CULTURALLY AND ECONOMICALLY SIGNIFICANT EDIBLE INSECTS IN THE BLOUBERG REGION, LIMPOPO PROVINCE, SOUTH AFRICA

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Culturally and Economically Significant Insects in the Blouberg Region, Limpopo Province, South Africa

by

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Declaration

I declare that the thesis hereby submitted to the University of Limpopo, for the degree of Doctor of Philosophy in Zoology has not previously been submitted by me for a degree at this or any other university; that it is my own work in design and execution, and that all material contained herein has been duly acknowledged.

Egan, BA _________________________ **Date** ___________________________

DEDICATION

This work is dedicated to my parents, Bryan and Kathleen Wallis,
my husband, Vincent Egan,
and my children, Aine and Tadhg Egan.

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Mountains have always been the place for me to go for solitude, serenity, wonder and for spiritual quiet. Blouberg Mountain, however, is not only a still and isolated place of natural splendour. It is also vibrant with the clamour of the community living on the slopes and plains below. I thank you, the Bahananwa of Blouberg, for teaching me about the edible insects of your mountain. You have taught me much more than what is encapsulated within these pages. You shared your homes, your knowledge, your mountain and your friendship. I have learnt that mountain people are just as extraordinary and beautiful as the mountains they inhabit. *Ke a leboha* and may we meet again, often.

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Those who confirm themselves in favour of the Divine give attention to the wonders which are displayed in the production both of plants and animals.

Divine love and wisdom 351

How wonderful it is that the insignificant silkworm should clothe with silk and magnificently adorn both women and men, from queens and kings to maidservants and menservants, and that a petty insect like the bee should supply wax for the tapers which make temples and palaces brilliant

True Christian Religion 13

ABSTRACT

Edible insects have been used as a nutritious food source by mankind for millennia, but in the modern era their use in more industrialised and western countries has dwindled. In the face of concern over the global food security crisis, scientists are urging investigation into edible insects as an alternate food. This study contributes to this global initiative by investigating entomophagy in the Blouberg area of the Limpopo Province, South Africa. The research develops a database of Blouberg edible insects, documents the importance of entomophagy to the people of Blouberg and for the wider community, and investigates aspects of the biology, ecology, socio-economics and nutritional value of a key species harvested in the area. Semi-structured questionnaires were carried out between 2007 and 2008 amongst households in the vicinity of Blouberg Mountain. Nearly 91% of the households in the Blouberg area consume insects. The most important reasons cited for consuming insects are that they are a traditional food, that they taste good and that they are a free food resource. Twenty eight species of edible insects were identified to at least genus level. Education was more important than income in influencing whether or not insects were consumed in a household. Households with lower education scores were more likely to consume insects than those with mid-level education scores. However, those with low income scores consumed a greater quantity of insects than those with higher scores. Similarly, those with low education scores consumed more insects than those with higher education scores. Pasture land was the area most preferred for collecting insects, with crop lands second in importance. Natural vegetation was not a preferred collecting habitat. Most households (78.57%) believe there has been a decline in edible insect consumption in recent years. According to the Blouberg insect collectors, edible insects are also on the decline in Blouberg and most households are unhappy about this. The lepidopteran, *Hemijana variegata* (*bophetha*), which was targeted for more in depth research, was found to be univoltine in the field, with caterpillars emerging in early November. The caterpillars feed predominantly on *Canthium armatum* and to a lesser extent on *Pyrostria hystrix*. They take four weeks to develop, burrowing into the soil to overwinter as pupae to emerge as adults in late spring. The development of the moth is profoundly influenced by temperature at all life stages and ceased below 17ºC and above 35ºC. Temperatures between 23ºC and 29ºC were most favourable for growth.

The food value of the *bophetha* caterpillars was found to be high. The protein value of traditionally prepared caterpillars is 45.5%, with carbohydrates at 11.86 mg/100 g and fat at 19.75%. The caterpillars are not as rich in vitamins as fruit or vegetables, but compare favourably with beef. Traditionally prepared *bophetha* were found to be contaminated by two bacteria and one fungus, none of which are dangerously pathogenic to humans. *Bophetha* are traded between Blouberg villages at costs equivalent to other edible insects in South Africa (R10.19 per cup). Almost one third of Blouberg inhabitants sell *bophetha,* with this percentage decreasing to about 10% in poor seasons. Households collect between 3 and 3.5 litres of *bophetha* per season. Blouberg households are of the opinion that knowledge about edible insects is important enough that it should be included in formal education as a way of ensuring that the younger generation assimilates aspects of this knowledge despite cultural changes. The results of the study emphasise the importance of natural resource use with respect to edible insects in a marginalised community.

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CHAPTER ONE

GENERAL INTRODUCTION, EXTENT OF THE STUDY SITE AND THESIS OUTLINE

Motivation and setting for the study on Blouberg edible insects

1.1 INTRODUCTION

Calls to maximise levels of food production have become urgent in the face of a global human population exceeding 7 billion (U.S. Census Bureau 2012) and world leaders and scientists are searching for new and innovative means of feeding the world as well as resurrecting ancient practises that have relevance to human nutrition (Hodges 2005). These methods must satisfy international nutrition and food safety standards. They must also “meet the needs of the present without compromising the ability of future generations to meet their own needs’’ (Brundtland 1987). The recent upsurge in attention given to edible insects as food is therefore understandable (Allotey and Mpuchane 2003). Edible insects are not a novel food source by any means, having been utilised for millennia on all continents of the world (Capinera 1993, Capinera 1995, El-Mallakh and El-Mallakh 1994, van Schalkwyk and Moifatswane 2000, van Itterbeeck and van Huis 2012). They are, however, relatively underutilised in many resource hungry, developed countries. Thus insect eating or entomophagy is today rare in America and Europe but widely practised in South America, Africa and the Asia-Pacific (DeFoliart 1999, Gullan and Cranston 2000). There is also a concern that just as the world is starting to recognise the value of insects as a food source, so entomophagy is declining in those areas where it is still practised, such as Africa and South America (Gracer 2010, Van Itterbeeck and van Huis 2012). Insects are therefore increasingly targeted for research relating to 1) species suitable for consumption, 2) nutritional value, 3) suitability for semi-domestication, 4) ways and means of improving their palatability and 5) ecological aspects relating to harvest sizes (Yen 2009, van Huis 2010). World-wide, the majority of edible insects are harvested from the wild and are neither domesticated nor semi-domesticated (FAO 2012).

1.1.1 Indigenous Knowledge and the Scientific Methodology

It is important that such research and the resulting applications and products, for example, the development of commercial rearing and the production of insect-based food items, are all conducted within the framework of sustainable development. It is also important to understand that the achievement of global sustainable development is hindered by the fact that this is a world-wide goal with no associated action plans for how to achieve this in all the myriad of specific social, ecological, economic, cultural and historical scenarios present the world over (Rist and Dahdouh-Guebas 2006). Thus the FAO (2012) cautions that promoting edible insect consumption should be accompanied by research into methods of achieving sustainable management of the resource.

In the well-developed field of medicinal plant research, both ad hoc bio-prospecting as well as information from indigenous knowledge holders have contributed to identifying useful plants and their associated active phytochemicals (Artuso 2002). In contrast, the specific expertise of indigenous knowledge holders has always been the initial spur to further research on edible insects and will be the foundation for the progress of entomophagy (Yen 2009). Communities who still retain this ancient knowledge have done, and continue to do so through the oral tradition of passing information from one generation to the next, through stories, songs and hands on demonstration and experimentation during the course of daily work (Sen 2005). The body of information lodged in the group consciousness of local indigenous and generally rural people is known, with some variations, as indigenous, traditional, aboriginal or local knowledge. A subset of such knowledge known as traditional ecological knowledge refers specifically to that indigenous knowledge about the environment (Usher 2000). In general, this type of knowledge is seen as separate from the body of information produced through the scientific methodology. In science, knowledge is generated through a relatively rigid process of setting hypotheses to be tested through stringent observation and experimentation (Snively and Corsiglia 2000). Results and generated bodies of theory are validated through the peer review process. Such knowledge is generally disseminated through formal written documents by means of journals, and eventually, books, schools and universities (Machlup and Leeson 1978). Often the knowledge is universally applicable. In contrast, indigenous, local or traditional knowledge is acquired through an informal learning process (Reyes-Garcia *et al*. 2010). It should not be assumed that since a certain body of indigenous knowledge was developed in a particular area that it would only be relevant to that scenario (Agrawal 1995). Thus, the organic farming revival taking place globally draws on knowledge generated scientifically, but is based on a large body of indigenous knowledge that has been transferred throughout the world. In this way, limitations imposed by using only one body of information can be overcome by a combined approach (Rist and Dahdouh-Guebas 2006). The two methods of discovery or ways of knowing (indigenous testing as opposed to the scientific methodology) have, until recently, been seen as discrete and therefore challenging to combine (Stevenson 1996). Of late, however, authors such as Agrawal (2008) as well as Becker and Ghimire (2003) have reasoned eloquently that the two methods share many commonalities and should be combined to meet common challenges. It may thus be useful to view various methods of knowledge generation as non-exclusive and part of a continuum. Finding solutions to environmental challenges should therefore draw on all types of knowledge.

In accordance with this model, Kaschula *et al.* (2005) promote the approach of incorporating indigenous knowledge as an aspect of natural resource management. In their view scientific methodologies alone are not adequate when ecosystem research is broadened into a holistic investigation of the ecosocial system (ecosystem + humanity's social aspects). The engagement of researchers with local communities has been known to assist researchers to link their efforts to the local environmental and cultural context (Sileshi *et al.* 2009). Thus Moller *et al.* (2004), in exploring the use of indigenous knowledge in wildlife harvesting amongst the Cree of James Bay, Canada and the Rakiuri of New Zealand, concluded that combining indigenous wildlife management practises with scientific inferences of prey population numbers resulted in a better understanding of population dynamics of certain marine resources.

In all sectors of the developing world, rural communities are dependent to a greater or lesser degree on locally harvested natural resources (Dufour 1987, Rankoana 2001, Twine *et al.* 2003) and a growing body of scientific literature supports the notion that indigenous knowledge is important and often vital to marginalised communities (Byers 1996, Posey and Dutfield 1996, Usher 2000). Indigenous knowledge is not necessarily 'old' knowledge, but the knowledge and the means of acquiring the knowledge are unique to each indigenous culture (Stevenson 1996). Many rural people do not have access to formal education or have left school at an early age. Indigenous knowledge thus plays a proportionately greater role in the lives of rural people than those of recent school leavers. Isolated rural communities do not always have facilities for adult learning and opportunities for learning school-taught subjects in an informal way from neighbours are usually low due to general low literacy. Opportunities to gain knowledge and skills are important and may occur when funded projects are undertaken in the area. Researchers, NGO's and government personnel can also represent opportunities for learning.

The view that science and technology are the main and sometimes only role players in the generation of knowledge and subsequent project development and achievement of sustainable development, has gradually changed. There is now an acceptance that although these are important, there are other equally valuable inputs to consider such as cultural diversity (Redclift 1993). For the purposes of this thesis the view of Rist and Dahdouh-Guebas' (2006) is adopted, where science is seen as being only one of a number of sets of knowledge and that all knowledge, science included, is embedded in cultural and historical settings. It is now recognised that an interaction between science and indigenous knowledge can produce beneficial results (Stevenson 1996, Huntington 2000, Toms 2007). Where there is a common problem to be solved, such as food security, areas of overlap between two or more ways of knowing are of particular significance in pointing the way to a solution. Thus, where mopane worms (*Imbrasia belina*) are harvested by marginalised communities in South Africa, communal land provides an important source of protein (Toms and Thagwana 2005). The indigenous knowledge concerning mopane worms gives people the know-how of where and how to collect the caterpillars. However, in the face of a burgeoning and poverty stricken human population in mopane areas, the caterpillars and their host plants are being over-harvested. A scientific investigation into the reasons for caterpillar decline and methods to manage the mopane worm population sustainably can be combined with traditional knowledge of harvesting methods and result in better resource management (Toms 2007).

There have been a number of attempts to merge information from diverse systems of knowledge in order to achieve sustainable management of resources within marginalised communities (e.g. de Walt, 1994, Kaschula *et al.* 2005, Payton *et al.* 2003, Rist and Dahdouh-Guebas 2006). In particular, the Botswana government actively promotes the use of traditional ecological knowledge (that indigenous knowledge pertaining specifically to information relating to ecosystems) in the management of wildlife resources (Phuthego and Chanda 2004). For example, in the Kgalagadi North (Botswana), points of convergence between traditional knowledge around wildlife natural history and distribution patterns, and conventional wildlife management are noted and used together to build a comprehensive plan of wildlife resource use. Furthermore, there is a system of co-management between scientific experts and the local community. This participation strengthens the implementation of management measures because the local community are active stakeholders and also decision makers. Combining the strengths of each knowledge system in a particular situation for a specific resource is important when dealing with a resource that enhances the livelihoods of a community. Management decisions around a local resource that are made and imposed solely by outsiders to that community, no matter how well supported by scientifically validated facts, will inevitably be resented, particularly if they concern harvest limitations.

Becker and Ghimire (2003) provide the background to the success of a joint project which used both indigenous knowledge around forest management, and new knowledge about water catchment from the formal discipline of conservation science, to ensure the protection of indigenous forest in Ecuador. The Loma Alta farming community held rights to the forest surrounding the community and managed it according to common law. Conservation scientists working in the area provided evidence that clearing of forest trees would reduce water supply to the community. Links were made to the traditional ecological knowledge held by the elders of the area. This resulted in the community implementing measures to curtail the destruction of forest trees through traditional management policies.

Paoletti and Pimental (2003) stress that if local knowledge around useful species is lost, then the exchange of knowledge between isolated areas and the international arena will decrease. Protection of a resource will also not be promoted and thus local knowledge concerning biodiversity should be augmented and dissemintated outside of the villages where it originated. This is particularly true of the edible insect resource. To date, research around edible insects has either: 1) documented the indigenous knowledge of the edible insects of an area by listing insect species and how they are used (Banjo *et al.* 2003, Ramos-Elorduy *et al.* 1997), or 2) has used the scientific method to generate new knowledge around nutrition (Banjo *et al.* 2006), life history (Dzerefos *et al.* 2009) and impact of harvesting (Ditlhogo 1996). To the best of the author's knowledge, there has been no attempt to combine indigenous knowledge around edible insects of a particular location with new knowledge to generate a more complete picture of entomophagy in that area.

In 2010, Johnson called for research into the following aspects of edible insect consumption in the Asia Pacific region:

1. Filling geographical information gaps on edible insect species distributions.
2. More accurate species identification and documentation of information about each insect, particularly in light of the fact that in many cases immature stages are consumed making accurate identification difficult.
3. Ecology of edible insects, in particular the effect of pesticides on these populations and the extent to which pest species may also be edible.
4. The dual role edible insects play as a food resource for humans, and in the environment, to ensure that by targeting insects for food their role in the ecology is not compromised (e.g. pollination).
5. Improved processing, packaging and storage of edible insects to minimise harmful effects of inappropriately processed food such as botulism and food poisoning.
6. Economic marketing, an aspect that has been poorly investigated.

By February 2012, these aspects had been expanded by the FAO (2012) to include world-wide goals focussing on research into:

1. managing and conserving ecosystems where edible insects occur,
2. developing sustainable edible insect harvesting practices,
3. assessing the impacts of climate change on such insects,
4. making an inventory of traditional knowledge around edible insects,
5. documenting ethno-taxonomic practices with data that includes not only insects but all edible arthropod species, and
6. conserving the edible insect gene pool.

Due to the fact that the insect resource in South Africa is so closely linked to traditional, rural communities, the achievement of the above research goals will depend on the co-operation and participation of people who own this knowledge. This thesis therefore explores the contributions that indigenous knowledge around edible insects and new knowledge generated through the scientific methodology, can together make towards achieving the above goals. Figure 1.1 illustrates the various components interacting within a rural community using two ways of knowing to improve the surrounding eco-system and ultimately the well-being of the community members.

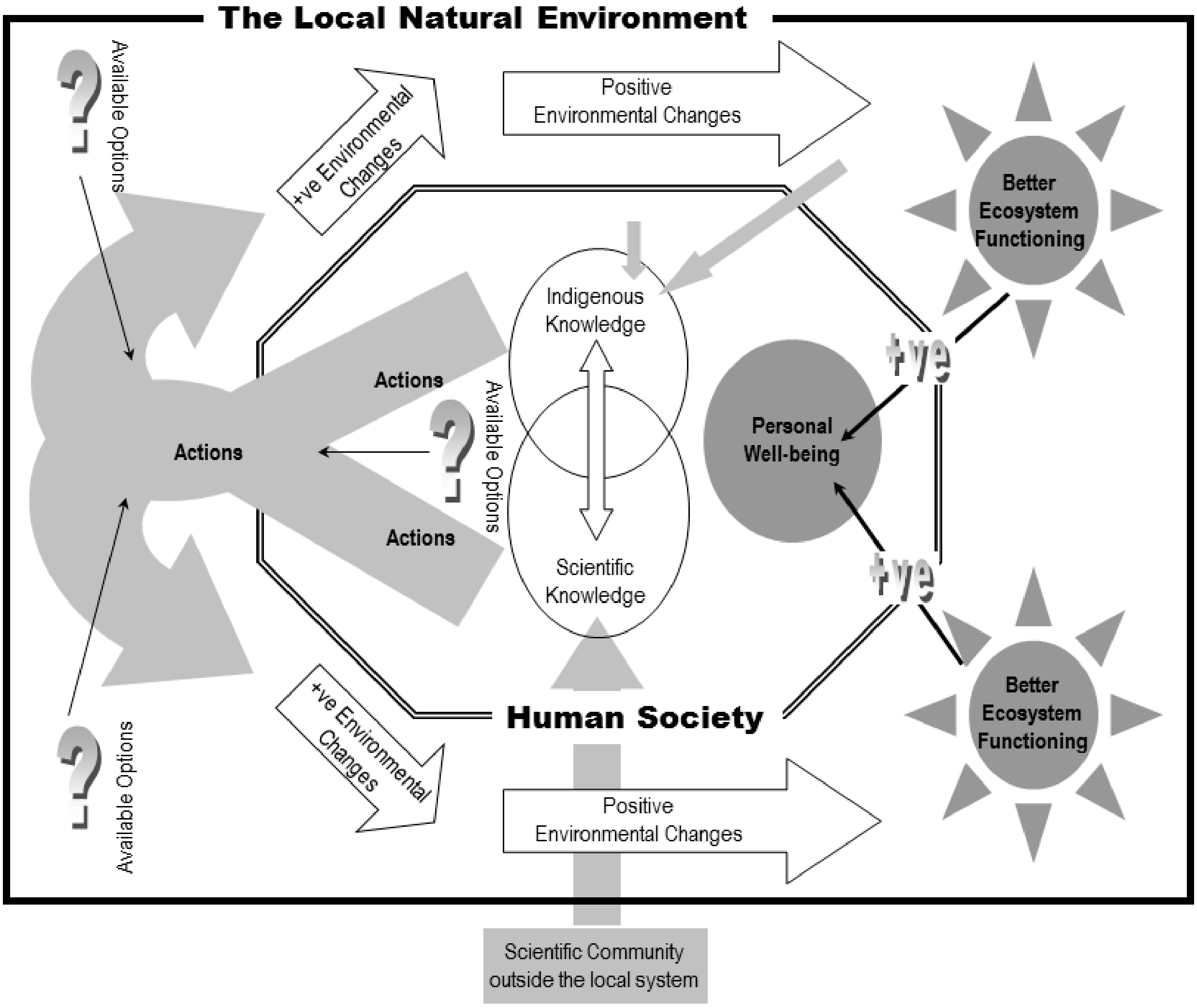

Figure 1.1 Conceptual model of the interactions between society and the environment and how knowledge informs actions.

Indigenous knowledge (gained primarily from within the social and local environmental system) and scientific knowledge (gained primarily from formal instruction and players outside the local system) combine to inform actions. Actions will be influenced by the options available both within the social community and the environmental system. In a “perfect” system, actions should lead to positive environmental changes, which in turn contribute to better ecosystem functioning, which should ultimately influence personal well-being. This thesis homes in on the central area of knowledge generation through indigenous knowledge practitioners and the scientific methodology.

Focussing on the specific challenges listed above with respect to required edible insect research as seen by Johnson (2010) and the FAO (2012), Figure 1.2 demonstrates the importance of the indigenous knowledge / scientific methodology interface in developing an understanding of this resource.

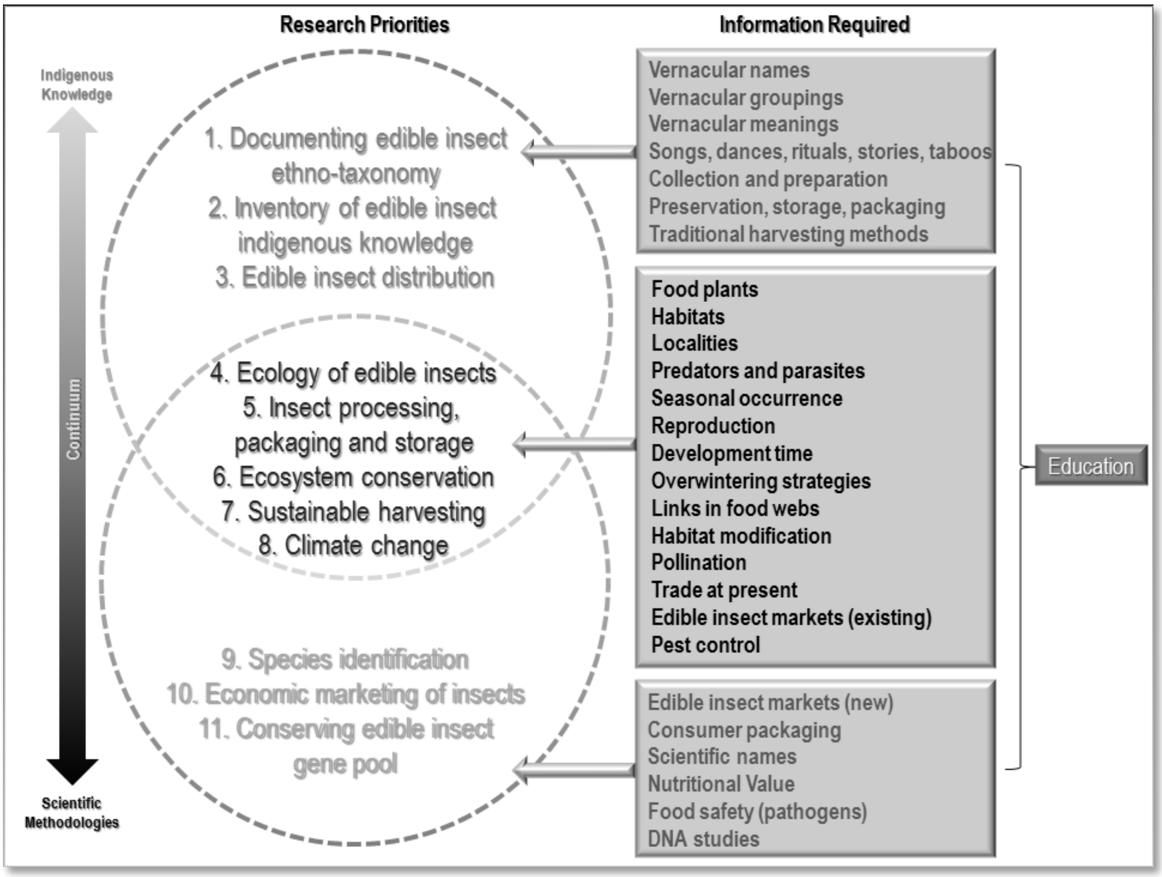

Figure 1.2 Conceptual model of the sources of knowledge and their interaction as well as the type of information, tools and skills required to reach an understanding of the edible insect resource in a particular community.

Resource priorities 1−3 can be fulfilled using information gained mainly from indigenous knowledge around insect use in a certain area. Priorities 9−11 can be adequately accomplished by means of investigations using a predominantly scientific methodology. Those priorities at the intersection of the two knowledge sources (4−8) will benefit most by a combined approach with information, tools and skills accessed from both indigenous and scientific ways of knowing. Chapter Seven discusses the findings of this thesis with respect to Figure 2 in an endeavour to demonstrate the value of the connection between indigenous knowledge and knowledge gained by means of scientific methodology.

1.1.2 Edible Insects

Edible insects have been noted in scientific publications since at least 1885 when V. M. Holt endeavoured to counteract Western prejudice against insect consumption in his now classic book *Why not eat insects?* (Morris 2008). Entomophagy was, however, largely ignored by the scientific world, apart from isolated studies, until a series of papers by DeFoliart between 1975 and 1999. This research sought both to popularise the idea of eating insects as well as to scientifically investigate the place of insects in human nutrition, their economic role as well as their ecological function. Some exceptions occur and as early as 1951, Bodenheimer details reasons on why entomophagy is beneficial to the environment and human populations. Two decades later, Meyer-Rochow (1973) investigated insects used in Papua and New Guinea and notes that such a resource should be promoted by the government. He also suggests the use of pest species as food. By 1979 Posey had formally described the study of entomophagy and edible insects as ethnoentomology. It is DeFoliart's work however, that provided the impetus for further research into this topic. In one of his earliest papers DeFoliart suggests that due to the phobia that most industrialised countries have towards eating insects, this protein source should initially be promoted as a high quality livestock food (DeFoliart 1975). Later publications move towards advocating the direct consumption of insects by mankind and exploring the nutritional benefits as well as food safety concerns inherent in this protein source (DeFoliart 1989 and 1992). More recent articles (DeFoliart 1997 and 1999) shift the focus to the environmental benefits to be accrued if a greater percentage of the world population consumed insects as a protein source. These include enhancing forest conservation, reducing poaching in protected areas by allowing managed harvesting of insect resources, reducing pesticide use by harvesting pest insects and reducing organic waste through recycling it into insect protein.

From the early 1980's onwards, scientists working in South America produced a large body of work on edible insects. This initially began as a record of edible insects from the area but rapidly expanded to include analyses of the nutritional value of many species (De Conconi *et al.* 1984, Ramos-Elorduy 1997). Thus De Conconi *et al.* (1984), upon analysing the protein content of 101 insect species, concluded that their amino acid profiles compared favourably with those recommended by the FAO (1981). To date, research includes investigations into the ecological aspects of insect consumption (Ramos-Elorduy 2006), as well as ways and means of domesticating and semi-domesticating edible insects as agricultural products (Ramos-Elorduy 1997). Ecological studies are particularly pertinent when investigating the impact of harvesting on insect communities and the possible disruption of other important roles of insects in the environment (for example as pollinators). As Ramos-Elorduy (2006) points out in a study on threatened edible insect species of Hidalgo, Mexico, the overharvesting of 14 of these insects has led to degradation of the ecosystem in which they are found. This research lists a number of contingency measures to prevent this degradation, including, the formation of reserve zones which exclude collection, augmenting insect numbers in impacted areas through semi-cultivation, growing host plants and education through formal courses. As a result of the long history of edible insect research, Mexico has a useful and growing database of edible insect species (Acuna *et al*. 2011).

Edible insect research is now well-established on all continents and particularly in countries such as India (Chakravorty *et al.* 2011), Japan (Mitsuhashi 1997, Nonaka 2010), Thailand (Yhoung-Aree and Vitwatpanich 2005), Australia (Yen 2012), Nigeria (Banjo *et al.* 2006), South Africa (Teffo *et al.* 2007, Toms 2007, Dzerefos *et al*. 2009) and the Netherlands (Verkerk *et al.* 2007, Vogel 2010). In countries where edible insects are traditionally consumed, such as Africa and Australia, research is focussed on documenting the indigenous knowledge around the insects, identifying the species used and developing databases to store the information (FAO 2012). In more industrialised, and often Western countries, the focus is on developing insect products, and increasing the palatability of insect protein to encourage consumption (Van Huis 2010, Gracer 2010)

Most edible insects used the world over, come from a fairly small number of orders. Crickets, termites, grasshoppers and locusts, ants, water bugs, lepidopteran larvae, beetles, wasps and bees are the most commonly eaten throughout a number of countries (Gullan and Cranston 2000). Nutritionally, insects compare well with other forms of protein such as beef, fish and poultry (Quinn 1959, Dufour 1987, Gullan and Cranston 2000). In many countries, edible insects are a valuable source of income (DeFoliart 1999). In Asia in particular, there is a lucrative trade in insects that are preserved, bottled and sold to the general public in supermarkets and restaurants (Nonaka 2010). In Japan, the larvae of wasps and aquatic insects, rice field grasshoppers, pupae of the silk moth, caddis flies and cicadas, appear on menus of restaurants (Pemberton & Yamasaki 1995). The rural Thai people collect about 90 different species of edible insects, and a number of Hymenoptera are sold in local markets. In addition, there is a developing export market with Japan for fresh insects (Chen *et al.* 1998). Restaurants in Japan can serve five or more different edible insects cooked in various ways (Pemberton 1994) and canned insects such as wasp brood and giant water bug eggs (Heteroptera) are commonly sold in supermarkets (Chen *et al.* 1998). In southern Africa, the best-known commercially available insect is the mopane worm (*Imbrasia belina*), the larva of an Emperor moth. During the summer, when the caterpillars feed on mopane tree leaves, locals participate in a lucrative market built around the harvesting, preservation and selling of the worms (van der Waal 1999, Makhado *et al*. 2009). They are sold in local markets and are also available in certain urban shops in season. To a lesser degree, stinkbugs (*Encosternum delegorguei*) and termites (Isoptera; *Hodotermes mossambicus*) are also an important source of income, although they are seldom available in formal shops, trade being limited to markets and hawking (van der Waal 1999).

In a number of countries where insects are used commercially, there is concern that edible species are affected by over exploitation, or that insects are declining due to changes in land use patterns, such as deforestation of indigenous forest, afforestation in the form of exotic tree plantations, urban expansion or inappropriate farming practices (DeFoliart 1999). Interestingly, there has been a recent revival of the commercial use of rice field grasshoppers (*Oxya* spp.) in Korea (Pemberton 1994). For a number of decades this once popular insect dish declined due to a programme from the 1960's onwards, designed to increase insecticide use. From the late 1980's the decrease in insecticide use and the concurrent increase in demand and production of organic crops resulted in an increase in the rice field grasshoppers. The grasshoppers are collected by rural farm workers during the course of harvesting rice and sold in markets or to co-operatives, which then sell them on to supermarkets, or to individuals by mail order. The grasshoppers are therefore available to urban dwellers who would not otherwise have access to this food source, but who are nonetheless willing to pay for the privilege of eating them.

In a review of edible insects, DeFoliart (1999) noted that in Mexico there is a thriving economy surrounding "escamoles", which are the immature stages of certain ants (*Liometupum apiculatum* and *Liometupum occidentale*). The pupae are reportedly delicious and are sold in rural markets as well as upmarket restaurants in urban areas. The nests are privately owned and well cared for, being covered with grass to maintain a constant environment. The rural people who tend the nests and harvest the pupae can earn more in a season than most of their rural counterparts do in a year. Furthermore, the ants are exported to Japan, Canada and the United States. Husbandry and conservation are an age-old tradition with regard to edible insects in Mexico (DeFoliart 1999), a practise that might be worth adapting to African conditions.

1.1.3 The South African Context

In South Africa, the BaSotho and the San of the Kalahari have a history of utilising insects, mainly for food, but also for medicine (Quin 1959, Monnig 1967, Shaw 1974). In the 1950's, Quin (1959), working in Sekhukhuneland, produced a list of 12 species of insects eaten by the Pedi tribe in the area. This excluded insects used in medicine, art or religion. Recent anecdotal reports by entomologists and anthropologists working in rural baSotho communities, suggest that insects still form an important component of Sotho culture, which extends, to some degree, into urban areas. Relatively little formal research has been conducted into the importance of insects in the culture of South Africans in general. In light of recent interest in into the effect of climate change on agriculture and in the search for alternate land use practices that are sustainable in the face of prolonged drought and elevated temperatures, it is pertinent to document ways in which natural resources have been used in the past and how these techniques can be modified for future use. In addition, rural communities give valuable insight into the customs of past generations that, if not documented, are bound to be lost as younger generations move away from traditional ways of life to become more Eurocentric in their habits.

Much of the research concerning edible insects in South Africa, with the exception of work on the mopane worm, has focused on producing lists of edible species, usually with some information on their nutritional content. There are fewer studies that provide detail on the importance of insects in the diets of entomophages, or on how predictable they are as a food resource that can be gathered from the natural environment (Dufour 1987). In much of the developing world, including South Africa, natural resources are an important supplement used directly for food, housing and utensils and are offered for sale to generate income (Gardiner and Gardiner 2003, Twine *et al*. 2003). In the Limpopo Province, insects are widely used as a supplementary protein source (Quin 1959, Twine *et al*. 2003). One study estimated the annual direct-use value of edible insects to be R565.00 per household in three rural villages in Limpopo Province (Twine *et al*. 2003). Wild herbs, wild fruit and fuel wood were the only other natural resources out of 12 analysed, which had a higher annual value than insects (Twine *et al*. 2003).

The Blouberg municipality in the Limpopo Province, South Africa is home to up to 200 000 people, many of whom practise subsistence farming and rely on government grants for their income (Blouberg Local Municipality 2011). The area is characterised by low literacy and high unemployment, with more than 130 000 people receiving no income at all (Fourie 2006). There is, however, a rich cultural heritage and a well-developed sense of community, together with strong traditional leadership and a valuable indigenous knowledge base (Blouberg Local Municipality 2011). This knowledge is valuable to the people, many of whom gather wild natural resources from the surrounding vegetation (Boonzaaier and Philip 2007). Conversations with local teachers during the roll-out of an environmental education programme (WESSA Eco-Schools Programme) and with two former residents of the area revealed that edible insects are one of the natural resources gathered in the area (J. Legwai, a research assistant at the Ditsong Museum of Natural History and P. Morata, a local traditional healer, pers. comm., Blouberg, 2006). Blouberg municipality provides a well-defined study area where indigenous knowledge around edible insects exists but has not previously been documented (Figure 1.3). Recently there has also been a call in the 2011 Vhembe Biosphere Reserve Report, to acknowledge, document, use and disseminate information about the indigenous knowledge of the Blouberg and Soutpansberg before it is lost (Alberts *et al.* 2011). The area is thus suitable for an investigation into overlaps, synergies and possible conflicts between indigenous knowledge around edible insects and knowledge gained by means of the scientific methodology.

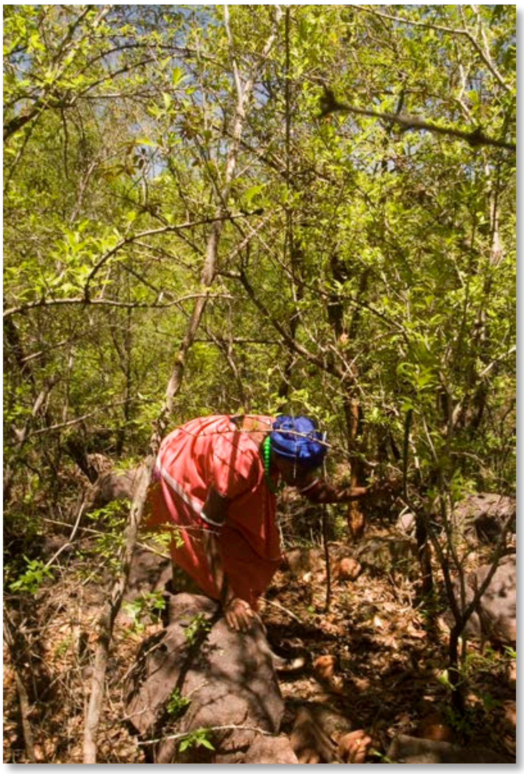

Figure 1.3 Blouberg resident collecting edible *Hemijana variegata* caterpillars

1.2 MOTIVATION FOR THE STUDY

The body of information possessed by the people of Blouberg about the edible insects of the area, is generally a combination of folklore or traditions passed down over generations, together with the knowledge gained from working directly with the insects as a resource. The community generally has poor access to the extensive, specialist pool of knowledge compiled by modern researchers about their particular environment. Combining indigenous knowledge with modern research will lead to a better understanding of the role of such edible insects, both within the environment as a whole and also specifically as a valuable food resource for mankind. This will empower both the 'outside' researcher who does not reside in the community, as well as the local members of the community. This empowerment of the community should be most effective if the local people themselves are involved in the research, including decisions on questions to be investigated, research design, fieldwork and compilation of the resulting reports and any implementation plans developed from the reports.

Research into Blouberg's edible insect resource will be valuable in that it will:

1. Contribute to local, national and global knowledge on edible insects as food.
2. Promote the value of this local food resource to the Blouberg people, who are losing their cultural roots through modernisation.
3. Document aspects of indigenous knowledge that may otherwise be lost.
4. Provide information that can be used to ensure the sustainable management of the edible insect resource.

1.3 GENERAL AIMS AND OBJECTIVES

1.3.1 Aims

The general aim was to investigate and document indigenous knowledge of the edible insects that occur within the Blouberg region and to integrate this with new knowledge attained through scientific investigation in order to develop an understanding of the resource and how it can be enhanced and managed sustainably.

1.3.2 Objectives

Specific objectives of the study were to:

2. Investigate the extent and importance of entomophagy in the Blouberg area, with respect to socio-economic factors and ecological aspects.
3. Choose one insect for further investigation using scientific methodologies.
4. Investigate aspects of the biology of this species including thermal tolerances for each life history stage.
5. Investigate aspects of the nutritional value and food quality of this species.
6. Gain an understanding of the significance of the species as a resource to the people of Blouberg in terms of its contribution to household income and the possible effects of over-harvesting.
7. Explore the value of introducing information on edible insects into Blouberg schools.
8. Link the two sets of information (indigenous knowledge vs. scientific enquiry) on Blouberg edible insects in order to determine how to manage the resource.

1.4 STUDY AREA

The study area is situated in the Blouberg Municipality, Limpopo Province. It is located at S23º 05' and E29º00' and is roughly 120 km north-west of the provincial capital of Polokwane. The municipality covers 5,054.84 km^2 and services 194 119 people (Capricorn District Municipality 2009). The administrative centre of the municipality is Senwabarwana. The area is dominated by the Blouberg Mountain, an inselberg consisting of four peaks: *Monnaasenamoriri* (man without hair, for a bare hill), *Lenare* (buffalo, for a peak resembling this shape), *Sehlong* (for one looking like a porcupine) and *Sesalong* (the lonely one that was left behind) (Kriel 2005). The mountain rises to 2 051 m above the surrounding plain and stretches over a distance of approximately 40 km from northeast to northwest (Scholes 1978). It is the westernmost extension of the Soutpansberg and is separated from this range by a gap of approximately 30 km (Boonzaaier and Philip 2007). Thus, although there are elements of Soutpansberg's vegetation and climate, the area is sufficiently separated from the Soutpansberg to be treated as a separate entity (Mostert *et al.* 2008)

1.4.1 Locality

The study area encompassed the following villages situated on the Blouberg Mountain itself and up to 50 km from it on the plains below: Mohlakeng, located on the mountain, Rakwele, Ramaswikana (Simson), Sebalamakgolo (Grootpan), Moismanne (Arrie), Burgerrecht, Stocking (the Grange), GaKgatla (Varedig) and My Darling (Gorkum) on the northern, northeastern and northwestern plains below the mountain (Figure 1.5). These villages were chosen as they represented a gradient from the most remote, traditional and least transformed vegetation (Mohlakeng) to villages successively further from the mountain and more accessible. The Glade, GaManaka, and Leipsig to the south of the mountain were chosen once the focus species (*Hemijana variegata*) had been identified, as these villages encompassed the outbreak area in which this caterpillar is harvested (Figure 1.4).

Figure 1.4 Blouberg insect harvesters with Blouberg Mountain in the background

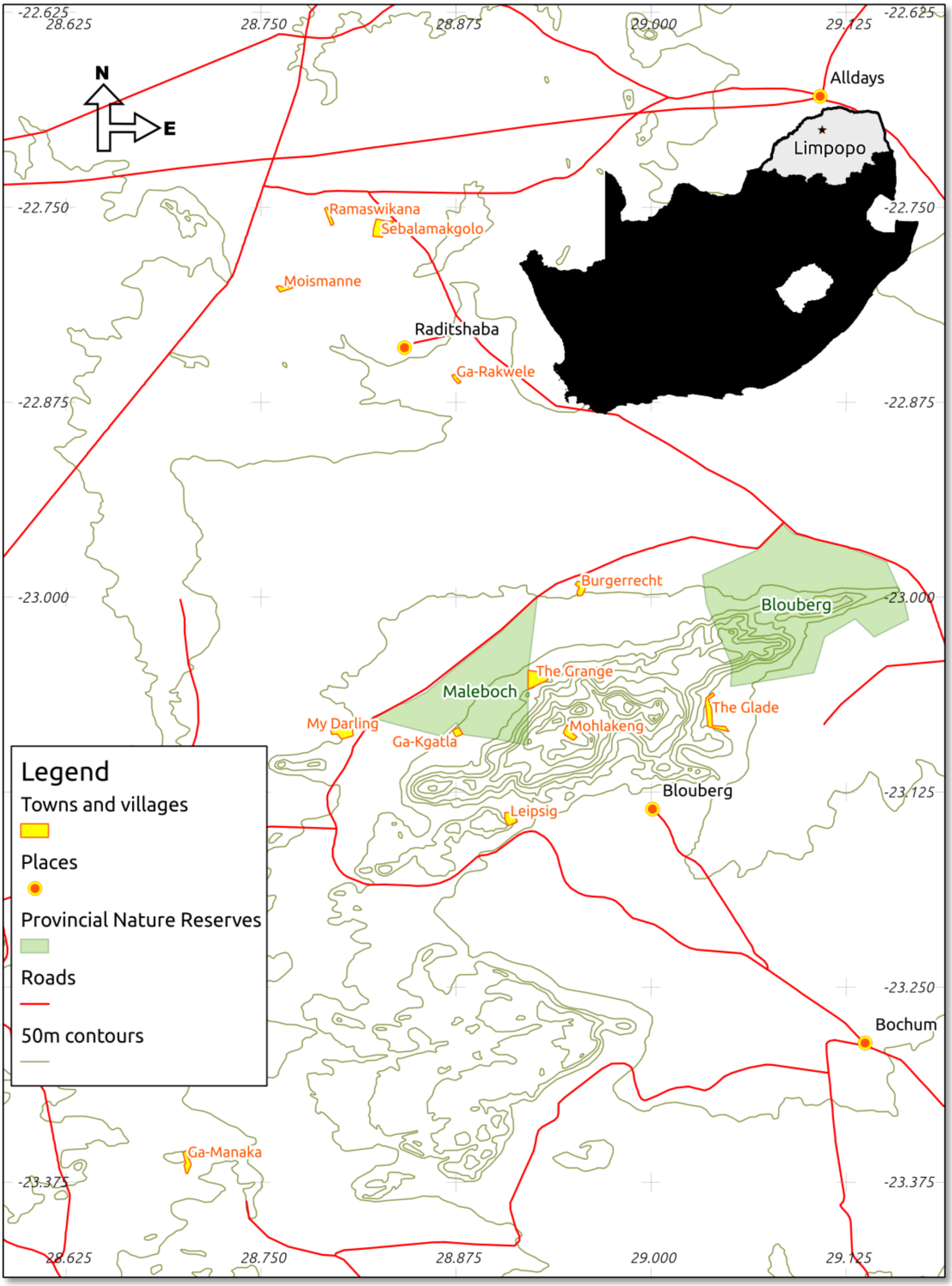

Figure 1.5 Position of the study villages around the Blouberg Mountain (Map assistance courtesy V. Egan)

1.4.2 Geology and Soils

The underlying geology of the Blouberg Municipality comprises elements of the Waterberg group and the Soutpansberg group, which rest unconformably upon a basement consisting mainly of gneiss (Jansen 1977). An additional sequence known as the Blouberg formation, is interposed between the basement and the Soutpansberg and Waterberg groups. The Blouberg is the only place where the Waterberg group, Soutpansberg group and Blouberg formation adjoin (Bumby *et al.* 2001). The Blouberg formation was deposited between c. 2000 and 1900 Ma (Barker *et al.* 2006). According to Mostert *et al.* (2008), the soils can be divided into four groups. Those derived from quartzite and sandstone are acid, shallow and gravelly with few nutrients. Basalt and diabase dykes produce deep, well-weathered clay soils. They are prone to erosion on the southern slopes. Soils originating from the Aeolian Kalahari sands are deep and fine-grained and occur on the plains to the north of the Blouberg Mountain. Small areas of peat soils occur within the wetland areas on the summit of the mountain. They act as sponges slowly releasing water into mountain streams and aquifers. There are also large areas on the hot, sunny northern slopes which contain no soil and where the bedrock is exposed.

1.4.3 Climate

Blouberg Municipality falls within the semi-arid summer rainfall area (Mostert *et al.* 2008). There is, however, a great variation in both temperature and rainfall between the low-lying plains and the Blouberg Mountain. Temperatures are high on the plains with the mean minimum temperature of 5°C rising to a mean maximum temperature of 26°C, with the mountain approximately 6°C cooler with occasional frost (Scholes 1978).

Rainfall decreases gradually from east to west, and due to the fact that winds are easterly to north easterly the effect is heightened by the rain shadow of the mountain (Scholes 1978). The northern slopes are exposed to a greater radiation load compared to the south slopes and therefore the north and north-west slopes are much drier than the south and east slopes. This affects local plant distribution and therefore that of the fauna of the area (Mostert *et al.* 2008). The average annual rainfall in the plains is between 450 mm and 500 mm, with this figure rising to between 800 and 1 000 mm at the summit of the Blouberg Mountain (Scholes 1978). Due to the mountainous nature of the area, which results in extreme topography and significant changes in altitude over short distances, there is considerable variation in rainfall and mist in the vicinity of the Blouberg Mountain (Mostert *et al*. 2008). The areas just below the escarpment trap most of the atmospheric water vapour and therefore yield the highest precipitation (Mathews 1991). The plains below the mountain are arid; particularly the northern areas, and the population below the mountain are heavily reliant on aquifers that feed boreholes for potable water. Thus the mountain forests and wetlands are crucial to the water supply of large parts of the Blouberg Municipality.

1.4.4 Vegetation

The Blouberg Mountain and surrounding villages fall into the Soutpansberg Centre of Endemism (Mucina and Rutherford 2006, Capricorn District Municipality 2009). The area is a component of the savannah biome and has been further divided by Mucina and Rutherford (2006) into nine vegetation types (units) within the municipality. Seven of these are represented within the study area. **Northern Escarpment Afromontane Fynbos** occurs in small patches on the summit of the Blouberg Mountain. In general it has a very restricted distribution occurring only on the highest peaks of the Limpopo and Mpumalanga Provinces. Sclerophyllous shrubs dominate with herbs of ericoid growth. The unit is adequately represented in nature reserves and due to the rugged nature of the landscape in which it is found, little transformation has occurred. In Blouberg Municipality, **Northern Mistbelt Forest** is restricted to the high lying areas of the Blouberg Mountain. In general it is found between 1 050 to 1 650 m along the escarpment in Limpopo and Mpumalanga Provinces (South Africa) and in Swaziland. Common canopy trees of this element found in Blouberg include *Podocarpus latifolius, Olea capensis,* and *Syzigium gerrardii.* Understory elements are dominated by *Gymnosporia harveyana* and *Mackaya bella,* with *Dalbergia*, *Jasminum* and *Plectranthus* common in the herb layer. Although not included in the protected areas of the Blouberg Municipality, the unit is well represented elsewhere in the country and is listed as Least Threatened. It is species rich but threatened by subsistence agriculture, medicinal plant collection and fuel wood collection. Recently promulgated legislation has identified this vegetation type as a protected ecosystem which is safeguarded according to the Government Gazette no. 34809 of 2011 of the National Environmental Management Act 10 of 2004. **Soutpansberg Summit Sourveld** is confined to higher crests in the Limpopo Province, with Blouberg being the highest area where this vegetation type occurs (2 051 m). Vegetation features include closed grasslands and scattered closed-canopy bush clumps with rocky outcrops being the dominant influence on the occurrence of various species. The unit is part of the Soutpansberg Centre of Endemism and is listed as Least Threatened. Overgrazing and exotic plantations are the dominant threats to the unit. Most of the villages in the study fall into the **Soutpansberg Mountain Bushveld** which is located on the low lying hills around the Blouberg Mountain. This unit is limited to the Limpopo Province and found on high to low mountains from West to East between 600 and 1 500 m. Subtropical moist thickets dominate on the southern slopes with open savannah sandveld on the dry middle and northern slopes and arid mountain bushveld along the very arid northern ridges. The vegetation is vulnerable with only 2% conserved within nature reserves. High rural human population densities have led to cultivation, overgrazing and plantation use which threaten this unit. The **Roodeberg Bushveld** vegetation unit occurs only in Limpopo on plains between 850 and 1 100 m. In the Blouberg Municipality the vegetation unit occurs on the plains around the Blouberg Mountain and there are a number of sampled villages falling into this vegetation unit. The vegetation varies between short closed woodland to tall open woodland with a poorly developed grass layer. It is listed as Least Threatened and in Blouberg Municipality it is conserved in the Maleboho and Blouberg Nature Reserves. **Limpopo Sweet Bushveld** is distributed mainly in the Limpopo Province and into Botswana between 700 and 1 000 m. It covers the north and northwestern side of the Blouberg Municipality extending from the plains below the Blouberg Mountain. It is dominated by short open woodland and areas where *Acacia erubescens*, *A. mellifera* and *Dichrostachys cinerea* are dense and impassable. Less than 1% is conserved and it is threatened by cultivation. The vegetation unit is listed as Least Threatened. **Makhado Sweet Bushveld** is limited to the Limpopo Province and in the Blouberg Municipality is located on the plains south of the Blouberg extending to the north of the Polokwane Plateau and east to the town of Vivo. The vegetation is made up of short shrubby bushveld with a poorly established grass layer and is dominated by

Acacia species, *Terminalia sericea* and *Dichrostachys cinerea*. This unit is listed as vulnerable with only 1 % of the targeted 19 % conserved, none in the Blouberg area. Cultivation and urban development due to the proximity of dense rural populations are the main threats.

1.4.5 Fauna

There have been few formal studies on the fauna of the Blouberg Municipality (Capricorn District Municipality 2009). Results have been extrapolated from the Vhembe Biosphere Reserve reports (Hahn 2003) due to the fact that the Soutpansberg is geologically and biologically linked to the Blouberg (Mostert *et al.* 2008) and that it is classified as a biodiversity hotspot within the Vhembe Biosphere (Alberts *et al.* 2011). Reptile diversity is particularly high in the Vhembe Bioshere Reserve with 116 species recorded (Branch 1988), four species of which are endemic to Blouberg (Alberts *et al.* 2011). With respect to mammals, up to 60% of the species represented in South Africa occur in the reserve. The diversity of bats, carnivores and larger hoofed animals is particularly high. In terms of birds, 56% of South African bird species occur in the area (Hockey *et al.* 2005). The Cape vulture colony (*Gyps coprotheres)* on the south facing cliffs of the Blouberg Mountain is particularly significant as a breeding refuge for these endangered birds. In addition the endangered Saddle-billed stork (*Ephippiorhynchus senegalensis*) has been recorded in the Blouberg area although this is not its main area of occurrence (Alberts *et al*. 2011). In terms of biomass, the greatest contribution is from the invertebrate fauna. Despite this it is poorly studied, with little information available on distributions and species lists (Capricorn District Municipality 2009). Most of the available research reports focus on the spider populations at Lejuma in the Soutpansberg where 46 families were recorded (Foord 2002). National records collated for use in the 2011 Vhembe Biodiversity Reserve 2011 Report (Alberts *et al.* 2011) indicate that Blouberg itself has a high spider diversity with the Soutpansberg and Blouberg sharing most of the endemics in the Vhembe Biosphere Reserve. There are a number of endemic insect species in the area but to date there has been no overall investigation into this group (Capricorn District Municipality 2009).

1.4.6 Environmental Threats and Conservation

Mountains are hotspots of biodiversity as they provide a series of climatically diverse elevations over a short distance (Kőrner 2004). In addition they act as refugia in times of environmental change (Hahn 2003). The combination of the rural nature of the area and the presence of the Blouberg Mountain results in the impressive species diversity present in the Blouberg Municipality (Mostert *et al.* 2008). This is one of the reasons why it is included in the Vhembe Biosphere Reserve (Capricorn District Municipality 2009). Established nature reserves such as Blouberg Nature Reserve, Maleboho Nature Reserve and Wonderkop Nature Reserve afford further protection to the area. The forests of the Blouberg Mountain itself have recently been conserved under the aforementioned Act 10 of 2004. In addition, most of the privately owned land in the municipality is under game farm management and is therefore also afforded environmental protection (Capricorn District Municipality 2009).

Notwithstanding these conservation areas, there are a number of threats to the natural environment of the Blouberg Municipality. The Blouberg IDP (Blouberg Local Municipality 2011) states that deforestation, over-grazing and erosion are the dominant environmental impacts in the area. On the mountain, marijuana plantations and medicinal and food plant collection also have a negative effect on the vegetation. Based on the mining applications in process there is a medium risk of mining occurring to the north and south of the Blouberg Mountain (Alberts *et al.* 2011). The natural vegetation is an important resource in this rural, low income area, the degradation of which destroys important ecosystem functions.

1.4.7 Demographics

The people of Blouberg are predominantly Basotho (Monnig 1967). They are from the Hananwa tribe who split from the Hurutshe of Botswana in the 1800's. They moved into the Blouberg area from 1820, and displaced the resident Madebana tribe, taking the Blouberg Mountain as their stronghold (Boonzaaier and Philip 2007). The Hananwa have a proud history of action against colonisation in the Blouberg area. Despite the surrender of their traditional leader *Kgoši* Kgalushi Ratshaatshaa to General Piet Joubert of the *Zuid Afrikaansche Republiek* (ZAR) in 1894 and the later marginalisation of the area as a homeland during the apartheid era, the Hananwa have retained their traditional roots and their mountain birthplace (Capricorn District Municipality 2009). As such the people still have access to a reservoir of indigenous knowledge built up over centuries and modified with the advent of the 21st century.

At present, the two tribal authorities active in the study area arose through the splitting of the Hananwa into two groups which are now under the leadership of *Kgoši* Maleboho in the south and *Kgoši* Kibi in the north. People living on the slopes of the Blouberg Mountain itself are members of the Batlokwa tribe, a subdivision of the Hananwa. In addition Venda, Shangaan, Indians and Whites are minority ethnic groups also residing in the municipality (Fourie 2006). Thus, although people in this study were not asked to divulge their ethnic or racial origins, most of the information attained is, by default, accessed from the Basotho culture.

The vast majority of inhabitants live in the foothills of the Blouberg Mountain and on the plains beyond, however a small proportion of people maintain a traditional lifestyle on the upper plateau of the mountain (Boonzaaier and Philip 2007). There are no work prospects on the mountain itself and people grow sorghum and maize, maintain goats and cattle and collect wild food and medicine from the surrounding vegetation (Fourie 2006). Some qualify for old age pensions, child or disability grants. In this study these mountain homesteads were compared to the less isolated and more modern villages below the mountain.

Blouberg Municipality is classified as the most marginalised of the municipalities in the Capricorn District Municipality (Capricorn District Municipality 2009). Poverty, lack of education and deterioration of family structures as a result of migrant labour have led to social problems including alcohol abuse, the spread of HIV/Aids and high teenage pregnancy rates in certain areas.

1.5 CONSTRAINTS TO THE STUDY

The subject matter, as well as the area in which the study was conducted held a number of constraints which are here recognised. Insects are ephemeral and very sensitive to climatic conditions therefore poor rainfall in one season can lead to the failure of a harvest and have a negative impact on data collection. The severity of the impact varies with the species concerned. Unfortunately many of the caterpillars consumed in the Blouberg are sensitive to such changes and thus one or two species for which vernacular names are available could not be positively identified as they did not appear in sufficient numbers during the study period. The *Hemijana variegata* population, for which more intensive research was undertaken, was also negatively affected by lack of rain or unpredictable timing of the rain during the study and certain aspects of the life history could not be explored due to lack of specimens.

All information gathered through questionnaires and the school questionnaire competition, as well as many of the insect specimens collected and harvesting data obtained, was entirely reliant on the goodwill and voluntary work of the residents of the Blouberg area. Most people were happy to volunteer their knowledge, time and interest to the project with no possibility of material reward, however, there were exceptions with uncooperative people. In these cases it is acknowledged that there are gaps in the study.

Furthermore, the home language of the researcher is not Sepedi but English. Fortunately most Blouberg residents understand and speak at least some English and/or Afrikaans (the second language of the researcher). Communication was therefore usually effective, particularly where interpreters were used. Difficulties were mainly experienced during group meetings (*gorahs*) where, because of the nature of group dynamics, interpreters could not keep track of the various conversations in progress and the participants found it inhibiting to speak in English or Afrikaans and reverted to Sepedi.

The large size of the Blouberg Municpality, the poor state of the roads and the lack of public transport in the area as well as a project budget constraint conspired to limit the size of the study area. Thus the entire Blouberg Municipality was not surveyed.

1.6 ORGANISATION OF THE THESIS

The thesis comprises the introductory chapter, five data chapters and a concluding chapter. The data chapters two to six, have been prepared as individual works to be submitted for publication and therefore although overlap is minimised, some repetition was unavoidable.

Chapter Two comprises an investigation into the overall significance of edible insects in a continuum from the most remote and traditional homesteads in the Blouberg Municipality to those that are more influenced by modernity and are located further away from untransformed vegetation. This chapter gives an indication of the importance of the edible insect resource as well as factors that influence insect consumption in a rural setting. The reasons for the selection of the edible insect *Hemijana variegata* for further, more in depth investigation are highlighted. **Chapter Three** documents my investigation into the life history characteristics of *Hemijana variegata.* As an introduction to the biology of an insect previously poorly documented in scientific literature, the chapter explores development from egg to adult, instar number, egg clutch size and effects of temperature on development. **Chapter Four** is concerned with *Hemijana variegata* as a food resource and thus the safety and nutritional value of the insects are explored. Specifically the potential of bacterial and fungal contamination of the dried insects is investigated, as well as the proximate nutritional value of the prepared product, including the effects of various drying regimes. In addition the vitamin content of fresh *Hemijana variegata* specimens is investigated. **Chapter Five** gives an overview of the utilisation of *Hemijana variegata* within the socio-economic environment of the Blouberg people. Aspects investigated include: quantities harvested, factors affecting the type of harvest experienced, overharvesting and perceptions of local people on the importance of the resource. **Chapter Six** shifts the thesis focus from pure science towards an exploration of the process of making linkages between indigenous knowledge around edible insects and scientific research on these insects. This is done within the framework of the formal education system in Blouberg. **Chapter Seven** is a review chapter discussing the relevance of the Blouberg edible insect resource to the global arena and showing the importance of linkages between new knowledge and indigenous knowledge. **Chapter Eight** serves as a concluding chapter to link the various threads of knowledge around edible insects in Blouberg into a coherent whole which will be of interest both to international scientists and the local people of Blouberg.

