CHAPTER 1

INTRODUCTION

1. The Insects

Insects are arthropods, i.e. a type of invertebrate animals that lack backbones. At present, the estimated figure for total living species on earth is 10 million, of which a mere 3% are vertebrates and over 60% are insects. Insects are by far the most diverse group of organisms on earth. They have existed for around 500 million years in comparison to mammals which appeared around 200 million years ago, with human ancestors *Homo sapiens sapiens* only arriving ~ 120.000 years ago. Insects have colonized most parts of the globe and as such, have confronted microorganisms and predators during their existence. To survive in this wide variety of environmental conditions and to combat enemies, insects have evolved powerful defense systems. These rely mainly on the synthesis of peptides and organic small molecules with predefined biological activities (Dimarcq and Hunneyball, 2003). The larva of the pine sawfly (*Neodiprion sp*., Hymenoptera), when attacked by a predator such as an ant, it raises its prolegs and emits from its mouth a viscous droplet composed of terpenes such as α- and β-pinene and resin acids (Edwards and Wratten, 1980).

1.1 Insects as human food

Insects have played an important role in the history of human nutrition, and it is probable that the first hominids in Africa were eating insects. They are good source of protein, with high fat content (and thus energy) and many important minerals and vitamins (DeFoliart, 1992). One major problem with consumption of insects in southern Africa is that many people are more into Western lifestyle and that makes them ashamed or ignorant of consuming insects. The more educated population, are more reluctant to admit that entomophagy still exists. This can affect populations that are economically marginal, as they cannot afford meat or fish in order to provide protein. It is well documented that iron deficiency is a major problem in women's diets in developing countries, especially in poorer continents such as Africa (Orr, 1986). Vegetarians also are at risk of zinc deficiency because zinc content in vegetables is very low; as such eating of insects should be promoted as insects also contain high levels of iron and zinc (DeFoliart, 1992).

Consumption of insects is widespread especially in Africa and Asia. In the Bikita district of Zimbabwe, *Encosternum delegorguei* which commonly known as "*harurwa*" is much sought after and can be bartered for grain (Wilson, 1990; O'Flaherty, 2003). Harurwa is such an important insect that it is also distributed as gifts to the local chiefs, district administrator and the local police. The management of the forest in which harurwa is found is regulated by a team made up of a representative of 24 villages in Bikita district, with members rotating every year. Harurwa is a highly priced insect and is therefore an important source of income in Bikita, Central Zimbabwe (O'Flaherty, 2003). Other species that are consumed in Zimbabwe includes the *Pentascelis remipes (local name "magodo"*) which feeds on *Combretum molle* and *C. imberbe as we as*. *P. wahlbergi (local name "nharara"*) that feeds on *Gardenia resiniflua (mutara*) and occur in clusters. The insects are a delicacy among the Manyika and Ndau tribes*. Gonimbrasia belina*, the"mopane-worm", is a particularly a major food item and is collected, transported and sold on an industrial basis at price of Z$0.60 per 100 g dry (during mid-1986), its price is similar to that of fresh beef (Wilson, 1990).

Caterpillars, termites, locusts, honeybees and ants are among the favorites and mostly consumed insects. Harvesting of insects is seasonal, but they can be collected, processes and stored for longer periods. In southern Africa, the most widely consumed insects are mopane worms, locusts, bugs, termites, honeybees and crickets. Chavunduka, (1975) has highlighted the significant role of insects in curing kwashiorkor. According to the above author, winged termites and giant crickets (*Brachytrupes membranaceus*) are frequently consumed in Zimbabwe. They are collected during rainy season. These insects are processed by grilling or frying without additional fat or they can be eaten raw. They are storable for later use. In South Africa, mopane worm (*Imbrasia belina*) is the most frequently consumed insect. Quin, (1959) reported that the Pedi tribe preferred mopane worm to beef and the availability of mopane worm could seriously affect the sale of beef. This worm is also widely consumed in other parts of southern Africa, such as Botswana, Zambia and Zimbabwe. Consumption of mopane worms can to a substantial degree supplement the predominantly cereal diet with many of the protective nutrients (Dreyer and Wehmeyer, 1982).

