AN INVESTIGATION OF FACTORS INFLUENCING THE ABUNDANCE OF EDIBLE CATERPILLARS IN KOPA'S CHIEFDOM, MPIKA DISTRICT, ZAMBIA

By

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APPROVAL

THIS DISSERTATION BY *MS. ETHER HARA* ENTITLED: *"AN INVESTIGATION OF FACTORS INFLUENCING THE ABUNDANCE OF EDIBLE CATERPILLARS IN KOPA'S CHIEFDOM, MPIKA DISTRICT, ZAMBIA"* IS APPROVED AS FULFILLING THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN GEOGRAPHY OF THE UNIVERSITY OF ZAMBIA.

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DECLARATION

I, Esther Hara, declare that this report represents my own work. It has not previously been submitted for a degree or any award at the University of Zambia or any other institution. All published work or materials from other sources incorporated in this report have been specifically acknowledged and adequate reference thereby given.

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ABSTRACT

The sale of edible caterpillars of two species, *Gynanisa maja* (Klug) and *Gonimbrasia belina* Westwood is the main economic activity through which the majority of the households in chief Kopa's chiefdom earn income. Even though edible caterpillars have been harvested every year in the chiefdom, the annual abundance has been fluctuating, such that the quantities of the harvests vary. The study therefore focused on finding out the factors that influence the variations in the yearly edible caterpillar abundance since a reduction in the abundance means less harvest for the households, resulting in less income through the sale of the edible caterpillars and in turn reduced access to goods and services.

The study used primary data. The primary sources of data included in-person interviews and focus group discussions. In the in-person interview the 100 respondents sampled, based on accessibility and availability in the sample areas of the chiefdom, were interviewed using an interview schedule with open ended questions. Single-sexed focus group discussions were held with each group constituting 12 participants and a checklist of semi-structured questions was used to guide the discussions. To verify some of the claims from the two sources of data, a discussion was held with the District Forestry Officer.

Edible caterpillars show periodicity in abundance in which there is a definite pattern of peak abundance. Beside entomological factors yet to be investigated, the abundance seems to be influenced by both chitemene cultivation land use and climatic factors. Chitemene appears to influence the abundance of edible caterpillars by facilitating the rapid re-growth of desirable tree species on which caterpillars feed following woodland clearing. Three climatic factors, namely temperature, rainfall and wind speed seem to influence the abundance of *Gynanisa maja* and *Gonimbrasia belina* by impacting on the egg, larva and pupa stages.

Therefore, climatic factors and land use have an influence on the abundance of Gynanisa maja and Gonimbrasia belina.

I dedicate this work to my husband Yobbe, my children Chisomo and Shalom for their confidence, tolerance, love, financial support and encouragement during the duration of my study.

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LIST OF ACRONYMS AND ABBREVIATIONS

CIFOR:	Center for International Forestry Research
MENR:	Ministry of Environment and Natural Resources
NEAP:	National Environment Action Plan
NGO:	Non Governmental Organisation
WVZ:	World Vision Zambia

OPERATIONAL DEFINITIONS

Abiotic factors:	Influences on abundance that originate from non living things.
Abundance:	Quantities of a species of insects at any stage of the developmental cycle in a given area at a given period of time.
Biotic factors:	Influences on abundance that originate from living organisms.
Chitemene:	A form of cultivation in which trees are cut, branches piled up in a portion of the cut area and burnt to create an ash-field which is used for a period of about four years to grow food crops and then abandoned when the soil loses its fertility.
Climatic factors:	Weather elements which include temperature, rainfall, pressure, relative humidity, wind direction and speed.
Fluctuation:	The changes in the quantities over a given period of time.
Habitat:	An area which a given species inhabits.
Land use:	The way a given piece of land and its resources are used by human beings.

CHAPTER ONE: INTRODUCTION

1.1 Background

Edible caterpillars of the species *Gynanisa maja* (Klug) and *Gonimbrasia belina* Westwood are a forest resource and CIFOR (2004) argues that in rural areas the forest resources need to be taken into account in sustaining livelihoods. The two species are of nutritional and economic importance among some local people in Zambia as sources of dietary animal protein and household incomes (Mbata et al., 2002).

Though research work has been carried out on edible caterpillars in Zambia (e.g. Chidumayo and Mbata, 2002; Mbata and Chidumayo, 1999; Mbata and Chidumayo, 2003; Mbata et al., 2002; and Holden, 1991), there are gaps in the knowledge on factors that influence the abundance of edible caterpillars. There is also scanty documentation on the abundance of edible caterpillars in Zambia, for example, Chidumayo and Mbata (2002) state that reports from the local people in Kopa Chiefdom indicated that edible caterpillars were more abundant in 1994, 1998 and 1999. This information only covers a period of five years. There is need to do a more comprehensive study covering more years. Infact, Chidumayo and Mbata (2002) state that there is need for research on the factors that influence the yearly variations in the abundance of edible caterpillars so as to generate a better understanding of the population dynamics of *Gynanisa maja* and *Gonimbrasia belina* in the Kopa area.

The study, therefore, focused on investigating:

a) Years of edible caterpillar abundance over a 16-year period, from 1989 to 2004.

b) Factors that influence the abundance of *Gynanisa maja* and *Gonimbrasia belina*.

1.2 Statement of the problem

Edible caterpillar sale is the main economic activity through which the majority of the households in Kopa Chiefdom earn income (Mbata and Chidumayo, 2003). Inspite of the edible caterpillar availability, the chiefdom is said to be the poorest of the nine chiefdoms in Mpika district (WVZ, 1997). The edible caterpillar resource can therefore be used to improve the welfare of the people in the chiefdom.

Even though edible caterpillars have been harvested every year in Kopa Chiefdom, their abundance has been fluctuating such that the quantities of the harvests vary annually. For example, Mbata and Chidumayo (2003) noted that the edible caterpillars were more abundant in the year 1999 than in 2000.

There is, therefore, need to investigate why there are variations in the yearly abundance of edible caterpillars, since a reduction in their abundance means less harvest for the households, thus resulting in less income and in turn reduced access to goods and services which the households gain access to through incomes generated through the sale of edible caterpillars. Therefore, the study sought to investigate factors that influence the abundance of edible caterpillars in Kopa Chiefdom.

1.3 Aim

The primary aim of the study was to investigate the factors that influence the abundance of *Gynanisa maja* and *Gonimbrasia belina* in Kopa Chiefdom of Mpika district, Zambia.

1.4 Objectives

The specific objectives of the study were:

a) To document years of abundance of *Gynanisa maja* and *Gonimbrasia belina* from 1989 to 2004 based on local indigenous knowledge.

b) To investigate land use and climatic factors that might influence the abundance of *Gynanisa maja* and *Gonimbrasia belina*.

1.5 Hypothesis

The study tested the hypothesis that the abundance of *Gynanisa maja* and *Gonimbrasia belina* is influenced by land use and climatic factors.

1.6 Research question

The study was guided by the following research question. How do people assess the impact of their activities on land in relation to the abundance of edible caterpillars, especially those of the species *Gynanisa maja* and *Gonimbrasia belina*?

1.7 Assumptions

The main assumptions made before undertaking the present study were that:

a) Local people have good memory and can recall previous years when edible caterpillars were abundant.

b) There is sufficient indigenous knowledge in the management of caterpillars.

1.8 Significance of the study

The study on abundance of edible caterpillars was worth investigating because little research has been done to assess the influence of land use and climatic factors on the abundance of *Gynanisa maja* and *Gonimbrasia belina.* The findings of the study will therefore fill the gap of this knowledge deficiency.

In addition, it was important to do this study because its findings will:

a) Help the people in Kopa's chiefdom to play a positive role in influencing the abundance of *Gynanisa maja* and *Gonimbrasia belina.*

b) Help policy makers develop policies on edible caterpillar management that will enhance development in Kopa.

c) Enable the Kopa community and the Forestry Department to agree on a common stance in forest management for edible caterpillar production.

1.9 Organization of Report

Chapter One gives the introduction of the study by providing the background, statement of the problem, aim, objectives, hypothesis, research question, assumptions, and significance of the study. Chapter Two gives the description of the study area and the culture of the people. Chapter Three covers the literature that has been reviewed on insects in relation to population cycles and factors that cause the cycles. Chapter Four gives the methods used in the collection of data. Chapter Five focuses on the presentation of the research findings and Chapter Six discusses the findings. The last chapter comprises summary, conclusions and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter deals with literature pertaining to caterpillars as well as other insects and reviews findings of some previous studies on insects and their abundance in the context of population cycles and factors that influence their abundance.

2.2 Insect population cycles

The edible form of *Gynanisa maja* and *Gonibrasia belina* is the larva of these emperor moths. Most insects undergo four stages in their developmental cycle, namely: egg, larva, pupa and adult (Delobel, 1983; Fraval and Villemant, 2005), though there are some that undergo three stages in their developmental cycle and the stages include egg, nymph and adult (Parajulee et al., 1993; Pomeroy and Service, 1986).

Many species of forest foliage feeding insects, to which the emperor moths belong, show a phenomenon of periodic abundance oscillation or population cycles (Liebhold and Kamata, 2005; Berryman, 1995; Varley *et al.*, 1973). Thus many insect populations show increases followed by crashes at regular intervals and to some degree the population peaks can be predicted (Owen, 1985). Insect population cycles differ depending on the species. Some insects have well-defined seasonal peaks of abundance. For example, some insects like the cocoa moth pest, *Characoma strictigrapta* (Schott et Endl) have several peaks in a year and others like the mosquito have a single peak in a year while insects like the gypsy moth and tsetse fly have peak populations after a number of years. An investigation in Tanzania on the tsetse fly, known as *Glossina swynnertoni* (Austen) for a period of twenty two years (1935 to 1957), revealed some periodicity in the numbers caught: a few years of high catches followed by several years of small catches. The lowest catches were in 1934 and 1944 and the highest catches were in 1937, 1947 and 1948 (Pomeroy and Service, 1986).

