Tick control practices in communal Tsholotsho

By

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Submitted in accordance with the requirements
for the degree of

MASTER OF SCIENCE

in the subject

AGRICULTURE

at the

UNIVERSITY OF SOUTH AFRICA

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MARCH 2015

DECLARATION

I declare that *Tick control practices in communal Tsholotsho* is my own work, that has not been submitted before for any degree or examination in any other university and that all the authors I have quoted have been indicated and acknowledged as complete references

Christopher Jabulani Mkhize

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Date: _______________________________________

ACKNOWLEDGEMENTS

First of all I would like to thank the University of South Africa together with EduRite for sponsoring this study. Without the assistance of the two institutions, it would not have been possible to pursue this study.

I would like also to thank both my supervisor Dr James W. Oguttu and co-supervisor Dr Francis Babi for guiding me throughout my studies, and for the assistance with the logical presentation of ideas and statistical analysis in the study.

Lastly I have to thank my two families; the Orthodox Church and my biological family both immediate and distant for their love and care. Above all else, I am humbled by the communal livestock producers who allowed me into their homes, gave me access to their livestock and shared with me their knowledge.

DEDICATION

This work is dedicated to all my special colleagues who participated in data collection and my uncle Mr Aaron Mkhize who helped me to appreciate indigenous traditional knowledge more so ethnoveterinary medicine and its role in the treatment of animal diseases and parasites. The origin of this study is deeply rooted in the emotional attachment to livestock care that Themba my young brother and I share ever since childhood in communal lands. May all your efforts that are already tied up in this work live on to benefit future generations.

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ACRONYMS AND ABBREVIATIONS USED IN THE TEXT

ACIAR: Australian Centre for International Agricultural Research

AGRITEX: Agriculture Technical and Extension

AHMC: Animal Health Management Centres

BCAs: Biological Control Agents

GOZ: Government of Zimbabwe

EVA: Ethno veterinary acaricides

EVM: Ethno veterinary medicine

ILRAD: International Laboratory for Research on Animal Disease

KZN: KwaZulu Natal

NGO: Non-Governmental Organisation

ORAP: Organisation of Rural Associations for Progress

USDA: United States Department of Agriculture

SEPASAL: Science Education Partnership & Assessment Laboratory

ABSTRACT

Title: Tick control practices in communal Tsholotsho

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Degree: Master of Science in Agriculture Science

This study assessed the use of indigenous acaricides in Tsholotsho, Zimbabwe. An observational study design plus laboratory analysis were used in this study. Data on demographic profiles and tick control practices in 21 villages was collected using a questionnaire. Seven hundred and fifty nine (n=759) ticks were collected from cattle using systematic sampling at 15 dip tanks. Marula efficacy was assessed using pregnancy, repellence and mortality tests. Farmers used several tick control remedies (physical removal, chemicals, and plant and animal extracts), some of which have potential to harm the health of the public. Marula caused significant decrease in mass among pregnant ticks ($p<0.05$), had a significant kill percentage ($p< 0.05$), and also repelled, killed and hindered egg laying. The active ingredients in marula formulations should be investigated. The extra-label use of conventional acaricide, and the use of compounds with potential to harm the public health needs to be regulated.

Key terms

Tick control practices; indigenous acaricides; efficacy of marula formulations; marula as acaricides; resource poor cattle farmers; indigenous tick control remedies; ethnoveterinary acaricides; physical removal of ticks; engine oil as acaricide; cattle rearing in communal areas.

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Conventional tick control includes applying acaricides using various approaches outlined below (Jonsson, 2006; Lubulwa & Hargreaves, 1996; Nari, 1995; Madalena et al., 1985; Sutherst et al., 1983; Graham & Hourrigan, 1977):

- *Absolute tick control*: here zero tolerance approach to tick control is adopted.
- *Prophylactic treatment*: this aims at reducing tick numbers to acceptable levels thus reducing the mortalities due to infestation or tick-borne diseases and hence reduced losses in productivity.
- *Threshold treatment*: this is based on the determination of the maximum number of ticks, above which treatment is indicated
- *Opportunistic treatment*: this is an extremely common approach to tick control in extensive production systems where the costs of gathering the animals are high. In these circumstances, cattle are often treated alongside with acaricides when they are gathered together for another purpose, such as marking (castration, branding and tagging)
- *Integrated tick control*: is a combination of a series of complementary control measures to make the best use of each without placing too much reliance on any single component. The emphasis is on biological control, vaccination, host resistance or management to reduce tick populations.
- *Strategic tick control* often refers to the application of acaricides from a predetermined commencement date and at specified intervals, regardless of the number of ticks present at the time of dipping and
- *Selective acaricide application* involves the application of acaricide either to a percentage or proportion of all animals in a group.

However among resource poor farmers, there is a tendency for them to use none conventional methods to control ticks. According to McCorkle (1975), non-conventional tick control methods include the use of ethno veterinary' preparations.

