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Olfactory reactions of *Cryptolaemus montrouzieri* Mulsant (Col., Coccinellidae) and *Chrysoperla carnea* (Stephens) (Neur., Chrysopidae) in relation to period of starvation

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With one table and one figure

Abstract

In a laboratory study, it was tried to measure the extent of olfactory responses of two predators namely *Cryptolaemus montrouzieri* Mulsant and *Chrysoperla carnea* (Stephens) to their respective preys at varied levels of their starvation. Results indicated that both the predators, irrespective of their developmental stage, oriented more positively to their preys odour when they were deprived of food for certain period of time than they did so when tested directly without subjecting them to starvation. The first, second, third and fourth instar larvae and adults of *C. montrouzieri* showed maximum response at 4 h, 8 h, 12 h, 12 h and 24 h of starvation, respectively. Similarly, the larvae of *C. carnea* responded maximum with 4 h, 8 h and 12 h of hunger in first, second and third instar, respectively. However it was also evident that the continued starvation for more than certain ideal period affected the predators olfactory orientation negatively. But the adults of *C. montrouzieri* differed slightly in their behavior as they could respond positively for comparatively longer period of starvation.

1 Introduction

One of the important basic characteristics of a predator which affects its success in acquiring food is its foraging efficiency, which in turn is influenced by many internal and external factors. Hunger is one of the internal factors affecting the food finding behavior of the predators (CURIO, 1976). The response of food-deprived insects is observed to be more than the recently fed ones to the olfactory cues provided by the food (LA CHANCE, 1964). There are indications that the level of hunger influences the searching mechanism and related behaviors of many predators e.g. larvae of *Syrphus ribesii* (L.) (ROTHERAY and MARTINAT, 1984), predatory mites *Amblyseius mackenziei* Sch. & Pre. (BAKKER and SABELIS, 1986), carabid larvae of *Poecilus cupreus* (L.) (LOVEI et al., 1985), adults of *Parena rufotestacea* (LANG and LIU, 1986), the larvae of *Eupeodes corollae* (Fab.) (SCOTT and BARLOW, 1990), the bugs of *Diplonychus indicus* Venk. & Rao (CLOAREC, 1990) and adult females as well as larvae of *Stethorus punctum* Le Conte (HOUCK, 1991).

Eventually, in the biological control it is necessary to consider hunger as one of the factors in evaluating the efficiency of a predator, especially when it comes to the timings of release and establishment of a predator in an ecosystem. There is no much information available in literature particularly with respect to the influence of hunger on olfactory reactions of the predators.

Hence this study was planned to investigate how actually the degree of starvation in different development stages influences the olfactory responses of the predators, considering an oligophagous predator *Cryptolaemus montrouzieri* Mulsant and a polyphagous predator *Chrysoperla carnea* (Stephens) to their respective prey odour.

2 Materials and methods

Both the predators namely *C. montrouzieri* and *C. carnea* used in the present study originated from the culture maintained in the Institute of Phytopathology. The mealybug predator *C. montrouzieri* was further reared on *Planococcus citri* (YANUWIADI, 1993) and the green lacewing *C. carnea* was reared using *Acyrthosiphon pisum* (Harris) as prey for adults and an artificial diet as food for adults (HASSAN, 1975). The test populations of the predators were subjected to starvation for different periods of time, by confining them individually in small petri plates with wet cotton wool, after one day of moulting in each instar of the larvae of both the predators and after 10 days of eclosion in adult stage of *C. montrouzieri*. The different stages of predators were deprived of their prey for 2, 4, 8, 12, 16, 20, and 24 hours, and the population directly removed from their preys, i.e. with zero hours of starvation, was taken as control. The 8-armed air-flow olfactometer was used for this purpose (LIU and ŞENGONCA, 1994). The prey insects of the respective predators were used as odour sources.

After having set the olfactometer with test population and the odour source, it was covered with a thick paper box so as to avoid the predators immediate reacting to light. All the experiments involving the developmental stages of both the predators were conducted at evening hours under laboratory conditions of 22 ± 1 °C temperature and 45 ± 5% relative humidity. Each experiment was repeated six times, every time using 15 new individuals of predator as sample population and about 30–40 crawlers of *P. citri* or nymphs of *A. pisum*, depending on the predator under test, as odour sources. Thus, the predator was given a choice between its prey odour and no odour. The number of predators caught in the prey odour chamber within one hour of release was recorded. The observations were subjected to single variance analysis and the means were compared using Tukey's HSD Multiple Range Test (PAYNE et al., 1983).

