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Edible insect as a sustainable diet in Sub-Saharan Africa: Case of Mopane worms (Imbrasia belina) in Zimbabwe

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled “edible insect as a sustainable diet in Sub-Saharan Africa: Case of Mopane worms (Imbrasia belina) in Zimbabwe’ independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague on 4 May 2020

.....

Belinda Moyo

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Abstract

Presented thesis documented the collection and use of edible insect by households in Zimbabwe in-order to better understand how these species contribute to the sustainable diets and livelihoods. Specific objectives drawn were to identify the types of edible insects collected by the households and why, to determine which groups or individuals were involved in the collection of edible insects, and to capture the effects of household characteristics on edible insect use. Data was collected in Plumtree and Bulawayo between 14 December 2019 and 15 January 2020 from 25 households and 10 traders respectively. Descriptive statistics, graphs, pie charts and tables were used to analyse the data . Results show that the most collected species are Mopane worms, flying alates, and flying ants. Among these, Mopane worm is the most collected edible insect with 61 % respondents confirming that they consume or trade in Mopane worm. Women and children are mainly involved in collection and preparation of edible insects. It is also key to mention that all the 25 households indicated that the main driver for collection of edible insects was for food consumption and income generation. From data collected respondents indicated that mopane worm populations are under threat from natural and man hazards causes such as droughts and deforestation, respectively. Several studies support the latter and thus the study recommends that, households and traders cooperate with government departments and community authorities to enhance sustainable collection and trade of mopane worms. This can enhance the mopane populations through preserving Mopane forest

Key words: market survey, household survey, Mopane worms, Bulawayo, Plumtree district

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1. Introduction

Hunger and malnutrition are serious problems during current unprecedent growth of population. Food shortages and poor nutrition have various roots. Nevertheless, many households across the world use resources from external environment to supply nutrition security. Nevertheless, utilisation of these resources is less monitored and thus they can be under pressure from overexploitation. One of example of these resources are insect species. Generally, edible insects have a high feed conversion efficiency, low land use, and can transform low value organic side streams into high value protein products. It is estimated that 2.5 billion people in the world currently supplement their diet with insects, but they could be also sold and contribute to household income generation. One of the countries where population utilise insect for either food or income purposes is Zimbabwe. This thesis is specifically focused on this country.

2. Literature Review

2.1. Tradition and drivers of eating insect

Insects have been in existence for at least 400 million years, making them among the earliest land animals (Tiencheu and Hilaire 2017). Estimates show that more than 1000 species of insects are consumed by a population of around 2 billion mainly from the developing world (Van Huis 2013; Bomolo et al. 2019). The cost of animal proteins for food and feed has increased over the past decades with least developed countries facing serious threats on food security and nutrition. In the past two decades scientists have attempted to pursue alternative and sustainable methods to bridge the threat posed by the ever-growing world population and traditional protein production methods (Tae-Kyung Kim et al. 2019; Polesny et al. 2018).

Entomophagy practice is a longstanding tradition which has not been affected by changes in lifestyles over the past decades. For example, in Zimbabwe, Lepidoptera and Isoptera have been the dominant species of edible insects which form part of the diet of most rural and low-income households (Dube et al. 2017).

Figure 1: Green mopane worm in forest

Source: Masau 2018

In most Western countries, United states and Europe in particular, edible insects are promoted as a snack and, like nuts, can be coated with chocolate, mixed into baked goods, or sprinkled on salads. Mildly processed, fried, roasted, or finely ground, they are used to add a unique flavour to foods or to increase their nutritional profile (Melgar-Lalanne et al. 2019).

More than 800 million people are estimated as lacking enough food to conduct an active life, and an additional 2 billion have undernutrition and micronutrient deficiencies (FAO 2013). At the same time, about 1.5 billion experience being overweight or obese due to unhealthy diet continuum that is created by excess energy consumption (Popkin et al. 2011). The latter is growing and is part of the ‘‘nutrition transition,’’ the shifting prevalence from undernutrition with high rates of infectious diseases, to that of overnutrition characterized by excess consumption of highly processed food and dominance of chronic diseases (obesity, cardiovascular disease, cancer).

2.2. What is known about edible insects in Zimbabwe?

In Zimbabwe, just like any other Sub-Saharan African country, nutrition and food security is a challenge for most low-income households. About 25% of the rural households were at risk of food insecurity in the period of 2013 to 2014 (ZIMVAC 2014). The report by ZIMVAC further stated that, meat, legumes, and other important protein sources, were the least consumed food in rural areas. Entomophagy might be the key to food and feed insecurity and thus replace the conventional animal protein sources (Manditsera et al. 2018).

Over 1900 species of edible insects in 300 ethnic groups in 113 countries worldwide have been recorded by various authors to be part of human diet (Tiencheu and Hilaire 2017). According to Ramos-Elorduy (2010) tropical and subtropical populations eat greater numbers of edible insect species than in habitants of temperate climatic zones.

Over 65% of total global edible insect population is accounted for by Africa and Asia. The diet reflects the socio-economic conditions of a people. Dietary habits and taste

perception are closely bound to a people's history and their geographic origin and evolve in relation to lifestyle, tradition, and education. This may explain that in some developed cultures insects are looked upon as a primitive food, whereas some other cultures consider them to be a valuable and integral part of the diet (Ramos-Elorduy 2010).