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CHAPTER TWO

TOWARDS AN UNDERSTANDING OF THE EXTENT OF EDIBLE INSECT USE IN THE BLOUBERG REGION, LIMPOPO, SOUTH AFRICA

An investigation into species and quantities of insects used including attitudes of the Blouberg residents to entomophagy

2.1 INTRODUCTION

There has recently been a call from a number of quarters for a survey of the global extent of entomophagy as well as the expansion and refining of the identification of edible insects (Meyer-Rochow 2008, FAO 2012, Yates-Doerr 2012). Yen (2009) points out that the social, economic and nutritional value of edible insects is overlooked, despite the fact that more than 1 500 species have been recorded from 113 countries.

In January 2012, the UN's Food and Agriculture Organisation (FAO) called for research aimed at mapping world-wide activities in this field. They also proposed a communication strategy and funding for field projects, all aimed at highlighting the value of insects as a source of protein (FAO 2012). Delegates from both developed and developing countries met to discuss the re-evaluation of the resource in the developing world and to evaluate technologies to develop insects as a more acceptable food source in western countries. The fact that the FAO is also considering a policy paper on edible insects as reported in the Observer (2010) lends further credence to calls for research on this topic.

South Africa has a well-established tradition of entomophagy, predominantly in the northern areas of the country (van der Waal 1999, Illgner and Nel 2000, van Huis 2003, Makhado *et al.* 2009). Despite this, the number of scientific articles dedicated to the subject in South Africa is scanty. In an early global review of edible insects in 1996, Ramos-Elorduy (1996) lists just one study by Quin (1959), relating to South African edible insects. By 2003 this number had grown to seven in the review on edible insects in sub-Saharan Africa by van Huis (2003). In 2011 Wageningen University published a global edible insect working list on the World Wide Web (Wageningen 2011). This list refers again to only seven papers investigating South African edible insects, none of them more recent than 1975. The majority of papers currently available on the subject investigate mopane worms (*Imbrasia belina*) (Ditlhogo 1996, Illgner and Nel 2000, Makhado *et al.* 2009) or explore the nutritional content of specific insects (Banjo *et al.* 2006, Teffo *et al.* 2007, Igwe *et al.* 2011, Longvah *et al.* 2011). Few papers investigate the suite of edible insects utilised by the people of a specific area or ethnicity or the attitudes and perceptions of the people eating these insects. Two exceptions are: a paper by van der Waal (1999), on grasshoppers used in Venda, and a thesis by Quin on the feeding habits of the baPedi in Sekhukhune, written in 1959 and therefore probably outdated. Edible insects are not the focus of the latter, but rather a component of an investigation into diet as a whole.

In South Africa the majority of records of entomophagy are from the Limpopo Province (Shackleton and Shackleton 2004a, Dovie *et al.* 2001, Twine *et al.* 2003, van der Waal 1999), with some records from the Kalahari (Morris 2008), one from KwaZulu/Natal (Shackleton *et al*. 2002) and a passing reference to the edible abdomens of termites from the Eastern Cape (Mkize *et al.* 2003). Available information on edible insects is thus frequently anecdotal, consists predominantly of lists of insects utilised or investigates the nutritional value of selected species (Shadung *et al.* 2012). In Europe there is increasing interest in developing insects as a mainstream source of protein and there has been worthwhile investigation into methods of increasing the palatability of insects for human use (Verkerk *et al.* 2007) but in South Africa this line of research has been confined to the use of insects as a feedstock for poultry (Pretorius 2011). While the above are all important it is also crucial to develop an overall database on South African edible insects and conduct in-depth investigations of the ecological factors that control edible insect population size and the effects of harvesting on these resources. Socio-economic studies investigating the role insects play in food security for rural areas would also be of value.

South Africa is a middle income country but there is a vast discrepancy in household incomes across the nation and a comparatively large proportion of poverty-stricken households (Altman *et al.* 2009). There is thus a drive to improve food security at household level by promoting small scale agriculture and by supporting households to enhance their own food supply. Edible insects form a commodity which can be collected close to the homesteads of many South African rural families (Shackleton and Shackleton 2004b). They are used to supplement food needs, as a luxury food item and as a saleable commodity (Shackleton *et al.* 2010). In addition, insects can be farmed or semi-domesticated, although to date there is little evidence of this occurring in South Africa (van Huis 2003).

The most commonly consumed insects in sub-Saharan Africa include lepidopteran caterpillars (Mbata *et al.* 2002), grasshoppers (Orthoptera) (van der Waal 1999), and termites (Isoptera) (Banjo *et al.* 2006). In addition, Coleoptera and Hymenoptera make a small but important contribution (Bodenheimer 1951, Shadung 2012, van Huis 2003). It is noteworthy that in South Africa, poor rural households spend more money on foodstuff than do their urban counterparts, one reason being the larger numbers of people in rural households (Altman *et al.* 2009). Edible insects are primarily a rural commodity and thus their collection, consumption and trade benefits the sector that needs it the most. Research into the species of edible insects utilised in South Africa and the attitudes and perceptions of the insect harvesters will provide policy makers, government organisations and NGO's with the knowledge to implement the FAO's call to investigate edible insects as a means of enhancing food security.

From anecdotal evidence it is known that the Hananwa people of Blouberg Mountain and the surrounding plains (Limpopo Province, South Africa) consume insects (personal communication, Jan Legwai, Transvaal Museum and resident of Blouberg, 2005). It is however unknown to what extent insects in this area are eaten, the degree to which they contribute to annual household consumption, the species utilised and where they are found or the attitudes and perceptions of the local community towards these insects.

2.2 AIM AND OBJECTIVES

2.2.1 Aim

To investigate the extent and importance of entomophagy in the Blouberg area, with respect to socio-economic factors and ecological aspects.

2.2.2 Objectives

1. To determine the **extent of entomophagy** in the area surrounding Blouberg Mountain focussing on the proportion of people consuming insects, reasons for entomophagy, age of people consuming insects, direct-use value of the resource, trade in edible insects and trends in this aspect of Blouberg culture.
2. To investigate **factors influencing the consumption of insects.** In particular how distance from natural vegetation, income level and educational

qualifications impact on whether households consume insects or not, the quantity of insects consumed per household, the number of ethno-species each household is familiar with, and whether or not households engage in the trade in edible insects.

3. To gain an understanding of some **ecological aspects** of edible insects as perceived by the Blouberg community with regard to the species utilised, most favoured insect species, habitat in which the species are collected, decline in edible insects and drought hardiness.

2.3 METHODS

2.3.1 Study Site

Blouberg Municipality (S23º 05’ and E29º00’) is situated in the northern Limpopo Province and is dominated by the Blouberg Mountain, an inselberg separated from the Soutpansberg Mountain Range by the eroded bed of the Sand River (Chapter One). Nine villages were surveyed at increasing distances from the Blouberg Mountain, which was considered as the area of natural vegetation in the municipality, least transformed by development.

Permission to work in the area was obtained from the municipality, and in particular, the relevant tribal authorities of the Blouberg: Kgoshi Maleboho and Kgoshi Kibi. Furthermore, permission to work in the villages was obtained from the relevant headman (*induna*) of each of the nine villages selected (Figure 1.3). Mohlakeng Village is situated on Blouberg Mountain itself and considered the most remote, traditional and least affected by development. Burgerrecht, ga Kgatla (Varedig), My Darling and The Grange (Setlokeng) are within walking distance of the Blouberg Mountain but situated on the road infrastructure and have access to electricity. Ramaswikana, Sebolamakgolo and Moišmane are all too far from the mountain to be accessible by foot and although Ramaswikana is near a private nature reserve, the latter is not freely accessible to the local inhabitants and cannot be used to harvest insects. Relevant permits for insect collection were obtained from the Limpopo Department of Environmental Affairs, Economics and Tourism.

2.3.2 Data Collection

During 2007 data were collected using an in-depth household questionnaire survey, key informant interviews and group discussions (Appendix I). Group discussions were held in each of the nine villages to discuss the project and gain information on insects utilised and also to call for volunteers to aid with the surveys. Collection and preservation methods were discussed and volunteers trained to collect samples of edible insects as voucher specimens for identification. Three key informant interviews were held with edible insect traders from the area in order to gain information on the harvesting season and pricing of the product.

Two field assistants from each village were trained to conduct the edible insect questionnaire survey. The questionnaire was prepared by the researcher and then translated into Sepedi. A pilot study was run in a nearby village which was not included in the study in order to refine questions and techniques. Each selected village was divided into four and interviewers ensured that they covered each quarter, selecting houses randomly per quarter. Questions were addressed to households rather than individuals. Between 17 and 30 households per village were sampled, resulting in a total of 213 questionnaires covering 5% of households in each village. Not all questions were completed by each household, resulting in varying sample sizes depending on the question asked.

Residents referred to edible insects by their vernacular (Sepedi) names (ethno-species). Specimens of edible insects were collected by community members and preserved in 70% ethanol for future identification. Most of the insect species collected are seasonal in nature and therefore specimens could not be obtained for all the insects referred to in the questionnaires. Some aspects of the analysis were therefore carried out on the ethno-species names, rather than on species names.

2.3.3 Data Analysis

All statistics tests were performed at the 95% level of significance using the computer programme SPSS (The Statistical Products and Service Solution, Inc., Chicago, IL, USA version 13.0). In order to determine the most sought-after species in Blouberg, data from the questionnaire survey and the competition questionnaire conducted for Chapter Six were combined.

2.3.3.1 Extent of entomophagy (percentage of people eating insects):

Data recorded in binary format were expressed as a percentage of households per village consuming insects. Edible insect use was quantified in terms of cups (one enamel cup was equivalent to 0.4 *l* as this is the method whereby insects are sold, bought or prepared as food. The direct-use value of insects was determined using a price of R11.11 per cup of insects based on the average price per cup (n = 150). Annual household consumption of insects was determined by recording the number of cups consumed per household per week and multiplying this by the number of weeks per four months. Edible insects in general are collected from the beginning of November until the end of February when they are most numerous. Demographic data on numbers of people per village and household income were obtained from the Blouberg Municipality's social demographics department (information provided by Mr S. Moremi manager, Blouberg Municipality, November 2011) and Statistics SA (2000).

2.3.3.2 Factors influencing the consumption of edible insects in Blouberg (why do people eat insects and what quantities do they eat?):

Distance of households from Blouberg Mountain, household income and highest educational qualification of households were all analysed with respect to their influence on the probability that households consumed insects, the quantity of insects consumed by households, the households' knowledge of various insect ethno-species, and the probability of households engaging in the edible insect trade.
Households were compared in terms of those within walking distance (within 5 km) of the mountain, which were considered to be near this source of natural vegetation and those that were not within walking distance.

Households were classed according to the highest educational qualification in each household as it was assumed that educated individuals influence the values and attitudes of their families. To score a household's education level, the household representative was asked to list the highest education qualification in the household as a whole. This was then scored as one of three classes: No schooling, schooling from primary up to secondary level or schooling at tertiary level (including extra training or certificates). A potential constraint to this question is that many households may have adolescents with a higher level of education than their parents or grandparents, and that out of respect for their elders, adolescents might hesitate to challenge traditional food sources prepared in the family.

It was considered challenging and impolite to ask outright questions about income level therefore households were scored in terms of material goods and objects. A range of potential possessions were listed as indicative of household income. Each possession was then weighted as follows: Chicken: 1, Electricity: 1, Goat: 2, Donkey: 2, Donkey cart: 2, Television: 2, Cow: 3, Horse: 3, Car: 3. Sheep were not included as they are rarely farmed in Blouberg other than by commercial farmers and none of the sampled households possessed them. Households listed the number of possessions of each type they possessed and this number was multiplied by the weighting value. The resultant scores were totalled for each household. To determine whether more low income compared with high income households consumed insects and traded in insects, the percentage of households eating insects for the six highest income households per village were compared to the six lowest. For comparisons between low and high income households in terms of ethno-species known and quantities of insects consumed, thirty of the highest income and thirty of the lowest income households were compared, regardless of the villages they came from. Quantities of insects consumed were analysed in terms of cups per person per week in each household. Questions regarding whether or not local Blouberg insects were bought or sold were also asked to elucidate their role as a trade commodity.

A correlation analysis using Spearman's rank correlation for non parametric data was performed on education and income data. This was in order to aid in analysing the trends in consumption of edible insects with respect to these factors.

The non-parametric Mann-Whitney statistical test was performed on data, where two variables were tested for significant differences and the non-parametric Kruskal Wallis test was used in cases where there were three or more variables.

2.3.3.3 Ecological Aspects of Entomophagy as perceived by the Blouberg Community:

In order to develop a list of edible insect species from Blouberg, names of ethno-species were recorded, and where possible, specimens of these insects were collected and identified by the Northern Flagship Institute in Pretoria, South Africa (Ditsong Museum of Natural History). In certain cases unidentified larvae were collected and maintained on their food plant until they pupated and the adult moths identified as they emerged. In the rare cases that parasites emerged from the pupae, these were collected and identified by the National Museum, Bloemfontein, South Africa and the *Centro Nazionale Biodiversità Forestale "Bosco Fontana"* in Rome, Italy.

The fourteen most favoured insect ethno-species were determined, using information from both the household questionnaire and the competition questionnaire (Chapter Six). For the household questionnaire, a frequency table was drawn up of the insect ethno-species most enjoyed per household. For the competition questionnaire, two frequency tables were drawn up: - one for the learners' favourite insects and one for the grandparents' favourite insects. The top ten most cited insects for learners in the competition questionnaire and secondly, for the grandparents in the competition were then scored, with 10 points given to the most mentioned insect in each table, and 1 given to the 10^{th} most cited insect. For each insect, the three points were then totalled (household questionnaire + competition questionnaire learners + competition questionnaire grandparents) giving the top fourteen ethno species and their relative scores. Thus the higher the score measured, the more desirable the insect.

The most productive habitats for edible insects, as perceived by insect collectors were analysed in terms of the frequency with which they were cited. The Blouberg Mountain was assumed to be a reservoir of edible insect species because it was the least transformed area of natural vegetation in the municipality which was openly accessible to the local communities. This assumption was tested by analysing all villages with respect to edible insect habitats and then separating the village located on the mountain itself and analysing that data separately.

2.4 RESULTS

2.4.1 How Many People Eat Edible Insects in Blouberg Municipality?

People from the majority of households in the Blouberg area consume insects (90.57%, n = 213). In households in which insects are not consumed, the most cited reason for not eating, or for ceasing to eat insects was the perceived decline in edible insect species (Figure 2.1). All those who listed this reason cited lack of rain and the corresponding decrease in edible insect numbers as the reason why they had ceased to eat insects. A change in tastes was the second most cited reason. This refers to the fact that people have stopped enjoying the taste of insects as modern food has become more available in the area. The third most cited reason was conversion to the local Zion Christian Church, which outlaws most insect eating.

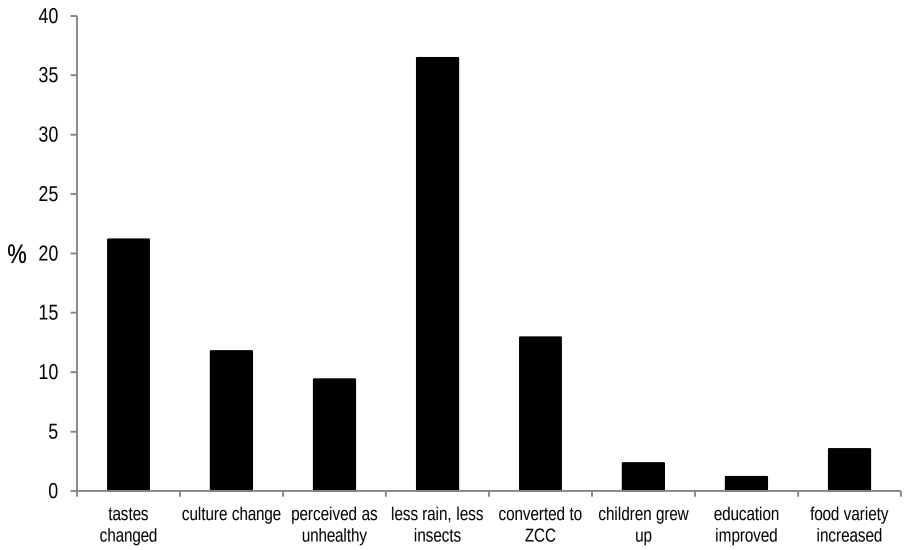

Figure 2.1 Percentage of households that cited various reasons for not eating insects or for ceasing to eat them (n = 85).

The data reveal that 78.57% of households believe that fewer people eat insects than in the past, with 17% believing there has been no change and 12.85% believing that edible insect eating has increased over the last few years (n = 210). That minority who believe that insect eating has increased, cite the following reasons: a) many people still follow the old traditions, b) insects have medicinal properties and it is therefore an advantage to eat them, c) there has been more rain and therefore insects are more freely available than in the past, d) insects are a free source of food therefore people want to eat them and e) they are tasty. These statements were not analysed in depth as the overwhelming majority of people believe that insect eating has declined.

The above reasons are similar to those given by the grandparents of the learners who completed the questionnaire competition (Figure 2.2) where they were asked why they believe entomphagy is declining.

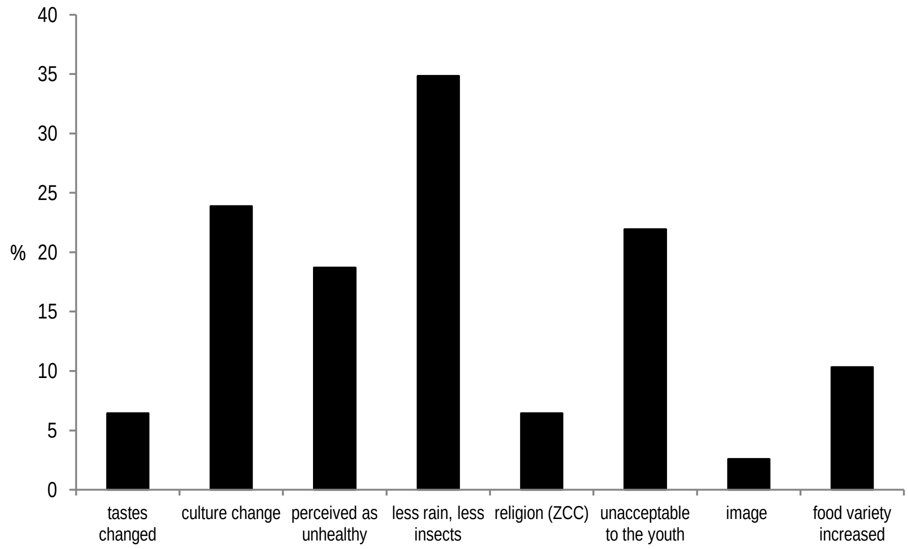

Figure 2.2 Percentage of grandparents that cited various reasons for a decline in entomophagy (n = 210).

For those households that do still consume insects, a number of reasons for doing so were cited, with tradition the most prevalent (Figure 2.3). The fact that insects are a free food type was not as important as the fact that insects are a tasty source of food. Other reasons were relatively unimportant, but include: insects are seen as healthy; - by eating insects the African gods are remembered and a connection made to them; - that they can be used as medicine and that they are easy and fun to collect.

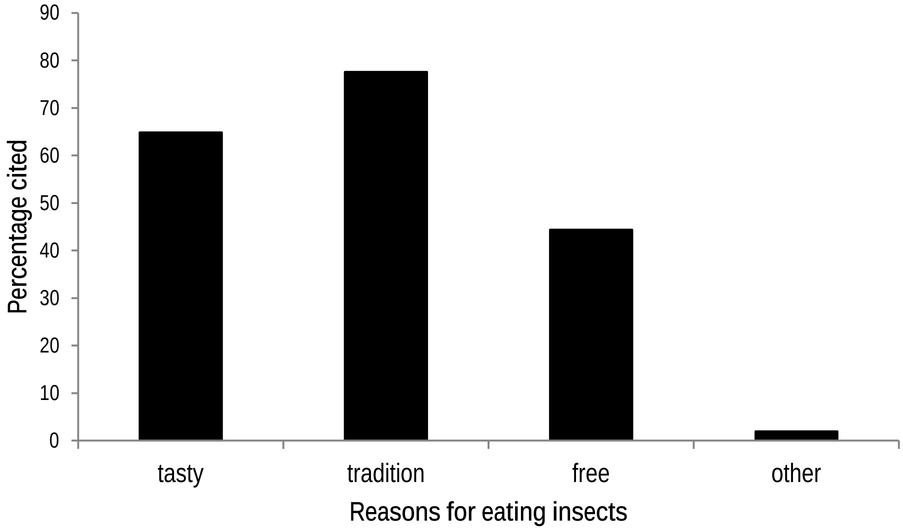

Figure 2.3 Reasons cited for consuming insects (n = 213).

The Blouberg community's attitude towards eating insects was generally positive. Insects are seen as healthy food by 82.14% (n = 196) of respondents. The majority (68.69%, n = 198) of people also believe that insects are tastier than meat, which is generally accepted as a highly desired food type (Oxfam 2011). Due to the high percentage of entomophagy, most people (81.42%, n = 172) would be unhappy if edible insects were no longer available for collection, 15.3% would be indifferent and 3.29% would be happy if insects could not be collected due to declining numbers. Of those who do not eat insects, 10% would be unhappy if they were to decline (n = 10), even though they themselves do not utilise them. In terms of attitude towards trading in edible insects, 69.54% of respondents would be happy if they were asked to provide insects for sale, 14.21% would be indifferent and 30% would be unhappy to be asked to participate in trading activities because they feel that insects should be freely available to anyone who wishes to utilise them (n = 197). They also do not wish their culture to be taken for granted or exploited.

During the harvest season, which generally lasts about four months depending on rainfall for that year, the average number of cups (0.4 ℓ) of insects eaten per household per week is 3.63 (±4.31 cups). This translates to a direct-use value per household of R40.33 per week in season. Thus the direct-use value of insects in Blouberg is estimated at R725.93 per household per annum (n = 201).

Approximately one third of respondents engage in the edible insect trade, with 35.24% (n = 210) selling insects and 36.36% buying insects (n = 209).

2.4.2 Why do People Consume Edible Insects in Blouberg?

The correlation analysis performed on education and income data indicated that only 5.76 % of the variation is shared between the two (Spearman's rank correlation for non parametetric data). Thus although the correlation is significant, the association between income and education is not strong and having a high level of education does not guarantee a high household income (0.237; p=0.01). Further results were therefore interpreted with the understanding that education does not influence income strongly and these two factors were analysed separately.

The likelihood of the people in a household consuming edible insects, increases with distance from the Blouberg Mountain with 85.71% of households within walking distance of the mountain eating insects compared with 94.44% of households further than walking distance eating insects. This difference is significant at the 95% level: Mann-Whitney, p = 0.033, U = 5175.000, n = 213.

Income score does not influence whether or not people in Blouberg consume insects. The percentage of households consuming insects for the six households with the highest income score was identical to the percentage of households consuming insects for the six lowest income scores (n = 9). No statistical tests were therefore performed (94.44% of both high and low income households eat insects).

Households with lower education scores were significantly more likely to consume insects than those with higher scores. 100% of households with no schooling consume insects (n = 52), 81.11% of households with only primary and secondary schooling eat insects (n = 89) and 94.92% of houses with tertiary education eat insects (n = 59). This difference was significant at the 95% level (Kruskal Wallis, Chi-square = 13.829, df = 1, p = 0.001).

Households from villages within walking distance of the mountain are more likely to know a greater number of ethno-species of edible insects than those that have houses further away from the mountain. This difference is significant at the 95% level (Kruskal Wallis, Chi square = 445.04, df = 1, p = 0.000).

Households with a lower income score do know more ethno-species than households with a higher income score, however this difference is not significant (Mann-Whitney: U = 406.5, p = 0.506)

Households with a lower educational qualification score also know more ethno-species than households with a higher score but this is not significant at the 95% level (Kruskal Wallis: Chi-square = 0.281, p = 0.869)

2.4.3 What is the Quantity of Edible Insects Consumed in Blouberg?

The quantity of insects eaten per person per household did not differ significantly between households within walking distance of Blouberg Mountain (0.51 ± 0. 67 cups, n = 103) and those further away (0.53 ± 0.66, n = 107). Mann Whitney: U = 5085.5, p = 0.333, n_{total} = 210)

The quantity of insects consumed per person per household per week was significantly higher in low income households compared with higher income households. Mann Whitney: U = 276.000, p = 0.010)

Households with a lower education score ate significantly larger quantities of insects per person per week than those with a higher education score, particularly at the highest educational qualification. Kruskal Wallis: Chi-square = 11.338, p = 0.003).

2.4.4 Trade in Insects

Although a greater percentage of households that are within walking distance of the mountain sell insects (40.78%, n = 103) than those that are further away (30.19%, n = 105), this is not significant (Mann-Whitney U = 4919.000, P = 0.135). A significantly higher percentage of households with a higher income sold insects than households with a lower income (70% of high income households compared with 33.33% of low income houses, n = 30). Mann-Whitney: U = 300, p = 0.01. Similarly, a higher percentage of high income households bought insects than lower income households (63.33% high income households compared with 19% low income households, n = 30). However, this was not significant at the 95% level, Mann-Whitney: p = 0.073, U = 345.000. A significantly higher percentage of households with a lower education score sell insects compared with those with a higher education score. Kruskal Wallis: Chi-square = 15.883, p = 0.000.

The above results are summarised in Table 2.1.

Table 2.1 Influence of distance, income and education on the probability of households eating insects, amount consumed, knowledge of insects and trade in insects in Blouberg.

Factor		Probability of eating insects (Percentage of households eating insects)		Amount of insects consumed (Cups per household per week)		Knowledge around insects (No. of ethno species known)		Trade (Percentage of households selling insects)	
Distance	**Close**	85.71	U=5175.000	0.51±0.67	U=5085.5	4.04±2.35	X^2=445.042	40.78	U=4919.000
	Far	94.44	p=0.033 *	0.53±0.66	p=0.333	5.32±4.26	p=0.000 *	30.19	p=0.135
Income	**High**	94.44		0.59±0.61	U=276.000	3.68±1.58	U=406.5	70	U=300
	Low	94.44		0.28±0.41	p=0.01 *	5.03±3.95	p=0.506	33.33	p=0.01 *
Schooling	**None**	100	X^2=13.829	0.60±0.73	X^2=11.338	4.98±3.90	X^2=0.281	56.6	$X^2$15.883
	School	81.11	p=0.001 *	0.54±0.71	p=0.003 *	4.88±3.99	p=0.869	27.47	p=0.000 *
	Tertiary	94.92		0.31±0.43		4.35±2.36		26.32	

*significant at the 95% level

2.4.5 Ecological Aspects

2.4.4.1 Species utilised (ethnospecies name in parentheses):

In total 29 species of edible insects from Blouberg were identified to at least genus level. The pentatomid bug, *Encosternum delegorguei* (*thongolifa*), although known by the Bahananwa people, is not utilised in Blouberg as it occurs in very small numbers. It is collected in the Modjadjikloof to the east and was thus not included in the analysis. A further 23 insects were identified to order and are thus included in

Table 2. This number is an under-representation of edible insects available in the area, as a further 39 vernacular names were recorded of insects which have not yet been identified due to a lack of specimens (Chapter Six, appendix 4). It is known that some of these names are duplicates of the same species but on the other hand, two or more species are frequently given the same vernacular name. Of those identified to at least order level, five orders of edible insects are represented in Blouberg (Table 2.2), with Orthoptera the best represented.

Table 2.2 Orders of edible insects consumed in Blouberg and their relative importance.

	No. species	Percentage
Orthoptera	35	67.30
Lepidoptera	10	19.23
Hymenoptera	3	5.77
Coleoptera	2	3.85
Isoptera	2	3.85

The Blouberg people's favourite insect is the coleopteran *Sternocera orissa (lebitsi)*.The second most sought after insect, *hlankgo*, falls into the order Orthoptera. *Hlankgo* is a generic term referring to a number of different grasshoppers and locusts and therefore cannot be narrowed down to a particular species. The third most favoured insect is the thief ant *Carebara vidua (dintlhaamakhura)* of the hymenoptera. The lepidopteran caterpillar, *Agrius convolvuli* (*makotopodi*), is fourth with the well-known mopane worm (*Imbrasia belina)* (*legalakgala* or *mašotša*), fifth. Other favoured insects are listed in Tables 2.3 and 2.4.

Table 2.3 The eight most sought after insects in the Blouberg area from most to least favoured.

Ethno-species (Sepedi name)	Score	Scientific Name	Order
lebitsi	29	*Sternocera orissa*	Coleoptera
hlankgo	23	*Acanthacris ruficornis*	Orthoptera
dintlhaamakhura	22	*Carebara vidua*	Hymenoptera
makotopodi	20	*Agrius convolvuli*	Lepidoptera
legalakgala / mašotša	19	*Imbrasia belina*	Lepidoptera
nemeneme	16	*Macrotermes* sp.	Isopteran
bophetha	8	*Hemijana variegata*	Lepidoptera
nose	6	*Apis mellifera*	Hymenoptera

Table 2.4 A further six favoured insects in the Blouberg area from most to least favoured.

Ethno-species (Sepedi name)	Score	Scientific Name	Order
makotsane	6		Orthoptera
mabitsana	6		Orthoptera
motlatlapudi	4	*Acrida* sp.	Orthoptera
boešitšana	3		Lepidoptera
monhloro	2		Orthoptera
bobilo	1	*Petovia marginata*	Lepidoptera

Parasites emerged from only two species of insect maintained for identification purposes. The edible caterpillar *Agrius convolvuli* hosted the tachinid fly *Drino atropivora* (previously known as *Zygobothria atropivora).* A second edible caterpillar, *Hemijana variegata* hosted two species of tachinid fly: *Lydellina* sp. and *Exorista* sp. (cf. *xanthaspis*).

2.4.4.2 Habitat:

The area cited as the best place to collect insects is the pasture land, with the crop lands second in importance and the yard (around the house) third in importance (Figure 2.4, Table 2.4). Natural vegetation is the least important collection area.

Table 2.5 Percentage frequency with which each habitat was cited for all villages compared with only the mountain top village.

Villages	Habitats			
	around yard	pasture land	crop land	natural veg.
All villages	10.52632	62.20096	53.58852	6.220096
Mountain top	6.25	93.75	18.75	0

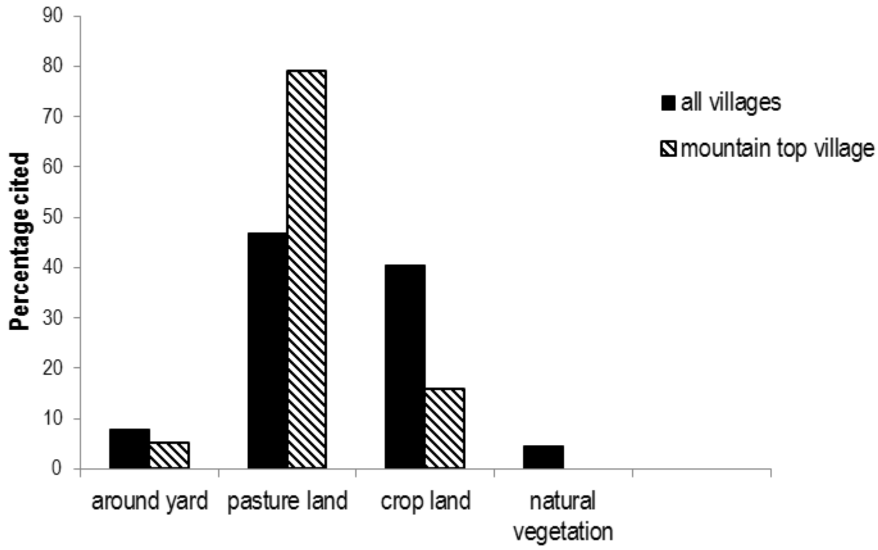

Figure 2.4 Percentage citations for each habitat in which the most edible insects are harvested for the mountain top village only and for all other villages combined. More than one habitat could be chosen per respondent (n=209).

2.4.4.3 Decline in edible insect species

Most respondents (76.54%) believe that edible insect numbers have declined over the years, with 22.38% believing they have stayed the same and a small minority (0.7%) believing they have increased in numbers (n = 143). Of those who responded (n = 183) the majority (81.42%) were unhappy at this perceived decline, with 14.75% indifferent and 3.78% happy. All 100% of respondents who answered the question on reasons for this decline believe it is the lack of rain (n = 64) and 81.42% were unhappy about this.

2.4.4.4 Species available during drought

Of the 213 respondents, 37.56% listed insects that can still be collected during drought years, with the remainder noting that no insects are available in dry years. Of those insects available, *Sternocera orissa* was listed most frequently as being drought tolerant (Table 2.5). *Imbrasia belina* (legalakgala / m*ašotša)* is listed but this is not an insect that occurs in Blouberg unless it is an exceptional season. It has been included because many Blouberg residents migrate to the harvest areas in season (Chapter Five).

Table 2.6 Frequency table of insects cited as available during drought years (most available to least).

Sepedi Name	Species	Order	Frequency Cited
lebitsi	*Sternocera orissa*	Coleoptera	24
mašotša/legalakgala	*Imbrasia belina*	Lepidoptera	13
makotopodi	*Agrius convolvuli*	Lepidoptera	11
hlankgo		Orthoptera (Acridinae)	9
nemeneme	*Macrotermes* sp.	Isoptera (alates)	6
mmamati	*Chrotogonus hemipterus*	Orthoptera	4
nose	*Apis mellifera*	Hymenoptera	3
ditšie/tšie		Orthoptera	2
dinhlamakuru	*Carebara vidua*	Hymenoptera (alates)	2
makeke	*Macrotermes* sp.	Isoptera (workers)	2
monhloro	*Truxalis* sp.	Orthoptera	2
bonito	*Sphingomorpha chlorea*	Lepidoptera	2
bophetha	*Hemijana variegata*	Lepidoptera	2
bophane		Lepidoptera	2
kgakgaripane	*Polyclaeis equestris*	Coleoptera	1
lempuru	*Oedaleus tenuicornis*	Orthoptera	1
boešitšane		Lepidoptera (Noctuidae)	1
sebotšabotšane			1
pokapokane			1

2.5 DISCUSSION

2.5.1 How Many People Eat Edible Insects in Blouberg Municipality?

The vast majority of respondents from the nine sampled villages consume insects (90.57%), which is an even greater proportion than that found by Makhado *et al.* (2009) in Giyani, another traditional, rural area in north-eastern Limpopo, where 71% of sampled households consumed insects. Although recent studies show that poorer households use more natural resources to supplement food and/or income (Shackleton and Shackleton 2004b) this is not true for edible insect use in Blouberg, where even high income households consume insects. This lends weight to the argument that insects, although a valuable supplementary source of protein, are not seen predominantly as a famine food. The positive attitude towards the use of insects as food in the Blouberg area is evident in this statement by Linah Mosena (92 yrs): “Insects are healthy, just like medicine, they are delicious and free”.

The fact that those who do not eat insects cite the lack of rain and the corresponding decline of insects as the overriding reason, points to a possible environmental cause for switching food sources. Thus Morongwa (72 yrs) states, “Nowadays there is no rain, so many children will not eat insects because they don’t know some of the edible insects”. This is disturbing in view of the decline in global food security (Casabona *et al.* 2010), and in marginal areas such as the dry Blouberg, climate change is likely to further negatively affect local food production. The decline in the quantity of any food source is worrying and because edible insects are essentially a production free food this will particularly impact those who utilise the resource from need rather than as a luxury item.

Culture change is the second most important reason for people shifting away from an entomophagic life-style. Considering the nutritional advantages of consuming insects (Chapter 4) it would be beneficial to actively promote the value of edible insects to the Blouberg youth, either through schools or youth programmes (Chapter Six). A move away from a nutritional, free and tasty food source, because it is old fashioned, could cause people to compromise their health for lack of knowledge. The negative image of entomophagy amongst the youth is verbalised by Pienkie (45 yrs) “the youth don’t want to know about culture because they live a modern life”. Maria Molapo (74yrs) adds that, “people nowadays like sweets and they like to eat meat more than traditional food. They think that if you eat insects you are a poor person or not well educated. The youth dislike to eat insects because they have enough money to buy food. They can afford expensive food".

On the other hand, the main reason that people consume insects in the Blouberg is because they are a traditional food and most of the Bahananwa still live a predominantly traditional way of life. However, these customs are eroding as Blouberg people adopt a more modern, western way of life and thus the practise of entomophagy is also in decline. As the younger generation adopt more and more western consumer habits, so the eating of insects will become less popular. This would not necessarily be a matter of concern but Blouberg communities are marginalised in terms of income, which impacts upon their diet (Capricorn District Municipality 2009). Thus a change in lifestyle that results in a reduction of good quality food within a household is negative and ways to mitigate this trend should be investigated. The fact that over 60% of respondents also eat insects because they are tasty means that one hurdle to the consumption of this nutritious source of food has already been overcome. People are not eating insects as a last resort because there is nothing else to eat. This is clear from the fact that 'Insects as free food' was listed by less than half the respondents as a reason for entomophagy. This positive attitude towards the consumption of insects is not limited to Blouberg. In Thailand, where insect consumption is widespread, the main reason for eating insects is for their tastiness (Hanboonsong 2001). Indeed, entomophagy is increasing there as standards of living increase (Yen 2011). It is also actively promoted (Yhoung-aree 2010), which is important to ensure that poorer, rural dwellers have knowledge of a relatively cheap nutritious food. The perception, growing amongst the Blouberg youth, that insects are not nutritious, could be combated by such campaigning. This may assist in reversing the trend that Rebbeca Mabeso (77 yrs) observes. As she says, "Children of nowadays don't like to eat insects. They like to eat modern food. They dislike traditional food."

The predominantly positive attitude of the Blouberg community to eating insects will facilitate any programmes promoting the value of edible insects. An interesting aspect of this attitude is the fact that people from many households that do not consume insects would also be unhappy if entomophagy were to disappear. The

Bahananwa are proud of their traditional roots (Boonzaaier and Philip 2007) and this may be one reason for the positive view they take of entomophagy.

Almost one third of respondents would not be comfortable with selling insects because they feel the resource is free and should remain available to everyone as an open food source. Thus, despite the fact that 'insects as a free food' is only rated third in importance as a reason to eat insects, the free availability of the commodity is important and valued. Despite this, one third of respondents do engage in the insect trade, selling insects during the outbreak seasons. The price of Blouberg insects compares favourably with that of the well-known mopane worm (*Imbrasia belina*) at just over R10.00 per 0.4 *l* cup (Makhado *et al.* 2009). This figure has the potential to increase as the attitude to selling insects is, in general, favourable. In households where insects are consumed, this translates into a saving on food of approximately R700.00 per household per annum. In the marginalised community of Blouberg where the average annual income is below R18 000.00 and many households are dependent on migrant labourer's earnings and subsistence farming, this represents a substantial saving (Fourie 2006).

2.5.2 Factors Influencing Consumption of Insects

2.5.2.1 Distance:

Contrary to expectations, those closer to the area of untransformed natural vegetation (Blouberg Mountain) were less likely to eat edible insects than those further away. This may be due to the fact that edible insects are collected predominantly from pasture and crop lands, even in the mountain-top village (Figure 4). Thus it is not necessary to be close to pristine natural vegetation to utilise edible insects. This is encouraging in view of the fact that although rural, the Blouberg area is in the process of being transformed by village buildings, road infrastructure, as well as overgrazing and fuel-wood harvesting (Fourie 2006).

The quantity of insects consumed per household is not affected by distance from the Blouberg Mountain. Thus it is presumed that where edible insects occur around homesteads in crop and pasture land, their species composition may differ from that found on the mountain, but they are plentiful enough to facilitate collection.

Distance of a household from untransformed vegetation such as that on Blouberg Mountain does however have an influence on the numbers of edible insect ethno-species known per household. Thus the closer a household is to Blouberg Mountain, the more likely it is that the people living there have a greater knowledge of edible insect ethno-species. This may be due to the fact that the suite of insects in untransformed land is greater than in transformed land (Collinge 2000). In 1999, Hoffman *et al*. classified the rangeland deterioration in the Blouberg area as moderate, one step away from the worst class of severe. However, Shackleton (1993) and Wessels *et al.* (2004) report that communal lands supporting large numbers of livestock are generally as stable as corresponding natural areas although they carry a lower species richness. This may be one reason why edible insects are still available in crop and pasture-lands but a greater diversity of ethno-species are known from the untransformed Blouberg Mountain.

People in homesteads located further from the Blouberg Mountain are less likely to sell insects than those living closer. It is not clear why this should be the case unless it has to do with the species of insects sold. *Bophetha*, (*Hemijana variegata*), one of the most prominent insects in the Blouberg edible insect trade, occurs in numbers only on trees (*Canthium armatum*) growing in the foothills of the mountain. Traded insect species may therefore only occur close to the mountain despite other insect species occurring elsewhere.

2.5.2.2 Income:

Income does not influence the likelihood of people eating insects. Presumably this is because insects are eaten mainly due to their status as a traditional food and for their flavour, rather than because they are free.

Income does however influence the number of ethno-species known and used in the household. This result, although not statistically significant is an indication that higher income groups probably do not have enough time to spend in the field learning all the available edible insect species as they are working elsewhere. Predictably, households with lower incomes consumed significantly more edible insects than those with higher incomes. This makes sense in terms of the savings in food costs that can be made by consuming insects as a relish with the meal instead of buying food such as meat. It is more important for lower income households to make this saving than those with higher incomes.

Of significance is the fact that people with higher incomes are more likely to sell insects than those with lower incomes. They are also more likely to buy insects. Possibly, community members with higher incomes are more entrepreneurial by nature, taking advantage of any opportunity to improve their livelihood and thus tend to earn more. Furthermore, those with higher incomes would have more cash available to buy insects and less time to collect them.

2.5.2.3 Education:

With regards to education, the results are interesting in that people in households with no schooling were more likely to consume insects than people in households with members having secondary and tertiary education. However, a higher percentage of households whose members have tertiary education were likely to consume insects than those households whose members had only secondary schooling. This result may be artificial and due to the small sample size of those households with tertiary education (only 11.27% of the participating households). It is also possible that because tertiary education is rare in Blouberg, there is generally only one person in a household educated to this level. One person may not have much influence on the food consumed in a household as food would, no doubt, be prepared to suit the majority. A further explanation is that those with a little knowledge (primary and secondary school) do not have enough information to make a fully informed decision regarding the advantages of eating insects. Those at tertiary level may have more information about the importance of edible insects. Despite this, the statistically significant difference in edible insect consumption between those with no schooling and those with secondary schooling indicates the significant effect of education on entomophagy. Those with some education may be more influenced by negative perceptions around entomophagy than less educated people. Further investigation is needed to determine whether this is because entomophagy is actively discouraged in schools or because of a lack of time available to school children for the collection of insects.

In addition, as education levels in a household increase, so the variety of edible insects known, decreases. Although not statistically significant, the result corroborates the findings of Reyes-Garcia *et al.* (2010) that education can cause a loss of indigenous knowledge (Chapter Six).

What is statistically significant is the inverse relationship between level of education and quantity of insects consumed. As above, further investigation is needed to determine whether this is because there is less time to collect insects due to schooling taking priority or due to the development of a bias against such food through exposure to a more modern culture. A statement by Pienkie (45 yrs) supports the idea that self-image may influence the consumption of insects, “If we eat insects, people will see that we are suffering”. In Gambia a similar sentiment is voiced where people see wild harvested food as ‘monkey food’ for low status people who do not have sufficient income to buy food (Madge 1994).

Another statistically significant result is that the less educated a household is, the more likely they are to engage in trade (selling) of insects. Linah Maribeng (65 yrs) supports this by saying that people do not eat insects because, “people of nowadays are well educated”. This may be due to the fact that poorly educated people have fewer options for making a living than those with a higher level of education.

In general then, income and education are more likely to influence whether or not insects are eaten as well as the quantities and species consumed than is the distance from the untransformed vegetation on the Blouberg Mountain.

2.5.3 Ecological Aspects

Most of the Blouberg edible insects belong to the order Orthoptera. In contrast, on a global scale most edible insects are coleopterans. This is not surprising considering that the Coleoptera is the largest insect order by species numbers and biomass (Evans and Bellamy 2000). Of the insects eaten in Blouberg, however, this order is one of the least represented (5.7%) with only two species present: *Sternocera orissa*, and *Polycleias equestris.* One reason for this discrepancy may be that a large number of edible water beetles are utilised in other countries and are not available in Blouberg due to limited water resources. Those species that are present are much smaller and insignificant compared to elsewhere. On the other hand Cerambycidae, Curculionidae and Scarabaeidae, are all families that are well represented in the Blouberg (Picker *et al.* 2002) but not consumed in this area.

It is not surprising that Orthoptera is the best represented of the orders of edible insects as this order is also globally important being second after the Coleoptera. Locusts and grasshoppers can be collected in large numbers during outbreaks and are well adapted to dry conditions, often swarming during droughts due to an increase in essential nitrogen produced by stressed plants (White 1976). Most of the species consumed in Blouberg are generalist feeders (Picker *et al.* 2002) and are available on a large number of different vegetation types and can also be collected close to homes. They are thus less adversely affected by over-grazing and fuel-wood collection than are the host-specific edible caterpillars and are available for a number of months each year, rather than for only a few weeks as is the case with many other edible insects.

Edible Lepidoptera are second in importance in Blouberg and in this respect Blouberg is more similar to other areas of Africa than it is to the rest of sub-Saharan Africa, where the Lepidopteran order is best represented and the Orthopteran third. Hymenoptera, consisting of bees and ants are third in Blouberg, with Isoptera and Coleoptera on a par as the orders with fewest edible insects (Figure 2.6).

Figure 2.5 Two favoured edible insects from Blouberg a) *kgakgaripane* (*Polyclaeis equestris*) and b) *lebitsi* (*Sternocera orissa*)

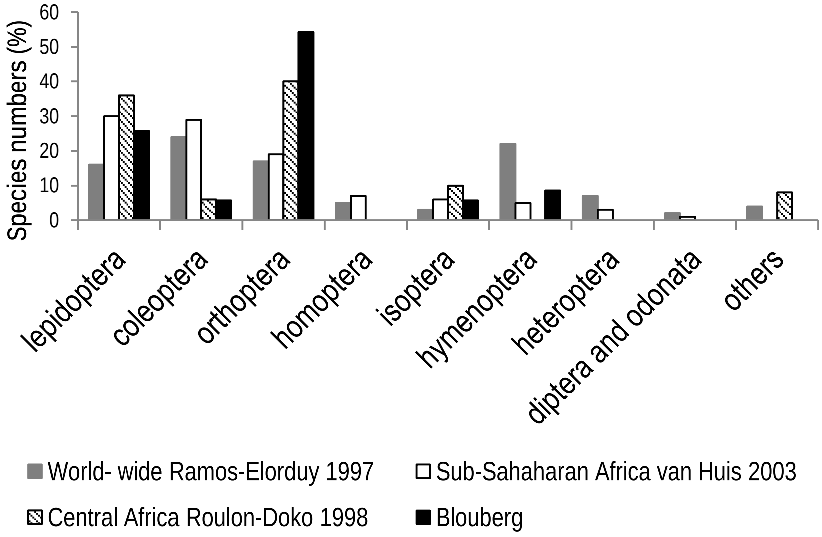

Figure 2.6 A comparison of the best represented insect orders in Blouberg, Sub-Saharan Africa, Central Africa and world-wide. Adapted from van Huis (2003).

The possibility exists that highly sought after insects could be heavily targeted for collection and so decline in numbers as has been documented in Mexico (Ramos-Elorduy 2006), Australia (Yen, 2009) and with the mopane worm elsewhere in South Africa (Makhado *et al.* 2009). In the Blouberg, the top three favourite insects are *Sternocera orissa*, *Carebara vidua* and unspecified grasshoppers and locusts. None of these insects are listed as threatened nor vulnerable and neither are they traded in the Blouberg area. Thus, unlike *Imbrasia belina* (mopane worms) (Ditlhogo 1996) and *Encosternum delegorguei* (*thongolifa*) (Dzerefos *et al.* 2009), which are heavily traded throughout northern Limpopo, they should be in no immediate danger of overharvesting. The caterpillar *Hemijana variegata* (*bophetha*), which is seventh on the favourites list is, however, both a specialist feeder and is traded. It is thus further investigated in chapters Three, Four and Five. Other host specific edible insects of Blouberg are under less threat of over harvesting as they are not generally collected for sale.

The most favoured insect, *Sternocera orissa* is a coleopteran and it is therefore interesting that only two beetle species are utilised in the Blouberg (Figure 2.5). It seems logical that if one beetle species is an acceptable taste experience then other species could also be satisfactory. The use of only two beetle species may thus be due to long-standing traditional food preferences, as social context is a strong external character which influences our taste in food (Eertmans *et al.* 2001). *Sternocera orissa* is not only eaten by the Bahananwa of Blouberg. In Mokopane (central Limpopo Province) and Giyani (northern Limpopo Province) the local communities also enjoy the beetle (Shadung 2012) and further afield the San of the central Kalahari and Botswana rate it as highly desirable with a taste similar to that of eland meat (*Taurotragus oryx*) (Nonaka 1996). They roast and eat the entire beetle after removing the wings and legs and also prepare a paste of the insects with roots and wild plants. This is of interest due to the current trend to find a means of marketing insects to the west by mixing them with other ingredients and developing patties and meal (FAO 2012). The conspicuous nature of this species is conducive to collection. The beetle is conspicuous in the veld as it clings to branches of small acacia trees with sparse foliage, it is also diurnal, flying during the day which facilitates collection. Other large beetles such as certain click beetles (Elateridae) take refuge out of sight in the day and only fly at night.

Hlankgo are listed as the second most favoured Blouberg insects. This is a general term referring to grasshoppers as a whole. It is certainly true that grasshoppers and locusts are generally relished globally due to the fact that they do not have a distinctive taste but take on that of the sauce in which they are prepared (Ramos-Elorduy 1998). Thus most grasshoppers and locusts have a similar bland taste except in the case of the pyrgomorphid *Zonocerus elegans* which is eaten but not relished by all people (personal comment, Morata, P. 2007).

The third most sought after insect in Blouberg, *Carebara vidua* (*dintlhaamakhura*), the thief ant, is available only immediately after the first rains of the season (Lepage and Darlington 1984, personal comment Waleng, F. 2007). Furthermore, the ant cannot be stored for more than a few days following preparation (Chapter Six). It is relished raw, however, and is a favourite impromptu snack for children. The ant is also well known in the central parts of Africa as well as in other areas of Limpopo province (DeFoliart 1995 and Rastogi 2011). The ants belong to the order Hymenoptera, of which only three species are utilised in Blouberg. The other two representatives, *Apis mellifera* (honey bee, *nose*) and *Meliponula sp.* (mopane bee, *pokapokane*) are generally not eaten but valued for their honey.

Termites are one of the least well-represented orders in the Blouberg with only one species being consumed; however, they are rated fairly highly in terms of flavour and are well known edible insects throughout Africa (van Huis 2003 and Sileshi *et al.* 2009). It is likely that more than just one species of termite are eaten in Blouberg as they are known to be a taxonomically challenging order (Sileshi *et al.* 2009). As in the case of *C. vidua*, termites are only available sporadically, just after rains, although swarms occur throughout the early part of the summer. The high fat content of the termites leads to early spoilage and they can also only be stored for a few days. In Venda, the local inhabitants prefer to consume the soldier and worker castes of these insects (van der Waal 1999). They collect them by pushing long grass stalks into the termite mounds and pulling out the termites that grasp the stalks, as do chimpanzees (*Pan trogolodytes*) in the Congo (Suzuki *et al.* 1995). In this manner they can obtain insects for longer periods as they are not reliant on the swarming of the alates that occurs only after early rain.

The lepidopteran *Agrius convolvuli* (*makotopodi*) is one of the top five most favoured insects in the Blouberg and was also the third most cited drought tolerant edible insect. This economically important insect (see below) is also considered to be a delicacy by the San of Botswana, who would camp near *Ipomoea* plants during the caterpillar outbreaks (Nonaka 1996). In Blouberg and Botswana the caterpillar is squeezed out to eject the gut contents and then roasted on a fire or fried in a pan with the addition of salt, after which it can be kept for months for future use. The San grind the caterpillar into a paste to be added to melon or maize meal to enhance the meal. This adds protein to an otherwise protein deficient dish, a technique which is being considered as a means of enhancing the nutritional quality of flour, maize and rice (Solomon *et al*. 2008).

Waterhouse (1998) reports that *Agrius convolvuli* is parasitised by the tachinid flies *Zygobothria atropivora* and *Sturmia dilabida.* This was confirmed in Blouberg where *Zygobothria atropivora* was collected from pupating caterpillars from My Darling village. The implications of parasitism on the quality of the caterpillars as human food have yet to be assessed. Furthermore parasites have an impact on insect numbers in the same way that predation would. Any investigation into the impact on harvesting edible insects should take these factors into account.

All but four of the identified Blouberg edible insect species have been documented previously in the scientific literature. They are listed as edible, either in van der Waal (1999) or in the recent list of edible insects of the world compiled by Wageningen University (2011) (Table 2.6). Occasionally the species itself has not been recorded as edible but other species within the same genus have been listed as such. *Petovia marginata, Hemijana variegata, Karasicola sp.* and *Phyxacra sp.* have not previously been documented as edible and are not well understood even in terms of their general distribution and biology (Chapter Three). In addition, over 60 edible insects from Blouberg are still known only by their vernacular names and further investigation is required for their identification and inclusion into the global inventory (Chapter Six). This chapter can thus be used as a starting point to guide further investigations into both their natural history and their utility as a food source in terms of nutritional value, micro-livestock potential and sustainable harvesting issues.

Table 2.7 Blouberg edible insects documented in the literature (source: Wageningen University 2011 and van der Waal 1999).

Genus	Species	Ethno-species	Global Edible Insect Inventory	Van der Waal 1999
Acanthacris	*ruficornis*	hlankgo	X	
Acorypha	*palidicornis*	hlakwanapitsana		X
Acrida [1]	species[1]	mohlalapudi	X	
Acrotylus [1]	species[1]	mmamati		X
Agrius	*convolvuli*	makotopodi	X	
Anacridium[2]	*moestum*[2]	mamoshu		X
Apis	*mellifera*	nose	X	
Carebara	*vidua*	dinhlamakuru	X	
Catantops	*melanostictus*	malefiswane		X
Chrotogonus	*hemipterus*	mmamati		X

[1]indicates species where there is only a record for members of that genus

[2]indicates entry into the online Catalogue of Life (University of Reading 2012)

Table 2.7 Cont.

Genus	Species	Ethno-species	Global Edible Insect Inventory	Van der Waal 1999
***Gastrimargus*[2]**	*cf africanus*[2]	lengetla		X
Hemijana	*variegata*	bophetha	Not documented	
***Humbe*[2]**	*tenuicornis*[2]	lempuru	X	X
Imbrasia	*belina*	masotsa	X	
Karasicola/Rhodesiana	species	mankoko	Not documented	
***Macrotermes*[1]**	*natalensis*[1]	nemeneme	X	
***Oedaleus*[1]**	species[1]	masebaraki		X
***Oedaleus*[1]**	species[1]	mmamati		X
***Oedaleus*[1]**	species[1]	hlankgo		X
***Oedaleus/Gastrimargus*[1]**	species[1]	lempuru		X
***Petovia*[2]**	*marginata*[2]	bobilo	Not documented	
***Phyxacra*[1]**	species[1]	hlankgo	Not documented	
Polyclaeis	*equestris*	kgakgaripane	X	
***Pycnodictya*[2]**	*flavipes*[2]	hlankgo		X
***Sphingomorpha*[2]**	*chlorea*[2]	bonato	X	
Sternocera	*orissa*	lebitsi	X	
***Truxalis* [1]**	species[1]	monhloro	X	
***Zonocerus*[2]**	*elegans*[2]	tlatlawele	X	

[1]indicates species where there is only a record for members of that genus

[2]indicates entry into the online Catalogue of Life (University of Reading 2012)

The list of edible insects generated in this chapter and Chapter Six should now be incorporated into the global list of edible insect species maintained by the Wageningen University (2011) and should also be compared to the available South African literature on threatened species. In addition, the World Conservation Monitoring Centre (WCMC) in the United Kingdom maintains a database of species of conservation concern which can be used to further assist in assessing the conservation status of the Blouberg edible insects (Johnson 2010). For those insects that are reliant on specific host plants, such as the Lepidoptera, the conservation status of these plants should also be determined. This initial list of identified Blouberg insects does not contain any species that are of conservation concern at present other than the mopane worm (*Imbrasia belini*) (Makhado *et al.* 2009). This insect does not occur in large numbers in Blouberg, as the primary host plant, the mopane tree (*Colophospermum mopane*) is not present and thus Blouberg is a marginal habitat and not important in terms of mopane worm conservation.

The perception held by traditional healers, that the edible insect resource as a whole is dwindling, is however of concern. This may only be a local phenomenon but further investigation is required to determine the reality, extent and reason for this decline. Half of the ethno-species listed as edible in Blouberg have not been identified and therefore their conservation status is unknown. Samways (2005), in a review on insect conservation, emphasises that insects as a whole are declining but that to date we only know a fraction of the species on the planet and are therefore losing biodiversity that has not yet been documented. Samways (2002) points out that atlasing, monitoring and development of conservation strategies for invertebrates can only take place after species have first been identified. Identification of Blouberg's edible insects will therefore also feed into the general overview of insect biodiversity.