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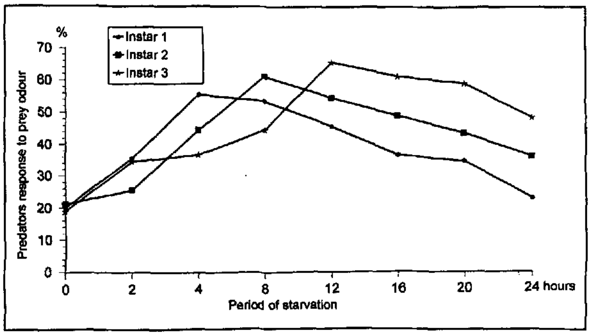

Fig. 1. Percentage attraction of different instars of *Chrysoperla carnea* to the odours of *Acyrthosiphon pisum* at different hunger-regimes.

3 Results

3.1 Olfactory reactions of C. montrouzieri in relation to period of starvation

The numbers of different stages of *C. montrouzieri* with different hunger regimes responded to the prey odour of *P. citri* are summarized in table 1. As can be seen, the response of all the stages of predator was significantly affected by the duration of their starvation ($P < 0.05$). As many as 9.33 individuals of first instar oriented to the odour source when starved for 4 h, which was on par with 8 h of starvation (8.83) but significant over other hunger regimes. There was significant reduction in the olfactory response when they were starved beyond 8 h. The orientation of second instar larvae was significantly higher (9.50) when starved for 8 h and reduced then onwards. Third instar larvae were attracted to prey odour in significantly more numbers (8.83) when starved for 12 h, was on par with 8 h (8.50) and 16 h (7.67) of starvation. The average number of 9.17 fourth instar larvae responded to the prey odour at 12 h of starvation which was significantly superior over other hunger regimes and afterwards there was reduction in the number attracted. While the adults oriented to the prey odour significantly more (9.50) when starved for 16 h and unlike in the case of larvae, there was no reduction in the response due to further starvation till 24 h studied.

3.2 Olfactory reactions of C. carnea in relation to pe: of starvation

The larval stages of *C. carnea* with different hungei gimes were tested for their reactions to the prey odou *pisum*, the results obtained were analyzed statistically response in terms of percentage is plotted in fig. 1. response of all the three instars was significantly when tested directly without subjecting them to sta tion ($P < 0.05$). The percentage of first instar larvae enting to the prey odour was 55.5% at 4 h of hu: which was significantly higher than at any other hu: regimes studied except at 8 h (53.3%) of hunger. Anc maximum olfactory response of second instar was 61 at 8 h of starvation which was significantly superior rest of the hunger regimes. Third instar responded si; icantly higher to the extent of 65.5% at and above 12 starvation but the response dropped down to 41.8' 24 h of starvation.

4 Discussion

The olfactory response of all the stages of *C. r trouzieri* was low in case of test population directly t after removing them from food source i.e. without jecting to starvation and increased with increase in th riod of starvation but only up to a certain level of ger-regime and then afterwards decreased. This decli the response of first instar started at the earliest hu regime namely at 8 h followed by second instar at third and fourth instar at 16 h, but surprisingly n crease in the olfactory orientation was noticed in th of adults up to 24 h of hunger period studied, as they tinued to show steady increase in reaction. These r indicated that the adults could tolerate and survive ger comparatively for a longer period of time than th vae. This may be attributed to the high amount of s energy in them. It needs to be further investigated long they could produce similar results which could much use in the field application of this predator.