In his research Dube et al. (2013) found out that Mopane worm (*Gonimbrasia belina* L.*)* generates its highest mass and nutritional value between the months of November and April. They argue that the harvesting and preservation techniques are critical to maintain these high nutrition levels of the caterpillars.

Edible insects are part of long tradition in many cultures particularly African, Asian, and American indigenous communities (Afam and Rinah 2017; Butner 2018). Edible insects contain between 40 to 75 % more crude protein compared to animal protein (Tang et al. 2019) and the energy content is estimated to be at par with fresh meat sources (Doberman et al. 2017).

There are more than 2,000 edible insect species being documented around the world that are regularly used for human diet (Tiencheu and Hilaire 2017; Jongema 2017). One of the most popular ones are Mopane worms. They represent an important source of protein in Zimbabwe and southern Africa in general (Benitez 2017). They are usually served as a snack to visitors or tourists in households as well as relish for lunch or dinner amongst rural and urban dwellers. Mopane worms are a delicacy served in many fast food outlets and restaurants in Zimbabwe (Benitez 2017; Masau 2018). They are recognized as the most valuable forest resource produced from the mopane woodlands in Southern African countries, particularly Zimbabwe, Botswana, South Africa, and Namibia (FAO 2013).

Estimates indicate that about 9.5 billion Mopane worms are harvested each year and earnings total around US$85 million with 40% of these earnings benefiting the rural households in particular women (Ghazoul 2006; Masau 2018).

Insects make up 70% of the species of multicellular organisms on the planet. Although they are one of the leading causes of disease vectors, they also play a crucial role in our natural ecosystem and as a source of nutrition for low income household in the global south.

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Researchers of entomophagy have suggested that insect farming is a viable and environmentally sound alternative to big livestock rearing due to rapid urbanisation in the global south where the biggest meat production occurring (Pechal et al. 2019). Unlike in the global south where insects are a key source of human diets, insects form the bulk of animal feed components in the Western world (Kim et al. 2019).

The capturing, processing, transporting, and marketing of edible forest insects provide interesting income and livelihood opportunities for an undetermined number of people around the world. Traditionally, these activities were all locally based and largely under-recognized. Recently, however, more sophisticated, and wide-reaching marketing and commercialization of edible forest insects have been advanced, including attractive packaging and advertising (FAO 2010).

In Democratic Republic of Congo edible insect accounts for at least 15% of the protein diet (Van Huis 2013) with caterpillars being the predominant species. Majority of forest dwellers (95%) dependent on eating insects in the Central African Republic (FAO 2004; Van Huis 2013) and insects are sometimes the only source of essential proteins (amino acids), fats, vitamins, and minerals for forest people.

In West Africa (Cameroun and Nigeria), most villagers have better knowledge about nutritional value of edible insects. In these communities the main species consumed are crickets, termites, honeybees, and cockchafers (Alamu et al. 2013; Muafor et al. 2015; Meuthieye et al. 2016; Tamesse et al. 2016). have provided information about villagers' knowledge of edible insects. The main utility of crickets, termites, honeybees, and cockchafers is consumption, but some additional uses were reported like medicinal and ritual uses (Tamesse et al. 2016). Entomophagy is a form of biological method to minimise harvest losses caused by insects. Mostly termites are popular in diets (Reis de Figueiredo et al. 2015) among many households. Tamesse et al. (2018) found out in his study that 96% of consumed insects in Nigeria are termites followed by crickets at 94% and lastly cockchafers at 87%.

The collection and processing of edible insects is mostly done by women and children. Taking the example of southern Zimbabwe, many households utilise insects as a livelihood strategy for many low-income families. The mopane worm is more popular in this region and it has moved from a diet supplement to become a household income

generation enterprise (Hobane 1994; Kozanayi and Frost 2002). Thus, mopane worm form is an important contributor in the eradication of hunger, malnutrition and food insecurity in Africa and development agenda (Kozanayi and Frost 2002).

World food supplies are increasingly dominated by a limited number of plant and animal food species, limiting the markets of biodiverse foods that can enhance nutrition and other aspects of human diets. Various strategies and activities have been utilised overtime to sustain the well-being of people in developing countries. Livelihood activities can be divided into two main categories (Ellis 2000): natural resource, and non-natural resource-based activities. The natural resource-based activities include collection and gathering from forests and woodlands, agriculture, brick making, fishing, weaving, and thatching. The non-natural based activities are activities such as rural trade, rural services, remittances, and pension from former formal sector employment (Ellis 2000).

Main insects consumed in Africa are grasshoppers, termites, bees, caterpillars, stinkbugs, jewel beetles and white grubs (Agbidye et al. 2009). The edible stink bug encosternum (Haplosterna) delegorguei Spinola (Heteroptera, Hemiptera) or thongolifha is a delicacy to Venda people living in Limpopo province in South Africa and the Shona people who live in Bikita South of Zimbabwe. Stink bugs contain a high content of protein, vitamins, some amino acids, and minerals (Teffo et al. 2007).

