWPEA APHID, *APHIS CRACCIVORA* [*HOMOPTERA : APHIDIDAE*] : EFFECT OF PREY STAGE AND DENSITY

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Consumption of larvae and females of *Aphis craccivora* Koch by 1st and 4th larvae and adults of *Cheilomenes vicina* (Muls.) was studied under fluctuating temperature (24-30°C). The early aphid instars were consumed in significantly greater numbers than later instars and females.

The feeding rates of *C. vicina* were significantly positively correlated with the population density of prey. The number of prey consumed daily by each predator stage tested, increased more steeply at lower than at higher prey densities, exhibiting thus the type 2 functional response.

KEY-WORDS : *Cheilomenes vicina, Aphis craccivora,* prey consumption, positive correlation, type 2 functional response.

Predaceous Coccinellidae are a major factor in the natural control of the cowpea aphis, *Aphis craccivora* Koch in cowpea fields in many areas in Africa (**Bohlen,** 1973). *Cheilomenes vicina* (Muls.), is prevalent seasonally in cowpea plots as well as other agro-ecosystems in Nigeria, and is often seen feeding on the cowpea aphid (**Booker,** 1964 ; **Don-Pedro,** 1980). The high fecundity and fertility of *C. vicina* indicate its potential in biological control of the cowpea aphid (**Ofuya**, in press).

The purpose of this study was to evaluate the prey consumption of larval and adult *C. vicina* on different developmental stages of *A. craccivora* and to determine the effect of varying densities of the prey.

MATERIALS AND METHODS

GENERAL

Aphids used as prey were reared in a greenhouse and were handled with a damp camel brush. The larvae of 1st and 4th instar of *C. vicina* were progeny of 3 ovipositing couples. The adults of *C. vicina* were collected in the field as copulating pairs.

The tests were carried out in an open laboratory where the temperature fluctuated between 24 and 30°C and the relative humidity from 43 to 90 %.

Larval and adult *C. vicina* were preconditioned before testing to standardize their levels of hunger. The larvae were at least 8 h after the last moult and were starved isolated for 12 h. The adults were individually starved for 24 h.

The larvae of *C. vicina* were supplied with aphids on fresh cowpea leaflets in 9.0 cm Φ glass Petri dishes. Wilting of the plant was prevented by a moistened filter paper. Adult ♂ and ♀ of *C. vicina* were provided with aphids on shoots of cowpea, kept in water inside cages (13.3 cm Φ × 23.7 cm high). Fifteen replicates were made for each combination with *C. vicina* larvae and 10 replicates with each sex of adults.

Different prey stages

Larvae of 1st, 2nd, 3rd and 4th instar and females of *A. craccivora* were used. The prey density was always 100 aphids.

Different prey densities

The 1st instar larvae of *C. vicina* were fed with a mixture of 1st and 2nd instars of *A. craccivora* while the 4th instar larvae and adults of the predator were fed with a mixture of 3rd and 4th instars of the prey. Predation was measured at aphid densities of 10, 20, 30, 40, 50 and 60 for 1st instar larvae of *C. vicina* and 20, 40, 60, 80, 100 and 120 for the 4th instar larvae and adults. An individual larva or adult of *C. vicina* was tested at 1 of the selected densities for a 24 h period and a predator was never tested more than once.

Data analysis

At the determination of the 24 h period in the respective predatory tests, the number of aphids consumed were recorded. Analysis of variance was used to compare differences. Duncan's new multiple range test was used to separate significant means. Functional response curves were drawn and correlation analyses carried out to determine the relationship between prey consumption and prey density.

RESULTS AND DISCUSSION

The mean numbers of larvae and females of *A. craccivora* consumed daily by the selected stages of *C. vicina* are presented in table 1. There were significant differences ($P = 0.001$)

TABLE 1

Effect of prey stage on predation by C. vicina

A. craccivora	Mean number of prey consumed daily by *C. vicina* (± SD)*			
	1st instar	4th instar	Adult male	Adult female
1st instar	22.3 ± 2.4a	89.1 ± 7.2a	92.7 ± 6.3a	95.8 ± 5.6a
2nd instar	20.8 ± 2.1a	88.3 ± 6.8a	90.4 ± 7.1a	94.2 ± 5.1a
3rd instar	15.4 ± 1.7b	62.6 ± 6.3b	63.9 ± 6.5b	72.5 ± 5.5b
4th instar	10.3 ± 1.9c	53.8 ± 5.4b	56.2 ± 6.1b	63.7 ± 4.1b
Female	5.3 ± 0.8d	34.5 ± 2.1c	41.6 ± 4.3c	47.4 ± 5.2c

