Prey preference and Stage preference

I.a. Prey preference

Introduction

Preference of an insect population for specific resources is generally considered to result from the natural selection processes maximizing population development (Esterbrook and Dunham, 1976). Moreover, diet specialization is a fundamental aspect of an animal’s biology and has at the same time far reaching ecological implications. To properly value the ecological impact of food selection behaviour and its evolutionary significance, it is helpful, if not a dire necessity, one should understand the underlying mechanisms of the behaviour (Schoonhoven and Van Loon, 2002).

Generalist arthropod predators feed on varied prey species belonging to different families or even orders, among which they show no clear preference (Hsiao, 1985). Most predaceous Heteroptera are governed in their choice of prey principally by its availability and size rather than its taxonomic affinity (Dolling, 1991). Although reduviids are polyphagous predators, they exhibit a narrow range of host preference (Ambrose, 1996, 1999, 2000a, 2003; Ambrose and Claver, 2001).

Simply observing a predator preying upon a prey species is not sufficient to conclude that the particular prey is the predator’s preferred prey or its normal prey
(Huffaker and Messenger, 1964). Flinn et al. (1985) defined preference as the disproportionate selection of prey type relative to the proportion of prey types available in the environment to a polyphagous predator. Preference is evident when the predator selects certain species among others that are equally available (Saint-Cry and Cloutier, 1996). Hence, it is imperative to understand the host specificity of predators before employing them in biological warfare.

Behaviour leading to feeding is guided by intrinsic and extrinsic stimuli i.e., prey size, shape (Enders, 1975; Law, 1979; Sadana and Kaur, 1980), speed of the prey (Howell and Pienkowski, 1971; Guillebeau and All, 1989), movement of the prey (DeClercq and Degheele, 1994), colour (Den Boer, 1971; Shelly and Pearson, 1978), texture of the prey i.e., softness and hardness of cuticle (Wirtz, 1987), chemicals produced by the prey (Greany and Hagen, 1981; Dicke, 1988; Guillebeau and All 1989; Yasuda, 1997), the nature of chemicals i.e., odour and taste of the prey (Slansky and Redriguez, 1987; Yn, 1987; Pasteels et al., 1989; Borges and Aldrich, 1992; Ambrose and Claver, 2001), both physical and behavioural defensive functions of the host i.e., regurgitation, biting, thrashing, swift running and falling to the ground (Crocker and Whitcomb, 1980; Damman, 1986; Wirtz, 1989; Stamp, 1992; Sahayaraj and Ambrose, 1994a; Venkatesan et al., 1997; Sahayaraj, 1999a; Ambrose and Claver, 2001), age of the prey and the predator (Beddington et al., 1976; Dos et al., 1995) and the chemical cues emanating from the environment (Kennedy, 1978; Hayness and Birch, 1985; Hsiao, 1985; New, 1991). Generally, flexible prey selection behaviour in generalist predators may result from a lesser need than specialists for specific cues from the environment, before the potential prey is recognized. Ability to choose and alternate between the prey types has an important bearing on the outcome of a biocontrol project using predatory insects (Weseloh, 1988). When one prey type becomes scarce, it may be important that the presence of another suitable local prey type will not only be
suppressed by the agent, but may also be instrumental in stimulating the predator to stay in the area and not disperse. This phenomenon provides predatory insurgence against a possible resurgence in numbers of the first pest. Another important consideration is prey substitution and its subsequent suitability in the rearing of a predator. Often the target pest is not easy to rear, even though it may be notorious in the field. An alternative insectary prey may therefore determine whether the predator can be successfully maintained for later field release. The problem then is that such a secondary prey may or may not predispose the predator to switching to the target prey when released in the field (Hattingh and Samways, 1992).

Preference of the reduviid predator was determined by the activity of the prey, size of the prey and preying habits of the predator. Preference response elicited by a particular prey varied from one reduviid predator to another (Dolling, 1991; Ambrose, 1999, 2000a, 2003). Such prey preference is intimately bound with prey choice. Yet, the ability of reduviids to choose between prey types is not entirely clear. However, information on prey preference from the laboratory work enables one to assess the importance of any predator. Further, it may be possible to obtain relevant ecological factors involved in prey preference (Weseloh, 1988, 1993). Hence, an attempt was made to understand the prey preference of a reduviid predator *Acanthaspis pedestris* Stål against three chosen economically important lepidopteran pests viz., the American bollworm, *Helicoverpa armigera* (Hübner), leaf cutworm, *Spodoptera litura* (Fabricius) and castor semilooper *Achaea janata* (Linnaeus) by choice experiments in the laboratory.
Materials and Methods

