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STUDIES ON THE ASSOCIATED MIRID FAUNA OF THE MANGO LEAF WEBBER PEST, *ORTHAGA EXVINACEA* HAMPSON (LEPIDOPTERA : PYRALIDAE)

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ABSTRACT : Miridae have been generally understudied, despite their importance as generalist predators in agro-ecosystems. Two species of predatory Miridae have been recovered from the larval gallery of the mango leaf webber pest, *Orthaga exvinacea* Hampson (Lepidoptera:Pyralidae). They are *Termatophylina indiana* (Hemiptera: Deraecorinae) and *Charagochilus sp (Hemiptera: Mirinae)*. Both species exhibit the same pattern of behaviour and always found within the larval galleries of the Pyralid pest. Preliminary observations on the activity budget of these Mirids were done. The different categories of behaviours of these Mirids are identified and an ethogram of the same is prepared by simple behaviour scan method.

Key words : Leaf webber, Miridae, behavioue scan, activity budget, Kinematic, entomophagy.

INTRODUCTION

Orthaga exvinacea Hampson (Lepidoptera: Pyralidae) commonly called as the mango leaf webber, was considered as one of the minor pests of mango but since last few years, it has attained the status of a major pest of mango in Kerala. When the pest is active in the field, almost all the trees become heavily infested by the leaf webber. Trees of all ages were found infested. The caterpillars of this pest make webbings to join the mango leaves in to clusters and eat those leaving only ribs. It has attained the status of a major pest of mango in several parts of India. The pest is found to infest all varieties of mango trees in Kerala. The complete development of the leaf webber pest, *Orthaga exvinacea* Hampson passes through seven larval instar stages and a pre-pupal stage. The female moths laid greenish dull, oval and flattened eggs singly or in clusters usually on lower surface of leaves near the midrib or vein. The caterpillars on hatching reached to tender leaves nearby and feed gregariously on leaf chlorophyll by scraping the leaf surface.

The larval leaf web of *Orthaga exvinacea* was found associated with two species of Mirids, *Termatophylina indiana* and *Charagochilus sp*. Mirids represent nearly one third of the described species within the Heteroptera, with at least one third of those estimated exhibit predatory habits, and of those, a number are important predators in agro-ecosystems (Wheeler, 2001). Yet, compared to other predaceous Heteroptera, relatively little research has been performed on predatory Mirids. The damage caused by Mirid bugs on the host plant could not be easily detected. Symptoms may include curling, distortion, leaf spots, wilting or browning. Damage is usually concentrated on upper areas of host plant leaves. Damage is mainly cosmetic. In the present study ethograms and activity budget of the two species of Miridae, *Termatophylina indiana* and *Charagochilus sp* were constructed by simple behaviour scan method. An ethogram is an inventory of the behaviours of a species, with the behaviours thoroughly described and organized into categories. Ethograms are useful for analyzing the activity budget or time budget of various behaviour transitions. Behaviours often do not occur in isolation thus, once the action patterns are clearly defined and the ethogram written down then we can begin to record sequence data. The ultimate goal will be to produce a diagram that summarizes the likelihood of various behavioural sequences. This type of diagram is called a kinematic diagram.

MATERIALS AND METHODS

Laboratory colonies of the Mirids, *Termatophylina indiana* and *Charagochilus sp*, were established with adults and nymphs collected from mango leaves. The conditions of the rearing and laboratory experiments were 28 ±1°C and 60 ± 5 RH. Adults and nymphs of the Mirids were transferred into glass jars with fresh mango leave webs. Every other day, fresh mango leaves were placed in the glass jar by removing the old ones. Newly emerged nymphs were transferred to individual Petri dishes, containing fresh mango leaves and host larvae. Resulted insect cultures were used for bioassays.

Behaviour scan

The individual Miridae are kept in a Petri dish with cover and food. They are kept undisturbed for some time and help them to explore its new surroundings until it seems calm enough to observe. Insects which are not distressed and not starving often have a very quiet behaviour. More different elements can be seen when the insect is hungry, when the insect is brought into a new environment, or if the insect is brought together with conspecifics. Some insects within a half hour show many behavioural elements. Less active insects have longer been viewed. Durations of the different behaviours were measured with an accuracy of one second with stop watches.