* Means within the same column followed by the same letters are not significantly different at the 1 % level by Duncan's new multiple range test.

between the number of 1st/2nd, 3rd/4th instar larvae and females of *A. craccivora* consumed daily by any of the *C. vicina* stages tested, except in the case of the 1st instar larvae of *C. vicina* where the number of 3rd and 4th instar larvae of *A. craccivora* consumed were also significantly different. All the stages of *C. vicina* tested consumed more of the 1st/2nd instars of the prey than the 3rd/4th instars, which in turn suffered heavier predation than the females. **Firempong & Kumar** (1975) obtained similar results with the coccinellid predators of the cocoa aphid, *Toxoptera aurantii* (Boy.).

The aphids are known to exhibit various defence responses and mechanisms against attacking coccinellid predators as kicking movements, movements of the body, pulling free the appendage seized by the coccinellid or by simply walking away (**Dixon**, 1958 ; **Brown**, 1974 ; **Firempong & Kumar**, 1975). The effectiveness of these defensive tactics is greater in older aphid instars than in the younger instars (**Brown**, 1974). Thus, a coccinellid predator attacking a young aphid larva is more likely to succeed in capturing and consuming it than if it attacks on older larva. This may explain why the older aphid instars of *A. craccivora* were consumed less than the younger ones by larvae and adults of *C. vicina*. It is also probable that under natural conditions, predation by the early larval instars of *C. vicina* is restricted to the early aphid instars while the older aphid instars are consumed by adults and late larval instars of *C. vicina*.

Correlation analyses (table 2) showed that prey consumption by larvae and adults of *C. vicina* was significantly positively correlated with the density of *A. craccivora*. Positive correlations between food consumption and the population densities of prey have been reported for some other coccinellid species predaceous on aphids (**Hodek**, 1967). The density respon-

TABLE 2

Correlation between prey consumption and prey density for C. vicina *preying on* A. craccivora

C. vicina stage	Value of r
1st instar larva	+ 0.92*
4th instar larva	+ 0.92*
Adult male	+ 0.94*
Adult female	+ 0.93*

* Significant at P = 0.01.

siveness exhibited by both larvae and adults of *C. vicina* to varying densities of the cowpea aphid (fig. 1) exemplifies the type 2 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.

The increase in the number of aphids killed by coccinellids at high aphid density may be the result of several factors operating simultaneously. **Hodek** (1973) reported that hungry coccinellids completely devour the 1st few prey they tackled but exploit subsequent prey with a gradually decreasing efficiency. Thus, with an increase in prey population density, the proportion of partially consumed prey may increase. This was however not evident in this study. **Hodek** (1973) also noted that when prey is abundant, the coccinellid larvae may consume considerably more than the minimum required for their development.

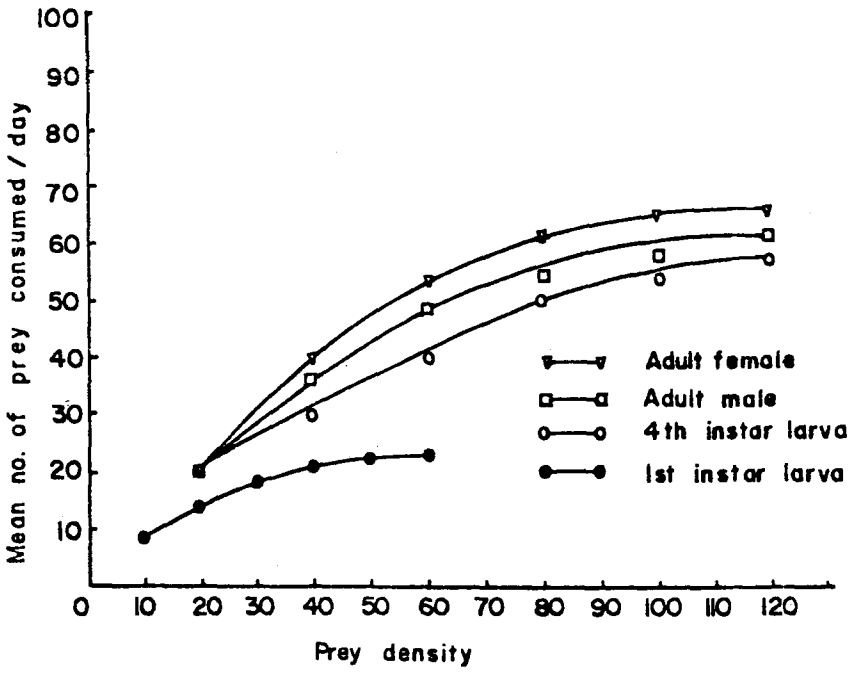

Fig. 1. Functional response of *C. vicina* to increasing density of *A. craccivora*.

