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RESOURCE EXPLOITATION BY MANGO LEAFMINER (*ACROCERCOPS SYNGRAMMA* MEYRICK): A CASE STUDY IN MICROHERBIVORES

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ABSTRACT

The mango leafminer *Acrocercops syngramma* Meyrick (Lepidoptera: Gracillaridae) will mines tender mango leaves, feeds and develop inside the mines. The insect usually active from October/November to April/May is when tender leaves are scarce as the tree is in its reproductive phase. So efficiency in foraging for food resource is significant. Hence the study on the strategic niche utilization of tender mango leaves by leafminer was carried out at Indian Institute of Horticultural Research. It was found that the insect mined only the lower tender leaves of the shoot between 13-18 cm lengths wherein older mature leaves were avoided. Hence mango leafminer wouldn't exploit all mango leaves and also all positions on leaf to utilize resource.

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INTRODUCTION

In ecology, herbivores are the first level of consumers; these are particularly well-known as agricultural and forestry "pests", but their ecological roles are far more complex, often stimulating plant growth, affecting water and nutrient fluxes, and altering the rate and direction of ecological succession (MacMahon, 1981, Schowalter and Lowman, 1999, Trumble *et al*. 1993). Microherbivores, constituted mainly by invertebrates, specifically phytophagous insects, are more studied for their crop depredations, than for their foraging ecology (Maschinski and Whitham,, 1989). The capacity for rapid response to environmental change makes insects useful indicators of change and potential regulators of ecosystem conditions, and frequent competitors with human demands for ecosystem resources (Price, 1997). However herbivory is an interesting area as they also show strategies of ecological and biological advantages with respect to an insect's niche resource exploitation, including food.

The present study was taken up on leafminers of the family Gracillaridae (Order:Lepidoptera). These are concealed leaf tissue feeders that make tunneling injuries on leaves (http://www.ncipm.org.in, 2011). They are so named because of their mining action on leaves. The tiny caterpillars on hatching mine below the epidermis and feed on the chlorophyll (Vanitha, 2015). They spend their entire life in mines and pupate within it, while a few may cut open the mines in their last instar and pupate outside or fall to the soil for pupation (Kanhar *et al.,* 2016).

The studies on the test insect *Acrocercops syngramma* Meyrick (Gracillaridae: Lepidoptera) related to ecological efficiency of the foraging or food resource exploitation by this microherbivore is hardly studied. So the objective of this study was to understand if the leafminer adults have definite strategic niche exploitation of tender mango leaves where it oviposits, and subsequently where the larva feeds and completes the life cycle.

MATERIALS AND METHODS

The study was conducted at the Indian Institute of Horticultural Research (IIHR), Bangalore, India (12°58′ N; 77°35′E). An orchard with mixed mango varieties (Alphonso, Totapuri and Banganpalli) was selected to discount the influence of a variety on herbivory of *A. syngramma*. The terminal shoots were initially categorized as very young (< week old) and young (> week old to a fortnight). In order to find the preference of *A. syngramma* for the age of shoot, 2000 random terminal branches in one tree or ten random trees was carried out in October 2012. The presence or absence of the insect's herbivory, as evidenced by the mine was recorded and presented in Table 1.

Preliminary studies on phenology with respect to the defoliator have shown two aspects of leafminer foraging: one, new shoots are scarce between October-April but occurs staggered facilitating the survival of *A. syngramma* ; two, the adults mine only tender leaves which are about a fortnight old (Maruthadurai *et. al.,* 2012). We critically examined the resource utilization by the leafminer by sampling randomly the irregular emerging vegetative new terminal shoots during reproductive phase of the tree, when the pest was active. Mango has two major cycles of flushing in March/April and September/October (Gundappa *et al.*, 2014). So such leaves were sampled randomly in a staggered manner from November 2013 to February 2014 and during 2015, from March-April. Thus a total of 125 leaves were sampled when staggered flushing was seen in the orchard. Between October-February (2014-15), the population of *A. syngramma* was so low that sampling could not be done. In each sampled leaf, the position of the mines on the leaf such as tip of the leaf or distal (D), the base of leaf or proximal (P) and mid- central (C) were recorded.

The lengths (cm) and widths (cm) of each sampled leaf and the mine were measured using a centimetre scale in the field. All the sampled mines were marked and monitored till pupation to confirm the normal development of *A. syngramma* into pupa and adult. The measurement of the mines was taken only at the later instar, when larva stopped feeding and further expansion of mines was ruled out. The total absence of parasitism enabled all the larvae to pupate. The results were subjected to analysis of variance (ANOVA) with LSD (5%) as test of significance and correlation coefficient '*r*' was calculated and interpreted at $p = 0.05$ (Little and Hill, 1978). During the study period, there was no parasitism, hence all the 125 larvae completed the life cycle and pupated normally.

RESULTS

Our investigation was to find out whether length and width of a leaf mattered in the resource utilization by *A. syngramma*. It was found that only new leaves which was a fortnight old (lower half of new terminal shoot) with length and width ranging from 13.98-18.13 cm and 3.93-4.32 cm respectively were preferred by the moths for egg laying (Table 2).

The study showed that moths selectively chose bigger tender leaves between 13.98 to 18.13 cm. There was no significant difference among the length of a leaf between positions of the mine (Table 2). So, also with respect to width of a leaf, as leaf length and width were highly significant correlated at p=0.05 (Table 3). From Table 2 it is clear that a larvae needs an optimum mine length and width ranging from 1.91-2.71 cm and 1.25-1.58 cm width respectively, irrespective of position on a leaf (Fig 1). Therefore, unless the leaves have a half-width exceeding the maximum potential width of a leaf mine, a leaf may not be exploited by *A. syngramma*. The adults choosed only those leaves which had adequate mine space especially width of >1.25 cm for the developing larva seemed to be a parasitoid avoidance strategy, as a ruptured mine made the larvae vulnerable. So the next answer we sought was, whether there is a preference for a position. It was found that in leaves with maximum mean length (18.13 cm) the moths seemed to prefer the proximal position. However this seemed a weak inference, as there was no significant difference in the length of the leaf for all the three positions. The same was true for leaf width.

Acrocercops syngramma preferred only the lower leaves (100%) (Table 1) of a new shoot which is usually upto about a foot from the apex of the terminal branch. Beyond this, the leaves mature with darker hue of green. Thus the *A. syngramma* did not prefer too young (< 13cm length) or older leaves. This helped us to further sample only the lower tender leaves >13cm on a new shoot of a terminal branch, as these were preferred for foraging by *A. syngramma* (Table 1).

As the foraging niche is scarce and limiting, one strategy that surfaced was the moths tolerance to joint occupancy of a leaf as in >50% of cases two mines were seen on the same leaf, thus, optimally maximising on the food. Interestingly these mines were displaced in position within a leaf (Fig. 2) in most cases. Thus joint occurrence in same position was low (Fig. 3) as D&D, P&P and C&C were only a low proportion.

Space crunch in a mine would occur only in terms of width of the mine as on a mango leaf longitudinal space is not a limitation. It was found that in all positions the width of the leaf facilitated at least one centimetre mine width (Table 2). Thus leaves with < one centimetre half width (terminal new leaves) were never chosen for oviposition.

DISCUSSION

A new mango leaf of nearly fortnight old was the critical food resource for the larva of *A. syngramma*. The larval period lasted for about 8-10 days (Maruthidurai *et al.*, 2012). The larva seemed to prefer young tender leaves only, as mature leaves were never chosen by the adult female. Mined leaves showed rusty brown blotches as residual mines as the leaves mature (Dwomoh *et al.*, 2008).

Table 1: Preference on the terminal branch

Leaf maturity category	Position of leaves on terminal branch	% mining	Remarks
Young leaves (<13 cm)	Top	0.00	Not preferred by moths for oviposition
Young leaves (>13 cm)	Middle	100.00	Preferred for oviposition and larval development
Older leaves (Dark green)	Base	0.00	Not preferred (Only residue infestation seen)

Table 2: The mean leaf and mine sizes with respect to mine positions

Positions	Mean leaf length(cm)	Mean leaf width(cm)	Mean mine length(cm)	Mean mine width(cm)
Proximal	18.13	4.32	2.71	1.58
Central	13.98	3.98	2.54	1.25
Distal	14.45	3.93	1.91	1.32
LSD (5%)	NS	NS	NS	NS

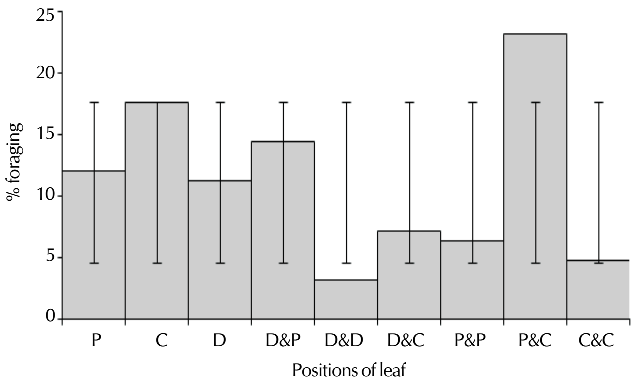

Fig 1: Percent infestation of mango leafminer *A. syngramma* on different positions of leaf. P = proximal, C = Central, D = Distal,

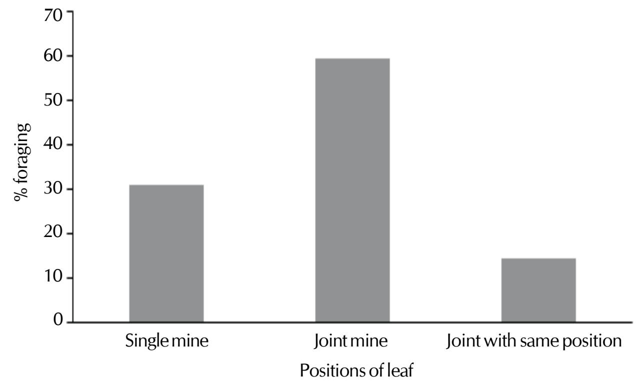

Figure 2: Mining pattern of *A. syngramma* on mango leaves

Table 3: Correlation coefficient of leaf and mine traits

	Leaf length Proximal	Central	Distal
Leaf width	0.67*	0.84*	0.75*
Mine length	0.25*	-0.01	0.07
Mine width	0.22*	0.12	0.21*

LSD = Critical difference; NS = Non significant

Our first hypothesis is to find out if length and width of mango leaf mattered for resource utilization. It was found that the female which alights on a new shoot would invariably leave the terminal young leaves (Table 1) and exploit only the leaves on lower half of the shoot. Size of the upper terminal leaves of a new shoot is inadequate for mining. Thus each new shoot would have only a few leaves infested. So there is no major deprivation of photosynthesizing leaves subsequently. This is an evidence of the moth yet again strategizing not to destroy the host tree shoots completely, again indirectly ensuring its own survival, through resource conservation. Further these terminal leaves, after a fortnight are suitable for oviposition.

The present study clearly established that the ability to evaluate resource availability and subsequent utilization do exist with females of *A. syngramma* as observed in other leafminers. The female leafminer moths, *Paraleucoptera sinuella* (Reutti) walk carefully around several leaves of a host plant before laying eggs (Kagate and Ohgushi, 2001). The authors concluded that this behaviour may enable a female leafminer to measure leaf size to adjust the clutch size accordingly (Godfray, 1986). Further, ability of leafminers to measure the leaf size suitability by estimating the leaf chemical composition. This argument probably seems to be appropriate in this as *A. syngramma* avoided mature leaves and young leaves to lay eggs. The former being tannin rich and the latter being a low-risk in terms of nutrient flow and space crunch.

The very first question we needed to answer, basic to this study was to which position (proximal, distal and center) on the shoot, the moth preferred to raise its progeny. The results in Fig. 1 showed that mines were found across all positions. However one strategy was pronounced *i.e.*, in 70 % cases, the female chose to oviposit at two different of the three positions on a single leaf to maximize the resource utilization but not one next to the other on the same side (Fig. 2). Thus in 76% of the cases, where two mines occurred on a leaf only 24% of these were adjacent to each other, but always on the left or right side of the lamina and not on the same side of the lamina. This strategy seemed to be advantageous as the larvae in the mine could develop and pupate normally. As larvae stuff the mine with the excreta, space crunch can rupture the mine if limited by lamina space making it vulnerable to parasitoid attack.

One of the foraging strategies of the leafminer should be to avoid coalescing between mines, when two mines expand contiguously this may result in competition for food, enhance the chances of rupturing and subsequent parasitoid attack. This coalescing is common on cashew for the same species, as cashew leaves have broad lamina as observed by one of the authors (Verghese 2015). In case of mango leaf, the leaf shape being triangularly long and coalescing is being a possibility; the moths seemed to strategically avoid adjacent mines on one side of the leaf. This became clearer when the mining pattern on the leaves was examined. Though the mid rib prevents coalescing in mango leaf there appeared to be a strategy by the moths to avoid positioning two mines in one position even if one on either side of the midrib as this may limit the nutrient flow from mid rib to the side rib-branches. Two mines if in same position may exert equal pull of nutrients to either side probably depriving nutrition to the growing larvae.

This case study established the hypothesis that mango leafminer randomly exploits new leaves is rejected. Results suggested an evidence of foraging strategy by the micro herbivore *A. syngramma* to optimize exploitation of food and breeding niches for its survival. Such studies on ecology of micro herbivores have bearing on better understanding of tropic systems and energy flow in ecosystems at a micro level.

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