Initial observation

The first observation last about 15-20 minutes. After this time the different categories of behaviour (Table 1) can be recorded. By these initial observations the primary goal is to identify and describe categories and count (quantify) the number of times each behaviour is performed.

Second behaviour scans

This phase of behaviour scan lasts for about one hour (60 minutes) using the behaviour scan method to observe the various behavioural categories for the construction of an ethogram for the Miridae. In this method regular scans are made and record the behaviours that are occurring at the instant. The results of the behaviour scan method can then be used to construct a time budget of behaviour (the percentage of time spent in each category), or to identify the sequence in which behaviours occur.

Data analysis and presentation of results

The ethogram data can easily be summarized and was used to draw conclusions about the duration (how long), frequency (how often), and sequences (in what order) of the categories of behaviour that are identified. The various behavioural transitions were analyzed using kinematic diagrams.

OBSERVATIONS AND RESULTS

The study was designed to record the various behaviour patterns of the two Mirids and also to quantify the amount of time spent on phytophagy and entomophagy among different life-stages of each species and between life-stages of the two species. Individual adult and late stage nymphs of both *Termatophylina indiana* and *Charagochilus sp* were observed continuously under a stereomicroscope for 1 h by confining them in an arena created by affixing half of a Petri dish (3.5 cm in diameter) to the undersurface of a mango leaf. The magnified view of Mirid behavior allowed distinguishing a few additional behavioral categories. Recording were done on various activities of the bugs (resting, walking, orienting, probing, grooming, and feeding) and identity of food items probed or consumed (leaf blade, leaf vein or prey). Preliminary observations revealed several distinct events in the feeding arenas.

Feeding patterns

Occasionally *Orthaga exvinacea* larva escaped initial attack by the Mirid bugs, *Termatophylina indiana* and *Charagochilus sp* which probed quickly in all directions with its proboscis, and moved its antennae up and down apparently in an unsuccessful attempt to relocate its prey. Stationary Mirid often appeared to respond to *Orthaga* larva passing in front of them by turning their antennae to follow the movement of the prey. The distinction between a Mirid feeding and probing event was determined by the length of time that the mouthparts were inserted into the prey or plant tissue. Specifically, if the mouthparts were inserted into a food item for < 5 sec, it was designated as a probing event (e.g., exploratory) and if the mouthparts were inserted for = 5 sec, it was designated as a feeding event (e.g., committed to feeding). This time frame was arbitrarily chosen based on the time that a bug committed to a feeding event (e.g., most of the probing events were < 3 sec in duration while the vast majority of feeding events were much greater than 5 sec in duration).

The proportional amount of time that *Termatophylina indiana* Carvalho and *Charagochilus sp* spent in the various behavioral categories is summarized in an ethogram. Plant feeding and plant probing events occupied 38% of the time for *Termatophylina indiana* and 34% for *Charagochilus sp*. Time spent on predation occupied 18% of the activity budget in the case of *Termatophylina indiana* and 24% for *Charagochilus sp*. The time spent in other behavioral categories account 44% for *T. indiana* and 42% for *Charagochilus sp* (Figures 1 and 2). Other activities comprise grooming, resting, walking and orienting, respectively. It was found that in adults herbivory occupied the majority of the time budget dedicated to plant feeding and plant probing events.

Interestingly the time spent by the immature stages in each behavior category was also similar between the two species. The immature stages of *T.indiana* spent approximately 42% of their time on plant probing and feeding, 24% on predation and 34% for other activities. *Charagochilus sp* spent 38% of their time on plant probing and feeding, 26% on predation and 36% for other activities (Figures 3 and 4).