With over 70% of respondents perceiving a decline in the edible insect resource, and 81.42% of people unhappy at this decline, there is an incentive to investigate more thoroughly whether this phenomenon is real and if so, the reasons for such declines. Dovie *et al.* (2001) report a similar perception amongst insect-eating people from Thorndale, Limpopo, where 100% of respondents perceived a decline in edible insects over the last ten years. In their study, less than half of the respondents felt that there were sufficient insects available for their needs. In Blouberg anecdotal comments by Mr. Morata and Mr. Jackson from Inveraan and the Glade villages respectively revealed that some residents agree that protecting the host trees will assist in arresting the edible insect decline. In Zambia, where edible insects are also on the decline, and deforestation is on the increase, Jumbe *et al.* (2008) advocate that semi-domestication of caterpillars be promoted in order to both protect the caterpillar resource and the dry woodland from which they are harvested. Despite the fact that it is unknown to what degree edible insects in Blouberg are declining and what the driving forces are, the majority of respondents attribute it to a lack of rain. Climate is indeed the dominant force behind distribution patterns amongst most insects (Sutherst 2000) and with many species having already responded to regional changes in climate (Olfert *et al.* 2011) it is conceivable that this could also be the case amongst insect guilds of Blouberg. At present, none of the identified edible insect species from Blouberg is listed on the IUCN's Red List (IUCN 2011). This is not surprising considering the magnitude of the task required to categorise each insect species in the world. Only seven of the Blouberg edible species are even listed in the Catalogue of Life (University of Reading 2011) (Table 6). With a suite of edible insects ranging from generalist pest species (many of the grasshoppers), to host specific and ephemeral caterpillars, it is probable that most species are not in imminent danger of decline from overharvesting but that certain key species are in need of conservation action to ensure their sustainable use into the future.

Habitat transformation is perhaps more of a threat to the edible insects of Blouberg than over-harvesting. Blouberg is undergoing rapid vegetation transformation through infrastructure development (roads and buildings). Over-grazing and over-harvesting of fuel wood continue to cause the destruction of natural vegetation and thus insect habitat (Capricorn District Municipality 2009). Relatively little work on collecting sites and habitat preferences of edible insects has been published, particularly in South Africa. A paper by Dovie *et al*. (2001) is one exception wherein the results from this Blouberg study are corroborated. Edible insects in Thorndale (Limpopo Province) were harvested predominantly from the grazing fields and around homesteads rather than from nature reserves, a similar finding to the above, where insects in general are collected mainly from croplands and grazing fields. Despite this, a range of habitats is important in the conservation of edible species as some species such as *Sphingomorpha chlorea* (*makotopodi*) and *Hemijana varigetata* (*bophetha*) are reliant on specific plants which do not grow on croplands and grazing areas (*Burkea africana* and *Canthium armatum* respectively).

The role that insects play in forest ecosystems in particular has been stressed by Johnson (2010). He notes that worldwide, the decline in insects has been linked most strongly to habitat degradation through land clearing and development. Both Johnson (2010) and Mbata *et al.* (2002) suggest strengthening existing traditional resource management methods with government interventions through legislation and infrastructural support. Some measures for enhancing both edible insect conservation and that of the associated habitats as suggested by Johnson could be applied to the Blouberg situation as follows: -

1. Enhance the management of the Blouberg forest by taking into consideration the advice of local people. For example in Central Africa seasonal burning practises are necessary to ensure a good caterpillar crop. In Blouberg the *Canthium armatum* tree that hosts the *bophetha* caterpillar is traditionally protected from use as fire-wood. This protection, has, in recent years been eroded through a decline in the authority of traditional leaders. Local government by-laws against the destruction of edible insect host trees could strengthen this traditional decree.
2. Allow local people limited use of the edible insects within otherwise protected areas. The Blouberg Nature Reserve is a repository of a number of edible insect species, notably the *bophetha* (*Hemijana variegata*). Insect harvesting is prohibited on the reserve. In addition the forest on the Blouberg Mountain has also very recently been declared a protected ecosystem and gazetted in national legislation (Government Gazette no. 34809 of 2011 of the National Environmental Management Act 10 of 2004). There is the potential that this could also be declared off-limits to caterpillar harvesters unless measures are put in place to formally protect the rights of traditional insect collectors and ensure that they practise sustainable harvesting. Blanket exclusion of wild resource collectors from reserves within their communities can lead to resentment towards conservation strategies (Kremen *et al.* 1994, Sebola 2005). Limited, sustainable harvesting of certain species fosters good relations between conservation officials and community members (Kremen *et al.* 1994). If it is decided that these areas are too sensitive to be opened up for harvesting, they could still be used as reservoirs of insects to be used to populate decimated areas outside of the reserve. This role should be well-

understood and managed by reserve managers and community members alike.

3. Investigate the use of pesticides in nearby agricultural lands and determine the feasibility of supporting edible insect collection as an alternate means of pest control of certain species.
4. Increase the overall productivity of the land by developing dual product systems such as growing non-invasive host plants (such as *Canthium armatum, Sclerocarya birrea* and *Vangueria infausta*) within areas used for conventional grazing or crop lands.

In northern Zambia, the Bisa people harvest eight species of caterpillar and have regulated this harvest by traditional means through many generations (Mbata *et al.* 2002). Regulation involves four key aspects: monitoring the resource abundance and changes in the ecosystems of the caterpillars, protecting vulnerable life history stages (early instars), protecting specific habitats and lastly, temporal restrictions of harvesting.

In the Blouberg the local municipality and the Limpopo Department of Economic Development Environment and Tourism (LEDET) could strengthen the traditional authority's mandate that edible insect trees be protected from harvesting for fuel wood. At present, monitoring for the appearance of edible insects in Blouberg is *ad hoc* and undocumented. Such information is important and could be used to feed into the recent Conservation Plan for the Limpopo Province which depends, for its implementation, on the gathering of long term data on the province's biodiversity as a whole.

In terms of protecting life history stages there is a general understanding among Blouberg insect collectors that early instars should not be collected for consumption. This action should be more formally upheld. Information on the importance of protecting these life stages should be disseminated to the Blouberg community through the schools and through the weekly village *gorahs* (meetings).

The protection of specific habitats in which edible insects occur has a two-fold benefit to both Blouberg's biodiversity and to the edible insect guild. Despite the fact that a large number of species are found in transformed land, highly sought after caterpillar species such as *bobilo* (*Petovia margninata*), *bophetha* (*Hemijana variegata*), and *boešitšana* (unknown noctuid) are specialist feeders on host trees that are vulnerable to deforestation in Blouberg (*Vangueria infausta, Canthium armatum* and *Elephantorrhiza burkea* respectively, Chapter Six). These trees all occur in the newly protected vulnerable ecosystem on the Blouberg Mountain and their protection will ensure the conservation of micro-habitats and other biodiversity associated with them.

In contrast to the situation in Zambia (Mbata *et al.* 2002) there are at present no temporal restrictions, either traditionally practised or legislated by government, on the harvesting of any edible insects in Blouberg. Such restrictions may not be as important as conserving the host plants and habitat of the insects but could become necessary in the future if harvesting pressure increases.

Yen (2009) advocates the use of certain edible insects as flagship species to promote the conservation of insects in rural areas rather than the more usual choice of attractive and iconic butterflies or dragonflies of Western scenarios. Flagship species have conservation value as rallying points for attracting donor money and volunteers for further study of the species. Conserving one such species would ensure the protection of that species' habitat and by default other species and processes linked to that habitat (Samways, 2005). On another level, Samways (2002) also emphasises the importance of invertebrates as keystone species whereby those which modify and build habitat deserve particular conservation attention. In the Blouberg, the two obvious keystone edible insects could also be classified as pests and therefore conservation may not be as important as pest management. The termite *Macrotermes natalensis* creates new habitat that changes the physical environment even to the extent of influencing behaviour patterns of larger species such as aardvark and porcupines (Jones 1990). Grasshoppers, particularly the gregarious locusts, can also act as keystone species during outbreak periods when they can modify ecological processes such as carbon and water cycles through soil erosion and runoff, as well as destroying food sources for other species (Latchininsky *et al.* 2011). Human reaction to such outbreaks can in turn alter the functions of biological systems by destroying non-target organisms through pesticide use.

While some insect species are in decline and require conservation intervention, many edible insects are pest species and occur in such numbers that they are detrimental to agriculture. Some interest has been shown in the collection of edible pest species for human consumption thus lessening the necessity for pesticide control of insect outbreaks and benefitting the environment as a whole (DeFoliart 2005). Ramos-Elorduy (1996) supports this view, noting that it is ironic that crops containing only 14% protein are saved at the expense of the insects which can contain up to 75% protein. The characteristic large outbreaks of pest species is one of the useful traits that characterise edible insects as it allows for the collection of a large amount of protein in a short time period. This may also be the reason that most of Blouberg's edible insects are not listed for conservation priority as they are associated with outbreaks and therefore regarded as common.

At least five insect species consumed in Blouberg are declared pest species: *Anacridium moestum* (Figure 2.8) on fruit trees (Picker *et al.* 2002), *Zonocerus elegans* on vegetables and fruit trees (Picker *et al.* 2002), *Agrius convolvuli* on sweet potato (Waterhouse 1998), *Sphingomorpha chlorea* (Figure 2.7) on citrus and stone fruit (Ngampongsai *et al.* 2005) and *Macrotermes natalensis* on agricultural land (Sileshi *et al.* 2009). In the Blouberg area, insects are generally not controlled by pesticides and are therefore safe to consume but it would be important to verify this fact (Yen 2009). There is anecdotal evidence that this is already taking place with at least one species in Blouberg. Residents of My Darling village report that in outbreak seasons farmers growing sweet potato (*Ipomoea battatas*) inform local insect collectors of infestations of *makotopodi* caterpillars (*Agrius convolvuli*) and welcome them onto the farms in question. The caterpillar feeds on a number of exotic and indigenous members of the sweet potato family (Convolvulaceae) (Waterhouse 1998) and is also collected annually from indigenous Convolvulaceae growing in local yards. This particular species is a globally widespread pest, particularly of Asian countries. People from a number of Asian countries are enthusiastic entomophages and it would be worth investigating whether entomophagy is used to control this insect pest. Of further interest is the fact that one of the host plants, the morning glory (*Ipomoea indica*), is an exotic invasive plant in South Africa and a category three weed in Limpopo (Bromilow 2010). The caterpillar defoliates the plants, compromising fruit development and in the case of crop plants, delaying or causing a failure of harvest (Waterhouse 1998).

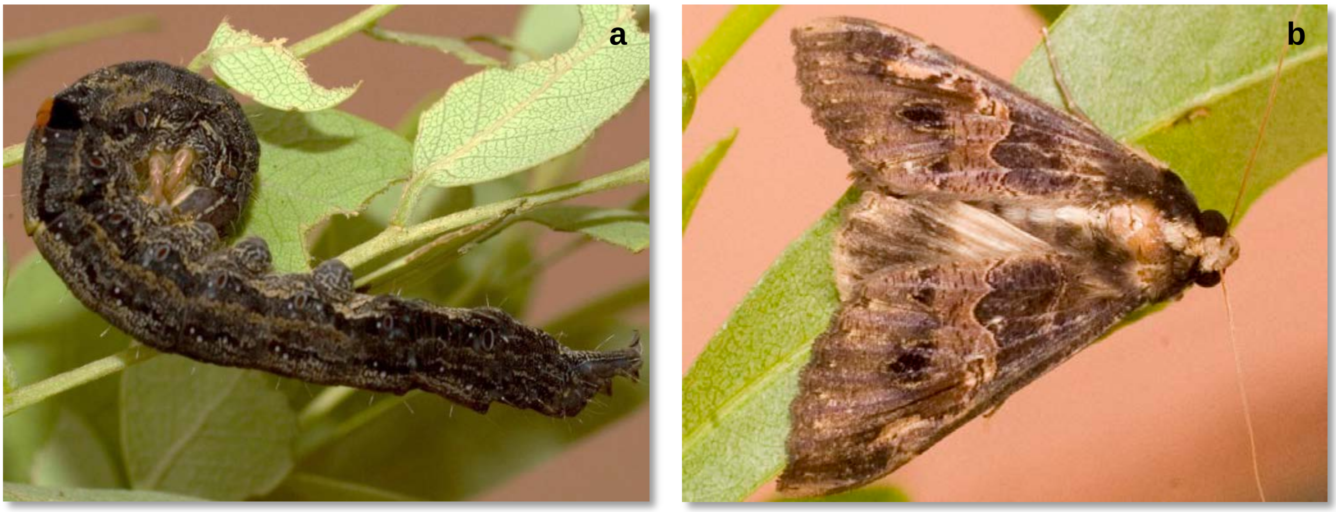

Figure 2.7 *Sphingomorpha chlorea* an edible pest insect known as *bonado* in the Blouberg a) the caterpillar b) the moth

One comparison between the impact made on grasshopper numbers by means of conventional insecticides and human harvesters showed that although collection for food made an impact this was not as great as the decline caused by the insecticides (Cerritos and Cano-Santana 2008). This was offset however by the fact that the environmental impact of collection was virtually zero, there were no costs involved and in fact income could be generated by selling the grasshoppers. Hanboonsong *et al*. (2001) report on a similar situation in Thailand where 40 years ago, widespread outbreaks of the locust *Patanga succincta* L. were unsuccessfully countered by insecticides. Campaigns promoting the use of these insects in cooking were initiated and over the years the locust became one of the most sought after edible insects in Thailand. The result has been a successful reduction in numbers of the locust which is no longer seen as a pest on agricultural land.

A further consideration is that if insects are to contribute to world food security, their reliability as a food source during times of drought should be assessed. Despite the concern amongst Blouberg people that edible insect numbers are dwindling due to lack of rain, there are a few species that were listed as drought hardy. Over a third of respondents listed insects that could be collected in dry years, with *Stenocera orissa,* the giant jewel beetle (*lebitsi)* cited most frequently. The perception by local inhabitants of *S. orissa's* drought hardiness is confirmed by van Jaarsveld *et al.* (2000) who predict that *S. orissa,* which is a robust, drought hardy species, will not experience large distribution shifts due to climate change. The mopane worm (*Imbrasia belini*) was the second most cited drought hardy insect but as it is not often available in Blouberg even during wet years this perception stems from the knowledge the people have of the caterpillar from other areas. Many people from Blouberg migrate temporally to the mopane worm collecting fields and this may be why they have knowledge of the insect. *Makotopodi* (*Agrius convolvuli*) is listed third most tolerant which is unsurprising considering it is adapted to a wide range of conditions (Waterhouse 1998). *Hlankgo* (grasshoppers) are also high on the list of drought tolerant insects (Figure 2.8). This may be an erroneous perception. It has been shown that grasshopper densities increase during warm, wet years. When these are followed by a year of drought, grasshoppers consume a greater proportion of available vegetation than during years of good rainfall. In addition, greater numbers move into more irrigated areas (Fielding and Brusven 1990). They are therefore more noticeable during the early part of a drought.

Figure 2.8 *Hlankgo*, an edible locust from Blouberg (*Anacridium moestum*)

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CHAPTER THREE

ASPECTS OF THE BIOLOGY OF THE EDIBLE INSECT *HEMIJANA VARIEGATA* ROTHSCHILD (EUPTEROTIDAE)

An investigation into the development of *H. variegata* and the influence of temperature on different life stages

3.1 INTRODUCTION

The edible insect, *Hemijana variegata,* also known as *bophetha* in the Blouberg vernacular, is a little known gregarious, eupterotid lepidopteran. In the Blouberg area of Limpopo, South Africa, it is the seventh most favoured insect in terms of tastiness out of a potential of 90 edible ethno-species (Chapter Two). The moth has no economic significance in terms of pest status. The adult possesses vestigial mouthparts and therefore does not cause crop damage and the larva is a specialist feeder on two indigenous plant species (*Canthium armatum* and *Pyrostria hystrix*), neither of which have commercial value. To the author's knowledge no scientific literature exists on the species other than two early descriptions (Rothschild 1917, Gaede 1927) and that pertaining to the classification and taxonomy of the Eupterotidae (Oberprieler *et. al.* 2003, Oberprieler and Nässig 2008). Indeed, the literature on life history characteristics of Eupterotidae as a whole is scanty. There has been more interest in the emperor moth family, a sister taxon of the Bombycoidea (Saturniidae), probably because of the greater size and beauty of the moths and also because a number of these species are well known to be edible, including the economically important mopane worm (*Imbrasia belina*) (Ghaly 2009).

Hemijana variegata was chosen for further investigation from a large suite of edible Blouberg insects, for the following reasons:

1. The caterpillar is used widely in Blouberg during poor and good insect seasons.
2. It was readily identified as *Hemijana variegata* whereas over 60 other ethno-species have not yet been identified due to unavailability during the project.
3. It is enjoyed widely amongst the Blouberg people.
4. There is little literature pertaining to the insect's life history.
5. It is one of four identified Blouberg edible insects that have not previously been documented as edible. The other species are not used as extensively or enjoyed as widely as *H. variegata* (Chapter Two).
6. Proximate nutritional analysis reveals that it is highly nutritious (Chapter Four).

Hemijana variegata was described by Rothschild (1917) and classified as follows:

Superfamily: Bombycoidea

Family: Eupterotidae Swinhoe

Subfamily: Janinae Aurivillius
Genus: Hemijana
Species: variegata

According to Oberprieler and Nässig (2008) there is taxonomic confusion regarding *H. variegata*. It does not belong in the genus *Hemijana*, nor in the subfamily Janinae. Oberprieler *et al*. (2003) removed the species from Janinae and placed it near *Poloma* in the informal Ganisa-group. This group has no taxonomic rank as it was formed to accommodate those genera that could not be placed in the existing eupterotid subfamilies. The group was formulated based on the characteristics of the eupterotid uncus. There are however, no clear synapomorphies and it was suggested that it might be a paraphyletic grade from which some or all of the eupterotid subfamilies arose. To date there has been no further change in the taxonomic status of this species.

Rothschild (1917) describes the species as follows: The antennae are black, with the head and thorax pale chocolate brown and the abdomen an orange-brown hue. The forewing is cinnamon pinkish white with the outer third umber-brown, washed and clouded with pinkish cinnamon and cinnamon-white. On the basal one fourth of the wing lie three large irregular umber-brown patches and several lines as well as a black stigmata beyond which is a brown patch. The outer one-third of the wing is sharply cut off from the basal paler two-thirds. The hind wing is salmon-pink and the outer one-third has an ill-defined broad sooty grey-black band and suffusion. Montirro collected the type specimen from Delagoa Bay. The length of the specimen's forewing was 24 mm and the expanse, 55 mm (Rothschild 1917).

The larval stage has not been formally described. It is a gregarious, host specific caterpillar, covered in soft non-urticarious grey hair, which burrows into the soil to pupate. It feeds at night, camouflaging itself during the day by resting motionless along the branches of the host tree (Figure 3.1).

Figure 3.1 Appearance of *H. variegata*: (a) fourth instar caterpillar, (b) adult male moth.

In South Africa the larvae are eaten as a delicacy in the northern parts of the country. This area has over six different languages and a number of dialects within those languages (Ross 2008) and therefore the larvae are known by different names depending on the geographic area. In the Blouberg area they are known as *bophetha* (seHananwa), in Venda as *matsowe* (chiVenda) and in Boyne and Sekhukhune as *netla* (Sepedi) (personal comments Mampuru, L. 2009, Waleng, F. 2007). In the Blouberg the young caterpillars which have not yet reached harvestable size are known as *bokoma* (seHananwa).

Hemijana variegata is a sought after food type in the Blouberg, Boyne, Sekhukune and Venda areas of the Limpopo Province, South Africa. Trade in the insect has been recorded in the Blouberg area (Egan *et al.* 2009) but is likely to occur in all areas where the insect is harvested. This insect has not previously been documented as edible and there is only one other edible eupterotid (*Strichnopteryx edulis* from equatorial Africa) listed in the literature (van Huis 2003, Wageningen University 2011). Despite extensive harvesting of the resource, no formal management tools are in place to ensure sustainable utilisation occurs. However, before such tools can be developed it is necessary to understand the biology of the species (Dzerefos *et. al.* 2009). Recently, there have been initiatives to rear a number of edible insects for commercial purposes and such projects rely on accurate information on the biology of the species in question (Ghaly 2009). Durst and Shono (2010) report that for the majority of edible insects worldwide, little is known about their life cycles, population dynamics and management potential. In addition, there is a dearth of knowledge on the impact of overharvesting of forest species on local vegetation, other fauna and the ecosystem itself. As Ditlhogo (1996) states with regard to the well-known and popular mopane worm (*Imbrasia belina*), populations of edible insects about which there is little knowledge, cannot be well-managed and therefore are at risk of over-exploitation. Basic computer simulation models can be developed from certain life history aspects. These can then be used to model population dynamics of the insect and provide important insights for management decisions (Ditlhogo 1996).

The local collectors do have knowledge of some biological aspects of the caterpillar but this knowledge is not exhaustive and can be inaccurate (Egan *et al.* 2009). Thus, they know in which season the larvae appear and which food plants they consume. However, they are not aware that the caterpillar metamorphoses into a moth, what the moth looks like or what happens to the caterpillars once they are fully developed. Information on life-history traits will therefore also be of use to the local consumers.

Insects are poikilothermic animals and as such, temperature plays an important role in all stages of their life history (Trudgill *et al.* 2005). With the current concern around climate change and the predictions of increasingly variable weather and more frequent extremes for the northern part of South Africa (Ziervogel *et al.* 2006) it would be useful to have an understanding of the temperature tolerance of *H. variegata.* The effect of changing temperatures on population characteristics can then be modelled. Due to the fact that there is a linear relationship between temperature and rate of development of most invertebrates, the distribution of such species is profoundly influenced by the environmental temperature (Trudgill *et al.* 2005). The possibility therefore exists that a nutritious food source (Chapter Four) could in future be compromised by changing temperatures. For instance, Ayres and Scriber (1994) found that in the lepidopteran, *Papilio canadensis,* two ecotypes of the species had differing temperature tolerances. Computer simulation predicted that if the ecotypes were geographically switched, the butterfly would become extinct due to temperature intolerance. Elevated or lowered temperatures due to climate change could therefore have serious consequences for lepidopterans. Trudgill *et al.* (2005) summarises as follows: Each insect species is adapted to a particular temperature range and within this range, with an increase in environmental temperature, the rate of development increases until an optimal rate is reached at a particular temperature (T_o). The rate of development decreases above this temperature until development stops at a maximum temperature (T_m). At environmental temperatures lower than $T_{o,}$ development slows until it ceases at basal temperature (T_b). This information is vital to an understanding of a species life history strategy, population dynamics and distribution. A number of authors have advocated the farming of mini-livestock such as insects (De Foliart 1999). Such species specific data will be essential for these initiatives. For *H. variegata* however, the basic temperature range suitable for the development of this insect is not known.

3.2 AIM AND OBJECTIVES

3.2.1 Aim

To investigate aspects of the biology of *H. variegata* and to gain an understanding of the thermal tolerances of each life history stage.

3.2.2 Objectives

The objectives of this study were to:

1. Determine the egg clutch size.
2. Investigate the number of larval instars.
3. Determine survivorship and development time for each life history stage at ambient temperature (temperature range as given below).
4. Investigate the effect of temperature on survivorship and development time for each life history stage.
5. Investigate possible overwintering strategies of *H. variegata*.
6. Identify the food plants utilised by the larva and relate this to moth distribution.

3.3 MATERIALS AND METHODS

3.3.1 Founder Stock

In late November 2008, 100 late instar larvae were collected from the Glade village (Chapter Five) in the foothills of Blouberg Mountain (23° 05.050’S, 029° 02.630’E) for use as founder stock from which to obtain adult moths and then eggs. Late instars are easier to maintain than early instars. Larvae were collected from the primary host plant, *C. armatum.* They were maintained at ambient temperature (between 25°C and 34°C) in chiffon-covered nine-litre buckets in Polokwane, South Africa. Fresh *C. armatum* branches were placed in the buckets on top of a 10 cm layer of commercially available potting soil used as a substrate for pupation. Branches were replaced each evening and were sourced from communal land at Boyne, 35 km East of Polokwane (23.946018°S, 29.811215°S). The number of larvae per bucket was recorded. Due to their gregarious nature, between 15 and 20 caterpillars were maintained per bucket. Klok and Chown (1999) showed that in gregarious larvae, the number maintained together can influence survival therefore it was important to simulate natural crowding conditions. Once pupation had taken place, buckets containing pupae were monitored to ensure that when emerging, adults could be paired immediately in order to obtain eggs and larvae. Parasites that emerged from the pupae were identified by dipteran specialists (Chapter Two).

3.3.2 Rearing Technique

Hemijana variegata has never been reared in captivity and therefore a technique for rearing and monitoring individual and/or early instar larvae using pottles was developed by modifying that described by Berndt *et al.* (2004). Early instars are highly sensitive to humidity and leaf quality and difficult to rear. Pottles were constructed using 250 ml clear polypropylene cups. Each pottle consisted of a cup with a two cm diameter hole drilled out of the bottom and stacked into a second identical but entire cup. Four to six short (15 cm) *C. armatum* branches were bound together by removing the thorns at the base of the branches and securing with adhesive tape. These were pushed through the hole in the upper cup such that 3 cm of the cut branches rested in 2 cm of water placed in the lower cup, keeping the leaves fresh until they could be replaced at each feeding. White chiffon gauze was secured over the upper cup with an elastic band. They were populated by larvae that hatched from eggs obtained from founder stock maintained as above. These larvae were used to determine development at ambient temperature and at four designated temperatures. For the first three instars, larvae were maintained at a density of 20 per pottle but from the fourth instar until pupation the density was reduced to five per pottle. Larvae were reared in a glasshouse at the University of Limpopo, with a temperature variation of 25 to 34°C as for the founder stock and the food plant was also sourced from Boyne. Misting was found to be unnecessary as the caterpillars obtained sufficient water from the food plant. From the fifth instar onwards, garden soil was provided at the bottom of the upper cup to allow the pre-pupae to bury themselves prior to pupation. Unfortunately this soil became waterlogged due to water leaking in from the lower cup and none of these pupae survived. Investigations into pupal development time therefore required that a second batch of late instar larvae were collected from the field as below.

Due to the high mortality rate in the larval stage, individuals were not monitored throughout their life span but each life stage was examined separately. Insects were maintained at four temperatures for each life stage in order to investigate the temperature range over which the species can survive. Temperatures in the Blouberg area can range from an absolute minimum in July of –3°C to an absolute maximum in December of 38°C (Scholes 1978). No previous studies have investigated the temperature range at which *H. variegata* can survive or develop and therefore a wide range of temperatures was chosen at which to rear the insects including ambient temperature. For all temperature experiments except that at ambient temperature, the insects were reared in incubators under a 16hL:8hD light regime at the following constant temperatures: 17°C, 23°C, 29°C and 35°C.

3.3.3 Development of Life History Stages at Ambient Temperature

3.3.3.1 Clutch size, development time and hatching success at ambient temperature: Buckets with pupae obtained from the founder stock larvae were checked weekly from pupation in November 2008 until 23 December 2008, after which eclosion commenced and buckets were then checked daily at 20h00. Moths emerged sporadically in the early evening and were placed in pairs in 30 cm wide plastic tubs covered with white chiffon. Twigs of the food plant were placed in the tubs as laying substrate although moths frequently laid the eggs on the chiffon covering. Copulation usually commenced rapidly after moths were paired and egg batches were collected and eggs counted the following morning to record egg clutch size. Due to the wide variation in pupal development time it was difficult to obtain adult pairs. One individual of a pair would usually die before another adult of the opposite sex emerged. Occasionally, more than one pupa eclosed at the same time in a bucket.

This resulted in a number of adult moths of different sexes pairing and egg clutches being laid with no record of how many pairs had produced the eggs. These eggs were therefore not utilised in the investigation into egg clutch size. Twenty four clutches of eggs were obtained in the above manner and in January 2011 eggs were again obtained following a similar procedure whereby late instar larvae were collected and reared until pupation and eclosion. Four clutches of eggs were obtained, and again, because the moths seldom emerged synchronously, a low number of egg clutches were acquired. These egg clutches were maintained at ambient temperatures (25°C–35°C) and the date on which the larvae emerged, as well as the number of eggs per clutch that hatched successfully, was recorded. Eggs were described. For thirteen of these clutches, the proportion of egg hatching success was regressed against egg clutch size to determine whether there is a relationship between the two as is in the case of the edible caterpillar, *Imbrasia belina* (Wiggins *et al.* 1997).

3.3.3.2 Larval development at ambient temperature:

In February 2009, four clutches of eggs were obtained from laboratory maintained pupae that emerged as adults in captivity. Pupae developed from late instar larvae collected from the Glade village. The 242 eggs were produced by four separate adult pairs and were laid on the chiffon gauze covering the pupal buckets. Upon hatching, 242 first instar caterpillars were immediately placed into pottles in groups of twenty and maintained as above. Sterilised, fine, horse-hair paint brushes were used to transfer the minute caterpillars. Survivorship data as well as number of days from hatching until pupation were recorded. Pottles were maintained in a glasshouse at the University of Limpopo under ambient temperatures of 25–34°C. Survivorship data and days until pupation were recorded. Larvae were photographed and described. Development period of the pre-pupal stage was determined by recording the number of days elapsed between the disappearance of the pre-pupa beneath the soil and pupation (n = 80) (Ande and Fasoranti 1997).

Due to high larval mortality it was problematic to rear larvae individually in order to directly observe the number of larval instars. An indirect method was therefore used. Dyar (1890) found that head capsule size remained static during instars, only growing in the short period during moulting and before the exoskeleton becomes hardened. Head capsules were measured across the widest portion of the head capsule, from the outside of each eye capsule. Provided there is no developmental polymorphism in the species, successive stages of larval head capsule widths (hcw) would thus describe a regular geometric pattern (Dyar 1890, Schmidt *et al.* 1977, Floater 1996). This geometric progression can be described as:

$$\mathbf{Y = ae^{bX}}$$

Here **Y** = head capsule width, **X** = instar number (1,2,3 etc), **e** the slope of the curve and **a** & **b** are constants (Floater 1996).

It serves as a growth curve and a method for checking of an overlooked instar. A frequency distribution can be plotted of head capsule widths, with each peak representing one larval instar. The assumption is made that the distribution of head capsule widths within each instar is normal and that there is no sexual dimorphism in head capsule width (Delbac *et al.* 2010). In order to test that one or more instars have not been missed by following this method, the above equation is made linear by taking the natural logs of both sides thus giving:

$$\mathbf{\ln Y = c + bX}$$

Here c = ln(a) and the relationship between lnY and X should be a straight line with slope b and serves as a growth curve. A significant deviation from a straight line indicates that an instar has been overlooked in the frequency distribution and/or that the species exhibits developmental polymorphism (Floater 1996).

Larvae were reared in pottles as above (rearing technique) and all exuviae (n = 534) were collected as they moulted. Following Floater (1996) the head capsule widths of all larval exuviae were measured to the nearest 0.001 mm across the widest section of the head using a stereoscopic dissecting microscope equipped with a drawing arm. The resulting frequency distribution was used to delineate a number of instar classes according to peaks in the graph. The range in head capsule widths (hcw) per instar class was determined and all hcw were log transformed and thus translated into larval size in mm. The average ln(hcw) per instar class was determined and regressed against instar class.

3.3.3.3 Pupal development time at ambient temperature:

A further 186 late instar larvae were collected from the Blouberg Nature Reserve in late November 2008 and maintained in buckets in the same way as that for the founder stock. The number of caterpillars per bucket was recorded and each evening the number of caterpillars remaining above ground per bucket was noted and thus the number of caterpillars that had pupated could be deduced. The remaining caterpillars per bucket were removed and placed in fresh buckets. The number of caterpillars that pupated and the date of pupation were recorded for each old bucket. Pupae were observed on a daily basis each evening for the emergence of moths. Tap water was sprayed on the soil when rain occurred to simulate the timing of natural precipitation. The buckets of pupae were maintained and pupal eclosion recorded until November 2010, two years after the onset of the experiment. The number of pupae remaining per bucket and whether or not they had been parasitized was recorded and observations were terminated.

3.3.4 Development of Life History Stages at Four Constant Temperatures

3.3.4.1 Influence of temperature on egg development time and hatching success:

During January and February 2009, seven clutches of eggs were reserved for an investigation into the influence of temperature on egg development time and hatching success. The eggs were obtained from adult moths which laid eggs on white chiffon gauze as described above. The gauze was cut such that the same number of eggs from each clutch was placed (still on the chiffon) in incubators at four different temperatures (17°C, 23°C, 29°C and 35°C). Thus 334 eggs were maintained at each temperature and monitored daily until hatching occurred. Hatching success and development time for each individual egg was recorded.

3.3.4.2 Influence of temperature on larval survivorship:

During January, February and March 2009, seven clutches of eggs were obtained from 100 late instar larvae, collected from the Glade village and maintained on *C. armatum* leaves in buckets as described above under founder stock. Equal numbers of eggs were placed at each temperature. Earlier pilot studies had revealed that the eggs generally took between nine and 10 days to hatch at ambient temperature from the time of laying. Thus on the eighth day after oviposition they were transferred to pottles with fresh leaves and placed in incubators at four different temperatures:

17°C, 23°C, 29°C and 35°C. The number of larvae maintained from the start of the experiment at each temperature differed slightly due to the fact that not all the eggs hatched successfully. Larval mortality was very high and therefore development could not be monitored and percentage of larvae surviving every third day was recorded. By the seventh day all larvae at all temperatures had expired and the experiment was terminated.

3.3.4.3 Influence of temperature on pupal development time:

Due to larval mortality mentioned above these caterpillars could not be used in pupal development experiments. Thus, in early December 2010 late instar caterpillars were collected from the Glade village and maintained in captivity as described above. Twenty pupae developed from these caterpillars and were maintained at each of the four temperatures in honey jars filled with potting soil to a depth of 4 cm (17°C, 23°C, 29°C and 35°C). They were monitored daily for eclosion, which was recorded for 90 days, after which the experiment was terminated.

3.3.5 Food Plants and Distribution

People who harvested the caterpillars were interviewed to identify the caterpillars' food plants and also to ascertain the number of generations per year. Plants on which the caterpillars were present and actively consuming the leaves were sampled and identified at the Larry Leach Herbarium, University of Limpopo. Distribution records of *H. variegata* were requested from all natural history museums with Lepidoptera collections in South Africa. The Ditsong Museum of Natural History, Gauteng, South Africa was the only collection that housed specimens of *H. variegata*. These records were compared with distribution records of the primary host plant, *C. armatum*, obtained from the South African National Biodiversity Institute (SANBI). Unpublished open source distribution data on *Canthium armatum* and on the secondary host plant, *P. hystix,* was acquired from the GBIS database which supplemented data acquired from SANBI. Distribution data on *Hemijana variegata* was not available from this source. Geographical data obtained for *H. variegata* and *C. armatum* was converted to degree format and imported into the Open Source GIS programme, Quantum GIS, Lisboa version1.8.0. A distribution map was generated for *H. variegata, C. armatum* and *Pyrostria hystrix*. which *H. variegata* is consumed.

3.3.6 Statistical Analysis

The computer package program SPSS (The Statistical Products and Service Solution, Inc., Chicago, IL, USA version 13.0) was used to analyse the data. One-Way Anova (ANOVA) was performed on the results to determine whether or not there was a significant difference in development time for each life history stage for different temperatures. ANOVA was also performed on the results of hatching success of eggs at different temperatures. The strength of the linear regressions performed on instar head capsule widths vs. instar and on egg clutch size vs. egg hatching success was tested using ANOVA.

3.4 RESULTS

3.4.1 Development of Life History Stages at Ambient Temperature

3.4.1.1 Clutch size, development time and hatch success at ambient temperature:

Eggs were laid in clusters, which is characteristic of gregarious lepidopterans (Bouyer *et al.* 2004). In the field they were laid within 3 m of the ground on dry grass stalks and on the thorns and branches of the host plant, *C. armatum* (Figure 3.2). Newly laid eggs were 1.5 mm in diameter and deep chocolate brown in colour, each egg bearing a minute hair at its apex. The eggs were usually laid in contact with each other, in groups, with gaps between each group. Each female laid only a single clutch before expiring soon afterwards.

Figure 3.2 Eggs of *H. variegata* laid on dead grass stalks in early summer before the first rains, 2009, Blouberg Nature Reserve, Limpopo Province.

Twenty four egg clutches were obtained from January to March 2009 and a further four in January 2011. Each clutch contained between 180 and 490 eggs, with an average of 262.32 ± 66.43 eggs laid per clutch (n = 28). Larvae started to emerge in the early morning, generally between 06h00 and 07h00. Usually, all larvae in a clutch would emerge within four hours but in some clutches emergence took up to 24 hours. Generally, if eggs started to hatch on a cooler day, it took longer for all caterpillars in that clutch to emerge. Twenty four egg clutches were monitored for development time at ambient temperature. Eggs took between eight and ten days to hatch (Figure 3.3), most frequently eight days and on average 8.45 ± 0.60 days (n = 4217).

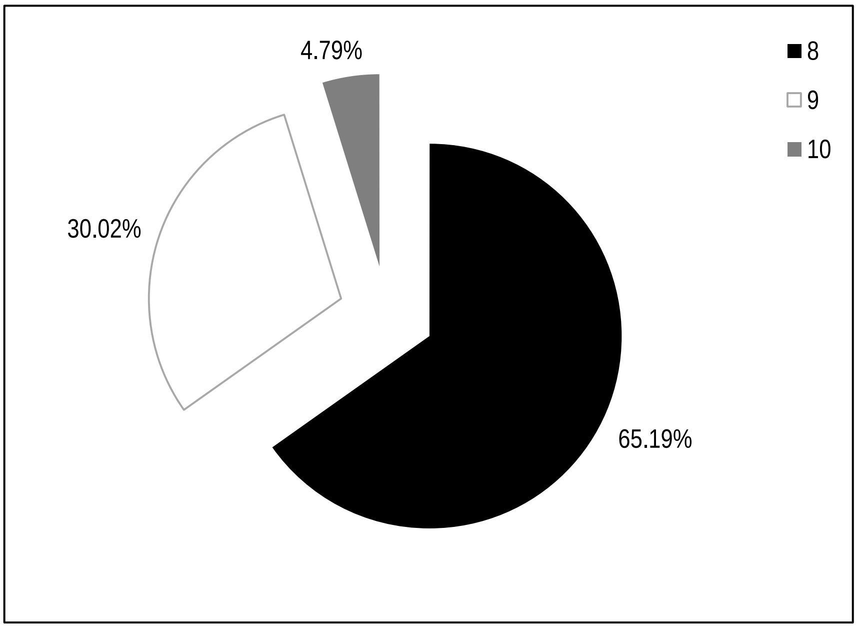

Figure 3.3 Percentage of larvae hatching in 8, 9 or 10 days at ambient temperature (n = 4217).

Thirteen clutches were monitored for egg hatch success at ambient temperature. Hatch success was on average 98.67 ± 1.77 (n = 3 529) and ranged between 93.78% and 100%. A regression of the proportion of egg hatching success against egg clutch size did not reveal a significant correlation between them. Equation: y = 0.0001X + 0.9344 (R^2 = 0.024; F = 0.272; standard error of the estimate = 0.005840; p = 0.613; total df = 12).

3.4.1.2 Larval development at ambient temperature:

The appearance of the larvae was very similar throughout this life stage, with instars differing mainly in size. Upon hatching each larva weighed 0. 68 ± 0. 13 mg (n = 21). They were covered with soft, grey, non-urticating hairs (Figure 3.4). At each successive instar, the lateral line on each side of the grey body became progressively darker, as did the mid-dorsal line. At regular intervals along these lines, orange-brown tufts of hair were present, co-inciding with short dark transverse stripes. Hair was longer and darker at the anterior and posterior ends of the body. The head capsule was a deep russet red-brown colour. The captive maintained larvae were nocturnal, feeding during the evening and hiding along the twigs of the foodplant during the day.

Figure 3.4 Three larval instars of *H. variegata* indicating instar 2 (a) instar 4 (b) and instar 5 (c).

Survivorship of larvae from hatching until pupation under laboratory conditions was 30.12% (n = 73 clutches). The high rate of larval mortality created difficulties in determining growth rate under differing temperature regimes and laboratory techniques should be refined. The average number of days from hatch until pupation was 25.79 ± 3.69 days, ranging from 20 to 33 days (n = 73). The pre-pupa develops into a pupa in 2–5 days (average 3.39 ± 0.61 days) (n = 80).

3.4.1.3 Number of larval instars at ambient temperature:

From an examination of the frequency distribution, five instar classes were delineated according to the peaks in the graph, ranging in head capsule size as follows (Figure 3.5):

Instar 1: 0.3 – 0.7 mm

Instar 2: 0.716 – 1 mm

Instar 3: 1.016 – 1.35 mm

Instar 4: 1.367 – 1.95 mm

Instar 5: 1.967 – 2.833 mm

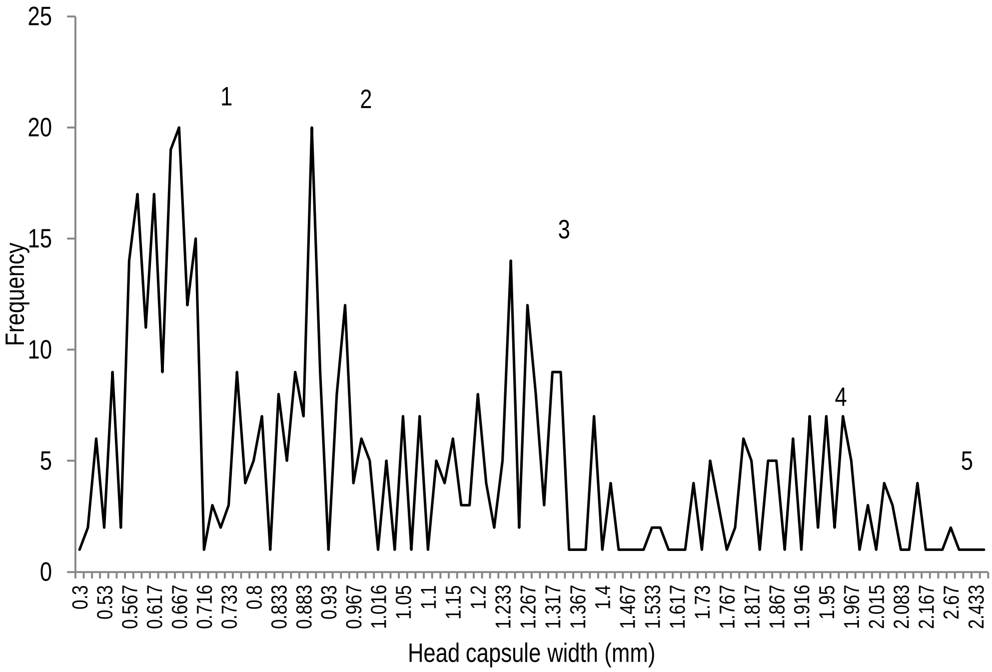

Figure 3.5 Frequency distribution of number of head capsules against head capsule width in mm showing five larval instars (n = 534).

Head capsule widths were log transformed and thus translated into larval size in millimetres. The average size per instar class was determined and regressed against instar class (Figure 3.6). The equation for the line is: $y = 0.3149 X – 0.7746$ ($R^2 = 0.9934$, standard error of the estimate = 0.04677, F = 453.266, P = 0.000, df = 4, 95% confidence level). The fit to the straight line is good, giving support to the hypothesis that there are indeed five larval instar classes in *H. variegata.* There is no evidence of larval polymorphism.

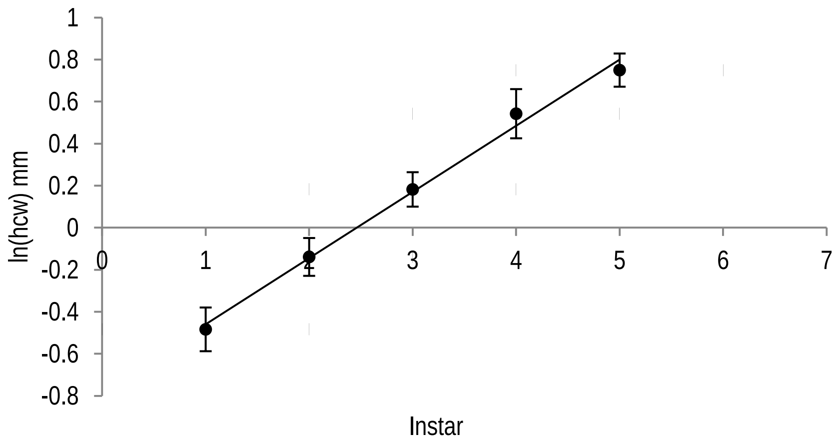

Figure 3.6 Regression of larval size, ln. (head capsule width), against larval instar (n = 534) showing a good fit to the straight line.

3.4.1.4 Pupal development time at ambient temperature:

Pupae were approximately 20 mm long and 7 mm wide (Figure 3.7). No cocoon was present and the pre-pupae burrowed into soil for protection. The pupae were smooth and chocolate brown in colour. Roughly 24 hours before pupating, the caterpillars would become restless, cease feeding and search for a pupation site. They would then move into the soil to pupate, frequently emerging some hours later to repeat their search until finally settling in the soil. Moths always emerged in the early evening and once they had been paired, copulation usually took place immediately, upon which females would lay one clutch of eggs, generally expiring by the third day. Males would live for slightly longer; on occasion, up to five days.

Figure 3.7 Newly-formed pupae of *H. variegata.*

Of the 186 caterpillars that were collected, 119 emerged as moths between the beginning of January and the end of April 2009. Development time varied between 32 and 116 days with most moths emerging after 60–69 days (Figure 3.8). The average number of days to eclosion was 62.45 ± 18 days. Twenty four percent of the pupae had not emerged by November 2010 and 12% of the 186 caterpillars were parasitized by two tachiniid flies: *Lydellina* sp. and *Exorista* sp. (cf. *xanthaspis*) (determinative Pierfilippo Cerretti 2012). The minimum number of days to eclosion at ambient temperature was 32 days and the maximum was 116 days.

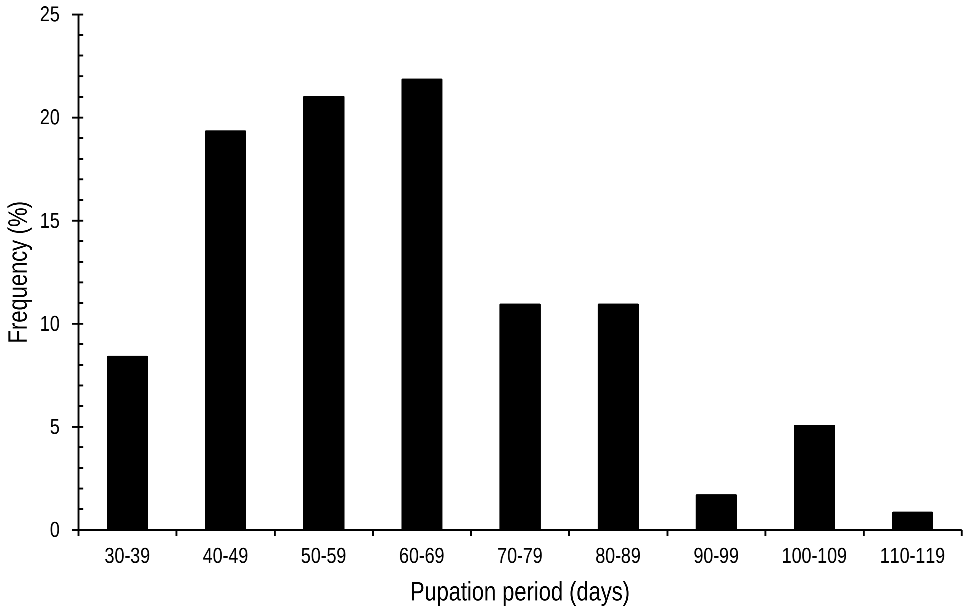

Figure 3.8 Percentage of pupae emerging at various time periods (n = 119).

3.4.1.5 Duration of life cycle at ambient temperature:

The life cycle of *H. variegata* takes approximately 100 days to complete in the laboratory (Figure 3.9). This is highly variable due to the pupal life stage which can be completed in as little as 32 days or take longer than 116 days.

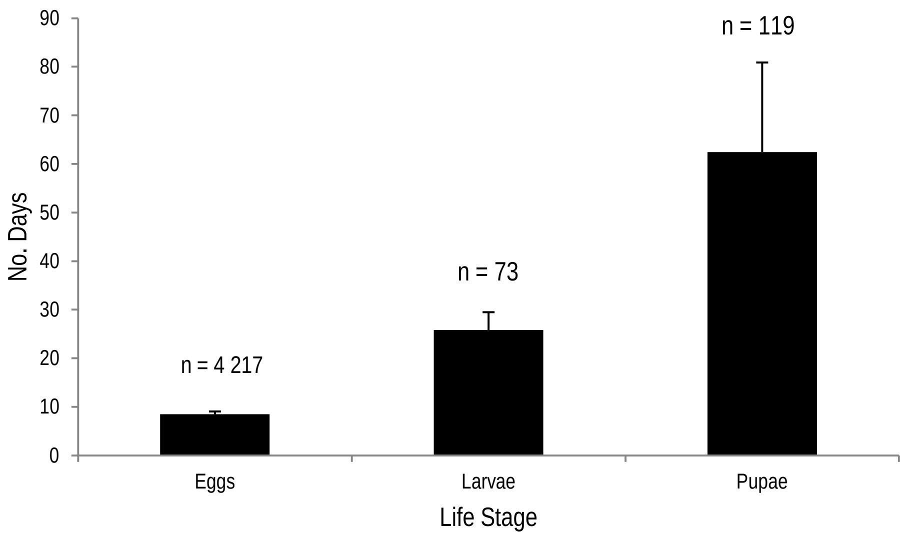

Figure 3.9 Average duration in days for three life stages of *H. variegata.*

In the field, larvae were observed to appear after the first rains. In 2007, the first year in which they were collected, final instar larvae were found at Glade village on 12 November, indicating an earlier hatch date than the following two years. In 2008 first instar larvae were collected on 11 November at the Glade and in 2009 they first appeared on 8 November. Under laboratory conditions pupal eclosion occurred after approximately three weeks. These moths emerged to oviposit immediately resulting in two generations within one summer season.

3.4.2 Development of Life History Stages at Four Constant Temperatures

3.4.2.1 The influence of temperature on egg hatching success and on egg development time:

At 17°C and 35°C none of the eggs hatched successfully. However, hatching success was 86% ± 17.43 at 23°C and 80.86% ± 18.66 at 29°C. One-way ANOVA performed on results at all four temperatures showed that there was a significant difference between all temperatures ($F = 99.855$, $p < 0.0001$, df 27) with a Tukey HSD test revealing that the difference between 23°C and 29°C was not significant at the 0.05 level ($n = 334$).

Eggs incubated at 17°C were left for 30 days to simulate winter and to test whether it is possible for *H. variegata* to overwinter in the egg stage. After 30 days they were incubated at 29°C for 30 days and monitored for hatching. None of these eggs hatched during this period. Eggs incubated at 35°C were not utilised further.

Egg development time was 11.29 days ± 0.74 (range 8–10) at 23°C and 8 days ± 0 at 29°C. One-way ANOVA performed on results at all four temperatures showed that there was a significant difference between all temperatures ($F = 973.563$, $p < 0.0001$, df 28). Furthermore the Tukey HSD test confirmed that the difference between 23°C and 29°C was significant at the 0.05 level ($n = 334$).

3.4.2.2 Influence of temperature on larval survivorship:

By the seventh day all larvae maintained at all four temperatures had died (Figure 3.10). Larvae kept at 17°C suffered the highest mortality over the shortest time duration, while larvae at 29 °C survived the longest. Rapidly deteriorating quality of the host plant leaves was the most likely cause of the high mortality rate.

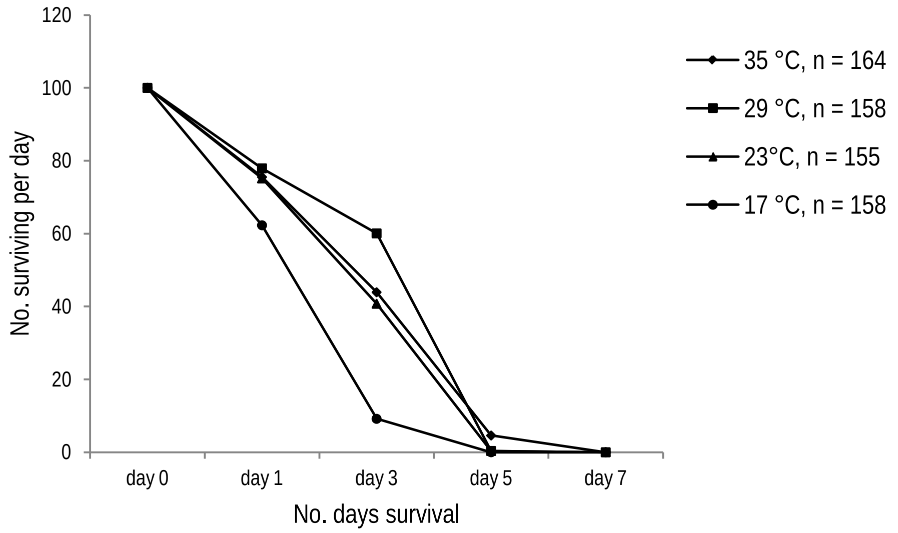

Figure 3.10 Larval survivorship at four temperatures over seven days.

3.4.2.3 Influence of temperature on pupal development:

Eclosion did not occur at all at 17°C and 35°C. Twelve of the pupae maintained at 17°C were left at this temperature for 90 days to simulate winter and to test whether it is possible for *H. variegata* to overwinter during the pupal stage. After 90 days the temperature was raised to 29°C for 30 days and eclosion was monitored. After approximately four weeks, four adult moths emerged indicating that it is possible for pupae to successfully overwinter. One pupa was parasitised and six were drowned when the incubator developed a leak.

At 23°C, 45% of the pupae emerged as adults over the time period of the experiment (90 days) and at 29°C, 65% emerged.

At 23°C the average time to eclosion was 49 ± 5.59 days (range 43 to ≤ 90 days) and at 29°C it was 40.69 ± 5.36 days (range 33 to ≤ 90) (Figure 3.11). This difference was significant with $F = 9.26$, $p < 0.006$, df = 21 (ANOVA). The maximum number of days to eclosion was not known as the experiment did not continue past 90 days. Minimum number of days to eclosion are depicted in Figure 3.12.

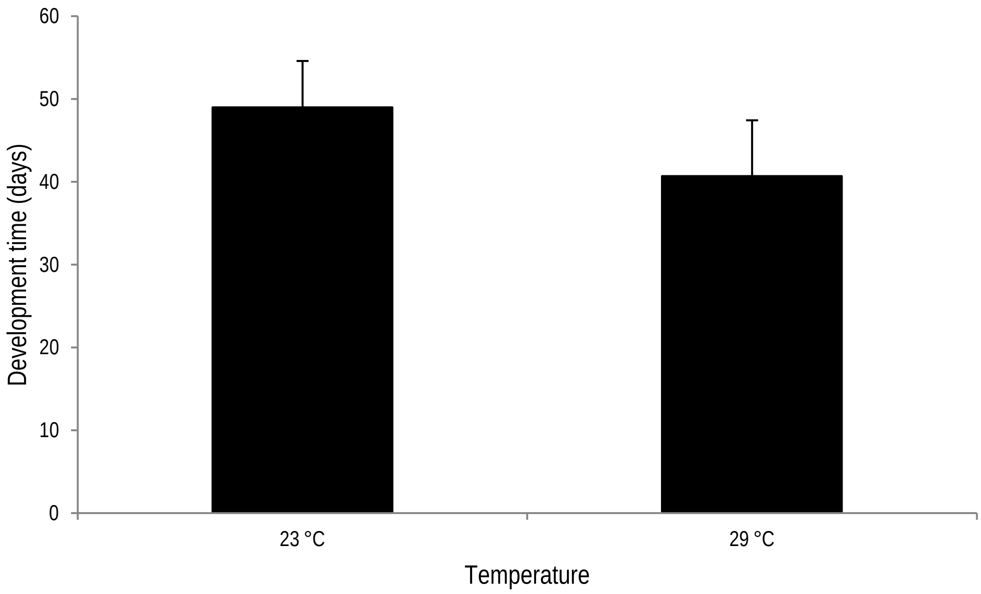

Figure 3.11 Average number of days to eclosion at two temperatures.

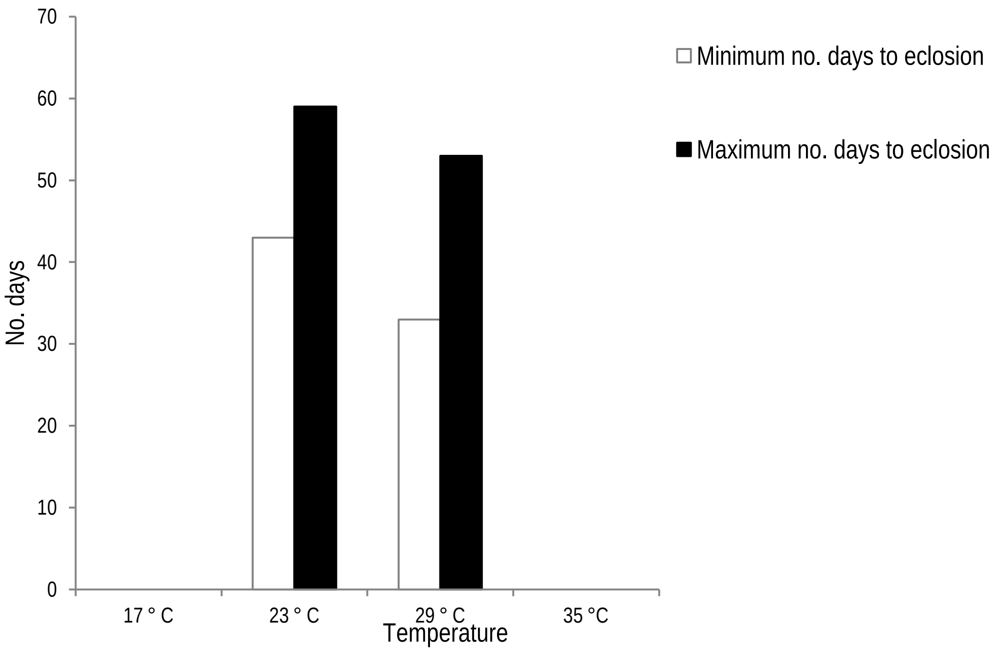

Figure 3.12 Maximum and minimum number of days to eclosion at four different temperatures (n = 20). At 35°C and 17°C pupae did not eclose at all.

