BEHAVIOUR, PREY PREFERENCE AND FUNCTIONAL RESPONSE OF Coranus spiniscutis (Reuter), A POTENTIAL PREDATOR OF TOMATO INSECT PESTS

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ABSTRACT: The predatory behaviour of the fed and the starved adult of reduviid bug, Coranus spiniscutis (Reuter) to pod borer, Helicoverpa armigera (Hübner) larva was observed in the laboratory. The daily fed predator took more time for predation (0.2 ± 0.02, 0.13 ± 0.1, 0.17 ± 0.03 and 3.55 ± 0.20 min. for arousal, approach, capturing and paralysing the prey, respectively) when compared with one, three and five day starved predators. The sucking duration of the daily fed predator was found less (41.83 ± 17.97 min.) than that of one, three, and five day starved predators. The fed predator took less time (2.76 ± 0.35 min.) for post-predatory activities than that of starved predators. C. spiniscutis preferred III nymphal instar of cotton sucking bug, Dysdercus cingulatus (F.) (54.16%) followed by III larval instar of semi-looper, Anomis flava (F.) (37.5%) and III larval instar of Helicoverpa armigera (8.33%). C. spiniscutis exhibited Hollings’ type II functional response as indicated by the positive correlation obtained between the prey density and the number of prey killed by the predator. The attack ratio decreased as the prey density was increased. The correlation was positive between the prey density and the handling time whereas it was negative between the prey density and the searching time at all prey densities.

Key Words: Behaviour, Coranus spiniscutis, functional response, prey preference

INTRODUCTION

The reduviid predators (Heteroptera: Reduviidae) are important natural enemies, which can be used as biological control agents against vegetable crop pests (Singh, 1994; Ambrose and Claver, 1995). Tomato, Lycopersicon esculentum Miller is one of the important vegetable crops of both tropics and subtropics. It is infested by a number of insect pests right from germination to harvesting, which not only reduces its yield but also spoils its quality (Gour and Pareek, 2002). Insect pests such as Helicoverpa armigera (Hüb.), Anomis flava F. and Dysdercus cingulatus (F.) feed on foliage and fruit and inflict an yield loss of up to 55% in tomato (Berlinger, 1986). Management of pests infesting tomato through chemical measures should be least preferred, keeping in view the development of resistance in the pest population and also residual toxicity in the fruits (Kashyap, 1983). Use of biocontrol agents like reduviid predators with ecofriendly components have been reported to be effective in the management of insect pests in vegetable crops (Ambrose, 2002). The genus Coranus is a predominant group of harpactorine reduviids in
South India and its members are very good predators with biological control efficiency. The impressive prey record of *C. spiniscutis* (Claver and Ambrose, 2002) prompted the authors to study the feasibility of utilizing this biological control agent by augmenting and subsequently releasing it into the agroecosystem. The effective utilization of any biological control agent is feasible only when information on its predatory behaviour, prey preference and prey suppression potential is available. But no such information is available for *Coranus spiniscutis* except the preliminary information available on its biology (Bose, 1949). Hence, the authors studied its predatory behaviour, prey preference and functional response to three tomato pest species.

**MATERIALS AND METHODS**

1. **Insects**: The nympha1 instars and adults of *C. spiniscutis* were collected from Alankulam (77°, 55′ E and 8°, 70′ N) tomato fields. They were reared in the laboratory in plastic containers (5 x 4 x 3 cm) on their natural pests *viz.*, *H. armigera, A. flavus* and *D. cingulatus*.

2. **Predatory behaviour**: The adult was fed with *H. armigera* larvae to satiation and then starved for 24 h, 72 h and 120 h. A predator was placed on a tomato leaf with a larva at 3 cm away in the potted tomato plant. The sequential pattern of predatory behaviour was recorded in daily fed and one, three and five day starved adult of *C. spiniscutis* on *H. armigera*.

3. **Prey preference**: Choice experiment was carried out to study the prey preference of adult *C. spiniscutis* against *H. armigera, A. flavus* and *D. cingulatus* in plastic containers. The tomato leaf and branches were spread inside the plastic containers to simulate the natural conditions. After the introduction of predator and prey, the prey preference was assessed in terms of prey consumed by the predator in 6 hours. Fifteen replicates were maintained for each category.