HEIDARI and COPLAND (1992) observed significa sual as well olfactory response by adults when they held without food for 24 h. However, according t same authors, the fourth instar larvae which were se just after moult and subjected to starvation for 24 not perceive the prey odour. But the present resul broadly in agreement with ŞENGONCA and LIU (

Table 1. Olfactory reactions at different hunger regimes of different stages of *Cryptolaemus montrouzieri* to the prey odour *nococcus citri.*

Starvation period (h)	Average number of predators (out of 15, replicated 6 times) attracted to its prey odour				
	Instar 1	Instar 2	Instar 3	Instar 4	Adult
0 (control)	5.67 ± 0.21 b	4.83 ± 0.17 a	3.83 ± 0.31 a	3.17 ± 0.17 a	7.17 ± 0.1
2	7.83 ± 0.17 c	6.83 ± 0.17 bc	4.33 ± 0.33 ab	3.67 ± 0.33 a	8.17 ± 0.1
4	9.33 ± 0.21 d	7.67 ± 0.21 d	5.17 ± 0.17 bc	5.17 ± 0.17 b	8.50 ± 0.2
8	8.83 ± 0.17 d	9.50 ± 0.22 e	8.50 ± 0.34 d	6.83 ± 0.17 d	8.17 ± 0.3
12	7.17 ± 0.17 c	7.83 ± 0.31 d	8.83 ± 0.17 d	9.17 ± 0.17 f	9.33 ± 0.2
16	5.33 ± 0.21 b	7.17 ± 0.40 cd	7.67 ± 0.21 d	7.83 ± 0.17 e	9.50 ± 0.2
20	4.83 ± 0.17 ab	6.00 ± 0.36 abc	6.17 ± 0.31 c	6.50 ± 0.22 cd	10.00 ± 0.1
24	4.00 ± 0.26 a	5.67 ± 0.21 ab	5.83 ± 0.31 c	5.83 ± 0.17 bc	10.00 ± 0.2

Means in the column followed by same letters are not significantly different at 5% level of significance (Tukey's HSD Multiple Test).

who could obtain significant results in the olfactory response showed by *Coccinella septempunctata* L. with 2, 4, 6 and 12 h of hunger in the first, second, third and fourth instars respectively, and with 24 h of hunger in adults and also confirmed by our own further studies made on *C. montrouzieri* (ŞENGONCA and KOTIKAL, 1994).

Similarly, the orientation of *C. carnea* to its prey odour increased with increasing period of hunger. These results are broadly in agreement with the earlier findings of BAUMGAERTNER et al. (1981) who noticed a higher number of visits made by larvae to the alfalfa stems infested with aphids with increasing level of hunger up to 24 h. However, in the present study, olfactory response reached maximum for first, second and third instar at 4 h, 8 h and 12 h of starvation, respectively and then onwards it went on decreasing till 24 h of hunger regimes tested for all the instars. These findings are in confirmation with ŞENGONCA et al. (1994) who obtained significant response of the predator with these hunger regimes while measuring the olfactory reactions of it to prey arthropods.

Based on these observations made on the two predators, it could be concluded that the larvae are not able to withstand the starvation beyond certain level of starvation and the level of tolerance increases with increase in the age of larvae. A similar trend was reported in the case of the predatory bug *Cantheconidea fucellata* Wolff., whose second, third, fourth and fifth instar nymphs were able to survive 2.1, 3.1, 3.2 and 4.6 days without prey under field conditions (VAIKAKUL et al., 1981). This physiologically induced phenomenon of increasing orientation to the cues provided by the prey consequent to relative increase in ability to survive hunger with increasing age could be related to the varied amount of stored energy they possess in different stages. Such observations could be taken as hints in increasing the efficiency of the predators especially in handling them before release, and in trying to establish them in an ecosystem.

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Zusammenfassung

Olfaktorische Reaktionen von *Cryptolaemus montrouzieri* Mulsant (Col., Coccinellidae) und *Chrysoperla carnea* (Stephens) (Neur., Chrysopidae) in Abhängigkeit von der Hungerperiode