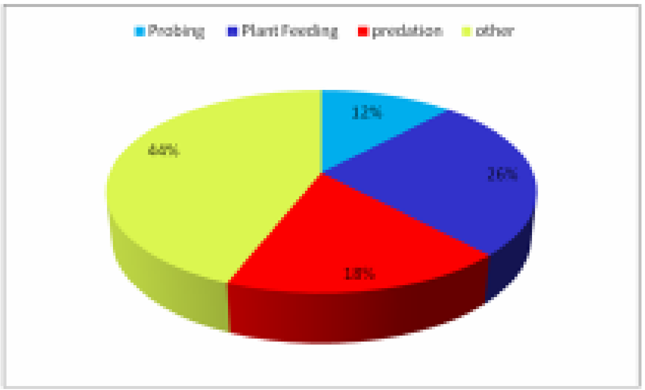


Fig. 1 : Activity budget of *Termatophylina indiana* (Adult).

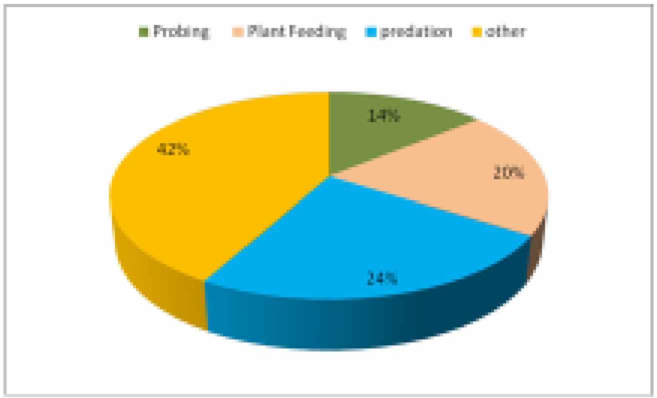


Fig. 2 : Activity budget of *Charagochilus* sp (Adult).

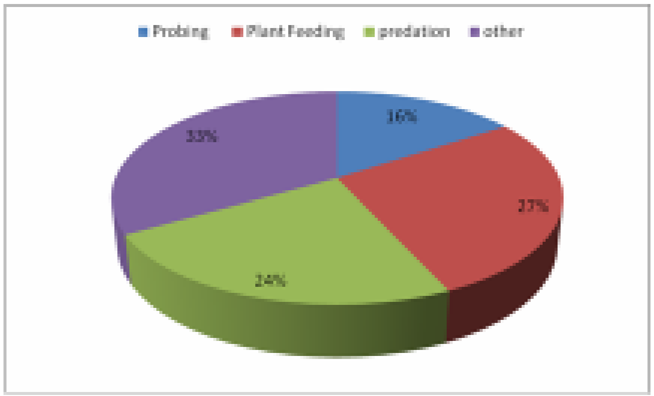


Fig. 3 : Activity budget of *Termatophylina indiana* (Nymph).