3.4.3 Food Plants and Distribution

The caterpillar inhabits the canopy of open woodland areas feeding mainly on *C. armatum,* a small tree armed with large decussate thorns (Palgrave 2005). It also feeds, to a much lesser extent, on the thornless shrub, *P. hystrix* (personal communication, Waleng, F. 2009 and personal observation, 2009). *C. armatum* is known as *mophetha* in seHananwa and *P. hystrix* is known as *molebatja* and is much less common. *Bophetha* harvesters from Liepzig Village are familiar with this shrub and its role as a food plant of the caterpillar but this is not well known in other villages where the caterpillar is collected. *H. variegata* has been recorded from the Lebombo Mountains and along the coast of KwaZulu Natal Province, into Sekhukhune, Venda and Capricorn districts of Limpopo Province. It also occurs in Swaziland but distribution records are scanty (unpublished distribution data: Ditsong Museum of Natural History, Gauteng). All interviewees stressed that the caterpillar has only one generation per annum.

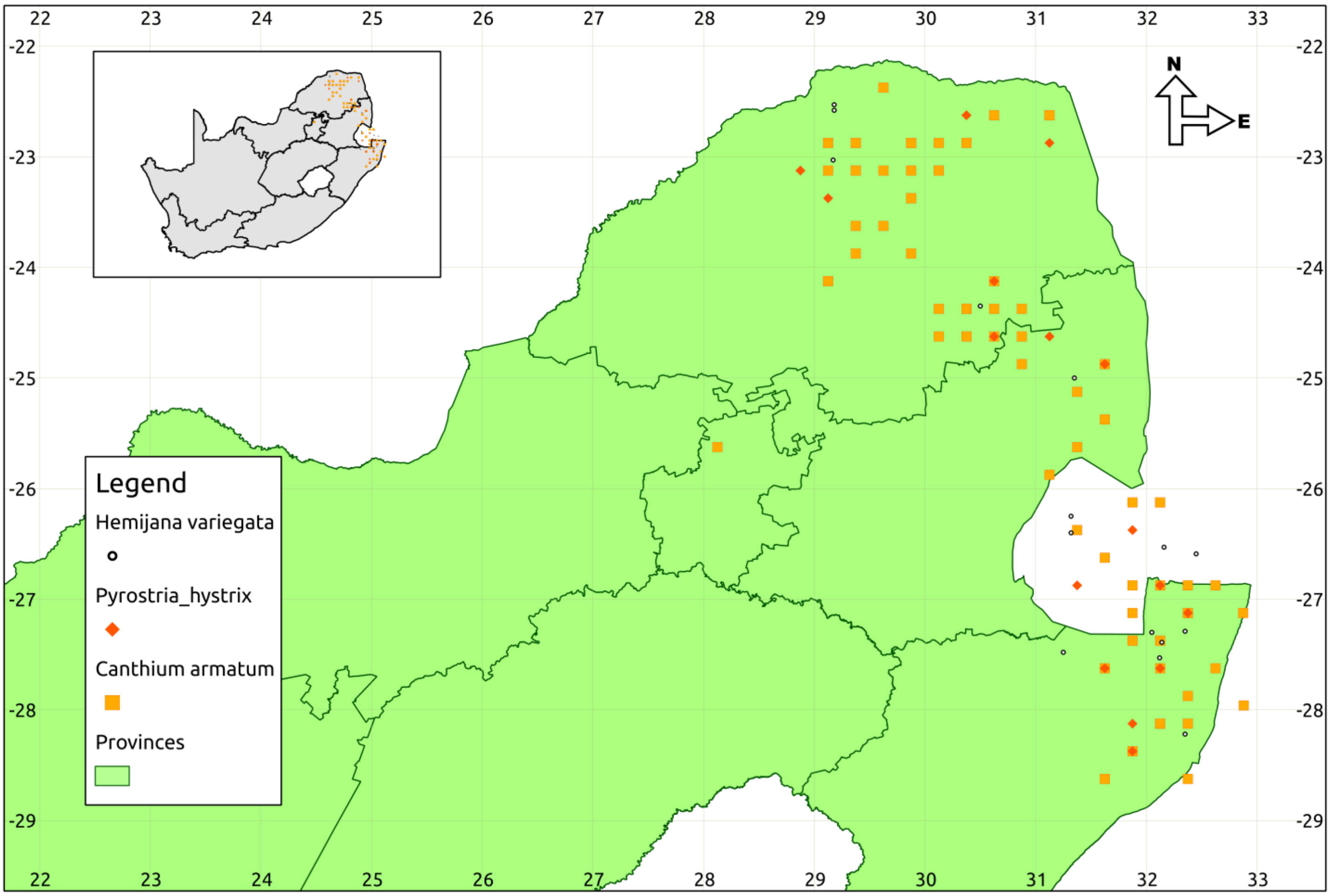

Figure 3.13 Map indicating distribution of the primary host of *H. varigeta*, *C. armatum* trees, that of the secondary host, *P. hystrix*, as well as the overlapping distribution of *H. variegata* in South Africa. (Map assistance courtesy V. Egan).

The general distribution range of the moth coincides with the distribution of both host plants. From anecdotal information, the caterpillar appears to be consumed in most areas where it occurs in Limpopo, but no records of consumption exist for Swaziland or KwaZulu Natal (Figure 3.13). Thus inhabitants of Venda, Sekhukune and Capricorn Districts all consume caterpillars.

3.5 DISCUSSION

3.5.1 Development at Ambient Temperature

First instar *H. variegata* larvae appear on *C. armatum* trees in early November. This is generally two to three weeks after the first rain of the season. The mean annual rainfall data for Blouberg Nature Reserve is shown in Figure 3.14. The appearance of the larvae coincides with the emergence of new leaf buds (unpublished data, Blouberg Nature Reserve).

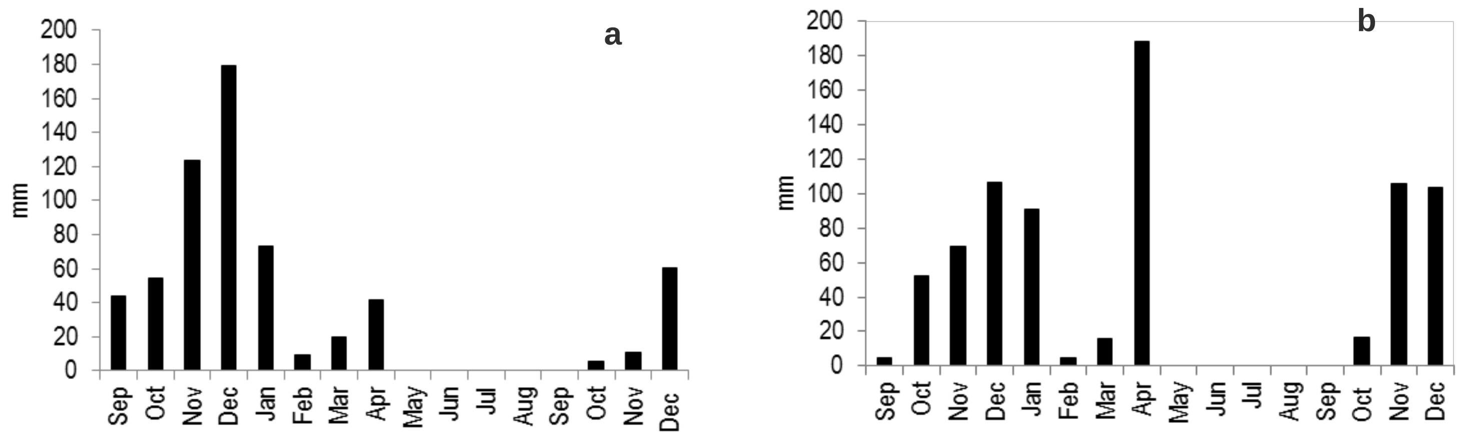

Figure 3.14 Rainfall data from Blouberg Nature Reserve for the period September to December for the years 2007–2008 (a) and 2009–2010 (b).

Laboratory observations revealed that first instar larvae are unable to feed on older leaves and thus hatching must be synchronised with leaf emergence. *C. armatum* is deciduous, which may account for the fact that *H. variegata* produces two generations in the laboratory but is univoltine in the field. By the time the second generation of larvae are ready to hatch, *C. armatum's* leaves have hardened and a new flush of leaves is unlikely until the following season, leaving the young larvae unable to feed. The surface and internal characters of the leaf strongly influence the success or failure of first instar larvae to establish themselves on a food plant (Zalucki *et al.* 2002). Furthermore, the simple process of rapid leaf expansion and consequent decrease in leaf quality has also been shown to contribute to larval mortality and is thus one of the defence mechanisms available to plants (Aide and Londono 1989). It is known that lepidopteran larvae feeding on young leaves develop faster than those feeding on mature leaves (Scriber and Feeny 1979). *C.*

armatum exhibits synchronous flushing of leaves in early summer, which has been shown to decrease damage to host plants by satiating larvae (Aide and Londono 1989). In a study in a dry tropical forest in Ghana it was concluded that although the primary driver of synchronous flushing is a constraint in moisture, a consequence of such flushing is folivore escape for the plant in question (Lieberman and Lieberman (1984).

In the laboratory, early instar, second generation *H. variegata* larvae exhibited such high mortality rates that developmental experiments were compromised. The probable cause of the high mortality was that the caterpillars hatched after the available host plants had already produced the spring flush of new leaves. Thus it was not possible to feed the larvae on freshly emerged leaves. Aide and Londono (1989) found that in *Gustavia superba*, the host tree for the herbivorous lepidopteran *Entheus priassus,* leaf toughness increased from 0.11 MPa to 0.34 MPa, the level of a mature leaf, over ten days. Similarly, water content decreased over 10 days from 85% in ¼ expanded leaves to 76% in fully expanded leaves, the same content as that of mature leaves. First instar larvae therefore have a short window period in which to become established on a host plant with leaves at a suitable stage and to rapidly grow so that once the leaves are fully expanded, they have developed enough to exploit the maturing leaves. The same study found that hatching date should be correlated with leaf expansion to ensure survival. Larvae hatching on the day before the leaf reaches full expansion are four times more likely to survive than larvae hatching on the day the leaf is fully expanded. Oviposition should occur at least three days before the leaves are due to reach their full size or it is unlikely that any of the larvae will survive.

In *H. variegata,* an investigation into the effect of leaf quality and the timing of leaf flush would assist in maintaining captive colonies in the laboratory and also help to predict harvest time of caterpillars in the field. The possibility of rearing larvae on an artificial medium should be explored as this has been found to be successful with mopane worms (*I. belina*) where corn flour, wheat germ, wheat bran, brewer's yeast, milk, castor oil, chicken mash and water were blended into a medium for mass rearing (Ghaly 2009). Rearing on artificial medium may not be feasible for *H. variegata* as not all caterpillars will take such a food source and when given a choice most caterpillars studied will opt for the natural diet (Fitzgerald 1995). If rearing on a synthetic diet is possible, it will facilitate further investigation into the developmental biology of *H. variegata* as experimental procedures will not need to be linked to the timing of the first flush of leaves on *C. armatum*. Developing an artificial medium for *H. variegata* will also allow for exploration of the prospect of mass rearing the caterpillars for commercial use. The possibility of freezing new leaves for later use should also be examined as this has been found to be successful for tent caterpillars (Fitzgerald 1995).

Development time between hatching to pupation in the larvae of *H. variegata* ranges between 20 and 33 days. Larval growth rates are generally determined by temperature as well as food quality and quantity (or availability) (Liemar 1996). According to Blouberg harvesters, larvae are only available at the correct size for consumption for one to two weeks per annum per area before they pupate (Chapter Five). Only fourth and fifth instar larvae are collected, as younger instars are considered too small for consumption. Thus during the course of this study, first instar larvae that emerged in early November, were harvested in late November or early December (Chapter Five), which corresponds to the larval development time in the laboratory.

In contrast to the larvae, which have a narrow developmental time range of only 13 days, *H. variegata* pupae can take as little as 32 days, or more than 119 days, to eclosion. This wide variation may be an adaptation to climate fluctuation. In years when rainfall is poor, or late, harvests of *H. variegata* are lower (Chapter Five) indicating the negative effect of at least one climatic variable on the population. The presence, in populations, of individuals capable of delaying eclosion until precipitation has occurred, may be a strategy that ensures their survival in areas where droughts are often experienced.

Egg clutch size varies widely as it was also found to do so in mopane worms (*I. belina*) (Wiggins 1997). However, although it was speculated that the discrepancy in clutch size in *I. belina* was due to each female laying multiple batches of eggs, this was not the case for *H. variegata.* In this study each female laid only a single clutch over a short period of a few hours in the early evening. In contrast to *I. belina*

(Wiggins 1997) hatching success was not correlated with clutch size. In *I. belina* this correlation was attributed to the fact that as moths become older they produce smaller clutches of eggs and the decrease in hatching success in these later, smaller clutches could be due to female senescence. Smaller clutches in *H. variegata* are however not due to senescence of the female as she lays only one clutch which could be small or large and early or late in her lifespan.

3.5.2 Influence of Temperature on Development

In the laboratory, eggs do not survive temperatures below 17°C, and since winter temperatures drop to below 10°C in Blouberg (Scholes 1978), it is probable that the moth does not overwinter as an egg, but rather as a pupa. This is similar to the mopane worm (*I. belina*) which also overwinters by burrowing into the soil as a prepupa to moult into the pupal stage underground (Toms *et al.* 2003). Adult *H. variegata*, which only live for about three days, emerge after the first rain of the season, pair within a few days of emergence and lay eggs on the host plant and on vegetation growing at the base of the plant.

Life tables could not be constructed as these require mortality information from one and preferably more, generations, monitored from egg to adult stage (Southwood 1978, Martin *et al.* 2004). In this study, rearing techniques were still being refined and larvae that pupated in the pottles died from water logging of the soil. In future, late instar larvae should be transferred from the pottles to buckets containing soil for pupation to take place.

H. variegata is sensitive to temperature at all life history stages. Although more precise minimum and maximum temperature thresholds were not determined, it was found that development ceased at all stages below 17°C and above 35°C. The species was found to be vulnerable to average temperatures lower than 23°C and higher than 29°C. The mean daily maximum temperature in the area around Blouberg, where the insects occur, is 26°C (Scholes 1978). Climate change models predict an increase in average temperatures of 3° C by mid-century and 5° C by the end of the century for north-eastern South Africa (Davis 2010). Such increases would significantly affect populations *of H. variegata*, possibly resulting in a change in its distribution, as population simulation models predict an eastward shift of species distribution ranges under the influence of climate change (Erasmus *et al.* 2002).

3.5.3 Domestication

Food safety issues are always a concern particularly when a food source becomes commercially available (Chapter Four). As Harduoin (1995) cautions, all organisms are subject to parasitism and insects are no exception. The presence of parasites in a food type are generally a reason for apprehension, however, unlike the situation with mammalian livestock where parasites are readily able to bridge the divide between human and livestock host, insects are so remotely related to humans that this is unlikely (Cunningham *et al.* 2003). Parasites emerging from the pupae were identified as *Lydellina* sp. a member of the group Exoristini (Townsend 1932) and *Exorista* (cf. *xanthaspis*), both tachiniid flies. *Exorista larvarum* has been used with much success as a biocontrol parasitoid of lepidopteran pests (Dindo *et al.* 1999). No evidence of larval or egg parasitism was found in laboratory reared caterpillars. Eggs were however never exposed to field conditions and therefore parasites had no opportunity to infect them.

It is essential to understand the biology of *H. variegata* before it can be of use in mini-livestock or semi-domestication programmes. Rearing techniques should be modified as below before this can be achieved:

1. First instar larvae must be provided with new growth leaves to prevent starvation and/or dehydration. Alternately a synthetic growth medium should be developed.
2. Late instar larvae should be removed from pottles and allowed to pupate in buckets with 10 cm of soil as a substrate.
3. If possible potted trees should be used. This may be challenging as large numbers of potted trees will be required due to the growth form of the trees which results in minimal leaf cover and an abundance of inedible thorns.

3.5.4 Sustainable Harvesting

As shown above, *H. variegata* is a univoltine insect. When edible insects are bivoltine, such as the mopane worm (*Imbrasia belina*) (Ditlhogo 1996), there is the option of imposing a ban on collecting caterpillars from the second generation in order to allow the populations to recover from harvest of the first generarion. This is not possible for *H. variegata* and imposing quotas such as Ditlhogo (1996) proposes for mopane worms will be difficult to enforce in the Blouberg, where the authorities do not have the manpower for environmental law enforcement. There have been instances in the mopane worm trade, where owners of the land on which the caterpillars occur banned harvesting for an entire season to allow the population to recover from the previous year's harvest (Toms and Thagwana 2005). This has been successful, but, once again, requires the co-operation of the land owner as well as law enforcement officials.

Conservation of *H. variegata* would best be promoted by growing appropriate food plants and inoculating them with *H. variegata* eggs. In addition it is important to continue to protect the two nature reserves (Blouberg and Malebogo) where very little harvesting occurs at present, in order that these areas can be used as a source for recruitment if harvest areas become depleted. Additional zones of 'no harvest' should also be proclaimed although this will also depend on law enforcement. The most feasible means of ensuring recruitment in depleted areas is the transfer of egg clutches. Pupae bury themselves underground and are difficult to locate and moving them could damage the insects. In addition, there is a large variation in the time at which they eclose and thus the danger of moving a large quantity of pupae, which may not eclose for more than a year. This study found pupal mortality to be greater than egg mortality giving another reason to choose eggs over pupae. Larvae are delicate and have a high mortality rate and it would be inappropriate to move them. Egg clutches can easily be transferred to new plants by removing the entire section of the branch on which they are laid to a new area and attaching it to the appropriate tree with minimum disturbance to the eggs. The difficulty with this approach is that there is only a small window period of 10 days during which they can be moved, as eggs hatch within 10 days of being laid. It is, however, easy to distinguish hatched from un-hatched eggs in the field, as hatched eggs have a pinhole on the dorsal side of the egg and are lighter in colour than eggs that are un-hatched.

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CHAPTER FOUR

NUTRITIONAL SIGNIFICANCE OF THE EDIBLE INSECT, *HEMIJANA VARIEGATA,* OF THE BLOUBERG REGION, LIMPOPO, SOUTH AFRICA

An analysis of the proximate nutritional value of the *H. variegata* caterpillar and possible pathogens associated with its preparation.

4.1 INTRODUCTION

Consumption of edible insects, or entomophagy, is an ancient practise, with Ramos-Elorduy (2009) asserting that the insectivorous diet predated the development of hunting. Sutton (1990) highlights the role it played in human evolution and in Africa there are indications that termites were harvested as a food source during the Iron Age, 700 years ago (Van Schalkwyk and Moifatswane 2000). Today, despite increasing globalisation and the tendency for communities to conform more and more to a western lifestyle and culture, entomophagy is still practised in all continents of the world (Ramos-Elorduy 2005), with most edible species recorded from Africa and the Americas. A recent international meeting held by the Food and Agricultural Organisation (FAO 2012) predicted an important role for edible insects in food security as the world's population soars to a projected nine billion in 2050.

In rural Africa particularly, edible insects are not only a source of valuable protein but also a delicacy to be relished in the few short months that they are available (van Huis 2003). With an energy component equivalent to or better than that found in beef and correspondingly favourable values for protein, carbohydrates and fat, research increasingly suggests that entomophagy be promoted (Quin 1959, Dufour 1987, Gullan and Cranston 2000, Yen 2010). Caterpillars eaten by the Bemba in Zambia contain 65 g protein per 100 g of dried caterpillars in comparison to 32 g for dried fish and 30 g for dried beef (DeFoliart 1999). It has been recorded that for mopane worms (*Imbrasia belina*) in southern Africa, the protein and fat values are twice those of beef (Gullan and Cranston 2000, DeFoliart 1999). Protein is, however, not the only benefit to be gained by the consumption of insects. Certain insects contribute significant levels of other important nutrients, for example, the lake fly (*Chaoborus edulis*), harvested in Malawi, possesses significantly higher levels of iron than does beef or liver (DeFoliart 1999). In terms of energy and fat content, caterpillars, ants and termites are comparable, or superior to those of beef, pork and poultry (Dufour 1987). Furthermore, Ramos-Elorduy (2008) found that the fats in holometabolous larvae, such as lepidopteran caterpillars, are polyunsaturated and therefore a healthier option than fats found in conventional beef. Certain insects are consumed not only for their health benefits but also to satisfy the human craving for sugar. In northern Italy for instance, children have, for generations, consumed the nectar-filled crops of day-flying moths of the *Zygaena* and *Syntomis* genera as an easily accessible, cost free source of sugar (Zagrobelny *et al.* 2009).

In contrast to cattle, sheep and other large domestic animals, almost the entire insect, apart from the gut, can be utilised as food rather than discarded as offal (Meyer-Rochow 2010). Insects also have multiple uses. A case in point is the use of grasshoppers in Italy where children collect these Orthoptera both as a source of food for domesticated turkeys and also as a protein rich snack for themselves (Dreon and Paoletti 2009). While collecting the grasshoppers for the turkeys, the hind legs are removed and eaten raw and the remaining insect retained and fed to the poultry. As agriculture becomes increasingly difficult in the face of unpredictable climatic conditions, any food source, particularly that which requires minimal production input, is hardy and can be harvested from agro-ecosystems, becomes extremely valuable (Johnson 2010).

In the same vein, the agricultural sector, chiefly the livestock industry, contributes roughly one fifth of greenhouse gas emissions worldwide (McMichael *et al.* 2007), and it is livestock production which makes up 80% of this sector's emissions (Oonincx *et al.* 2010). McMichael *et al*. (2007) therefore advocate a freeze on the increased emission of these gasses from agriculture in general but with the focus on livestock production. They advise that the quickest and most effective means of reducing greenhouse gas emissions would be to reduce the average worldwide consumption of meat. In addition, the intensity of emissions per unit of livestock production must also be reduced. Switching to alternate sources of animal protein (non-ruminant, monogastric animals), which do not require the deforestation of carbon sequestering vegetation for their production, would mitigate greenhouse gas emissions. In addition, such animal protein does not release the quantity of greenhouse emissions that conventional livestock does. So-called mini-livestock, including edible insects, have higher feed conversion efficiencies than chickens or pigs and more than five times higher for sheep and cattle

(Nakagaki and DeFoliart 1991). Thus a conversion ratio of 4 or 5 : 1 is common in insects, compared to 2.6 : 1 for poultry, 19 : 1 for sheep and 20 : 1 for cattle (Ramos-Elorduy 1996). Oonincx *et al.* (2010) produce evidence that in four out of five insects studied, greenhouse gas emissions were only 1% of that released by ruminants per kg of mass gain. Both these phenomena are due partly to the fact that insects are poikilothermic and do not utilise a large proportion of food for the maintenance of a high body temperature. Another advantage to insects over conventional livestock is that they make use of a broader range of food plants than do cattle, sheep or goats. Finally, insect rearing also utilises less space and generates less pollution than does rearing of livestock (Durst and Shono 2010).

A fairly recent development which highlights the importance of traditional, low cost and healthy foodstuff is that of shifting dietary preferences to more modern and usually less healthy food choices. This is occurring throughout the world and particularly in societies that have until now maintained their traditional roots (Yen 2010). In a paper promoting edible insect consumption in Mexico, Ramos-Elorduy (1996) cautions that due to a change in lifestyles whereby quick and convenient food is preferred over meals that take time to prepare, diets are no longer in tune with appropriate local agricultural practises, the economic level of communities or the health requirements of the population. The same is true in South Africa. Bourne *et al.* (2002) show, in an analysis of urban and rural studies investigating trends in South African dietary choices, that there has been a move towards a more Western diet over the past decades. This would not be a problem if the shift was to a healthier alternative but the opposite is happening. Thus the diets of both urban and rural dwellers have changed such that the proportion of fat consumed has increased while that of carbohydrates and fibre has decreased. Alarmingly, the number of portions of fruit and vegetables has decreased to less than half the recommended number. This has been accompanied by a conversion in eating habits from a fairly large range of food types to a much narrower range. The result is a corresponding increase in obesity, diabetes and hypertension. Diabetes and hypertension are two of the five chronic illnesses that are the leading cause of death worldwide (Yach *et* *al.* 2004), and obesity contributes to the onset of both diseases (Abbasi *et al.* 2002). Moreover, an unhealthy diet is listed as one of the four key risk factors for acquiring these diseases, together with tobacco use, lack of physical activity and alcohol abuse (Yach *et al.* 2004). This is certainly true of South Africa, where, even in rural areas and despite the prevalence of HIV/AIDS mortality, the number of patients dying of such illnesses is steadily increasing (Tollman *et al*. 2008, Mayosi *et al.* 2009). There is thus growing concern amongst health workers in this country that preventable, non-communicable diseases will need to be combated using resources already stretched by the HIV\AIDS epidemic (Mayosi *et al*. 2009).

Promoting healthy lifestyles through the use of nutritious, traditionally available food, is one relatively inexpensive tool that can be used to combat this trend (Mayosi *et al*. 2009). It would seem, from previous research that edible insects are good candidates for such work (Ramos-Elorduy 1996). According to those who have eaten insects, they frequently have a nutty, pleasant flavour (Gullan and Cranston 2000, Chen *et al.* 1998). In southern Africa, many people prefer mopane worms (*Imbrasia belina*) and certain ants (*Carebara vidua*) to meat (Quin 1959), while in South America, beetle larvae (*Rhynchophorus sp*.) and reproductive ants (*Atta* sp.) are highly sought after delicacies, also favoured over more conventional forms of protein such as fish and poultry (Dufour 1987).

In much of the developing world, including South Africa, natural resources are an important supplement used directly for food, housing and cooking and for sale to generate income (Twine *et al*. 2003, Ghazoul 2006). In the Limpopo Province, insects are widely used as a supplementary protein source (Quin 1959, Twine *et al*. 2003, Akpalu *et al.* 2009). One study estimated the annual direct-use value of edible insects to be R565.00 per household in three rural villages in Limpopo. Wild herbs, wild fruit and fuel wood were the only other natural resources out of twelve analysed, that had a higher annual value than insects (Twine *et al.* 2003). Thus insects are valued for their taste, the income they generate and for their calorific value.

Some caution should, however, be exercised. Certain edible insects such as *Cirina forda* and *Anaphe venata*, have been implicated in cases of ataxic syndrome, resulting in severe muscular tremors and gait ataxia (Akinnawo 2002, Paoletti and Dufour 2002). This can be mitigated by processing and cooking of the insects which results in a decrease in the toxicity of the active substances (Akinnawo 2002). The method of harvesting and preparing the insects also influences the ultimate quality of the food source. Pathogens present in the environment and particularly on the hands of the harvesters and processors can infect the insects, transferring a number of diseases to the consumers (Yen 2010). Correct preparation is also sometimes essential for the removal of unpleasant body chemicals used in defence, or plant toxins that build up in the insect gut. In the case of the Amazonian cassava hornworm (*Erinnyis ello*), the digestive tract must be removed before the caterpillars are toasted in order that the residual toxins of the food plant (*Manihot esculenta*) are not ingested (Paoletti and Dufour 2002). The South African edible stinkbug, *Encosternum delegorguei,* must be stirred in a quantity of warm water to ensure that the volatile chemicals causing their offensive smell are discharged before cooking (Dzerefos *et al.* 2009).

Quality can also be affected in certain species by the absence of particular amino acids. For example, edible insects analysed from South America indicate that the amino acid tryptophan is generally lacking and that this affects the quality of insect protein (Dufour 1987), which should then be balanced with the appropriate plant protein (Gullan and Cranston 2000). Isoleucine is lacking in certain insects in Africa (Kodonki *et al.* 1984). Furthermore, there have been isolated incidences of allergic reaction to certain caterpillars. Mopane worms (*Imbrasia belina*) are known to induce hives, urticaria and nausea in certain individuals and in Botwana were implicated in the severe reaction of a 36 year old woman (Okezie 2010). There is also concern that because insects are targeted with pesticides in agricultural lands, harvesting in such areas could be dangerous due to the possibility of ingesting such chemicals (van Huis 2003). These findings are relevant in light of the fact that the FAO are actively promoting the consumption of edible insects as a cheap source of quality protein (FAO 2012).

It is known that in the Blouberg area of Limpopo Province, South Africa, insects are consumed, but the extent of their use and the details of the insects themselves have, until recently, been merely anecdotal and focused mainly on the mopane worm (*Imbrasia belina*), an edible caterpillar from southern Africa (Fourie 2006). From 2005, information collected via questionnaire surveys revealed that at least 30 species of insect from the villages around Blouberg are considered to be edible (Egan *et al.* 2009). For most of these species, research elsewhere has documented their edibility and in some cases their nutritional value (Quin 1959, Shadung *et al.* 2012). Indeed, to date, over 2 086 species of insects worldwide have been documented as edible, being consumed by 3 071 ethnicities (Ramos-Elorduy 2009). However there are a number of species eaten in Blouberg for which the information available is scanty. This paper investigates the nutritional value and the potential pathogens present on traditionally prepared *H. variegata* caterpillars, for which this information is unavailable.

4.2 AIM AND OBJECTIVES

4.2.1 Aim

To investigate aspects of the nutritional value and food quality of the lepidopteran caterpillar, *Hemijana variegata.*

4.2.2 Objectives

The objectives of this study were to:

1. Investigate the proximate nutritional value of *H. variegata* caterpillars.
2. Compare proximate nutritional value of *H. variegata* caterpillars at different drying regimes including traditionally prepared caterpillars.
3. Analyse the vitamin content of fresh caterpillars.
4. Identify possible pathogens present on traditionally prepared caterpillars.

4.3 STUDY ANIMAL

The Eupterotid lepidopteran, *H. variegata* is poorly known from the literature, with mention made only of its distribution and no information available regarding edibility, nutritional value or indeed life history. The caterpillar is, however, one of the best loved, most utilised and most freely available edible caterpillars of the Blouberg area (Chapter Two). Residents of the Sekhukhune and Venda regions of the Limpopo Province attest to the fact that in their villages the caterpillars are also popular as a relish (personal communication, Mampuru, L., University of Limpopo, 2009). *H. variegata* is mentioned frequently as a favourite insect and is also traded each year amongst Blouberg villagers and further afield (Chapter Five). Residents of the villages close to Blouberg Mountain are familiar with the caterpillar and even those who do not eat insects have a good understanding of where to find the food plant and of the timing of the caterpillar's appearance each year (Egan *et al.* 2009). Despite the widespread knowledge and use of the caterpillar there is no documented evidence of its nutritional value. Older residents attest to the fact that it is healthy to eat but some of the younger members of the community feel that edible insects are not a healthy alternative (Chapter Two). The possession of scientific evidence to support claims that *Hemijana variegata* is a nutritionally valuable food source would assist doctors and dieticians as well as school personnel who promote healthy eating among the residents of Blouberg.

The larval stage of this medium sized moth is gregarious and host specific (Chapter Three). The caterpillar inhabits the canopy of open woodland areas feeding predominantly on *Canthium armatum* (Rubiaceae), a small tree armed with large decussate thorns (Kroon 1999). In addition, it feeds, to a much lesser extent, on the thornless shrub, *Pyrostria hystrix,* of the same family as *C. armatum* (personal observation and personal communication, Waleng, F., resident of Blouberg, 2008). This has not previously been documented but is widely known amongst the Blouberg community. The caterpillar is known from the Lebombo Mountains and along the coast of KwaZulu-Natal Province, into Sekhukhune, Venda and Capricorn Districts of Limpopo Province. It also occurs in Swaziland, but distribution records are scanty (unpublished data: Ditsong Museum of Natural History, South Africa).

4.4 MATERIALS AND METHODS

4.4.1 Collection of Caterpillars

In early December 2010, over 100 late instar caterpillars were collected from *Canthium armatum* trees on the slopes of Blouberg Mountain behind the village of The Glade (S 23° 05.050’ E 029° 02.630’). They were placed in buckets containing leafy *C. armatum* twigs collected from the same trees on which they had been feeding and covered with gauze to prevent escape. The buckets were kept shaded to minimise mortality and the caterpillars transported to the University of Limpopo for analysis. Approximately 90 live caterpillars were used for the proximate nutritional analysis, with the remaining 50 being stored at -80°C for later analysis of the vitamin content.

In late December 2010, 1 kg traditionally prepared caterpillars were bought from vendors in the village of Ga Manaka, roughly 3 km from The Glade Village. The local vendors collected the caterpillars from *C. armatum* trees on the slopes of the Blouberg Mountain close to Ga Manaka village. During collection, the caterpillars were placed in buckets filled with water to prevent their escape. Once home, the collectors washed the caterpillars three times in water to purge them and then boiled them on an open fire for approximately one hour in salty water. The water was then drained and they were spread out on a flat rock to dry in the sun for a day until they were brittle. Finally, the remaining hairs were shaken off by “winnowing” in a basket or bucket. After the caterpillars were purchased they were stored for two months in brown paper bags in a cupboard at ambient temperature, in a similar environment to that in which they would have been stored by local Blouberg residents.

4.4.2 Proximate Nutrient Analysis

Samples of field collected caterpillars were oven dried at 60°C for three different time periods: 24, 48 and 72 h. The caterpillars were neither rinsed nor boiled but were frozen before drying. The traditionally prepared samples had been sun-dried *in situ* by the caterpillar collectors. All samples were then ground and kept at ambient temperature for chemical analysis, according to the standards of the Official Analytical Chemists, (A.O.A.C. 1999).

Protein and nitrogen determination:

A TRU-SPEC© Protein analyser was used to determine the protein and nitrogen content in the caterpillars. Roughly 0.2 g of sample was weighed into foil which was folded over and inserted into the machine presenting the results after five minutes.

Energy determination:

A LECO© bomb calorimeter was used to determine the energy content in the caterpillars. Approximately 1 g of sample was weighed, transferred to the crucible and inserted into the calorimeter with pressurised oxygen. Energy content was determined 10−20 min. thereafter. Energy content was determined in kilojoules but converted to kilo calories for ease of comparison with the literature.

Fat determination:

A LECO© total fat extractor was used to determine the fat content. A 0.2 g sample was weighed and mixed with 2 g of LECO© dry and the mixture transferred to a sample holder. The sample holder was then inserted into the machine and the extraction process continued for an hour. The oil was extracted into a glass bottle containing cotton wool.

Moisture determination:

A LASEC© moisture balance was used to determine the moisture content. A sample of 2 g was weighed into the moisture pan, inserted into the balance and the moisture percentage determined.

Ash determination:

A muffle furnace was used to analyse a 2 g sample. This was weighed and transferred to a preheated and pre-weighed crucible and then inserted into the muffle furnace at a temperature of 550°C for five hours. The mass of the crucible and ash was weighed and the ash content calculated using the following formula:

$$\%\ \mathrm{Ash} = \frac{(mass\ of\ ash + mass\ of\ crucible) - mass\ crucible}{(mass\ sample + mass\ of\ crucible) - mass\ crucible}\ X\ 100$$

Fibre:

Fibre was analysed according to the methods recommended by the Association of Official and Analytical Chemists (A.O. A.C. 1999).

Statistical analysis of the influence of drying regime on proximate nutritional value:

ANOVA was performed using the computer package program SPSS (The Statistical Products and Service Solution, Inc., Chicago, IL, USA version 13.0) to determine whether or not there was a significant difference between treatments. A post hoc Tukey test was performed to determine where this difference lay.

4.4.3 Vitamin Analysis

Approximately 50 fresh caterpillar specimens were stored at -80 °C for three months until they could be analysed at the Analytical Services Laboratory of the Agricultural Research Council in Irene, Pretoria. This is a South African National Accredited laboratory. Caterpillars were freeze dried and ground and 100 g of material was analysed for vitamin content. Vitamins B_1 and B_2 content were determined using high performance liquid chromatography (HPLC). Vitamin C content was determined using acetic acid and meta-phosphoric acid as well as HPLC with fluorescence. Vitamin A was detected using HPLC followed by ultra-violet and fluorescence analysis.

4.4.4 Presence of Pathogens

One hundred millilitres each of nutrient broth and 'Yeast extract-Malt extract' (YM) broth were prepared in 250 ml Erlenmeyer flasks. Both were aseptically inoculated with traditionally prepared, dried *H. variegata* caterpillars. The nutrient broth flask was then incubated in an incubator shaker at 37°C overnight. The YM broth flask was incubated in an incubator shaker at 25°C for two days. Serial dilutions from the overnight incubated nutrient broth were then performed by transferring 1 ml of broth into a 9 ml sterile 0.8% saline tube labelled 10^{-1}. The procedure was repeated until tube 10^{-4}, discarding the 1 ml from the 10^{-4} tube.

Each saline solution mixture was plated by inoculating each of four nutrient agar plates with 1 ml of each dilution (10^{-1}, 10^{-2}, 10^{-3} and 10^{-4}) using the spread plate technique. The same serial dilution and plating procedure was repeated with the YM broth culture. The nutrient agar plates were incubated at 37°C overnight and the YM agar plates were incubated at 25°C for two days or until growth had appeared.

Two colonies developed from the nutrient agar (brownish and yellowish). These were gram-stained and were further purified by carrying out a four way streak technique. Both were found to be Gram-positive bacilli. Biochemical tests were performed on each organism for identification purposes: Spore formation, catalase and nitrate reduction.

Only one type of colony was observed on the YM agar plates (brown and shiny). It was also gram stained and found to be a Gram-positive bacillus. The following biochemical tests were performed for identification purposes: Spore formation, catalase and glucose tests.

4.5 RESULTS

4.5.1 Proximate Nutrient Analysis

No significant difference in energy value, fat content, nitrogen or protein was detected between drying treatments of 24, 48 and 72 hours. However, j/100 g of caterpillar was significantly lower ($F = 37.741$, $p<0.0001$) for caterpillars dried in the traditional manner compared to those dried in accordance with any of the other drying regimes (24, 48 and 72 hours). There was also significantly less protein ($F = 60.706$, $p<0.0001$) and nitrogen ($F = 60.376$, $p<0.0001$) in caterpillars dried traditionally compared to those processed using any of the other drying regimes. There was no significant difference in fat content for any of the drying treatments or for caterpillars prepared traditionally ($F = 1.857$, $p>0.05$)

Traditionally dried caterpillars had more moisture, ash and carbohydrate per 100 g of caterpillars than did laboratory dried caterpillars, but less fibre. The significance of these results could not be tested due to the lack of samples as they were outsourced.

Table 4.1 Proximate nutrient values for *H. variegata* caterpillars under different drying regimes.

Proximate Chemical Composition	Preparation Method			
	24 hours	48 hours	72 hours	Traditional Preparation
Energy (j/g)	23119.17 ± 1.15	21783.33 ± 53.13	21083.33 ± 33	12823.50 ± 6.08
Energy (Kcal)	552	520	503	306
Protein (%)	52.42 ± 1.50	51.41 ± 0.22	53.84 ± 0.29	44.48 ± 0.81
Nitrogen (%)	8.39 ± 0.24	8.23 ± 0.04	8.45 ± 0.05	7.12 ± 0.13
Moisture (%)	5.868	5.042	5.765	7.046
Fat (%)	19.33 ± 0.31	18.93 ± 0.3	18.93 ± 1.79	19.75 ± 0.65
Ash (%)	5.23	5.53	5.85	10.47
Fibre (g/100 g)	8.32	8.56	8.41	7.29
Carbohydrates*(g/100g)	9.49	10.52	9.52	11.86

*Carbohydrate(100g – g (protein+ fat+moisture+ash+fibre)

4.5.2 Vitamin Analysis

Vitamin content varied depending on the type of vitamin analysed as noted from Table 4.2.

Table 4.2 Results of the vitamin analysis for fresh *H. variegata* caterpillars.

Vitamin	mg/100 g
Vitamin A	0.02
Vitamin B_1	0.01
Vitamin B_2	0.65
Vitamin C	14.15
Vitamin E	0.64

4.5.3 Presence of Pathogens

Two micro-organisms were found on the nutrient agar plates, *Corynebacterium kutscheri* and *Corynebacterium xerosis,* and one micro-organism, *Lactobacillus fermentum*, growing on the YM agar plates (Table 4.3 and Table 4.4).

Table 4.3 Micro-organisms grown on Nutrient Agar plates.

Biochemical Test	**Outcome**	
	Brownish Colonies	**Yellowish Colonies**
Spore Formation	Negative	Negative
Catalase	Positive	Positive
Nitrate Reduction	Negative	Positive
Concluded Name of Organism	*Corynebacterium kutscheri*	*Corynebacterium xerosis*

Table 4.4 Micro-organisms grown on YM agar plates.

Biochemical Test	**Outcome**
	Brownish Colonies
Spore Formation	Negative
Catalase	Negative
Glucose Test	Positive (Acid and Gas)
Concluded Name of Organism	*Lactobacillus fermentum*

4.6 DISCUSSION

Hemijana variegata is a promising candidate for more in depth investigations into aspects of nutritional significance. Initial analysis demonstrates that the caterpillar is a high quality food that is safe to consume.

4.6.1 Proximate Nutrient Analysis

In common with other edible insects, *H. variegata* is a good source of energy (Table 4.5). Drying for 24 hours at 60°C produced the most energy at 552 Kcal/100 g. This is in the mid-range for lepidopteran larvae, which vary between 293 and 762 Kcal/100 g (Verkerk *et al.* 2007). For traditionally prepared caterpillars the value drops quite dramatically to 306 Kcal/100 g, however this is still higher than values for beef which range from 112 to 115 Kcal/100 g (Chizzolini *et al.*1999). The calorific value is also higher than that for goat meat which varies between 96.36 and 101.47 Kcal/100 g (Brzostowski *et al.* 2008). Most significantly, it is greater than that for chicken (144 Kcal/100 g) (Chizzolini *et al.* 1999), which is the most commonly consumed animal protein in the Blouberg area (Boonzaaier and Philip 2007). When compared to conventional fast foods such as hamburgers and sandwiches, traditionally prepared caterpillars are comparable in terms of energy. Hamburgers contribute 313 Kcal/100 g, and beef sandwiches, 316 Kcal/100 g (Chizzolini *et al.* 1999) (Table 4.5).

In a long term study on the nutrition of residents of Dikgale, a rural area in the Limpopo Province, where people have similar lifestyles to the people of Blouberg, it was found that the number of kilojoules consumed daily varied from 1090.11 Kcal to 1737.09 Kcal depending on the age of the consumer (Steyn *et al.* 2003). WHO/FAO/UNU (1985) supply data that show that on average a male subsistence farmer requires 2 780 Kcal per working day. Thus 400 g of dried *H. variegata* would contribute significantly to the calories people in Blouberg are likely to consume daily. An investigation into the average serving size of these caterpillars would be of interest to more accurately predict their energy provision.

Preparing the caterpillars in the traditional manner compared with simply freezing and then drying them, negatively affects calorific value, nitrogen and protein and this indicates that there are possibilities for improving the end product through modification of the processing method. This also has implications when considering that edible insects are candidates for fortifying grain products such as maize meal and sorghum cereals. Preparation methods of such insect supplements must ideally provide the greatest proportion of protein and energy.

As described under materials and methods, traditionally prepared caterpillars are initially rinsed three times in water to purge them and ensure that gut contents are ejected. They are then boiled for one hour (Figure 4.1). In the laboratory tests on the influence of drying time, these first two steps were eliminated and the caterpillars frozen immediately upon collection and then oven dried. Purging the caterpillars is an important step as it ensures that undigested plant remains are not consumed (Dreyer and Wehmeyer 1982). Boiling, particularly in salt, improves the palatability of the caterpillars, thus, leaving out one of these steps in the interests of gaining on nutritional value may not be an option. Drying the caterpillars for different lengths of time did not affect the nutritional value significantly, and thus it would not be necessary to dry caterpillars for more than 24 hours, thereby saving on costs and time.

The fact that traditionally prepared caterpillars which have been purged, have a decreased protein content when compared with those that have not been purged, differs from the results for the mopane worm (*Imbrasia belina*). Madibela *et al.* (2009) found that de-gutting mopane worms, which has the same effect as purging by removing undigested plant matter, resulted in higher protein content. The explanation given was that the undigested leaf matter in the gut dilutes crude protein in larvae which have not been de-gutted. For *H. variegata*, the purged caterpillars were also boiled as part of the traditional preparation method, whereas those not purged were not boiled but merely frozen before oven drying. Proteins are denatured by heat and thus boiling may have had a greater negative influence on the protein content than the positive effect of eliminating the dilution factor through purging.

The analysis of protein in *H. variegata* shows a percentage similar to that of other caterpillars (Ramos-Elorduy Blásquez *et al.* 2012). The high crude protein of between 51 and 54% for oven dried and 44.5% for traditionally prepared caterpillars compares well with the much sought after mopane worm (*Imbrasia belina*). These caterpillars have a protein percentage of between 10 and 65% (Illgner and Nel 2000). *H. variegata* compares even more favourably with beef in terms of protein, as well as with chicken (Table 5). The only source of local protein that has a higher percentage of protein is that of the jugo bean (*Vigna unguiculata*), which has between 80 and 82% protein (Yusuf *et al.* 2008). This food source however, also possesses a high percentage of anti-nutrients such as tannins, trypsin inhibitors and phytic acid (Fasoyiro *et al.* 2006), which reduce the desirability of the bean. Fish also has a higher protein content at 81.1% ± 0.8 (Ramos-Elorduy Blásquez *et al*. 2012) but is rarely consumed in Blouberg. People of Blouberg use maize as a staple food (Boonzaaier and Philip 2007). Maize is, however, low in protein (9−11%) and this is exacerbated by the way in which it is processed (Booyens 2001). The milling of maize removes the germ and pericarp in which 75% of the protein resides. The conversion to the popular product, samp, destroys the aleuron resulting in a product consisting mostly of starch and a small amount of poor quality protein (Truswell 1959, Shukla and Cheryan 2001). Fortifying staple cereals with insects such as *H. variegata* would increase the quantity and quality of the available protein.

Dreyer and Wehmeyer’s (1982) investigation of the nutritional value of mopane worms revealed that the protein in these caterpillars had a lower digestibility value than most proteins of animal origin. However, this is offset by the high protein value (up to 65.8% for dried mopane worms). Protein in *H. variegata* dried for 24 hours is lower, at 52.45%, than that of dried mopane worms. Digestibility should also be tested in *H. variegata* as this may lower the value even further.

Although the amino acid content was not analysed in this study, most edible insects possess an amino acid composition that falls within the recommendations of the World Health Organisation (Paoletti and Dreon 2005) and it is expected that this will also be true of *H. variegata.* The consumption of animal protein in marginalised areas such as Blouberg is generally low (Boonzaaier and Philip 2007) and therefore even though *H. variegata* is only consumed for a short period during summer months (Chapter Five), this is still a significant dietary input. It is of interest to note that in Venezuela, the

Makiritare Amerindians, who do not suffer from a lack of protein, consider it important to collect edible insects, in particular termites, as they consider them to be nutritionally important even though they do not consume them in large numbers (Paoletti *et al.* 2003). The amino acids tryptophan and lysine are frequently lacking in edible insects although not in all (van Huis 2003) and thus it is important to ascertain the status of these amino acids in *H. variegata*.

It is likely that anti-nutrient chemicals are present in *H. variegata* caterpillars, which would negatively influence food quality. Madibela *et al.* (2009) found significant quantities of tannins in mopane worm (*Imbrasia. belina*) caterpillars. The leaves of the tree on which the caterpillars feed, (*Sclerocarya birrea*) possess condensed tannins which remain as undigested plant matter in the caterpillar gut. Degutting the caterpillars helps to reduce these tannins in the end product. The leaves of *Canthium armatum,* the food plant of *H. variegata*, have yet to be tested for the presence of condensed tannins.

Hemijana variegata has a fat content of 20% which is slightly higher than that of beef and much higher than chicken (Table 5). Further research should focus on investigating the composition of the fat as it is likely to consist of a high percentage of polyunsaturated fats. Ramos-Elorduy (2008) found that a high percentage of lipids in most holometamorphic caterpillars are polyunsaturated. This is supported by work done by Ekpo *et al.* (2009) on the larvae of *Macrotermes bellicosus, Imbrasia belina*, *Oryctes rhinoceros,* and *Rhynchophorus pheonicis* which were found to have a higher percentage of unsaturated fats than beef or mutton as well as palm and coconut oil, although not as high as it is in herring, salmon and mackerel. This is important as a food with a high fat content would be desirable in combating malnutrition and would be even more preferable if polyunsaturated.

The high protein and fat content makes the *H. variegata* caterpillar a suitable food source for children who require greater proportions of these components in their diet than do adults (WHO/FAO/UNU 1985). In light of concerns over stunting and malnutrition in rural children, particularly from the Limpopo and

Eastern Cape Provinces (Zere and McInytre 2003), the nutritious nature of this low cost, traditional food should be advertised and promoted. It is therefore of interest that many Blouberg residents collect and eat insects as children but abandon this practise as they grow older (Chapter Two). The most common form of malnutrition world-wide is energy and protein deficiency (Klunder *et al.* 2012) and thus the favourable protein and energy content of this caterpillar are an important contribution to the diet of those in the marginalised Blouberg area.

The high ash content of traditionally prepared *H. variegata* (10.47%) indicates an elevated percentage of minerals (Braide *et al.* 2010). These caterpillars were boiled in salted water thus elevating the mineral content. Further investigation of these nutrients is necessary to determine their proportions and quantities. It is probable that the increased levels of salt do not negatively affect the nutritional value of the larvae as this was not found to be the case for mopane worms (*Imbrasia belina*) (Madibela *et al.* 2009). In fact, these researchers advocate the addition of salt in the preparation of the mopane worms in order to increase shelf life and palatability. For mopane worms, degutting had a greater effect on the chemical composition than salting of the larvae (Madibela *et al.* 2009).

The ash content of 5.23% for *Hemijana variegata* dried for 24 hours without the addition of salt (not prepared traditionally) was still higher than that of five other species of edible caterpillar from Africa (1.5−3.2%). These caterpillars contain calcium, phosphorous, iron and magnesium and it is probable that this will also be true of *Hemijana variegata* although the overall higher percentage of ash suggests that the percentage of each may be greater. Edible caterpillars are high in calcium, containing between 7.58 and 10.52 mg/100 g which compares well with milk, a generally accepted favourable source of calcium (1.2 mg/100 g) (Banjjo *et al*. 2006, Ramos-Elorduy Blásquez *et al*. 2012). Iron in edible caterpillars also compares well with beef, a conventional source of iron (Ramos-Elorduy Blásquez *et al*. 2012).

Crude fibre represents the indigestible portion (non-structural carbohydrate) of the insect (Ramos-Elorduy *et al.* 1997). This was lowest in the traditionally prepared caterpillars, another indication of an increase in palatability once caterpillars have been cooked.

Figure 4.1 Steps in the preparation of edible caterpillars a) collection b) rinsing c) boiling with salt d) sun drying e) winnowing dust out f) finished product

Table 4.5 Proximate nutritional values of *H. variegata* compared with those of some conventional food types commonly consumed in Blouberg, as well as with examples of Blouberg edible insect species and of certain closely related edible insects.

Food type	Protein %	Lipid %	Carbohydrate mg /100 g	Moisture %	Ash %	Energy Kcal/100 g	Source
Chicken,fresh	20.6−23.4	1.9−4.7	0	73.7	1.0	144	Bodenheimer 1951
Beef, fresh	18.4	15.8−25.1	0	56.9−63.9	0.8−0.9	112−115	Bodenheimer 1951, Ramos-Elorduy Blásquez *et al.* 2012, Ghaly 2009
Carrots, fresh	22	8.7	9.7	75.54	ND	366	Ramos-Elorduy Blásquez *et al.* 2012, Ramamoorthy *et al.* 2010
***Vigna subterranean,* roasted**	80.2	ND	11.4	0.89	2.19	362	Yusuf *et al.* 2008, Fasoyiro *et al.* 2006 Ijarotimi *et al.* 2009
***Vigna unguiculata*, raw**	22.34	1.88	62.87	8.90	4.03	375	Sasanam *et al.* 2011, Ayssiwede *et al.* 2011
Red kidney bean (*Phaseolus vulgaris),* raw	21.83	1.30	60.65	12.39	3.90	265	Sasanam *et al.* 2011,
wild spinach *(Amaranthus hybridus*), dried	17.92	4.65	52.18	ND	13.80	269	Akubugwo *et al.* 2007
****Sternocera orissa* (Coleoptera), dried**	63.00	9.83	20.62	3.74	2.80	426	Shadung *et al.* 2012
***Encosternum delagorguei* (Hemiptera), dried**	35.2	50.5	7.63	4.9	1.7	621	Teffo *et al.* 2007
Grasshoppers (Orthoptera), dried	62.1−71.4	4.2−10.8	4.0−21.6	ND	1.3−3.0		Bodenheimer 1951
***Melanoplus mexicanus* (orthoptera), dried**	58.9	11.0	16.5	ND	3.94	390	Ramos-Elorduy Blásquez *et al.* 2012

Table 4.5 Cont.

Food type	Protein %	Lipid %	Carbohydrate mg/100 g	Moisture %	Ash %	Energy Kcal/100 g	Source
***Zonocerus variegatus* (Ortohoptera), dried**	26.8	3.8	ND	2.61	1.2	ND	Banjo *et al.* 2006
***Cyrtacanthacris aeruginosus* (Orthoptera) dried**	12.1	3.5	ND	2.56	2.1	ND	Banjo *et al.* 2006
***Atta cephalotess* (Hymentoptera), female**	48.1	ND	ND	6.9	ND	580	Paoletti and Dufour 2002
******Macrotermes natalensis* (Isoptera), dried**	22.1	22.5	ND	2.98	1.9	467	Banjo *et al.* 2006, Paoletti and Dufour 2002
******Imbrasia belina* (Lepidoptera), dried**	56.7−65.8	9.2−15.16	9.2−10.98	12.7	7.6−12.5	352	Moruakgomo 1996, Siame *et al.* 1996, Dreyer and Wehmeyer 1982, Ghaly 2009
***Cirina forda*, (Lepidoptera) dried**	20.2	14.2	ND	4.4	1.5	ND	Banjo *et al.* 2006
******Hemijana variegata* (traditionally prepared)**	**52.42**	**19.33**	**9.49**	**5.868**	**5.23**	**552**	

*insect species consumed in Blouberg
'Dried' refers to drying in an oven and not in the sun as with traditionally prepared caterpillars
Standard deviations have been removed for ease of comparison and can be viewed in the original publications.
ND: not determined.

4.6.2 Vitamin Content

A number of vitamins are denatured during food preparation and it is therefore important to highlight the fact that the vitamin analysis was performed on freeze dried caterpillars that were not prepared in the traditional manner. This was to obtain baseline information on vitamin content. Future investigations should explore the vitamin content in boiled, sun-dried caterpillars for comparative purposes. Vitamin C was found in the highest concentration of 14.15 mg/100 g. This is below that of many fresh vegetables, which is approximately 30 mg/100 g in peas and over 90 mg/100 g in broccoli (Favell, 1998) but is over ten times the amount found in uncooked beef (Table 4.6). It is probable that the vitamin content of the fresh caterpillars is boosted by vitamins in the leaves of the host plant (*Canthium armatum*) remaining in the gut. In mopane worms (*Imbrasia belina*) the vitamin content is considerably reduced during the soaking and later, the heat treatment prior to canning the caterpillars (Dreyer and Wehmeyer 1982). This is almost certainly true for traditionally prepared *H. variegata* which are subjected both to heat and light (Chapter Six).

Kinyuru *et al.* (2009) explored the effects of processing methods on digestibility and vitamin content of the edible termite *Macrotermes subhylanus* and the grasshopper *Ruspolia differens*. It was found that processing of both insects resulted in a general decrease of all vitamins tested (ascorbic acid, pyroxidine, folic acid, niacin, riboflavin, retinol, α-tocopherol) and in particular, ascorbic acid and niacin. Teffo *et al.* (2007) found that traditionally prepared edible stinkbugs (*Encosternum delegorguei*) had no detectable vitamin C and thus the high vitamin C content in fresh *H. variegata* will almost certainly be diminished once the caterpillars are prepared. With traditional preparation the caterpillars are purged by washing them, alive, three times in water, causing the undigested leaves and their associated vitamin C to be released. It is vital to test this, however, as dried Orthoptera from Mexico also yielded a high vitamin C content of 23.8—25.5 mg/100 g (Ramos-Elorduy Blásquez 2012), and Chinese insect tea can yield up to 15.04 mg/100 g (Chen *et al.* 2009). The rinsing process cannot be avoided in the interest of vitamin C retention as it is highly probable that it improves the palatability of the insects. Madibela *et* *al.* (2009) presented evidence that de-gutting mopane worms (*Imbrasia belina*) affects the chemical composition by decreasing the concentration of unwanted condensed tannins. This is likely to be true for *H. variegata* and should be tested.

Vitamin E and Vitamin B_2 are also present in higher concentrations in insects than in beef and further analysis should be performed to determine what effect traditional preparation would have on these vitamins. Vitamins, particularly B-group vitamins, are generally present in higher concentrations in insects than in meat or bread (Paoletti and Dufour 2002). Vitamins A and B are generally well represented in insects but in the case of *H. variegata*, they are two of the least well represented, with Vitamins B_2 and E the best represented. For example, in five caterpillar species from Africa, vitamin B_2 ranged from 0.09 to 2.21 mg/100 g (Banjo *et al.* 2006), in comparison with 0.65 mg/100 g for *H. variegata* (Banjo *et al.* 2006). B-group vitamins are generally lacking in the staple food of Blouberg which is maize (Booyens 2001). The absence of these vitamins has serious consequences, amongst which is the development of pellagra which causes diarrhoea, dermatitis and dementia. Vitamin B_2 and vitamin E, specifically, are lacking in the diet of South African school children and it has been recommended that they be included as supplements in a cereal fortification programme (Steyn *et al.* 2007). Fortifying maize with *H. variegata* would therefore be beneficial in terms of both vitamins and proteins.

Table 4.6 Vitamin content of *H. variegata* in comparison with that of some vitamins in various conventional foods consumed in Blouberg (mg/100 g) modified from Ramos-Elorduy Blásquez (2012).