4. **Functional response**: The newly moulted and 48 h starved adult females of *C. spiniscutis* were used in this experiment. The functional experiment was conducted in tomato potted plants at St.Xavier’s College campus during 2002. The entire flowering plants were covered with small nylon mesh iron cages (0.5 m dia. x 1.0 m height). Before covering, the plant was shaken to exclude insects, spiders etc., if any. Then a laboratory reared and prey deprived adult female of *C. spiniscutis* and freshly field collected fourth instar larvae of *H. armigera, S. litura* and *A. flavus* at 4 different densities, *viz.*, 1, 2, 4 and 8 prey/predators were released into experimental cages. Thus, three different categories (prey) of experimental setups each with four different prey density levels were maintained, separately. Twelve replicates were maintained for each category. After 24 h, the number of prey consumed or killed was recorded and the prey number was maintained constant by replacing them with fresh prey throughout the experimental period. The experiment was conducted for five days. Holling’s disc equation (1959) was applied to describe the functional response of *C. spiniscutis* to *S. litura, H. armigera* and *D. cingulatus*.

In the equations that follow, *x* = prey density; *y* = total number of prey killed in given period of time (*T*); *y/x* = the attack ratio; *T* = total time in days when prey was exposed to the predator; *b* = time spent in handling each prey by the predator, (*T* / *K*); *a* = rate of discovery per unit of search time ([(y/x) / *T*]). The parameters *b*, *k* and *a* were directly measured in the present study. The handling time *b* was estimated as the time spent for pursuing, subduing, feeding and digesting each prey. The maximum predation was represented by *K* value and it was restricted to the higher density. Another parameter *a* at the rate of discovery was defined as the proportion of the prey attacked successfully by the predator per unit of searching time.

Assuming that the predator efficiency is proportional to the prey density and to the time
spent by the predator in searching prey (T_s) the expression of relationship is:

\[ y = a \cdot T_s \cdot x \]  \hspace{1cm} (1)

However, time available for searching is not constant. It is equivalent to the total time (T_t) minus the time spent for handling the prey (b). We presume that each prey requires a constant amount of time b for the consumption, then

\[ T_s = T_t - b \] \hspace{1cm} (2)

Substituting (2) in (1), Hollings 'disc' equation is

\[ Y = a \cdot (T_t - b) \cdot x \]

The regression analysis was made to determine the relationship between the prey density and the number of prey consumed, the searching time, the attack ratio and handling time.

**RESULTS AND DISCUSSION**

1. Predatory behaviour: The sequence of predatory behaviour of adult *C. spiniscutis* to *H. armigera* was observed as follows: arousal-approach-rostral pinning and capturing-paralyzing-piercing and sucking-post predatory activities.

   **Arousal:** The predator got aroused by seeing the moving prey. It expressed the arousal response by one or more of the following acts: slightly orienting towards the prey, extending the antennae towards the direction of the prey and standing in tibial juxtaposition with intermittent extension of rostrum. The fed predators took more time (0.2 ± 0.02 min.) for arousal when compared with starved predators. For instance, one, three and five day starved predators took 0.13 ± 0.02, 0.09 ± 0.02 and 0.08 ± 0.01 min., respectively (Table 1). *C. spiniscutis* searched sporadically with its foretarsi raised and located the prey as reported by Putchkova in 1979 and Awan *et al.* in 1989. The involvement of local air movement and the participation of different antennal hairs and that the olfactory receptors in arousal were reported by Edwards (1962), Ambrose (1999) and Claver and Ambrose (2001) in many reduviids.