A study on gypsy moth in North America revealed that outbreaks occur with varying degrees and periodicity. Population densities varied by several orders of magnitude, often reaching epidemic densities that resulted in total defoliation of host trees. There is also some statistical evidence of a 10- to 11- year cycle in outbreak dynamics (Liebhold et al., 2000). In a similar study, it was found that gypsy moth outbreaks can last one to five years before outbreak populations decline and remain low for several years before the next outbreak occurs. In Oak dominated strands, gypsy moth outbreaks were found to persist for two to five years before collapsing and populations remained low for four to 12 years before increasing again (Program staff, 2005).

Insect population cycles have been attributed to a number of factors. Some of the factors that have been identified to influence population cycles include; temperature, relative humidity, rainfall, wind, host plant conditions, nutrition of the larva or adult insect, predators, parasites and pathogens. These factors can be divided into two groups: abiotic factors and biotic factors. Some authors attribute the cycles to abiotic factors only, others to biotic factors only and most authors attribute them to a combination of abiotic and biotic factors.

2.3 Abiotic factors

Some authors attribute the population cycles of insects to abiotic factors affecting survival and reproduction. Of the abiotic factors, weather interactions are said to have both direct and indirect effects on insect populations (Martinat, 1987; Solbreck, 1995). Temperature is known to affect the speed of development or growth rate in insects. For example, cotton stainners belonging to Pyrrhocoridae bugs can complete their life cycle, from egg to egg, in about 25 days at 30 degrees Celsius but take 35 days at 25 degrees Celsius and may need 40 days if temperatures drop to 20 degrees Celsius (Pomeroy and Service, 1986). This might be because temperature affects digestion in insects. For example, a female mosquito takes two days to digest a blood meal at 27 degrees Celsius while it takes a whole week at 15 to 18 degrees Celsius (Pomeroy and Service, 1986).

In another study on the seasonal population fluctuations in the Black Cowpea moth, increasing temperatures and decreasing relative humidity were found to be associated with population decline while decreasing temperatures and increasing relative humidity were associated with population increase (Olaifa and Akingbohungbe, 1982).

In India, a study on seasonal abundance patterns of insects inhabiting the understory vegetation on three forest types, namely: moist-deciduous, riverine and teak plantation, insect abundance varied depending on moisture conditions. Insect abundance was maximum in the moist – deciduous habitat and minimum in the teak plantation. Insect population was also highest during the southwest monsoon period in all the three habitats and the temporal pattern of fluctuations followed the same pattern in all the three habitats (Arun and Vijayan, 2004).

Rainfall and relative humidity are also known to have an effect on desert locust abundance. High but not excessive moisture in the soil is also needed for egg survival. However, if the weather is too wet there is an increase in the mortality of the immature stages of the locusts (Pomeroy and Service, 1986).

2.4 Biotic factors

Some authors attribute population cycles in insects to biotic factors. Of the biotic factors investigated host plant heights have been observed to have an influence on the abundance of insects. For example, in India, *Adisura* moths were observed to prefer laying eggs on host plants with a height of between 50.8 cm and 63.5 cm on the erect type of *Lablab niger* (Medick) and between 101.6 cm and 114.3 cm on the creeping type of the plant (Chakravarthy, 1983). In another study in Malawi, yields of the emperor moth larva varied significantly with forage tree height, with highest yield from height class of one metre to three metres, followed by three metres to ten metres and then zero metre to one metre; lowest yields were found at heights greater than ten metres (Munthali and Mughogho, 1992).

In another study by Fraval and Villemant (2005), the gypsy moth outbreak in Morocco was observed to be influenced by trophic interactions between the moth and its host plant, parasitoid wasps which attack young gypsy moth larvae, predators and destroyers of the gypsy moth egg masses. Some studies have attributed the population cycles to density dependent mortality caused by parasitoids, specialist predators and pathogens (Varley *et al.*, 1973).

A study on outbreaks of gypsy moth in North America found that density dependent mortality clearly limits high-density populations though there was little evidence for strong regulation on low density populations. Predation by small mammals were the major source of mortality affecting low density populations but because the small mammals are generalist predators and gypsy moths are a less preferred food item, mammals do not appear to regulate populations in a density dependent fashion. Instead predation levels appeared to be primarily determined by small mammal abundance, which in turn is closely linked to the production of acorns that are a major source of food for over-wintering predator populations. Predators and parasitoids may affect populations, but they do not appear to be linked in a strong negative feedback mechanism with their hosts. The conclusion was that it is more likely that oscillations in mast production were at least partially responsible for the episodic nature of gypsy moth outbreaks (Liebhold et al., 2000).

2.5 Combination of abiotic and biotic factors

Many authors have attributed insect population cycles to the interaction between abiotic and biotic factors. For example, weather, availability of host plant, action of parasites and predators are said to dictate the population of the Black Cowpea moth (Olaifa and Akingbohungbe, 1982). Ritchie (2000) also came to a conclusion that plant resources, predators and abiotic conditions represent three major factors that potentially influence insect herbivore abundance in terrestrial ecosystems. Freitas *et al.*, (2005) in a study between August 1991 and July 1996 on *Hepidopterous* species in a *Eucalyptus grandis* (Hill ex Maiden) plantation found that *Glena unipennaria* (Guenee), *Sabulodes caberata* (Guenee) and *Stenalcidia grosica* Schaus were abundant with different occurrence pattern in relation to temperature, rainfall and age of the plantation.

The study by Delobel (1983) on the influence of temperature and host plant on sorghum shootfly, *Atherigona soccata* (Rondani) revealed that the optimal temperature required for the development and survival of sorghum shootfly was 30 degrees Celsius. Lower threshold temperatures were 13.8 degrees Celsius, 10.2 degrees Celsius and 11.8 degrees Celsius for the egg, larva and pupa respectively. Host plant conditions were also found to affect the sorghum shootfly larval development and survival. It was also found that pupal weight was higher and larval mortality lower in insects reared on fertilized and normally watered seedlings than on unfertilized and water stressed seedlings.

Under laboratory conditions the tsetse fly, *Glossina morsitans* Westwood was observed to survive at the temperature of 30 degrees Celsius with relative humidity of between 19 percent and 44 percent. Under these conditions *Glossina morsitans* ingest more blood during feeding and produce more offspring than at other temperatures and relative humidity (Pomeroy and Service, 1986).

In a study by Lyla et al., (2005) on fecundity and fertility of *Pareuchaetes pseudoinsulata* (Rego Barros) where the sex ratio, temperature, relative humidity and food were considered, it was found that highest fecundity and egg hatching were obtained when the parental sex – ratio was kept at 1:1 level followed by 1:2 then 2:1. When the adults were fed on water alone the egg hatching was significantly lower than with other food combinations (honey, water, vitamin E, sucrose, and sodium chloride). The female – male sex – ratio of 1:1 at the temperature of 25 degrees Celsius and relative humidity of 75 percent gave significantly higher fecundity for all the food combinations than 1:2 and 2:1 sex - ratios. Egg hatching percentage of all the three sex – ratios at the temperature of 25 degrees Celsius and relative humidity of 75 percent was highest for all the food combinations except water. Least hatching occurred at 2:1 sex – ratio when water alone was given at the temperature of 30 degrees Celsius and 60 percent relative humidity.

Biotic and abiotic factors differentially affect the different developmental stages of insects both directly and indirectly, such that some studies attribute population regulation to a developmental stage of an insect. For example, Azerefegne *et al.*, (2001) identified the adult stage as the critical life history phase in population regulation of the sweet potato butterfly known as *Acraea acerata* Hewitson.

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA

3.1 Location

The study was conducted in Senior Chief Kopa's Chiefdom and lies between latitudes 11° 25′ and 12° 20′ South and longitudes 30° 22′ and 31° 08′ East. The area is found in Mpika district of northern Zambia and covers about 1,400 sq. km {Fig 1: (a) and (b)}.

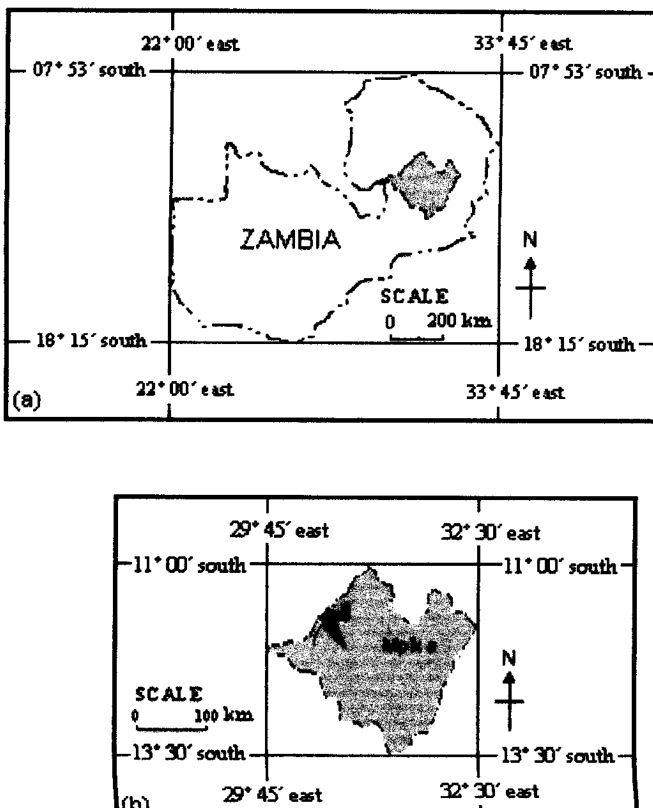

Fig. 1: (a) Location of Mpika District in Zambia and
(b) Location of the study area (in black) in Mpika District

3.2 Physical features

The study area spreads on a plateau lying between 1200 m to 1300 m above mean sea level, except in its western portion where the land slopes to the Bangweulu floodplain at 1000 m to 1200 m above mean sea level. This western portion of the area is grassland while the rest of the area is woodland. Three major rivers drain the area. The Munikashi drains the northern part while the Lwitikila drains the southern part and its main tributary- the Kanchibiya drains the eastern and central part of the area (Fig. 2). Five vegetation types characterize the study area, namely: miombo woodland, chipya, termitaria and riparian forests and grassland. The most widespread of these vegetation types is miombo woodland which is dominated by legume tree species belonging to *Brachstegia*, *Julbernardia* and *Isobelinia* (Mbata and Chidumayo, 2003).