Vitamin	*H. variegata*	Orthoptera	Conventional food mg/100 g					
			Rice	Beef	Spinach	Egg	Chicken	Orange
Vitamin A	0.02	0.03−16.0		0.08	875	97		
Vitamin B_1	0.01	0.27−0.87	0.44	0.70				
Vitamin B_2	0.65	0.59−1.28		0.23			0.19	
Vitamin C	14.15	23.8−25..5		<0.1			1 to 2	62
Vitamin E	0.64			0.133				

4.6.3 Pathogens

The results of the pathogen investigation answer, in part, the call from the FAO for more research into the handling, preparation, processing and storage of edible insects (Johnson 2010). In general, although it has been demonstrated that edible insects are a high quality food type (Johnson, 2010), cases of *Clostridium botulinum* poisoning and associated deaths from eating mopane worms have been reported in Namibia (Marais 1996). There is thus justifiable concern over the safety of food products and the promotion of a food source would be subject to strict quality control. Teffo *et al.* (2007) state that contamination and wastage of traditional food resources can be minimised by improving their preparation. In a comprehensive investigation into the deterioration of prepared mopane worms *(Imbrasia belina*), Mpuchane *et al.* (2000) confirmed that bacteria, mites, insects and moulds were responsible for the short shelf life of the product. Scriber (2011) notes that the traditional method of preparing mopane worms involves boiling the caterpillars for at least 20 minutes which kills most harmful microbes present and denatures many of the harmful enzymes and other allelochemicals in the caterpillars, but adds that post-harvesting processing needs to be improved to a) avoid the build-up of mould-induced mycotoxins which could result in ill-health of consumers, and b), decrease the loss of weight of the product due to bacterial infection and insect damage, which would lead to loss of income by the collectors. Braide *et al.* (2010) advocated the use of a modified atmospheric packaging system to prevent spoilage and prolong the shelf life of the edible caterpillar *Bunaea alcinoe.*

Preparation of *Hemijana variegata* is similar to that of mopane worms (Illgner and Nel, 2000), but the gut contents are removed by rinsing, whereas removal of the gut contents of the spiny mopane worms with the fingers is a painful procedure. Although the methods for preparing edible insects are simple and quite straightforward, slight variations can improve the final product in terms of food safety as well as nutritional composition. Shadung *et al.* (2012) found that for the edible beetle *lebitsi* (*Sternocera orissa*), oven drying and pan roasting were preferable to freeze drying because it raised the resulting protein, fat and carbohydrate content of the beetle.

While *bophetha* (*H. variegata*) is also susceptible to post processing spoilage, no fungal contamination was noted in the dried specimens and the bacterial species that were isolated are not especially harmful to humans. Indeed, *Lactobacillus fermentum* is frequently used as a probiotic supplement (Gardiner *et al.* 2002). *Corynebacterium kutscheri* is a commensal bacterium commonly found in the mouth cavities of healthy rodents (Holmes and Korman 2007). It can be transmitted to humans, but is generally not harmful (Adler *et al.* 2002), other than in a few very isolated cases (Holmes and Korman 2007). Klunder *et al.* (2012) demonstrated that boiling mealworm insects (*Tenebrio molitor*), consumed in Lao PDR, was successful in killing enterobacteria but that roasting the mealworms was not entirely effective. Thus the second step in the preparation of *H. variegata*, that of boiling, is vital for food preservation and reasons of safety.

In the Blouberg region, the processed *H. variegata* caterpillars are stored in old grain sacks and second-hand 25 litre buckets, amongst household food stores and in shacks or thatched rondavels. Rodents are common in and around such places and can pass on such bacteria whilst moving amongst the containers. The bacterium is generally only harmful to immuno-compromised individuals, but the presence of the pathogen does indicate less-than-sanitary preparation and storage conditions which could be improved upon.

The presence of *Corynebacterium xerosis* in prepared caterpillars may be of concern. This is a non-toxin-producing bacterium commensal in the conjunctival fornix of the human eye (Lipsky *et al.* 1982). It has been implicated as the causal agent in some infectious diseases but these are usually in immuno-compromised individuals. Furthermore, there is evidence to suggest that in many clinical test cases, the causal agent was misidentified as *Corynebacterium xerosis* and therefore the pathogenicity of this bacterium may be less severe than originally understood (Funke *et al*. 1996). The institution of a simple regime of hand washing before processing the *H. variegata* caterpillars should contribute to the eradication of this bacterium from the final product. Both *C. xerosis* and *C. kutscheri* are heat intolerant and therefore cooking of the caterpillars should destroy both bacteria (Arden and Barksdale 1974).

In general, fungi are the primary cause of food deterioration in stored food products worldwide (Munoz *et al.* 2010). Lack of adequate storage facilities are an impediment to the sanitary storage of edible insects in the long term in many rural settlements in Africa (Braide *et al.* 2011). Kozanayi and Frost (2002) note that in the case of mopane worms (*Imbrasia belina*), there is a danger of an entire consignment rotting if the storage facility is slightly damp. For this reason, if mopane worms are stored for long periods they are frequently taken into the sun and spread out to dry to prevent them from becoming mouldy or rancid. It is therefore encouraging to note that no fungal contamination was found on the stored *H. variegata* caterpillars. This will certainly contribute to a longer shelf life for the insects.

Residents of Blouberg noted that they could store caterpillars for about one year but generally they were too desireable for this and were usually eaten within a few weeks. Insect contamination was not investigated in this study, but it was observed that caterpillars stored for over a year were susceptible to attack by dermestid beetles (*Dermestes* sp.). A comprehensive study of the trade in mopane worms in Southern Zimbabwe revealed that contamination by *Enterobacteria* spp., fecal *Escheridia coli* and various fungi, including aflatoxin-producing species was very common (Gondo *et al.* 2010). This contamination increased as the product moved up the production line and therefore there may be fewer opportunities for contamination in the trade of *H. variegata* because there are fewer steps in the production line from collection to consumption.

Klunder *et al.* (2012) established that two simple procedures involving drying, or lactic acid fermentation of edible insects, neither of which rely on refrigeration or harmful preservatives, are promising methods of preservation. Drying was the simplest process, carried out with a dying oven in the experiment but which could also be done simply using sunlight, as is the norm in the Blouberg region. Successful lactic acid fermentation was reliant on correctly developing a starter culture of flour and tap water. This process is not technically difficult, nor does it require specialised equipment other than the means to incubate the culture at 30ºC. The starter must, however, be carefully prepared in the correct ratios. A combination of the two processes may be worthwhile, as boiling does not entirely eliminate spore forming bacteria, which are often introduced through contact with soil. Lactic acid fermentation techniques inactivate these bacteria more effectively and this technique should be more fully explored with respect to the edible insects of Blouberg.

More affluent societies have the resources to develop and improve traditionally prepared foods and generate larger volumes which conform to higher safety standards (Yen 2009). In Zimbabwe, government health officials periodically inspect shops to ensure that uncovered food is not sold, and this impacts somewhat on whether a shop will sell mopane worms or not (Kozanayi and Frost (2002). Traditional societies could work hand in hand with modern societies to generate high quality insect protein. Overcoming the prejudices of western society against eating insects would, however, require astute marketing.

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CHAPTER FIVE

THE UTILISATION AND SUSTAINABILITY OF THE *BOPHETHA* RESOURCE IN BLOUBERG, LIMPOPO PROVINCE: *HEMIJANA VARIEGATA* AS A NON-TIMBER EDIBLE FOREST PRODUCT

An analysis of socioeconomic factors relating to *H. variegata*

5.1 INTRODUCTION

Households living in marginal circumstances and with meagre incomes frequently make use of natural resources directly for consumption or to supplement their income (Shackleton and Shackleton 2003). The contribution made by these informally gathered, traded and/or consumed resources to such household economies, can be substantial (Shackleton and Shackleton 2003, Twine *et al.* 2003, Belcher *et al.* 2005, Delang 2006, Twine and Hunter 2008). Income from such sources has been documented as ranging from less than 20% to more than 50% of annual household income (Paumgarten, Shackleton and Shackleton 2009). The significance of edible insects as a portion of wild harvested resources has become increasingly evident in studies on all continents (Munthali and Maghogho 1992, DeFoliart 1999, Gullan and Cranston 2000, Paoletti and Dufour 2005), but detailed information regarding the direct value that insects provide to household economies is more difficult to obtain. Shackleton and Shackleton (2004) noted that more than 53.5% of people in rural villages sampled in Limpopo make use of edible insects, either by collecting them themselves, or by purchasing them from harvesters. The collection of mopane worms (*Imbrasia belina*), in particular contributes to household incomes by paying for grain, food, school fees, tools, medical costs and travel (Stacks *et al.* 2003) and in recent years this activity has become increasingly commercialised (Kozanayi and Frost 2002). Edible insects are therefore valuable, particularly to marginalised societies and it is important to understand both the impact harvesting has on wild populations as well as the contribution they make to household incomes.

The edible lepidopteran caterpillar, *Hemijana variegata,* or, as it is better known in Blouberg, *bophetha,* (Sepedi dialect of seHananwa), is the product of a specific ecosystem within the Blouberg area. The host plant, *Canthium armatum* converts solar energy into plant matter, which in turn is converted to biomass suitable for human consumption by *H. variegata*. As with all ecosystem services, the continued existence and integrity of this system is essential to the on-going production of such a food source and this is not always recognised (de Groot *et al.* 2002). Values placed on an ecosystem can be grouped into ecological, socio-cultural and economic (de Groot *et al.* 2002). By using anthropocentric methods, such as economics, to value the components of an ecosystem, the vital role played by a specific natural system within a community can be highlighted. The ecosystem service of providing food is defined by de Groot *et al.* (2002) as a production function and therefore one means of assessing its value is by means of direct marketing valuation techniques, or, in other words, the exchange values that these services have in trade. Understanding the contribution *bophetha* makes to household income and its role in local trade will highlight the value of the ecosystem in which it occurs.

A suite of ecosystem products, whose importance has recently been recognised, is that of non-timber forest products (NTFP). As Belcher (2003) asserts, NTFPs are generally defined in terms of what they are not and this definition is usually specific to the research objectives of the investigation undertaken. For the purposes of this chapter, NTFPs are described using a modified version of Paumgarten's (2005) definition and refer to products of the Blouberg forests and woodlands that include fauna and flora used for construction, consumption and trade but excluding large scale commercialised timber. As such, *bophetha* can be defined as an NTFP of the Blouberg area.

It is challenging to assess the economic magnitude of NTFP's that are edible (e.g. small game, edible insects, mushrooms, ferns and edible fruit). It is generally the harvesters themselves who consume the products as they are not widely traded and are frequently used by a particular community for a specific reason (Gregerson *et al.* 1995). One cannot merely compare them to products used more universally and the determination of a realistic monetary value for each natural resource is thus subject to some degree of bias.

The use of economic methods to assess the value of such a service to the villages in the Blouberg will contribute to recommendations to ensure the continued availability of the insect. Conventional questionnaires can provide important data which can be supplemented by group valuation in which members of a community democratically decide on the value of a service (de Groot *et al.* 2002). This method is particularly suited to the Blouberg area where issues are frequently discussed at village *gorahs* (meetings) and actions decided in group discussions.

The market for edible insects is growing worldwide with a recent media announcement reporting that the EU is looking to fund research into edible insects with a view to creating a greater European market in this environmentally friendly and healthy protein alternative (Sunday Times 2011). Thus, as markets expand and international interest in local natural products grows, the valuation of ecosystem functions, goods and services becomes ever more important (de Groot *et al.* 2002). The growth of the internet has facilitated the procurement of unusual and exotic food stuffs (Haines and Sammells 2010) and a number of websites bear requests for information on where to buy edible insects or advertisements for their sale such as:
http://edibug.wordpress.com/where-to-get-bugs/,
http://www.edibleunique.com/,
http://www.ask.com/questions-about/Where-Can-I-Buy-Edible-Insects,
http://adventure.howstuffworks.com/survival/wilderness/edible-bug.htm,

Accurate information on the status of wild edible insect populations is important for managing harvesting by local consumers as well as to ensure that edible insects are not over-exploited by markets from further afield.

Bophetha (Hemijana variegata) caterpillars are irregular, eruptive insects which have a single annual emergence per annum. They are collected on the slopes of the Blouberg Mountain (Limpopo, South Africa) during the rainy season, from November to December. As noted in Chapter Three, there is very little documented information regarding the insect other than references to its taxonomy which is unstable at present (Oberprieler & Nässig 2008). Many inconspicuous taxa, such as insects, mites, earthworms and other invertebrates are often ignored in terms of scientific investigation, unless they are economically significant or noticeable with respect to size or colour (Paoletti 2005). Estimates of insect species numbers range from 850 000 to 1 000 000 (Mora *et al.* 2011) and thus it is not surprising that insects such as *bophetha* are not well-known to science, despite the recent focus on biodiversity research.

The fact that *bophetha* are an important food source, provides a good reason for more in depth scientific investigation of the insect. Due to their value to local communities there is much local traditional knowledge around the insect's life history, behaviour and habitats. Thus certain aspects of the biology of *bophetha* can be gleaned from local harvesters who have an intimate knowledge of the emergence time of the caterpillars, the duration of the caterpillar stage as well as the host plants and habitats in which they are found. This knowledge is confined to information relevant to the harvesting of the food source, rather than details concerning the adult, which is not utilised. There is thus much to be gained from linking scientific investigation of the insect with knowledge already available through the local harvesting community. On a broader scale, using local people's knowledge of the biodiversity with which they are familiar, can lead to positive actions conserving biodiversity. However, this relies on the preservation and further development of local indigenous knowledge, much of which is eroding rapidly with the widespread and rapid adoption of western values and ways of life (Laird 2002). To close this loop it is vital that new knowledge gained through scientific investigation of an aspect of a local community's biodiversity is transferred to the community (Chapter Six). Equally important is that the local knowledge concerning the biodiversity is disseminated to the broader global community (Paoletti 2005). There are challenges regarding this knowledge dissemination, not least of which is the protection of people's and communities' (both the scientific and the local) intellectual property rights. However, leaving the status quo as it is will result in the loss of both biodiversity and local traditional knowledge and give little validation for initiating sustainable utilisation practises for this resource.

This chapter seeks to capture some aspects of traditional knowledge concerning *bophetha* (*Hemijana variegata)* in terms of harvest yields, procedures and preparation of the caterpillars, and to initiate an investigation into the effects of harvesting. The direct-use value of the insect is used to further clarify the contribution the insect makes to livelihoods in the Blouberg area. The findings are compared with those obtained from studies on the mopane worm (*Imbrasia belina*), whose range overlaps with that of *bophetha* and which is the most widely used and thoroughly investigated edible caterpillar in the northern parts of South Africa (Dreyer and Wehmeyer 1982, van Huis 2003, Makhado *et al.* 2009). These data will support sustainable management recommendations regarding the use of *bophetha.*

For the purposes of this chapter, *Hemijana variegata* caterpillars are referred to as *bophetha*, as this is the name by which the living caterpillars, as well as the processed product are best known and marketed in Blouberg.

5.2 AIM AND OBJECTIVES

5.2.1 Aim

To gain an understanding of the significance of the *bophetha* (*Hemijana variegata)* resource to the people of Blouberg in terms of its contribution to household income and the extent to which over-harvesting is a potential threat to this resource.

5.2.2 Objectives

The objectives of this study were to:

1. Gain an understanding of the overall quantity of *bohpetha* that is harvested per household and village during good and poor harvests.
2. Determine the quantity of *bophetha* caterpillars that can be harvested per unit effort during good and poor harvests.
3. Investigate the perceptions of local harvesters regarding the factors that determine a good harvest.
4. Investigate harvesting methods and food preparation techniques of *bophetha.*
5. Investigate the importance of the insect as a local trade commodity and whether there is potential for this trade to grow.
6. Explore the possible impact of harvesting the *bophetha* resource over and above the impact of natural predation.

5.3 MATERIALS AND METHODS

5.3.1 Study Site

Three villages were chosen in the foothills of the Blouberg Mountain (2328BB): Sesalong (Leipsig), Morale (The Glade) and Ga-Manaka (Bulbul) (Chapter Three). The villages were chosen out of a total of 16 potential *bophetha* harvesting villages according to the following criteria:

1. Harvesting of *H. variegata* was a regular event in the villages, occurring irrespective of whether *bophetha* seasons were poor or good.
2. The harvesting sites were within walking distance of the village households.

3. The villages were in close proximity to one another to facilitate transport between them for the researcher (between ten and twenty kilometres).
4. Permission was received from both the Tribal Authority of Kgoshi Malebogo and the village headman (*induna*) in each village for the research to take place in the area.
5. Villages were located within 50 km of the local Blouberg Nature Reserve to facilitate comparative field surveys.

The Blouberg Nature Reserve was used as a comparative site because little to no harvesting takes place there. The reserve is situated to the north east of the three villages sampled and within 20 km of the closest village. It is 9 300 ha in extent and encompasses the eastern extension of the Blouberg Mountain. Established in 1982 it is owned and managed by the Limpopo Provincial Government and because of the varied topography it possesses a rich diversity of fauna and flora. The veld type ranges from Kalahari-sandveld in the north to Sweet Bushveld in the east and west. The mountain slopes are covered in Mixed Bushveld and the plateau consists of assorted vegetation comprising Grassveld and Arid Fynbos with Riverine Bush to the south.

5.3.2 Participant Observation Sessions (walk and talk interviews)

One session per village was used to gather information on methods of harvesting and preserving the caterpillars, as well as food preparation procedures (recipes). Additional information on the attitudes of the villagers to this unique food source was also gathered informally during these sessions. A local person, fluent in the Blouberg dialect of Sepedi (seHananwa) translated the questions and answers.

5.3.3 Questionnaire Surveys and Key Informant Sessions

Households were chosen as sampling units rather than individuals because demographic income is available in terms of households. Furthermore, *bophetha* are usually harvested per household, with only one or two members collecting the caterpillars for consumption by everyone in the family. Data were captured using questionnaire surveys (Appendix 2), key informant interviews and participatory rural assessments (PRA). During the 2009 harvesting season (November to December), as well as the 2010 harvest, questionnaire surveys were completed by means of door to door interviews in each of the three villages. The 2009 harvest was richer than the poor harvest of 2010, allowing for a degree of comparison between the years. As is the case for mopane worms (Ghazoul 2006), labelling the harvests, “good” and “bad”, was subjective but based on perceptions by the local collectors. Trained students from the University of Limpopo conducted the interviews in Sepedi which is understood by local people who speak a dialect of Sepedi known as seHananwa. Data on the number of households per village, provided by the Local Economic Development Unit of the Blouberg Municipality were used to ensure that at least 5% of households were sampled per village. This demographic data indicated that Sesalong consisted of 667 households, Ga Manaka of 430 and Morale of 106.

The villages were each roughly divided into four sections and interviewers randomly selected households within each section such that the entire village was sampled. In each household, one individual answered the questions, with input from all members.

The questionnaire was designed to capture information regarding the percentage of households harvesting *bophetha* and attitudes to this practice, amounts harvested and sold, amount of time spent harvesting, the length of time of the season, type of harvest (good or poor) and the perceived reasons for the type of harvest.

In order to capture information regarding the trade in *bophetha* and the amount collected for sale, key informant interviews were held with ten women who sold their harvests. Most harvesting was undertaken by women. Packets of *bophetha* were bought from these traders in order to determine the weight per cup and the number of litres of prepared *bophetha* collected. This data facilitated the determination of the approximate mass of *bophetha* that can potentially be harvested per village during a good season.

Additional information on inflation costs and willingness to pay for harvesting *bophetha* was obtained during the 2011 season when interviews were being conducted for Chapter Six.

5.3.4 Harvesting Field Trial

This trial was designed to augment data collected during the questionnaire surveys to reveal the approximate amounts of *bophetha* that are harvested from the Blouberg villages. The questionnaire surveys were at household level and the objective of the trial was to determine the amounts of *bophetha* that could be collected per individual per hour. This data was used to validate information obtained from the household collectors. The trial commenced during the December 2008 harvest season, which was universally acknowledged by the villagers as a good season (100% of those who were interviewed in 2009 acknowledged that the 2008 season was good). The Blouberg Nature Reserve was selected as the field site as this is an area where harvesting does not occur but is similar in habitat and climatic conditions to the villages. Six harvest areas were selected in areas in the reserve where groups of the host plant, *Canthium armatum,* are common. Three areas were deemed to be areas where *bophetha* was particularly plentiful and trees were located in deep soft sand. The remaining three areas occurred where there were fewer trees, rockier soils and fewer caterpillars. These sites were chosen so as to replicate the harvest areas available to villagers where the caterpillar resource is patchy in terms of abundance, with certain areas yielding more caterpillars than others. Thus poorer harvest areas and richer harvest areas were used in order to determine the average mass that villagers can harvest. Each harvesting area was 30 m by 120 m in extent.

Canthium armatum trees occur in clumps and it is very seldom that a single tree occurs on its own. Generally, trees are clumped in groups from four to roughly one hundred. In each of the six areas all clumps of *C. armatum* trees were sampled exhaustively in an area of 30 m by 120 m. The sites were chosen such that the nearest neighbouring clump outside of the site was at a distance of more than 15 m.

Four people harvested all late instar larvae from all the trees in the chosen clump following the same method that Blouberg harvesters use when collecting the caterpillars (see participant observation results), with one difference: The buckets in which the caterpillars were collected were not filled with water as the harvesters often do to prevent the caterpillars from escaping. This would have compromised the accuracy of the weight measured. Escape was prevented manually. Once all the late instar caterpillars were collected in buckets, they were weighed on a field scale to the nearest gram. The time taken for four people to harvest all the caterpillars in a clump was recorded. The number of trees per clump was also recorded to give an idea of the size of the bush clump as this is an indication of the potential size of the harvest. The average number of grams harvested per hour per person was thus determined. These values were converted to litres as most Blouberg residents harvest the worms in litre buckets and sell the worms in cups. Using demographic household data obtained from the Blouberg Municipality, and Census SA (2000), an estimate of the amount of caterpillars that could be harvested per village was obtained. Information on trade value was used to determine the significance of this harvest in terms of annual household income. The number of live caterpillars per 100 g was also recorded.

5.3.5 Effect of Harvesting on *Bophetha*

In order to determine whether harvesting has a greater impact on reducing the numbers of *bophetha* in a season than does natural predation, sampling was undertaken in three villages subjected to heavy harvesting pressure, as well as in the Blouberg Nature Reserve where harvesting does not occur.

In November 2008, one transect was surveyed through the harvesting field of each of the selected villages. Two transects were surveyed in the Blouberg Nature Reserve, one through *Canthium armatum* vegetation growing on a sandy substrate, and one transect through trees growing on a rockier substrate, so as to ensure that substrate did not influence *bophetha* counts in the nature reserve. This was unnecessary in the villages as the substrate did not vary in the harvesting fields. Each transect was approximately two km in length, except for the two in the reserve which were approximately one km each. For each transect, all the *C. armatum* trees on that transect were examined for caterpillars. *C. armatum* occurs in clumps (due to runners producing shoots) and therefore if a tree was found on the transect, then it, as well as all the others in that clump were examined, regardless of whether the other trees were on the transect line or not. All trees within two m of each other were regarded as belonging to a single clump. For each clump, total number of caterpillars on each tree was recorded and the tree was allocated a size class. In the interests of time, trees were divided into size classes based on height rather than measured precisely. Five size classes were defined: T1 = 0−50 cm, T2 = 50−80 cm, T3 = 80−140 cm, T4 = 140−200 cm, T5 ≥ 200 cm. The number of caterpillars per tree height class was then determined for each transect and transects compared to each other with respect to these numbers.

The experiment could not be repeated during the harvesting season due to the fact that the *bophetha* are ephemeral, and harvest-size caterpillars (later instars) are only available for about two weeks. There was therefore inadequate time to complete more than one field sampling session.

5.3.6 Statistical Analysis

The main analytical tool was descriptive statistics. The student's t test was used to test for differences between the means of each season (good and bad). One way Analysis of Variance (ANOVA) was used to determine whether transects in areas where caterpillars were harvested, differed in terms of numbers of caterpillars per tree length class compared to areas where harvesting did not take place. A post hoc Tukey test at the 95 % level of significance was used to determine where these differences lay. The computer package, SPSS (The Statistical Products and Service Solution, Inc., Chicago, IL, USA version 13.0) was used for these tests.

Note that in the questionnaires, litres collected reflected dried *bophetha.* In the harvest trials field workers collected fresh *bophetha* and recorded the amount in grams. These were then converted to dried weight in order for valid comparisons to be made.

5.4 RESULTS

5.4.1 Participant Observation Sessions

Men were never observed to harvest *bophetha* and although children were involved they could not collect the caterpillars during school hours. Men do collect caterpillars but discussions held during village meetings (*gorahs*) revealed that this is primarily an activity performed by women. This was confirmed in November 2009 when 72%

of the households surveyed indicated that it is principally women who collect *bophetha* in their households.

On harvesting walks through the forest the following actions were observed and confirmed by word of mouth. Only late instar (fourth or fifth) caterpillars were harvested as the younger instars are deemed to be too small to be worth harvesting. Caterpillars were picked off the branches individually; trees were shaken such that caterpillars dropped to the floor and were collected from amongst the debris under the trees, or branches were knocked with stones to dislodge the caterpillars. Long branches were pulled down to grasp the caterpillars from above head height. Branches and trees were never broken or cut in order to obtain more caterpillars, although trees were frequently cut for fuel wood and fences. The caterpillars were placed in buckets which were occasionally filled with water (to a third of the volume) to ensure that they would not escape.

Once harvested, the caterpillars were rinsed three times with fresh water to purge the gut contents and dislodge most of the hairs. They were then placed in a cast iron three-legged pot, covered with water, to which one handful of coarse salt was added and boiled over a fire for approximately an hour. The remaining water was poured away and the caterpillars spread thinly over a zinc sheet or a flat rock and allowed to sun dry for half a day to three days, depending on the weather. Once they were brittle to the touch they were placed in a grass basket or tin tub and “winnowed” to remove most of the remaining hairs. Open buckets and maize sacks were used to store the caterpillars. Care was taken to ensure that air could circulate during storage to prevent the build-up of moisture which would lead to fungal and bacterial growth. *Bophetha* were then eaten, without further preparation, as a snack or as a relish with maize during the main meal. Alternately they were fried in fish oil or boiled in water, then cooked in tomato and onion and eaten as a relish with maize together with a local vegetable.

5.4.2 Questionnaire Survey and Key Informant Sessions

For the percentage of households who harvested *bophetha* during the good and bad seasons, an independent t test revealed that, although there was a difference, with smaller quantities harvested during the poorer season, this is not significant (t = 3.1, p = 0.083 and df = 4, 95 % level). The variance between villages was so high during the poorer season that equal variation cannot be assumed (Leverne's test for equal variance) (Table 5.1).

The percentage of households who sell *bophetha* was also not significantly different between seasons. Leverne's test for equality of variances showed that equal variances could be assumed and at the 95 % level, t = 1.445, p = 0.222 and df = 4. The price per cup of *bophetha* ranged from R5 to R10 per cup, with most sales at R10 per cup.

On average the price per cup was R8.57 ± 2.44 in the poor season and R8.24 ± 2.19 in the good season. An independent t test revealed that the difference in price was not significant at the 95% level of significance (t = 0.000, p = 1.00, df = 19). However, when costs per cup were compared over three years, there was an increase in cost of *bophetha* per cup revealing the influence of inflation (Table 5.2).

The total number of litres (dried) harvested in the good and poor seasons did not differ significantly. Leverne's test for equality of variance showed equal variances could be assumed (t = 0.328, p = 0.743 and df = 93, at the 95% level of significance). However, the maximum number of litres (dried) collected by one person in the good season was 25 litres (taking 7.5 hours to collect) compared to 12 litres (taking 40 hours) in the poor season.

There was a significant difference between the number of man hours taken to harvest one litre of *bophetha* in the good season compared to in the poor season. Laverne's test for equal variance shows they could not be assumed and t = -4.749, p = 0.000 and df = 95 at the 95% level of significance.

When questioned about the reasons for poor *bophetha* seasons, residents overwhelmingly cited lack of rain as the main reason (72%). Twelve percent did not know what influenced *bophetha* harvests. The other reasons cited were rain coming from the east as opposed to the usual westerly direction, leaves forming before the rain, butterflies (white migratory) arriving late and rain accompanied by lightning (4% each). In some cases mention was made of the fact that *C. armatum* trees had been chopped down leading to a bad season (Figure 5.1). The numbers of *bophetha* available was the main factor that determined whether people were prepared to collect *bophetha* or not (Figure 5.2).

Table 5.1 Comparison of results on *bophetha* utilisation during a good and a poor season.

	Good season	Poor season	T test results 95% level of significance	
			t value	p value
% of households who harvest *bophetha*	89.65 ± 4.31	36.03 ± 24.09	3.1, 4 df	0.0083
% of households who sell *bopetha*	27.19 ± 20.44	9.34 ± 6.33	1.445, 4 df	0.222
Average total no. litres collected per household	3.28 ± 3.2	3.04 ± 3.10	0.328, 93 df	0.743
Man-hours spent collecting one litre	*1.16 ± 0.78	*4.34 ± 3.31	-4.749, 95 df	0.000

***** indicates a significant difference between the two seasons

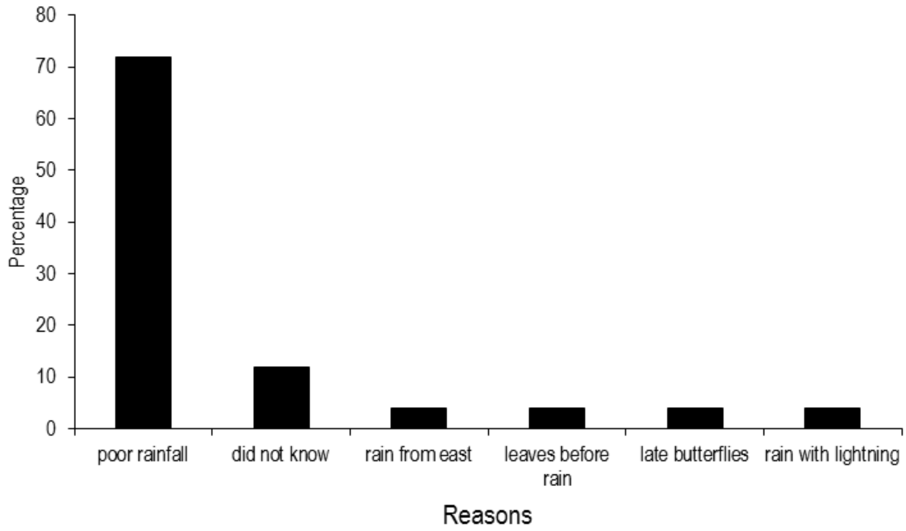

Figure 5.1 Reasons cited for the poor *bophetha* harvest of 2010 (n = 25).

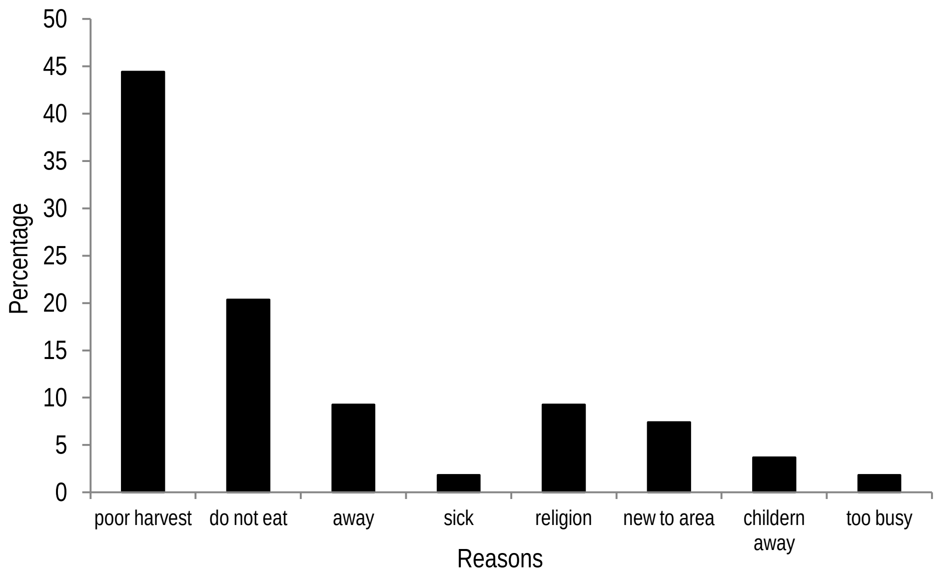

Figure 5.2 Reasons cited for not harvesting *bophetha* in 2010 (n = 54).

In November 2011, the average distance that people were prepared to travel to reach *bophetha* harvest sites was 2.44 ± 2.23 km. None of the collectors interviewed were willing to pay for the privilege of harvesting *bophetha*.

Table 5.2 Increasing cost of one cup of dried *bophetha* over a three year period.

Year	Cost (in Rand) of one cup of dried *bophetha*
2009	8.24 ± 2.19
2010	8.57 ± 2.44
2011	10.19 ± 2.23

Information from the key informant sessions included insights into the rituals and taboos surrounding the collection and preparation of the caterpillars. Young caterpillars, known as *bokoma* in Sepedi, are not harvested, only the larger ones. Late instar caterpillars are harvested in a particular area and the younger instars left, but harvesters frequently return to these sites to collect the caterpillars as they reach mature proportions. There is a belief that if *bophetha* are not collected during one year, then in the next year there will be more *bophetha* and one can resume collection.

There is a taboo against cutting live trees, either for fuel wood or to reach *bophetha* clinging to the higher branches. If these branches are cut, then it is said that the *bophetha* that have been harvested and left to dry at home by the collector, will become mouldy. Similarly, another belief states that if a harvester cuts trees in spring, then the caterpillars that he/she has dried will become rotten. One elderly *induna* (village headman) from the village of Liepzig stated that there is a Traditional Authority policy that no-one may cut the tree, however, he also states that only the older people adhere to this rule. There is no official punishment for disobeying this policy although villagers do rebuke those who cut the trees down. As mentioned above, harvesters are concerned that chopping the trees leads to fewer caterpillars.

Mophetha (Canthium armatum), the food plant for *bophetha*, bears an edible and much sought after fruit. In addition, the branches are prized as fencing material due to the vicious thorns that repel intruders. This, combined with the fact that the tree makes fairly good firewood, means that the tree itself is prized for its own characteristics and is seen as a valuable commodity.

An interesting belief concerning the preparation of the caterpillars is that if one *braais (*roasts) the caterpillars on an open fire instead of boiling them in the traditional manner, those in the wild will disappear.

It frequently occurs that those who collect *bophetha* for sale also collect *mašotša (Imbrasia belina* or mopane worms). The *bophetha* collectors, particularly children, frequently collect for those who cannot collect for themselves, such as those who are blind or elderly. In the good season, 68.4% of the harvesters were women and children.

5.4.3 Harvesting Field Trial

On average, taking into account both rich and poor harvest sites, one person harvested 302.78 g hr^{-1} (± 220.52, range 60.24 – 494.38) of fresh *bophetha* during the height of the harvest season. This is equivalent to 169.57 ml per collector per hour of dry *bophetha*. On average therefore, 251.31 individual *bophetha* caterpillars could be harvested per person per hour. In addition, each 30 m by 120 m (0.36 ha) harvesting site yielded highly variable numbers of *bophetha* (Table 5.3).

Table 5.3 Results showing wet mass of *bophetha* caterpillars harvested per sampling unit (30 m x 120 m), converted to hectares and per metre of tree for the harvesting field trials.

Site	Quantity harvested/ 0.36 ha (g)	Quantity harvested/ ha (g)	Quantity harvested/ m tree (fw)
1	3 110	8 638.89	24.14
2	3 955	10 986.11	12.00
3	1 190	3 305.56	32.31
4	110	305.56	5.26
5	150	416.67	2.23
6	20	55.56	0.63
average	**1 422.5** ± 1 10.22	**3 951.39** ± 4 750.6	**6.63**

The average fresh weight harvested per 0.36 ha was 1 422.5 g (± 1710.2 g, range 20 – 3955 g). Thus 1 ha can produce on average, 3 950 g wet mass *bophetha*, but in a good season, or at a good site, 1 ha could produce approximately 10 kg. This is equivalent to 6 152.16 ml dry weight (6.15 litres), or, assuming mopane worms and *bophetha* weigh the same when dried, then 1.81 kg ha $^{-1}$. This can be compared to 14.63 kg ha $^{-1}$ for mopane worms.

5.4.4 Effect of Harvesting on *Bophetha*

Bophetha caterpillar numbers differed significantly during the harvest season between the nature reserve where they were not harvested and the three villages where harvesting occurred (ANOVA, F = 11.6, P = 0.000, df = 3). The post-hoc Tukey test revealed that there were no significant differences between villages but significant differences between the nature reserve and all three villages.

5.5 DISCUSSION

In Blouberg, *bophetha* are collected about 50 km from the traditional mopane worm (*Imbrasia belina*) harvesting areas and many Blouberg people who eat *bophetha*, also eat mopane worms. Mopane worms are a highly sought after South African edible insect collected from the northern areas of the country and into Zimbabwe, Mozambique, Namibia, southern Angola and Botswana (Ditlhogo 1996, Gondo *et al.* 2010). As they are a significant trade commodity to the rural people of these countries, when edible insects are mentioned in analyses of non-timber forest products (NTFP's) it is generally the mopane worm resource that is discussed (Stacks *et al.* 2003, Leakey 2001, Prabhu *et al.* 2003). It is therefore of interest to compare the two resources in terms of significance to household income and sustainability of the resource. An important point to note is that *bophetha* forms only one of more than twenty species of edible insect collected in the Blouberg area (Chapter Two). Although it is the most visible, there are other forms of insect protein available which further contribute to the protein complement of wild harvested resources in the area. The impact that these other insect species may have on the total amount of edible insect protein consumed has yet to be quantified.

5.5.1 Collection and Preparation

Processing mopane worms for consumption and sale is highly labour intensive (Kozanayi and Frost 2002). *Bophetha* require a much less labour intensive method and the manner of processing is also less damaging to the hands (Table 5.4). They are, however not extensively traded and therefore returns on labour are not as significant as is the case with mopane worms. In terms of packaging, mopane worms have been canned and plastic wrapped with successful results (Gondo *et al.* 2010), whereas *bophetha* are only sold locally and are therefore stored in maize bags or buckets and sold per cup using plastic bags at point of sale.

Table 5.4 Comparison between *bophetha* and mopane worm processing (adapted from Kozanayi and Frost 2002).

	Bophetha	Mopane Worms
Collection	Predominantly women and children	Predominantly women and children
	Trees never cut to reach caterpillars	Sometimes trees are cut to reach caterpillars
	Trees knocked with stones or shaken or picked off tree manually	Collected from small trees or when crawling down trees to pupate
	Premature larvae seldom collected as they are very small	Premature larvae collected when harvests are poor
	Collected in buckets often with water to prevent crawling out	Collected in buckets or tins
	Collectors do not pay and are not prepared to pay landowners for permission to collect	Collectors are prepared and often do pay landowners for the right to collect
Removing gut contents	Quick and not painful	Labour intensive, time consuming and painful to hands.
	Worms rinsed thoroughly by the bucketful three times in water to stimulate expulsion of gut contents	Worms individually squeezed by hand resulting in painful, discoloured skin due to the spines. Bottles used to squeeze out contents (less painful and quicker but expels nutritive material)

Table 5.4 Cont.

	Bophetha	Mopane Worms
Cooking and drying	Boiled in a cast iron pot for an hour on the fire in salted water	Roasted on coals on the fire to remove spines. Time consuming but preferred as it removes spines.
	Sun dried on a rock or a piece of zinc	Boiled in salted water (spines remain and cannot be sold to outsiders)
	Winnowed in a basket to remove the remaining hairs	Salted and dried directly in the sun (spines remain)
Packaging	Collectors sell directly to consumers by the cupful from 50 or 70 kg maize sacks	Traders buy from collectors and package into tins and maize sacks
	No re-packaging	Traders re-package into plastic bags or newspaper or sell directly by the cupful

5.5.2 Demographics of Insect Collectors

During mopane worm harvests, women and children are traditionally the collectors and processors, although men become more involved when bulk sales occur (Kozanayi and Frost 2002). This is a common trend in insect collecting throughout southern Africa (Hunter *et al.* 1990). In fact, few women are involved in long distance, bulk trade, particularly when cross-border trade is involved. This is due to the fact that women have many family obligations requiring that they remain at home. It is also cumbersome to transport large quantities of mopane worms over the distances required. Similarly with *bophetha,* most collectors are women and children and they are involved in the collecting and processing. However, in the limited study area in which the investigation took place, it was women rather than men who traded in *bopetha* in contrast with mopane worm trade. This may be due to the fact that selling *bophetha* does not necessitate long journeys with cumbersome sacks as the consumers come to the collectors and it is therefore easier for women to be involved.

An investigation by Stacks *et al.* (2003) into mopane worm harvesting and livelihoods highlighted that although 80% of people in the mopane worm "belt" harvested the caterpillars, wealthy families seldom collected mopane worms because they did not have time but they participated in the industry through buying the processed resource. For *bophetha*, household income data was not collected but results from Chapter Two indicate that it is the rural location of families, rather than their income status that determines whether or not they collect edible insects.

For mopane worms, households frequently have to compromise between important household tasks and mopane worm collection. The mopane worm and *bophetha* seasons both fall within the annual ploughing and planting period. For mopane worm collection this problem is acute since collection and particularly processing, is time consuming and very often takes place far from home (Stacks *et al.* 2003). For *bophetha* harvestors, the important tasks of ploughing and planting can continue simultaneously with insect collection as harvesting can take place in the morning and farm work in the afternoon.

Many children are involved in the collection of *bophetha* after school hours and the timing of the harvest can also influence the amount of caterpillars collected by a family. Usually, the school holidays coincide with the *bophetha* season and thus children are more available to help with the harvest. In the case of mopane worms women are generally in the majority with respect to harvesting (Rebe 1999). Children are occupied with their schooling and men are involved with farming activities or at work. There is also a perception that mopane harvesting is “women’s work” and men are therefore less likely to take part.

5.5.3 Timing of the *Bophetha* and Mopane Worm Harvests

Bophetha are generally available for harvest a few weeks before the mopane worm harvest. Emergences of mopane worms in Blouberg are limited as only their secondary host plant; the marula tree (*Sclerocarya birrea*) is available. However, many Blouberg residents travel north to the Alldays area (northern Limpopo) and even further to Botswana in order to collect mopane worms. The *bophetha* traders generally sell their stocks within a few days to two weeks of the harvest, leaving them with enough time to travel to the mopane collection areas before that season ends. The *bophetha* collection period generally lasts over only two weeks whereas the mopane worms can be harvested for three to four weeks. In addition, in good years there is a second harvest from the beginning of March (Gondo *et al*. 2010), whereas *bophetha* appear only once a year (Chapter Three). Those trading in *bophetha* frequently also trade in mopane worms and therefore the timing of the *bophetha* harvest is particularly significant.

5.5.4 Travel Costs of Collection

In contrast to the mopane worm trade (Gondo *et al*. 2010), the market for *bophetha* is localised and it is the consumers who come to the traders to buy the product rather than the reverse. There are thus no travel costs to be borne by *bophetha* traders. In addition, many collectors do not have to travel by vehicle to the collection areas as they live in the villages close to the Blouberg Mountain where the host plants are located. Local collectors are not prepared to travel more than three km to harvest *bophetha* in contrast to mopane worm collectors who are willing to travel up to 100 km to collecting sites (Letsie 1996). They are also not prepared to pay landowners for the privilege of collecting the caterpillars. Kozanayi and Frost (2002) found that the closer the mopane worm traders were to the mopane veld, the more difficult it was to make good mopane worm sales because consumers could collect the caterpillars for themselves.

In the same way, sales of *bophetha* may also be affected by the proximity of the consumers to *bophetha* sources. This aspect requires further investigation however, because it is likely that there exists a cut off distance after which people are unfamiliar with *bophetha* and therefore would not buy this resource. For example, in one conversation during the participant observation sessions, women harvesters of Blouberg observed that they would not eat the unfamiliar edible caterpillars of the Mokopane area in the south of Limpopo as they “looked unappetising” although they enjoyed several species of the local Blouberg caterpillars (personal communication Waleng, Blouberg resident, 2009). Similarly, during questionnaire surveys for Chapter Two, a number of respondents noted that although they enjoy eating insects, they don’t eat insects that are unknown to their area. Similarly in the Amazonian forest, several tribes of Amerindians utilise more than 209 known species of edible insects but not all tribes consume all the species, even when the tribes are not separated geographically from the species (Paoletti and Dufour 2005).

The fact that *bophetha* are almost unknown outside of areas where they are harvested is reflected in the fact that only a small percentage of households who collect them actually sell them (in good seasons 27.19% and in poor seasons 9.34%), while for mopane worms up to 47.0 % of people who collect mopane worms also sell them (Stacks *et al.* 2003).

5.5.5 Attitudes to Collectors from Elsewhere

Local collectors from certain villages close to large populations of *Canthium. armatum* trees complain of strangers from villages further afield arriving to harvest “their” *bophetha*. Despite the negative attitude towards these “outside” collectors, there are no formal policies or local traditions in place to prevent them harvesting the *bophetha.* In contrast, in the mopane worm situation, most collectors are not from the local villages. In southern Zimbabwe, some rural district councils charge traders a levy for buying mopane worms in certain areas (Gondo *et al.* 2010). Although charging collectors and/or traders from elsewhere a levy could be one means of managing the *bophetha* population, care would have to be taken to prevent illegal harvesting and to set up acceptable methods of dealing with offenders. Such regulations would have to be developed by the community in question with the endorsement and backing of the tribal authority and local municipality for them to be effective.

5.5.6 Percentage Contribution to Household Economy

In the Blouberg area where 37% of households have no discernible annual income (Statistics SA 2000), all contributions to household economies are important, whether on a small or large scale. Thirty nine percent of households have an annual income of between R1 000 – 9 600, with 13% receiving between R9 601.00 – R19 200.00 per annum. Only 11% have an income of over R20 000.00 per annum. Indeed, in 1996, 61.8% of Blouberg’s residents were unemployed (Capricorn District Municipality 2009) and this percentage has probably increased given the present economic downturn in the country.

With *bophetha* ranging in price from R5.00 to R10.00 per cup, the most expensive caterpillars cost R71. 43 kg^{-1}, dry weight, compared to approximately R50.00 kg^{-1}

for minced meat (the cheapest form of beef protein). Thus, *bophetha* can be regarded as a luxury item rather than as a famine food. It is important to note however, that most collectors do not sell their harvests but use them for own consumption and may therefore gain the benefits of a tasty, healthy, “luxury” food item without the cost usually associated with such food. For those who do not work, the time factor for collecting the insects may be more convenient than for those spending hours earning money in some other way.

The relative contribution made by *bophetha* to household income that increases as income decreases, will obviously be more significant in poorer households. Thus, even if *bophetha* are not sold, the percentage of savings made by eating a wild food source would be significant. For example, in the good season, one woman’s harvest of 25 litres, translated into monetary terms, would earn R1000.00. During the poor season she collected 12 litres, thus earning R480.00 that season. For those 37% of households who do not have an income, and even the 39% who earn up to R9 600 per year, this represents a sizeable portion of the year’s earnings. In the case of mopane worms, where sales may contribute anything between 11 and 26 % of total cash income (RIU 2007), poorer households will benefit proportionally more than those with higher incomes. For instance, mopane worm sales accounted for nearly 40% of cash earned in the poorest quarter of households, declining to 20% in the middle half of households and contributing less than 4% of cash income for households in the top quarter of earnings (RIU 2007). Agea *et al.* (2008) also report on the importance that a small contribution makes to the income in a marginalised household in Uganda where the edible grasshopper *Ruspolia nitidula* is collected and sold. Such findings for *bophetha* are similar to those of Dovie *et al.* (2001) who report that in Thorndale (Limpopo Province, South Africa), edible insects in general contribute 0.7% per annum (or $5.05 per annum) to household income. It should be borne in mind that in Blouberg a suite of edible insects are consumed and thus the contribution of edible insects in general will be more significant.

Cups of *bophetha* are always filled to overflowing by the sellers as is the case in the sale of mopane worms (Kozanayi and Frost 2002). Maize sacks of 50 and 90 kg are used to transport *bophetha,* as is the practise in the transport of mopane worms

(Kozanayi and Frost 2002). Mopane worms and *bophetha* are on a par regarding price and indeed, all insects in Blouberg are sold between R5.00 and R10.00 per cup (Chapter Two). Further afield, *thongolifa* (the pentatomid bug *Encosternum delegorguei*) is sold for between R5.00 and R20.00 per cup in Venda, northern South Africa (Dzerefos in prep., Makhado *et al.* 2009). This is a premium price, being higher than that for beef which sells for R50 kg^{-1}, for the cheapest cut (minced beef), whereas in Uganda, the grasshopper *R. nitidula* costs roughly the same amount as goat meat (Agea *et al.* 2008).

In southern Zimbabwe, mopane worms can contribute up to one quarter of a household's cash income (Gondo *et al*. 2010), and assist in the following ways:

1. Supplementing seasonal shortages of cash or food due to the fact that the outbreaks occur at a lean time.
2. Buffering against unexpected shortages of cash or food for example, illness, natural and financial disasters.
3. Supplementing expenditure on important things such as education, capital outlay and ceremonies.
4. Providing cash for investment such as farming, savings or other enterprises.

There is evidence that insects are subject to the same inflation effects as any saleable commodity. Termites, *thongolifa* (*Encosternum delegorguei*) and mopane worms were sold for R5.00 per cup in Giyani, South Africa in 2009 (Makhado *et al.* 2009) and this increased in price to between R10.00 and R20.00 per cup in 2012 in Venda (Dzerefos *et al.* in prep). Over the three years in which this study was conducted the price of the *bophetha* did increase. This was not merely due to the difference between poor seasons and better seasons. In the poor 2010 season *bophetha* were only R0.34 per cup more expensive than in the good 2009 season. In yet another poor season in 2011, *bopetha* increased dramatically by R1.62 per cup indicating it is not only the type of season that contributes to the price of the caterpillars but that this may be an indication of price hikes in more conventional food.

Bophetha are not sold on the same scale as mopane worms, where traders in Venda, Thohoyandou reportedly make up to R20 000.00 per annum in a good year

(Makhado *et al.* 2009). Thus, although *bophetha* fulfil some of the above needs, point one is the most significant.

Mopane worm traders generate more income if they sell their stock in urban rather than rural areas (Gondo *et al.* 2010), but this is unlikely to be true of *bophetha.* Consumers are not always adventurous eaters and *bophetha* is a local delicacy which is at present little known in urban areas. This situation is similar to that in the Amazon where local forest dwellers collect and consume indigenous insects but only trade with them amongst themselves. Most of the insects are not known at all in the urban areas of the country (Paoletti and Dreon 2005). The authors of this investigation advocate the dissemination of the knowledge of such products amongst urban dwellers in order to expand the diet base in cities, to encourage the preservation of the knowledge of these food resources and to contribute to biodiversity conservation. For the *bophetha* resource, a fledgling market may already exist in Limpopo's urban areas consisting of people who have moved to the city from rural places where *bophetha* are eaten. At least one collector mentioned that he sells *bophetha* in the urban centre Seshego, a suburb of Polokwane (the provincial capital). Caution should be exercised however, as it is also possible that a market could be created for a resource that cannot be sustainably managed.

Stacks *et al.* (2003) indicated that for mopane worms, harvests varied enormously between households, between villages, between seasons and between countries (with Botswana realising greater harvests than Zimbabwe). This is also true for *bophetha* but additionally, harvests of *bophetha* are much smaller than those of mopane worms. In Botswana, harvesters could collect up to 350 kg of dried mopane worms per person in a good season. Even in Zimbabwe, which has poorer harvests, collectors managed up to 217 kg per household. In a similar study on mopane worms Ghazoul (2006) reports that in good seasons an average of eight 20 litre buckets of dried worms were collected per household. In poor seasons this was reduced to two 20 litre buckets per season. Even in the poor season this exceeded *bophetha* harvests in Blouberg, where, in a good season, 7.5 kg of dried *bophetha* was the highest amount collected for a household.

Mopane worms have only recently become more significant as a commercially traded commodity and were originally collected predominantly for subsistence (Stacks *et al.* 2003). In the early nineties, only up to 39% of stock was sold whereas, ten years later in 2001/2002, 59% was sold for cash and a further 19% exchanged for goods. Reasons given for the increase in commercialisation of the product in Zimbabwe are the decline in economic stability in that country coupled with the extreme droughts of the late eighties and early nineties which forced economically vulnerable communities to seek other forms of income generation. In Botswana, where the economic climate is more favourable than in Zimbabwe, interest in mopane worm collection is declining (Stacks *et al.* 2003). It is thus possible that in worsening economic or climatic conditions, Blouberg communities would turn to *bophetha* and other edible insects as a means of increasing cash flow, despite the relatively small yields and the fact that the resource may not be robust enough to absorb increased harvesting levels.

5.5.7 Livestock Farming as Compared to Edible Insect Collection

The most common form of land use in the Blouberg Municipality is that of smallholder farming (Grwambi *et al.* 2006). Most households maintain livestock of some sort, ranging from poultry through to goats, cattle and donkeys (Chapter Two). However, only the poultry is consumed regularly. Goats, cattle and donkeys have a number of uses including the following: Generation of income, food security, social status, paying of school fees, draught power, investment and manure (Grwambi *et al.* 2006). Each village possesses at least one small general shop where consumables can be bought and most households prefer to buy beef rather than slaughter a goat or cow for everyday consumption (personal communication, Morata, P. 2006).

Harvesting of *bophetha* is an activity that is compatible with this type of farming, as long as pockets of indigenous woodland remain in the foothills of the mountain. Goats and cattle are frequently encountered grazing and browsing in areas where *bophetha* are being actively harvested. Tefera *et al.* (2008) report that in Swaziland *C. armatum* leaves are browsed by both cattle and goats, but the extent to which this occurs in Blouberg is not known and neither is the effect that such browsing could have on the caterpillar population.

A large investment in time, as well as money, is necessary for livestock production. For example, farming in rural areas with goats requires 84 man days per annum and most rural people only have about 5% of their time available for livestock management (Coetzee 1998). *Bophetha* havesting is also time consuming but time expenditure is limited to two, or, at most, four weeks per annum of between two and six hours per day. Depending on the size of the harvest, the resource can be stored for up to one year ensuring a year round supply of a nutritious resource. In addition, storage does not require expensive refrigeration or freezing and the drying process is less intensive than that for meat (van der Merwe *et al.* 2009). Paoletti and Dreon (2005) mention that, because of the high quality protein and fat available in edible insects, they are a sought after resource and are worth spending time to collect. Indeed chimpanzees spend up to 39% of their time collecting insects although they represent less than 5% of their food intake (Hladic 1973). Thus, even though the harvest of *bophetha* might not be significant in terms of mass, the high quality insect protein makes it worthwhile collecting. The harvest would have to be unusually large before it would be necessary to store *bophetha* for an extended length of time as the caterpillars are much sought after when they are in season. One collector indicated that he would easily sell 25 litres of dry *bophetha* in one day.

In contrast to *bophetha*, mopane worms are ranked second only to livestock in terms of agricultural importance in areas where they are harvested (RIU 2007). This is not the case with *bophetha.* For example, the largest amount of *bophetha* collected in a household in the good season was 25 litres*.* According to the results from the harvesting trials, where the greatest yield was 11 kg ha^{-1}, it would be necessary to have access to about 153.75 ha of harvesting land to collect this quantity of *bophetha*. The harvest trials indicate that a harvest of this amount should take between one and two hours per litre; therefore 25 to 50 hours. However, it took this collector only 7.5 hours, or one day, to collect 25 litres in the good season, although 40 hours were spent collecting 12 litres in the poor season. The discrepancy in number of hours calculated to harvest 25 litres is due to the fact that *C. armatum,* the food plant, is not distributed evenly throughout the landscape. Thus it is extremely difficult to predict yields and productivity of the land in terms of *bophetha* harvests. Despite the measurement difficulties, it is still clear that *bophetha* harvests will never be comparable to mopane worm harvests, either in terms of yield per hectare or trade value. Further reasons for the greater harvest possibilities of mopane worms include the following:

1. mopane veld is extensive making up an entire bioregion within the savannah biome (Mucina and Rutherford 2006), whereas *Canthium armatum* trees are confined to a much narrower set of climatic and biogeographical conditions in the north-eastern regions of South Africa, extending slightly into Mozambique (Palgrave 2005)
2. Mopane worms are able to exploit at least 22 different host plants both within the mopane bioregion and outside of it (Rebe 1999) in contrast to *bophetha* which are known to feed extensively only on *Canthium armatum* and less often on *Pyrostria hystrix* (Chapter Three)
3. Mopane worms produce two generations per season and it is therefore possible to harvest the caterpillars twice per annum (Rebe 1999). On the other hand *bophetha* are known to have only one harvest per annum, even during years when conditions are good (Chapter Three).

On the surface therefore, *bophetha* collection does not compare favourably with livestock farming, mopane worm harvesting, or even with other types of edible insect collection. For instance, in Malawi, mopane worm yields were, on average, 14.63 kg ha $^{-1}$ dry weight (Munthali and Mughogho 1992) compared with the *bophetha* yield for 2008, which was only 1.81 kg ha $^{-1}$. Edible termites have been recorded to yield up to 40 kg ha $^{-1}$ (deFoliart 1995), although it is not known if this was dry or wet weight. In terms of the amount of time spent collecting insects, the edible palm weevil (*Rhynchophorus palmatus*) can yield 2 kg per hour in Columbia, which is more comparable to *bophetha* yields (deFoliart 1994). A saturnid caterpillar in Zambia can yield 20 litres per day in favourable seasons, something that is rare with *bophetha* unless harvests are exceptional (Holden 1991). The yields for *bophetha* are highly variable between sites and, as the experiment was only conducted for one harvesting season, it would be necessary to repeat this over the years to obtain a more accurate estimate. Further investigation is also needed to determine the agricultural carrying capacity of the pockets of *C. armatum* land. Information on the amount of *bophetha* actually consumed per annum by men, women and children in Blouberg would add to our knowledge of the nutritional contribution the caterpillars make to the local diet. For instance, the Tukanoans consume approximately 1.7 g ha^{-1} per annum which is less than 0.01% of the total 18 kg ha^{-1} of edible caterpillars in the Amazonian Amerindian harvest region (Paoletti *et al.* 2000). Again, it is important to bear in mind that *bophetha* are not the only edible insects harvested in the Blouberg area and therefore switching between insect resources as they become available will increase the yield per hectare of insects in general.

The harvesting efficiency for *bophetha* may be more comparable to figures from the Amazonian jungle. For the Tukanoan Indians for example, the foraging efficiency for caterpillars was 300 g ha^{-1} (Paoletti and Dreon 2005). Yields per hectare for *bophetha* ranged from 20 to 3 955 g ha^{-1}, but these figures are based on harvesting trials and were not taken from actual local collectors in the field. The Tukanoans harvest earthworms and termites with a similar foraging efficiency to that of caterpillars. When hunting for fish the value increased to 494 g ha^{-1} and game was even more efficient with a figure of 1 003 g ha^{-1}. Despite the lower foraging efficiency, insects were still a sought after food. This may therefore be true of *bophetha* which have recently been found to be a high quality protein source (Chapter Four). Thus despite the fact that the figures for quantities of *bophetha* harvested per ha are not directly comparable with livestock farming or mopane worm harvesting, a choice is not required between these three. *Bophetha* collection can continue in conjunction with both livestock farming and the annual migration to mopane collection sites.