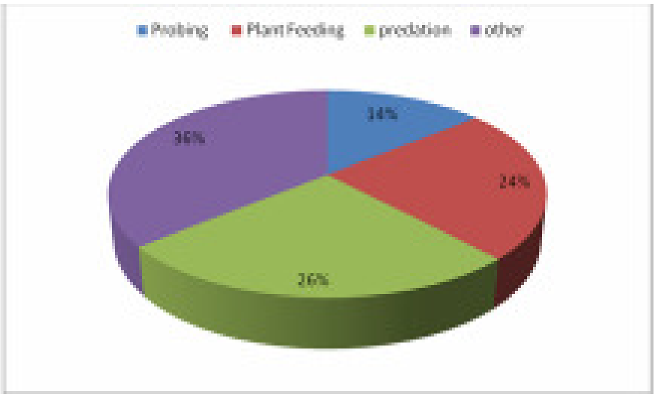
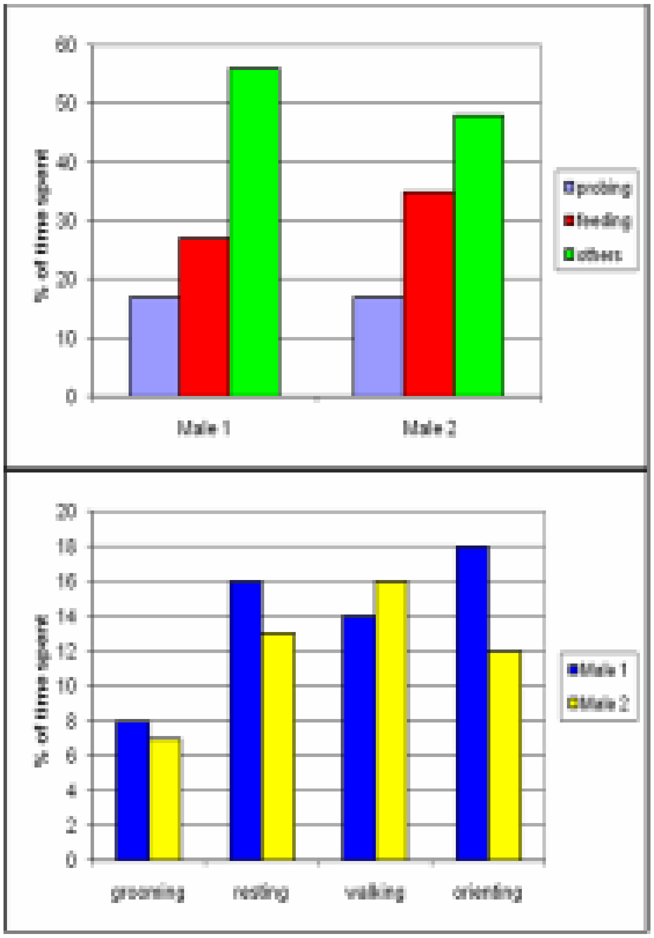


Fig. 4 : Activity budget of *Charagochilus* sp (nymph).

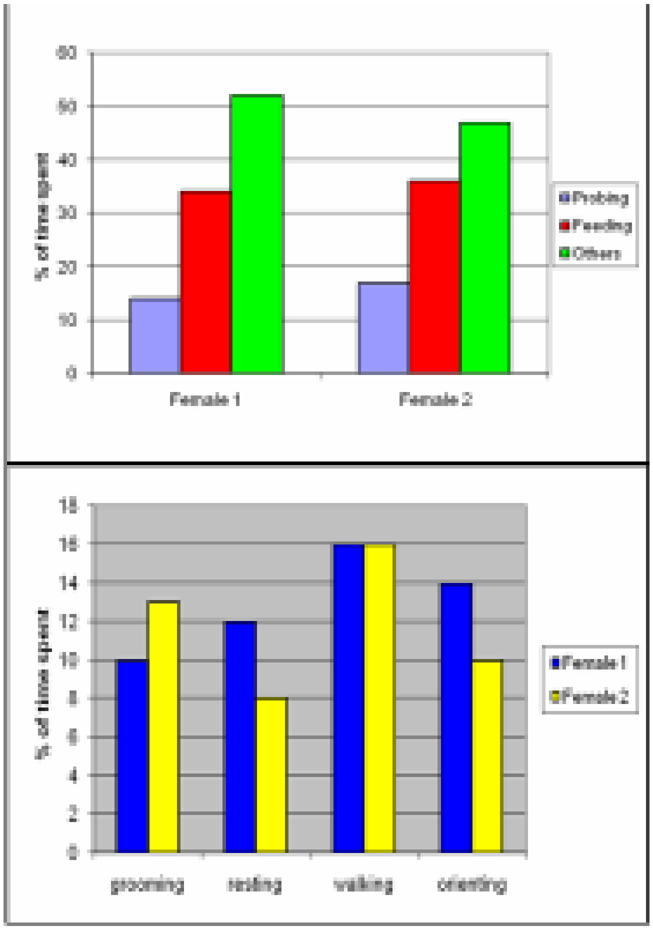


Male 1- *Termatophylina indiana,* **Male 2-** *Charagochilus* sp.