   **Approach:** Once the predator got aroused, it turned towards the direction of the prey and moved nearer to the prey. While approaching the

<table>
<thead>
<tr>
<th>Days of prey deprivation</th>
<th>Arousal</th>
<th>Approach</th>
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<th>Piercing and sucking</th>
<th>Post predatory act</th>
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<tbody>
<tr>
<td>0</td>
<td>0.2±02b</td>
<td>0.13±0.01b</td>
<td>0.17±0.03a</td>
<td>3.55±0.2a</td>
<td>41.83±17.97a</td>
<td>2.76±0.35a</td>
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<td>0.15±0.01a</td>
<td>3.29±0.42a</td>
<td>44.16±2.47ab</td>
<td>2.53±0.28a</td>
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<td>3</td>
<td>0.09±0.01a</td>
<td>0.06±0.01l</td>
<td>0.18±0.01a</td>
<td>3.18±0.38a</td>
<td>8.33±20.85ab</td>
<td>3.22±0.18a</td>
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<tr>
<td>5</td>
<td>0.08±0.01l</td>
<td>0.05±0.01l</td>
<td>0.16±0.01a</td>
<td>2.60±0.21a</td>
<td>69.16±9.75ab</td>
<td>3.25±0.42a</td>
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Values followed by different letters denote that data are statistically significant by Tukey's test (p = 0.05)

\* Mean ± Standard Deviation

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prey, predator stood in tibial juxtaposition and extended its antennae towards the prey. Slow gait was the very characteristic feature of fed predators. The fed predators took $0.13 \pm 0.01$ min. for approach whereas one, three and five day starved predators took $0.11 \pm 0.02$, $0.06 \pm 0.01$ and $0.05 \pm 0.01$ min. for approach, respectively. Edwards (1962) reported that antennal movement of the *Rhynocoris carmelita* Stal was the key sensory input to approach the prey. Chemical stimulation in the antennae of predator was reported in prey location (McLain, 1979; Awan et al., 1989) and prey odours were first perceived by antennal receptors, triggering the approach and extension of the proboscis (Rani and Wakamura, 1993). Claver and Ambrose (2001) stated that under normal circumstances information was first perceived through the compound eyes before eliciting a predatory movement.

**Rostral pinning and capturing:** At close proximity of the prey, the predator extended its rostrum and captured the prey by rostral pinning preferably in the head region. When the prey was motionless, the predator held the captured prey firmly by its fore and midlegs. When the prey was agile, the predator used to raise its forelegs and antennae and wait for the prey to settle. The fed predators took more time ($0.17 \pm 0.03$ min.) for capturing when compared with the starved predators. For instance, one, three and five day starved predators took $0.15 \pm 0.19$, $0.18 \pm 0.01$ and $0.16 \pm 0.1$ min. for capturing, respectively. The predator was found probing the motionless prey with its antennae followed by inserting the rostrum into the prey to test suitable sites for sucking. The sensory hairs of the forelegs were responsible for immediate capture of the prey (Putchkova, 1979). Edwards (1962), Ables (1978) and Ambrose (1999) stated that reduvid predators with tibial pads are better adapted for capturing and pinning the prey. Moreover, antennal perception of kairomones and allomones plays a major role in prey capturing (Hagen, 1987). Initial antennal contact of predator with prey was also found essential for rostral insertion (Ables, 1978).

**Paralyzing:** After the successful capturing of the prey the predator paralyzed the prey by injecting its toxic salivary secretion. The predator pinned at a second site and injected more saliva when it could not paralyze the prey by its first injection of saliva. The most preferable site for paralyzing the prey was the head region. The fed predator took more time ($3.55 \pm 0.20$ min.) for paralyzing the prey when compared to the starved predators. For instance, one, three and five day starved predators took $3.29 \pm 0.42$, $3.18 \pm 0.38$ and $3.60 \pm 0.21$ min. to paralyse the prey, respectively. Ambrose and Claver (1996) attributed this remarkable reduction in paralyzing time of the starved individuals to the accumulation of more saliva in the anterior lobe of principal salivary gland. This was further proved by the enlarged principal lobes of the salivary glands with full secretion in the starved bugs when they were dissected and seen (Maran and Ambrose, 2000). The paralysis was due to neuroactive proteins of medium and low molecular weight, the neurotoxin. The neurotoxic protein content increased in the starved insects. The toxic action of saliva was due to hyaluronidase and protease alone, through which they facilitated entry of toxins into tissue (Ambrose, 1999). Hence, prey deprivation shortened the time required for paralysis after the injection of venom.