In Laborversuchen wurde das Ausmaß der olfaktorischen Reaktionen der beiden Prädatoren *Cryptolaemus montrouzieri* Mulsant und *Chrysoperla carnea* (Stephens) auf deren Beuteinsekten *Planococcus citri* Risso respektive *Acyrthosiphon pisum* (Harris) und in Abhängigkeit von der Dauer einer vorangegangenen Hungerperiode, namentlich 2, 4, 8, 12, 16, 20 und 24 Stunden, ermittelt. Wie die Ergebnisse belegen, reagieren beide Prädatoren-Arten unabhängig vom jeweiligen Entwicklungsstadium stärker auf den Geruch ihrer Beute, wenn sie zuvor eine bestimmte Zeit unter Ausschluß von Nahrung gehalten worden waren. Dabei zeigte sich bei den Larven beider Arten ein typischer Verlauf der Attraktivität durch die Beute, nach dem diese mit zunehmender Dauer der Hungerperiode zunächst zunahm, um nach einem Maximum wieder deutlich abzufallen. Dieser Verlauf erwies sich für die einzelnen Larvenstadien als unterschiedlich. So wurde für *C. montrouzieri* das Maximum bei den L_1-Larven mit durchschnittlich 9,33 von 15 durch die Beute angelockten Individuen bereits nach einer Hungerperiode von 4 h erreicht, für die L_2 jedoch mit 9,50 Individuen erst nach 8 und für die L_3 sowie L_4 erst nach 12 h mit 8,83 respektive 9,17 Individuen. Lediglich bei den *C. montrouzieri*-Adulten war eine kontinuierliche Zunahme der Attraktivität der Beute während des Untersuchungszeitraums von 24 h festzustellen, wobei das Maximum bei 10,00 Individuen lag. Analog wurde für das erste *C. carnea*-Larvenstadium bei einer 4stündigen Hungerperiode mit 55,5% attrahierten Individuen das Maximum erreicht, wohingegen das zweite Stadium mit 61,1% bei der 8- und das dritte mit 65,5% bei der 12stündigen Hungerperiode die maximale Attraktion durch die Beute aufwies.

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Effects of fenamiphos and biocontrol agents on cotton growing in nematode-infested soil

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With 2 tables

Abstract

Efficacy of a chemical nematicide, fenamiphos and three microorganisms in controlling *Rotylenchulus reniformis* and *Tylenchorhynchus latus* on cotton planted in field plots was investigated. Monthly records of the nematode population levels showed that fenamiphos had the highest ($p \le 0.05$) levels of their control which resulted in the top cotton yield. Plots receiving the bacterium *Bacillus* sp. had various degrees of nematode control though their cotton yield was comparable ($P \le 0.05$) to the fenamiphos-treated plots. Plots inoculated with a fungus *Chaetomium spirale* recorded the least effect for controlling the two nematode species and their cotton yield was not significantly different from the untreated plots. Plots treated with an actinomycete, *Streptomyces* sp., had an intermediate effect on both nematode population densities and cotton yield. At harvest, *T. latus* population densities were equally suppressed ($P \le 0.05$) in all treatments which should be reflected on the subsequent crop.

1 Introduction

Growing dissatisfaction with chemical nematicides including environmental problems, resistance development of the target species and destruction of natural enemies serves as a strong impetus for the development of alternative nematode control measures. Particular attention in recent years has been focused on biological control using antagonists of plant-parasitic nematodes such as bacteria, fungi, viruses, insects, mites and other invertebrates (STIRLING, 1991). Parasitism of nematodes by the obligate hyperparasite *Pasteuria penetrans* has been widely studied but other association between phytonematodes and bacteria remain largely unexplored (SAYRE and STARR, 1988). The actinomycetes (e.g. *Streptomyces*), which are considered separately from bacteria by numerous soil microbiologists, are usually present in high population densities and make a significant contribution to bacterial biomass in soil (STIRLING, 1991). Hence, the nematode activity in the rhizosphere is likely influenced by antibiosis because most common genera of antibiotic-synthesizing microorganisms (*Streptomyces*, *Bacillus* a.o.) are abundant in the rhizosphere of most cultivated crops. On the other hand, three *Chaetomium* species were found among the mycoflora of cysts of *Heterodera glycines* suggesting possible nematode-fungus relations (GINTIS et al., 1982; RODRIGUEZ-KABANA and MORGAN-JONES, 1988).

In Egypt, preliminary trials were conducted to control nematode pests using biocontrol agents. These latter included nematode-trapping (ABOUL-EID, pers. comm.) and mycorrhizal fungi (OSMAN et al., 1990), predacious nematodes (HENDY et al., 1993), *Pasteuria penetrans* (OSMAN et al., 1993) and plant extracts (KORAYEM et al., 1993). Recently, native populations of *Streptomyces* sp., *Bacillus* sp. and *Chaetomium spirale* showed promising greenhouse and laboratory results as biocontrol agents of

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