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McCorkle (1975) is of the view that “ethno veterinary” is a holistic, interdisciplinary study of local knowledge and its associated skills, practices, beliefs, practitioners, and the social structures pertaining to the health care and healthful husbandry of food, work and other income-producing animals.

Ethnoveterinary practice is wide spread among resource poor farmers. For example, Masika et al.,(2009) found that 10.2% of farmers in Eastern Cape Province of South Africa used crude engine oil to control ticks, and 5.1% used drag and squashing of ticks. According to the same study, while the majority (84.7%) used conventional acaricides, some still improvised. Forse (2000) observed that farming communities in marginalized areas of Kenya mix 100 Ml of nicotine with 1 L of used engine oil to control ticks. Chamboko et al.,(1999) made similar observations among Zimbabwe resource-limited farmers.

According to some authors, adulterated petroleum products are effective in controlling cattle ticks (Mbati et al., 2002; Masika et al., 1997). This could explain why they are commonly used by resource poor farmers. However, this practice has major safety concerns for animals on one side and meat and milk consumers on the other side because of the potential to leave chemical residues in these products (Turkson et al., 2001).

The engine oil contains aliphatic, aromatic and polycyclic aromatic hydrocarbons (PAHs) as well as cadmium, chromium, aluminium, lead, manganese, copper and zinc (Delistraty & Stone, 2007). The heavy metals are toxic environmental contaminants which, according to many authors alter biochemistry and biomass, pH, oxygen, soil aeration and nutrient availability in the soil (Achuba & Peretiemo-Clarke, 2008; Dominguez-Rosado & Pichtel, 2004).

Motor oil has been verified to be a cause of skin cancer, diarrhoea, and stomach cramps in laboratory animals. In view of this Moyo (2009)recommends that the use of motor oil to control ticks should not be promoted on the basis of toxicity.

The drag and squash method mentioned by Homann et al., (2007); and Masika et al., (2009) have very low implied costs, but are not recommended because in the process of pulling, ticks do get irritated and in the process regurgitate their stomach contents into animal tissue thereby transmitting the pathogens. Furthermore, their two pronged hypostomes may tear the skin opening up wounds for subsequent opportunistic infection to occur.

Magano (2012) in his presentation: “Towards the use of plants in tick control”, points out that most livestock keepers in Africa are subsistence farmers and cannot afford the expensive synthetic acaricides. He further notes that the need for alternative non-acaricidal tick control methods cannot be over-emphasised

There are several alternatives of controlling tick populations that do not involve use of synthetic acaricides and these include (Canada, 2011; Jongejan et al., 1993; Latif & Pegram, 1992; Rechav et al., 1992; Khalil et al., 1980):

- *Increasing host resistance*. The best example here is the N’dama cattle of West Africa, Nkedi Zebu and Ankole of Uganda that are known to be resistant to ticks.
- *Simple modification of the tick ecology (habitat)* using cultural control tactics of horticulture, silviculture and animal husbandry.
- *Enhancing the immunity of animals* by vaccinating for instance against heart water with attenuated *Cowdria ruminatum* organisms and Gavacplus to control *Rhipicephalus* infestation.
- *Using Biological Control Agents (BCAs)* that destroy tick populations. Some known BCAs include predatory oxpeckers ,rodents ,spiders, beetles , scavenger chicken, Ixodiphagus wasps, parasitic bacteria, entomopathogenic fungi (*Metarhizium Beauveria*) and the nematodes (*Steinernematodae & Heterorhabditidae*)
- *Poisoning and killing ticks using biocidal exudates from plants*. *Stylosanthes* is one good example of such plants.
- Establishing *pasture grasses capable of repelling, trapping and killing ticks* together with some that are capable of reducing tick feeding, moulting, fecundity and egg viability.
- *Controlling female tick pregnancy* by mating them to sterile male hybrids and

- *Hand picking, crushing, piercing and cutting with sciss*ors.

Homann et al., (2007) singled out tick infestation and subsequent infection as a major production constraint in goat production. The same authors stated that communal goat farmers in Tsholotsho resort to traditional practices involving the use of *medicinal plants, soot* and *salty soil* to control ticks on their goats. The farmers do this in order to defray losses and increase profit margins by default. However, the researchers did not provide specific details of the botanical and animal extracts used by the farmers in resolving tick infestation. The current study which seeks to assess and document the specific tick control products adopted by farmers in Tsholotsho is necessary.

1.2 Background

Historically, chemical tick control practice introduced in Zimbabwe in 1914 was driven by an eradication mentality that favoured intensive applications of acaricide to all animals (Perry et al., 1998). This dipping regime led to endemic instability following the disruption of dipping services from 1973-1978 and caused the loss of a million Zimbabwean herds of cattle (Perry et al., 1998).

According to the United States Department of Agriculture (USDA) (1967) conventional acaricides:

- can be toxic to livestock and humans;
- can create residues in animal tissues:
    - meat,
    - milk,
    - wool, and
    - hides and
- may be destructive to the environment if they are not used in a safe and correct manner.