5.5.8 The Influence of Season on Collection

In Blouberg area, a greater percentage of households (89.65 ± 4.31%) harvested *bophetha* in the good season compared with 36.03 ± 24.09% in the poor season indicating the impact of season on the gathering of this resource.

There are a number of articles attesting to the use of NTFPs, including edible insects, as a famine food or food security safety net (Shackleton and Shackleton 2003, Twine and Hunter 2008). This may not be entirely true for *bophetha* nor indeed for most edible insects. Both mopane worms (Ditlhogo 1996, Illgner and Nel 2000) and *bophetha* are profoundly influenced by rainfall patterns. In addition, *bophetha* are also affected by high temperatures at all life history stages (Chapter Three). High temperatures and low rainfall are two of the most profound negative environmental influences on subsistence farming (Mendelsohn *et al.* 2000) and therefore when crops such as maize and sorghum fail because of these effects then the same will be true of *bophetha* harvests. It will therefore not be possible to switch to collecting these insects during drought years. Mopane worms constitute a resource that is relatively more important when crops fail and there is much investigation into developing laboratory/farming methods to make it a more reliable source of income (RIU 2007) but to date little success has been achieved in stabilising the resource through changeable climatic conditions. This would almost certainly also be true of the *bophetha* resource which is not well suited to laboratory production due to the labour intensive nature of the rearing procedure (Chapter Three).

Thus, *bophetha* are harvested in good and bad years and are also sold in these seasons but the amount of effort that goes into doing so increases dramatically in bad seasons. Harvesting as much in the poor season as in the good, as happens at this point in Blouberg, could negatively impact on *bophetha* numbers, as there would be few left to recover in the next season. The implications for climate change in general are therefore that *bophetha* may diminish if temperatures increase drastically and might become unavailable as a wild resource to supplement diminishing agricultural returns. For mopane worms however, numbers of caterpillars harvested are reduced greatly, sometimes tenfold, during poor seasons (Ghazoul 2006). It has been noted that for mopane worms, the host plant, *Colophospermum mopane*, is better adapted to drought than most crops and therefore the caterpillar could provide a slight buffer to famine in drought years (RIU 2007). *Canthium armatum*, the host plant for *bophetha*, is found in drought prone environments and is therefore adapted to dry conditions (Palgrave 2005), but a more detailed investigation of the thermal development range for the caterpillars is required to reliably estimate the impact of drought on this resource.

For mopane worms, the percentage of worms reserved for trade and those used for household consumption varies depending on the type of harvest experienced (Ghazoul 2006). Thus, in "good" harvests, a higher percentage of caterpillars are sold immediately than are stored for food. For *bophetha* the percentage of households selling caterpillars varied from 27.19% in the good season to 9.34% in the poor season. Thus, in a good season the percentage of households engaging in trade is similar to that of households in Giyani (north-east Limpopo) where 29% of households sell mopane worms (Makhado *et al.* 2009).

During poor seasons, mopane worm traders must travel much further (approximately 170 extra km) for supplies or wait and buy in bulk from other collectors who have made the journey themselves (Kozanayi and Frost 2002). In the case of *bophetha*, collectors do not travel in search of other caterpillar outbreaks but spend much longer collecting the same amount of caterpillars that they would have collected in good years. Travel costs therefore remain the same but effort and time spent collecting increase in poor seasons. Host plants of *bophetha* are not as widespread as those of mopane worms and therefore it may not be worth travelling further afield to harvest *bophetha* as the harvest may be poor throughout the distribution of the insect. Relatives from a rich *bophetha* harvesting area give presents of the caterpillars to other family members and friends, thus even though one family may not collect *bophetha* from within their area, they may acquire the delicacy from elsewhere.

5.5.9 Causal Factors of Poor Harvests

Kozanayi and Frost (2002) report that mopane worm collectors in southern Zimbabwe attribute poor mopane seasons to high temperatures and low rainfall. This is in agreement with Madibela *et al.* 2009 who state that the availability of the caterpillar relies on the amount and timing of rainfall, both of which are erratic and unreliable. In Blouberg, low rainfall is also seen by collectors as the main reason for low *bophetha* harvests but high temperatures were not considered a factor. In the case of mopane worms it is generally acknowledged that high harvesting rates are causing a decline in the caterpillars (Gondo *et al.* 2010). In Blouberg, the fact that this activity could also impact negatively on *bophetha* numbers is only indirectly referred to by one or two individuals in the statement that foregoing harvesting in one year would lead to an increase in caterpillars the following year.

5.5.10 Non-collection of the Insect Resource

The main reason given for not collecting *bophetha* was that the season was poor, with few caterpillars available. Almost half of those who did not collect *bophetha* during the poor harvest of 2009/2010 gave as their reason the fact that there were so few caterpillars and that they would rather wait and collect in the next season if the harvest improved. The next most common reason (20.37% of respondents) was that people do not enjoy the taste of the caterpillars. Thus these respondents would never collect *bophetha* regardless of the conditions.

It is interesting that, despite the prevalence of the Zion Christian Church (ZCC) in the area, most people do consume *bophetha* (89.65%±4.31). People of this religion do not eat insects other than locusts, as they follow the commandment in the book of Leviticus in the Old Testament, chapter 11 verses 41 and 42, which states: *"…and everything that creeps on the ground and (multiplies in) swarms shall be an abomination; it shall not be eaten. Whatever goes on its belly, and whatever goes on all fours or whatever has more (than four) feet among all things that creep on the ground and swarm, you shall not eat; for they are detestable."* Similarly, reasons for not eating mopane worms have also included belonging to the ZCC church (Kozanayi and Frost 2002). In Blouberg 9.26% of respondents do not collect *bophetha* because they are ZCC members, although locusts are permissible.

People who are new to the area do not always adopt new eating styles, and this is reflected in the fact that 7.41% of respondents do not collect *bophetha* because it is a novel food to which they are unaccustomed.

The *bophetha* harvest is not always something that is important enough to ensure that people stay at home to collect the caterpillars. Almost 10% of respondents did not collect *bophetha* because they were away at the time. It is also interesting to note that some families (3.7%) did not collect *bophetha* because their children were still in school. Ill health and lack of time were minor reasons (1.85% each) for people not to collect caterpillars and could change in the following year.

5.5.11 Management Options

In light of the findings by Rebe (1999), that mopane worms are being overharvested, with people collecting larger amounts for trade than they used to collect traditionally for their own consumption, Gondo *et al.* (2010) argue that some kind of management intervention is necessary. They advocate a system whereby the natural resource as a product, is given sufficient cash value to increase cash income into the community and thus elevate the resource as something to be valued and therefore utilised sustainably. With local people adding value to the product through preparation, packaging or cooking and stimulating people to manage their own resources, the resource will have a stronger chance of being valued and managed well. In contrast to mopane worms, where harvest areas include open access (communal and homesteads) land as well as large commercial farms where access is often on condition of payment (Stacks 2003), *bophetha* are collected from open access communal lands behind the villages in the foothills of the Blouberg mountain. These areas are under the jurisdiction of the chief and any management options considered for *bophetha* would have to be endorsed and implemented by this tribal authority. Bophetha have traditionally been an “open” access resource and this could account for the reluctance that existing collectors have towards paying for the right to collect the caterpillars.

Bophetha are also found in large numbers in the provincial Blouberg Nature Reserve, with transect work and harvesting field trials indicating a healthy population (Figure 5.3). At present, harvesting of edible insects is not officially permitted on the reserve, although some *ad hoc* collection does occur. It is possible that the nature reserve could act as a reservoir from which recruitment into nearby communal lands could occur if these areas were overharvested. This would need investigation as the moth is a poor flyer and only lives for three to four days. It is probable that if the reserve were to be used as a recruitment zone, some kind of physical intervention would be required to re-populate decimated areas. It is important that the role of the reserve in terms of *bophetha* management be clarified. At present, the best way of integrating the reserve with the surrounding community's needs is being investigated. The Manoko tribe has recently won a land claim in the area including the nature reserve and there are discussions on how to protect the natural resources of the reserve while at the same time maximising the benefits of owning the reserve. Permitting the harvesting of edible insects on the reserve could benefit the Manoko tribe but research is required to ensure that this is not mismanaged and that the role of the reserve as a recruitment source for the insects is not compromised. It should be borne in mind, as Paoletti (2005) states, that it is difficult to protect fauna and flora that is not considered useful. The fact that *bophetha* are a valued resource should facilitate conservation measures if the resource is found to be declining. Conserving the *Canthium armatum* host plants on which the *bophetha* depend, would in turn conserve the natural communities and species populations within and around these stands of trees. Those adults who are familiar with old traditions, taboos and traditional authority policies around protection of the *bophetha* resource, would not find simple management actions alien. Table 5.5 demonstrates management options including suggestions that were implemented in past times by the traditional authority in the area in comparison with those suggested for the mopane worm.

Figure 5.3 Weighing *bophetha* (*H. variegata*) in the field during harvesting trials

Table 5.5 Management options proposed and in place for mopane worms (modified from Ditlhogo (1996), Gondo *et al.* (2010), and Toms (2007) as compared with traditional management and suggested formal management options for *bophetha*.

Mopane worm	*Bophetha*	
	Equivalent tradition, taboo or traditional policy	**Formal management recommendation**
Maintain sufficient 5th instar caterpillars by leaving a certain number on each tree	Taboo on collecting instars smaller than 4th or 5th stage	Do not remove the last 30 caterpillars from any one tree
Maintain caterpillars for recruitment by banning harvest in particular areas	Taboo on visiting certain sacred mountain areas, some of which possess *C. armatum* trees	Maintain Blouberg and Malebogo nature reserves as harvest free areas for recruitment
Safe-guard host trees against over-exploitation (wild fires, over grazing, fire-wood collection, chopping to obtain caterpillars or for carving)	Taboo on cutting *C. armatum* trees to reach inaccessible *bophetha* or for fuelwood or fencing	Plant *C. armatum* trees in private yards and communal lands
Restock yard host trees with eggs or young caterpillars	No known	Re-stock depleted areas and yards with eggs or caterpillars from the local nature reserve
Prevent digging up of pupae for food	Not applicable: pupae not used	Not applicable: pupae not used
Institute variable quotas: no harvest during poor rainfall years	Customary for collectors to waive harvesting during a poor season	Institute variable quotas: no harvest during poor rainfall years
Impose levies on those coming from further away	Not known	Impose harvest levies for collectors outside of the area

Taboos and rituals can protect a resource to a certain degree but are vulnerable to abuse and misinterpretation whether deliberate or accidental. For example, in the Blouberg area, according to Mr Mafala, a ranger at Blouberg Nature Reserve (2009), people do not collect the small *bophetha* caterpillars (*bokomo*), in line with traditional taboos, but frequently come back later to collect them once they've grown to the acceptable size. The expected resource reservoir of unexploited, late developing instars is therefore non-existent. As Gondo *et al.* (2010) state, it is vital that there is a blending of such traditional taboos, knowledge and local circumstances with goal driven scientific research to ensure that a resource is truly managed sustainably. Findings should be translated into legislation at local government level to ensure that implementation of these management options occurs. In the case of *bophetha*, the most promising formal means of ensuring sustainable management would be to continue with the ban on harvesting within the two local nature reserves, to facilitate the planting of *Canthium armatum* trees in yards and communal land and to institute means of re-stocking depleted areas with caterpillars and eggs from the nature reserves. Other options are too dependent on costly law enforcement agencies, or inappropriate with regard to the natural history of the caterpillar. For example, in Zambia, one caterpillar species is so sought after that government legislation limits harvesting to a four week period to allow for early and late hatching caterpillars to survive to repopulate targeted areas (deFoliart 1999). Such a strategy would not be appropriate for *bophetha* due to the highly variable nature of the harvest where, in poor seasons the harvest period only lasts for one week but can continue for more than four weeks during good seasons.

The Capricorn District Municipality (2009) has acknowledged that Traditional Authorities in the Blouberg Local Municipality should restore ancient processes whereby activities that may cause environmental degradation can be adequately managed. Thus traditional taboos and practises that favour the sustainable use of *bophetha* should receive government support. The Blouberg Traditional Authority's influence in the area has dwindled over the years and unfortunately the vacuum left in the monitoring and importantly, the disciplining of offenders, has not been filled by relevant government departments (Capricorn District Municipality 2009). Where in the past, the traditional authority monitored and implemented processes to manage the sustainable use of fuel wood, grazing areas, building of houses and other natural resources such as wild sourced food and medicine, this no longer occurs very effectively. Such natural resources are therefore vulnerable to over-exploitation by harvesters who are degrading the environment for short term gain rather than long-term sustainability. Even where perpetrators are arrested, courts seldom issue fines or sentence offenders to jail. Van Itterbeeck and van Huis (2012) have stressed the importance of traditional means of securing future good harvests of edible caterpillars in other areas of sub-Saharan Africa. Thus, in the Kopa area of Zambia, moths with edible caterpillars and their egg clumps, are closely observed and collecting practices modified depending on the size of each year's crop (Mbata 2002). The collection of final instar caterpillars only, is strictly enforced and where necessary harvest restrictions are put in place and adhered to. All community members are involved with the management of the caterpillars and a top down approach is avoided.

Mopane worms have been known to disappear from certain areas in Botswana after heavy harvesting. Damage to mopane trees also negatively affects the abundance of these caterpillars (Ghazoul 2006). In Namibia and Zimbabwe, increasing degradation of mopane veld has resulted in a positive attitude amongst the local people towards implementing management strategies to increase yields of the caterpillars, as they can see the effects of habitat destruction (Musvoto 2006). It is thus imperative to investigate the effect of harvesting and damage to the host trees on post-harvest recruitment in *H. variegata.*

5.5.12 Mini-livestock and Semi-domestication

Madibela *et al.* (2009) advocate the use of agroforestry farming methods to improve the yield of mopane worms, including larvae-culture. They do admit however, that the cost implications of such activities should first be carefully assessed. Ghazoul (2006) reported that despite these reservations, the prosperity of the area should increase by introducing innovative, semi-domesticated farming methods to areas where mopane worms are collected. Villagers in Botswana and Zimbabwe have already participated in a pilot project on the semi-domestication of this caterpillar but despite initial high levels of enthusiasm continued high level support is necessary for the success of the project (Ghazoul *et al.* 2007).

In a review on mini-livestock, Paoletti and Dreon (2005) mention numerous examples where wild food resources are semi-domesticated either by scattering seeds close to homesteads, cultivating insect nests near to human habitation or propagating edible invertebrate food plants in convenient areas. In a comprehensive review of manipulation of the environment for the purposes of enhancing edible insect harvests, van Itterbeeck and van Huis (2012) describe several strategies from various parts of the globe, including sub-Saharan Africa. Many of these strategies were practiced by prehistoric people and have continued through the ages in modified forms. For instance, semi-cultivation for palm weevils is practiced in Africa, Asia and South America. Strategically placed cuts and holes are made in the palms to allow the palm weevil easier access to the nutritious inner wood. In South America, palm trees have been deliberately planted at campsites by nomadic tribes who return to the same campsites on a regular basis.

Of more relevance to *bophetha* exploitation are the reports of host plant and caterpillar manipulation for sub-Saharan Africa (Mbata 2002, Toms *et al.* 2003). Van Itterbeeck and Van Huis (2012) group five strategies for improving caterpillar harvests:

1. Collecting and/buying young caterpillars and placing them on host plants near their homes or in other suitable areas for observation and protection from predators, other collectors and fires. Many of the mature caterpillars are collected for consumption but a certain proportion is left to pupate under the trees and so produce the next crop.
2. Planting host trees in areas where the trees are scarce in order to attract moths and so introduce caterpillars to an area previously lacking in edible insects.
3. Shifting cultivation to stimulate the growth of host plants in an area where the host plants have been damaged for crop cultivation.
4. Protecting host plants through fire manipulation or prevention.
5. Preventing the damage or destruction of host trees for either fuel-wood or shelter purposes.

At present, these practises are not widely followed in the Blouberg area, other than point five. However, anecdotal comments from residents indicate that some of these suggestions would be favourably received.

Preliminary laboratory rearing of *bophetha* indicate that fully domesticated farming methods for *H. variegata* could be prohibitively expensive and time-consuming (Chapter Three) and probably unnecessary considering that merely increasing the number of *C. armatum* trees available for the caterpillars would automatically increase *bophetha* numbers. In mopane worms, the choice of oviposition site was correlated with tree size, rather than quality, which is typical of an outbreak species (Hrabar *et al.* 2009) and it is assumed that this is the case for *bopthetha*. In common with mopane trees, *C. armatum* coppices readily and caterpillars have been found feeding on the shortest coppice shoots growing closest to the ground (Ghazoul 2006). There is thus a strong possibility that *bophetha* will readily colonise new areas containing *C. armatum* trees.

Blouberg Municipality has identified the erosion of land due to over-grazing and fuel wood harvesting, as well as the loss of biodiversity due to the clearing of land for cultivation as threats that require immediate remedial action (Capricorn District Municipality, 2009). Any action that mitigates the removal of indigenous vegetation is therefore worth supporting and encouraging. Residents identified the removal of edible insect host plants as one of the perceived reasons for the decline of edible insect species (Chapter Two). *Canthium armatum* is seen as valuable in its own right for edible fruit, fuel wood and fencing, and this is an additional reason to plant the trees. Although there is electrification in Blouberg Municipality, the high cost precludes most families from using it for cooking and they prefer to use open fires (Capricorn District Municipality 2009). There are thus a number of reasons to ensure that the tree is used sustainably rather than merely removed to clear land for agriculture or development. Conserving stands of *mophetha* (*C. armatum*) will ensure not only a supply of *bophetha*, but also prevent soil erosion and loss of biodiversity. The Environmental Management Plan for Blouberg Municipality specifically advocates the planting of indigenous trees (Capricorn District Municipality 2009) and *C. armatum* should therefore be placed on their list of suitable trees.

Blouberg Municipality is, in general, a water scarce area (Scholes 1978) and therefore any livestock production initiatives must take water availability into account.

As a wild-harvested food source, adapted to the harsh dry landscape of the Blouberg, *bophetha* do not require excessive amounts of water. More research is required to predict the effects that climate change will have on the resource.

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CHAPTER SIX

ENTOMOPHAGY AS AN EDUCATIONAL TOOL IN THE CULTURAL MILIEU OF BLOUBERG

The case for including edible insects in the local education curriculum

6.1 INTRODUCTION

Lomax (1968) laments that big government, national education, information networks and a world-wide marketing system all contribute to the demise of unique cultures that do not conform to the norms of those in power. Languages, cuisines, traditions and creative styles of numerous cultures that provide the distinctive character of specific regions are continually being lost. Valuable information on natural resources and the technologies that go hand in hand with the exploitation of these resources vanish as less powerful cultures become submerged in the ethos of the dominant way of life (Snyder *et al.* 2003). Folk societies provide most of the variety of human culture on the planet (Lomax 1968) and thus it is not only for the obvious utilitarian reasons of knowledge around resource use that such cultures should be cherished, but also for the less palpable aspect of our own emotional well-being. According to Prescott-Allen (2001) well-being is the capability of all people to define and meet their needs through access to a wide range of prospects that will help to fulfil their potential. Dutfield (2000) agrees, listing four reasons for the protection of indigenous cultures and their knowledge: to improve the livelihoods of indigenous knowledge holders and communities, to benefit national economies, to conserve the environment and to prevent biopiracy.

In the thirty years since Lomax (1968) voiced these concerns, the process of cultural disintegration has accelerated and more than half the languages and most of the associated cultures of the 6000 languages spoken at the beginning of the 20th century have been lost (Cox 2000). Cox further elaborates on the importance of conserving indigenous cultures and the knowledge embedded in them for the benefit not only of the people practising such cultures but also for humanity as a whole. While Cox (2000) emphasises the importance of the knowledge around medicinal plants that such people possess, equally important is the knowledge of other natural resources, such as agricultural methods and food technologies (Mauro and Hardison 2000). This knowledge is known predominantly as indigenous knowledge but also referred to as traditional knowledge, local knowledge or traditional ecological knowledge (Battiste 2002, Kaschula *et al*. 2005).

Indigenous knowledge around local edible insects is the heritage of a number of cultures worldwide (Nonaka 2009, Chung 2010, Yen 2010, van Itterbeeck and van Huis 2012) and has intrinsic value to the particular culture practising entomophagy, as well as to humanity in general due to its contribution to world food security. Mechanisms for preserving this knowledge are therefore valuable and should be examined, particularly in light of the view that the knowledge is eroding too fast for investigation and documentation and that the most efficient manner of preserving it is to support the cultures possessing such knowledge (Mauro and Hardison 2000, Agrawal 2008). A literature search revealed that at present the focus is on protecting the indigenous knowledge itself through legislation, and there is less emphasis on supporting existing cultures to practise their lifestyles in the face of modern transformation.

Ramos-Elorduy (2006), in her article on entomophagy in Hidalgo, Mexico, considers that the consumption of modern, urban foodstuffs by rural pastoralists in the Mexican mountains is a kind of social pollution, implying that healthy, indigenous feeding patterns have been altered for the worse by the adoption of a modern, western diet. She further explains that in the above Mexican culture, young adults, particularly men, migrate to large capitals or to different countries in search of employment. The mountain communities are influenced by new information, concepts and values which filter back from the young men through correspondence and visits. This results in the rejection of traditional ways of living and a consequent loss of knowledge on how to live off the available natural resources. More specifically, the rich knowledge of edible insects that Mexican people in Hidalgo possess is being lost through cultural changes.

In South Africa the situation is comparable. Hart and Vorster (2006), in their book on agricultural development, note that indigenous knowledge is eroding in every province of South Africa. Children have less time to gain knowledge of local food and also develop a negative view of indigenous knowledge because it is referred to in a disparaging way. This is unfortunate because traditional food is often cheaper and more nutritious than the conventional foods sold in grocery stores (Hart and Vorster 2006).

Specifically, in the Blouberg area (Limpopo South Africa), people practise a culture rich in knowledge about edible insects. In a similar way to that in Mexico, many young men and women, seek employment in urban centres away from their rural roots (Fourie, 2006). They too change their living patterns and influence family and friends in their search for a more modern lifestyle. This desire is further fuelled by the media, schooling, government and NGO programmes, as well as by visitors to the area. In Mexico, however, this has resulted in a loss of the will and/or know-how to collect edible insects in a sustainable manner, rather than in people losing their partiality for edible insects. Both rural and urban Mexicans still enjoy their consumption and therefore unqualified collectors now harvest insects with no regard for the environmental degradation they cause. Rural inhabitants have also begun exploiting this resource in order to gain money for the purchase of items that have become necessities in a modern lifestyle. As Ramos-Elorduy (2006) emphasises, this has caused a decline in at least 40 edible insect species.

In contrast to the Mexican situation, as lifestyles change in Blouberg, edible insects are losing their status as a favoured food source and the younger generation are less likely to enjoy the insects than are the older generation (Chapter Two). As in Mexico, edible insect populations are apparently declining but the local population attributes this to lack of rain and the destruction of their habitat, rather than overexploitation by collectors. In fact, few collectors arrive from outside the area to exploit the resource, as happens in Mexico. In both countries however, important indigenous knowledge concerning the use of edible insects is being lost; knowledge that could be used to safeguard these valuable sources of protein. In Mexico, knowledge and taboos that promote sustainable harvesting methods and semi-domestication of some of the species are lost as the culture changes. In Blouberg, knowledge about which insects are edible, their habitat requirements and the season in which they appear, all vital to conservation programmes, is lost for the same reason: a rejection of traditional ways of life.

Growing populations require more food. As more people become reliant on a resource, harvesting methods are often adapted to gain the most from the least effort (Kgathi *et al.* 2005). The sustainable insect harvesting methods of small isolated populations of people may not be sufficient to meet the needs of an exponentially increasing human population, particularly if the life history of the insect is not known. As younger generations take up the new, unsustainable harvesting method, the knowledge around the older, more balanced harvesting method is lost. The export of edible insects, while bringing income to local communities, can exacerbate this trend. This process is not inevitable and actions by local communities can avert resource degradation but this depends on knowledge about the situation and willingness to adapt harvesting methods (Agrawal and Yadama 1997).

The process whereby edible insect knowledge is eroded is by no means unique to Mexico and South Africa. Yen (2010) describes a similar process among the aborigines of Australia, due to a change in diet and social structures, towards a more European model. Chung (2010) describes the disgust with which urban dwellers in Borneo view entomophagy, despite the fact that in times past and in adjacent rural areas, edible insects were and are consumed as a source of cheap protein, for their delicious taste and also because they are easy to catch and do not have to be farmed. In a review of traditional practices Durst and Shono (2010) confirm that in many societies throughout the world insect eating has been spurned as a result of the misconception that the practice is dirty, unhealthy and old-fashioned.

The search for a better life is a human characteristic that cannot and should not be discouraged, either officially through legislation, or indirectly through the false glamorisation of traditional means of living. To make useful choices however, people do require knowledge based on credible facts. Abandoning all aspects of a traditional lifestyle in pursuit of the “modern” dream would be to lose the benefits of a number of practices that contribute to physical and emotional well-being. Durst and Shono (2010) list all the nutritional benefits to be gained from eating edible insects (Chapter Four), but emphasise that for many urban dwellers in societies across the globe, insects are also a “nostalgia food”, which, when eaten bring pleasant memories of the countryside and earlier days. They are not only nutritious but can also fulfil an emotional need and at the same time they taste good. A learned or assumed disgust for edible insects due to a cultural shift therefore results in the loss of a positive aspect of traditional knowledge.

Maila and Loubser (2003) argue that traditional ways of life and local knowledge are not equated with an improved quality of life because of the low status society accords them. However, a change in lifestyle does not necessarily mean a complete loss of all useful indigenous knowledge. In a paper on house gardens of Peru, Padoch and de Jong (1991) observed that urban peasants following an essentially modern lifestyle still practised a large number of traditional agricultural methods in their gardens. Similarly, in Australia, children of aboriginal parents knew significantly more about the local wildlife, than did children of white parents living in the same urban neighbourhoods (Linden 1991). Raising the status of indigenous knowledge within the local milieu, could thus lead to a more efficient transfer of such knowledge from one generation to the next, even while lifestyles shift under the influence of more modern trends.

Considering that edible insects and the indigenous knowledge that surrounds them play a significant role in the Blouberg culture and that this knowledge is gradually being lost (Chapter Two), it would be worthwhile to find ways to raise their status and promote the dissemination of this knowledge. One such mechanism is the incorporation of edible insect knowledge into the formal education system. Maila and Loubser (2003) suggest that the incorporation of local knowledge into the South African education system could most effectively be achieved through environmental education programmes. The South African Department of Education (2002) concurs, noting that educators should be addressing the development of a curriculum which includes world-views, as well as indigenous knowledge systems.

Reyes-Garcia *et al.* (2010) found that, on the basis of work conducted in schools in the Bolivian Amazon, learning within a context based on indigenous environmental knowledge, helped prevent the loss of cultural diversity that occurs through universal education. A number of writers contend that if schools use local knowledge to contextualise learning and also conduct lessons in the vernacular then formal schooling could assist in the protection and promotion of such knowledge (Maila and Loubser 2003, McCarter and Gavin 2011). In addition, contextualising lessons using indigenous knowledge can lead to a richer learning experience and better retention of new knowledge (Minter 2005).

Another way in which indigenous environmental knowledge can assist and expand learning in a conventional manner is by establishing links between esoteric knowledge and practical everyday occurrences within the students' life (Taylor and Mulhall 2001). If this is not done however, then there is a very real risk that such knowledge will be lost through dilution with general world views. Placing aspects of indigenous knowledge into the school system could raise its status as a legitimate and valuable source of knowledge and perhaps allow it to be more favourably compared with other aspects of modern culture in areas such as diet and nutrition.

Reye's-Garcia *et al. (*2010) review the reasons for including indigenous environmental knowledge in school curricula and list a number of articles which provide evidence that indigenous, or local knowledge contributes to society's and in particular, indigenous society's well-being. In an African context indigenous or local knowledge is the basis for the use of natural resources as a food safety net (Shackelton and Shackleton 2004), as medicine (Williams *et al.* 2005), as vetinary products (Rao 2006), as a source of human shelter and as fodder for livestock (Twine *et al.* 2003). This knowledge thus bears the same relation to the improvement of circumstances and well-being as conventional schooling in the Western urban context (Wolfe and Zuvekas 1997).

In a South African context, Botha (2010a) believes that, particularly for indigenous communities, a dual-mode of schooling is important. He acknowledges that while the country's current Curriculum 2005, which is a predominantly western education system, does provide universal skills, it also has an alienating effect on most traditionally-based communities by ignoring and repudiating much of the local knowledge present in these communities. In agreeing with Maila and Loubser (2003), that learning should be contextualised within a familiar framework, he argues for a culture-centred education system. This enriching approach will ensure that one means of knowing will not be elevated above another, thereby preventing the alienation and degradation of local cultures.

In this chapter, entomophagy is examined as one aspect of the culture of the Bahananwa people of the Blouberg, with a view to introducing aspects of this behaviour into the local education curriculum. More specifically, the chapter explores the possibility of preserving knowledge pertaining to edible species, including songs and recipes, in a more formal manner through the school system, while at the same time utilising this knowledge to enrich conventional learning. The way in which new knowledge about the insects, generated through research, can be combined with local knowledge and incorporated into the school curriculum, is examined.

The methodology, although based on a conventional approach of interviews and questionnaires, uses some reflexive ethnographical methods (Botha 2010b) in order to derive deeper insights into the possibility of incorporating local knowledge into the education of Blouberg's learners. While it is fairly easy to incorporate local knowledge of the natural history of edible insects into a natural science lesson, this is only one aspect of the local lore of edible insects. A number of authors advocate more rigorous enquiry into cultural aspects of entomphagy such as medicinal use, songs, dances, visual art and rituals involving insects as subject matter (Meyer-Rochow 2008, Van Huis 2003, Ratcliffe 2006). Minter (2005) successfully incorporates local myths and songs about frogs into a grade 7 science lesson. In a conventional school setting such myths and songs would be confined to a humanities lesson but Minter's (2005) research demonstrates that scientific information can be easier for the learners to absorb if enriched by the use of such indigenous knowledge. In this chapter, songs, recipes, medicinal uses, taboos and rituals surrounding the insects are documented and discussed with respect to their possible role in the curriculum.

6.2 AIMS AND OBJECTIVES

6.2.1 Aims

To explore the value of introducing information on edible insects into Blouberg schools as:

1. a means to maintain and revitalise indigenous knowledge by promoting the participation of community members in schools and simultaneously for safeguarding this aspect of local knowledge for the future,
2. a vehicle for increasing environmental awareness and,
3. an instrument for situating learning in a local context.

In other words, "is it worth including knowledge around edible insects in the local curriculum?"

6.2.2 Objectives

1. To develop a school competition questionnaire suitable for use in the classroom to:
    a. Engage older community members in an aspect of their grandchildren's school work.
    b. Capture local opinion on the value of edible insects to the Blouberg community.
    c. Investigate the current status of entomophagy and of the associated knowledge around edible insects.
    d. Document opinions on the possible decline of the edible insect resource.
    e. Document and preserve aspects of the culture around entomophagy (songs, medicine and preparation).
    f. Be used as a vehicle to corroborate results from the semi-structured questionnaire survey (Chapter Two) and relate this to information gathered within a school and by the local community itself.
2. To compile and conduct an 'insects in schools' questionnaire to:
    a. Investigate whether or not the local community value knowledge about edible insects.
    b. Determine whether the local community supports the inclusion of this knowledge into the local curriculum.
    c. Garner opinion on how such knowledge could be included in the curriculum.
    d. Determine whether there are any local people willing to teach such information and whether or not they are teachers themselves.
3. To examine barriers to including local knowledge formally within a local school curriculum.

6.3 METHODS

6.3.1 Study Site

This chapter uses some results of the 'semi-structured questionnaire survey' of Chapter Two in order to triangulate and verify data obtained in the 'competition questionnaire' and 'insects in schools questionnaire' described below. This would contribute to a better overall understanding of the value of incorporating edible insect knowledge into the local schools' curricula. Thus the study area includes the greater Blouberg area as in Chapter Two (Chapter One, Figure 1.2) but for questions relating specifically to the Blouberg community's attitude towards incorporating indigenous knowledge on edible insects into schools then a subset of three villages was used. These villages are located in areas where the edible insect, *bophetha* (*Hemijana variegata*), are extensively harvested, as for Chapter Three (Figure 3.1). The villages were the Glade, GaManaka and Liepzig and were chosen for their importance during the *bophetha* harvest, the willingness of the local inhabitants to participate in the study, the availability of schools and their proximity to one another, which facilitated transport during fieldwork.

6.3.2 Competition Questionnaire

During July 2008 a lesson on edible insects was drawn up in the form of a questionnaire to elicit information on edible insect use in the area and particularly to determine whether older people from the community had more knowledge of the insects than younger people. The questionnaire was developed in the form of a competition and designed to be completed as a school project in order to generate enthusiasm and a sense of pride around the project and importantly, to gauge the response of teachers and learners to a school exercise on edible insects. It was emphasised that the goal was not "getting the answers right", but rather to give as much information as possible. The competition questionnaire was designed to kindle the interest and input of the elderly relations of the school learners. Prizes were nominal and as a gesture of appreciation all participants received a small chocolate. Two learners from each school who gathered an exceptional amount of information were also given bags or footballs.

Schools from the nine villages in the Blouberg Municipality which were sampled for Chapter Two were invited to participate in the project. Permission was granted by the Education Department (Capricorn District) for the schools to participate, but participation was voluntary and depended on the principal's decision based on time required and his or her perception of the relevance of the project. In total, six schools from six villages took part: two secondary schools and four primary schools (Table 6.1). Two of the secondary schools approached, declined to participate due to time constraints in finishing their syllabus.

For each class involved, the teacher gave a short, researcher briefed, overview of the research project on edible insects and explained what the results would be used for. It was emphasised that the results would be made known to all the participating schools in the form of posters. The questionnaire was then explained and learners answered the first part of the questionnaire themselves. This section was designed to capture the following information: whether or not the learner consumed insects, reasons for not consuming or consuming insects and type of insects eaten.

Table 6.1 Total of all schools participating in the edible insect competition questionnaire.

School	Type of school	Village	No of learners
Mantshabe	Primary	Rakwele	42
Ngwakwana	Secondary	Ramaswikana	14
Raphotololo	Primary	Moismane	17
Pokanong	Primary	Burgerrecht	45
Lenare	Secondary	GaKgatla	8
Kawena	Primary	My Darling	49
Total (n)			**175**

Each learner then took a copy of the questionnaire home and asked their grandparents questions relating to the following: whether or not they eat insects and if so why or why not, type of insects they eat, the most commonly collected and most valued insects in Blouberg, their perception of the decline or not of entomophagy and of edible insect numbers and reasons for the phenomenon, their beliefs regarding the life-cycle of some common edible insects, some important preservation and preparation methods, songs relating to edible insects and edible insect use in medicine. There was a section in which learners and/or grandparents could enter any other information they perceived as important or any questions they might have either regarding the insects themselves or about the project in general. The questionnaire competition was designed for individuals rather than households (Appendix 3).

Recipes for preservation and preparation of edible insects were recorded in full format and are attached in Appendix 5. The words of songs were chronicled in Sepedi, translated into English and recorded in both languages in Appendix 6. Live recording was not possible due to time and monetary constraints.

For quantitative results, percentages were graphed and compared and where appropriate the Mann-Whitney U-test was used to determine where significant differences lay. Statistical analysis was performed to determine whether learners differed significantly from their grandparents in terms of entomophagy and in the number of ethno-species familiar to each group. Data were further analysed by separating secondary school learner's results from the results for primary school learners in order to determine whether there are differences in insect resource use between older and younger youth. Mann-Whitney non-parametric tests were used to test for significant differences. The computer package program SPSS (The Statistical Products and Service Solution, Inc., Chicago, IL, USA version 13.0) was used to analyse the data.

For qualitative results the analysis was based on thematic coding whereby transcripts of the interviews were read and then overall themes identified and coded. Responses were analysed according to the coding and finally, anomalous cases identified and interpreted.

Results from the competition questionnaire were compared with results obtained from the semi-structured interviews employed in Chapter Two in order to corroborate findings. This is important because if results were found to be widely disparate then entomophagy in Blouberg cannot be said to have overall significance in the area and thus inclusion in the local school curriculum would not be a relevant tool to use for situated learning.

6.3.3 Insects in the Class Questionnaire Survey

In December 2011, towards the close of fieldwork for the project, three villages were chosen in which to conduct interviews regarding the inhabitants' attitude towards the importance of specific edible insect knowledge and its inclusion into local schools. The Glade, Ga Manaka and Liepzig villages were involved in research into the natural history (Chapter Three) and socio-economics (Chapter Four) of the edible insect *bopetha* (*Hemijana variegata*). As such, members of these villages were familiar with the edible insect research and were willing to participate in a further questionnaire survey. The questionnaire (Appendix 4) was drawn up to elicit information from individuals on the following:

1. Whether or not they eat *bophetha* and why,
2. whether or not they perceive knowledge about *bophetha* to be useful,
3. their attitude towards including this knowledge into the local school curriculum,
4. if it should be included, how they feel this information should be conveyed to learners,
5. whether or not they would themselves be willing to teach such information in schools and lastly,
6. whether they are teachers or not.

A local, literate, inhabitant of Blouberg was engaged to interview the residents of the three villages. He was trained in the use of the questionnaire and he asked the questions in Sepedi, translating the answers into English. Each village was divided roughly into four quarters and he interviewed people from each quarter. A total of 96 inhabitants from all the villages took part in the survey. All individuals that were approached, except for one, were willing to participate. The questions were not of an intimate nature, nor did they relate to specifically male or female activities. It was thus deemed acceptable that the interviewer was male and that this would not have an undue influence on the answers given.

Most of the results of this survey were analysed using descriptive statistics.

6.3.4 Examining Barriers

The most recent curriculum statements were examined in order to evaluate obstacles to including knowledge around edible insects within the local curriculum.

In all cases of interaction with people from the Blouberg community, respondents were given the opportunity to provide their full names, ages and contact details and thus when quoting respondents, names are used if provided. However, this information was not compulsory and therefore this was not always possible.

6.4 RESULTS

6.4.1 Competition Questionnaire (Lesson Plan)

6.4.1.1 Engagement of grandparents:

Of the 175 questionnaires taken home by the learners, 100% were answered by the grandparents, reflecting a positive attitude toward sharing such local knowledge and being involved in the learners' school work. In terms of the attitude of the teachers to including such an unconventional lesson in their work, this differed between primary and secondary schools. All primary schools approached agreed to conduct the lesson and all completed the work, however, although all secondary schools approached agreed to work on the lesson and were positive towards the project, only 50% of the schools actually completed the questionnaire, citing pressure to complete the formal curriculum as a reason for the lack of time. The competition aspect of the work also generated enthusiasm. Learners showed excitement at being involved in work that was slightly different to their regular lessons.

6.4.1.2 Value of edible insects to the Blouberg community:

Reasons for eating insects

Learners and grandparents both ate insects for the same reasons and for each group of people these reasons were of a similar importance (Figure 6.1). Thus for both learners and grandparents health was the over-riding reason at 91% and 90% respectively, taste followed at 46% and 51% respectively, tradition third at 13% and 23% respectively and the low cost of the food was the least important reason at 10% and 25%.

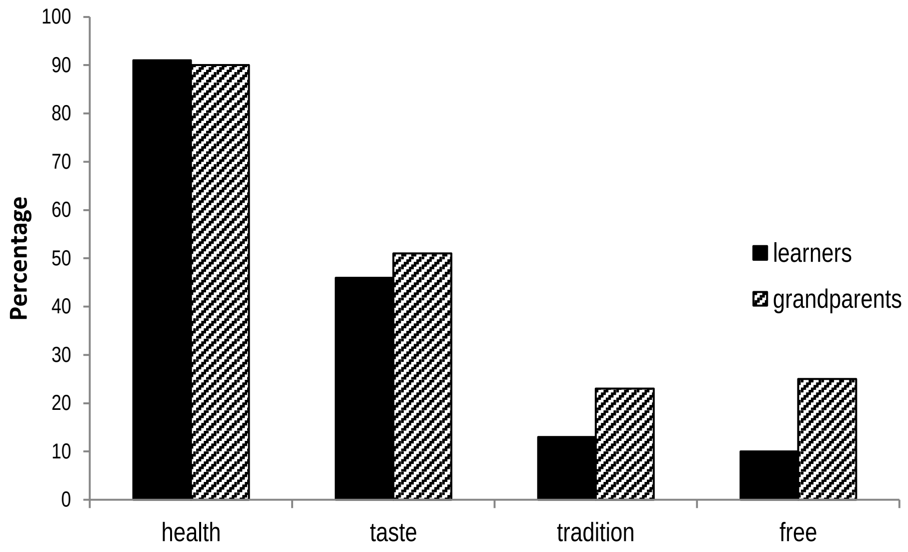

Figure 6.1 Reasons for entomophagy in Blouberg, Limpopo (learners: n=168, grandparents: n = 174).

Reasons for not eating insects

Only a very small proportion of people in the Blouberg did not eat insects (6.29% of grandparents and 9.14% of learners). The reasons cited for not eating insects were the same for both groups, namely, that they are an unhealthy food source, that the people who don't eat insects don't practise the old traditions anymore but live a more modern lifestyle, that insects do not taste good and that their religious beliefs forbade the eating of insects (those belonging to the ZCC Church). However, the proportion of different reasons cited differs between grandparents and learners (Figure 6.2). Thus, 46.16% of learners cited insects as unhealthy as a reason, compared to 14.29% of grandparents. The percentage of learners who found insects distasteful was also greater than that of the grandparents at 38.46% compared with 28.57%. A change to a more modern way of life where traditions are not followed as strictly accounted for 23.08% of the reasons learners do not eat insects compared with 14.29% for grandparents. A taboo on consumption of insects by the ZCC Church (Zion Christian Church) was cited by 42.86% of grandparents compared to 15.38% of learners.

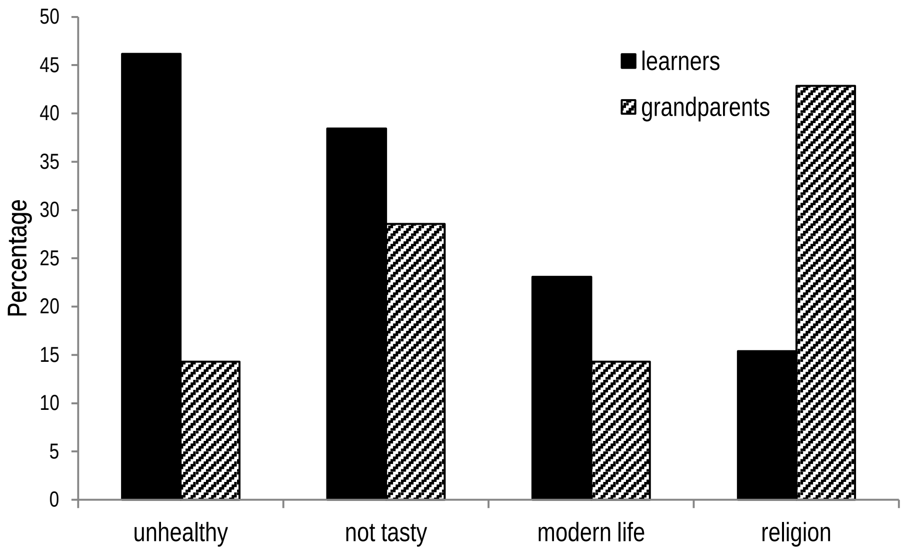

Figure 6.2 Reasons cited for not eating insects in Blouberg, Limpopo (grandparents: n = 7, learners: n = 13).

This does not corroborate the results from the interview survey which overwhelmingly cited lack of insects due to less rain as the main reason insects are not eaten as much as in the past (Chapter Two). However, there is a similarity in the other reasons listed, although proportions may differ.

6.4.1.3 Decline of entomophagy and associated knowledge from one generation to the next:

The data reveal that although a slightly higher percentage of older people (93.71%) consume edible insects when compared with their school going grandchildren (90.86%) (n = 175), this is not significant at the 95% level. Mann-Whitney:
U = 14 875.000, p = 0.317, n = 350. According to this data there is thus an overall high incidence of entomophagy in the Blouberg, which confirms the result obtained through the semi-structured questionnaire survey (Chapter Two).

However, when older people are compared only with secondary school children, rather than learners as a whole, a significantly greater percentage of older people (95.45%, n = 22) eat edible insects compared to that of their secondary school grandchildren (68.18%, n = 22). Mann-Whitney: U = 176.000, P = 0.020.

In addition, when children are separated by age, significantly more primary school children eat insects than older, secondary school children at the 95% level. Thus 92.68% (n = 123) of primary school children surveyed eat insects compared to 68.18% (n = 22) of secondary school children. Mann-Whitney: U = 1021.500, p = 0.001.

When a comparison is made between grandparents and school children in terms of the numbers of ethno-species each group is familiar with, older people do know more edible insects (on average 2.90 types) than younger people (on average 2.83 types). This is not, however, significant at the 95% level. Mann-Whitney: U = 16141.000, p = 0.070, n = 190.

Despite this high incidence of entomophagy at present, 94.34% of the grandparents believe that entomophagy is on the decline, with only 5.03% believing that numbers of people eating insects have stayed the same and 0.63% believing entomophagy is increasing (n = 159). This corroborates the questionnaire finding in Chapter Two, where the majority of respondents also believe that entomophagy is on the decline (78.57%), with 12.86% believing it to be increasing and 8.57% believing it to be staying the same (n = 210).

The overwhelming reason cited for the decline is that of a change in culture to a more modern lifestyle (50% of citings), with particularly the youth eating insects on a less frequent basis. This is a similar finding to that in Chapter Two, where 40% of reasons cited are to do with change in culture. A change in religion to the ZCC church is the second most cited reason for the lesson plan (18.29%), whereas in the questionnaire this covers only 4.86% of citings. Other reasons include a change in tastes whereby people feel disgusted by the taste of insects, less rain and therefore fewer insects to harvest, an increase in other available and more modern food and a perception that insects are unhealthy. These reasons are the same as those cited in Chapter Two for the questionnaire but proportions differ as can be seen in Figure 6.3.

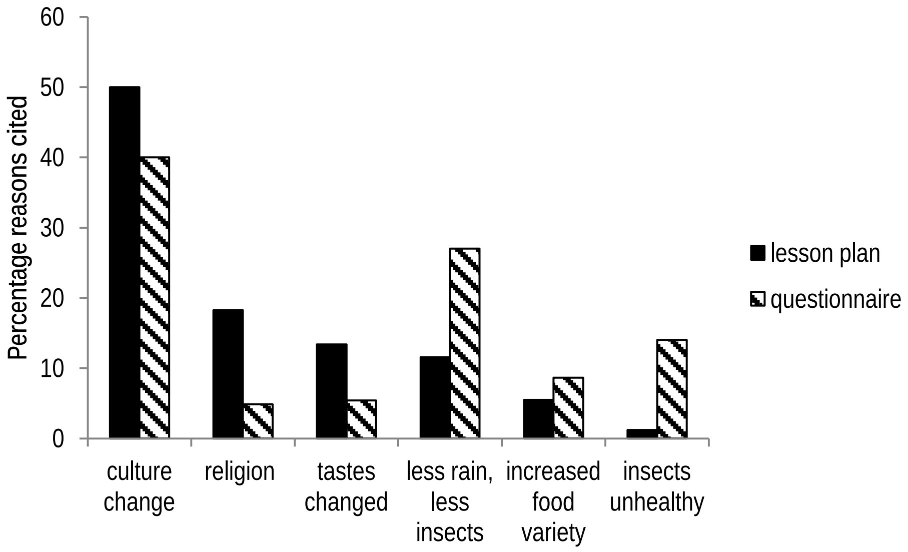

Figure 6.3 Reasons cited for the decline in entomophagy for the competition survey (lesson plan) compared with the semi-structured questionnaire from Chapter Two.

In the comments section of the competition questionniare, the link between more education and less entomophagy is vocalised by 91 year old Raesebe Mpya "the children of nowadays, they are very clever and so they are not eating (insects)". This sentiment is echoed by anonymous from the Grange Village who says "in those days we used to eat insects because we were stupid".

6.4.1.4 Opinions on the decline in the edible insect resource:

The grandparents' response to this question was an overwhelming majority of 94.5% believing that insect numbers are declining. A small minority (3.7%) believe there has been no change in numbers with a smaller minority (1.8%) believing that insect numbers are increasing.

Of the grandparents who answered the question on why edible insects should be declining, 89.7% of them cited lack of rain as the reason (n = 113). Other reasons listed were lack of green vegetation (which is related to lack of rain) and an increase in the number of people eating insects. One comment specifically noted in detail the results of a lack of host trees for *boešitšana,* a geometrid lepidopteran caterpillar that could not be identified as there were no outbreaks during the project. Ramokone (78 years) states that lack of rain has significant impact because "some other trees like *moešitšana* (*Elephantorrhiza burkea,* the host plant for *boešitšana*) are no longer there because there's no rain. *Moešitšana* are dying because there's no rain where we found *boešitšana'*".

These findings corroborate those from the semi-structured questionnaire survey (Chapter Two) where 76.54% believe that edible insect numbers have declined over the years, with 22.38% believing they have stayed the same and a small minority (0.7%) believing they have increased in numbers (n = 143). All 100% of respondents who answered the question on reasons for this decline believe it is the lack of rain (n = 64).

6.4.1.5 Limitations of local knowledge about insects (Understanding of insect life cycles) (n = 168):

The majority (63.69%) of the grandparents interviewed who answered the question could not correctly describe the complete life-cycle of even one of the edible insects they consume. Of the remaining 36.31% who correctly described a life-cycle, only 1.64% described a life cycle that was specific to a Blouberg edible insect and not one that was found in a text book. Correctly described life cycles were those of the locust (*Schistocera* sp.) and the mopane worm (*Imbrasia belina*), both of which are taught in local schools.

Unsolicited comments on this issue include the understanding that little is known about the insects and the wish to learn more about the biology of the edible insects consumed. Masipa (53 years) declares "we don't know where they (the insects) come from; insects are from miracles".

6.4.1.6 Documentation of aspects of the culture around entomophagy:

A number of respondents writing in the comments section voiced their concern that the local knowledge around edible insects is dying out and should be documented.

6.4.1.7 Insect Species Collected and Utilised in Blouberg:

Appendix 7 lists 88 vernacular names of species consumed in Blouberg and where identified, the related scientific names and important host trees.

Insect Preservation and Preparation

In Blouberg, the main method of preserving insects is to boil or fry them in salted water or oil. A number of insect species are then dried in the sun. They can then be eaten without further preparation as a snack, or boiled with water, onion and tomato and eaten as a relish with maize porridge (*borogo*). For further information consult Appendix 5.

Insects in Medicine

The majority (72.57%) of interviewees agree that certain insects are used medicinally in Blouberg. Those who responded to the question (n = 79) gave four uses of insects as medicine, none of which were mutually exclusive. The most common ailment cured through the use of insects is that of chest pains (77.22%) whereby a locust is placed upon the ailing individual's chest and induced to 'drink the blood' of the patient and thus relieve the condition. The second most common use of insects in medicine (20.25%) is that of an insect by-product, honey, which is used to relieve a cough when drunk with water or tea. *Imbrasia belina*, the mopane worm, is used medicinally as a prophylactic in order to prevent illness as it is believed to possess health giving properties (mentioned 1.27%). A small proportion of respondents (1.27%) mentioned that insects are used to treat stomach complaints. Unsolicited comments involving the use of insects as medicine or the potential pitfalls of eating them include the following:

2. Traditional healers use mopane worms (*I. belina*) as a cure for HIV/AIDS.
3. If children consume insects they could get chest pains.
4. Some locusts cause lethargy if eaten.
5. Some people are allergic to edible insects such as mopane worms (*Imbrasia belina*) and/or *lebitsi* (*Stenocera orissa*).
6. In the past there were fewer deaths and eating insects contributed to good health.
7. Movšima (age unknown) notes that one of the good points of having entomophagy as part of one's culture is that "by eating insects, this protects our bodies against *malwetši* or illness".

Insects in Song and Dance

Fifteen songs were recorded involving edible insects. These are mainly sung by children when collecting insects entreating them to stay still to be caught. Sixty percent of people interviewed listed songs they knew of involving edible insects. Many of these were repeated. Appendix 6 documents each song, translated into English.

6.4.2 Insects in the Class Questionnaire Survey

6.4.2.1 Perceptions of the efficacy of knowledge around edible insects (n = 96):

The questionnaire survey revealed that 80.21% of respondents eat *bophetha* although a greater percentage may include other edible insects in their diet (Chapter Two). An even greater percentage of respondents (84%) believe that knowledge of edible insects is useful, with 10.42% indifferent to the knowledge, and 5.21% feeling the knowledge was worthless. Unsolicited comments around this question could be grouped into two categories:

1. Edible insects are an indigenous food source and therefore important.
2. Entomophagy is part of the Blouberg people's culture and therefore of heritage value.

6.4.2.2 Perceptions of the value of including information about edible insects in the formal school curriculum (n = 96):

The majority of respondents felt that it is important to teach this knowledge in schools (83.33%), with 10.42% indifferent to the idea and 6.25% indicating that they were unhappy about the teaching of this sort of knowledge. Some respondents noted that they did not eat insects but despite this they still felt that edible insect-knowledge should be included in the school curriculum. No comments were received as to why respondents were unhappy or indifferent but unsolicited comments about the importance of teaching edible insect information were grouped as follows:

1. Teaching will be good for the youth as it will help them to learn about their culture.
2. Teaching about edible insects to the next generation is necessary to prevent the loss of such knowledge.
3. Teaching about edible insects is valuable as it is important to know about an indigenous food source.

4. The children do not know enough about their natural heritage of edible insects and should be taught.
5. The youth should learn about the nutritional value of the insects.
6. Knowledge of all kinds is important to build a better future.
7. Children are unfortunately becoming afraid of insects and need to be taught more about them.

Of those who did not feel that this knowledge was useful, 63.12% stated that it was still important to learn it as it is part of their culture and it is extra knowledge which is always worthwhile knowing.

6.4.2.3 Perceptions of the manner in which the local knowledge should be taught: (n = 44):

Suggestions as to the methods with which indigenous knowledge around edible insects could be taught were divided into classes (Table 6.2) with corresponding percentages. Not all respondents voiced an opinion on the means of teaching such knowledge in schools, therefore the sample size was less than the respondent number (44).

Table 6.2 Percentage of citings for various methods by which information on edible insects could be taught in local schools (n = 44).

Method of teaching	**Percentage of citings**	
	separate	**combined**
A local expert (elder) on edible insects teaching in the classroom	28.57	46.94
A local expert (elder) on edible insects teaching in the field	18.37	
Posters	5.10	37.75
Textbooks	32.65	
An individual from a tertiary institute	15.31	

Open ended comments concerning the different proposed teaching methods are grouped in Table 6.3, showing that most of the comments related to conventional teaching methods utilising textbooks and posters.

Table 6.3 Open-ended comments grouped by teaching method and listed by number.

Local experts teaching and showing	Textbooks and posters	Outside educator: tertiary institutes
1. It should be taught in a practical manner: Recognising the species, learning where they live and learning how to cook them. 2. Local people have the most knowledge of the insects. 3. Teachers do not know enough about the insects.	4. Someone local can give information to be included in textbooks. 5. Textbooks will save time. 6. Text books will have more information. 7. Textbooks will last forever and the information will not be lost. 8. School learners will understand the books. 9. Textbooks will ensure that the information is disseminated further afield, not just to the villages. 10. People can keep going back to a book to check up on certain aspects. 11. Many learners are afraid of the insects therefore textbooks should be used.	12. Local people don't have enough knowledge of the insects. 13. Someone from a tertiary institute has more information to give.

6.4.2.4 People willing to teach this knowledge: (n = 96):

Just under half the respondents (48.96%) were willing to teach information about edible insects in local schools despite the fact that only 4.17% of the respondents were teachers. All of the teachers consumed insects and all but one were willing to teach this information. From unsolicited comments it is probable however, that many individuals teaching in Blouberg schools do not eat insects themselves and therefore would not be able to teach this local knowledge. Of the 18 unsolicited comments received about teaching this knowledge, only two mentioned that they would like to teach for financial gain. The remaining comments reflected the value the respondents felt that this knowledge held for the community and further afield, and the importance of disseminating it to younger generations.

6.5 DISCUSSION

The majority of local people from the Blouberg area eat insects and enjoy them as a tasty, nutritious source of protein, and not merely because they are free and therefore a famine food. These findings corroborate those in Chapter Two, lending credence to the theory that a culture of entomophagy is intrinsically linked to the

Blouberg communities. The majority of the older people who do not eat insects are generally ZCC members belonging to the Zion Christian Church which forbids the consumption of insects other than locusts. Most of the younger people who do not eat insects do so because of an aversion to the taste and a change in cultural preference.

There is a perception amongst most of the people in Blouberg that both entomophagy and edible insects themselves are on the wane. According to the community this decline is linked to a lack of rain, which causes a decline in insects making it more difficult to find and collect the resource and also to a shift in culture in that that the youth do not eat insects due to the wide variety of other food available. The perception that insect eating is old fashioned also plays a role. Young children still consume insects but as they get older they drop this practise and thus there is a significant difference in the extent of entomophagy between the older youth and their grandparents, as well as between younger children and older youth. The availability of more disposable income also influences food choices. Maria Molapo (74 yrs) elaborates on the effect of money as well as the changing attitudes of the youth towards the practice of entomophagy, “people nowadays like sweets and they like to eat meat more than traditional food. They think that if you eat insects you are a poor person or not well-educated. The youth dislike to eat insects because they have enough money to buy food. They can afford expensive food”.

Local inhabitants of Blouberg believe knowledge about edible insects is valuable and that it is important to include such knowledge in schools. This is confirmed by the fact that over half of those who do not themselves eat insects still wish this knowledge to be incorporated into local schools. All grandparents solicited to assist with the questionnaire competition were willing and interested in giving information thus endorsing the positive attitude of the community to edible insect knowledge. Furthermore, the people of Blouberg are willing to themselves be involved in this knowledge transfer, with almost half of the respondents indicating that they were available to instruct learners about edible insects even if they were not teachers themselves.