In Japan the most popular and widely eaten insect is the rice-field grasshoppers (mainly *Oxyya yezoensis* or *Oxyjaponica sp*.). They are fried and slightly seasoned with soy sauce to prepare a luxury dish called "inago", mostly sold as a luxury item in Japan (Mitsuhashi, 1997). Another widely consumed insect in Japan is "hachinoko", a bee or a wasp larva that is eaten raw, boiled down in soy sauce or served over boiled rice. Bee and wasp brood are canned and sold at a high price. The wasp-rice was reported to be the late Emperor Hirohito's favorite dish. Following surgery in 1987, the Emperor Hirohito "would finish the wasp-rice dish even when he had no appetite and left most of the other dishes" (Mitsuhashi, 1988).

1.2 Chemical composition of insects

A series of studies over the last 25 years have established the basic nutritional requirements of most major taxonomic groups of insects, the nutritional ecology of immature forms, and also the behavioral and physiological mechanisms by which individuals respond to variation in diet quality (Dadd, 1985; Simpson and Simpson, 1990, Slansky and Scriber, 1985). More recent work has focused on multidimensional aspects of insect nutrition. A fundamental problem faced by feeding insects is how to adjust physiology and behaviour to obtain simultaneously all necessary nutrients at reasonable rates (Raubenheimer, 1992; Raubenheimer and Simpson, 1993; Simpson and Raubenheimer, 1993).

It has been proven that insects can be an important source of protein (DeFoliart, 1975; Ramos-Elorduy, 1974, 1982a, 1982b), with caterpillars and termites being the most widely eaten and marketed insects in Africa. They have been shown to contain high concentrations of good quality proteins and high digestibility (Ramos-Elorduy *et al*., 1993a; Defoliart, 1989; Dreyer and Wehmeyer, 1982). According to Dreyer, (1968) the amino acids composition of dried mopane worms is relatively complete, with high proportions of lysine and tryptophan (which are limiting in maize protein) and of methionine (limiting in legume seed proteins). Dreyer and Wehmeyer, (1982), have concluded that the consumption of mopane worms can sustainably supplement the predominantly cereal diet with many of the required nutrients. The nutritional content of the mopane worm has been found to comprise of 60.7% crude protein, 16.7% crude fat and 10.72% minerals, on a dry matter basis and it is therefore a highly nutritious supplement to the diet of people consuming them (Dreyer and Wehmeyer, 1982).

Some caterpillars that are eaten in Africa Countries like Angola, Zaire and South Africa have higher protein content than those of America that have a deficiency in isoleucine (Kodonki *et al*., 1987), phenylalanine, and tyrosine and/or in tryptophan (Santos-Oliveira, 1976). The insects' species with the largest deficiency in essential amino acids were some members of the Family Saturnidae in America, reported by Landry (1986), with up to six species that do not reach the requirements of the WHO/FAO/UNU. The least deficient were the caterpillars of Zaire (Kodonki *et al*., 1987).

Ramos-Elorduy *et al*., (1997), analyzed nutrient composition of seventy-eight species of edible insects representing twenty-three families from the state of Oaxaca in Mexico. They include the orders of Anoplura, Diptera, Orthoptera, Hemiptera, Homoptera, Lepidoptera, Coleoptera and Hymeaoptera. The dry basis protein content ranged from 15-81%. The highest was found in a wasp of the genus *Ploybia*. Fat content ranged from 4.2% (several grasshopper species, *Boopedon flaviventris*; *Sphenarium* species, *Melanoplus mexicanus*) to 77.2% in the larvae of a butterfly *Phasus triangularis*. The insect richest in carbohydrates was found to be the ant *Myrmecosis tusmelliger* with 77.7%. Protein digestibility varied between 76% and 98%. The calorie contribution varied from 293-762 kcal/100 g, the highest value also being for the butterfly larvae of *Phasus triangularis* constituting a significant component of the diet of some rural communities in Oaxaca. Consumption parameters vary depending on the species, season, habitat, climate and biotope. The fact that seventy-eight species were registered and obtained for analysis in only a few places and over a short period indicates that, eating insects occurs generally as a habit both in the poor (Mixteca) as well as the more developed regions (La Costa).

Insects are not just emergency foods; they constitute an important product of the daily diet of a large proportion of some communities. In several cases, they are more of luxury product, and/or culturally important delicacy, a specialty eaten by custom due to their taste or special properties. It is also interesting that some families complement their income harvesting insects and selling them at the markets.

1.3 Why care for insects?

Mbata, (1995), has demonstrated the multiple importances of honeybees of the species *Apis mellifera adansoni* and *Apismellifera capensis* in Zambia. Honey if obtained from these species can be used as a source of sugar for rural people, and it is also used to brew local beer. The wax is used to make candles and to condition animal skins on the traditional drums. The brood (larvae and pupae) may be eaten with honey, or they may be extracted, fried and consumed as relish with the main meal. Silk from the cocoons of silkworm moths, *Bombyx mori* and related species has been used for fabric for centuries. Insects are essential in maintaining the ecosystem in aspects such as: plant propagation which includes seed dispersal and pollination, nutrient recycling via leaf-cutter and wood degradation, dispersal of fungi, disposal of carrion and dung and soil turnover (Gullan and Cranston, 1986).

1.4 Economical importance of insects

Insects are regarded as important food source and as such they contribute significantly to local economies. They are not only sold widely in the village markets but many of the favorites have made their way to urban markets and restaurants of the developing world. In Mexico white maguey worm (larva of the Hesperriid, *Aegiale hesperiaris*) as well as the "ahuahutle" (egg of several species of aquatic Hemiptera) are being exported to the United States and Europe. Thailand exports giant water bug (*Lethocerus indicus*) and canned silkworm pupae (*Bombyx mori*) to the Asian community shops in the United States (Ramos-Elorduy, 1997).

In sourthern Africa, mopane worm is widely sold and exported between African countries such as Botswana, Zimbabwe, Angola, Namibia and South Africa. Harvesters mainly sell mopane worm at roadsides vendors, open markets, tuck shops, supermarkets and bus termini and in some instances the marketing chain is quite long. Mopane worms are also being exchanged for goods and for gifts (Stack et *al*., 2003). In South African about 16 000 tonnes were traded during 1996 on the commercial market during the year 1982 (Dreyer and Wehmeyer, 1982). Styles, (1994) estimated that an annual population of 9,500 m mopane worms in South Africa's 20,000km^2 of mopane veld worth £57m, of which approximately 40% goes to producers who are primarily the poor rural women. There are industries in South Africa, Botswana and Zimbabwe that are involved in canning and processing of mopane worm. The sale price range from $2.50-$4.00 per kg (Marais, 1996) which compares favorably with that of beef retailing at approximately -$4.00 per kg. Mopane worm is therefore a cheaper source of protein for low-income earners.

1.5 Insects as animal feed

Insects have also been incorporated into animal feeds to enrich their nutritional contents. House cricket (*Acheta domesticas*) when fed to weaning rats, was found to be superior to soy protein as a source of amino acids at all levels of intake and mormon cricket, (*Anabrus simplex*) was found to be equivalent to soy protein (DeFoliart, 1999). In a similar study conducted with a variety of insects in feeding trials in poultry, (Phelp *et al*, 1975; Dreyer and

Wehmeyer, 1982) obtained the same convincing results. The concept of feeding insects to domesticated animals such as poultry, pigs and farm-grown mink is popular in China, whereby more feeding trials have shown that insects-derived diets can be cost-effective to more conventional fish meal diets. The insects that are utilized are primarily the pupae of silworms, *Bombyx mori*, the larvae and pupae of house flies, *Musca domestica*, and the larvae of mealworms, *Tenebrio molitor*. In India they feed chickens with the meal that remains after the oil has been extracted from the pupae (Gullan and Cranston, 1986).

1.6 Insects as source of drugs

Insects are also an important source of novel drugs. The first antibacterial peptide, cecropin was isolated from an insect (the pupae of the moth *Hyalophoria cecropia)*, (Steiner *et al*. 1981) and since then more than 170 antimicrobial peptides have been found in insects. Furthermore, a cysteine-rich peptide drosomycin was the first inducible antifungal peptide to be isolated from insects and to date, has only been reported in the fruit-fly *Drosophila melanogaster* (Fehlbaum *et al*., 1994). Drosomycin is active against both human and plant fungal pathogens at concentrations often below 5 µM, delaying fungal hyphae growth at low concentrations and inhibiting spore germination at high concentrations (Dimarcq *et al.*, 1988).

Insect defensins also have activity against a wide range of Gram-positive bacteria, exerting an almost immediate lytic effect (Dimarcq *et al*., 1988). Studies conducted on a recombinant version of *Phormia terranovae* defensin demonstrated that the peptide instantly disrupts the permeability of the bacterial cytoplasmic membrane in *Micrococcus luteus*, resulting in loss of cytoplasmic potassium and ultimately, inhibition of respiration (Cociancich *et al*., 1993). The first broad-spectrum insect peptide to be reported was thanatin with activity against both Gram-negative and Gram-positive bacteria as well as filamentous fungi. It exerts bactericidal and fungicidal effects at minimal concentrations, often below 2.5 µM and is highly specific (with no side effects on red blood cells for example). Although the mode of action for thanatin is not yet understood, data suggest that it differs depending on the microorganism being targeted (Fehlbaum *et al.,* 1996).

Current antibiotics act by inhibiting protein synthesis or nucleic acid synthesis or by disrupting the cell wall. To achieve this, they only target the specific receptors, enzymes or a protein which makes the antibiotics vulnerable to the development of resistant strains. Insect peptides are being explored because insect antimicrobial peptides exhibit a high level of structural diversity, which could prove to be the good candidates to resolve the increasing problem of microbial drug resistance This is because insect-derived peptides use modes of action that should restrict the development of resistant strain because they have much broader target i.e., the microbe cell membrane. One promising insect derived compound being taken for clinical development is the ETD151, an antifungal 44 amino acid peptide analogue based on naturally occurring peptide from the Lepidopteran *Heliothis virescens*. This compound has been optimized by genetic manipulation of the native peptide and it is now in advanced preclinical development for treatment of life threatening hospital acquired fungal infections in immunosuppressed patients. Insect derived molecules are not only sought solely as a source of antimicrobials, approximately 25% of the peptides involved in the immune response are antimicrobial, with the remaining 75% performing an array of different biological roles such as anti-inflammatory, anti-proliferative and anti-viral activities as well as ion channel modulators (Dimarcq and Hunneyball, 2003).

2. The plants

2.1 The use of plants extracts

Over three quarters of the world's population rely mainly on plants extract for healthcare. The study of plants that are used in traditional medicine in various cultures has yielded important drugs that are critical to modern medicine. The use of crude plant extracts poses some dangers. Many plants extract display variation of activity due to environmental conditions and time of collection. Due to these factors the amount of particular active constituents in plant extract may vary. This makes a difference when a particular dose of the extract is applied. If the amount is higher than normal, toxic effects may occur and if lower than normal the desired effect may not be achieved. For these reasons, it is necessary and desirable to identify the active constituents from plant extract to be able to have a reliable degree of efficacy and safety.

Since the development of organic chemistry at the beginning of this century, extraction and fractionation techniques have improved significantly. It is now possible to isolate and identify many of the active chemicals from plants (Srivastava *et al*., 2000). For example, quinine derived from the bark of the cinchona tree was used for treating fevers as early as the 17th century, although not until 1820 was the active ingredient of the bark isolated by French Scientists, Caventou and Pellentier and was used to treat malaria (Wright, 2005). Sertürner in 1806 identified morphine alkaloids from opium, which is the dried latex material that exudes from cut seed capsules of the opium poppy *Papaver somniferum*. Morphine is the major alkaloid component of opium, making up approximately 42% of total alkaloid content and is used mainly as analgesics (‘pain relief drugs’) (Huang and Kutchar, 2000).

2.2 The problem of drug resistance

Worldwide, a large burden of diseases is due to bacterial infections. Recently, treatment of bacterial infections in modern medicine has become a major problem due to emergence of bacterial strains, which are resistant to antibiotics (Rice, 2006; Tenover, 2006). The use of traditional herbs is more wide-spread than the use of modern medicine. This is one of the reasons why so many people especially in Africa and Asia are still relying on traditional herbs to treat diseases because of it costs less and easily accessible to the people in rural communities. Plants contain reservoirs of secondary metabolites that present potential for developing new drugs as they are now widely screened for medicinal purposes and their biological properties are determined. Thus far, ethnopharmacology of plants that are used in traditional medicine in various cultures has yielded important drugs that are critical to modern medicine (Farnsworth, 1984).

2.3 Importance of antioxidants

Antioxidants are natural compounds occurring widely in plants or synthetic compounds and are added to food in order to delay free radicals accumulation and hence strengthen its stability against oxidation and are thus very useful in human health (Halliwel and Gutteridge, 1995). Oxidative stress causes cell damage that later induces various kinds of diseases/disorders such as neurodegenerative disorders, inflammation, cancer and ulcers in humans. The balance between reduction and oxidation is believed to be a critical concept maintaining a healthy biological system (Aruoma, 2003).

Many medicinal plants have potential antioxidant components. Medicinal plants are recognized as sources of antioxidants components mainly because they contain flavonoids, phenolic acids, coumarins and antioxidant micronutrients. These antioxidants components contained in medicinal plants are of high interest because of their natural origin and the ability to act as efficient free radical scavengers (Langley-Evans, 2000). Potential sources of antioxidant compounds have been found in many types of plant materials such as fruits, leaves, seeds etc. Teas like mate, green and black tea, rooibos and honeybush are reported to have multiple biological effects, including antioxidant activity. Rooibos tea (*Aspalathus linearis*) and honeybush tea (*Cyclopia intermedia)* have been marketed for their high antioxidant potential largely due to their high polyphenol content. Green tea has been reported to have high antioxidant activity because it contains tannin with most of its antioxidant activity attributed to catechins (Nanjo *et al*., 1996).

2.3.1 Flavonoids

Flavonoids are important phytonutrient components that are present mainly in vegetables, fruits, nuts and beverages (Kim *et al*., 2006) and they are also formed in plants from the aromatic amino acids phenylalanine, tyrosine and malonate (Harbone, 1986). The basic structure of flavonoid is the flavan nucleus, which consists of 15 carbon atoms arranged in three rings (C_6-C_3-C_6) which are labeled A, B and C. Various classes of flavonoids have been identified and they include: flavones, flavonones, iosflavones, flavonols, flavononols, flavan-3-ols, coumarins and anthocyanidins (Pietta, 2000).

The flavonols such as myricetin, qurcetin, kaempferol and galangin are effective scavenger of free radicals generated by both enzymatic and nonenzymatic systems (Kim *et al*., 2006). The B-ring -OH moiety is the most significant determinant factor in the scavenging of reactive oxygen species (Sekher *et.al.*, 2001; Burda and Oleszek, 2001). The flavonols, myricetin, qurcetin, kaempferol and galangin contain three, two, one and none –OH moieties on the B-ring respectively. Myricetin has been reported to have antiviral activity by inhibiting the reverse transcriptase, antiaggregatory effects on blood platelets, and antiatherosclerotic effect via inhibition of oxidative modification of low density lipoprotein (de Whalley *et al*., 1990). Quercetin has been reported to prevent atherosclerosis chronic inflammation (Havsteen, 1983). Biological activities for kaempferol includes mainly the inhibitin of lipoxygenase and cyclooxygenase, it also posses antiaggregatory, antibacterial, and anticancer activities (Moriyama *et al*., 2003). Galangin is present in high concentrations in honey (propolis) and it is widely used in Asia countries for the treatment of respiratory infections, subcutanueo-mucosal and viral infections (Park *et al*., 1995). Galangin has antioxidative, radical scavenging, antimutagenic, anti-inflammatory activities as well as an inhibitory effect on cytochrome P450 hydroxylase in human liver microsomes (Cholbi *et al*., 1991; So *et al*., 1997; Kang *et al*., 2003; Buening *et al*., 1981; Ciolino and Yeh, 1999).

The presence of more –OH moieties on the B-ring plays a vital role in electron resonance and in the donation of electrons to the oxidizing agent. Oxidation pattern is however, affected by the number and pattern of –OH substitutions on the B-ring and by the presence of structural groups required for extended conjugated between the B- and C-rings. A study by Kim *et al.*, (2006) has demonstrated that among this group of flavonols, myricitin and quercetin which contains three and two-OH moieties on the B-ring, respectively, have the highest antioxidant capacity and intracellular antioxidant activity whereas, kaempferol and galangin with one and no-OH moiety on the B-ring respectively, have the lowest antioxidant capacity and intracellular antioxidant activity.

3. The host plants

Insects are known to sequester toxic materials from food plants. *Encosternum delegorguei*, local name (thongolifha); the edible stink bug that was investigated in this study was found mainly on *Dodonaea viscosa* although it was also found scarcely on other host plant such as *Diospyros mespiliformis.* Moreover, Getie *et al*., (2003) have reported that the two host plants posses medicinal properties and so far, *D. mespiliformis* is been widely studied. In this study we decided to focus on analyzing some of the medicinal properties of *D. viscosa* because the plant is widely spread at Modjadji, a village where thongolifha is harvested.

3.1 *D. viscosa*

3.1.1 Taxonomy and description of *D. viscosa*

In the latest taxonomic treatment of the plants of southern Africa (Germizhuisen and Meyer, 2003) two taxa are acknowledged.

Dodonaea viscosa var a*ngustifolia* (L.f.) Benth. includes *D. angustifolia* (L.f.) and *D. viscosa* Jacq. subsp. *angustifolia* (L.f.).

D. viscosa Jacq. var *viscosa* includes *D. viscosa* Jacq. subsp. v*iscosa. This species occurs mainly in KwaZulu-Natal.*

Dodonaea viscosa Jacq. var. *angustifolia* (L.f.) Benth. (Family Sapindaceae) is the species investigated in this study. For ease of reference it will be referred to as *D. viscosa* in this thesis. It is a shrub of 3-4.6 m tall and prefers full sun. The shrub has green leaves all year with yellow flowers and it prefers moist soil (Fig 1.1). The soil conditions can either be acidic, neutral or alkaline (Palgrave, 2002).

Figure 1.1: *D. viscosa* (Picture by: Cathy Dzerefos) and its distribution map (Palgrave, 2002).

3.1.2 Biological activity of *D. viscosa*

The leaves of *D. viscosa* have traditionally been applied internally to treat fevers, toothache and sore throat or externally to treat skin rashes, wounds and stings. The bark is employed in astringent baths and poultices (Bown, 1995). The plant can also be pruned to make a neat hedge that is popular in rural areas whereas the leafy branches are used to make brooms that are used to sweep around the yard. Getie *et al*., (2003) reported that methanol leaf extract from Ethiopia demonstrated antibacterial activity against *Staphylococcus aureus, Streptococcus pyogenes, Cornybacterium diphtheriae* and exhibited antiviral activity against Coxsackie virus B3 and Influenza A virus. However, their quantitative data was performed by using the agar diffusion technique which can only measure the width of a zone of growth inhibition to indicate the activity of the plant extract. This method is however not convincing enough to quantify activity of plant extract. It was therefore necessary in our study to quantify the activity of *D. viscosa* with solvents of various polarities by applying the microdilution assay as described by Eloff, (1998) and to further determine the total activity of the *D. viscosa* extracts.

Apart from these, the leaves of *D. viscosa* are reported to be toxic, as dairy cattle have died of poisoning after consuming the leaves; postmortem results have shown liver damage with massive hepatocellular necrosis (Colodel *et al.*, 2003). This has never been found in southern Africa based on the latest highly regarded publication in this field (Kellerman *et al*., 2005).

3.1.3 Major chemical constituents of *D. viscosa*

Chemical constituents previously isolated from *D. viscosa* include the following:

diterpernoid acids (hautriwaic acid, dodonic acid, oleic acid, linolenic acid);

flavonoids (5-hydroxy-3,6,7,4'-tetramethoxyflavone, santin, penduletin, quercetin, kaempferol, acacetin-7-methyl ether and aliarin and a new flavonoid with an isoprenoid side chain 5,7-dihydroxy-3'-(3-hydroxymethylbutyl)-3,6,4'-trimethoxyflavone; isorhamnetin; pinocembrin)

and quinones, tannins, saponins, triterpene steroids as well as a new clerodane diterpenoid identified as 15, 16-epoxy-5,9-diepicleroda-3,13(16),14-trien-20,19-olide (Dominguez, 1980; Ibid, 1983, Sachdev and Kulsreshtha, 1983, 1984; Rojas *et al*., 1992; Getie *et al*., 2000; Abdel-Mogib, 2001). The chemical composition is also discussed later in the thesis.

Problem statement

It is not widely appreciated in the western world that insects are a good and cheap source of protein. Although it is well evident that all societies have consumed insects during the past, including biblical times with reference to John the Baptist who reputedly depended almost entirely for his diet on locust and honey (New Testament, Mark 1:6). However, in Africa entomophagy, is widely appreciated, although it is more prevalent in rural than urbanized areas. More educated persons are sometimes reluctant to admit that indigenous customs, including eating of insects still exist. Some people secretly eat insects and are ashamed of their culture. However, eating insects can significantly reduce protein deficiency and this should be promoted through education especially in schools. Malnutrition remains a major problem, for which one reason is the lack of a mixed, balanced diet. Information on multi-use of insects' products should be known. Sustainable harvesting must be achieved in order to optimize the harvest and protect the environment and limit the loss of host plants. Sustainable harvesting of host plant is necessary because the insects can not survive without their host plants.

E. delegorguei feeds mainly on *D. viscosa*, a plant with known antibacterial and antiviral activities. It may be possible that some compounds that are present in *D.viscosa* are also present in *E. delegorguei* since insects are known to sequester compounds from host plants. The chemistry of *D. viscosa* has been investigated thoroughly and it is unlikely that any new compounds will be identified. Compounds with antibacterial activity extracted from *D. viscosa* will be isolated and characterized. The possibility that these compounds also occur within *E. delegorguei* will be investigated.

Aim of the Study

To investigate the nutritional value of the edible stink-bug *E. delegorguei* and the possible interaction between the insect and its host plant, *D. viscosa* (In this thesis *D. viscosa* is used as an abbreviation to indicate *Dodonaea viscosa* Jacq. var. *angustifolia*).

Objectives of the study

- ✓ To determine the nutritional components of thongolifha that will benefit the Venda community both economically and ecologically.
- ✓ To evaluate the antibacterial activity of insect extracts.
- ✓ To extract components from *D. viscosa* and determine its medicinal properties.
- ✓ To isolate antibacterial compounds from *D. viscosa* and elucidate their structures.
- ✓ To evaluate whether bioactive compounds present in *D. viscosa* possibly occur in *E. delegorguei.*