Fig. 5 : Average time spent on various activities in individual male Mirids.

Bugs, regardless of the life-stage or species examined, shows same pattern of behaviour. There were no significant differences in the activity budget or time budget between each life-stage of the two species or among the life-stages of each species. There were no significant differences in the frequency of predation events among the life-stages of each bug or between the any life-stage of the two species.

The time the adult males and females spent on the different behaviours was also measured for the preparation of a time budget. Two adult males and two females of *Termatophylina indiana* and *Charagochilus sp* were used for recording the time budget. If the time required for particular behaviours was summed for each of the individuals, insignificant inter-individual variability became apparent. In males time spent on walking, resting, orienting and grooming showed no differences between individuals and also between species. Time spent on probing and feeding also seemed to consume a similar amount of time between individual male Mirids (Figure 5). The behaviour of the two females on the host plant



Female 1- *Termatophylina indiana,* **Female 2**- *Charagochilus* sp

Fig. 6 : Average time spent on various activities in individual female Mirids.

Table 1 : Description of the behavioural events recorded for the Mirids.

Observed Behavior	Description of behaviour
Walking	Bug moving forward across the leaf surface
Resting	Bug standing motionless
Grooming	Bug making rapid movements with its fore or hind legs across its body surface and antennae
Orienting	Bug pivoting on the leaf without advancing in any particular direction
Probing	Bug probing a larva/leaf for <5sec, but not feeding
Feeding	Bug consuming a larva/leaf for >5sec.

leaves was quite similar (Figure 6). Both individual females of the two species performed the same behaviours for nearly the same time.

Transition frequency and Kinematic diagrams

The observed sequence of action patterns are used to construct a matrix that lists the number of times that each behaviour follows another. Thus, it gives the number of times that there is a transition from one type of behaviour to another. This primary transition matrix has in its left-most column the codes for all the action patterns that were observed. These same abbreviations are also

Table 2 : Total number of behavioural transitions performed by *Termatophylina indiana.*

Behaviour	**Followed by**						
	RT	**WK**	**PB**	**FD**	**GR**	**OR**	**Total**
RT	0	1	0	0	1	0	2
WK	0	0	1	0	2	0	3
PB	0	1	0	5	0	0	6
FD	1	1	1	0	1	1	5
GR	0	0	3	0	0	0	3
OR	0	0	1	0	0	0	1

Table 3 : Total number of behavioural transitions performed by *Charagochilus* sp.

Behaviour	**Followed by**						
	RT	**WK**	**PB**	**FD**	**GR**	**OR**	**Total**
RT	0	0	1	0	2	0	3
WK	0	0	1	0	1	0	2
PB	1	0	0	5	0	0	6
FD	1	0	0	0	0	4	5
GR	0	0	3	0	0	0	3
OR	0	2	1	0	0	0	1

RT-resting, WK- walking, PB- probing, FD- feeding, GR- grooming, OR- orienting.

Table 4 : Transition frequency for each behavioural sequence in *Termatophylina indiana.*