**Piercing and sucking:** The predator released its grip over the prey after paralyzing and sucking the predigested body fluid of the prey by inserting the rostrum at different regions of body of the prey. The forelegs and midlegs were used to hold the prey while sucking. Though the predator changed the sucking sites frequently, it preferred to the suck around the head region, followed by the abdominal region. The sucking duration of fed predators was $41.83 \pm 17.91$ minutes whereas one, three and five day starved predators took $44.16 \pm 2.47$, $48.33 \pm 20.85$ and $69.16 \pm 9.74$ min., respectively. Claver and Ambrose (2001) reported that the daily fed predators consumed lesser amount of food through more number of sites whereas the starved
predators consumed more amount of food through less number of sites. Thus, negative correlation between number of sucking sites and the amount of food consumption was observed. While sucking, the antennae were brought down, presumably to test various regions of the prey and it was accompanied by rostral probing to select the suitable sucking sites. The mechanoreceptors on the predator’s antennae and rostrum provide contact stimulation whenever possible for site selection in the prey (Claver and Ambrose, 2001). Putchkova (1979) stated that while probing with the proboscis for a suitable insertion point, reduviid’s forelegs were more important for holding its victim against the surface. Tarsal claws on the foreleg of adult reduviid predator, Saitavata variegata Amyot and Serville were used for prey manipulation (McMahan, 1983).

2. Prey preference: The adult C. spiniscutis highly preferred the III nymphal instar of D. cingulatus (54%) followed by Anomis flava (38%). Low preference was expressed towards III instar larvae of H. armigera (8%) (Fig. 1). Reduviid predators generally prefer lepidopteran caterpillars (Edwards, 1962; Able, 1978; McMahan, 1983; Ambrose, 1999). They further noted that reduviids’ preference for one prey to another in choice test might be influenced by the noxious smell or unpleasant taste of the prey. But James (1994) and Fuscini and Kumar (1975) stated that reduviid bugs apparently preferred heteropteran bugs by their better taste. Similarly, Singh et al., (1973) reported that an asopine pentatomid, Amyolea malabarica (p.) preferred southern green stinkbug, Nezara viridula (L.) in preference to lepidopteran pests. In the present

Fig. 1. Prey preference (%) of adult C. spiniscutis to III larval / nymphal instars of H. armigera, A. flava and D. cingulatus

Post predatory act: After sucking the prey at all possible sites, predator started to clean its tibiae, antennae and rostrum. The duration of post-predatory activities was shorter (2.76 ± 0.35 min.) in fed C. spiniscutis when compared to starved predators. In the final act of predation, the empty case of the host was dragged and left off and the predator cleaned its antennae androstrum by the foretibial pads (Ambrose, 2002).

observation, H. armigera and A. flava larvae were least preferred than D. cingulatus nymphs. The reduviid attacked-caterpillars were found to roll themselves and emit greenish viscous fluid in self defense (Ambrose and Claver, 2001). However, this behavior of the caterpillars did not deter the predator as observed by Saharyaraj and Ambrose (1994) in Acanthaspis pedestriss (Stat).
Table 2. Functional response of adult female *C. spiniscutis* to III larval/nymphal instars of *S. litura, H. armigera* and *D. cingulatus* for 5 days

<table>
<thead>
<tr>
<th>Prey density</th>
<th>Prey M ' attacked</th>
<th>Max y'</th>
<th>Days/y</th>
<th>Days all searching</th>
<th>Attack ratio</th>
<th>Rate of discovery</th>
<th>Disc equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x)</td>
<td>(y)</td>
<td>K</td>
<td>y/T-K</td>
<td>(by)</td>
<td>(y/x)</td>
<td>a=(y/x)/Ts</td>
<td>y=a (Tt-by)x</td>
</tr>
<tr>
<td>1</td>
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<td>0.32</td>
<td>0.50</td>
<td>1.53</td>
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<tr>
<td>8</td>
<td>2.13</td>
<td>4.98</td>
<td>-</td>
<td>0.26</td>
<td>Mean=0.89</td>
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</table>