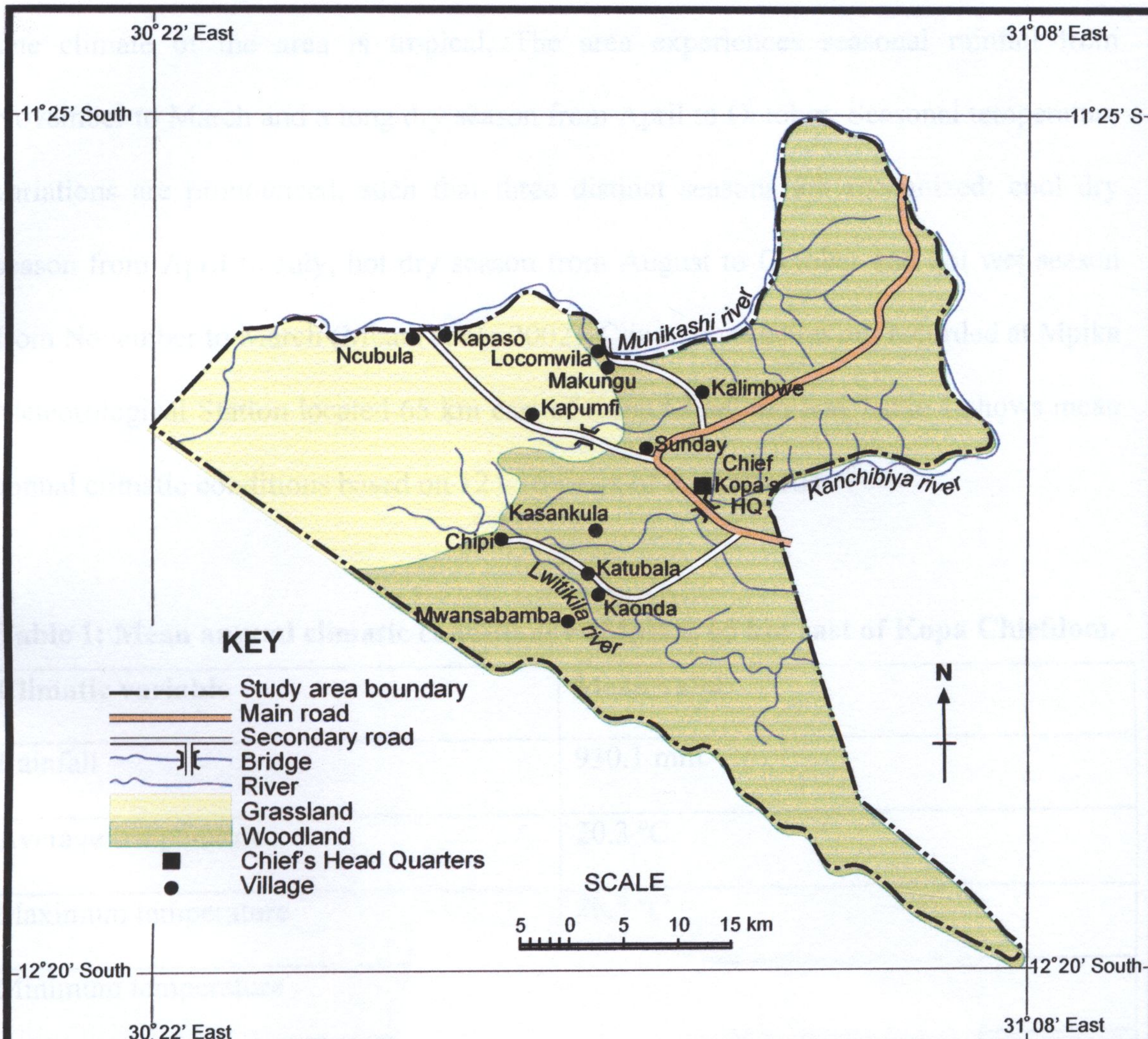

Fig. 2: Map of the study area

The soils are highly leached. The dominant soil group is Chambeshi associated with the Lungu and Twingi soil types. Lungu soils are well drained red to dark red sandy soils while the Twingi soils are well-drained strong brown loamy sand to sandy loam soils with loamy sand (Surveyor General 1967).

3.3 Climate of the area

The climate of the area is tropical. The area experiences seasonal rainfall from November to March and a long dry season from April to October. Seasonal temperature variations are pronounced, such that three distinct seasons are recognized: cool dry season from April to July, hot dry season from August to October and hot wet season from November to March (Mbata et al., 2002). Climatic variables are recorded at Mpika Meteorological Station located 65 km east of Kopa Chiefdom and Table 1 shows mean annual climatic conditions based on 12 - 16 years of data records.

Table 1: Mean annual climatic conditions at Mpika, 65 km east of Kopa Chiefdom.

Climatic variable	Mean value
Rainfall	930.1 mm
Average temperature	20.3 °C
Maximum temperature	26.5 °C
Minimum temperature	14.1 °C
Relative humidity	64.5 %
Pressure	635.7 mb
Wind speed	3.8 km/h

Source: Mpika Meteorological Records

3.4 The people and their culture

Kopa Chiefdom is inhabited by the Bisa people whose major sources of livelihood include *chitemene* subsistence farming of millet, cassava and sweet potatoes, edible caterpillar collection and hunting of game (Mbata et al. 2002).

Chitemene is a form of shifting cultivation which involves the cutting of trees or lopping branches in a given area and when adequately dry, piled in a portion of the tree-cut area and burnt to create an ash-field also known as an infield that is cropped for several years before abandonment as a result of loss of soil fertility (Araki, 2003; Sugiyama, 2003). The cut area which is not part of the infield is known as the outfield. *Chitemene* is practiced for food crop production and results in large areas being cleared of tree cover (i.e., deforestation) but the regeneration of cut trees in the outfield is rapid (Fig. 3).

Fig. 3: Cut trees regenerating before the infield is burnt. Photo by M. Mulengu.

Though the regeneration of the cut trees may start at the same time in the *chitemene* area, the process is disturbed in the infield when the pile of branches is burnt and the resultant intense heat kills the regenerating trunks and stumps. The burning of the branch piles produces ashes that form an ash-field or infield (Fig. 4). The ash-field is utilized for growing food crops for three to four years, after which it is abandoned due to soil fertility loss (Trapnell, 1996).

Fig. 4: Ash-field (white patch) of a recently burnt *chitemene* biomass pile surrounded by an outfield. Photo by E. N. Chidumayo.

Indigenous tree species do grow in the abandoned infield but it takes a long time for the species to get established, because many of the seedlings of tropical trees take a long time to get established as they grow very slowly (Delissio et al., 2002; Stromgaard, 1986).

Edible caterpillar collection is said to be a part of the Bisa culture. There are eight species of edible caterpillars known to occur in Kopa Chiefdom. The local names for the species are Chipumi, Mumpa, Fikoso, Mpambata, Namusuku, Nakayonga, Namusamfwa and Namusoso. Of these eight species, Chipumi (*Gynanisa maja*) and Mumpa (*Gonimbrasia belina*) (Fig. 5) are the species that are most cherished and traded (Mbata and Chidumayo, 2003).

Fig. 5: (a) *Gynanisa maja* on the trunk of the host plant. (b) *Gonimbrasia belina* on a branch of the host plant. Photo by K. Mbata.

The edible caterpillar culture amongst the Bisa is evidenced by beliefs, rituals and taboos prevalent amongst them and the presence of traditional shrines related to the harvesting of edible caterpillars. This culture involves four monitoring processes. These are carried out by three groups of people namely village scouts, members of the neighbourhood watch units and bush police. Each monitoring stage is associated with ceremonies and rituals performed by members of the Senior Chief Kopa's Royal establishment (Mbata and Chidumayo 2003).

The first monitoring stage involves identifying sites with high densities of moth eggs on host plant foliage in the woodlands. This is done in September by daily walking through woodlands in the chiefdom. The findings pertaining to sites are then reported to the Senior Chief after which a traditional ritual is performed by his local assistant known as Chilukuta. This ritual involves placing a white cloth in a small shrine (Chipinda) located on the burial grounds of Senior Chiefs. The ritual is done so as to appease the Bisa ancestral spirits for sending edible caterpillars in the chiefdom area. The cloth is then cut in half by the Senior Chief, one half is left in the shrine and the other is cut into many strips and the male grand children under the guidance of the three groups of monitors go and tie the strips on selected caterpillar host plants in sites with high moth egg densities (Mbata and Chidumayo 2003).

The second stage is the monitoring of the appearance of the first caterpillar larval stage in the woodlands. Once the eggs hatch, two caterpillars of each species in the first instar stage are presented to the Senior Chief through the advisor after which a meeting is convened, when the senior wife of the Senior Chief is commissioned to offer the tiny caterpillars to the ancestral spirits in a shrine called Babenye found at the palace.