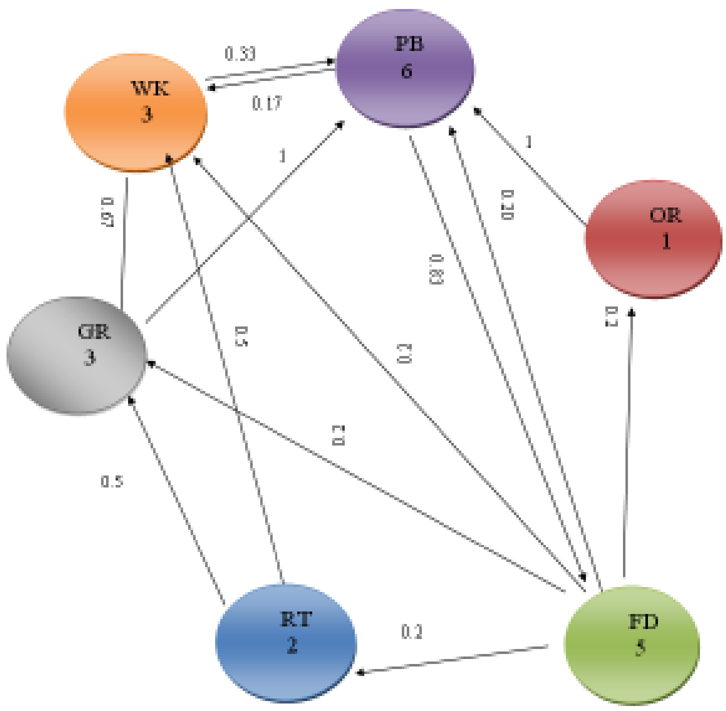
Behaviour	**RT**	**WK**	**PB**	**FD**	**GR**	**OR**
RT	0	0.5	0	0	0.5	0
WK	0	0	0.33	0	0.67	0
PB	0	0.17	0	0.83	0	0
FD	0.2	0.2	0.2	0	0.2	0.2
GR	0	0	1	0	0	0
OR	0	0	1	0	0	0

Table 5 : Transition frequency for each behavioural sequence in *Charagochilus* sp.

Behaviour	**RT**	**WK**	**PB**	**FD**	**GR**	**OR**
RT	0	0	0.33	0	0.67	0
WK	0	0	0.5	0	0.5	0
PB	0.17	0	0	0.83	0	0
FD	0.2	0	0	0	0	0.8
GR	0	0	1	0	0	0
OR	0	0.67	0.33	0	0	0

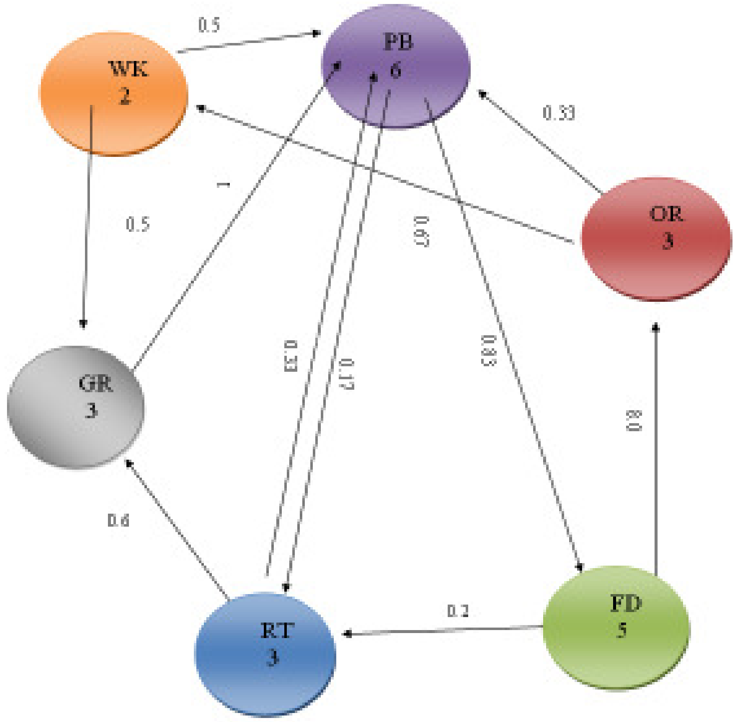
used as headings for each for column in the top row. Each cell will contain the number of times the behaviour indicated at the left was followed by the behaviour heading the column (Tables 2 and 3).

The result is a matrix that shows the number of times each behaviour listed in the column on the left is followed by each other behaviour. Thus, it gives the number of times there was a transition from one type of behaviour to another. The total number of times a sequence is starts with a particular action pattern is given in the right-most column. The transition frequency for each behavioural sequence is simply the percentage of times that a particular action pattern follows another (Table 4 and 5). The action patterns and transition frequency can be represented in a kinematic diagram (Figure 7 and 8).