The above sentiments are echoed in Australia where McCarter and Gavin (2011) state that including indigenous knowledge in formal education has the support of educators, ethnobiologists and anthropologists. In a South African context, Masuku (1999) found that elderly people with a wealth of indigenous knowledge from the Eastern Cape wished to contribute to the education of the youth in their area. They believed they had a role to play, not just in passing down information relating directly to natural resources but also their knowledge associated with the spiritual values and responsibilities embedded in their culture. McCarter and Gavin (2011) group the positive reasons for including indigenous knowledge into formal education into four aspects which will be discussed in the Blouberg context:

1. Indigenous knowledge can be maintained and revitalised by increasing its status in the eyes of the local population and facilitating its transfer between generations. Education is universally prized and therefore the use of the education system may increase the status of this knowledge base, which is vulnerable to change.
2. Environmental awareness amongst students and actions for conservation can be intensified by increasing the content of traditional ecological knowledge taught in schools.
3. Indigenous knowledge can be used to contextualise learning and give a sense of place and identity to lessons that can often be foreign to learners who cannot envisage practical everyday examples of the concepts taught.
4. Indigenous knowledge can be used to address power inequities between essentially Western, centralised, powerful education systems and small minority or indigenous groups.

6.5.1 Maintaining and Revitalising Edible Insect Knowledge through Formal Education

A plethora of scientific papers promote the documentation and preservation of indigenous knowledge in electronic databases, scientific journals and books (Pauly *et al.* 1993, Harmsworth 1998, Sen 2005), and these include a proportion with an African focus (Greyling *et al.* 2011, Ngulube 2012). Specifically, there is a call to document and identify edible insects utilised by indigenous knowledge-holders and to database this knowledge (Yen 2009, Durst and Shono 2010). Such methods will conserve certain aspects of this knowledge, particularly those parts that can be exported for use by humanity in general and usually relating to medicinal and food resources. However, it is an error of judgement to believe that such databases alone will conserve all knowledge of even one culture or that this is always in the best interests of the bearers and custodians. The nature of indigenous knowledge is dynamic and intrinsically linked to living cultures and is therefore preserved in its most useful form by the actual practitioners of such knowledge (Agrawal 2008).

Kuhnlein *et al*. (2006) and Agrawal (2008), advocate for *in situ* conservation of indigenous knowledge by encouraging the cultures possessing this knowledge to practise their traditional lifestyles. Separating aspects of indigenous knowledge recognised to be useful to humanity in general and entering them into a database can remove the incentive to afford the holders of that knowledge any power or protection (Agrawal 2002). Attempts should thus be made to prevent the demise of the lifestyles, practices and cultures of holders of indigenous knowledge, which are impacted by modern development and cultural homogenisation (Coombe 2005). In the Blouberg area the overwhelming reason given for the decline in entomophagy and associated knowledge is the shift to a more modern lifestyle. Local Blouberg inhabitants believe that entomophagy is beneficial and this was confirmed in Chapter Four and thus it is of value to support the continuation of this practise in the face of lifestyle changes.

Agrawal (2008) argues convincingly that traditional cultures are frequently marginalised both by temporal isolation (being behind the times) and economic constraints, both of which limit access to technological advances through lack of opportunity or cost. Individuals therefore do not always have access to innovations such as the internet which would allow them to utilise the databases they themselves contribute to. On the other hand, large multinational companies are in the position to perform powerful internet searches to assist in bio-prospecting and thereafter to develop patents derived from the indigenous knowledge freely submitted to populate digital databases. Products developed using information from these databases can certainly be used to benefit humanity in general, including those communities contributing this information, but it should be understood that databases alone will not protect indigenous cultures. For example, the vincristine and vinblastine used widely to treat childhood leukaemia and Hodgkins Disease (Hunter 1997) were isolated from the rosy periwinkle (*Catharanthus roseus*) and inspired by leads from Asian indigenous medicine (Mann 2002). Neither Madagascar, from which the original high quality plants were obtained and commercialised, nor the Asian holders of the knowledge who provided the incentive to further analyse the species, were awarded any part of the substantial profit, nor supported with respect to practising their culture (Stone 1992). It is important to note that the original use of the plant was to treat diabetic patients, not as a cancer drug and also, that the benefits of these developed drugs have been felt world-wide, including in their countries of origin (Foster 2010). Asian medicinal plant knowledge provided the catalyst to analyse *Catharanthus roseus*, and cutting edge pharmaceutical research developed and distributed a useful medication to the world. Databases of such knowledge are thus worthwhile, but should be combined with other methods to protect and cherish indigenous knowledge.

If practitioners of indigenous knowledge are to be supported then it is important to understand and support the manner in which knowledge is transferred between generations. Worldwide, with the drive to fulfil the second millennium goal of primary education for all, schools are becoming increasingly important, even in strictly traditional societies, as the medium through which knowledge is transferred, rather than through oral traditions (Ban 2007). Therefore, any attempt to support traditional cultures and preserve, *in situ,* the knowledge they possess, would of necessity have to include school interventions. Thus, not only would some of the community's indigenous knowledge be preserved, but other aspects relating to this knowledge such as intellectual property rights and additional information gained through recent research could be included. The community could then use this knowledge to mitigate the danger inherent in data-basing and making globally available, valuable local information.

The overwhelming local support for including knowledge about edible insects in schools indicates that such interventions would be met with approval by the Blouberg community. Support was not only forthcoming from the elderly custodians of the knowledge but also from the younger generation, as well as from those who do not even utilise insects as food, which indicates how highly Blouberg people value their culture. Textbooks and posters, as well as the use of local people as educators, were both popular choices as methods with which to teach such knowledge in schools. Posters would be a more feasible way of piloting the introduction of insect knowledge into schools as they would be quicker and cheaper to produce. There was no indication that the people of Blouberg are concerned about the possibility that indigenous knowledge used in learning materials could be exploited in any way without due acknowledgement. In the Blouberg information was freely given for purposes of research only after edible insect collectors understood how their knowledge was to be used and that results from the study would be provided to the community on completion of the research.

There was a slight bias toward teaching in a conventional manner using textbooks. However, when textbooks and posters were combined and compared with the combination of teaching by local experts, plus taking learners into the field, then there was bias towards teaching by local experts (Table 2). It is interesting that a number of respondents voiced the belief that it is important to document their knowledge so that humanity in general and future generations can benefit. Both these points are clarified by the following anonymous respondents:

1. Ga Manaka Village, 49 years: textbooks are good "because books are things that last forever"
2. Liepzig Village, 40 years: textbooks must be used because "this is information that we never lose".
3. Liepzig Village, 24 years: "textbooks are good because we'll give information to many people".
4. Liepzig Village, 26 years: textbooks should be used "because even to the third generation we will learn about insects"

Thus, despite Agrawal's (2008) concern that such processes are not to the benefit of local bearers of indigenous knowledge, in the Blouberg, such bearers are enthusiastic about these documentation methods.

This dichotomy could be resolved by a combination of methods whereby local knowledge of edible insects is captured in textbooks but local people are also invited into the classroom to give the learners practical experience. A small proportion of people believed that an individual from a tertiary institute should teach this knowledge as they have access to more information. Thus anonymous from Liepzig

Village (15 years) states "a person from a tertiary institute has more information", and anonymous from Ga Manaka Village (29 years) agrees that "a person from tertiary has made more research". All such comments were made by people younger than thirty years old. This may reflect a distrust of the ability of local people to deliver a quality education experience to the learners. It might also be an indication that people would like to have a value added product whereby extra information around the insects is taught, not just that known by the local community.

These viewpoints expressed by the Blouberg community support Botha's (2010b) proposition that education should be dual-moded and give status to local indigenous ways of knowing as well as to Western orientated knowledge. Capturing the information in textbooks would go some way to satisfying those in Blouberg who wished to see the knowledge preserved for humanity in general and for future generations. In addition, as observed by Van Eijck and Roth (2007), including indigenous knowledge in a formal education system often validates that knowledge in the eyes of the local community and outsiders, offering it the "cloak" of truth, whether or not this should be necessary. Giving local experts the opportunity to enter the classroom and share their knowledge would raise the status of this knowledge and allow learners to benefit from expertise which otherwise may not be available to them due to the time constraints of a modern lifestyle. Results from the semi-structured questionnaire in Chapter Two confirm that Blouberg residents feel that there is now less time to practically learn indigenous knowledge, particularly because the youth are at school. This is not a sentiment confined to Blouberg. Sternberg *et al.* (2001) note that in Kenya, time and resources spent in school detract from those that could be spent learning local environmental knowledge, as do Reyes-Garcia *et al*. (2010) for Bolivian mountain tribes.

Including indigenous knowledge into local schools would address, to a degree, the finding that formal education systems have played a role in the loss of indigenous knowledge (Reyes-Garcia *et. al.* 2010). That this is the case in Blouberg can be seen in the results from Chapter Two, as well as in the open-ended comments from the 'insects in schools' questionnaire, reflecting that the educated youth are now seen as being too "clever" to eat insects (listed under results). Further open-ended comments focus on the concern that older people express at the fact that younger people do not practise their culture any longer. Kakgarope (67 years) articulates this loss, “If we eat insects then our ancestors are happy. They feel good because their culture does not get lost easily, but already we have lost our cultures. We don’t follow our tradition. We like the modern life but we don’t belong to our ancestors”. Mokobela (age unknown) agrees with the sentiment saying, “We will feel bad if there are no insects because our ancestors are very angry because their culture is already lost”. It is not only older people who are concerned about the loss of culture and tradition. Thompson, a young man of 26 years has this to say, “We feel bad because our culture is being lost. Our children don’t know anything about insects, which means they will forget their ancestors. We don’t want to lose our culture. We can get ill anytime. Insects are natural medicine. Some healers are using these insects to help the people. We are forgetting our culture. That is why most of the people are having a bad luck. Because they don’t know where they are in these times.” Makobela (79 years) emphasises the importance of teaching children, “we teach our kids a culture. Our children will follow their children if they’ve seen what happened.” Kobe (44 years) believes that “older people are not so many to show the youngsters these insects”. These comments all express a longing for the continuance of the people’s culture in general and entomphagy in particular and an understanding that the youth must be actively taught in order to facilitate this.

One of the dangers of including such knowledge into formal schooling however, lies in the attitude many youth have to ‘going to school’. A reluctance to spend the majority of their formative years in school is a fact of life for most modern youth (Eccles *et al.* 1993, Prensky 2001). Larson and Richards (1991) found that although adolescence is marked by experiences of boredom, the rate of boredom is greater during school time than at other times. Incorporating indigenous knowledge into a system that is already viewed with dislike could negatively bias students against its study from the outset. Elders responding to interviews regarding the inclusion of indigenous knowledge into schools in Vanatua in the Asia-Pacific developed a novel way around such issues (McCarter and Gavin (2011). Instead of forcing the body of information into formal lesson plans and subjecting it to specific school oriented ways of learning, such as memorising and test writing, pupils themselves were encouraged to access experts within their communities. These indigenous knowledge holders gave learners hands on experience in various aspects of their culture during school time. Such an approach ensured that:

1. The knowledge was not isolated from its cultural context,
2. the actual practitioners (experts) taught the knowledge rather than a third party teaching and,
3. the learning process was slightly removed from conventional schooling, thus generating more enthusiasm amongst the students.

An important aspect was that claims of infringement of intellectual property rights would not be necessary as the practitioners would only teach what they themselves deemed appropriate and acceptable. Such an approach may well be possible in the Blouberg area where there are a number of local edible insect experts who are willing to be involved in the teaching process and who are easily accessible by foot within each village.

6.5.2 Increasing the Content of Edible Insect Indigenous Knowledge in Schools to Increase Environmental Awareness

Fourie (2006) suggests that the environmental degradation in Blouberg should be combated through environmental awareness programmes as many of the negative aspects of wood harvesting and overgrazing could be reduced once people are sensitised to these issues. In the above study there is evidence that environmental awareness can be promoted by the use of edible insects as practical examples in a school context. The awareness that the majority of respondents have of insect numbers decreasing and the role that rain and lack of vegetation play in this decline, could be channelled into environmental aspects of the school curriculum. Issues such as climate change, habitat and biodiversity loss through development and resource utilisation are all pertinent subjects covered in the school curriculum, which could be given local associations through edible insects. There is even a perception that children are afraid of insects and this is one reason why they do not wish to eat them (comments in results). Fear is also an impediment to the conservation of any organism, as is unfamiliarity. An emotional affinity with nature or the organism in question is a strong motivating force for its conservation (Vining and Ebreo 2002). According to Nonaka (1996) the games that San children play with a number of insect species familiarises them with the behaviour of insects and assists them to value something that might otherwise be considered useless.

The fairly untransformed nature of the vegetation in the Blouberg area is, at present an important asset to knowledge about edible insects. The positive association of these areas with the collection of a desired resource will facilitate the protection of these areas. A study comparing more urban communities with those more isolated and reliant on natural resources showed that those with better access to natural vegetation and less influenced by modernisation through schooling had more knowledge around medicinal plant species than those closer to urban centres Monteiro *et al*. (2006). Thus it is possible that as the Blouberg area becomes more developed, as is presently happening with the upgrading of roads and buildings (Capricorn District Municipality 2009), these patches of vegetation will become fragmented and result in a decline of edible insects and a consequent loss of associated indigenous knowledge. The inclusion of edible insect knowledge into local schools influenced by such development may counter some of this loss of knowledge and help to emphasise the importance of these patches of natural vegetation.

Environmental awareness in a community is of little value unless this is translated into some action for positive change (Vining and Elbreo 2002). In the past, schools have focussed on the theoretical at the expense of the practical, often through time constraints or through the subject matter being too divorced from the reality of where the learners are situated (Ruben 1999) For example, teaching learners about the impact of oil pollution in the ocean and how to mitigate this when they are located inland in drought prone Blouberg, is important, but cannot lead to practical know-how on what exactly is required to clean up or prevent such a spill. A lesson that might resonate more would be that of the human and environmental impact of pesticides on an edible insect resource and how to prevent this. Such a lesson could have a practical aspect whereby learners physically identify areas from which pesticide pollution comes and advocate for more careful or different pesticide application. Furthermore, there would be ample opportunity to study, at first hand, the dynamics involved in edible insect resource utilisation and the impact of over-harvesting on annual caterpillar recruitment.

Projects such as these would require the combined input of local edible insect experts and the teachers, who would have specialised knowledge of the curriculum and the outcomes required for each grade. Ideally, the participation of outside experts on the edible insect resource, either from tertiary institutions, local government or nature reserves, would add further value and knowledge to the community through the learners. The identification of an environmental problem in the community and finding the tools to address this issue and the motivation to do so is the goal of many environmental education practitioners (Tilbury 1995). Edible insects and their decline provides a practical problem that learners could address through actions such as planting host trees, advocating the protection of the insects' habitat and determining harvest quotas that could be implemented by traditional authorities and local government structures. For behaviour to change, the attitude towards that behaviour or, ultimately, the belief that the behaviour is valuable, will determine whether the change occurs or not (Sanders 2006). Most Blouberg residents believe that knowledge around edible insects is useful and they would be unhappy if such insects were to disappear (Chapter Two), thus there is a motivating factor to protecting their habitat. Good management of the edible insect habitat could lead to other environmental benefits, such as the protection of medicinal and/or endangered plants.

Such projects might seem to be too long term and impractical for school level, but the international Eco-schools programme has been successful in combining action between a local school and other community structures to tackle and solve community environmental problems (Rosenberg 2008). The Eco-schools programme, managed by the Wildlife and Environment Society of Southern Africa and endorsed by the South African Government's education department, is country-wide and aims at assisting teachers to include environment education in the curriculum across all subjects and in a practical manner (Ward 2003). The programme has a local node co-ordinator for the Blouberg area that has already facilitated the successful completion of projects such as hornbill awareness, indigenous plant knowledge and food gardening (Ringdahl 2010). Open ended discussions with a number of Blouberg residents (e.g. Mr. Jackson, the Glade Village, Mr. Morata, Inveraan Village and Mr. Chipu, the Glade Village) revealed that people would be interested in workshops run through the schools to promote ways of ensuring the good management of the insect resource.

6.5.3 Using Edible Insect Indigenous Knowledge to Contextualise Learning to give it a Place and Identity

Research generally confirms that contextualized instruction can improve students' curricular learning (Reyes-Garcia *et al.* 2010). However, there are also several authors who attest that school and related activities are negatively associated with acquiring indigenous knowledge (Snively and Corsiglia 2000, May and Aikman 2003, Quinlan and Quinlan 2007,). Reyes Garcia *et al.* (2010) conducted an in depth investigation into the Bolivian Tsimane tribe's indigenous knowledge and the effects of schooling on both theoretical and practical indigenous knowledge. The researchers found that even though schooling did have a negative association with the acquisition of indigenous knowledge, it was a weak association and that it was practical skills that were most negatively affected by schooling. It was speculated that because the Tsimane schooling system is highly contextualised in the local setting there has been a lower rate of loss of indigenous knowledge than in other cultures. The local language is used as the medium of instruction and many local examples, values and knowledge are incorporated into the curriculum. The study demonstrated that theoretical indigenous knowledge, such as the names of plants and animals, was more easily incorporated into the schooling system, whereas practical skills, which took time and repetition to perfect, were incorporated with more difficulty and not transferred to the learners as readily. Thus, in the Blouberg context, it may be more important to engage the expertise of a local indigenous knowledge holder to teach practical skills simultaneously with the theoretical. This will lead to better knowledge transfer than simply opting for the majority of the people's suggestions of a local expert merely talking to the learners in the classroom, or simply translating the knowledge into textbooks.

The method of teaching should be carefully chosen. Modern research supports a constructivist approach whereby learners' existing knowledge is used as a platform upon which to build new knowledge and lessons are learner centred (Lederman *et al.* 2004). Chin and Chia (2004), in exploring problem based learning in a secondary school context, used edible insect consumption as a project topic in Singapore. They report more active and student centred learning, resulting in better retention of knowledge through a sustained interest in the topic. It is important to note that the method of teaching was more important than the topic that was taught in achieving these positive outcomes. In this case, learners themselves chose a broad topic, identified a problem within the topic that required solving and then developed questions around the problem. Ultimately they had to find solutions to the problem and present their findings to the class with the teacher acting as a facilitator rather than as an authoritative mouthpiece of information. In a South African context, Minter (2005) found that including indigenous knowledge around frogs in a science lesson and doing so using a constructivist approach resulted in a high level of enthusiasm amongst the learners. It also reinforced lessons on biodiversity and conservation. Teaching knowledge about edible insects in a conventional teacher-centred “read and memorise” manner, will not necessarily result in better learning. Active, or life-learning, which acknowledges and uses varied means of teaching and information sources, is effective because it is often collaborative, experiential and peer based (Ruben 1999). These are in fact, precisely the characteristics of indigenous knowledge acquisition (Battiste 2002).

Battiste (2002) reports on the Canadian government’s innovation in appointing First Nation indigenous knowledge experts to develop portions of the curriculum in relevant regions where local schools serve aboriginal populations. Teaching goals, methods and time-frames are structured for and by the relevant community to better reflect the manner in which indigenous knowledge is acquired and passed on. Schools must therefore acknowledge that experiential learning is the prime means of information transfer used by aboriginal people and restructure accordingly. Direct learning, by seeing and doing, and the use of multiple sources of information and styles of participation are important approaches.

In Blouberg, there is a willingness to become involved in teaching edible insect knowledge and therefore a pool of local experts is available. Just under half of the respondents were interested in teaching about edible insects in their local school. This pool may be dwindling however, as Kobe (44 years) states, “older people are not so many now to show the youngsters these insects”. However, on the positive side, learning through local knowledge holders is seen as just as important as learning by means of conventional methods such as textbook material. The necessity of learning to recognise species, discover where they live and practise how to preserve and cook them is reiterated in comments by the respondents.

Contextualising lessons by including edible insect knowledge in schools will lead to certain challenges. Much indigenous knowledge is eminently practical and directly linked to what people need to know in order to survive (Agrawal 2002). Thus, the fact that most grandparents could not describe the life cycle of an edible insect may be due to the fact that this information is not relevant to the Blouberg people, who need to know when the insect appears, where it appears, on what food plant it appears and when it can be harvested, but not necessarily how it reproduces. This would also explain why collectors of *bophetha* (*Hemijana variegata*) erroneously believe, like many collectors of mopane worms (*Imbrasia belina*), that the caterpillar dies once it burrows into the soil (Ghaly 2009). There is thus no understanding of how the cycle is completed or a link to the silkworm life-cycle that is taught ubiquitously in South African schools (Toms 2007). This knowledge gap pertaining to the life-cycle of insects is also found amongst the San, who, although they possess astounding knowledge of the natural history of the local fauna and flora, do not have a complete understanding of the metamorphosis of Lepidoptera (Nonaka 1996). Thus they believe that moths lay eggs from which edible caterpillars hatch but that these caterpillars then burrow underground and change into black scorpions. Such gaps in indigenous knowledge could be filled by conventional research in this area, as has been done for the *bophetha* caterpillar (Chapter Three). Contrary to Agrawal's (2008) view that an indigenous knowledge database will generally not benefit the people who donate information to such a system, is Minter's (2005) recommendation to populate such a database for use by teachers designing lessons that incorporate indigenous knowledge into their science curricula. In this way, local knowledge can be combined with facts generated by conventional scientific research to enhance learning.

Some knowledge and beliefs around insects are directly contrary to scientifically validated facts. For example, the belief that locusts can cure chest pains by drinking the sufferer's blood has no foundation in science. Masuku's (1999) injunction to be aware that "indigenous knowledge practices have limitations and cannot be applicable to all situations and times" should be borne in mind when contextualising lessons. Despite this, beliefs and rituals that cannot be validated scientifically are not automatically the less valid or important to the people who practise them and should be treated with respect, even if they cannot and often should not be integrated into the school curriculum.

Compartmentalising aspects of the knowledge around edible insects within appropriate subjects, although leading to the danger of isolating such knowledge from its cultural context, could facilitate local learners' understanding of otherwise foreign concepts. In discussing the incorporation of indigenous knowledge into conservation strategies, Toms (2007) proposes a solution to the quandary of dealing with conflicting or contradictory information generated by indigenous vs. western knowledge systems: use the areas where they overlap. This strategy could be of value when including indigenous knowledge into schools. A lesson plan developed by Toms (2007) on the edible mopane worm (*Imbrasia belina*) is a case in point. Using the learners' knowledge of the life cycle of the caterpillar such as where it is found and the number of eggs the female lays, he built a mathematics word problem designed to teach concepts of multiplication, division and subtraction. Learners simultaneously explore insect life cycles and the use of mathematics in conservation. The core lesson could be taught anywhere in the world but the example is locally situated and gives the learners a familiar anchor to new concepts. Similar lessons could be taught using any of the Blouberg edible insects and this method could include other subject matter. The fact that the *bophetha* caterpillar is utilised in trade, makes it an excellent subject for economics lessons as well as for comparisons to the edible insect trade in other parts of the world. Simultaneously, learners would be exposed to the fact that other cultures across the globe also enjoy edible insects and that this practise is not an isolated, unimportant anomaly of their own culture.

The examination of confusing statements within a body of indigenous knowledge could lead to interesting and possibly useful revelations. It is important that learners understand that knowledge changes and grows and is not a static set of information, unvaried from area to area and era to era. It is acknowledged, even by scientists themselves, that there is no absolute reality and completely objective scientific knowledge is difficult and often impossible to obtain (von Glasersfeld 1980). Debates and discussion generated by different world views can be healthy if facilitated sensitively. For example, insects have been used in medicine in Mexico since ancient times and up to the present (Ramos-Elorduy de Conconi and Moreno 1988). Amongst 43 species of insect reportedly used as medicine in Mexico, the locust *Schistocerca* sp. is known to alleviate the asthma and coughs associated with chronic lung disease. Similarly, in Venda, South Africa, a number of grasshoppers are used for medicinal purposes (van der Waal 1999) and in the Blouberg, grasshoppers are said by some to relieve stomach ailments. There is a comparable claim made in Mexico regarding the efficacy of grasshoppers (*Sphenarium spp., Taenipoda sp,* and *Melanoplus sp.*) in curing intestinal disorders (Ramos-Elorduy de Conconi and Moreno 1988). Pursuing the link between the Blouberg medicinal grasshopper which is said to cure chest pains, those used in Venda and the Mexican grasshopper cure for coughs, would probably not lead to a ground breaking medicinal discovery, but this option would not even be there if this indigenous knowledge had disappeared. For example, traditional healers from the East have long used the saliva of blood sucking insects, such as horseflies (*Tabanus yao*), as anti-thrombosis medication and this shows potential as a novel medicine to treat platelet-aggregation association illness (Ma *et al.* 2009). In addition, Yang *et al*. (2011) report that the beetle *Eupolyphaga sinensis* is currently reared in China as a safe source of thrombolytic medication. This ancient treatment is preferred due to the fact that the risk of bleeding is reduced. This indigenous knowledge has motivated research into isolating the active components and evaluating their clinical potential (Yang *et al.* 2011).

Possibly a simpler, more direct means of including local insect-eating culture into the school curriculum is to link songs with language and arts lessons. A danger to bear in mind, however, is that song writers and poets have creative licence and can place nonsense into their songs. This is not a hazard in an arts lesson but would be problematic in a natural science setting as would including myths and unfounded beliefs.

The Sepedi words of fifteen songs relating to edible insects were captured in the competition questionnaire and translated into English (Figure 6.4). Future work should focus on recording the associated tunes and actions. Lomax (1968) reviews the importance of songs in culture, describing the function of song in any human community as the expression of shared feelings and the explanation of common activities. As such, all human societies share this social behaviour, which is an act of communication with characteristics unique to the culture concerned. Songs are therefore an indicator of the significance of certain behaviour in a community.

Figure 6.4 Learners singing in celebration of the environment and insects in particular

Nyota and Mapara (2008) note that all cultures have unique knowledge and ways of articulating and learning this and that songs and dances have a powerful role to play in the learning of such teachings. As such, these songs become part of the local knowledge that is unique to the particular community in which they developed. The existence of songs relating to edible insects is thus an indication of the significance of the insects to the Blouberg people. As Warren (1991) notes, local knowledge is used as a basis for decision making at the community level and is therefore significant for the socialisation of the young, food production, processing and preservation, in addition to natural resource management. The knowledge around edible insects encompasses a number of the above facets and therefore any songs and dances relating to entomophagy could fulfil such a teaching role.

Nyota and Mapara's 2008 research illustrates the importance of songs and play in the Shona culture and how these culture-specific childhood activities teach children about their biophysical environment and prepares them for their adult roles by teaching them appropriate value systems. They lament the fact that urban Shona people no longer have any knowledge of these song-games and learn social interaction skills in a foreign language and culture (English) and emphasize the importance of finding ways to ensure the on-going traditions of childhood song and play. Nonaka (1996) notes that the familiarity with which insects are viewed in San children's lives through songs and games allows them to develop the healthy outlook that insects are useful. The list of unwholesome and even dangerous insects is long and thus the western prejudice against insects as dirty and unwelcome is understandable. The recording of edible insect songs and their incorporation into formal school instruction can play a role, not only in static preservation of the songs but in enriching the learning environment of Blouberg's youth and ensuring that insects continue to be viewed in a positive light.

In a similar vein, food preparation and preservation are useful skills which should be easy to transfer into a classroom situation. Preparation and preservation methods extend the shelf life of a product, sometimes sufficiently to make them available during lean months. Madge (1994) notes that despite the poor documentation of such local knowledge in the indigenous knowledge literature, these valuable technologies are common to a number of cultures. She notes that in West Africa, the cooking and preservation of locally collected food is an important coping strategy in lean times. Knowledge of such technologies is dynamic and related specifically to locality and circumstances. For instance, Gambian women who lived through the famine of the 1930's knew more recipes than those who did not. These recipes were created during a time of need and hunger and passed on to others highlighting the flexible nature of indigenous knowledge (Madge 1994). She also notes that although cooking recipes are constantly modified with ingredients and methods obtained from 'outside' rural Gambia through tourist contact, migration for work, tertiary education and the media (television and radio), the preservation methods are much more static and unchanged. This can be explained by the availability of refrigeration, particularly in urban areas and therefore the lack of new preservation methods to pass on to rural communities.

In the Blouberg, the hot, dry weather is conducive to sun drying as a preservation method and most caterpillars are preserved in this manner for up to a year. Locusts, ants and termites are very oily and must be consumed within a week of frying. Even with the advent of electricity in Blouberg, most households do not possess refrigerators and thus preservation technologies play an important role. With the current consumer demand for preservative-free food and healthy eating options (Liestner and Gorris 1995), technologies utilising natural means to prolong shelf life are important in a modern context.

The preservation and preparation techniques (Appendix 5) present an opportunity for teachers to engage with learners in a science or life orientation lesson whereby the pros and cons of modern as opposed to traditional preservation technologies can be discussed. These can be compared to ways in which insects are prepared in other parts of the world (Ramos-Elorduy 1996). In addition, the question of the nutritional value of insects is another means by which new knowledge, discovered during the course of this project (Chapter Four), could be amalgamated with information within the community.

It is of significance to note that amongst the learners, one of the most cited reasons for not eating insects is the perception that they are not healthy. This was the least cited reason amongst the grandparents, who cited religious reasons (belonging to the ZCC church) as the main reason for not eating insects. There is thus a misconception, perhaps fuelled in part by formal education, and in part by misplaced shame of traditional culture, that edible insects are unhealthy. Anonymous from My Darling Village, writes, “Insects are unhealthy, they don’t have proteins”. In a letter to a pen friend in Scotland (Egan *et al.* 2009), one primary school learner lists the healthy and unhealthy food that he eats in Blouberg. Prominent amongst the unhealthy food is *mašotša* (mopane worm) an edible caterpillar. There is thus a dichotomy in that some respondents are concerned that insects may not be healthy, despite the fact that traditionally they are considered nutritious. This is not confined to the Blouberg. In certain Zambian and other sub-Saharan schools entomophagy is actively discouraged due to the fact that it is now thought to be an unhealthy practise (deFoliart 1999). The change in perception from the view that insects are a healthy food to the opinion that they are not, occurs in other traditional cultures. In the Phillipines, older people believe that their communities are plagued by more health issues than in the past when they ate a higher percentage of traditional food and had a positive view of consuming such food (Solomon and Gayao 2006). It is therefore time that this situation was reversed, with schools incorporating new research and corroborating what older Blouberg residents believe about the nutritional value of insects.

One further point concerns meals sold to school learners. There is presently a concern over the unhealthy eating patterns of school-goers in South Africa that has resulted in an effort by the authorities to ensure that more healthy choices are available in school tuckshops (Temple *et al.* 2006). It is not only urban school tuckshops that offer unhealthy food options but in many rural South African schools vendors outside the school gates target learners when selling packets of crisps, boiled sweets and other food high in fat and/or sugar (Kroon and Alant 2012, personal observation of rural schools in Venda and Capricorn districts of Limpopo). Encouraging the sale of indigenous edible insects by such vendors would contribute to the nutritional needs of the learners and assist in elevating the status of knowledge around these local insects.

6.5.4 Incorporating Edible Insect Knowledge into Schools to Resolve Power Inequities between Essentially Western Education Systems and Small Minority or Indigenous Groups

The people of Blouberg are members of the large and widespread Pedi tribe of South Africa. The Bahananwa sub-tribe to which they belong are a small group of people living in close proximity to the Blouberg Mountain and speaking a unique dialect of Sepedi (seHananwa) (Chapter One) and in this respect they can be seen as a minority group. Due to their long history of residence on and around the mountain (Chapter One) they are also an indigenous group, which, more significantly, is marginalised in terms of income and educational opportunities (Capricorn District Municipality 2009).

Minority, marginalised and indigenous groups do not generally have the opportunity to influence the content or the teaching methods of the formal education system of their country (Dei 2000). However, a people's concept of truth is strongly influenced by the dominant educational system within their community (van Eijck and Roth 2007) and therefore local people should have input into their children's education. In the Blouberg case, formal education is driven by the state organised, National Curriculum, a largely Western system which nevertheless acknowledges the importance of indigenous knowledge in education but does not give clear outlines on how this is to be implemented (Msila 2007). By disregarding the body of knowledge around edible insects held by Blouberg elders (grandparents in this study), Blouberg educators teach only a portion of the available information on insects and could perpetuate the myth that most insects are either inconsequential or pests to human life. They also miss an opportunity to develop the learners' pride in their heritage and culture. Judy van Schalkwyk, an Eco-school's node co-ordinator for the Blouberg, remarked on an activity designed to introduce indigenous knowledge into a classroom in 2011, " the learners enjoyed learning about and also teaching others about their past and heritage, as did the teachers and community members. They were excited to talk about the leg rattles made from edible insect cocoons and thought of many reasons why they are mostly made from plastic nowadays" (Figure 6.5)

Figure 6.5 Leg rattles made of the cocoons of Blouberg edible caterpillars, possibly the lunar moth (*Argema mimosa*)

A centralised, state run education system, while efficient and often practical, is not conducive to providing learners with the opportunity to be exposed to different ways of knowing or to explore more fully the indigenous knowledge within their own culture. This can lead to barriers within indigenous communities between those who have been formally educated and those who have not (McCarter and Gavin 2011) and foster destructive feelings of superiority and inferiority. In Blouberg, the inclusion of learners' grandparents' knowledge into an aspect of their grandchildren's education during the course of the edible insect competition, promoted pride within the older generation and enthusiasm and interest within the younger, generating positive feelings beneficial to community living.

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CHAPTER SEVEN

BLOUBERG'S EDIBLE INSECTS IN THE GLOBAL ARENA

Linking new knowledge with indigenous knowledge

7.1 INTRODUCTION

The preceding body of work has shown that edible insects in Blouberg play a significant role in the lives of the local people. The notion that all insects are pests of the home and enemies of the farmer and are to be exterminated at all cost, is not the attitude of most of Blouberg's population. This corresponds to the views of subsistence farmers in sub-Saharan Africa who are tolerant of termites in their agricultural fields (Sileshi *et al.* 2009). They understand that termites fulfil a number of environmental roles and that the damage they cause to the farmers' crops is outweighed by the increased soil fertility, nutritional input and beneficial fungal gardens that termites provide. Sileshi *et al*. (2009) therefore advocate a termite management strategy based both on indigenous knowledge of termites and modern understanding of termite ecology. Similarly, in understanding the value of the Blouberg edible insect resource and how it can be managed sustainably, contributions from both these knowledge bases are crucial.

In Blouberg, edible insects contribute to human well-being in tangible ways through their use as a nutritious source of food, as well as intangibly by enriching the culture of the Blouberg people. There are thus compelling food security reasons for managing this resource with care and equally important motives for supporting the culture of entomophagy in Blouberg, in order that the indigenous knowledge around this practice is protected. However, the edible insects of Blouberg are significant not only to the local community but also to humanity in general.

7.2 BIODIVERSITY, ECOSYSTEM SERVICES AND EDIBLE INSECTS

The rich diversity of life on our planet has created the conditions that provide for mankind's existence (Pollom 2010). Currently this existence is threatened by our own actions. Inappropriate development, unsustainable agricultural practises and rising pollution levels are causing species extinctions on an unprecedented level (Vitousek *et al.* 1997, ICS/ UNESCO/ UNU 2008). This is of concern because species are vital links in the ecosystems which provide essential services to the planet (Ehrlich 2009). These services include carbon sequestration, water purification, maintenance of air quality, food provision, pollination, pest control and flood control (Mooney 2010). However, the functioning of ecosystems becomes compromised as biodiversity declines. Presently, the principal causes of this decline are habitat fragmentation and destruction, as well as rising CO_2 emissions which are leading to drastic disruptions in the climate as we have known it (Cox *et al.* 2000, Brussaard *et al.* 2010). Other major causes are alien plant invasions and pollution.

The epoch in which we live has been defined as the Anthropocene due to the inescapable fact that through the use of fossil fuels, we as a species are changing the geophysical nature of the planet in ways that were previously possible only through forces of nature such as earthquakes, volcanoes and flooding (Steffen *et al.* 2007). It is the industrial revolution that has driven drastic changes in lifestyle which impact so negatively on efficient ecosystem functioning. These modern lifestyles generate huge volumes of carbon that are released from their inert fossil fuel states into the atmosphere as carbon dioxide. The initial mining of such carbon stores causes severe habitat destruction leading directly to biodiversity loss. Once mined, the subsequent use of these materials such as oil and coal, also impacts negatively on biodiversity through the burning of fuels and the damaging waste disposal practices of the resulting petroleum products (Vitousek *et al.* 1997, Lal 2004).

In garnering support for a response to the global environmental crisis, scientists cite the outcomes of ecosystem services research (Daily *et al.* 2009). Increasingly, these outcomes reveal how indispensable healthy ecosystems are for the provision of fresh water, the maintenance of pollution free air and the production of soils that are agriculturally viable (Diaz *et al.* 2007). This information is now used by many of those campaigning for recognition and protection of vital natural assets. It is evident that from an era where the role of the natural environment in providing essential products was taken for granted or in many cases unknown, society is now beginning to accept that it is nature, in the form of ecosystem services, that provides all the raw material for every aspect of our material lives (Mooney 2010). The general public are therefore becoming aware that diverse services, from the role of insects in pollinating mankind's crop plants, to the importance of forests acting as fog catchers to replenish underground aquifers, are provided by effectively maintained ecosystems (Daily 2000). Thus, the dissemination of information to the public on the connection between functioning ecosystems and human welfare, both globally and on a local level, has become vital (Millenium Assessment 2005).

In particular, evidence of the contribution that healthy ecosystems make to global food security is growing (Boelee 2011). Brussaard *et al*. (2010) report that in 2009 more than 1 billion people in the world did not have access to sufficient food and there is no evidence that this figure has improved. In Africa particularly, governments and NGO's constantly fight the spectre of famine and associated malnutrition and thus the relationship between biodiversity and food security is an important consideration (Scherr 2000). It is of relevance to Blouberg that the Limpopo provincial government actively promotes research into ecosystem services in the province (Water Research Commission 2012). According to Wahlqvist and Specht (1998) a decline in biodiversity negatively affects food security in the following ways:

1. By reducing the variety of food sources and potential food sources available to omnivorous humans.
2. By decreasing the variety of foods available for switching if climate fluctuations or pest induced changes cause declines in some food types and
3. By shrinking the resource base of available organisms that have medicinal and other therapeutic properties.

Over the years a number of authors have highlighted the importance of maintaining genetic variety in both wild and domesticated food sources as well as the conservation of biodiversity as a safety net of future options in the event of a decline in current food resources (Jackson *et al.* 2010, Brussaard *et al*. 2010). Blouberg's edible insects form a suite of various genetically diverse species that occur in a number of habitats including pristine, untransformed woodland (*Hemijana variegata*), transformed but agriculturally viable land (most of the edible grasshoppers and *Sternocera orissa*) as well as amongst degraded habitat over-run by invasive species (*Agrius convolvuli*). The consequences of a decrease in Blouberg's edible insect diversity are a reduction in food source variety and a decrease in choices of food available for switching as in point one and two above. Although the Blouberg society makes limited use of insects for therapeutic and medicinal purposes, there are other South African cultures that use insects medicinally and therefore point three is also relevant (Van der Waal 1999).

7.3 THE KNOWLEDGE ECONOMY AND EDIBLE INSECTS

Growing awareness of the level of destruction that humanity has caused to earth's natural systems and their importance to human well-being has led to an accelerated search for knowledge around mechanisms to mitigate the effects of climate change and habitat destruction on biodiversity loss (Paoletti and Pimentel 2003, Adger *et al*. 2005). Mooney (2010) notes that scientists investigating biodiversity are making rapid progress in responding to this knowledge demand in the following areas:

1. Discovering, cataloguing and disseminating information on global biodiversity
2. Developing strategies to save and restore biotic richness in the context of rapid global change
3. Demonstrating the consequences of massive biodiversity loss to society

Indeed, knowledge in general is acquiring ever increasing significance as is evident from the universal use of the phrase, 'the Knowledge Economy' to describe the importance of know-how and expertise in global trade and international relations (Sen 2005). In addition, it is recognised that positive responses to environmental degradation will be more successful if research is interdisciplinary (MacMynowski 2007). Thus all knowledge is of potential value and that body of information linked to indigenous cultures world-wide is now being explored for insights into solving current world crises (Castillo and Toledo 2000, Arquette *et al.* 2002).

Godoy *et al.* (2005) report an annual increase of 9.45% in publications on indigenous societies. A substantial proportion of this literature relates to the contribution that indigenous knowledge has made and continues to make to our understanding of components and functions of ecosystems (Stevenson 1996, Rist and Dahdouh-Guebas 2006). Importantly, these investigations clarify the interactions between ecosystems and human societies (social-ecological systems) (Sen 2005, Butler 2004).

The value attached to indigenous knowledge in South Africa is indicated by its inclusion in the Department of Science and Technology's strategic policy to strengthen South Africa's position as a knowledge-based economy (Department of Science and Technology 2007). The opening statement of the vision specifies that indigenous knowledge and the country's prolific biodiversity will be used to enable

South Africa to become a leader in the pharmacological industry among others. Thus indigenous knowledge and biodiversity are seen to be equally valuable at national government level. The above department is in the process of developing an indigenous knowledge database that will act as a repository for the protection of indigenous knowledge through *ex situ* means, as well as facilitating its use on a broader level (Ndinda *et al.* 2011). Hart and Vorster (2006), in addressing the general failure of expensive agricultural extension and development programmes amongst Africa's poor rural communities, emphasise that it is vital to first understand what people know and where this knowledge comes from and then to build upon this local knowledge base. The blanket replacement of indigenous ways of accomplishing tasks with costly new technologies with which people are inexperienced or ignorant, results in failure of the project when external funding, infrastructure and/or manpower are withdrawn. There is thus a world-wide recognition of the importance of combining diverse knowledge bases to understand and then improve the functioning of social-ecological systems (Folke 2004).

Indigenous societies the world over are and have been for millennia, intimately acquainted with the direct use of natural resources from their own local environments (Wiersum 1997). They cannot live in ignorance of the life support provided by their natural world because they themselves extract the products and materials required for their welfare (Folke 2004). By harnessing indigenous knowledge about local biodiversity, humanity can gain insights into ways in which modern societies can live more sustainably.

This is not to say that the way in which indigenous societies extract such resources is always sustainable. For example, coral reef mining by the Kuna people of Panama over the last 30 years has significantly degraded the natural reef area and impacted negatively on the biodiversity of the reef (Guzmán *et al.* 2003). Scientists, working with Kuna leaders identified reasons for the decline and delineated new coral conservation areas. The reports were favourably received by the local communities and they have instigated changes in cultural practises to assist in coral reef protection. In Brazil, Firmo *et al.* (2012) report that land crabs (*Cardisoma guanhumi*) on the shores of the Bahia State are in decline due to overharvesting by local fisherman. The fisherman shared the local indigenous knowledge that they had acquired over the years on local distribution, biology, diet and habitat preference, as well as information on the recent decline in crab numbers. Scientists used this knowledge as a baseline for investigation into specific questions related to the decline. The results from the combined sets of information were utilised to update the existing harvest legislation to both better protect the crabs and also allow harvest at a more appropriate time for the collectors. This highlights the importance of

1. local resource users noticing and acknowledging declines in important natural products,
2. making their indigenous knowledge available to local authorities and scientists, and
3. working with new knowledge acquired through specific research to find ways of modifying their actions to allow for more sustainable utilisation

In Africa, certain edible caterpillar species are declining, not only because of direct overexploitation of the insects but also because of overharvesting of fuel wood which provides food and shelter for the caterpillars (Ditlhogo 1996, Mbata *et al.* 2002, Makhado *et al.* 2009). In Zambia, local caterpillar harvesters are concerned that this resource is declining despite traditional management practises (Mbata *et al.* 2002). They welcomed additional government harvesting policies developed in conjunction with their local knowledge and specialist advice from entomologists. Thus in the above cases, local people were fully aware of their impact due to their close proximity to the exploited resource. Significantly, because they were directly affected by the resource decline, they were therefore willing to take measures to counter this once they acquired the appropriate knowledge and tools (Guzmán *et al.* 2003). In Blouberg, the community are concerned over dwindling edible insect numbers and are thus supportive of research into the resource and so volunteer information and time. Future actions must involve dissemination of the new scientific knowledge gained from the above work to government officials, the traditional authority, educators and insect collectors in order to develop actions to promote sustainable edible insect utilisation in Blouberg.

7.4 GLOBALISATION AND INSECT USE

Technological advances since the industrial revolution have enabled people to benefit from resources not locally available (Pollom 2010). However, increasing globalisation has brought growing physical detachment from the ecosystems which provide us with our needs and desires (Aggarwal 2004). Materials and products can now be accessed from any part of the world by air or surface transport, resulting in direct environmental degradation through increased use of fuel and packaging and associated habitat destruction (Roe 2004). A more subtle negative environmental effect of globalisation is that communities lose physical contact with the environment providing their food, water, shelter, and minerals and are not aware of the effect the extraction of these products has on the environment from which they originate (Pollom 2010). There is evidence from ecological research that while environmental degradation caused by local activities can usually be reversed, ecosystems degraded due to more remote activities (for example logging forests for the production of beef cattle for international markets), are more difficult to restore (Aggarwal 2004). There are thus valuable lessons to be learnt from the ways in which local communities impact on ecosystems but more pertinently, the methods used to restore those that they have degraded. In the Blouberg situation there is recognition that over-harvesting and over grazing of insect host trees has led to a decline in edible insects. There were positive responses to the suggestion of a workshop to discuss ways of augmenting the number of host trees in the area.

Globalisation is underway and unlikely to be halted no matter the effects, whether positive or negative, on society and the natural environment (Roe 2004). Indeed globalisation is not all doom and gloom. One of its most useful aspects is that it has fostered a realisation that societies are not isolated from each other and that actions performed in one community usually have consequences to others elsewhere (Pollom 2010). Notwithstanding these positive aspects, it is imperative that humanity adopts lifestyles that promote the functioning of healthy natural systems. In order to achieve this it will be valuable for the global community to learn from those cultures which utilise their natural environment to deliver all their needs without destroying the vital ecosystem services these environments provide (Folke 2004). It is rare today to find cultures completely isolated from the modernising influence of the 21st century, let alone living in perfect harmony with nature. Despite this, many people who still extract natural resources directly from their local environments have knowledge and insights about what these resources are and how to collect them sustainably (Nakashima *et al.* 2000). These parcels of information can provide scientists with basic information on the biodiversity of an area as well as an understanding of how these species may be impacted by climate change, land use modification or pollution. Indigenous knowledge can therefore feed into all three of Mooney's (2010) categories of current research listed above. Specifically, the indigenous knowledge around Blouberg's edible insects contributes to these points in the following ways:

1. *Discovering, cataloguing and disseminating information on global biodiversity:* Almost thirty Blouberg edible insect species were identified, with details on life histories, host plants and reproductive strategies. Almost 100 ethno-species were recorded.
2. *Developing strategies to save and restore biotic richness in the context of rapid global change*:
   The practise of collecting pest insects for human consumption rather than using pesticides for their control was reported. The banning of the collection of insect host trees for fuel wood was observed.
3. *Demonstrating the consequences of massive biodiversity loss to society:* Local school teachers and members of the community were eager to incorporate edible insect knowledge into the local school curriculum with specific focus on the effects of habitat destruction and publicising information about the Blouberg edible insects further afield.

Mankind's ability to connect instantaneously with cultures and individuals across the world is another positive aspect of globalisation (Averweg and Greyling 2010). Learning from others is facilitated by the World Wide Web and rapid transport over large distances. The call from researchers since the early nineties for the use of aspects of indigenous knowledge to solve environmental challenges can today be implemented through our advanced communications networks.

Edible insects, being largely undomesticated, are a food resource that is intimately linked to the natural environment. They are also today, primarily utilised by cultures that are less urbanized and relatively unaffected by globalisation. As such, insect eating cultures often have alternate bodies of information and different ways of knowing that can be valuable in documenting and understanding the biodiversity of an area as well as in the investigation of more sustainable ways of living (Pollom

2010). In terms of ecosystem services, edible insects contribute directly to human food security (de Groot *et al*. 2002). In Africa particularly, the principal beneficiaries of this food source are those in marginalised rural areas who have fewer choices in terms of food stuff. Conserving the ecosystems in which edible insects occur will also protect the other functions of these insects such as pollination and their position in numerous food webs.

The knowledge specific to Blouberg's edible insects, for example the species utilised as food, can be efficiently preserved on the World Wide Web through the use of the Wageningen University's (2011) data base of edible insects and in the same way can be rapidly disseminated to the global community. Ideally this should be a two way correspondence with feedback from scientists and other interested parties reaching the Blouberg community through emails and discussion boards. In this manner local indigenous knowledge around edible insects can grow and metamorphose rather than becoming trapped in databases and libraries as described in Chapter Six. Although in no way universally available, there is access to the World Wide Web in Blouberg, with the youth in particular connecting through mobile phones and internet cafes. Indeed, although Africa is lagging behind many developed countries in terms of computer access, the use of mobile phones is becoming increasingly important in obtaining and exchanging information via the internet and this is also true for Blouberg (Greyling and McNulty 2011). Encouraging the use of the World Wide Web in the dissemination of this knowledge will automatically involve the youth in learning about an aspect of their culture that they may otherwise dismiss as not relevant to modern living.

7.5 LINKING KNOWLEDGE SYSTEMS

In the preceding chapters of this study, a large body of the indigenous knowledge around edible insects, which is lodged in the collective consciousness of the Blouberg community, has been documented and synthesised. In addition, further information around this resource has been gathered through scientific enquiry. The South African National Indigenous Knowledge Systems Office (NIKSO), a government initiative, has, as one of its mandates, the facilitation of interactions between indigenous and western forms of knowledge, as well as other knowledge systems, to solve national challenges (NIKSO 2012). This will be done with the aim of generating knowledge that benefits all sectors of society. Hart and Vorster (2006) emphasise that local innovations in solving local food security challenges depend on this interaction between indigenous knowledge and new knowledge which may be in the form of western or scientific knowledge. Importantly, the functionality of indigenous knowledge depends on access to local resources and if this resource base deteriorates or disappears, as will happen with a decline in biodiversity, so the knowledge around these resources will change or disappear.

The following diagram (Figure 7.1), modified from Figure 1.2, Chapter One, illustrates the specific input that indigenous knowledge and new knowledge generated through the scientific methodology have had in broadening our understanding of edible insects in Blouberg and their potential use in a global context. It is important to note the arrow on the left indicating that knowledge forms a continuum and that it is not always possible or necessary to place knowledge into discrete packages depending on its origin. Thus the information required (middle grey blocks) can sometimes be gained through differing means, in particular, that information in the central grey block. For example, local people may have knowledge about the predators of edible insects through day-to-day observations, but visiting researchers could also gain this knowledge and extend it using modern technology, such as camera trapping. Information in the first box is, however, more specific to local knowledge. This is information that is already known but in order to be used more widely, should be documented and disseminated. Information in the lower middle block needs to be extracted using modern technologies and more rigorous scientific enquiry.

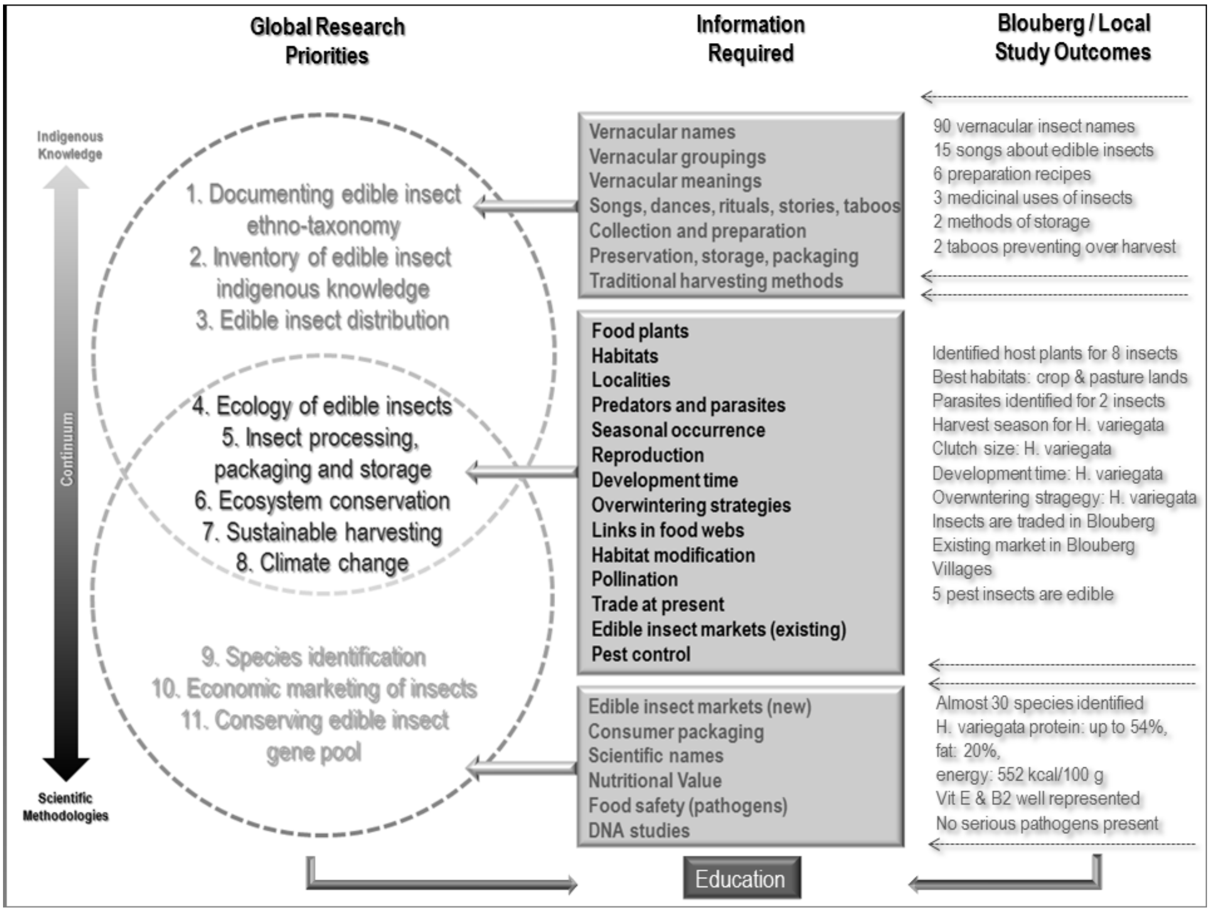

Figure 7.1 Information derived from indigenous knowledge, scientific enquiry and from their overlap (centre) with regard to the Blouberg edible insects and how this complements global research priorities on edible insects.

7.5.1 Indigenous Knowledge Contributions

The holders of Blouberg's edible insect indigenous knowledge contributes to research priorities one to three (Figure 7.1) in a number of ways elaborated below. Over 90 vernacular names of edible insects have now been documented. This expands the global knowledge base on ethno-taxonomy as called for in research priority one. It also makes it possible to compare edible insect utilisation in Blouberg with that of other areas where Sepedi is spoken. It enriches our knowledge of the vernacular names of South Africa's fauna and will contribute to South Africa's indigenous knowledge database which is being developed by the Department of Science and Technology (Ndinda *et al.* 2011).

Research priority two (Figure 7.1), calls for the widespread documentation of edible insect indigenous knowledge. In Blouberg the number and variety of songs, rituals, taboos and stories about edible insects of the area reveals the importance of this resource to local people. These expressions also give insight into the habits of the insects and some actions that could aid in their sustainable management. For example, the traditional authority's taboo against cutting down the food plant of the edible insect *Hemijana variegata (bophetha*) for firewood, does, although not strictly enforced, assist in protecting this insect. The information provided on the palatability and the perceived quality of various edible insects informs decisions regarding the choice of insects for further research into nutrition or ecological aspects. A case in point is the edible beetle, *Sternocera orissa* (*lebitsi),* which, because it is available during dry years as well as being highly favoured, makes it a good candidate for the above mentioned research.

Entomophagy in Blouberg is on the decrease due to a change in lifestyles to more modern ways of living. As a consequence Blouberg's indigenous knowledge around insects is constantly shifting and if, as research priority two suggests, it should be incorporated into a national or global inventory, then this should happen without delay. Simultaneously, mechanisms to support the culture of entomophagy should be implemented. It is the way of life of the rural Blouberg people that nurtures this body of information. Without people who practise entomophagy in Blouberg, all the intricate and changing facets of the knowledge of these insects will disappear, even assuming some of it has been captured in a database. Van der Waal's (1999) results on the use of edible grasshoppers in Venda (northern Limpopo Province, South Africa) indicate that the trend of urbanisation and rejection of insects as food is not isolated to Blouberg but also prevalent in other areas of the country. Thus loss of indigenous knowledge around edible insects is occurring countrywide.

The information on harvest localities of edible insects can now be included in national insect distribution databases and is thus an important contribution to research priority three. Insect distribution data is generally scanty unless it involves species of economic importance. It is however particularly important because research into the effects of climate change on biodiversity is facilitated by the monitoring of species distribution changes over the years. The Limpopo Department of Economic Affairs, Environment and Tourism (LEDET) is in the process of implementing a conservation plan for the province, which calls for details on faunal and floral distributions and the monitoring thereof (LEDET 2012). Indigenous knowledge of the distributions of these edible species will be useful to such a plan in view of the fact that insects form a large taxon. Country-wide databases are maintained on Coleoptera, Lepidoptera, Neuroptera and invertebrates in general but extra information would be valuable due to the large size of Limpopo Province.

7.5.2 Scientific Enquiry

Contributions to research priority nine (Figure 7.1) are dependent on the determination of the scientific names of edible insects. Collation of the known facts about any organism is impossible before verifying its universal scientific name (Randler 2008). This process is generally undertaken by professional taxonomists, particularly for little known organisms. It is time consuming and meticulous work, especially when only one life stage or caste is consumed, as with Lepidoptera such as *Hemijana variegata* larvae and *Macrotermes* sp. workers. This necessitates the artificial rearing of the insect to adulthood for correct identification. For Blouberg's edible insects, this process is on-going and has and will continue to engage experts in all the orders consumed (Orthoptera, Coleoptera, Lepidoptera, Isoptera and Hymenoptera). Thus far the collaboration of taxonomists for this purpose has contributed to the identification of 28 insect species which can now be listed in the international edible insect database (Wageningen 2011)

Research priority ten (Figure 7.1), appeals for information on economic marketing of edible insects. In the Blouberg context, analysis of the nutritional value and food safety aspects of the insects consumed feeds into this priority. An understanding of the nutritional value of insects will add value to marketing the insects to both the established and a new consumer base. Most Blouberg residents, particularly older people, believe that edible insects are nutritious but they do not have a detailed understanding of why this should be so. Scientific methodologies in the form of modern nutrition analysis were employed to determine the nutritional value of *Hemijana variegata*. This research confirms that the insect possesses favourable percentages of protein (higher than beef or poultry) as well as an impressive energy component. The encouraging results on food safety recorded in Chapter Four would also be important in assuring the public that there would be no harmful effects in consuming this food. The fact that, when compared with the views of their grandparent's, the views of most of the Blouberg youth are that edible insects are not healthy, indicates that marketing the benefits of entomophagy is important even in an area where it is commonly practised. Studies in both rural and urban areas reveal that although South Africans have a poor knowledge of nutrition in general, increasing nutritional knowledge does lead to healthier food choices (Steyn *et al.* 2000, Temple *et al.* 2006). A number of studies advocate advertising the nutritional qualities of insects in order to promote insect consumption (Xiaoming *et al*. 2010, Melo *et al.* 2011, Ayieko *et al.* 2012), however, few studies have investigated whether edible insect marketing does indeed change eating habits. An FAO project in Laos has had some success in increasing awareness and interest in edible insects but this is in an area where insects are traditionally consumed (UN Volunteers 2010). Investigations into the best way of promoting the health-giving qualities of insects will therefore be of value.

A recent study by Shadung *et al.* (2012) investigates the proximate nutritional value and the effect of drying regime and food quality of the favoured Blouberg beetle *Sternocera orissa* (*lebitsi*). Results show high percentages of protein, fat and carbohydrates with slight variation depending on processing method and beetle locality. Such results and other nutritional value and food safety information that is available for the rest of the Blouberg insects should be collated and distributed when marketing these edible insects. There is a growing interest in insects as a novel food source amongst western restaurateurs (Gordinier 2010), and this, together with the FAO's call for greater utilisation of food insects generally (FAO 2012), means that there is global interest in determining and broadcasting the nutritional value of Blouberg's insects.

The eleventh research priority (Figure 7.1) focuses on the conservation of the edible insect gene pool. For the Blouberg insects, a contribution to this priority has begun with the accurate identification of species consumed. Conservation of diverse genetic resources is important in that it increases the chances of that species surviving changes to its environment (Hughes *et al.* 2008). With respect to agriculturally important species, in this case edible insects, genetic variety also confers options of selecting for favourable traits from a pool of available resources. For example, the edible beetle *Sternocera orissa,* varies in nutritional properties depending on the locality in which the beetle is collected (Shadung *et al.* 2012). If this is a genetically linked trait then it would be possible to selectively breed those with the most favourable nutritional trait. However, if beetles from various areas were not available or had become locally extinct this would not be an option. The aim of conserving gene pools is thus the maintenance of a gene base that is as diverse as possible. This is challenging considering that it is difficult to recognise genetic variation and it has to be surmised, unlike in conventional conservation where disparate habitats and ecosystems are conserved, which are visibly discernible (Samour 1993). Conserving genetic diversity therefore involves conserving areas that are diverse in aspects such as locality, altitude and climate. For the Blouberg edible insects, there is now a database of known species all of which have been documented from other areas in South Africa but may be genetically unique to the Blouberg area and therefore of conservation interest.

7.5.3 Overlap

None of the information feeding into the above research priorities can be viewed in isolation and the division into two forms of knowledge and their overlap serves mainly to highlight the relevance of all knowledge around edible insects. The following points serve as a particular illustration of insights gained through the merging of indigenous knowledge with scientific enquiry into Blouberg's edible insects.

The information provided by the local people on the host plants and habitats from which insects are harvested most frequently contribute to research priority four (investigating edible insect ecology, Figure 7.1). In addition, acquiring this information from local people meant that the need for time-consuming and often expensive pilot studies was lessened. Local people were consulted for their knowledge about the type and locality of food plants utilised by *Agrius convolvuli* (*makotopodi*), *Petovia marginata (bobilo)* and *Sphingomorpha chlorea* (*bonado)* when rearing these caterpillars to adulthood for identification (Figure 7.2). This technique also allowed for the identification, with the input of expert taxonomists, of several caterpillar parasites thus contributing to further understanding of the ecology of these insects.

Figure 7.2 Mary Tsita explaining how to harvest *bonado* (*Sphingomorpha chlorea*) from *Burkea africana* (*monado*).

The knowledge of the insect harvesters contributed to refining certain research techniques. For instance, people who collect *Hemijana variegata* (*bophetha)* regularly, advised researchers on the size of bucket to use when capturing the caterpillars during quantification field work as well as on methods of collecting those feeding at the tops of the trees (Chapter Five). The people themselves often assisted in field work and in collecting laboratory specimens as they were especially efficient at spotting and catching the insects through years of experience.

The local people's identification of the food plant of *Sternocera orissa* (*lebitsi*) was significant, as the beetle feeds on *Dichrostachys cinerea* which is indicative of bush encroachment (van Wyk and van Wyk 1997). Further research into the feeding ecology of the beetle could be useful in developing control strategies for *D. cinerea*. The fact that many people, particularly children, enjoy the fresh eggs of these beetles as a tasty snack, could impact on such a control strategy especially in light of the fact that these beetles are the most favoured insect in Blouberg and therefore consumed frequently.

Insects that have a combination of tastiness, drought tolerance and economic value are also worthwhile candidates for further investigation. The knowledge of which insects fulfilled these requirements informed the decision to investigate *Hemijana variegata* more fully in terms of life history strategy and nutritional value.

Hellier *et al*. (1999) acknowledge that utilising indigenous knowledge provides valuable insight into determining biodiversity trends in an area, particularly as it is possible to obtain rapid results by using this existing knowledge and in light of the urgency with which biodiversity mapping is required. The Blouberg edible insect harvesters believe this resource to be shrinking and this should be a motivating factor in an analysis of the conservation status of the more valuable of Blouberg's edible insects. A further consideration is to use Geographic Information System technology to map the distribution and abundance of these insects.

Indigenous knowledge was also found to be especially useful in assessing fine-scale habitat changes and the corresponding impact on associated human communities (Hellier *et al.* 1999). For instance, in Blouberg, insect habitat information at village level indicates that the suite of edible insects differs from one side of the Blouberg Mountain to the other. Mapping insect distribution based purely on satellite imagery and according to vegetation type or habitat would not reveal that *Sternocera orissa* occurs predominantly on the plains around the mountain, *Hemijana variegata* is found only on the bottom third of the mountain and *Sphingomorpha chlorea*, despite its pest status, is, in Blouberg, located only on the tall *Burkea africana* stands halfway up Blouberg Mountain. This information was volunteered by the insect collectors of the area.

Traditional methods of collection, preparation and storage of Blouberg's edible insects, recorded here, can now be compared with methods used by other cultures and contribute to research priority five. Modern methods of food storage rely heavily on preservatives to prolong shelf life but consumers are now becoming wary of the negative aspects of food additives (Young 1997). New investigations into improving on traditional insect preservation methods should endeavour to retain the positive aspects of traditional approaches (such as lack of additives or excess packaging) and focus on methods such as sanitisation of the preparation process and packaging using vacuum sealing or other natural preservatives such as vinegar or lemon juice to prevent bacterial growth

A valuable aspect of the Blouberg edible insects is the wide diversity of habitats in which they can be found. Such information is useful for fulfilling research priority six. Certain species, particularly the caterpillars, are highly specific and located only on certain host plants: e.g. *Hemijana variegata* is found on *Canthium armatum* and to a lesser extent, *Pyrostria hystrix*, while *Petovia marginata* feeds on *Vangueria infausta*. These tree species are typical of untransformed vegetation on the Blouberg Mountain (Figure 7.3). Their conservation would lead directly to the protection of the ecosystems in which they occur. Blouberg Mountain's vegetation performs the vital service of trapping fog that collects around the mountain, which drains into the aquifers from which the boreholes on the plains below the mountain obtain their water (Scholes 1978). Destruction of the mountain vegetation will have serious consequences in terms of water management for the drought prone area surrounding the mountain. Conservation of these plants as edible insect habitat therefore fulfils more than one function.

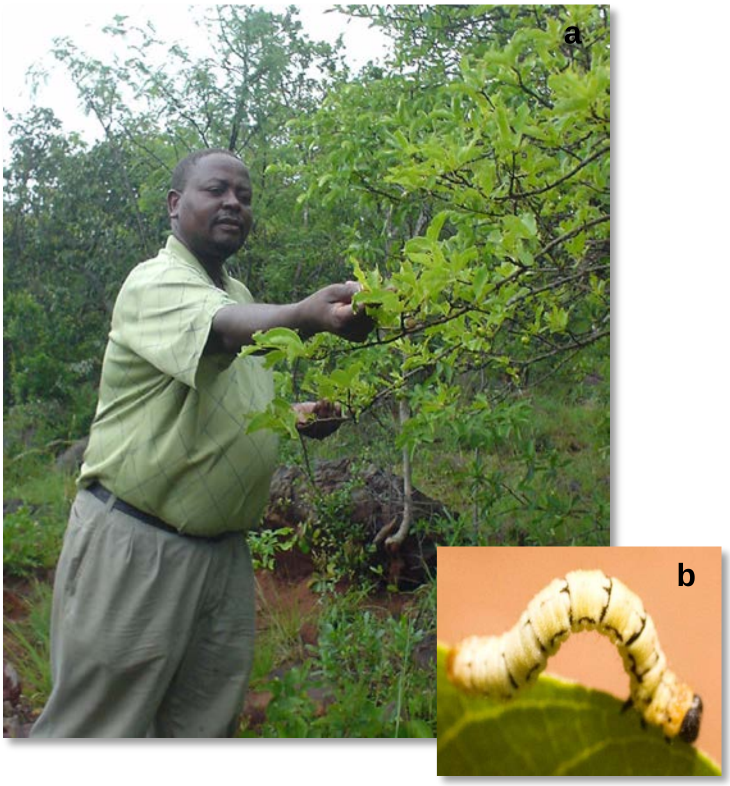

Figure 7.3 Patrick Morata (a) pointing out *Vangueria infausta* (*mobile*), the tree on which to find *Petovia marginata* (*bobilo*) (b)

Most edible insects are harvested from crop and pasture lands. These agro-ecosystems are thus of two-fold importance. They provide conventional crops such as maize, sorghum and vegetables, as well as nutritious insect protein. This additional food source is however, only available if pesticide and herbicide use is minimal to non-existent. Limiting the use of these chemicals will also be beneficial to the conservation of other species. Traditionally managed agricultural lands often contain indigenous plants and animals and are consequently of conservation value (Oldfield and Alcorn 1987). The fact that some pest insects are harvested as food and that certain edible insects are closely associated with problem plants should be borne in mind when advocating pesticide use in such systems.

For research priority seven (Figure 7.1), which calls for contributions to knowledge about sustainable harvesting techniques, Blouberg insect harvesters contributed valuable information on quantities of insects harvested as well as their perceptions regarding the type of harvest (good or bad) and factors that influence harvest size. Such information was combined with field trials to determine possible edible insect yields and the effect of harvesting on insect populations. This combination of indigenous knowledge with scientifically conducted field sampling gave insight into the importance of the edible insect resource to the Blouberg people and the necessity of managing this resource more effectively. The huge impact of rainfall, both the timing and amount, on the harvests of *Hemijana variegata* (*bophetha*) is similar to the influence of rain on *Imbrasia belina* (mopane worm) harvests in Botswana (Ditlhogo 1996). This has implications for management of the resource where harvest quotas may be unnecessary in years of favourable rainfall but important in poor rainfall years. Such a variable quota system, rather than a fixed quota, has been recommended for mopane worm management in Botswana and may be appropriate for the Blouberg situation (Ditlhogo 1996).

Local people repeatedly cite decreasing rainfall as the reason for the perceived decline in edible insects. Due to the important influence that rainfall patterns have on insect populations, several edible insects could act as useful climate change indicators and thus contribute to research priority eight (Figure 7.1). Climate change modelling is a multifaceted science requiring information on population ecology, species distributions and reproductive strategies as well as biological and behavioural responses to temperature and photoperiod changes (Kearny and Porter 2009). Indigenous knowledge holders can contribute general information such as food plants required, seasons at which the insects appear and information on distribution. Much of the in depth biological data necessary for such models must however be gathered through rigorous experimentation using scientific methods and modern GIS and computer simulation technologies. Distribution information obtained from holders of indigenous knowledge will give important baseline data but may also be limited to the communities who utilise the insects. Indigenous knowledge alone will not be comprehensive enough for climate change modelling. For instance, *Hemijana variegata* is distributed in the northern Limpopo Province, in parts of the Eastern Cape and in KwaZulu/Natal, however, there is no evidence that Xhosa people from the Eastern Cape consume the insect (Majova 2011) and therefore it may not be recorded in indigenous knowledge studies in that area.

For a number of better known Blouberg edible insects, particularly those recognised as pests such as *Agrius convolvuli*, basic natural history information is readily available and can be included in climate change simulation models. This study therefore concentrated on gaining baseline information on the development of the little known edible insect, *Hemijana variegata* (*bophetha*). Temperature tolerance data and information on egg clutch size and over-wintering strategies have now contributed to an understanding of this insect's likely response to increase in temperature levels (Chapter Three). This information is relevant to climate change monitoring together with historical scientifically validated distribution data and the local community's knowledge of where the insect is found.

7.6 ACTIONS AND FUTURE RESEARCH

Knowledge without action will not halt the progression of the unsustainable processes that are driving biodiversity decline. There is often more likelihood of protecting a resource that is overtly useful to mankind, than protecting a species that cannot be directly linked to human well-being (Gadgil *et al.* 1993). For instance, garnering public support for the conservation of a vital but obscure link in a complex food web such as a mayfly species will be more challenging than campaigning for the sustainable management of a species that has direct food value such as an edible fish or insect species like the mopane worm (*Imbrasia belina*). Actions to conserve such species may be easier to initiate than actions to conserve the mayfly example. Thus developing education programmes for the conservation of edible insect food plants in Blouberg such as *Canthium armatum*, *Elephantorrhiza burkei* or *Burkea africana,* would probably resonate with government officials and lay people as one way of supporting the fight against malnourishment in the area and therefore generate positive conservation action. By conserving food plants, other aspects of the biodiversity of the area will be protected. Invertebrates associated with the plants would remain undisturbed as would some of the ecosystem services provided by the trees, such as prevention of soil erosion. In this way, the protection of edible insect habitats will reduce habitat fragmentation and destruction, and thus support biodiversity conservation.

The Blouberg community are the custodians both of the area's edible insects and the knowledge around them. For the wise use of both, additional information contained in this thesis and other relevant information they may not yet be aware of, must be appropriated by the Blouberg people. The transfer of this information should not be merely in the form of written text but in a format accessible both to literate and illiterate community members. Posters, text books and popular articles could be lodged in libraries, schools and at the Maleboho Tribal Authority offices. However, these will not be useful to people who cannot read and may not resonate even with those who can. Written information should be supplemented using other methods which could include:

1. Airing an edible insect series on the local radio station which delivers programmes of interest in the Blouberg (Sehananwa) dialect of Sepedi. Radio is accessible to most residents as was evident when a solar charged radio was heard playing in an isolated homestead on the summit plateau of Blouberg Mountain.
2. Running workshops or interest days both for school-going learners and all interested members of the society. Workshops could focus on transferring skills around edible insects (e.g. planting insect host trees, augmenting insect populations or using the internet to capture indigenous knowledge). In contrast, interest days could be designed to disseminate information, not only about Blouberg edible insects but also the global trend in entomophagy.

There are few opportunities for entertainment in the area and therefore all meetings, sports events and cultural activities are enthusiastically attended.

3. Using the internet through mobile phones to post and receive information through web pages, social networking media and blog sites. This technique has been successfully piloted through the ULWAZI library programme in the Ethekweni Municipality, KwaZulu Natal (Greyling and McNulty 2011). It will appeal to younger members of the community who use cell-phone technology and opportunities offered by the World Wide Web.

The close proximity of two nature reserves in the foothills of the Blouberg Mountain could facilitate environmental education about the edible insect resource. Both nature reserves have close links to the Blouberg villages, with Maleboho Nature Reserve being managed directly by the community and Blouberg Nature Reserve being awarded to the Manoko Tribe during a recent land claim case. Both reserves receive monetary and staffing input from the provincial nature conservation government department (LEDET) who are mandated to deliver environmental education programmes in the area as well as ensure the reserves are adequately managed from a conservation point of view. Information about edible insects can therefore be disseminated from these reserves which are already visited by a number of local schools. The existence of at least some traditional taboos on cutting down edible insect food plants for fuel-wood is a strength that should be enhanced in such education programmes. The reserves also act as important reservoirs of edible insects. They could thus expedite augmentation programmes whereby insects are collected on the reserves to stock host plants growing in household gardens, rather than for harvesting.

7.7 REFERENCES

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CHAPTER EIGHT

CONCLUSIONS

Discussion, recommendations and conclusions regarding edible insects in Blouberg

8.1 EDIBLE INSECT SPECIES IN BLOUBERG

In January 2012 The FAO working group on edible insects promoted the idea of an international list of “society approved” insects for human food. The blind screening of any new resource is expensive and time consuming; therefore they call for the inclusion of knowledge from local indigenous experts as well as international scientists who have investigated such insects. Information such as vernacular names, species names, habitat and perceived local abundance is important for the development of an international edible insect database as well as for inclusion in local conservation and municipal planning.

At present there is a vibrant culture of entomophagy in the Blouberg, with four insect species newly documented as edible. In common with other countries where entomophagy is practised insects are in the main eaten because they are tasty, nutritious and a traditional food (Yen 2012) but this practise and knowledge is declining due to a change in lifestyle and to a perceived decline in edible insects. Although the insect decline is believed to be caused by lack of rain, there is a strong possibility that this is also due to habitat transformation and should be further investigated.

8.2. BIOLOGY OF *HEMIJANA VARIEGATA*

Promoting edible insect use in Blouberg will contribute to food diversification which is encouraged by South African agricultural policy makers (Altman *et al.* 2009). On the other hand, it is important that such a resource is not overexploited and that investigations are undertaken into determining the viability of domestication or semi-domestication. For these two actions, data on the biology of the insects is vital.
Chapter three addresses such issues for a little known edible insect species from Blouberg. *Hemijana variegata* (*bophetha*) caterpillars emerge in spring and undergo five larval instars before overwintering as a pupa. There may be the possibility that a second emergence occurs as this has been observed in the laboratory but to date there is no evidence of this occurring in the field. The emergence and development of the *H. variegata* moth is significantly influenced by food quality, temperature and rainfall. The availability of the caterpillars as a freely accessible source of protein can therefore be compromised by predicted changes in climate. Artificial rearing of the

caterpillar is possible but complicated by the necessity of obtaining very young fresh leaves for the first instar larvae. Investigations into developing a rearing medium to replace fresh *Canthium armatum* leaves would be valuable.

The caterpillar inhabits the canopy of open woodland areas in the northern parts of South Africa, feeding mainly on *C. armatum,* a small tree armed with large decussate thorns (Palgrave 2005). It also feeds, to a much lesser extent, on the thornless shrub, *Pyrostria hystrix* (personal communication, Waleng, F. 2009 and personal observation, 2009). *C. armatum* is known as *mophetha* in seHananwa and has a number of other uses, such as providing fuel-wood and edible fruit. The tribal authority of the area has decreed that the tree be protected from fuel-wood harvesting due to its value as an edible insect host and bearer of fruit but this is largely ignored by residents (Chapter Five). Fortunately the tree does coppice and is therefore not completely destroyed but carrying capacity is reduced. It is valuable that the primary host plant is seen as a useful tree in the Blouberg community as this can assist in promoting the sustainable use of the tree and can help to prevent the destruction of stands of these trees during development projects. *P. hystrix* is known as *molebatja* and is much less common. *Bophetha* harvesters from Liepzig Village are familiar with this shrub and its role as a food plant of the caterpillar but this is not well known in other villages where the caterpillar is collected.

8.3 NUTRITIONAL VALUE

It is crucial to understand the health implications of any food that is promoted and particularly where this is a novel food. This study revealed that *H. variegata* is a foodstuff rich in protein, fat and carbohydrates and is free of harmful pathogens. As with edible insect-eating cultures world-wide (Ramos-Elorduy *et al.* 1997, Paoletti and Dreon 2005), in the Blouberg region this insect is not only eaten as an emergency or famine food; it is also consumed for custom’s sake and for its good taste. Now it can also be promoted as a healthy alternative to beef.

Any new food source, method of collection or food production process has potential risks and should be carefully monitored (Paoletti and Dreon 2005). Risks of pesticide contamination are not high in the Blouberg region but do exist and should be considered with respect to *H. variegata*. The rural and more traditional society of Blouberg is closely connected, both in terms of distance and communication, to the urban and more affluent society of Polokwane city. Linkages should be made with the Limpopo Agro-Food Technology Station (LATS) and the local University of Limpopo in Mankweng near Polokwane to facilitate the improvement of insect food processing techniques.

8.4 SUSTAINABLE HARVESTING

The harvesting of *bophetha* forms a livelihood strategy that is similar to the harvesting of most other NTFPs in that it occurs during a particular time of year after the dry season and before the summer is sufficiently advanced to provide fresh agricultural resources. Stacks *et al.* (2003) note that the value of such resources lies more in their timing than in their size. Thus by overcoming seasonal cash or food shortages *bophetha* perform an important stop gap function.

The *bophetha* harvests of the Blouberg are in no way comparable in terms of yield and trade, to the harvests of mopane worms from South Africa, Zimbabwe and Botswana. They do however make an important contribution both to protein consumption and cash income in an area where even small additions to the household economy are valued. A study by Nonaka (1996) on the importance of insects in the diet of the San in Botswana confirms this by noting that insects as food are limited by their seasonal appearance, annual fluctuations and the high energetic cost required for their collection. These drawbacks are however offset by their calorific value, fat content and delicious taste. He reasons that certain insects are an essential contributor to the quality of the San diet, despite their low availability. They are valuable as spices, luxury foods and snacks. These arguments also apply with regard to *bophetha* in the diet of the Bahananwa of Blouberg.

A long term monitoring project which investigates the *bophetha* yield each season coupled with a more intensive survey of *bophetha* harvest areas in Blouberg would give a better indication of the resilience of the population to harvesting impact and climatic conditions. This would inform management decisions both for the Blouberg Traditional Authority in terms of communal land and for the Blouberg Nature Reserve with reference to protected areas. As with other edible insects, it is not clear how harvesting affects edible insect numbers when isolated from the effects of grazing or habitat destruction for infrastructure development (Yen 2009).

Management options should not only ensure that the resource is protected but should also enhance the long term well-being of the community involved in harvesting. Blouberg collectors should be consulted for their input into any management options discussed. Promoting the use of *bophetha* by foreign markets is tempting in the face of increasing global interest in edible insects. However, creating a market without due thought to checks and balances would negatively impact this resource in an area of high unemployment where people often grasp any means to improve their economic circumstances.

8.5 TEACHING AND LEARNING

It is clear that knowledge about edible insects, although valued by the Blouberg community, is not being passed on to the youth as efficiently as in the past. This will ultimately result in the erosion of that knowledge and it is important that other means of supporting the practise of entomophagy are found. Including indigenous knowledge around local edible insects in the Blouberg school curricula may be one way of achieving this.

The inclusion of indigenous knowledge in formal school learning will never be a substitute for learning within a vibrant society where traditional ways of life are valued while at the same time modern influences are felt but not followed blindly. McCarter and Gavin (2011) emphasise the differences between the two modes of learning:

> "In western models of schooling, all students have the right to know everything. Knowledge is transmitted using paper, computers, theory and theoretical testing methods, often relying only on memory. In traditional knowledge learning, one person earns the right, or the knowledge gets passed to him or her from the previous knowledge holder via apprenticeships. Traditional ecological knowledge (or indigenous knowledge) is embedded in everyday life and is transmitted through many different methods including observation, practise and hands-on activity over years. Knowledge is passed

> on through the teaching of skills. Traditional knowledge as a whole with all the nuances of value and ethics is taught by way of life. The school system can thus only ever include the "outside" aspects of it."

If, as espoused by Battiste (2002), McCarter and Gavin (2011) and Reyes-Garcia *et al.* (2010), the formal education system can be implicated in the erosion of indigenous knowledge, then, despite the above shortcomings, this should be mitigated from within by including aspects of indigenous knowledge in the local curriculum. Kaschula and Twine (2005) record that there is a widespread perception amongst rural people in the Bushbuckridge area of Limpopo that government education is superior to the knowledge possessed by older generations. Schooling is emphasised at the expense of learning from elders. Thus including indigenous knowledge into schools will elevate its status. Edible insects, as a fairly discrete "package" of information, form a manageable portion of indigenous knowledge to pilot within schools in Blouberg.

The proceedings from the 2012 Food and Agricultural Organisation's (FAO) working group on edible insects, in Rome, emphasised the role of indigenous knowledge and the importance of maintaining this knowledge by recognising indigenous names, the strategies used to collect and prepare insects as well as indigenous methods to conserve and manage such species. These are all aspects that can be included in the existing school curriculum if there is sufficient support from provincial education officials. Unfortunately it is difficult and time consuming to change policies and modify curricula and the erosion of edible insect knowledge will be ongoing while such policies are developed. It is thus advocated that in the interim, information about edible insects be incorporated into school's activities as part of each school's enrichment programme in the same way that sport and cultural activities are included. This will require enthusiastic insect 'mentors' from the area and there would not initially be much support from the government education department. It is advised therefore that existing NGO's such as Eco-schools in Blouberg be approached to assist with such action.

The findings from Chapter Six support the South African government's policy on including indigenous knowledge in local schools with respect to the Blouberg area.

Evidence gathered confirms that teaching indigenous knowledge about insects in schools can increase the participation of community members in the school lives of their children. Sharing knowledge about these insects raised questions about the decline of insects and possible reasons for this, thus raising environmental awareness amongst the learners. It was shown that edible insects can be used in a variety of learning areas to contextualise lessons and help to make unfamiliar topics less intimidating.

8.6. CONCLUSIONS

The edible insect resource of the Blouberg area is currently important to the majority of the residents and has the potential to contribute to food security on a larger scale. The value of this resource is however dependent on maintaining the resource itself as well as on retaining and expanding the body of knowledge that exists around the insects and their collection, preparation and management. This knowledge should inform:

1. Actions taken to utilise the resource within Blouberg,
2. Programmes to prevent overharvesting and habitat destruction, and
3. Campaigns to promote such a resource amongst local people and further afield.

The continued harvesting of Blouberg's edible insects and the possibility of increasing such harvests in the event that an export market is established is completely reliant on the preservation of the habitat and food plants of the insects. Artificial rearing of insects is expensive and time consuming as was confirmed when maintaining certain Blouberg edible insects for identification purposes. At the present moment it would be more worthwhile to promote the protection of Blouberg's insect habitats and the augmentation of wild populations through stocking food plants with eggs or larvae.

DeFoliart (1999) emphasises the importance of reducing the Western bias against eating insects in order that a nutritious, appetising and environmentally acceptable food source can contribute to attaining global food security. The finding that entomophagy is declining in Blouberg reveals the importance of promoting edible insects not only in the West, but also in areas where the influence of modern lifestyles has triggered a rejection of traditional foods. Bearing in mind our modern emphasis on the importance of education and knowledge acquisition, the use of local edible insects within the school curriculum in order to contextualise learning as well as to promote and validate indigenous knowledge is an important goal to strive for.

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APPENDICES

Questionnaires, competitions, species lists, songs and recipes

APPENDIX 1: GENERAL HOUSEHOLD QUESTIONNAIRE

Motšiši (*Interviewer*): ______________________	Nomoro ya diputšišo *(Questionnaire number)*: _____
Naga magae *(Village)*: _______________________	Letšatši *(Date)*: Mmotwana *(Block):*

1. E ka ba go na le batho ka mo gae bao ba kilego ba ja dikhunkhwane tša go jewa? *(Have people in your household ever eaten insects in the past? E.g. worms, caterpillars, grasshoppers etc)* ________________

2. Ge e ka ba go na le ba go ja dikhunkhwane tša go jewa ka mo gae bontsha gore ke ba ba kae? *(If people in your household still eat insects, please complete the table to show how many of each group of people in your household still eat them.)*

a. Bana ba basimane goba basetsana go thoma ka ngwaga o tee go fihla go ye lesome tshela. *(No of children boys and girls age 1-16yrs).* ___
b. Basetsana ba mengwaga e lesome šupa ba ka fase ga mengwaga e masome nne. *(No. of younger women age 17-40 yrs):*___
c. Basadi ba bagolo ba go thoma ka mengwaga e masome nne le go feta. *(No. of older women age 40 yrs and older):*___
d. Basimane ba mengwaga e lesome šupa ba ka fase ga mengwaga e masome nne. *(No. of younger men age 17-40 yrs*):___
e. Banna ba bagolo ba go thoma ka mengwaga e masome nne le go feta *(No. of older men age 40 yrs and older):* ___

3. Ge e ka ba ka mo gae ba tlogetše go ja dikhunkhwane tša go jewa lebaka ke eng? *(If people in your household used to eat insects but don't anymore, why did they stop?*

4. E Fa maina a dikhunkhwane tša go jewa tšeo ka gae ba di jago goba ba kilego ba dija tšeo di humanegago ga Malebogo. *(Please list the insects that your household eats or did eat, that are found in the Blouberg area.)*

5. Kgetha lebaka goba babaka a gore le jeleng dikhunkhwane tša go jewa a ka feta le tee. *(Circle the reason/s why your* ***household*** *eats insects. You may circle more than one answer).*

Di monate *(They are tasty)*	Ke setšo *(It is a tradition)*
Ke dijo tša mahala *(They are free)*	A mangwe mabaka *(Other, explain)*

6. Kgetha lebaka goba mabaka a gore ka mo gae le ja dikhunkhwane tša go jewa ga kae. *(Circle how often your household eats insects.)*

a. Ga se nke ke dija *(Never)*
b. Feela ge go sena seo nkago seja *(Only when there is nothing else to eat).*
c. Ka kgwedi yeo di tla bago di le gona. *(A few times a month when they are in season)*

d. Ka beke yeo di tla bago di le gona *(A few times a week when they are in season)*
e. Ge di ka ba di le gona *(As often as you can find them in season)*

7. Ka mengwaga ya komelelo ke dife dikhunkwane tša go jewa tšeo di go lwago? *(Which insects can you still harvest in drought years?)*

____

____

____

8. Dira nkgokolo gore ke komiki tše kae tše le dijago ka gae ge e le nako ya dikhunkwane tša go jewa. *(Circle how many cupfuls of insects your household eats **when they are in season**.)*

Le feela *(None)*	Ka fase ga komiki ka beke *(Less than one cup per week)*
Komiki e tee ka beke *(one cup per week)*	Komiki tše tharo ka beke *(About three cups per week)*
Komiki tše lesome ka beke *(10 cups per week)*	Go feta komiki tše lesome ka beke *(More than 10 cups per week)*

9. Go na le diphe to go mo bathong mabapile go jewa ga dikhunkwane tša go jewa go bapiswa le mengwaga ya go feta, dira nkgokolo go dikarabo tše. *(How has the number of people eating insects changed over the years? Circle the answer.)*

Go ga swana *(Stayed the same)*	Go foko tšegile *(Decreased)*	Go oke tšegile *(Increased)*

10. O nagana gore mabaka e ka ba afe. *(What do you think could be some reasons for this?)*

____

____

____

____

11. Dira nkgokolo mo mebolelwaneng ye ge o kwana le yona. *(Circle the statement which you agree with.)*

Di na le phepo dikhunkwane tša go jewa. *(It is healthy to eat insects)*	Ga di na phepo dikhunwane tša go jewa. *(It is unhealthy to eat insects)*

12. Go na le o mongwe ka mo gae wo a **rekago** dikhunkwane tša go jewa (e se bego Mašotša)? *(Does anyone in your household buy insects to eat?* _______________

13. Ge go le bjale, ke bokae komiki. *(If so, how much do they cost per cupful? (Not Mašotša).* _____________

14. Go na le woo a **rekišago** dikhunkwane tša go jewa?*(Does anyone in your household **sell** insects? (Not Mašotša)* ______

15. Ge go le bjale, o dira komiki bokae? *(If so, how much do they sell them for per cupful? (Not Mašotša)* __________

16. Ke batho ba baka e ka mo gae bao ba golago dikhunkhwane tša go jewa tlatša mebolelwana ye? (*How many of each group of people in your household collect the insects? Please complete the table).*

a. Bana ba basimane goba basetsana go thoma ka ngwaga o tee go fihla go ye lesome tshela. *(No of children boys and girls age 1-16yrs).* ___

b. Basetsana ba mengwaga e lesome šupa ba ka fase ga mengwaga e masome nne. *(No. of younger women age 17-40 yrs):*___

c. Basadi ba bagolo ba go thoma ka mengwaga e masome nne le go feta. *(No. of older women age 40 yrs and older):*___
d. Basimane ba mengwaga e lesome šupa ba ka fase ga mengwaga e masome nne. *(No. of younger men age 17-40 yrs)*:___
e. Banna ba bagolo ba go thoma ka mengwaga e masome nne le go feta *(No. of older men age 40 yrs and older):* ___

17. Dikhunkwane tša go jewa di monate go feta nama naa? *(Are insects as tasty as meat?)* ______________

18. Ekaba o bone diphetogo go dikhunkhwane tša go jewa mo mengwageng? *(Have you noticed a change in edible insect numbers over the years? Explain.)*

19. Naa maikutlo a gago ke go reng ge go ka se sa ba le dikhunkhwane tša go jewa tšeo di rekišiwago goba go rekwa? *(How would you feel if there were no more edible insects left to collect, buy or sell?)*

20. Se sebotše goba se sempe sa setšo mabapi le go ja dikhunkhwane tša go jewa . *(What is good and what is bad about having a culture of eating insects?)*

Tše dibotše *(Good points)*:

Tše dimpe *(Bad points)*:

21. Ke dikhunkhwane tša go jewa dife tšeo o ratago go tseba ka tsona? *(Which edible insects would you like to know more about?)*

22. O tla ke kwa bjang ge mongwe a ka go botšiša gore ba ka reka dikhunkhwane tša go jewa go nena (e ge bego mašotša)? *(How would you feel if someone asked if they could buy insects from you (not Mašotša)?*

23. Ke lefelo lefe le lebotše la go gola dikhunkhwane tša go jewa? *(Which areas are good places to harvest insects?)*

- Ka gae *(Around the house)*
- Mo nageng *(In the communal pasture lands)*
- Mašemong *(In planted crops)*
- Lesoka la diphoofolo *(In the nature reserve or natural veld)*

24. Ke batho ba ba kae ka mo gae bao ba welago ka fase ga mebolelwana ye. *(How many of each of the following groups of people are there in your household?)*

- Bana ba basimane goba basetsana go thoma ka ngwaga o tee go fihla go ye lesome tshela. *(No of children boys and girls age 1-16yrs).* ___
- Basetsana ba mengwaga e lesome šupa ba ka fase ga mengwaga e masome nne. *(No. of younger women age 17-40 yrs):*___
- Basadi ba bagolo ba go thoma ka mengwaga e masome nne le go feta. *(No. of older women age 40 yrs and older):*___
- Basimane ba mengwaga e lesome šupa ba ka fase ga mengwaga e masome nne. *(No. of younger men age 17-40 yrs*):___
- Banna ba bagolo ba go thoma ka mengwaga e masome nne le go feta *(No. of older men age 40 yrs and older):* ___

Ge o rata go ngwadi di lo tšeo di latelang o ka dira bjale! ***(If you wish to, please leave your contact details if you would like to know more about the project, or you would like to get more involved.)***
Leina (Name):________________
***Mo o humanegago gona* (Contact details):**

Diputšišo tše di bohlokwa go tseba gore mai ba dikhunkhwane tša go jewa ba ja tše dintši bokakang go fapana ga setshaba (mohlala). Bao ba lebelelago telebišeni ga ba ma nako ya gola dikhunkhwane tša go jewa ba ka ja tše dinnyane. *(The following information is very important to determine how insect use differs among different members of the community. Eg. those that watch television might not have time to harvest insects and might eat less of them.)*

25.Ngwagwa ovo obelegilwego ka ona
(Date of birth): ______________________

27.Le tsene sekolo go fihla kae ka mo gae?
(What is the highest qualification in your household?)

1 : Ga re a tsena sekolo *(No schooling)*
2 : Mphato wa fase *(primary school)*
3 : Mphato wa godimo *(high school)*
4 : Marematlou *(further certificates)*
5 : diploma or degree

29.Ke dife tša dilo tše tšeo di bego gona ka gae?
(Which of the following does your household possess?)

pokolo (donkey)___ karikana (*donkey cart)*___ koloi *(car)* ____ kgogo *(chickens)*____
pudi *(goat)*___ kgomo *(cow)*___ pere *(horse)* ___ telebišene *(television)*___ mohlagase *(electricity)*___

26.Monna go ba mosadi (*Gender***):** _______________

28.Dira nkgokolo mo mebolelwaneng ye gore ka gae le humana ditšeno go tšwa kae?
(Circle the areas where your household obtains most of its income from?)

1 : Go kgwebo ya ka gae *(Own business)*
2 : Mogolong go tšwa mošomong *(Professional salary) (educator, engineer, municipal official, etc)*
3 : Mošomi goba mohlwekiši *(Labourer or cleaner)*
4 : Go ke tšhoma ka go ba molemi *(Owner farmer)*
5 : Go ke thekišetša ditamati go ba go otlela taxi. (*Informal eg taxi, street hawker)*
6: Mphuafeela go tšwa monšong *(Grants, child, pension, disability)*
7: Ga gona ditseho le ga tee *(No income at all)*

30.Ke batho ba ba kae ka mo gae ke a leboga? (*How many people are there in your household*) _______

Ke a lebogo

APPENDIX 2: QUESTIONNAIRE FOR *BOPHETHA* HARVESTING

1. Questionnaire number: ____________________________

2. Village name: _______________________________

3. Participant's age (estimate): _____________________________

4. Date: _____________________________________

5. Did you collect *bophetha* this season? _______________________

6. If you did not, why?

   a. Did not feel like it (feeling sick or tired)
   b. Not enough caterpillars / season too short
   c. Do not like the taste
   d. Too many other tasks that were more important to do (eg not enough time)
   e. Was away
   f. Other. Explain _____________________________________

7. How many buckets of fresh worms did you collect this season?__________________

8. What size were the buckets (e.g. 5 litres etc.) ________________

9. How many bags or buckets of dried worms did this make?____________

10. How many litres were the buckets or bags you used? ________

11. How long did it take you to collect this amount (eg 2 hrs per day for 3 days)? __________________

12. What date did the *bophetha* first appear this year? ________________________

13. What date did they stop? ___________________________

14. Was the season better, worse or the same as last year's season?___________________________

15. Why was it better or worse? ____

16. Did you sell *bophetha* this year?_______________________

17. Did you buy *bophetha* this year?_______________________

18. If so how much does one cup of *bophetha* cost this year?___________________________

19. Why did you stop collecting *bophetha*?
    a. There were no more caterpillars left to collect
    b. I had enough and did not need anymore
    c. I was tired of collecting

20. How many km are you prepared to travel to a harvesting site of *bophetha?* ____

21. Would you be prepared to pay a landowner to collect *bophetha* on his farm?

22. If so how much would you be prepared to pay per day?

APPENDIX 3: COMPETITION QUESTIONNAIRE

PHADIŠANO YA DIKHUNKWANE TŠA GO JEWA / INSECT COMPETITION

Ga re direng dinyakišišo tša dikhunkwane tša go jewa go tšwa go la Ga Blouberg Municipality / Let us research our edible insects from Blouberg!

Leina *(Name)*:	Sekolo *(School)*:	Motse *(Village)*:

Diphadišana di mabapi le eng? *(What is this competition about)*?

Setšhaba sa ga Blouberg Municipality sena le tsebo ya bohlokwa mabapi le dikhunkwane tša go jewa. *(Communities in Blouberg have important knowledge about edible insects)*.

Tsebo ye e bohlokwa ka lebaka la gore e akaretša dijo, efee la boramahlale ba na le letšhago la gore tsebo ye e ka hwelela. *(This knowledge is important because it involves food, but scientists are concerned that this knowledge is being lost).*

Boramahlale gape ba tšoga gore dikhunkwane tša go jewa ka bo tšona di a lebalwa. *(Scientists are also concerned that the insects themselves are declining).*

Boramahlale ba leka go nyakišiša ma babi le dikhunkwane tša go jewale go dira dingwala tša tšeba ka tšona. *(Researchers are trying to find out more about these insects and document the knowledge around them).*

Diphadišano tše ke tše di nngwe tša dingwalwa tša tsebo. *(This competition forms one way of recording this knowledge).*

Ka morago ga boramahlale ba fedi tše ka dinyakišišo tša bona ba tlile go botša setšhaba kudu kudu sekolo se se bego se thuša. *(After the research is completed all findings will be presented to the communities and especially schools who were involved).*

Melao ya diphadišano *(Rules of the competition)*:

E buletšwe go barutwana ba grata ya bo šupa le ya lesome tee go tšwa go dikolo tšeo di tla bago di kgethilwe go tšwa masepaleng wa ga Blouberg Municipality. *(Open to learners from Grade 7 and Grade 11 from selected schools in Blouberg Municipality).*

Ba grata ya bošupa ba ka tsenela phadišano ka sepedi ya fetolelwa go sejahlapi ka dithuto tša sejahlepi mo sekolong. Bag rata ya lesome tee ba swanetše go tsenela phadišano ka sejahlapi. *(Grade 7 learners can enter in Se pedi. Grade 11 learners must enter in English).*

Morutwana o mongwe le o mongwe o swanetše go ya go botšiša bokoko wa gagwe goba o mogolo ka mo gae goba wa le lapa mabapi le dikhunkwane tša go jewa. *(Each learner is to go home and interview his or her grandparents or older members of his or her family about edible insects).*

Potšišo ya pele go fihla go ya bone ke tša barutwana go araba, tše dingwe ke tša batho ba bagolo go araba. *(Questions 1 to 4 are for the learner to answer, the rest are for the elders to answer).*

Re kgopela gore e se kaba go araba diputšišo feela ngwaleng le tsebo ye nngwe go tšwa go ba bagolo mabapi le dikhunkwane tša go jewa. *(Please don't just answer the questions but also record any other information your elders have on edible insects).*

Go tla ba le meputso go ditsenelo tše kaone le dihlokolo tša meputso go sekolo se sengwe le se sengwe. *(There will be prizes for the best entries and also lucky draw prizes for each school).*

Tšatši le go tswalela diphadišano *(Closing date):*

Diputšišo go barutwana. ***(Questions for Learners)*:**

1. O ja dikhunkwane tša go jewa naa? *(Do you eat insects)*?
2. Ge e kaba go bjalo, ke ka baka la eng o di ja dikhunkwane tša go jewa? *(If you do, why do you eat insects)?*
3. Ge o dija dikhunkwane tša go jewa ke dife dikhunkwane tša go jewa tšeo o di ratago go dija? *If you eat insects, what are your favourite insects to eat?*
4. Ge o sa je dikhunkwane tša go jewa ke ka baka la eng o sa dije dikhunkwane tša go jewa? *(If you don't eat insects, why don't you eat insects)?*

Diputšišo go bokoko goba go babangwe ba bagolo. ***(Questions for grandparents or other elders).***

5. O ja dikhunkwane tša go jewa naa? *(Do you eat insects)*?
6. Ge e kaba go bjalo, ke ka baka la eng o di ja dikhunkwane tša go jewa? *(If you do, why do you eat insects)?*
7. Ge o dija dikhunkwane tša go jewa ke dife dikhunkwane tša go jewa tšeo o di ratago go dija? *If you eat insects, what are your favourite insects to eat?*
8. Ge o sa je dikhunkwane tša go jewa ke ka baka la eng o sa dije dikhunkwane tša go jewa? *(If you don't eat insects, why don't you eat insects)?*

9. Ke dife dikhunkwane tša go jewa tšeo di golwago ka boutši tukulogong ya ga Blouberg Municipality? *(Which insects are collected in the* ***most*** *numbers in Blouberg area)?*
10. Go diragalang ka dikhunkwane tša go jewa? Mengwageng ya go feta ge e bapišwa le gona bjale, e ka ba ke tše ntši, di a fokotšega goba kgale le gona bjale go a swana? *(What is happening to insect numbers? Getting more, getting less or staying the same)?*
11. Ke ka baka la eng ore yalo? *(Why do you think this is happening)?*
12. Go direga eng go palo ya batho bao ba jago dikhunkwane tša go jewa? Ba o ke tšega, ba a fokotšega goba ba swana? *(What is happening to the numbers of people eating insects? Getting more, getting less or staying the same)?*
13. Ke ka baka la eng ore yalo? *(Why do you think this is happening)?*
14. O ka hlalosa ka bophelo bja tše dingwe tša dikhunkwane tša go jewa? *(Can you explain the life cycle of some of the insects)?*
15. Ke dife dikhunkwane tša go jewa tše di bože tšeo O di ratang? *(Which edible insect is the most important to you)?*
16. O di apea bjang tšeo dingwe tša dikhunkwane tša go jewa le gona o di bea nako e kaakang. *(How do you prepare some of the insects and how long can they keep for)?*
17. O tseba koša, sereto sa setso goba diila ka ga dikhunkwane tša go jewa? O ka di ngwala fase? *(Do you know any songs about insects or rituals or traditions? Perhaps you could write these down)?*
18. E ka ba tše dingwe tša dikhunkwane tša go jewa di šomišiwa go alafa goba dihlareng? *(Are any insects used in medicine)?*

Re kgopela gore o re fe tsebo ye nngwe mabapi le dikhunkwane tša go jewa tšeo o naganang gore di bohlokwa le gona ki a kgahlisa. *(Please give any other information about insects that you think is interesting or important).*

APPENDIX 4: EDIBLE INSECTS IN THE CLASSROOM

1. Do you think knowing about edible insects is:

   a) Useful b) not useful c) don't know

2. How would you feel if knowledge about Blouberg's edible insects was taught in Blouberg schools?

   a) happy b) don't care c) unhappy

   Explain if you want to:

   ____

   ____

3. What would be the best way of getting this knowledge into Blouberg schools?

   a) Posters
   b) Text books
   c) A local person talking to the children
   d) A local person taking the children out to collect the insects
   e) A person from a tertiary institution talking to the children
   f) All five of the above

Other ideas:

____

____

4. Would you be interested in telling Blouberg school children about edible insects in school?

a) Yes b) no

Explain if you want to:

____

5. Are you a teacher? ______________

APPENDIX 5: INSECT PRESERVATION AND PREPARATION RECIPES

Insects eaten raw:
Very few edible Blouberg insects are consumed without some prior preparation. The exception is *dinhlamakura* (*Carebara vidua*), a large ant which appears only sporadically after the first spring rains. They are collected in numbers during their nuptial flights and as they dig into the ground to start new colonies immediately after the rain. Both males and females are harvested and their swollen abdomens, stored with fat, are much sought after. The females are entirely black with larger abdomens than the males who possess a vivid yellow abdomen. The live insects are collected, the abdomens bitten off as a delicacy and the thorax, legs and head discarded.

The eggs of *lebitsi* (*Stenocera orissa*) are also eaten raw. They are harvested by collecting gravid adults and maintaining them overnight in a dark box or bag whereupon the eggs are laid and collected the following morning.

Boiling and drying:
Most caterpillars are first prepared by removing the gut contents. With *mašotša* (mopane worms, *Imbrasia belina*) and *makotopodi* (*Agrius convolvuli)* these are squeezed out by hand and can result in painful lacerations in the case of *mašotša,* which is covered in urticating bristles. Other caterpillars, such as *bophetha* (*Hemijana variegata*) are rinsed a number of times to purge them and also to remove the hairs if necessary.

It is then customary to boil them for roughly an hour in a cast iron pot over an open fire. A handful of coarse salt is added to the water both for flavouring and as a preservative. They are then removed from the water and laid on zinc sheets or large flat rocks in the sunlight to dry. This may take anything from a day to a week depending on the weather. Although rain is infrequent in Blouberg, the harvest time of most caterpillars coincides with the rainy season and therefore insects may also be dried on sheets inside the harvester's houses if there is a long period of overcast weather. Caterpillars are considered dry when they break with a sharp snap. Once dry, those caterpillars possessing hairs (eg. *Hemijana variegata*) are 'winnowed' in a grass basket in order to remove the remaining hairs. Caterpillars can be reconstituted with water and eaten as a main meal or eaten dry as a snack. Most caterpillars can be kept for up to a year if they are stored in clean paper or linen sacks in a dry, cool, clean and dark place.

Frying:
Some caterpillars (*Agrius convolvuli*) are not boiled once they have been degutted but are placed directly into a shallow pan over an open fire and fried for about 10 minutes in fish oil and salt. They can then be stored for a week or two and eaten as a snack or re-heated for the protein component of a main meal.

Sternocera orissa is also fried after the wing covers of this well armoured beetle are removed.

Dintlhlaamakhura (*Carebara vidua* alates), *nemeneme* (*Macrotermes* sp. alates) and *makeke* (*Macrotermes* sp. soldiers) as well as all orthoptera harvested (see table

5.1) are fried. *C. vidua* and *Macrotermes* sp. are placed directly into a dry pan after collection, removing only the wings of each. The fat content is high enough that oil is not necessary and usually only coarse salt is added. In some instances a little water is added to the pan for *C. vidua* and frying continues until the water has evaporated. For *macrotermes*, particularly the soldiers, a little fish oil might be used for flavour. For all orthoptera the wings and legs are removed before frying in fish oil and salt. None of the above insects are stored for longer than a week because the high fat content of these insects causes rapid spoilage. They are eaten as a snack or with stiff maize (*bogobe)* or sorghum porridge (*mabele*).

Reconstitution:
Many of the dried caterpillars are stored and then reconstituted at a later date for use as a relish with stiff maize or sorghum porridge in a main meal. A favourite recipe for dried *Imbrasia belina*, for instance, is to fry them in fish oil, tomatoes and onions or chillies. *I. belina* may be substituted by any of the other edible caterpillars. Once reconstituted the caterpillars must be eaten within a day before spoilage occurs.

As in the Gambia, insect species that last the longest are preserved by means of drying in the sun (Madge 1994). The addition of salt to the boiling water also contributes to the preservation process. There is a clear understanding that insects should never be stored in plastic bags or containers as this allows the formation of condensation and the rapid spoilage of the product. Dried or cooked insects are thus always stored in paper bags or boxes away from water. Ramos-Elorduy (1996) records a number of preparation methods, most of which bear many similarities to the way in which insects are prepared in the Blouberg

APPENDIX 6: EDIBLE INSECTS IN SONGS AND ASSOCIATED NOTES

1. *serurubele dumela, kgelekgatha o tswa kae, kgabile ka mebala, o jele koto, go motle ga kaang ngwana wa batho*
   Greetings Butterfly, where are you from?
   With colours, you look beautiful
   You are beautiful, child of people.

2. *tši e tši e tsoga a borokong (four times)*
   Grasshopper, grasshopper wake up from sleep (four times)

3. *Belebele tšieng, mabele a rena a fedile, e fela re na ipshina ka wena, Mohloro o betha katara, dikhunwhane di a bina*
   Grasshopper in the mielie meal field,
   Mielies of us is finished,
   Fortunately we enjoy you,
   Big Grasshopper is playing guitar,
   Beetles are dancing.

(The big grasshopper could refer to the pamphagidae which have a loud stridulant call).

4. *Ke košana ye hlanko hlanko tsoga borokeng.*
   Wake up from your sleeping, locust.

5. *Belebele tšie ga e kotame rebone*.
   Big locust land down so that we can see you.

6. *Mabitsana a etla maraga ka meletse*
   Locust locust
   Come down please we want to play with you please.
   (Sung when catching grasshoppers)

7. *Mmamati mpopulele ngwana yoo k a lema, ke a lema, Wa mpna, wa mpona, ke a lema, ke a lema.*
   A lady was busy in the field but a locust was disturbing the child who was sleeping.

8. Yellow wings yellow wings where are you I want to kill you and eat.
   (only the English version recorded)

9. *Mmamati tšea dikgomo*
   Lazy grasshopper,
   Take cow.

10. *Tšielala*
    Grasshopper sleep

11. *Tsie ke yela, tsie ke yela, Haeya lala erobetše, Phuthegang phuthegang, Ra phutha masaka, Ra thuba lebelo, Re lebile gana spempenyane, Hae tšhatšha hase Makhura, ke dinose* (x2) Grasshopper is there,
Grasshopper is there,
Is not asleep tonight,
Being together, being together,
We pack the bags, we destroy runs,
We go *to epempenyane*, it's not oil, but honey comb (twice)

12. *Thatlhalakgope alafa kgara*
Thatlhalakgope cure breast

(This is a kind of large grasshopper)

13. *Dikhunkwane di ila selemo, marega le seruthasane, dinyaka le hlabula ge pula e nele dinhlamakura*
Edible insects denied summer, winter and autumn,
Need spring when rain rains dinhlamakura.

(This shows an appreciation of the relationship between summer rains and edible insects).

14. *Dinhlamakhura di ila selemo marega seruthwana di nyaka lehlabula*
Dinhlamakura (*Carebara vidua*) denied summer, winter and autumn,
Need spring.

15. Insects you are my favourite relish,
You make our land to be beautiful,
You make us to be healthy, because you give us more vitamins and protein,
When rain falls on our land, you increase very easily, and give us relish,
We are all proud of you,
Insects

(Only the English version recorded but the song typifies the Blouberg community's affinity for edible insects and would be appropriate on a poster)

APPENDIX 7: EDIBLE INSECTS CONSUMED IN BLOUBERG

Vernacular names	Order	*Genus*	*Species*	Notes
kgakgaripane	Coleoptera	*Polyclaeis*	*equestris*	*Acacia*
lebitsi	Coleoptera	*Sternocera*	*orissa*	*Dichrostachys, Acacia*
podile / poponono /pokapokane	Hemiptera	*Encosternum*	*delegorguei**	
thongolifa (tsivenda)	Hemiptera	*Encosternum*	*delegorguei**	
dintlhlamakhura	Hymenoptera	*Carebara*	*vidua*	
mooka	Hymenoptera			Stingless bee. Nests underground. Honey
nose	Hymenoptera	*Apis*		General term for all honey bees
semane	Hymenoptera			Stingless bees nesting in rocks
makeke	Isoptera	*Macrotermes*	*species*	
nemeneme	Isoptera	*Macrotermes*	*species*	
dikokobele	Isoptera			Nests underground with no mounds.
bobilo	Lepidoptera	*Petovia*	*marginata*	*Vangueria infausta*
bokgapane	Lepidoptera			
bolalakwatleng	Lepidoptera			
bonato	Lepidoptera	*Sphingomorpha*	*chlorea*	*Burkea africana*
bophetha	Lepidoptera	*Hemijana*	*variegata*	*Canthium armatum, Pyrostria hystrix*
bokomo	Lepidoptera	*Hemijana*	*variegata*	Name for young instars of *bophetha*
borula	Lepidoptera			Possibly Saturnidae family
boešitšana	Lepidoptera			*Elephantorrhiza burkei*
botshutshu	Lepidoptera			A small caterpillar. Host plant has edible fruit.
makotopodi	Lepidoptera	*Agrius*	*convolvuli*	Sweet potatoe or *motantang*
legakgala	Lepidoptera	*Imbrasia*	*belina*	Found on marula trees in

				Blouberg
mašotša (tšiVenda) legakgala	Lepidoptera	*Imbrasia*	*belina*	Found on marula trees in Blouberg
pani				Possibly Lepidoptera
belebeletšie	Orthoptera			A swarming locust
bokokodiane	Orthoptera			
hlankgo	Orthoptera	*Phyxacra*	*species*	
hlankgo	Orthoptera	*Pycnodictya*	*flavipes*	
hlankgo	Orthoptera	*Oedaleus*	*species*	
hlankgo	Orthoptera	*Acanthacris*	*ruficornis*	
hlakwanapitsana	Orthoptera	*Acorypha*	*palidicornis*	
lempuru	Orthoptera	*Oedaleus / Gastrimargus*	*species*	
lempuru	Orthoptera	*Humbe*	*tenuicornis*	
lengetla / lenjetla	Orthoptera	*Gastrimargus*	*species*	
lentloro	Orthoptera			Heals the chest and is good to eat.
lesausau / seshego/lesogosogo	Orthoptera			large grasshopper
malebiwsana	Orthoptera			
malefiswane	Orthoptera	*Catantops*	*melanostictus*	
maletsoku	Orthoptera			similar to lempuru but maroon
mamoshu	Orthoptera	*Anacridium*	*moestum*	
mamphiswana	Orthoptera			
mampuru	Orthoptera			
mankoko	Orthoptera	*Karasicola / Rhodesiana*	*species*	
masebaraki	Orthoptera	*Oedaleus*	*species*	
mammati	Orthoptera	*Acrotylus*	*species*	
mammati	Orthoptera	*Oedaleus*	*species*	
mammati	Orthoptera	*Chrotogonus*	*hemipterus*	

mmokotsane	Orthoptera			
mohlalapudi	Orthoptera	*Acrida*	*species*	
monhloro	Orthoptera	*Truxalis*	*species*	
pitsi / thonthokge	Orthoptera			
sebatahole/ seshego	Orthoptera			
seonqwane/belebeletšie	Orthoptera			small grasshopper
sieborokwane	Orthoptera			Eating this wakes you up
tlatlawele	Orthoptera	*Zonocerus*	*elegans*	
tshelalegora (Shangaan)	Orthoptera			
tshilwanatsoku (Shangaan)	Orthoptera			
tšie / belebeletšie	Orthoptera			swarming grasshoppers
yellow wings	Orthoptera			
batatang				
bolalakwane				
bophane				
bothophe				
hungwahungwa				
lebetla				
lentsentla / lentsetla				
lentshomakaka				
maanoke				
mabitsana				
makolo				
makotsane				
mamobobola/e				
mamoletse				
mamotete				
mangetla				
manoni				

mantshele

maphata

mononi

montshele

motetete

motlatlakgope

ngetse

nkwadu

nwadi

pokwane

raisibe

ratsweetswege

sebotšabotšane

segonwane

sejewane

sekwetla

sepatagowa

sepharamohlaka

tlatlakgope

tshalebeke

tsiegolaka

tsokwane

*this species occurs only in small numbers in Blouberg and is not eaten there thus is not included in the analysis