In the State of Benue in Nigeria the consumption of more than ten insects is common while in Zambia the consumption of caterpillars of eight saturniidae moth species have been reported among the Bisa people (Agbidye et al. 2009; Mbata and Chidumayo 2003). Because of the widespread consumption of insects as a cultural and food security practice and increasing commercialization of insect crops, there is a likelihood of unsustainable harvesting (Teffo et al. 2007). It should be noted that the degradation of natural resources presents a real threat to the food security and cultural wealth of rural people as reported for mopane worm harvesting in southern Africa (Agbidye et al. 2009)

The harvesting and processing of mopane worms throughout the mopane belt is still traditional in nature but extensive destruction of trees to speed up the collection process is increasingly identified as a problem (Stack et al. 2003). There are no modern

technologies or equipment used during the harvest, except the occasional use of gloves to protect hands from the sharp spines during collection and degutting (Stack et al. 2003).

2.2 Benefits of edible insects for household food and cash security

Significant numbers of people around the world depend on woodland resources for their livelihoods, welfare, income, preservation of local cultures and spirituality (Heubach et al. 2011; Shackleton and Pandey 2014; Pandey et al. 2016).

Non timber forest products are a source of income for most rural households (Dovie et al. 2002) in particular edible insects such as Mopane worms. However, forest products have attracted the urban poor households' attention thus the involvement of urbanites in edible insect trade and collection has surged recently (Chidumayo and Marunda 2010).

Mopane worm has established strong trade linkages between the rural dwellers and urbanites (Illgner and Nel 2000; Kozanayi and Frost 2002). One of the main nutrients derived from edible insects such as Mopane worms is protein (Dovie et al. 2002; Stack et al; 2003; Madibela et al. 2009) which is very scarce in times of droughts due to death of livestock. Ultimately edible insects become a household food security contributor.

The harvesting season for mopane worms stretch from November to April (Ghazoul et al. 2006). Mopane forests have a higher leaf density in their canopies in these months due to high rainfall received from November till April. Mopane worm has drawn the eyes of the private sector and public sector business entities (Kozanayi and Frost 2002) due to the high profitability margins of mopane worms. Most households channel the profits from mopane worms for households needs such as farm inputs and school fees (Stack et al. 2003; Thomas 2013).

Mopane worm harvesters presently trade over 80% of their yield, whereas it was once common for harvesters to collect mopane worms for home use and reciprocal bartering only (Stack et al. 2003, Gondo et al. 2010). In Mazvi village in Matopo, mopane worms play an important role in the lives of the villagers. To show the economic importance of the mopane worm, the community has constructed a state of art Processing Centre for packaging, storing, and selling of mopane worms. Many villagers in this area have stated the importance of mopane worms, as a source of money to pay for their children

school fees and buying them school uniforms. The profit that they get from selling mopane worms is also channelled into buying agricultural inputs including livestock (Jabson 2018). The mopane worm can be used to supplement expenditure on important things like education, food, health, and clothing.

Figure 2: Variable units of sale (left) and Mopane worm containers (right)

Source: Kozanayi and Frost 2002

The season for mopane worms comes when there is a shortage of food supply, so the worms are used as a food supplement. Local communities see mopane worms trading as a source of living. Sources have shown that women and children have contributed more to the harvesting and gathering of mopane worms. Smaller enterprises are run by women while men control the long-distance big market chains due to large volumes being traded (Kozanayi and Frost 2002)

As of April 2017, a total of 400 tonnes (881,849 pounds) of mopane worms have been harvested in Gwanda, Beitbridge, Matobo, Bulilima, Mangwe and Plumtree. Among the latter Gwanda recorded the highest produce (Global Press Journal 2017). The Forestry Commission (2018) is worried that most harvesters contribute to environmental destruction by cutting down trees to get firewood. Hazards emanating from fires are the greatest threat to environment. Most harvesters or collectors have no formal

employment. The local media (Chronicle News 2019) reported that nurses were leaving duty at Maphisa District Hospital in the same province to harvest the worms which is a sign that Mopane worm is more than just food for the locals but a significant household income earner.

2.3 Challenges associated with edible insect harvesting

Between December and May most low-income households run out of their maize supplies in the granaries and coupled with fewer options to raise household incomes many take advantage of the free forest resources such as mopane worms (Stack et al. 2003). As a result of the increased number of households involved in mopane worm harvesting, overharvesting, destruction of forests, dragnet harvesting (harvesting immature worms) have set in most of the Mopane forests in Zimbabwe and other neighbouring countries.

The outbreak of mopane worms can be sporadic, causing people to travel considerable distances to outbreak sites and often camp for several days in the collection area while harvesting. Hence there has been an emergence of informal settlements at breakout sites in recent years (Stack et al. 2003).

3. Aims of the thesis

The main aim of the thesis was to document the collection and use of edible insect by households in Zimbabwe.

