Management of Mopane in Southern Africa

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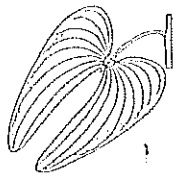
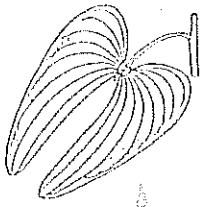
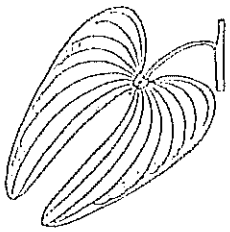




CHAPTER TEN

MOPANE *(COLOPHOSPERMUM MOPANE)* AS HOST FOR THE DEVELOPMENT OF THE MOPANE WORM, *IMBRASIA BELINA* WESTWOOD, IN BOTSWANA.



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ABSTRACT

The development of the mopane worm, *Imbrasia belina* Westwood, was studied under laboratory conditions (temperature range 20 - 24 °C and 50 - 80 % RH) from eggs collected in the field and reared on *Colophospermum mopane* (mopane), *Sclerocarya birrea* (morula) and *Terminalia sericea* (mogonono). Mopane was found to be the most suitable host for *I. belina* in terms of developmental period and number of emerged adults. Chemical analysis showed that the leaves of mopane and morula contained 5 % and 2 % DW of protein and 10 and 9 kJ/g DW of energy, respectively. The mopane leaves had a protein to energy ratio (P/E) of 8.1 ± 1.6 mg/kJ whereas morula leaves had a P/E of 1.9 ± 0.2 mg/kJ, indicating that mopane leaves are nutritionally better than morula leaves. The results show that *I. belina* can be reared successfully on mopane and morula under laboratory conditions and that mopane leaves are preferable since they provide a nutritionally richer diet. The implications of these findings for mopane management are discussed.

Keywords: *Colophospermum mopane, Imbrasia belina, Sclerocarya birrea, Terminalia sericea.*

INTRODUCTION

Colophospermum mopane (Kirk ex Benth.) Kirk ex J. Léonard, commonly known as mopane, is host to several insect species. These include *Imbrasia belina* (the mopane worm) (van Voorthuizen 1976), *Gonometa rufobrunnea* (the mopane silk moth), *Gynanisa maja* (the speckled emperor moth), and *Arytaina mopane* (the mopane fly). *I. belina* and *G. maja* both produce edible caterpillars and *A. mopane* secretes an edible gum on the leaves of the mopane tree. Among these insect species, *I. belina* is the most important because of its economic importance as a protein food source and its feeding effects on mopane. Mopane trees can become completely defoliated when the mopane worms are in season. The impact of the mopane worms within the mopane woodlands (an extensive vegetation type stretching from South Africa, through Moçambique, Zimbabwe, Botswana, Namibia, Angola, Zambia and Malawi) is immense. It has been suggested that *I. belina* is a keystone species within this vegetation complex, based on wildlife management findings (C. Styles[1], pers. comm., 1996).

It has been suggested that the mopane worm feeds exclusively on mopane leaves (Taylor and Moss 1982, van Wyk 1972). However, more recent reports show that some other plants, including *Sclerocarya birrea* (morula) and *Terminalia sericea* (mogonono) may also be hosts to *I. belina* (Table 10.1). Some insect species select the host plants on which they feed to obtain sufficient nourishment for growth, development and reproduction (Hodkinson and Hughes 1982).

Table 10.1: Possible host plants of the mopane worm, *Imbrasia belina* in Botswana (after Ditlhogo 1996).

Species	Family	Common name
Acacia nigrescens	Mimosaceae	mokoba
Colophospermum mopane	Caesalpiniaceae	mopane
Combretum apiculatum	Combretaceae	mohudiri
Commiphora sp.	Burseraceae	seroka
Dichrostacys cinerea	Mimosaceae	moselesele
Grewia bicolor	Tiliaceae	mogwana
Sclerocarya birrea	Anacardiaceae	morula
Terminalia sericea	Combretaceae	mogonono

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The life cycle of *I. belina* on mopane under field conditions is well known (Oberprieler 1995, Ditlhogo 1996). However, little is known about its comparative development on mopane, morula and mogonono and whether it can develop successfully from egg hatch (i.e. first instar larva) to the adult stage on these latter two host plants. We aimed to determine the preference of the mopane worm for a particular host plant, the effect of over dependence of this species on mopane and the management strategies necessary to sustain the mopane worm and its main host, mopane.

The mopane worm provides a seasonal product. The main harvesting period usually starts in late December and lasts for about three weeks. Depending on the rain, there is usually a second small crop in April or May. In favourable years many people, particularly women, are engaged in the harvesting of the worm. They cook, dry and sell the product. It is therefore a major rural industry (Allotey *et al.* 1996). Botswana is the largest producer of mopane worms for the open market in South Africa. If it were possible to raise mopane worms artificially, then the seasonal dependence on the market would be reduced, as well as the degree of exploitation on the natural occurrence of worms.

METHODS

The development of *I. belina* on the leaves of mopane, morula and mogonono was studied under laboratory conditions at the Department of Biological Sciences, University of Botswana. Eggs of *I. belina* were collected from the mopane woodlands in Topisi, Makoba-wa-Gashadi and Mmadinare, all in the north-eastern district of Botswana. Forty first instar larvae from newly hatched eggs were transferred with the aid of a camel hair brush, into plastic Petri dishes (9 cm diameter), one larvae per Petri dish. Each Petri dish contained two fresh mopane leaves attached to a piece of cotton wool, soaked with distilled water. The leaves were changed every second day for the first week and thereafter on a daily basis. The cotton wool was replaced with a filter paper after one week. At the third instar stage, the lid of each Petri dish was replaced with the base of a second Petri dish of the same size so as to create a larger space for the larvae. Each larvae was then transferred at the fourth instar stage, into a one litre glass kilner jar. Each jar had a filter paper inserted into the lid of the jar to allow for aeration. Mopane leaves attached to small twigs were placed in the jars and replaced with fresh ones every second day. Observations were made on the insect development within the jar from the fourth instar larvae to the pupae that went into diapause for seven months (18 March to 12 October 1996) before moth emergence.

Experiments were maintained at 20 - 24 °C, room temperature and 50 - 80 % RH. Development of *I. belina* on the leaves of morula and mogonono was studied under the same conditions as given for its development on mopane leaves. The numbers of first instar larvae used and the procedures were the same for the three host species.

The levels of protein and energy in mopane and morula leaves were chemically determined. The protein-energy ratio (P/E), which is a measure of the quality of plant diets, was then determined. The protein in the samples was hydrolyzed with 10 N sodium hydroxide solution and the amino acids were determined with the Spectrophotometric Ninhydrin method using a wave length of 570 nm (Allen 1981). Bovine albumen treated in the same manner as the samples was used to construct the calibration curve. The energy content of the samples was measured by burning in a Philip Harris food calorimeter. Digestive efficiency, the ability of the animal to digest and assimilate food, was calculated by the ash-ratio method of Conover (1996). Animal ecologists and nutritionists have used the concept of digestible protein-energy ratio to assess nutritional quality of plant diets.

RESULTS

The developmental period of *I. belina* from egg hatch (i.e. first instar) to the pupal stage ranged from 56 to 62 days when reared on mopane leaves (Table 10.2). Sixty-five percent of the larvae reached the pupal stage and 55 % of the initial population emerged as adults after diapause (i.e. pupae were in diapause during winter). The developmental period of *I. belina* on morula leaves from egg hatch to the pupal stage was 72 days (minimum), with 42.5 % and 27.5 % of the initial population reaching the pupal and adult stages, respectively (Table 10.3). *I. belina* could not complete development on mogonono leaves. Twenty percent of the larvae developed from the first instar stage to the second instar on mogonono, but there was no further development and the larvae died at the second instar stage.

The mean fecundity (i.e. number of eggs laid by mature female during its life time) of emerged female moths reared on mopane[2] leaves was 89.2 and the sex ratio of male to female from those reared on mopane leaves was 1.2 : 1.0 (Table 10.2). Mopane leaves contained 5 % Dry Weight (DW) of protein and a protein-energy ratio of 8.1 ± 1.6 mg/kJ. Morula leaves contained 2 % DW of protein and a protein-energy ratio of 1.9 ± 0.2.

DISCUSSION

Of the three plants studied, *I. belina* was well maintained on mopane leaves (55 % adult emergence) compared to morula (27.5 % adult emergence) and unable to develop beyond the second instar stage on mogonono. Field observations showed that *I. belina* could develop on mogonono (M. Ditlhogo[3], pers. comm., 1996).

[2]Fecundity was determined only for the development of *I. belina* on mopane leaves. Since the number of adults from the rearing on morula was only 11 and there was no development on mogonono leaves

[3] M. Ditlhogo, Department of Biological Sciences, University of Botswana, Gaborone, Botswana.

Table 10.2: Developmental period of *Imbrasia belina* from egg hatching (Instar I) to adult when reared on *Colophospermum mopane* leaves.

Attribute	N	Developmental period (days)	Range (days)	Survival (%)	Sex ratio (m/f)	Mean fecundity (S.E) n = 10, #
Instar I	40	16	16 - 17	97.5		
Instar II	39	6	6 - 9	95.0		
Instar III	38	8	8 - 12	95.0		
Instar IV	38	18	18 - 27	92.5		
Instar V	37	8	8 - 14	65.0		
Pupa	26	7 months*	197 - 223	55.0		
Adult	22			55.0	1.2 : 1.0	89.2 ± 3.0 (53 - 140)

* pupa in diapause
\# range in parenthesis
N initial population number

Ditlhogo (1996) noted differences in the fecundity of *I. belina* under field conditions in generations one and two. He reported mean fecundities of 231.1 and 156.2 for the first and second generations respectively. He reported that the reason was not yet known but could be related to factors that determine the size of the pupating larvae. Under laboratory conditions, there are several factors, for example quality / quantity of food and micro environmental conditions which could affect the size of the larvae, pupae and adult *I. belina*. Under field conditions the larvae are exposed to unlimited food supply and higher temperatures during the day compared to laboratory conditions. From the results, mopane leaves were found to be nutritionally superior to morula leaves. The nutritional quality of a diet may be an important factor in determining oviposition and host selection in insects. With the successful rearing of *I. belina* on the two host plants, mopane and morula, it is possible that mopane worm farming could become a reality. It should be possible to formulate an artificial diet from which the mopane worm can be reared commercially.

CONCLUSIONS

It is important that in our management strategies for both the host plant, mopane and the defoliator, *I. belina*, one should have sound knowledge of the developmental biology of the insect on its preferred host as well as on other host plants based on field and laboratory studies. The pressure of defoliation of mopane by the mopane worm, especially in predominantly mopane populated woodland, could be reduced by encouraging mixed planting / interplanting of mopane with morula, or mogonono where possible. In addition, the introduction of mopane worms onto monoplantings of morula could be undertaken in particular areas, while mopane worm farming could be undertaken in future using morula and / or an artificial diet.

Table 10.3: Development of *Imbrasia belina* on *Sclerocarya birrea* (morula) and *Terminalia sericea* (mogonono).

Condition	I	II	III	IV	V	Pupa	Adult
Sclerocarya birrea							
No. entering stage	40	35	24	24	20	17	11
Mortality per stage	5	11	0	4	3	6	
Survival per stage	35	24	24	20	17	11	
% Survival per stage	87.5	60.0	60.0	50.0	42.5	27.5	
Terminalia sericea							
No. entering stage	40	8	0	0	0	0	
Mortality per stage	32	8	0	0	0	0	
% Survival per stage	20.0	0	0	0	0	0	

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ISSUES RAISED DURING PARTICIPANTS' DISCUSSION

Why are worms found in some areas and not in others?
There are identified predators of worms e.g. birds. In time, in some areas, they have eliminated all worms in some of the woodlands, by predating the worms in their initial stage. Distribution is patchy and this could be due to the pupation substrate [soil].

Which is the correct name, Imbrasia or Gonimbrasia?
Currently, the correct genus is *Imbrasia.*

Chris Styles observes that in soils derived from granite, you have many worms and in adjacent areas where the soils are from basalt, there are no worms.

In South Africa people claim the mopane worm was extinguished by DDT spraying 15 years ago. How true is this?
DDT is not biodegradable and stays active for a very long time; it would be interesting to see how long after an area has been sprayed could worms survive again.

What is the difference between moth emergence in the farming area and controlled area? The game break the soil better than domestic animals, so could there be more or easier emergence from pupation?

What effect does degradation of woodland have on mopane worm populations?
There would be a loss of food resource, possible compaction of the soil, worms can feed on other food, but not sure if they can then molt and complete their cycle.