(RT-resting WK- walking PB- probing FD- feeding GR- grooming OR- orienting)

Fig. 7 : Kinematic diagram of *Termatophylina indiana.*



(RT-resting WK- walking PB- probing FD- feeding GR- grooming OR- orienting)

Fig. 8 : Kinematic diagram of *Charagochilus* sp.

DISCUSSION

Nymphs and adult bugs of both the species of Miridae are normally very active, running rapidly over the surface of the leaves in search of prey. The Mirids are immobile when feeding and not easily disturbed. The behavioral time budget for each life-stage of Mirid, *Termatophylina indiana* and *Charagochilus sp,* was clearly dominated by plant feeding and plant probing events. However, there was a slight difference in the total amount of time that *Termatophylina indiana* and *Charagochilus sp.* spent feeding on plant and insect tissue. In both sexes of the two species the time spent on walking, resting, orienting and grooming showed no significant differences between individuals. Time spent on probing and feeding also seemed to consume a similar amount of time between individuals of both sexes of the two species. The kinematic diagram obtained shows the transitional frequencies of each behaviour traits. However, in the case of weed- and pest management, individual variability in behaviour concerning host selection might be a problem, as long as the determinants of the variability are not known (Roitberg, 1990). Individual variability in insect behaviour leads to higher unpredictability: however pest management requires a certain amount of predictability to ensure constant success of management efforts (Ananthakrishnan, 1999). If the time spent on different behaviours was compared between single females or males the most noticeable result was high individual variability. It should be considered with caution, since individual variability may have influenced the outcome of these experiments. It is possible that different individuals may react differently to different situations.

Encounters with *Orthaga* larvae were often followed by Mirid moving away from rather than attacking the prey, possibly as a strategy to reduce the risk of reciprocal predation. There was no evidence that Mirid were able to locate prey by sight. They often walked, probing the leaf within a body length of a stationary prey, without reacting to it. Similar behaviour was reported in two Reduviidae species (Parker, 1969). The reaction of the Mirid to encounter with mobile prey suggested that they are not aggressive predators. Leaf feeding was frequent and not significantly reduced by the presence of prey. Even more significantly, each insect spent nearly 50% of its access time primarily standing motionless in place, walking, grooming, or in sensory exploration via antennation and labial dabbing. The insects spent a major proportion of their time budget for probing and feeding. The time budget did not show any significant differences between species, sexes, individuals and also between life stages.

Concerning the host plant selection behaviour of female phytophages, it is generally assumed that they are able to assess the quality of a host plant (Charnov, 1976; Pyke, 1984). Encountering an individual host plant, they estimate its quality and add the assessments of several hosts to an image of the overall host quality in a host plant (Roitberg, 1990). Similar probing into host plant or host tissue is reported from a variety of herbivorous or parasitoid insects (Casiraghi *et al.*, 2001 and Chabi-Olaye *et al.*, 2001). In the case of the two Mirids the host plant and the host larval web are the activity centre for the nymph and the adult insects. It serves as a place to feed, mate and, of course, as an oviposition site. Thus nearly all behavioural patterns performed by the adult male and female Mirids occur on the host plant. The important role of the host plant has also been stressed for other specialized Mirids (Donna Bartlett, 1996), indicating the unique role of the host plant for specialized herbivorous insects. These Mirid bugs feed on both the host plant leaves and arthropod prey, and therefore have potential both as a predator and as an economically important pest. Other hemipterans that may play these dual roles in agricultural system include *Campylomma verbasci* (Donna Bartlett, 1996); *Acrtactomus mali* (Collyer, 1953; Sanford, 1964; Lord, 1971; Jonsson, 1985); *Plagiognathus politus* Uhler and *P. obscurus* Uhler (Braimah *et al.*, 1982); and *Psallus ambiguous* (Jonsson, 1985). When pests are omnivores instead of strict herbivores, their impact on the host plant may change as the omnivore shifts between consumption of plants and consumption of prey. *Termatophylina indiana* and *Charagochilus sp* were known from laboratory studies to be an omnivore, but no field studies have ever quantified the importance of predation as a source of food.

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