Laffont et al., (2001) isolated residues of conventional acaricides in cattle dung. Latif and Jongejan (2002) cited rapid emergence of resistance in ticks against a range of the repeatedly applied acaricides. Ntondini (2009) reported:

- *R. (Boophilus) microplus* tolerance to:
    - amitraz,
    - cypermethrin and
    - chlorfenvinphos,
- *R. evertsi evertsi* tolerance to:
    - chlorfenvinphos and
- Resistance to cypermethrin in *R. appendiculatus*.

Martins et al., (1995) and George et al., (2004) refer to the emergence of tick species resistant to arsenic and organophosphosphatic acaricides in most areas of the world.

Tick resistance to acaricides is constantly evolving and the increasing awareness of their residual toxins in more affluent regions of the world is prompting their minimum use. The challenge of newly developed, synthetic drugs is that they are far too expensive for most resource constrained communal live stockists including those in places like Tsholotsho. Government service delivery in the developing world is also grossly unreliable or even bankrupt (Behaviour, 2001).

According to Graham & Hourrigan (1977), chlorinated hydrocarbon acaricides have been withdrawn from the market, because of their high toxicity and long residual lifespan. The Government of Zimbabwe (GOZ) lists in Section 2 of 9 of the Animal Health (Cattle Cleansing) Regulations that, ‘Effective Tick-Destroying Agents’ ,most of which have been phased out from the market due to either:

- residual toxicity,
- production costs and
- resource depletion or
- all of the above.

As a result, recommendations by the Australian Centre for International Agricultural Research (ACIAR) on reduced dipping of indigenous cattle, particularly in smallholder systems, were adopted by many countries in sub Saharan Africa including Zimbabwe.

When Homann et al., (2007) carried out a survey on goat marketing in six districts of Matabeleland North and South including Tsholotsho, they showed that 58.1% of the households interviewed in Tsholotsho bought more commercial acaricides than any other drug for their goats. They also mentioned that 10.5% of the farmers used traditional methods to control ticks not because they had a deep indigenous knowledge but rather by default because inputs and technical knowhow were inaccessible and unaffordable. The study further revealed that traditional methods were gaining ground but lacked shared knowledge and improved use. This was an indication that the knowledge bases were quasi and under the threat of extinction even though they remain the only panacea to problems posed by synthetic drugs.

Past studies revealed that 10.5% of small scale farmers from five dipping cluster zones in Tsholotsho Rural District Council of Matabeleland North Province use EVAs in the control of livestock ticks (ICRISAT, 2008; Homann et al., 2007). However, because these are undocumented, it is possible that this value has gone up. Moreover, it is also possible that the extracts from these EVAs possess very active ingredients whose chemical properties have not been documented leading to compromised efficacy from one generation of users to the next.

The extracts might be bio-degradable, friendly and open to wide range of good uses but just because their biochemical potential has not been described and their efficacy is not documented anywhere; EVAs are not considered by many as an immediate alternative to the conventional use of synthetic acaricides for now. This is in spite of the dramatic increase in demand for safer animal products and environmental protection (Georghiou & Lagunes-Tejeda, 1991; Georgiou & Lagunes-Tejada, 1991).

The control of tick species that affect animal production is vital for the economic wellbeing of the livestock industry but also from the animal welfare point of view. Therefore, it is necessary to test the efficacy of some animal and plant extracts against the most common ticks that occur in Tsholotsho such as:

- *Rhipicephalus (Boophilus) decoloratus,*
- *R. zambeziaensis,*
- *R. appendiculatus*,
- *R. e. evertsi,*

- *Amblyomma*, and
- *Hyalomma*.

Using plant extracts may be the solution to the problem of resistance development. This is because of the fact that resistance develops slowly against extracts because they tend to be composed of a mixture of different active agents with different mechanisms of action.

Since resource constrained livestock farmers in Tsholotsho use ethno veterinary acaricides (EVAs) either due to inaccessibility or unaffordability of inputs and not from in depth knowledge and understanding of the practice (ICRISAT, 2008; Homann et al., 2007), there is a need to study the remedies and their possible contribution to the control of ticks. This is particularly important given that some essential oil extracts of indigenous plants like *Tagetes minuta* have been found to be:

- 95% efficacious,
- biodegradable and
- usable in phytotherapies as food additive and/or preservatives.

For these reasons, this research will investigate and document the *in vitro* efficacy of some selected indigenous extract infusions, decoctions and smears considered bio friendly. The extent of ethno veterinary acaricide usage including the different ethno veterinary products in use, extraction and application techniques will also be assessed.

1.3 Problem statement

Although farmers in rural Tsholotsho made use of indigenous tick control strategies there is no evidence of studies that have assessed the efficacy of natural acaricides used in the area under study, nor have the different extracts/plants used to control ticks been documented.