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. 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. 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 (**Firempong & Kumar**, 1975). **Laing & 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. Such interruptions would obviously be more frequent at higher prey densities. In this study, interference with predation at higher prey densities and predation satiation may have resulted in the response shown by *C. vicina*.

An ability to adjust to variable resources of food is very important if predators are to have an effective impact on their prey (**Hodek**; 1973). The decreasing efficiency in prey consumption at higher prey densities exhibited by *C. vicina* in this study, can be compensated through numerical increase. As *C. vicina* has a high reproduction potentiel (**Ofuya**, in press), its numerical response merits investigation.

Under natural conditions, the efficiency of *C. vicina* as a predator of the cowpea aphid may be decreased, due to weather, interspecies and intraspecies competition etc., as compared with the laboratory results. However, the laboratory data are supportive for considering *C. vicina* as an important biotic control agent for the cowpea aphid.

RÉSUMÉ

Prédation par *Cheilomenes vicina* [*Coleoptera : Coccinellidae*] d'*Aphis craccivora* : Effet du stade de la proie et de la densité

La consommation des larves et des ♀ d'*Aphis craccivora* par les 1e stades, les 4e stades et les adultes de *Cheilomenes vicina* a été étudiée à une température variant de 24 à 30°C. Les jeunes stades du puceron sont consommés en nombre plus grand significativement que les derniers stades et les ♀.

Les taux d'alimentation de *C. vicina* manifestent une corrélation hautement significative avec la densité de population de la proie. Le nombre de proies consommées quotidiennement par chaque stade considéré du prédateur augmentait plus brusquement aux faibles qu'aux fortes densités de proies, manifestant ainsi chez le prédateur le type 2 de réponse fonctionnelle.

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REFERENCES

Bohlen, E. – 1983. Crop Pest in Tanzania and Their Control. – *Verlag Paul Parey,* Berlin.

Booker, R.H. – 1954. The effect of sowing date and spacing on rosette disease of groundnut in Northern Nigeria, with observations on the vector, *Aphis craccivora*. – *Ann. Appl. Biol.*, 52, 125-131.

Brown, H.D. – 1974. Defensive behaviour of the wheat aphid, *Schizaphis graminum* (Rondani) [*Hemiptera : Aphididae*] against Coccinellidae. – *J. Entomol.* (A), 48, 157-165.

Dixon, A.F.G. – 1958. The escape responses shown by certain aphids to the presence of coccinellids, *Adalia decempunctata* (L.). – *Trans. R. Entomol. Soc. Lond.*, 110, 319-334.

Don-Pedro, K.N. – 1980. A population explosion of *Aphis craccivora* following DDT application in a cowpea plot, *Vigna unguiculata* cultivar (Prima), in Nigeria. – *J. Nat. Hist.*, 14, 617-619.

Firempong, S. & Kumar, R. – 1975. Natural enemies of *Toxoptera aurantii* (Boy.) [*Homoptera : Aphididae*] on cocoa in Ghana. – *Biol. J. Linn. Soc.*, 7, 261-292.

Hodek, I. – 1967. Bionomics and ecology of predaceous Coccinellidae. – *Annu. Rev. Entomol.*, 18, 79-104.

Hodek, I. – 1973. Biology of Coccinellidae. – *Academia,* Prague.

Holling, C.S. – 1959. Some characteristics of simple types of predation and parasitism. – *Can. Entomol.*, 91, 385-398.

Holling, C.S. – 1966. The functional response of Intertebrate predators to prey density. – *Mem. Entomol. Soc. Can.*, 48, 1-86.

Laing, J.E. & Osborn, A.L. – 1974. The effect of prey density on the functional and numerial responses of three species of predaceous mites. – *Entomophaga,* 19, 267-277.

Ofuya, T.I. – (in press). Laboratory observations on the life history of *Cheilomenes vicina* (Muls.) [*Coleoptera : Coccinellidae*], a predator of the cowpea aphid, *Aphis craccivora* Kock [*Homoptera : Aphididae*].