*C. spiniscutis* vs. *S. litura*

| 1            | 1.00              | 1.56   | 3.44   | 1.00              | 0.29         |                  |               |
| 2            | 1.70              | 2.65   | 2.35   | 0.85              | 0.36         |                  |               |
| 4            | 1040              | 2.18   | 2.82   | 0.35              | 0.12         |                  |               |
| 8            | 3.20              | 4.99   | -      | 0.040             | Mean=0.25    |                  |               |

*C. spiniscutis* vs. *H. armigera*

| 1            | 0.86              | 1.09   | 3.97   | 0.86              | 0.21         |                  |               |
| 2            | 1.60              | 2.03   | 2.97   | 0.80              | 0.26         |                  |               |
| 4            | 2.13              | 2.70   | 2.3    | 0.53              | 0.23         |                  |               |
| 8            | 3.93              | 4.99   | -      | Mean=0.23         |              |                  |               |

*C. spiniscutis* vs. *D. cingulatus*

3. Functional response: Table 2 indicated that *C. spiniscutis* responded to the increasing prey density by killing more number of prey than it killed at lower prey densities and thus exhibited a typical type II functional response (Holling, 1959). This type II functional response accurately describes the curve linear relationship of variety of insect predators (Hassell et al., 1976).

The positive correlation obtained between the prey density and the prey killed confirmed this during the first five days of observation \( y = 0.6478 + 0.1539x, r = 0.9955; y = 0.7521 + 0.2860x; r = 0.9220; y = 0.5555 + 0.4198x, r = 0.9935 \) for *S. litura, H. armigera* and *D. cingulatus*, respectively). Similar positive correlation was obtained in *R. fuscipes* to *H. armigera, Euproctis subnotata* and *Exelastis atomosa* (Claver and Ambrose, 2002). The maximum predation represented by K value was always found restricted to the higher prey density \( K = 2.13, 3.2 \) and 3.93 for *S. litura, H. armigera* and *D. cingulatus*, respectively). Because, at higher prey density, the predator might have spent less time towards searching of prey but utilized all its time in attacking and consuming.
The highest attack ratio was observed at the density of 1 prey/predator and the lowest attack ratio was found at the density of 8 prey/predator. Hence, the ratio decreased as the prey density was increased ($y = 0.8141 - 0.1015x, r = -0.9539; y = 0.8721 - 0.0539x, r = -0.8921; y = 0.9595 - 0.0352x, r = -0.9309$ for *S. littura*, *H. armigera* and *D. cingulatus*, respectively). Such indirect proportional relationship found between the attack ratio and the prey level was similar to the observation of Mukerji and LeRoux (1969) in *Podisus maculiventris* (Say) and Claver and Ambrose (2002) in *R. fuscipes*.

A positive correlation was obtained between the prey density and the handling time of the predator at all tested prey densities ($y = 2.7817 + 0.3168x; r = 0.8301; y = 1.1711 + 0.4460x; r = 0.9218; y = 0.7026 + 0.5333x; r = 0.9934$ for *S. littura*, *H. armigera* and *D. cingulatus*, respectively). The resting time of the predator in the higher prey density was much longer than that at lower prey density indicating the reason for decrease of handling time (Tillman, 1996). Moreover, handling time distinguished the decelerating relationship (type II curve) from the increasing linear relationship (type I curve) (Hassell, 1978).

A negative correlation was obtained between prey density and the searching time of the predator at all prey densities ($y = 3.0500 - 0.7257x; r = -0.9320; y = 3.2050 - 0.1435x; r = -0.4011; y = 4.245 - 0.5678x; r = -0.9591$ for *S. littura*, *H. armigera* and *D. cingulatus*, respectively). It is presumed that the predator took lesser time in search of prey at higher prey density and spend more time at lower prey density which in turn might have caused a perceptible decline in the attack rate of the predator at higher prey density. Claver and Ambrose (2002) also observed lesser searching time at higher prey density.

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