1.4 Hypotheses/Assumptions

- Communal farmers in 21 (twenty one) village/clusters of Tsholotsho rural district use various indigenous based techniques to control ticks.

- Some of the products/remedies used as indigenous tick control remedies are highly effective.

1.5 Research questions

- Which indigenous based methods do communal farmers use to control ticks locally?
- Are EVMs extensively used in the Tsholotsho district area?
- Are selected ethno veterinary products effective as tick control remedies?

1.6 Aim and objectives

This section outlines the aims and the objectives of the present study.

1.6.1 Aims

The aims of this study included:

a) To document the various indigenous traditional tick control strategies adopted by farmers in the Tsholotsho district area.
b) To demonstrate the efficacy of selected indigenous tick control remedies.

1.6.2 Objectives

The objectives of the present study was accomplished by carrying out the academic objectives outlined below

- To determine the various indigenous traditional tick control strategies in Tsholotsho
- To determine the extent of ethno veterinary acaricide usage.
- To determine the efficacy of EVAs using three *in vitro* bio-assays.

[redacted]

After this investigation it will be possible to do the following;

- Document the various indigenous control strategies
- Describe the extent of ethno veterinary usage
- Describe the in vitro efficacy of the tested indigenous acaricides.

CHAPTER 2

LITERATURE REVIEW

This chapter includes a review of the literature on the classification of ticks, their economic importance, conventional tick control methods and their short comings. This section also covers indigenous/traditional knowledge based control systems as substitutes for commercial dips.

2.1 Classification and economic importance of ticks

In archaeo and paleo-parasitology traditions, ticks are classified as small exsanguinous ecto-parasites sizably larger than mites (De Candanedo Guerra et al., 2003). Both the ticks and mites belong with scorpions and spiders in the class of Arachnids (Gk.**αραχνε**) - referring to a spider or spider's web. The nomenclature according to Greek mythology is associated with the myth of Arachne, a maiden cursed by the goddess Athena that evolved into a weaving spider. The term was first used in 1815 by a French biologist Baptista Pierre Antoine de Lamarck for scientific classification.

Generally ticks are divided taxonomically into two main families, Argasidae and Ixodidae (Paskewitz, 2015). The hard bodied Ixodidae commonly found in Tsholotsho form the largest family and are economically the most important comprising between 650 to 692 species from 13 genera world over. The second largest group, the soft tick; *Argasidae* family is very rare in Tsholotsho but has between 150 and 193 species that belong to five (5) genera. The *Nuttallielidae* is a monotypic family represented by *Namaqua* in South Africa (Bedford, 1931).

According to Sonenshine (Sonenshine, Daniel & Roe, Michae, 2013) hard ticks are successful parasites because of morphological adaptation through different life cycle development stages. The soft bodied Argasides can resist starvation for many years because their cuticle can expand to capacities 5 to 10 times unfed body weights (Rajput, Hu, Chen, Abdullah G Arijo, et al., 2006).

2.2 Common tick species found in Tsholotsho district

The most widely distributed ticks in Tsholotsho include *Rhipicephalus (Boophilus) decoloratus, R. zambeziaensis, and R. appendiculatus, R. evertsi, A. hebraeum and H. truncatum* (Chatikobo et al., 2001).

These tick species belong to the Ixodidae family and are characterized by sclerotized (hard) chitinous plates on the dorsal surface (Walker et al., 2003). Structurally *Amblyomma* ticks have visible eyes, long mouth parts and festoons. The males may or may not have ventral plate coloured patterns on scutum and distinctly banded legs. *Rhipicephalus* species except *Rhipicephalus (B) decoloratus*are characterised by short mouth parts, eyes and festoons, ventral plates on males, no coloured patterns on scutum. The *Boophilus decoloratus genera* are small pale coloured ticks with very short mouth parts, eyes present, no festoons, ventral plates on males, showing gut, indistinct anal groove and infest cattle mainly. *Hyalomma* ticks can be identified by long mouth parts , visible eyes , festoons as well as ventral plates in males , indistinct banding of legs and lack of patterns on scutum.

The abundance of adults and nymphs of the *R. appendiculatus* and larvae of the bont tick; *A. hebraeum* show a positive correlation with rainfall, whereas no relationship with rainfall has been demonstrate for larval *R. appendiculatus,* adults of the red legged tick *R.evertsi* or larvae of the blue tick *Rhipicephalus (B) decoloratus*. Larvae of *Rhipicephalus* species and A*. Hebraeum* adults tended to be more numerous during the drier years. *Rhipicephalus evertsi* and another *Rhipicephalus punctatus* have been shown to occur on goats in all areas of Zimbabwe throughout the year (Horak et al., 1987).