The third stage is the monitoring of the appearance of mature harvestable caterpillar stages (5^{th} and 6^{th} instars) in the woodlands. When the mature caterpillars emerge several samples of the species are collected and presented to the Senior Chief through the advisor. The Senior Chief immediately calls for the second meeting in which the senior wife is commissioned to offer the caterpillars to the ancestral spirits at the palace shrine and consumes the excess mature caterpillars that were not used in the offering. As the offering is being done, a meeting is held to set up the date for the start of the caterpillar-harvesting period for the year (Mbata et al. 2002).

The fourth stage is monitoring caterpillar harvesting. The village scouts, members of the neighbourhood watch units and bush police ensure that community members adhere to the traditional rules that regulate caterpillar harvesting and taboos that must be observed during harvesting. They also give feedback to the Senior Chief on their observations, progress of the harvest and enforce the stoppage directive for the harvest once received from the Senior Chief (Mbata et al. 2002).

When the caterpillars are harvested they are de-gutted and roasted in hot ash until the setae and spine body adornments are burnt out and the caterpillars become hardened. The caterpillars are then sun-dried until they become crispy dry (Fig 6). The caterpillars so processed are then sold to traders or packed and stored for future use (Mbata and Chidumayo 1999).

Fig. 6: Sun-drying edible caterpillars in Kopa Chiefdom. After: Mbata et al. (2001).

3.5 Choice of the study area

The reasons for choosing this particular area for the study were:

a) This is an area where large quantities of edible caterpillars are harvested.

b) This area has some documentation on edible caterpillars.

CHAPTER FOUR: METHODOLOGY

4.1 Introduction

The present study used primary data. Field work was conducted during the months of June and July 2005 when the 100 sample respondents were interviewed and focus group discussions held. Additional field work was done in August 2005 when the District Forest Officer was interviewed.

4.2 Primary sources

The primary sources of data were in-person interviews and focus group discussions.

4.2.1 In-person interviews

One hundred respondents aged between twenty two years and sixty four years were sampled from the four sampling areas of the study area (Fig. 7). The distribution of the respondents was as follows: twenty seven from Kanchibiya sample area, twenty five from Lwitikila sample area, twenty four from Munikashi sample area and twenty four from Mono sample area. Munikashi sample area lies in the Bangweulu flood plains (grassland zone) while Kanchibiya, Lwitikila and Mono sample areas lie in the woodland zone on the plateau. The sampling of the respondents was based on accessibility and availability. The sample composed of forty eight females and fifty two males. Thirty two of the females were married and sixteen were single while fifty of the males were married and two were single. The respondents were interviewed using an interview schedule with open ended questions (see Appendix A).

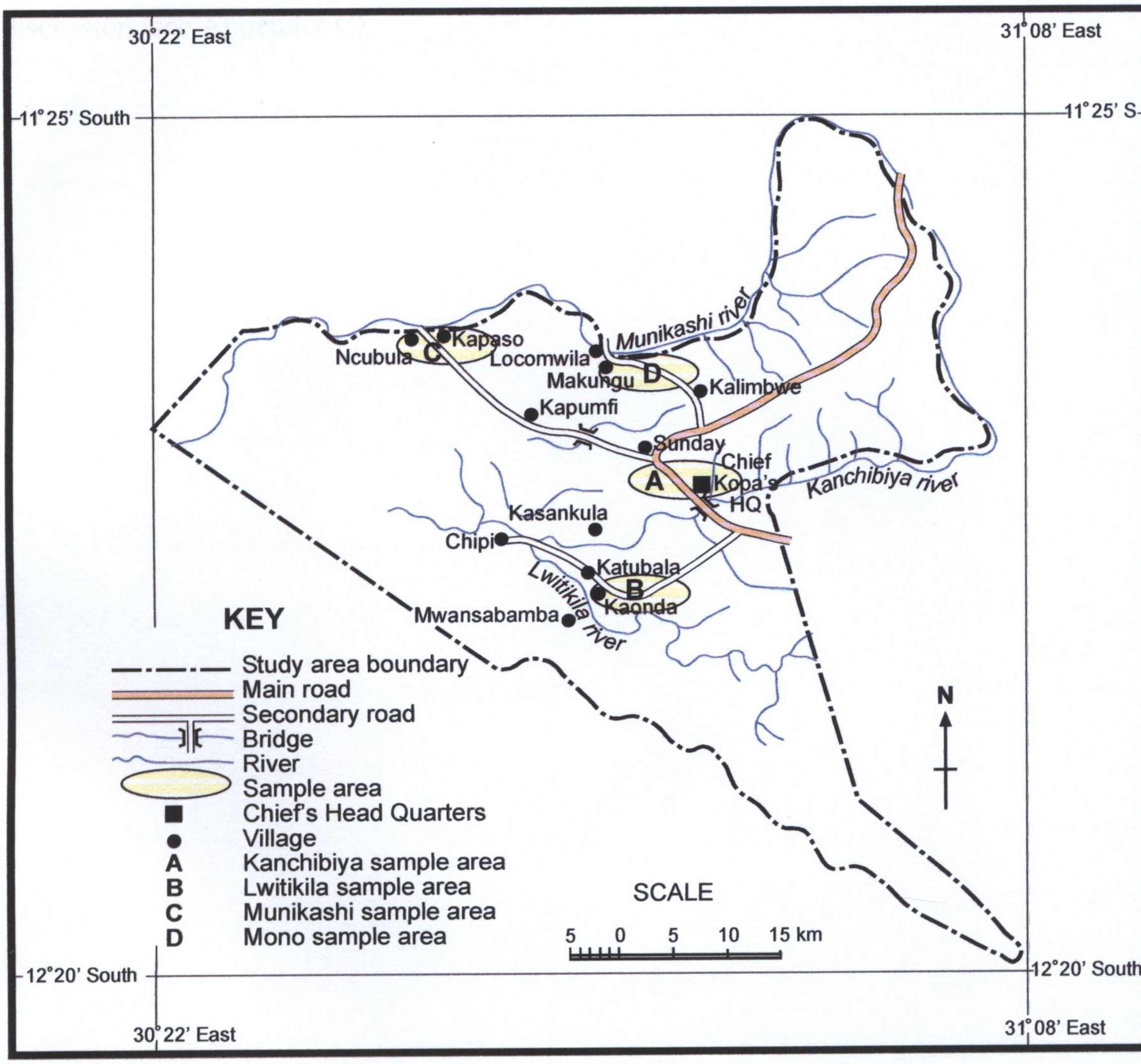

Fig. 7: Map showing location of sampling areas.

4.2.2 Focus group discussions

Six focus group discussions were conducted, each consisting of 12 individuals. Three groups comprised females only and the other three males only. A checklist of semi-structured questions (see Appendix B) was used to guide the discussions.

In addition to the in-person interviews and focus group discussions, a discussion was held with the District Forest Officer as a follow up to some findings from the 100 respondents and the focus group discussions. A list of items was used to direct the discussion (see Appendix C).

CHAPTER FIVE: ANALYSIS AND RESULTS

5.1 Introduction

This chapter focuses on research findings based on the interview schedule for sample respondents and focus group discussions. It focuses on years of edible caterpillar abundance, indigenous knowledge on climatic factors and land uses that influence the abundance of edible caterpillars.

5.2 Edible caterpillar abundance

The response frequency with which each of the 16 years, from 1989 to 2004 was mentioned as the year of more edible caterpillar abundance is summarized in Fig. 8. All the 16 years under study were indicated as having been years of high abundance. Given that people have different capacities for recalling past events and since it is not possible that all the 16 years had a high abundance, a high frequency means that edible caterpillars were more abundant and a low frequency means less abundance. The percentage response frequency ranged from 0.76 percent to 15.36 percent. Therefore frequencies of equal to and greater than ten percent represent years of more caterpillar abundance because years with lower response frequency are suspect. Based on this cut-off point, years when caterpillars were more abundant were 1992, 1994, 1998, 2000 and 2004.

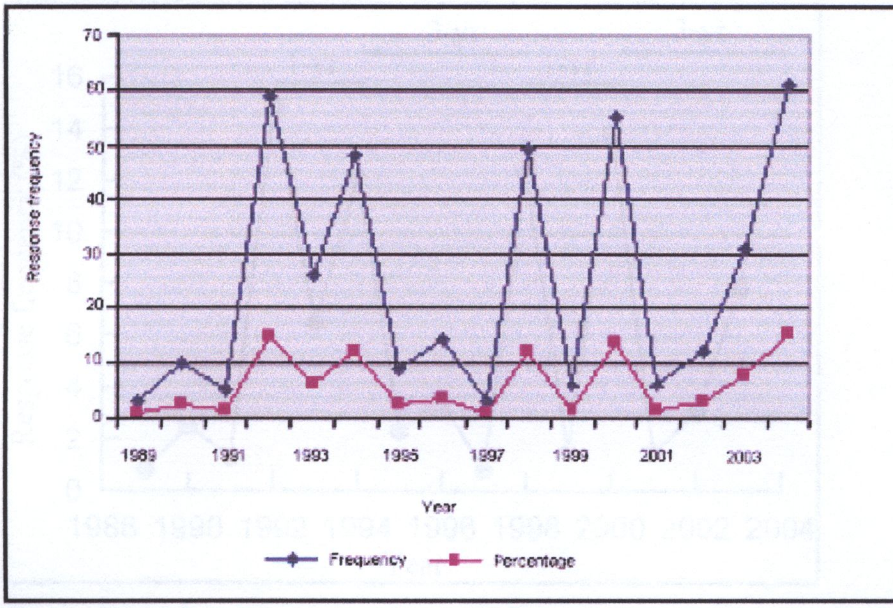

Fig. 8: Frequency distribution of responses for years in which edible caterpillars were more abundant.

Thus between 1992 and 2004 edible caterpillar population peaks were separated consecutively by one-year and three-year periods (Figure 9). Thus the cyclic abundance of edible caterpillars in Kopa Chiefdom is apparent from the responses of respondents. It can therefore be expected that, based on the pattern of the 1- and 3-year cycles, 2006 will be a year of high abundance. Similarly, the previous year of high abundance before 1992 appears to have been 1988 which is separated from 1992 by a 3-year interval.

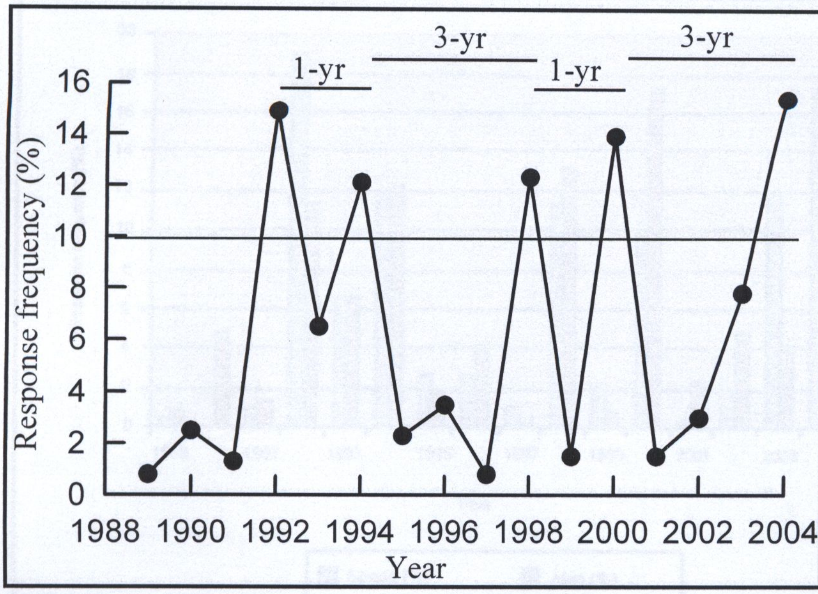

Fig. 9: Cycles of edible caterpillar abundance – as deduced from frequency responses equal to and greater than ten percent. Intervals between years of more abundance are shown by horizontal lines above the plot graph.

5.2.1 General trend in responses between sexes on abundance

There is a general agreement in the frequency of responses by the two sexes (Fig. 10), in that where the percentage frequency is below eight percent for females it is also below eight percent for males and where the frequency is above eight percent for females it is also above eight percent for males. The exception was for 2003 for which percentage frequency for females is 12 and that for males is 4.2. The difference in the percentage frequency could be due to the location differences in the habitats where the two sexes collected the edible caterpillars.

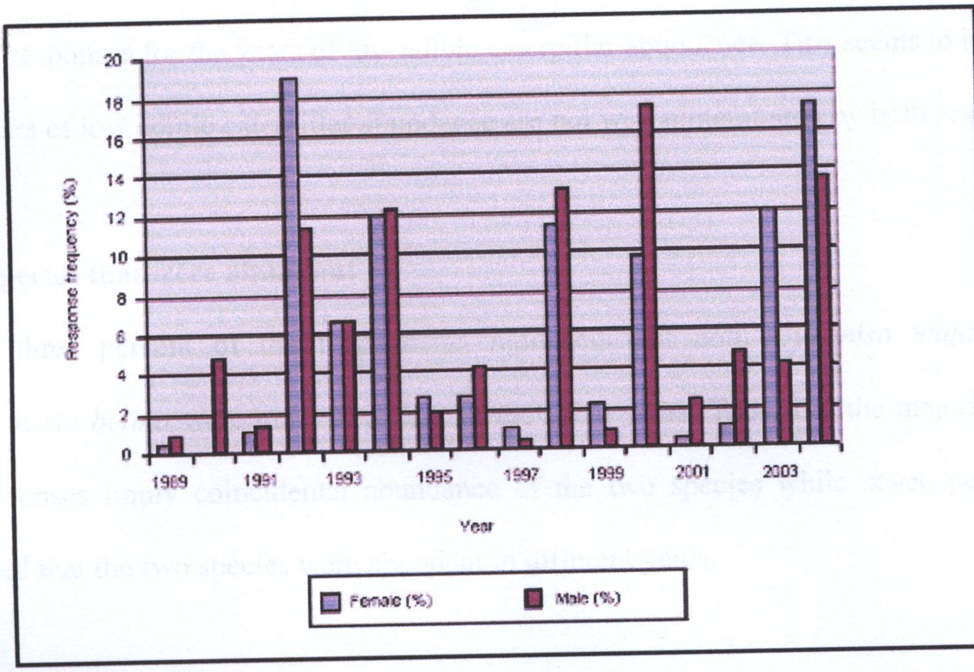

Fig. 10: Frequency distribution for responses by sex of years when edible caterpillars were more abundant.

Years of more caterpillar abundance (see 5.2) were tested for homogeneity in responses between the two sexes and the results are summarized in Appendix D. The total χ^2 observed is 3.378 while the critical χ^2 value at 0.05 significance level is 9.488. Therefore at 0.05 significance level, the proportion of female responses for the years of more edible caterpillar abundance is the same as the proportion of male responses for the years of more edible caterpillar abundance. This seems to imply that both sexes remembered the years of high edible caterpillar abundance fairly well.

Years of less caterpillar abundance were also tested for homogeneity and the results are summarized in Appendix E. The total χ^2 observed is 20.256 while the critical value at 0.05 significance level is 18.307. Therefore the proportion of female responses for the years of low edible caterpillar abundance is significantly different from the proportion of male responses for the years of low edible caterpillar abundance. This seems to imply that, years of low edible caterpillar abundance are not well remembered by both sexes.

5.2.2 Species that were abundant

Ninety three percent of the respondents indicated that both *Gynanisa maja* and *Gonimbrasia belina* were more abundant in the same years. Therefore the majority of the responses imply coincidental abundance of the two species while seven percent indicated that the two species were abundant in different years.

5.2.3 Spatial aspects of abundance

Ninety five percent of the respondents indicated that edible caterpillars were always more abundant in the wooded part of Lwitikila area (Fig. 11) while five percent of the respondents indicated more caterpillar abundance in the wooded part of Lwitikila and Locomwila. Locomwila is one of the areas in Mono sample area. An interesting point about the inclusion of Locomwila is that all the respondents from Mono indicated Lwitikila as the place where edible caterpillars were always more abundant. The respondents who included Locomwila were from Munikashi sample area and Kanchibiya sample area. The respondents could have been comparing the abundance in their areas with that of Locomwila. Nevertheless, all the 100 respondents indicated that the wooded part of Lwitikila area has always had a high abundance of caterpillars.

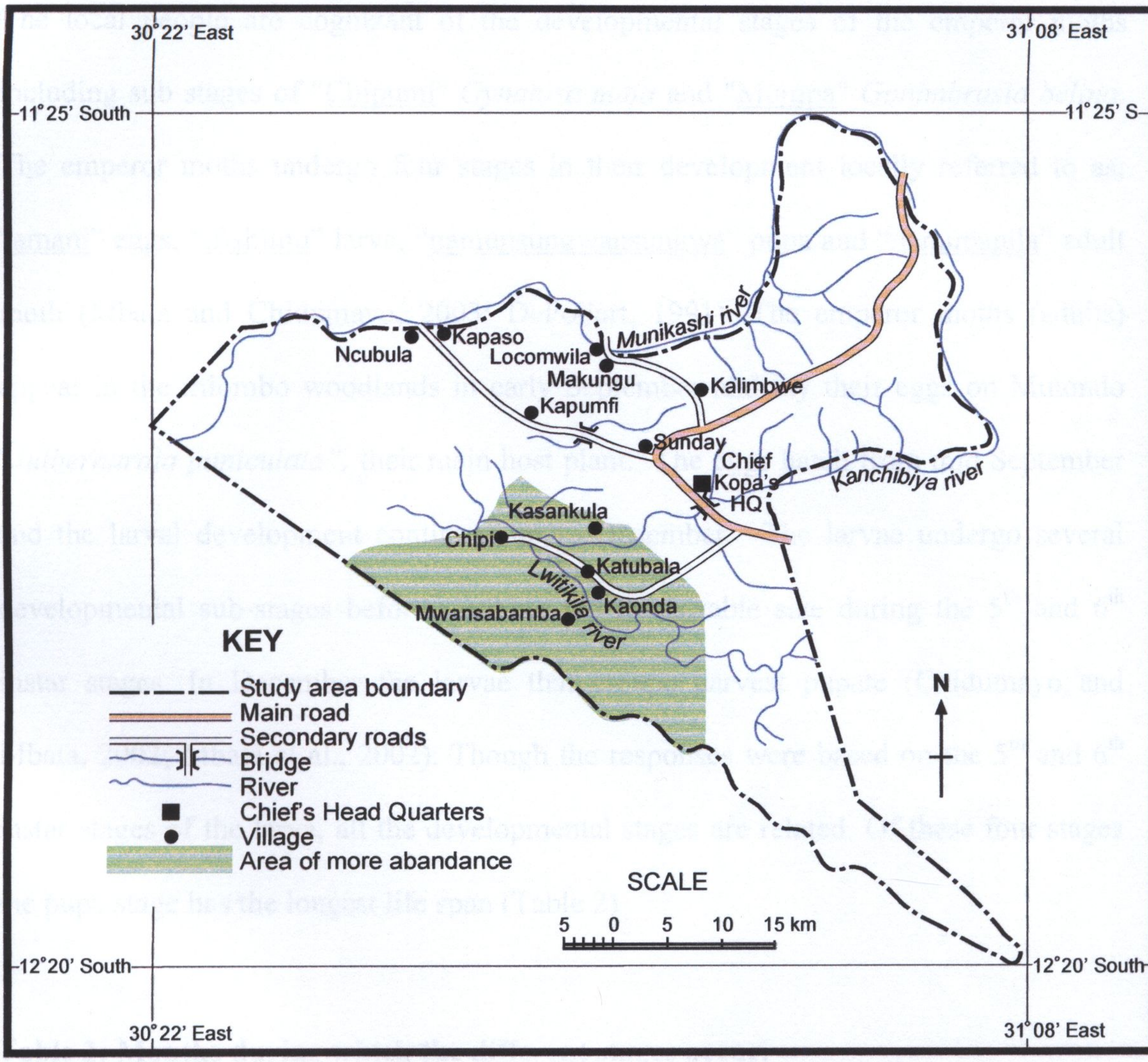

Fig. 11: Area that respondents indicated to have a high abundance of edible caterpillars.

The focus group discussions also revealed that Lwitikila area has a lot of *Julbernadia paniculata* (Troupin) the host tree of edible caterpillars, as compared to other areas in the study area and that even though Lwitikila area was where edible caterpillars were always more abundant, the abundance is not uniform. Sites of high edible caterpillar abundance vary from year to year.

5.3 Indigenous knowledge

The local people are cognizant of the developmental stages of the emperor moths including sub stages of "Chipumi" *Gynanisa maja* and "Mumpa" *Gonimbrasia belina*. The emperor moths undergo four stages in their development locally referred to as; "amani" eggs, "ifishimu" larva, "namunsungwansungwa" pupa and "namupapila" adult moth (Mbata and Chidumayo, 2003; DeFoliart, 1991). The emperor moths (adults) appear in the miombo woodlands in early September and lay their eggs on Mutondo "*Julbernardia paniculata*", their main host plant. The eggs hatch from mid September and the larval development continues up to December. The larvae undergo several developmental sub-stages before reaching the harvestable size during the 5th and 6th instar stages. In December the larvae that escape harvest pupate (Chidumayo and Mbata, 2002; Mbata et al., 2002). Though the responses were based on the 5th and 6th instar stages of the larva, all the developmental stages are related. Of these four stages the pupa stage has the longest life span (Table 2)

Table 2: Months during which the different stages occur.

Stage	Period (month)
Egg	September
Larva	October to November
Pupa	December to August
Adult	September

The local people also believe that some climatic factors like temperature, rainfall and wind speed affect emperor moths during the egg, larva and pupa stages.

5.3.1 Effect of temperature on abundance

The temperature in September and October was stated to affect the egg and larva stages of *Gynanisa maja* and *Gonimbrasia belina* in Kopa area. The majority of the respondents (76 percent) indicated that September temperatures are favourable for hatching eggs and that when it is too hot in October the young caterpillars are killed.

According to local knowledge temperature is considered to have two effects:

a) The temperatures in September are favourable for the hatching of eggs. Thus, favourable temperatures result in a high number of eggs hatching and unfavourable temperatures result in low number of eggs hatching.

b) October temperatures kill the young caterpillars when they fall to the ground because they get scotched by the hot ground thus reducing the abundance.

5.3.2 Effect of rainfall on abundance

Depending on the time and magnitude rainfall either has a positive or negative effect on the abundance of egg and larva populations. Forty eight percent of the responses were that moderate rainfall results in fast growth of the caterpillars while 25 percent revealed that heavy rains kill young caterpillars and 27 percent showed that rain destroy eggs.

According to local knowledge rainfall is considered to have three effects:

a) If it rains in September, before the eggs hatch, the eggs are destroyed,

b) If it rains moderately in October the caterpillars grow fast and

c) If it rains heavily in October young caterpillars are killed.

5.3.3 Effect of wind on abundance

Wind speed was indicated by the respondents to have an effect on the larva and pupa abundance. The majority of the respondents (fifty three percent) indicated that winds in August and September were predominately from the east and enhanced the unearthing of moths while the winds from the west entail rain which impact negatively on the egg stage and either positively or negatively on the larva stage depending on its magnitude (5.3.2). The effects of wind are summarized in Fig.12.

It is apparent therefore that according to local knowledge wind has two effects:

a) Moderate wind speed in August, and especially September, enhances the unearthing of moths.

b) Strong winds especially in early October, force young caterpillars to fall to the ground and die as they get scotched by the hot ground.

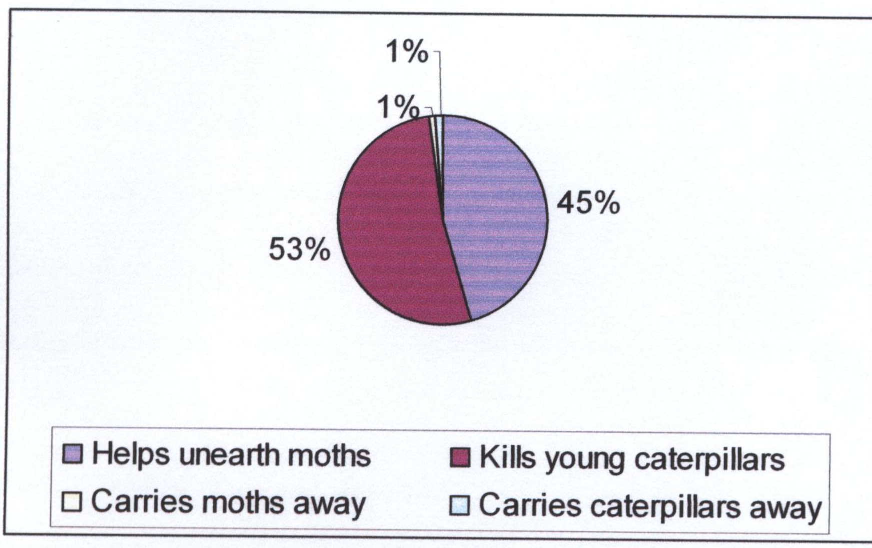

Fig. 12: Percentage distribution of responses on the effect of wind.

Based on local knowledge from the respondents, it seems that; temperature impacts on the egg and larva stages, rainfall impacts the egg and larva stages while wind speed impacts on the larva and pupa stages. Thus the abundance of *Gynanisa maja* and *Gonimbrasia belina* is affected in two ways:

a) Through the direct effect of climatic factors namely temperature, rainfall and wind speed on the larva stage.

b) Indirectly through the impact of climatic factors, namely temperature and rainfall on the egg stage and wind speed on the pupa stage.

5.4 Land use

The area where edible caterpillars are collected is also used for other activities (Fig. 13). The most common land use is *chitemene* because it has the highest frequency score. *Chitemene* results in the greatest visual change in the environment because it involves clear cutting of trees unlike pole and fibre harvesting that is selective.

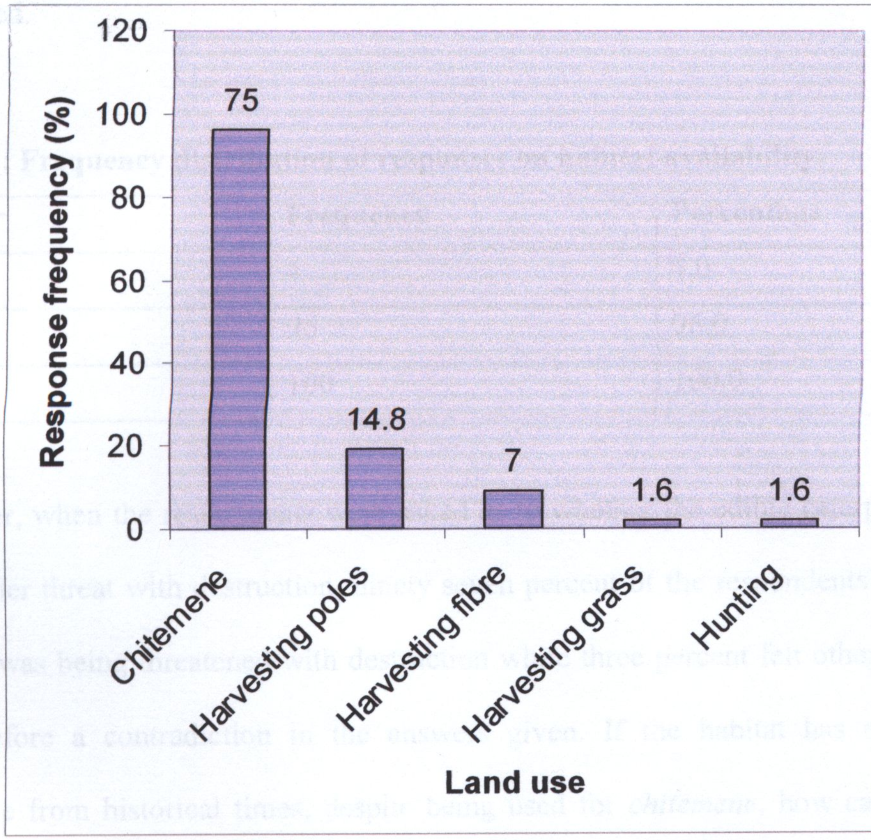

Fig. 13: Frequency distribution of responses on land use of areas where edible caterpillars are harvested.

5.4.1 Contradictions about caterpillar habitats

There were some contradictions concerning habitats of edible caterpillars based on responses of the respondents. The contradictions appear to be as a result of differences between indigenous knowledge and modern forest conservation extension messages.

5.4.1.1 Habitat availability and threats

The majority of the respondents believe that the habitat where edible caterpillars are collected is always available while a minority believes otherwise (Table 3). This means that despite the use of the caterpillar habitat for other activities, the habitat is not destroyed.

Table 3: Frequency distribution of responses on habitat availability.

Answer	Frequency	Percentage
No	4	4.0
Yes	96	96.0
Total	100	100.0

However, when the respondents were asked as to whether the edible caterpillar habitat was under threat with destruction, ninety seven percent of the respondents felt that the habitat was being threatened with destruction while three percent felt otherwise. There is therefore a contradiction in the answers given. If the habitat has always been available from historical times, despite being used for *chitemene*, how can it now be under threat? Indeed most respondents indicated that they harvest caterpillars from areas used for *chitemene* cultivation. Therefore the habitat is not under threat.

5.4.1.2 Causes for habitat destruction

The majority of the respondents indicated that *chitemene* was the main cause for the habitat destruction (Fig. 14). From the answers given there was no mention of population pressure, which means that the respondents did not feel that population pressure is a threat to the habitat despite the increase in population.

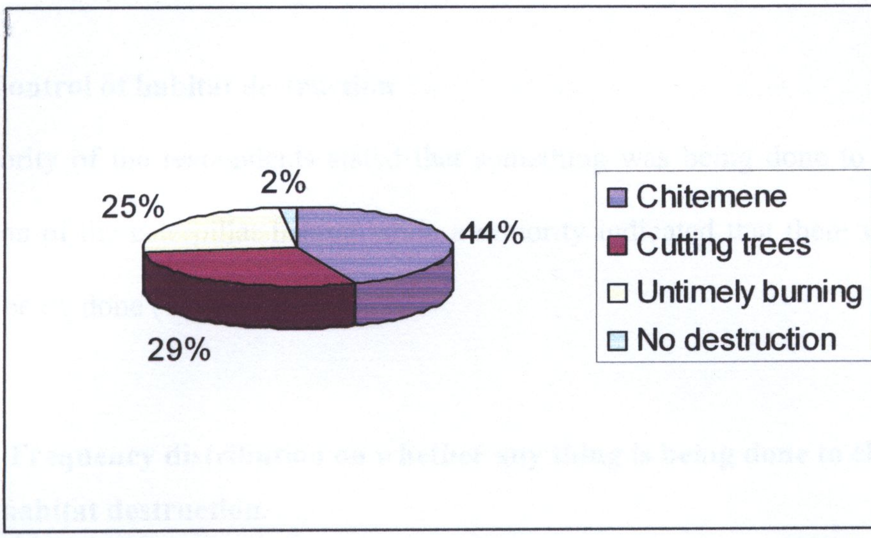

Fig. 14: Frequency distribution of responses on the causes for the habitat destruction.

However, a minority of respondents and focus group discussions revealed that, despite the cutting of trees for *chitemene*, edible caterpillars are harvested from the regrowth in *chitemene* fallows though the harvest is low in the years immediately after cutting. Thus the habitat can be said to be always available.

Though *chitemene* was stated as one of the causes for the destruction of the edible caterpillar habitat by the majority of the respondents, it has been found that *chitemene* results in an increase in the abundance of *Julbernardia paniculata*, the main host plant for *Gynanisa maja* and *Gonimbrasia belina*, in the *chitemene* outfield. The relative importance of this is that, tree frequency increases to 55 percent in regrowth woodland compared to 18 percent in old-growth woodland (Chidumayo and Mbata, 2002). One would, therefore, expect that, since there is an increase in the host plant the edible caterpillar abundance would also increase.

5.4.1.3 Control of habitat destruction

The majority of the respondents stated that something was being done to control the destruction of the caterpillar habitat while a minority indicated that there was nothing that was being done (Table 4).

Table 4: Frequency distribution on whether any thing is being done to check the habitat destruction.

Answer	Frequency	Percentage
No	40	40.0
Yes	60	60.0
Total	100	100.0

Of the sixty respondents who stated that there was something being done to check the habitat destruction, 35.3 percent indicated that the cutting of trees was being discouraged, 20.6 percent stated that there were sensitization programmes on nature, 16.2 percent indicated that the inhabitants were being encouraged to burn their fields at the right time i.e. 5th and 10th September. Another 16.2 percent stated that people were being encouraged to make fire breaks around the field if burning was after 10th September while 11.7 percent indicated that the practicing of *chitemene* was being discouraged. From the answers given above it can be concluded that discouraging *chitemene* as a control method had the lowest percentage frequency and yet the highest frequency of responses indicated that *chitemene* was the cause of habitat destruction. This shows that the people know that *chitemene* does not result in the destruction of the habitat for edible caterpillars, but since they have been told by forest extension workers that *chitemene* is destructive to woodlands they gave it as an answer to habitat destruction. The focus group discussions also revealed that, the officers from the Forest Department were telling them to stop practising *chitemene* and instead have permanent fields. This might have led to some of the people stating what they have been taught instead of what they actually know. In fact the officer from Forestry Department revealed that the sensitization activities in the area focused on the preservation of woodland and that the department does not manage forests for edible caterpillar production.

Focus group discussions also revealed that, *chitemene* enhances the abundance of edible caterpillars, in that, it is in areas that were utilized for *chitemene* and then left to fallow where the edible caterpillars become more abundant.

5.4.2 Abundance of edible caterpillars in chitemene fallows

A *chitemene* fallow is an area which was utilized as a *chitemene* field (both outfield and infield). Thus the area outside the ash-field is a *chitemene* outfield fallow just as much as is the ash-field after abandonment. The attribution of *chitemene* as a cause of deforestation may be true for the infield, since the area is burnt and trees are destroyed. It takes a long time for the tree species to colonize the infield and get established (Stromgaard, 1986). In the outfield woodland regrowth is faster because regeneration is from stumps and trunks (Fig. 15).

Fig. 15: A three-year old regrowth of the outfield.

With regard to the number of years it takes for edible caterpillars to occur in abundance in the outfield, thirty six percent of the respondents indicated that it takes three years, twenty seven percent stated that it takes five years and nineteen percent indicated that it takes one year. Another nine percent indicated two years while a similar frequency indicated four years.

Since about twenty percent of the respondents stated that edible caterpillars occur in abundance in the outfield after one year and the focus group discussions revealed that edible caterpillars are harvested in the outfield even in the very year the trees are cut, though the abundance is less as compared to the years that follow, means that the regeneration of the cut trees is rapid. On average edible caterpillars start becoming more abundant in the outfield after three years (Table 5).

Table 5: Descriptive frequency of the period it takes for edible caterpillar to occur in abundance in the outfield.

Variable	N	Mean	SD	Minimum	Maximum
Outfield	100	3.1600	1.4193	1.0000	5.0000

On the whole, the local people strongly feel that *chitemene* has a positive impact on the abundance of edible caterpillars since it is in these areas where *Gynanisa maja* and *Gonimbrasia belina* tend to be more abundant.

CHAPTER SIX: DISCUSSION

6.1 Annual variations in edible caterpillar abundance

The study revealed that between 1989 and 2004 there were five peaks in edible caterpillar abundance (see Fig. 9). *Gynanisa maja* and *Gonimbrasia belina* therefore show periodicity in abundance with two cyclic patterns: a short cycle separated by one year and a long cycle separated by three years (see Section 5.2). It appears that, the cyclic patterns in caterpillar abundance are caused by the impact of temperature, rainfall and wind speed on the egg, larva and pupa stages of *Gynanisa maja* and *Gonimbrasia belina*. This periodicity in the occurrence of abundance in the two emperor moths supports the findings made by Liebhold and Kamata (2005); Berryman (1995); Varley et al. (1973) on other insect populations. It is apparent from the responses of the respondents that abiotic factors may be important in determining the abundance of edible caterpillars in Kopa Chiefdom. This observation also supports the findings of Olaifa and Akingbohungbe, (1982); Pomeroy and Service, (1986); Martinat, (1987); Solbreck, (1995); Arun and Vijayan, (2004) that abiotic factors play an important role in determining the abundance of insect populations. The study set out to test the hypothesis that the abundance of *Gynanisa maja* and *Gonimbrasia belina* is influenced by climatic factors. This hypothesis was supported by the findings from the respondents that climatic factors affect *Gynanisa maja* and *Gonimbrasia belina* by impacting on the egg, larva and pupa stages.

6.2 Spatial variation in edible caterpillar abundance

Results from focus group discussions and to some extent responses of respondents revealed that caterpillar abundance varies spatially, such that even in the same general area sites of high abundance vary from year to year. However the sites of high caterpillar abundance were reported to be in *chitemene* fallows. Thus land use appears to affect caterpillar abundance. *Chitemene* land use appears to promote the abundance of the food plant *Julbernadia paniculata* in fallow regrowth as reported by Chidumayo and Mbata (2002). These observations support the hypothesis that land use influences the abundance of *Gynanisa maja* and *Gonimbrasia belina* in Kopa Chiefdom. However, this influence is best explained in relation to spatial variations in caterpillar abundance and not in relation to temporal variations in caterpillar abundance which is influenced by climatic factors (see Section 6.1).

6.3 Threat to edible caterpillar habitats

Chitemene cultivation has been blamed for woodland destruction and government has the policy of discouraging its practice (WVZ, 1997; Lungu, 1999). This policy of viewing *chitemene* as a destructive land use dates back to the colonial era, when the government repeatedly banned *chitemene* cultivation because it was seen as a destructive method of agricultural production (Moore and Vaughan, 1994; Sugiyama, 2003). This attitude towards *chitemene* still persists in some NGOs and Government Institutions. Infact in 1994 the government adopted a new environmental policy which identified deforestation as a major environmental problem in Zambia (MENR, 1994).

Therefore, in an effort to mitigate the perceived deforestation in the study area WVZ ran a project on woodlot establishment with the help of the Forestry Department that also carried out sensitization campaigns about the disadvantages of cutting trees for *chitemene* and advantages of preserving woodland. However despite the efforts to discourage chitemene cultivation the local people view chitemene as a good practice because it enhances the spatial abundance of edible caterpillars apart from making it possible to grow food crops without the use of artificial fertilizers.

The emphasis on woodland preservation seems to signify the lack of recognition by the Forest Department of the role that *chitemene* land use plays in influencing spatial abundance of edible caterpillars through the promotion of the regeneration of the host food tree, *Julbernadia paniculata.* Because of the sensitization campaigns by the Forest Department, most respondents considered that the biggest threat to caterpillar habitat was *chitemene* cultivation. This view was contradicted by the fact that the majority of respondents also confirmed that harvesting of edible caterpillars occurs in *chitemene* fallows which support regrowth miombo woodland in which *Julbernadia paniculata* is also more abundant (Chidumayo and Mbata, 2002). In fact if the c*hitemene* land use was a threat to edible caterpillar habitat, with more land under *chitemene* cultivation now due to population growth, caterpillar abundance should be more rare than in the past. This does not seem to be the case because the cyclic patterns in caterpillar abundance still persist as documented in this study (see Fig. 9). Furthermore, there seems to be no impact of caterpillar harvesting on the next caterpillar harvesting season because the harvesting is regulated (see Section 3.4). The impact of pupal parasitism on the recruitment of caterpillars for the next caterpillar harvest season and how wind affects the pupa stage while buried in the soil were not investigated.

This study, therefore, has not only provided the long term perspective about edible caterpillar abundance in Kopa Chiefdom based on indigenous knowledge but has also highlighted differences in the way government institutions and local people view the *chitemene* land use in relation to the woodland environment and edible caterpillars. These differences need to be bridged if edible caterpillars will continue to support local livelihoods in Kopa Chiefdom. Since the government is concerned about woodland destruction and the local people are concerned about their livelihood the government and Kopa community should work in partnership insuring sustainable utilization of the woodland environment for chitemene and edible caterpillar production.

CHAPTER SEVEN: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

Edible caterpillar sale is the main economic activity through which the majority of the households in Kopa Chiefdom earn income. However, despite the availability and yearly collection of the edible caterpillars, *Gynanisa maja* and *Gonimbrasia belina*, Kopa Chiefdom is said to be the poorest of the nine chiefdoms in Mpika district. Even though edible caterpillars have been harvested every year in the chiefdom, their abundance has been fluctuating such that the quantities of the harvests vary annually. Thus, low abundance means less harvest for the households, resulting in less income and in turn reduced access to goods and services which the households gain access to through incomes generated through the sale of edible caterpillars. This necessitated the need to find out factors that influence the edible caterpillar abundance.

The objectives were to:

a) Document years of abundance of *Gynanisa maja* and *Gonimbrasia belina* from 1989 to 2004.

b) Investigate land use and climatic factors that might influence the abundance *of Gynanisa maja* and *Gonimbrsia belina.*

The hypothesis tested was that:

The abundance of *Gynanisa maja* and *Gonimbrasia belina* is influenced by land use and climatic factors.

Kopa Chiefdom is found in Mpika district of northern Zambia. The chiefdom lies between 1000 m to 1300 m above mean sea level. The western portion of the area is grassland and the rest of the area is woodland. The climate of the area is tropical. The chiefdom is inhabited by the Bisa people whose major source of livelihood includes *chitemene* subsistence farming and edible caterpillar collection.

Gynanisa maja and *Gonimbrasia belina* are larvae of emperor moths. The emperor moths are insects and undergo four stages in their developmental cycle namely: egg, larva, pupa and adult. Many species of foliage forest feeding insects to which the emperor moths belong show a phenomenon of population cycles. Some authors attribute the population cycles to abiotic factors only, others to biotic factors only and most authors attribute them to a combination of abiotic and biotic factors.

Data were collected from one hundred respondents using an interview schedule with open ended questions, six focus group discussions and the District Forest Officer.

The abundance of *Gynanisa maja* and *Gonimbrasia belina* has been coincidental throughout the period between 1989 and 2004. In this period the two edible caterpillars were more abundant in 1992, 1994, 1998, 2000 and 2004. The caterpillar population peaks were separated consecutively by one-year and three-year periods. The abundance of edible caterpillars seems to be influenced by both *chitemene* cultivation land use and climatic factors. The land use of *Chitemene* cultivation appears to influence the edible caterpillar abundance by inducing the rapid regrowth of desirable tree species on which caterpillars feed following woodland clearing. Climatic factors influence the edible caterpillar abundance by impacting on the egg, larva and pupa stages of the *Gynanisa maja* and *Gonimbrasia belina.*

Edible caterpillars in Kopa Chiefdom show two types of variation in abundance; annual variation which is influenced by climatic factors and spatial variation influenced by the land use of *chitemene* cultivation. Although *chitemene* cultivation has a positive influence on the abundance of edible caterpillars, government institutions view *chitemene* cultivation as woodland destruction.

7.2 Conclusions

Gynanisa maja and *Gonimbrasia belina* show two types of population cycles; a short cycle separated by one year of low abundance and a long cycle separated by three years low abundance.

The abundance of *Gynanisa maja* and *Gonimbrasia belina* seem to be influenced by the action of temperature, rainfall and wind speed on the egg, larva and pupa stages.

The *chitemene* land use seems to influence the abundance of *Julbernadia paniculata*, the host plant for *Gynanisa maja* and *Gonimbrasia belina*, in woodland regrowth on fallows. This land use is probably the main factor that influences local spatial variation in edible caterpillar abundance.

7.3 Recommendations

Since *Gynanisa maja* and *Gonimbrasia belina* play an important role in the livelihoods of the people in Kopa Chiefdom in terms of income generation and nutrition:

- There is need for the government and the NGOs operating in the area to recognize the role of edible caterpillars in the lives of the people in the study area.
- In the effort to help the local community develop, traditional knowledge should be integrated in the development process. Local people should not be considered ignorant and therefore subject to domination by external knowledge systems.
- The portions of the uneven-aged old-growth of the National Forest which is part of the Lwitikila area should be cut clearly in the same manner as is done when clearing for *chitemene* cultivation and the regrowth managed for caterpillar production.
- The emphasis on woodland preservation during sensitization campaigns by the Forest Department should change to woodland conservation as the latter focuses on the use of the woodland in a sustainable manner.
- The policy of discouraging the practice of *chitemene* cultivation needs to be reviewed as *chitemene* enhances the spatial abundance of edible caterpillars.

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APPENDICES

Appendix A: Questionnaire for sample respondents

No.	Question	Answer
1.	Sex	
2.	Which sub area you from?	
3.	How old are you?	
4.	What is your marital status?	
5.	From your experience in which years were edible Caterpillars more abundant?	
6.	Were Chipumi and Mumpa abundant in the same years? If yes proceed to Q9.	
7.	If they were not, in which years was Chipumi more abundant?	
8.	In which years was Mumpa more abundant?	
9.	Where are edible caterpillars often abundant in the chiefdom?	
10.	What are the land uses of the areas where you collect edible caterpillars?	
11.	Is the habitat always available?	

12.	Is the habitat threatened by destruction in any way?	
13.	What are the causes for the destruction?	
14.	Is anything being done to check the destruction?	
15.	If so, what is being done?	
16.	After how many years do the edible caterpillars become more abundant in the outfield of the chtemene field?	
17.	In what ways does temperature influence the abundance of edible caterpillars?	
18.	In what ways does rainfall influence the abundance of edible caterpillars?	
19.	In what ways does wind movement influence the abundance of edible caterpillars?	
20.	In what ways does wind direction influence the abundance of edible caterpillars?	

Appendix B: Semi-structured questions for focus group discussions

1. Areas of frequent peak edible caterpillar abundance.
2. Reason for that particular area/s.
3. Reasons for habitat being always there.
4. Reasons for the contradiction in the answers.
5. Reasons for practicing chitemene.
6. Effect of climatic factors on edible caterpillar abundance
7. Uniformity of abundance in the area.
8. Land uses that enhance the abundance of edible caterpillars.
9. Harvesting of edible caterpillars and the chitemene fields.

Appendix C: Issues addressed by the District Forest Officer

1. Activities the department is involved in.
2. Non-wood products that the department manages in the district.
3. Areas in the district where the department is managing non-wood product.
4. Activities the department is involved in with the kopa community.
5. Information passed on through sensitization programs in the area.

Appendix D: Chi-square test for homogeneity of percentage responses for years with high frequency of edible caterpillar abundance

Year	Female				Male			Total
	% Fo	% Fe	χ^2		% Fo	% Fe	χ^2	
1992	12.868	10.208	0.693		8.824	11.484	0.616	21.692
1994	8.088	8.305	0.006		9.559	9.343	0.005	17.647
1998	7.721	8.478	0.068		10.294	9.538	0.060	18.015
2000	6.618	9.516	0.883		13.603	10.705	0.785	20.221
2004	11.765	10.578	0.133		10.662	11.900	0.129	22.477
Total	47.060				52.942			100.0

% Fo = percentage frequency observed, % Fe = percentage frequency expected, χ^2 = Chi-square

Appendix E: Chi-square test for homogeneity of responses for years with low frequency of edible caterpillar abundance

Year	Female				Male			Total
	% Fo	% Fe	χ^2		% Fo	% Fe	χ^2	
1989	0.8	1.075	0.070		1.6	1.325	0.057	2.4
1990	0.0	3.584	3.584		8.0	4.416	2.909	8.0
1991	1.6	1.792	0.021		2.4	2.208	0.017	4.0
1993	9.6	9.318	0.009		11.2	11.482	0.007	20.8
1995	4.0	3.226	0.186		3.2	3.974	0.151	7.2
1996	4.0	5.018	0.207		7.2	6.182	0.168	11.2
1997	1.6	1.075	0.256		0.8	1.325	0.208	2.4
1999	3.2	2.150	0.513		1.6	2.650	0.416	4.8
2001	0.8	2.150	0.848		4.0	2.650	0.688	4.8
2002	1.6	4.301	1.696		8.0	5.299	1.377	9.6
2003	17.6	11.110	3.791		7.2	13.690	3.077	24.8
Total	44.8				55.2			100.0

% Fo = percentage frequency observed, % Fe = percentage frequency expected,
χ^2 = Chi-square