Specific objectives were:

1. To identify which edible insect species were collected by households with special regard to commercialization
2. To document who were gatherers at household level
3. To document the households' characteristics and their potential effect on edible insect collection and use

4. Methods

4.1. Study sites characteristics

Plumtree is located about 100 kilometres southwest off Bulawayo. The average rainfall is estimated at 596 mm per annum (Climate-data 2019) which is one of the lowest in Zimbabwe. The population of Plumtree stands at 11556 (ZimStats 2012). Rail routes between Botswana, Zimbabwe and Zambia passing through plumtree border post drive the economic activities of the town (Plumtree Council Web 2020). Other economic activities include, livestock rearing and selling, collection of Mopane worm for sale and exchange of labour for food or cash.

Bulawayo is the second largest city in Zimbabwe located in the south of Zimbabwe. The total population of Bulawayo residents is 653,337 with 54% of this figure being women and 47% male (ZimStats 2012). The major economic activity in Bulawayo is vending. The economic decay post 2000 led to rapid deterioration of Bulawayo industrial sector which used to be the bedrock of Zimbabwe's manufacturing and construction sectors informal (Gumbo and Geyer 2011; Mlambo 2017)

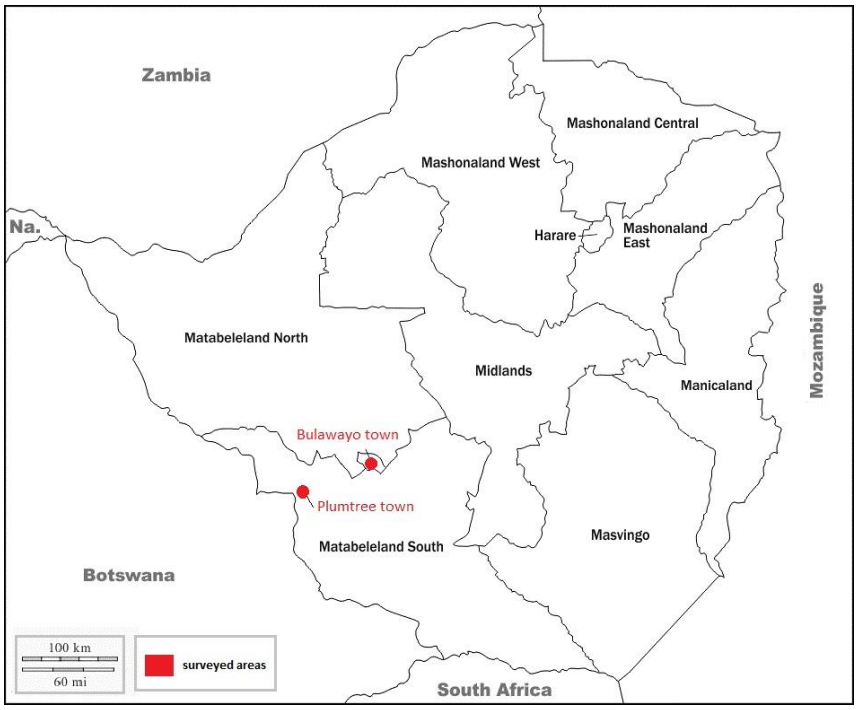

Figure 3: Study area

4.2. Data collection and analysis

This study used a mixed method approach which combined quantitative and qualitative household. A semi structured questionnaire was used to gather data from 25 household heads. Furthermore, to appreciate the market price general trend a focus group was conducted with 10 traders in the city of Bulawayo which forms the biggest Mopane worm market in Southern Zimbabwe. Data was collected from 14 December 2019 to 15 January 2020. A focus group discussion was conducted in Bulawayo town at the open-air market of Shasha market. Data was gathered from 10 vendors on edible insect pricing and gross margins. During the focus group vendors indicated that Plumtree town was the main location, where collectors came from. However, some vendors indicated also other zones such as Tsholotsho and Lupane. Therefore, Plumtree was chosen purposively for household survey. To select the participants of the household survey, snowballing technique (Coleman 1958; Goodman 1961) was used. This technique enabled the author to pick the households involved in edible insect collection.

A market survey was conducted at Bulawayo Shasha market with the retailers which zeroed in on wholesale and retail prices, gross margins, and the suppliers (middlemen and harvesters) of the edible insects. The second group discussion was conducted in Plumtree with social workers who acted as experts in this study to verify the data provided by households particularly on household characteristics and edible insects collection aspects**.** Social workers are mainly involved in advocacy initiatives with a focus on women enterprises such as Mopane worm trading and they are a key in triangulation of primary data. The focus group gave the opportunity to ascertain other unverified data such as middlemen, retail prices and the main harvest zones for Mopane worms. During the focus group discussions, consensus was the main technique used to select Mopane worm as the main edible insect utilized by households (Romney et al. 1987; Weller 2007)

A semi-structured questionnaire (Annex 1) was used to gather the variables under investigation. Data collected by the questionnaire included demography, income generation activities, reasons to participate in mopane worms to mention a few. The household head was interviewed as this is a cultural norm that the head represents the family. Photos of edible insects sold currently on the market were also taken.

Figure 4: Author collecting market data

The interview data was transcribed manually into Microsoft Excel to create graphs, pie charts and tables using the coded thematic data. The answers of the respondents were then further grouped in line with the main themes which were under investigation such as characteristics of households, use and trade of main edible insects, types of insects collected and their household or commercial purpose.