Ixodids develop in four stages involving egg laying, six legged larval stage, eight legged nympal stage and the eight legged adult stage. Each of the post embryonic stages requires blood nourishment for development (Horak et al., 2002). The ixodids are classed as single, two and three host parasites. *Rhipicephalus decoloratus* is a one host parasite, while *R.evertsi* and the *Hyalomma* species use two different hosts to complete their life cycles. *Rhipicephalus appendiculatus* develops on three different hosts (Walker et al., 2003).Ticks have peripheral sensory organs including hair like structures on the body, legs, mouthparts and a sensory complex located on the dorsal surface of the tarsus of leg 1.The latter contains a cluster of olfactory and gustatory receptors (Hailer's organ) which detect warm, humid carbon dioxide (CO_2) and ammonia gas vibrations from target hosts (Parola & Raoult, 2001).

Amblyomma hebraeum and *variegatum* usually attack the host from rocky habitats. Adult *Amblyomma* ticks very often attach to the soft warmer body portions for the blood, the udder, male genitals, the under line, under tail, on the switch of the tail, in clefs and inner second thigh. Nymphs and larvae can be isolated from birds and other wild animals as well (Sonenshine, Daniel & Roe, Michae, 2013).

Rhipicephalus species ambush (quest) on tall vegetation for suitable hosts (Sonenshine, Daniel & Roe, Michae, 2013). Some ticks like *R. sanguineous* with avid affinity for dogs and *A. americanum* for different avian and mammals show a very high level of host specificity. *Rhipicephalus (B) decoloratus* is often localized on the neck, dewlap, underline, brisket, short halves, inner and outer hocks on attachment to hosts. The larvae are sometimes found at the edges of ears. The other *Rhipicephalus* species are usually localised on the muzzle, cheeks, eyelids, crowns and occiputs, udder, horn bases, inner-outer ears, inner thigh, under and on tail switch. The larvae are usually found inside the ear (Keirans 1997).

2.3 The significance of ticks

Ticks parasitize a wide range of vertebrate hosts, and transmit a wide variety of pathogenic agents as compared to other groups of arthropods. In general though game and other small animals such as rabbits, reptiles and birds are alternative hosts for ticks, the favourite domestic hosts of ticks are cattle (Peter et al., 1998). Moreover, livestock is a source of household food security and poverty alleviation in most communal farming areas of Zimbabwe. It is also a source of draught power, manure, social security, rituals, milk and meat (Dovie et al., 2006; Chamboko et al., 1999; Perry et al., 1998).

[redacted]

According to some authors (Springell et al., 1983; Bram, 1975) ticks cause multimillion dollar losses worldwide in form of:

- human health,
- wild life losses and losses in livestock production.

Eighty percent (80%) of the world's 1.6 billion cattle are affected by ticks. The affected stock includes 186 million that are on 30 million km^2 of African soil. (Chamboko et al., 1999) contend that about 600 million cattle are affected by anaplasmosis and babesiosis with theileriosis affecting 200 million worldwide. From among those affected by theileriosis 25 million are in Central and Southern Africa. Furthermore, 1.1 million among the 175 million affected by cowdriosis within sub-Saharan Africa were reported dead by 1989. Zimbabwe alone recorded 4000 general cases of tick borne diseases (TBDs) related mortalities during the same period (Chamboko et al., 1999). Ticks make profit margins very thin for livestock farmers around the world, and it is known that the current global livestock losses due to tick borne diseases is enormous (Magano, 2012; Jongejan & Uilenberg, 2004).

Zimbabwe spent an estimated US$ 9 million during the 1988/89 financial year (Perry et al., 1990) on tick control and treatment of all tick-borne diseases. The cost of controlling *Amblyomma* ticks alone was US $5.6 million. The remaining US $3.4 million was used on other tick species. The direct cost breakdown of losses due to both tick groups is as follows:

- 76% due to acaricide costs,
- 18% to milk spoilages and
- 5% to curatives.

The other 1% accounts for revenue lost through (Chamboko et al., 1999; Perry et al., 1998):

- drop in beef quality and quantity,
- loss of traction,
- loss of manure,
- loss of hides and

- wool spoilage.

Heavy tick infestation leads to general production losses characterised by diminished herd sizes, reduction in live weight, meat and milk quality.

Ticks transmit viral, rickettsial, bacterial and protozoal diseases affecting both domestic and wild animals as well as human beings through salivary secretions during feeding (Lane, Richard & Crosskey,Roger, 1993).

Because of the ability to cause damage to the hides, severe tick bites can result in dermatitis (Rajput, Hu, Chen, Abdullah G Arijo, et al., 2006).

Hyalomma secrete lethal saliva that aids in transmitting rickettsia pathogens, and can also cause tick paralysis that may culminate in death of humans, young bovines, avian and pigs (Walker et al., 2003). *A. Hebraeum* transmits *Erhlichia (Cowdria) ruminitum* endoparasitic rickettsia, the causative organism for heart water (cowdriosis) in livestock while *Rickettsia africae* causes tick fever in humans(Artemenko, 1974).

The pathogen rickettsia can also be transmitted by some group of generalist *Rhipicephalus* species that were isolated by Habib(2006). Some of the rickettsia and parasite transmitted by some of these generalist *Rhipicephalus* species like the pathogen *Anaplasma marginalle* cause anaplasmosis (gall sickness) in susceptible bovines.

In addition *Rhipicephalus (B) decoloratus* and *B. microplus* are one host tick species that transmit *Babesia bigemina* and *B. bovis* pathogens that cause babesiosis (Red Water) in susceptible host bovines.

Given their role in disease transmission, the intensive use of chemical acaricides and other means of effective control are needed (Willadsen & Kemp, 1988).

2.4 Tick control: opportunities and challenges

Problems like environmental contamination, residues in food and feed, high prices relative to values of cattle and cattle products, development of tick resistance to acaricides have prompted a search for alternatives to their continued use (Ntondini, 2009; Kaaya & Hassan, 2000). Besides the indiscriminate use of acaricides has the potential to lead to a loss of enzootic stability to tick-borne diseases.

Resistance to acaricide is currently one of the most serious economic threats to the production of livestock worldwide coupled with toxic food and environmental contamination with acaricide (Kaaya & Hassan, 2000; Lane, Richard & Crosskey,Roger, 1993). For example, Fox and Leon (1984) reported the failure of carbaryl-based products to control *Rhipicephalus sanguineous* in dogs. The wettable powder carbaryl-based products contained carbaryl plus piperonylbutoxide and pyrethrins and N-octylbicycloheptene-dicarboxamide [2-(2-ethylhexyl) 3a, 4, 7, 7a-tetrahydro-4, 7 –dimetheno-1H isoindole-1, 3 (2H) - dione]. Strains of *Boophilus microplus* had developed resistance to organophosphates, carbamates and a succession of other chemical acaricides leading to investigation of alternative approaches for eradication of ticks (Floyd et al., 1995).

Tatchell (1992) cites studies that recommend that alternate innovations should be:

- robust, simple,
- flexible and
- not much more expensive than conventional methods already in use.

A concern similar to that of Tatchell was raised earlier in 1990 in a report by the International Laboratory for Research on Animal Disease (ILRAD) on their study of ethno veterinary preparations. The objective specified that any desire to redress tick control approaches and strategies should target needs of particular groups of cattle keepers and individual governments by embracing traditional prophylactic and curative practices. Such methods must be bio friendly and also accessible to all livestock keepers, including those who are poor and cannot afford transport costs to veterinary and retail outlets as well as the costs of synthetic products.

Jonsson (2005) considered the use of biological control strategies such as “pasture spelling” and tick resistant cattle to combat tick resistance. Vaccines from attenuated organisms such as *Cowdria ruminitum* which enhance the natural immunological means of affected animals against heart water were also produced (Willadsen &

Kemp, 1988). Slaughter and quarantine methods mentioned by Fletcher (1984) were found common among farmers in Tsholotsho as well by Homann et al., (2007) and van Rooyen et al., (2008). Pasture spelling controlled *Theileria parva* effectively and not *Babesia bigemina* and therefore was found less effective than slaughter and quarantine.

The use of natural medicinal plant extracts and animal oils as ixodicides is indigenous knowledge that is orally transferred from one generation to another and often lacks scientific validation (Magano, 2012). Because of its widespread use it has been taken for granted by many researchers to be the safest and most economically feasible substitute for synthetic commercial drugs (Jonsson et al., 2007). For example, Habeeb (2010) argued that farmers have global preference for botanical pesticides over synthetic chemicals because of:

- minimal mammalian toxicity,
- minimal impact on pollinators and natural enemies,
- minimal environmental pollution,
- less expense and readily availability.

This argument is very appealing but might not apply to Tsholotsho at the moment due to lack of well documented and scientifically validated evidence. What probably holds true is that the use of plant extract as parasiticides is widespread in developing countries (Magano 2012). That notwithstanding, the following issues need to be investigated:

- effectiveness of these plant extracts as parasiticides
- the safety of the extracts to humans and animals.
- feasibility of large scale production of marula exctracts
- potential of commercialization of plant parasiticides in production of stable products.

Available studies show that ethno-bio products have the potential to be effective. For example Kaaya (2000) and Kaaya & Hassan (2000) concocted herbal extract with 15% oily peanut suspension and the concoction was found to yield a 78 to 80%

efficacy. An aqueous extract of the same botanical extract yielded 36 to 64 % mortality rate to ticks. Jonsson (2007) also observed that for the botanicals to have more or less the same in vivo and in vitro effectiveness, they have to be mixed with oils.

While phytotherapy or the use of extracts from natural origin as medicines or health-promoting agents is cheap, familiar, locally available and offering a potent substitute for synthetic commercial drugs (Habeeb, 2010), their use by resource limited farmers is constrained by the cultural and religious beliefs. The oral mode of transmitting ethno-knowledge from generation to generation is liable to corruption, adulteration and or extinction through global social dynamics. The solution to this threat is to validate and document the knowledge.

2.5 Historical perspective of indigenous knowledge based veterinary practices and medicines

Indigenous knowledge stems from peoples' ingenuities, credulities and, their long insatiable curiosity passed on from generation to generation by word of mouth, traditional songs, poems, drawings, paintings, stories, legends, dreams, visions and initiation ceremonies. This knowledge is sometimes sketchily recorded in books and mostly stored and transmitted by means of practice or in the form of artefacts inherited either maternally or paternally (Barnhardt & Kawagley, 2005).

Botanical and animal arthropocides, minerals and sometimes animals themselves are amongst the end products of EVM that probably evolved simultaneously with the evolution of human beings and domestication of animals ever since Adam and Eve in the Garden of Eden (Genesis 2:15-20). Thrusfield (2005) ; Wynn (1999) and Magano (2012) argue that knowledge of natural acaricides already existed in the form of indigenous knowledge which required further subjection to scientific scrutiny and validation to improve its use.

Plotkin (1988); Spore (1992); Martin et al. (2001) and Nchu et al., (2005) suggested that ethno veterinary medicine forms the cornerstone of native peoples' cultural heritage, of which the elderly are repositories in and is an alternative to purchasing the more expensive modern orthodox medicines. They stressed that herbs represent one of the first pharmacological interventions attempted by healers and remain a very important and special component in new therapeutic and anti-pest agents for about 80% of the world's pharmaceutical industry. Our orthodox (conventional) drugs today derive from about 25% of plant compounds in traditional format. South Africa alone is home to more than 23 000 plant species from the Cape Floral Kingdom, representing around 10 % of all plant species in the world (Kofi – Tsekpo & Kioy, 1998).

The veterinary *Papyrus of Kahun* (*c.* 1900 BC) recorded veterinary therapeutic techniques of Egyptian priest-healers while Thrusfield (2005) recorded Indian practices retained in the Sanskrit. Rangnekar (1999) compiled 261 references detailing the ethnoveterinary medicine of the African continent, Latin America and Asia.

Even though the practice of ethnoveterinary medicine is somewhat wide spread, it lags behind modern veterinary medicine because its information is hidden in grey literature (Mathias et al., 2004). Useful ethno-knowledge and some of the traditional animal health care practices remain unknown to date in Tsholotsho, the scene for the current study and many other native stock raising communities. This is in spite of their increased demand to be integrated into primary animal health care delivery systems for wider use by rural and peri-urban communities (Wanzala et al., 2005; Stenhouse, 1975).

Rathore et al., (1997) argued that because of their level of education, local/native healers and animal owners are not in a position to distinguish between the various types of industrial medicines and understand their administration and action, a problem they do not encounter with their traditional preparations, and hence considered to be their best alternative.

Some arthropocides that are more environmentally benign and equally efficacious as commercial synthetic acaricides include tobacco, camphor, derris, turpentine, neem and Tagetes minuta (Zuberi, 1999). Extracts of some of these tropical and subtropical plants have shown acaricidal effects on *Rhipicephalus (B) microplus and* *appendiculatus*. Burg et al., (1979) and Abdel Shafy & Zayed (2002) and reported avermectin acaricidal properties from actinomycete *Streptomyces avermitilis*. Dipeolu & Ndungu (1991) discussed how a ground mixture of dried tobacco leaves and a mineral called ”Magadi soda” killed and prevented the completion of all feeding phases of *Rhipicephalus appendiculatus*

Arnason et al., (1985) classified alkaloids, terpenoids, phenolics and minor secondary chemicals as metabolites from plant extracts, seed, and leaves, barks of trees, roots and tubers of various trees that are valuable in animal health. Bentancur et al., (2010) described rotenone as an example of flavonoid extracts from roots of Derries and *Lonchocarpus species* that is an ingestible compound with repellent and contact toxicity to arachnids. The other specified common secondary metabolites with protective action against arthropods mentioned are non-protein amino acids, steroids, glycosides, glucosinolates, quinines, tannins and terpenoids.

Moghaddam et al., (2007) showed that the main components of *T. minuta* oil are α-terpinol, (Z)-β-ocimene, dihydrotagetone, (E)-ocimenone, (Z)-tagetone, and (Z)-ocimenone. Ayacko (2008) reported an efficacy of 55% against ticks when using a decoction. *Tagetes minuta* oil was shown to be very effective against both hard and soft ticks. Its efficacy at a concentration of 20% was comparable to the referenced conventional acaricides, and it reached over 95% efficacy as required by the Ministry of Agriculture in Brazil. Enan (2001); Knaak and Fiuza (2010) isolated a group of aromatic essential oils called monoterpenoids that selectively targets the octopaminergic system of insects and they are more environmentally benign than organophosphorus, carbamates, and synthetic pyrethroids. These observations suggest that the insecticidal activity and potency of monoterpenoids, as with the other insecticides, depend on several factors, including dose, species, application surface, route of penetration, and method of application. Olivo et al., (2009) showed that the Argasidae tick *A. miniatus* was five times more sensitive to essential oil than Ixodidae ticks.

Williams (1993); Kalakumar et al., (2000) and Schwalback et al., (2003) conducted several studies on the effect of neem extracts on cattle ticks, such as *Amblyomma* *hebraeum*, *Rhipicephalus evertsi*, *Hyalomma truncatum*, *R*. (*B*). *decoloratus*, *R*. (*B*.) *microplus* and *Hyalomma anatolicum excavatum*. The authors' demonstrated high *in vitro* efficacy (100% inhibition of reproduction) by an ether extract, while alcohol extracts resulted in a 70% reduction in tick reproduction. The ethanol neem extracts were found to be effective in hindering oviposition by inhibiting vitellogenin during the oogenesis of arthropods. Benavides et al., (2001) showed that the treatment of infested animals with a 5% soapy, aqueous neem extract was as effective against *R*. (*B*.) *microplus* as an Amitraz-based commercial acaricide. Broglio-Micheletti et al., (2009) analyzed the efficacies of a neem hexane extract and a 2% oil concentration against *R*. (*B*.) *microplus* and found *in vitro* efficacies of 73.2 and 65%, respectively. Abdel-Shafy & Zayed (2002) and Williams (1993) also concluded that neem oil could be used for tick control at economical concentrations of 1.6 to 3.2%.

Andreotti et al., (2011) demonstrated that only acaricides containing a mixture of cypermethrin, chlorpyriphos, citronella, piperonylbutoxide and a mixture of dichlorvos and clorpyrifos reached efficacies of over 95% against the resistant *R. (B.) microplus* hard ticks but *R. sanguineus* remained resistant to cypermethrin. In Zimbabwe Nyahangare et al., (2012) reported the use of a fever tea (L*. javanica)* by smallholder farmers as an acaricide. This plant has about 1 035 species in tropical and subtropical regions. The fever tea shrub is an aromatic herb. Its reported biological activity is associated with aromatic mono and sesquiterpene components in the plant's essential oils.

According to van der Merwe (2001), some of his small scale respondent farmers of the Tswana people had plants such as *Aloe marlothii, Asparagus laricinus, and Ziziphusmucronata, Peltophorum africanum* growing at their homes or close to cattle grazing areas. Most of the plants species used to treat cattle were collected only when the need arose. He also mentioned that traditional healers among his respondents thought the herbal strength of wild plants was much more and less toxic than cultivated plants. The lay people collected herbs for personal use only, while ethno-practitioners did so for money because they are guided by ancestors (Badimo).

Medicinal plants were usually not stored, but were collected and used fresh when needed. Most informants used by Van der Merwe (2001) stated that medicinal plants could be stored indefinitely as long as preferred in dry form. Plant material was dried by spreading it out on an outside flat surface in dry weather, or was hung from hooks mounted on walls indoors. Large pieces of plant material were sometimes cut into smaller pieces before drying. Dried materials were ground to a powder or tied into bundles in a cool place, out of direct sunlight and wind in cool parts of a house in plastic or paper bags, newspaper and glass, metal or plastic jars.

2.6 Extraction, administration and dosage of ethno veterinary medicines

Most commonly used sources of drugs amongst resource-poor animal keepers are herbs and plant extracts. The parts of the plants used include seeds, leaves, barks, bulbs, rhizomes, tubers, and roots that show different properties depending on the plant in question. Others use wood ash, kaolin, potassium, domestic detergents and spent engine oil. The crude plant extracts are prepared in various ways including infusion, decoction, ground fresh material, sap expressed from fresh material, charred and dried (Van der Merwe, 2001).

2.6.1 Extraction of active ingredients

Water extraction is the most common preparation method for EVA. Infusions and decoctions comprised 82 % of the total number of medicines (Van der Merwe, 2001). Decoctions are prepared by boiling plant material in water for a few minutes. Infusions usually require plant material to be soaked for a few hours or overnight. Infusions are preferred when it is not convenient or it is impossible to boil water and rapid preparation of a medicine is not necessary. However, fresh plant material is the preferred to preserved or dry material. When fresh plant material is not available, dried material is used accordingly following the same preparation methods as those used for fresh material.

2.6.2 How EVAs are usually administered

Several methods of administering EVA have been described and these include (Alawa et al., 2002):

- Wood-ash rubbed into animals' coats to repel insects potentially carrying disease organisms. Also smoke from certain plants (e.g. *Nicotianae tobaccum*) used to control fleas and ticks.
- Spent engine oil smears used for the treatment of skin conditions e.g. dermatophilosis, mange, and other fungal conditions and ticks as well.
- Viscous liquid form of boiled castor oil plant (*Ricinus communis*) is used for the treatment of mange and ectoparasites including ticks.
- Non-plant material and material not directly derived from plants, used in mixtures like salt, sodium permanganate, donkey faeces and orthodox medicine
- Other parenteral dosage forms are applied topically. