Management of Mopane in Southern Africa

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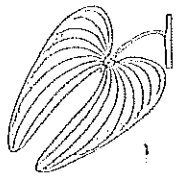
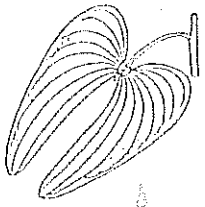
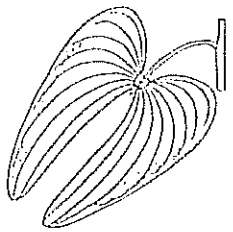




CHAPTER NINE

INTERACTIONS BETWEEN THE MOPANE CATERPILLAR, *IMBRASIA BELINA* AND ITS HOST, *COLOPHOSPERMUM MOPANE* IN BOTSWANA.



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ABSTRACT

In Botswana caterpillars of *Imbrasia belina* predominantly occur in *Colophospermum mopane* (mopane) woodland. Field studies showed that when mopane and *Terminalia sericea* (another known food plant of *I. belina*) occurred together in the same habitat, *I. belina* moths laid more eggs on mopane than on *T. sericea*. This appeared to suggest that the moths are selective in their oviposition behaviour and also that mopane is the preferred host. Decisions by the moths when selecting oviposition sites in the habitat were found to be density-dependent. The defoliation pressure exerted by the caterpillars on mopane was found to affect the fecundity of the plants. Eighty-six percent of defoliated mopane trees failed to produce seeds, while 84 % of undefoliated trees produced seeds. Bigger trees were however able to withstand the negative impacts of defoliation better than smaller ones. The implications of this interaction (host preference, density-dependent habitat selection and impact of defoliation on host plant) between *I. belina* and mopane on mopane management are discussed.

Keywords; *Imbrasia belina, Colophospermum mopane,* defoliation, host preference, habitat selection.

INTRODUCTION

In Botswana *Colophospermum mopane* (Kirk ex Benth.) Kirk ex J. Léonard, commonly known as mopane, mainly occurs in the north and north-eastern parts of the country (Fig. A). The plant has a variety of uses to the rural people in the areas where it occurs (Sekhwela *et al.* 1992). It is used in household construction, fencing homesteads, fencing fields, building kraals, firewood, wood carving and also as browse for both wildlife and livestock during the dry season. Mopane plants also benefit people indirectly because they are hosts of the "mopane worms" (or "phane" in Setswana) which are economically important to the rural people of north-eastern Botswana (Moruakgomo 1994).

Mopane worms are caterpillars of the moth *Imbrasia belina,* (Westwood), (Lepidoptera: Saturniidae) and they are an important source of food which is high in protein value. The harvesting of phane is seasonal and in Botswana there are two harvesting periods per season (December/January and April/May). In Botswana, phane harvesting has become commercialized and most of the harvest (90 %) is exported to South Africa. A study on the economics of phane in Botswana by Moruakgomo (1994) estimated the phane trade to run into millions of Pula.

Phane can exert heavy defoliation on its host plant (mopane) when densities of the caterpillar are high. In cases where the population is very high, large stretches of mopane woodland are completely defoliated. Caterpillars can feed on several food plants besides mopane (Ditlhogo 1996, Pinhey 1975). These include *Sclerocarya birrea* and *Terminalia sericea.* It was however not clear prior to this study whether this species shows any preference to the array of hosts it exploits. The purpose of this study was to determine if *I. belina* moths preferentially select mopane over other species when laying eggs, whether the oviposition behaviour of the moths is density-dependent and if defoliation by the caterpillars affects host fecundity.

METHODS

Host preference by *I. belina* moths:
The determination of whether *I. belina* moths preferentially lay their eggs on mopane was carried out in the field. A 50 m x 50 m quadrat was set up in the study site at Serule on 3 March 1995. Twenty trees were randomly selected from the quadrat. The species of each chosen tree was recorded and the presence or absence of egg clusters on it noted.

T. sericea is one of the food plants of *I. belina* larvae. However, it is not known whether *I. belina* moths would selectively lay their eggs on any one of its food plants, when more than one of them occur in the same habitat. Since none of the other known food plants for *I. belina* were encountered in Serule, this experiment was repeated at an area on the outskirts of Selibe - Phikwe. In this site a belt of *T. sericea* borders an area of mopane woodland. A 50 m x 50 m quadrat that included both *T. sericea* and mopane, was set up at this site. The sample size was increased to 30 trees at this site.

Data from this experiment provided frequencies of the different plant species sampled and the proportion of egg clusters found on each plant species. A chi-squared test was used to determine whether the observed number of egg clus-

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ters laid on each plant species significantly differed from that expected if egg laying was random. The data were grouped according to plant species and then classified based on presence or absence of eggs. Categories with low numbers were grouped.

Habitat selection by *I. belina* moths:
During the 1992/93 season, the cycle started late due to late rains. This resulted in the first generation ending at the end of January to beginning of February. On 7 February 1992, 50 m x 30 m quadrats were set up in Lechana, Bobonong and Matangwane. The positions of ten mopane trees were randomly chosen from each quadrat and the height and canopy diameter of each tree were recorded. Egg clusters were visually searched for in each tree and the number found was recorded.

This exercise was repeated during the 1994/95 season at Serule. The quadrat size was increased to 50 m x 50 m and the sample size was increased to 30 trees. This was done for both generations and it was carried out well after egg laying had ended. It was carried out on 6 December 1994 and 14 March 1995 during the first and second generations respectively.

The mean number of egg clusters laid per tree was used as an index of the density of the moths that laid them. That is, the higher the mean number of egg clusters per tree, the higher the density of the laying moths. ANOVA was used to test whether the mean number of egg clusters per tree was statistically different between generations (Serule), or between sites (Lechana, Bobonong and Matangwane). This also helped in determining whether the relationship between tree canopy diameter and the number of egg clusters laid per tree was influenced by moth density.

Consequences of defoliation on the host plant
Mopane trees produce hermaphrodite flowers and the flowering season for this species is between October and March (Coates Palgrave 1983). To determine the impact of defoliation by *I. belina* larvae on these trees, two 50 m x 50 m quadrats were set up in Serule on 13 April 1995. One quadrat was in an area of small trees (less than seven metres high), while the other one was in an area of big trees (up to 11 m high). Thirty mopane trees were randomly chosen in each quadrat and it was recorded whether they were defoliated and also whether they produced seeds. The height of each tree was also recorded. Data from the two quadrats were pooled and categorized into two groups based on tree size (height). The groups were less than or equal to 4.5 m, and greater than 4.5 m. The data were classified according to presence or absence of seeds.

All the mopane trees at Serule were completely defoliated and so there was no data from undefoliated trees with which to compare and analyze for the effects of defoliation on the host trees. This experiment was therefore repeated in a site about five kilometres east of Francistown. There were two distinct areas (about 1.5 km apart) with respect to the degree of defoliation in this site. A 50 m x 50 m quadrat was set up in each of these sites and the procedure described above followed for each site. Data from the two sites were pooled and classified into whether a tree was defoliated and also whether it had produced seeds.

The data from these experiments were analyzed using the nonparametric chi-squared test (Seigal 1956). Francistown data were used to show the impacts of defoliation on tree fecundity, while data from Serule was used to determine whether the size of a tree helped the tree to withstand the impacts of defoliation.

RESULTS

Results from field experiments show that when two of the known food plants of *I. belina* (mopane and *T. sericea*) occurred together in a site, the moths preferentially laid their eggs on mopane (Table 9.1). This suggests that mopane is the preferred host. Data from field studies also indicate that more egg clusters are laid on trees with more foliage than on small trees/shrubs when moth density is high (Table 9.2). This appears to indicate that the oviposition behaviour (habitat selection decisions) of the moths is density dependent. Defoliation by the caterpillars was found to affect the ability of the host to produce seeds. Only 14 % of the defoliated trees produced seeds, while 84 % of the undefoliated trees produced seeds. Older trees were able to produce some seeds, even when completely defoliated. This indicated that older trees are able to withstand the effect of defoliation better than younger ones.

Table 9.1: The availability of different plant species and the spatial distribution of *Imbrasia belina* eggs between species.

Site	Species	Frequency	No with Eggs
Phikwe (n=30)	*Acacia tortilis*	1	0
	Commiphora sp.	1	0
	Dicrostachys cinerea	2	0
	Terminalia sericea	13	3
	Colophospermum mopane	13	9

Table 9.2: The strength of the relationship between tree canopy diameter and number of egg clusters laid per tree, as the *Imbrasia belina* moth density increases.

Site & Generation	Mean (±SE) No. of Egg Clusters / Tree	Sample Size	Slope of Regression Line	r^2
Lechana 1st Gen.	6.4 ± 2.20	10	7.494	0.524
Bobonong 1st Gen.	8.9 ± 3.00	10	12.297	0.899
Matangwane 1st Gen.	1.9 ± 0.03	10	0.739	0.113
Serule 1st Gen.	2.2 ± 0.30	30	0.270	0.010
Serule 2nd Gen.	8.4 ± 1.42	30	6.566	0.557

Where: Gen. = generation

DISCUSSION

The study has shown that in the field, mopane will be the host most affected in mopane woodland since the moths selectively oviposit on it. The question which comes to mind is, 'why this preference?' Before an insect can feed or oviposit on a host plant, it must be able to select the host from an array of plant species (Hodkinson and Hughes 1982, Ditlhogo 1996). Intuitively this tells us that the insect selects the host on which it is able to maximize its fitness. The preferred host should therefore be in some way nutritionally better than other plant species in the habitat. Results of a study on the nutrient composition of mopane and another host plant of *I. belina* caterpillars are given in Allotey *et al.* (1998).

The oviposition behaviour of the moths has been found to be density dependent. There were significantly more egg clusters laid on bigger trees with increasing moth density. This phenomenon shown by some organisms to distribute their young ones proportionately to the amount of resources available is known as density dependent habitat selection (Milinski and Parker 1991, Rosenzweig 1991). This is an evolutionary mechanism shown by such organisms to try and maximize their fitness by reducing intra-specific competition amongst their young. Given this, one could speculate that perhaps at low-medium densities, shrubs would experience less defoliation pressure than bigger trees. This has some possible management implications since defoliation is known to affect wood growth (Crawley 1983).

The loss of the ability to produce seeds by the host means that the woodland loses potential recruitment through seedling establishment. Although not covered in this study, herbivory is known to affect wood growth and given that in Botswana the host is defoliated twice in one growing season, one would expect the impacts on wood growth to be quite significant. This has some implications if in addition to phane harvesting, the woodland is also managed to produce poles for construction purposes.

CONCLUSIONS

There is little research either on the management of mopane woodlands or the management of phane in Botswana. Due to the economic value of phane in Botswana, the immediate need is to develop a method to manage the insect instead of the plant. But it has to be borne in mind that the insect and the plant are strongly interrelated, such that the management of one (the insect) has to take into account the other (the host). Information obtained from this study is thus of potential benefit to management, since it has contributed to the understanding of insect / host interactions. More long-term quantitative research is still needed before we can get a full understanding of how populations of *I. belina* interact with their host (mopane) and how such interactions affect both the host (woodland) and populations of the insect in the long run.

ACKNOWLEDGEMENTS

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ISSUES RAISED DURING PARTICIPANTS' DISCUSSION

What is the number of eggs on the different sized trees?
There are more moths on bigger trees due to big trees having more leaves.

Was a percentage calculation done on the number of eggs per big tree?
No.

Does egg laying take place randomly or not?
High food value patches are selected first. Eggs are laid on big trees because it is safer than shrubs. Animals destroy shrubs faster. The insects also use sight when selecting trees. Of course they see the big trees first. Eggs are laid on shorter trees when there are no taller ones.

Are there any benefits of a 2-way benefit structure?
When decomposition takes place, the tree ultimately benefits. But not in the short term. Early flushing depends on tree reserves. Trees and the caterpillar have been co-existing for many years. There must be a link.

Are there fluctuations in eggs and caterpillar?
Yes, the rainfall has an effect.

Could no production be a sign of stress?
It is a sign of defoliation.