5. Results

5.1. Main edible insect species collected by households

Table 1 above indicate the main types of edible insects generally consumed by households and traded on the markets for cash or barter trade. We included the vernacular and the English names given to the edible insects.

Table 1. edible insect species consumed by surveyed households in Plumtree

Vernacular name	English name	Frequency
Mopane	edible caterpillar	61%
Nyenze	flying alates	15%
Ishwa	flying termites	17%
Tsambarafuta	edible ant	7%

The main insect consumed by most households in Plumtree, was Mopane worms which are in three different types when dried: yellow-coloured magandari, reddish harati and black macimbi with white spots (see Figure 4).

Figure 5: Subtypes of mopane worms

The mopane worms collected in Zimbabwe are further subdivided into three categories which are referred to in vernacular as Magandari, harati and macimbi or madora. The main difference between these is that they are different in colour. The haratis are reddish while the madora are white spotted and the magandari are brownish in colour when degutted and dried.

Figure 6: Mopane worms on market stall

Figure 6 shows the different standardised containers which determine the price of mopane worms. Retailers resale in 210 g teacups (smallest) and larger containers of 500 g, 1 kg up to 5 kg. The 210 g teacup is preferred by consumers while the 5kg is for those who conduct cross-border (between countries) trading or further retailing. Middlemen sell to retailers in 20kg units and not less to retailers.

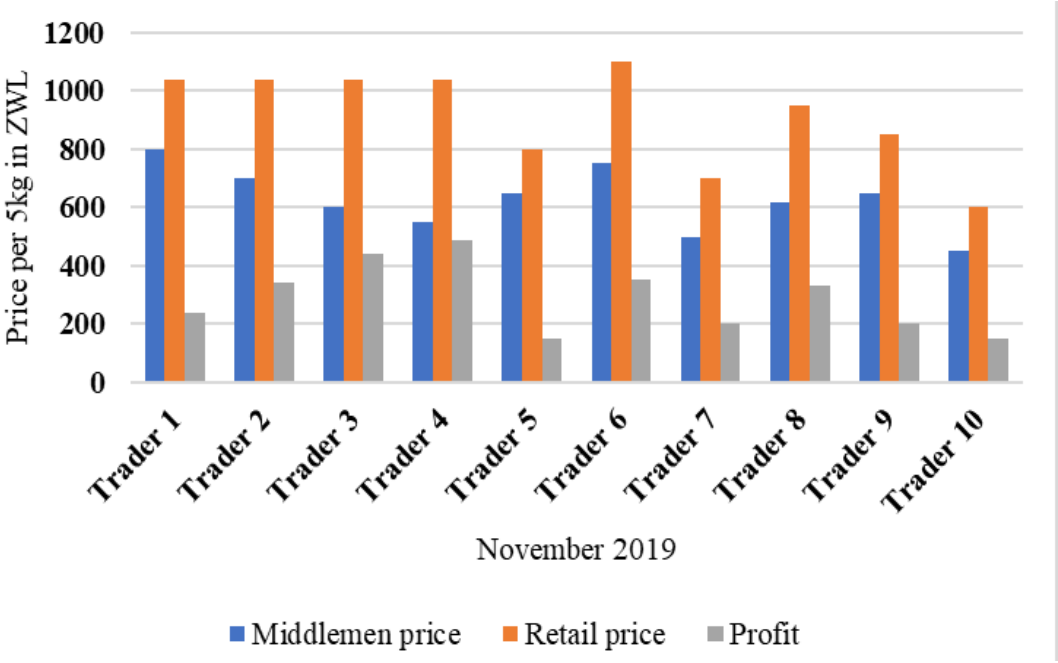

Figure 7: Estimated mopane worm gross margins per trader

Figure 7 illustrates the differences in gross margins per trader of mopane worms. The minimum price of mopane worms is 450 ZWL (22.5 USD) per bucket weighing 5 kilograms and maximum price was 800 ZWL per bucket. In the same vain traders sold mopane worms at a minimum price of 600 ZWL (30 USD) per bucket and a maximum of 1050 ZWL (per bucket). However, traders sold in small units denominated in cups as illustrated by Figure 5. The units normally are less than 100 grams (Frost and Kozanayi, 2002) in weight and most customers prefer to buy in small units.

5.2. Household characteristics and collection of mopane worms

Table 2 illustrate the characteristics of the surveyed households. As highlighted in our methodology the household head was interviewed as he/she was regarded as the family representative. 72% were female while the remaining 28% were men household heads. One key observation is that female heads are involved in insect collection more than their male counterparts. Among the 25 households 16 have a household size ranging between 4 and 6 people. The main source of income for 22 households is Mopane worm trade, livestock and also crop farming. However, 3 families also rely on remittances.

Table 2: Household demographics

Demography indicator of head	Number
Female	18
Male	7
No of members	
2 to 3	2
4 to 6	16
7 to 11	7
Age of Household Head	
21 to 30	1
31 to 40	6
41 to 50	11
51 to 60	4
61 to 70	3
71 to 80	1
Average age	47
Median age	46
Main sources of income	
MW trade and livestock farming	10
MW trade and livestock and crop farming	12
MW trade, Livestock farming and remittances	3
Ethnicity	
Kalanga	13
Shona	6
Manyika	1
Ndebele	4
Tshangane	1
Religion	
Christian	16
Others	9

MW is abbreviation for Mopane Worm

From Table 2 it is evident that the average and median age of the household heads surveyed was 47 and 46 years respectively. Furthermore, the majority of the household heads are between the age of 41 and 50 years old.

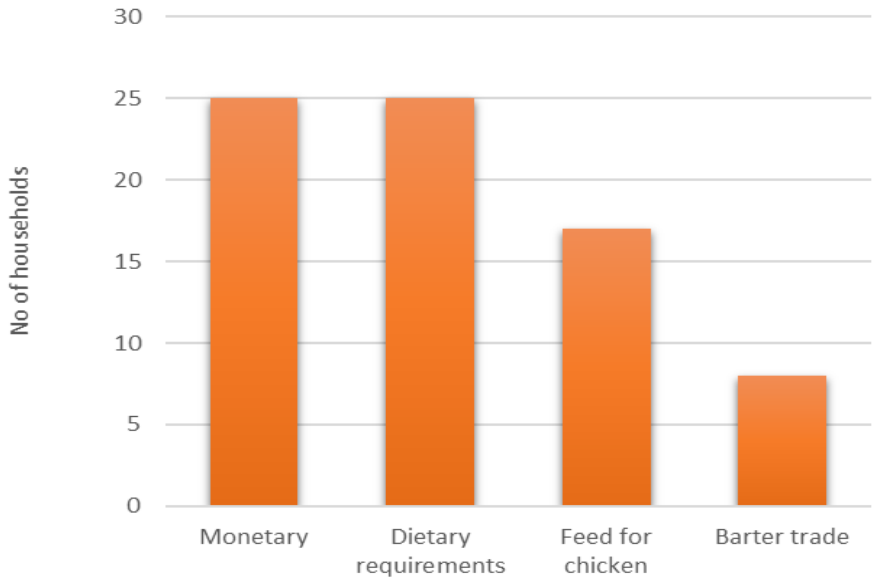

Figure 8: Drivers for collecting mopane worms

All the 25 respondents indicated as shown in Figure 8 their reasons for harvesting was both for trading and household consumption. The incentive for income generation appeared to be a significant factor for some respondents, especially with the selling prices fetching high amounts. Equally all households indicated that Mopane worm is utilized as a dietary requirement and is served as relish a food. However, 18 households utilize mopane worms for feed in particularly free-range feed during times of bad harvest.

Figure 9: Share of mopane worms sold on market by households

The share or percentage of mopane worms sold by households is illustrated in Figure 9. It is evident that 14 of the households sell an estimated 90% of their mopane worms on the market. At least 18 households suveryed sell 70 % plus of their total share of collected mopane worms. This indicates that monetary reason is the main reason for collection of Mopane worms. Only three housholds sell 10% of their share of mopane worms to middlemen or retailers while the other 90% is for consumption and other purposes such as barter trade.

5.3. Drying and preparation

All the households survey indicated utilised open fire charcoal method of drying and or sun drying in the preparation of the Mopane worms. When the worms are harvested from the forest, they are degutted and then salted after which they are sun dried or charcoal dried. Both methods are highlighted in fig 10 and fig 11.

Figure 10: Villager sun drying Mopane worm

After collection of the mopane worms, the bowel of the worms is squeezed out. This process is done with bare hands or sometimes with gloves. The mopane worms are then washed under running water and then boiled. They are then dried under the sun and when they are dried, they are then packed.

Figure 11: Charcoal method of drying Mopane worms

After squeezing the inner stomach contents the Mopane worms are mixed with hot charcoal. As illustrated in Fig 11 the worms are constantly turned with a shovel or any other tool . It normally takes up to 5 hours for the Mopane worms to dry (Ghazoul 2006). However charcoal drying method has a potential of reducing the quality which result in low price on the market.

5.4. Basic characteristics of insect collecting households

In the diagrams below Figure 9 and 10 illustrate the education levels and household size and possible impact on mopane worm collection, and use.

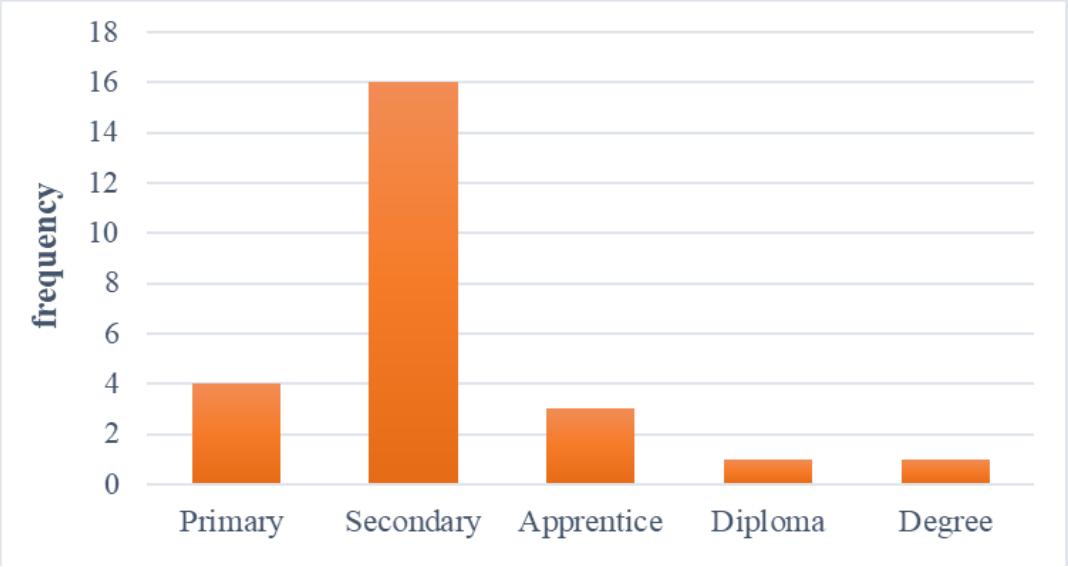

Figure 12: Level of education of households

According to (DFID, 1999) entails that human capital is a combination of skills, the know-how and ability to labour and good health are crucial for the households to pursue livelihood strategy. 16 household heads reached secondary education while 4 only have primary education. 5 household heads have at least apprenticeship or tertiary education

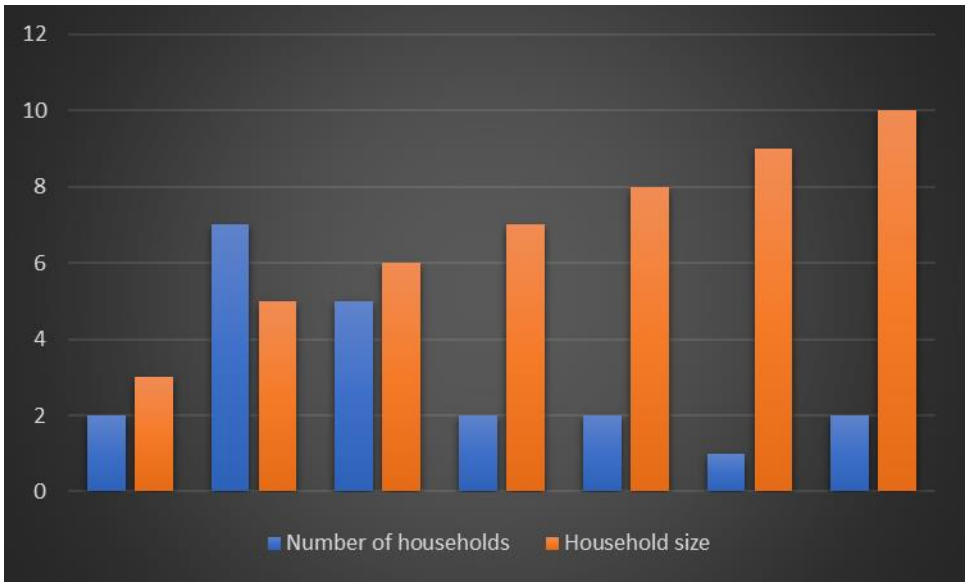

Figure 10: household size patterns

The average household size is 5.84 which can be rounded off to 6 people per household. However, the mode is 5 members per household. In summary we can put the number of members per household as between 5 and 6. It is important to mention that many families rely on family labour especially for the collection and preparation of Mopane worms. Human capital may be a limitation in mopane worm livelihoods as it restricts the respondents to harvesting and may prevent participation in other aspects of trade. However, mopane worm harvesting, and trading is usually done by the entire family those that are active, able to work thus resulting in high availability of labour.

6. Discussion

6.1. Edible insects, collection and use by target households

The primary motivation to collect mopane worms is mainly commercial and for farm consumption purposes(Stack et al. 2003; Ghazoul 2006, Baiyegunhi et al. 2015). While harvesting for subsistence is still one of the reasons, the predominant motivation for harvesters is the quest for income generation (Akpalu et al. 2009). In times when a household needs other basics for instance cooking oil, soap, clothing, mopane worms come in handy as a barter trade commodity.

However, the nutritional value of the caterpillar, may not be the only reason why the mopane worm is being consumed. Traditional beliefs contribute to the consumption of mopane worms. Respondents in this study harvested and consumed mopane worm because it is regarded as traditional food item and a form of cultural identity (Mutenje et al. 2011). In these notions, a clear relationship between nature and culture is shown. Some of the practices are driven by biocultural linkages (Cocks and Dold, 2004) and individuals have a belief that they must consume mopane worm to retain their traditional customs in existence.

In the survey we found out that some households participate in barter trade with mopane worms. Bartering is one of the modes through which harvesters trade in mopane worms. Some harvesters revealed that they have used mopane worms for bartering, but this is infrequent. They exchanged the worms for household goods such as kitchen utensils, bedding, and food stuffs (Ellgner and Nel 2000). One harvester revealed that she once bartered a 20-litre container of the worms for a standard blanket.

6.2. Characteristics of households which collect mopane worms

Generally, gender has been always influencing labour division at farm-household level. This is true either for internal or external activities, such as worms' collection and use. Gender and household size have a statistically positive effect on likelihood of households to participate in collection of insects (Biyegunhi and Oppong 2016).

Traditionally women and children are the main group involved in collection, but men control the long-distance insect market chains (Kozanayi and Frost 2002; Baiyegunhi et al. 2015).

Although the number of women (constituting 96% of harvesters) and children still predominate, participation of men and youth has increased extensively due to the high gross margins associated with Mopane worm trade.

6.3. Mopane worm collection season

The amount of rainfall received in a particular year or season is a main component for a bumper mopane harvest. Normally the seasons for harvest are in two parts that is December to January and then in April to May (Ellgner and Nel 2000). Other authors (Ghazoul et al. 2006) state that for example in Plumtree, mopane worm outbreaks occur from November to December and then from March to April when leaf quality appears to be at its best. This also show that the mopane harvest season has slightly stretched by one month.

There are important reasons why mopane worms are collected, that is for food source and trading commodity used for barter trade or monetary value. The outbreak seasons for mopane worms are between December and April (Stats SA, 2016). During this period, there is creation of temporary employment for those living in rural areas who harvest and collect for trading in exchange with money for household consumption. Makhado et al. (2014) and Baiyegunhi et al. (2015)assert that Mopane worm create employment during this season of mopane worm gathering and collection. However, according to (Shackleton, et al., 2005; Putzel & Cerutti, 2014) NFTP do not generate employment or income for a long period of time and this might not be helpful to those people in poverty as this money is short lived. Secondly, due to the short harvest period of the mopane worms, there is sometimes there is over exploitation of resources which leads to deforestation (Baiyegunhi et al. 2015)

6.4. Government role in mopane worm trade

The acute food shortage exacerbated by the drought (World Food Programme 2019) has resulted in the increase in Mopane worm collection and trade in the rural areas surrounding Bulawayo such as Plumtree. Social workers indicated that every year the Zimbabwe Ministry of Women, Community and Small to Medium Enterprise Development is promoting MW products at food exhibitions, trade fairs (Zimbabwe International Trade Fair-ZITF) to forge business linkages and broaden Mopane worm market. They have gone on further to set up a Mopane worm processing plant with the help of International Labour Organisation and this is specially targeting rural women as the main drivers and beneficiaries of this project.

To assess utilization and collection of mopane worms in relation to households, more empirical studies should be conducted. This is important to confirm harvester perceptions and unravel linkages between mopane worm populations and strategies for sustainable commercialization.

Enhanced cooperation between traditional leaders, harvesters and local authorities suggested as a choice for managing mopane worm resources in the communal harvesting regions. Community leaders tend to retain power over the use of natural resources in communal areas and influence the groups they are leading. It is proposed that this partnership be stepped up with feedback from conservation authorities on sustainable harvesting practices. For main players in this field this will also include harvesters and traders. This will instil a sense of ownership and responsible resources harvesting to encourage the survival of mopane worms and meet the needs of harvester and traders.

Further research is needed to interplay access, land tenure and harvesting. Mopane worm harvesting takes place across multiple types of tenure and is therefore an opportunity to understand tenure, governance, and access in the context of mopane worm living conditions. The budget was so constrained that the sample size was smaller than was originally anticipated.

Instead of visiting Masvingo and Bulawayo as was originally planned, the author changed her target area for household survey to Plumtree which is closer to Bulawayo.

The study used a snowball sampling approach, as a result the researcher was only able to interview the respondents to whom were referred by fellow respondents. Some of the traders in Bulawayo declined to participate in the focus group discussion and as a result only 10 traders willingly accepted. Due to the fear of authorities and political victimization which has previously occurred some households preferred not to be mentioned by name in the questionnaire while some declined to be interviewed.

7. Conclusions

This study investigated the utilization of edible insect as a sustainable diet among rural and urban households.

The value of edible insects in the study area is primarily twofold: it is a significant source of food and it is a valuable product of commerce. Mopane worm selection, trade, and consumption are activities conducted for the purposes of dietary supplementation and income generation. There is a tradition of mopane worms being bartered and exchanged for household goods. Trading is an important source of jobs for rural people with limited structured work opportunities and the potential to produce higher levels of income in rural contexts than wage labour.

Women and children are involved in collecting worms more than male counterparts. Men are usually involved in the value chain of the trade of mopane worms as middlemen and retailers. In summary the mopane worm trade industry is a woman dominated industry. High labour supply of the harvesters' family as denoted by household size provide good human resources to pursue the collection of mopane worms as a commercial enterprise. Lack of enough labour force inhibits the potential of households to increase their mopane worm harvest.

Mopane worm collection and trade provides an opportunity to examine and gain insights into the capital that households use to follow their livelihood approaches and future outcomes of living. Every livelihood vulnerability context is associated with hindrances which are both natural and man-made thus a holistic approach to address the underlying poverty effects is required. In mopane worm livelihood, patterns of household consumption and procurement are greatly altered when outbreaks are erratic and low levels of availability. Erratic outbreaks mainly emanate from the natural hazards such as droughts and in recent years deforestation of mopane trees caused by overharvesting.

Generally, we can conclude that edible insect is highly collected and consumed in Zimbabwe. However, based on our data, insect is collected mainly as a source of income and/or barter and not to support food security

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