*A. pedestris* adults were collected from the following areas: Muppandal scrub jungle (77°31' E and 8°22' N), Aralvaimozhi scrub jungle (77°45' E and 8°26' N), Pothayadi scrub jungle (77°55' E and 8°10' N), Pavoorchatram agroecosystem (77°40' E and 8°96' N) and Reddiarpatti semi-arid zone (77°78' E and 8°71' N), Tamil Nadu, South India (Fig.1) (Plate 1a, b). Economically important lepidopteran insect pest viz., *Spodoptera litura* (Fabricius) *Helicoverpa armigera* (Hübner) and *Achaea janata* (Linnaeus) were collected from cotton, lady’s finger and castor agroecosystems in and around Palayankottai (77°73' E and 8°72' N) and from such ecosystems in Arockianathapuram village and Alankulam agroecosystem (77°54' E and 8°93' N). *H. armigera* populations were maintained in separate plastic containers (7 x 7 cm) on fresh lady’s finger fruits and cotton bolls and flowers. *S. litura* and *A. janata* populations were maintained in the plastic troughs (15 x 30 cm) on fresh cotton and castor leaves. Predator and prey cultures were maintained in a constant laboratory environment at 30 ± 2°C temperature; 75 ± 5% relative humidity and 12 ± 1 h photoperiod. The nymphs and adults of *A. pedestris* were reared in the laboratory on larvae of the rice moth *Corcyra cephalonica* (Stainton). The stock culture of predators was used in these experimental studies. The prey preference of the newly emerged IV and V nymphal instars and adults with equal number of males and females of *A. pedestris* to *S. litura*, *H. armigera* and *A. janata* was studied. The newly emerged predators were placed in a mesh cage (38 x 38 x 15cm). The three lepidopteran insect pests were introduced on the castor leaves kept inside the mesh cage simulating the natural conditions. Prey preference was assessed in terms of prey consumed by the predator in 24h.
1a. Aralvaimozhi Scrub Jungle

1b. Muppanthal Scrub Jungle

Plate-1
Results

*A. pedestris* fourth nymphal instars preferred *S. litura* (58.06%) > *H. armigera* (25.81%) > and *A. janata* (16.13%). The data obtained on mean prey preference are given in figure 2.

Fig. 2. Prey preference (%) of IV nymphal instars of *A. pedestris* to larvae of *S. litura*, *H. armigera* and *A. janata*.

The fifth nymphal instars preferred *S. litura* (55.17%) > *H. armigera* (31.03%) > and *A. janata* (13.80%) (Fig.3).

Fig. 3. Prey preference (%) of V nymphal instars of *A. pedestris* to larvae of *S. litura*, *H. armigera* and *A. janata*.
2a. *A. pedestris* predates on *H. armigera* larva

2b. *A. pedestris* feeds on *A. janata* larva

2c. *A. pedestris* preys upon *S. litura* larva

Plate-2
3a. *A. pedebris* approaching the larva of *A. janata*

3b. Defensive hooding behaviour of *A. janata* larva to *A. pedebris*

3c. *A. pedebris* paralysing the larva of *A. janata*

3d. *A. pedebris* sucking the body contents of the larva of *A. janata*

Plate - 3
Adult *A. pedestris* preferred *S. litura* (48.28%) > *H. armigera* (37.93%) > and *A. janata* (13.79%). The percentage preference of *H. armigera* increased from fourth stadium to adult gradually whereas preference of *A. janata* gradually decreased from fourth stadium to adult (Plate 2a-c, Fig. 4).

**Discussion**

The reduviid predators generally prefer lepidopteran caterpillars (Edwards, 1962; Ables, 1978; Ambrose 1999, 2000a, 2003). Though *A. pedestris* accepted all the three lepidopteran insect pests, it preferred *S. litura* due to its softer cuticle and slow movement. The *H. armigera* larvae were less preferred than *S. litura* larvae due to its harder cuticle, very fast movement and aggressive behaviour. When *A. pedestris* tried to paralyze *H. armigera*, the prey exhibited an aggressive behaviour by moving haphazardly inside the container and sometimes biting the antennae and legs of the predator with its powerful mandibles that might have deterred *A. pedestris* from preying. The *A. janata* larvae were the least preferred prey by *A. pedestris* because of their defensive behaviour (baiting and threatening). They exhibited a defensive threatening posture by raising their entire body resting only with the pseudolegs as the
cobra raises its hood and struck *A. pedestris* with its head and emitted a viscous fluid (Plate 3a-d). Moreover, all the three lepidopteran larvae captured by *A. pedestris* were found to roll themselves and emit greenish viscous fluid in self defense which invariably repelled the predator and only after 1-3 minutes, the predator could again capture the prey and suck the body fluids. However, this defensive behaviour of the caterpillars did not deter the predator as observed by Sitaramaiah *et al.* (1975), Sahayaraj and Ambrose (1994a) and Ambrose and Claver (2001).

**I.b. Stage preference**

**Introduction**

Hemipteran predators are important biocontrol agents of many agricultural insect pests (Plate 2a-c) (Biever and Chauvin, 1992a; Clouteir and Bauduin, 1995; Ambrose, 1999, 2002; Grundy and Maelzer, 2000a). Of this group, reduviids are one of the least researched and most poorly understood families, although evidence in support of their potential in biocontrol is accumulating (Schaefer and Ahmad, 1987; James, 1994a; Ambrose, 1999, 2002; Grundy and Maelzer, 2000a).

*Acanthaspis pedestris* Stàl has been reported as a potential predator on various insect pests (Plate 2a-c) such as *Achaea janata* (Linnaeus), *Earias fabia* Stàl, *Earias insulana* Biosdual, *Helicoverpa armigera* (Hübner), *Macrotermes estherae* (Desneux) *Odontotermes assumthi* Holmgren, *Odontotermes wallonensis* Weismann, *Patanga succincta* Linnaeus, *Pectinophora gossypiella* Saunders and *Spodoptera litura* (Fabricius) (Sahayaraj and Ambrose, 1994a; Claver *et al.*, 2003a; Ambrose, 2003). Of these insects, the larvae of *S. litura*, *H. armigera* and *A. janata* are polyphagous, predominant and difficult pests to control in many agricultural crops. Although
A. pedestris has been observed preying on these pests, its preference over their life stages, i.e., its ability to attack, capture and consume them is largely unknown.

Even among the preferred prey species, the predator exhibits a specific selection to a particular stage of the prey. Selection of one stage over another could also affect the dynamics of prey-predator interaction, so it is important to assess the stage preference of any predator (Ambrose, 1996, 1999, 2003). Moreover, host specificity of reduviid predators has been governed principally by the size of the prey rather than taxonomic affinity (Schaefer, 1981, 1988, 1996; Dolling, 1991). Moreover, the assessment of a predator’s ability to capture and consume the relevant stadia of the targeted pest insect enables one to effectively utilize a natural enemy for biocontrol (Grundy and Maelzer, 2000a). Hence, the stage preference of nymphs and adults of A. pedestris to the life stages of three lepidopteran pests was studied in cages.

**Materials and Methods**

Predator and prey cultures were maintained in a constant laboratory environment at 30 ± 2°C temperature; 75 ± 5% relative humidity and 12 ± 1h photoperiod. The nymphs and adults of A. pedestris were reared in the laboratory on larvae of the rice moth Corcyra cephalonica (Stainton). Economically important lepidopteran insect pest viz., S. litura, H. armigera and A. janata were collected from cotton, lady’sfinger and castor agroecosystems in and around Palayankottai and from such ecosystems in Arockianathapuram village. H. armigera populations were maintained in separate plastic containers (7 x 7 cm) on fresh lady’sfinger fruits and cotton bolls and flowers. S. litura and A. janata populations were maintained in plastic troughs (15 x 30 cm) on fresh cotton and castor leaves.

Different stages of the above said prey insects were released into the experimental cages with life stages of reduviid predators and the predator’s stage preference was evaluated as follows.
The stage preference of *A. pedestris* to larval stages of *S. litura, H. armigera* and *A. janata* were evaluated by choice experiments. Preliminary tests were conducted for each predator-prey combination to estimate the quantum of the proportionate stage of the prey required by the predator. These preliminary tests were conducted to understand the average consumption of the predator, thereby avoiding the predators kept under fed during the experiments. First instar larvae of *A. janata* (0.1 to 0.5 cm size groups) were not used as prey due to their thin filamentous nature. Particular life stages of the newly moulted *A. pedestris* and different size groups of prey (10 each) were introduced individually into the experimental arena, i.e., a cotton plant covered by nylon mesh cages supported with iron frame. Thus, size preference of each stage of predator was assessed separately in terms of consumption consecutively for 24 hours.

Seven replicates were maintained for each life stage of the predator. Two predator-free controls were used for each prey treatment to assess prey mortality due to natural causes. When *H. armigera* was provided as prey, enough (4 to 6) lady'sfinger fruits (2 cm section) were placed in the centre of each experimental arena to provide sustenance and thus minimize *H. armigera* larval cannibalism. For *A. janata* and *S. litura* larvae healthy castor leaves were provided. The number of prey partially or totally consumed or killed was recorded for each stadium at 24h intervals for the entire nymphal duration.

**Results**

*S. litura*

The first and second instars of *A. pedestris* preferred larvae shorter than 1 cm reflecting their narrow range of size preference (Fig. 5). The third instars preferred between 0.1 to 0.5 cm long larvae. Fourth and fifth instars preferred between 0.1 to 2.0 cm long larvae. The adults preferred 0.6 to 2.5 cm long larvae.
H. armigera

The first and second instars preferred 0.6 to 1.0 cm long larvae. The third and fourth instars preferred 0.1 to 1.5 cm long size group larvae. Fifth instars preferred 0.1 to 2.0 cm long larvae. The size preference of adult males ranges from 0.1 to 2.5 cm and that of females ranges from 0.6 to 2.5 cm long (Fig. 6).
A. janata

The first instars preferred 0.6 to 1.0 cm long larvae. The second instars preferred 0.6 to 1.5 cm long larvae. The third instar preferred 0.6 to 2.0 cm long larvae. The adult males preferred 1.6 to 3.0 cm long larvae whereas the adult females preferred 1.6 to 3.5 cm long group larvae (Fig. 7).

![Preference of life stages of A. pedestris to different size groups of A. janata larvae](image)

**Fig. 7.** Preference of life stages of *A. pedestris* to different size groups of *A. janata* larvae

**Discussion**

Life stages of *A. pedestris* preferred different size groups of each prey tested. Such a particular size group preference could be attributed to the dynamics of prey-predator interaction (Weseloh, 1988), which is principally governed by the size of the predator in relation to its prey size. Stage preference studies of reduviids by capture success and choice experiments revealed that the stage preference is greater in younger instars and gradually fades as they grow (Richman *et al.*, 1980; McMahan, 1982, 1983; Inoue, 1985; Dolling, 1991; Sahayaraj and Ambrose, 1994a; Grundy and Maelzer, 2000a; Ambrose, 2003).

The size of *A. pedestris* and its relation to prey size appeared to be the major factor determining success in capturing and consuming prey. First and second instar nymphs were unable to successfully prey upon larger size groups of *S. litura,*
H. armigera and A. janata. A similar stage preference was observed in Alloeocranutn quadrisignatum (Reuter) on Dysdercus cingulatus Fabricius (Ambrose and Sahayaraj, 1993) and Pristhesancus plagipennis (Walker) on H. armigera and Nezara viridula (L.) (Grundy and Maelzer, 2000a).

The present choice experiment findings is also in close agreement to those recorded for other reduviids i.e., Rhynocoris fuscipes Fabricius to S. litura, H. armigera and Euproctis mollifera W. larvae (Ambrose and Sahayaraj, 1993) and R. kumarii to H. armigera, S. litura, E. mollifera larvae and D. cingulatus (Claver and Ambrose, 2002). Similar size determined preference was also reported for nabids (Perkins and Watson, 1972) and pentatomid predators (DeClercq and Degheele, 1994).

Consumption of prey in relation to prey size (Fuller, 1988), strength of prey’s struggling (Inoue, 1985) and predators preference towards relatively larger size prey (Hassell et al., 1977) due to higher benefit per unit effort (McMahan, 1983) might be the reasons that A. pedestris preferred relatively larger prey.

The body thrashing and biting by the larger prey larvae probably deterred some attacks by carabid predators (Riddick and Mills, 1994). However, Schaefer (1981) reported that heteropteran predators are restricted in their choice by their own size to any particular prey tried. Hassell et al. (1977) stated that the predator response to the prey is often exhibited by predators feeding on preferred prey of relatively larger size. Generally the larger predator preferred the large sized prey and smaller predator preferred the small sized prey. Therefore, timely release of the life stages of predator in synchronization with the availability of the particular stage of the pest population is very important in biocontrol programme.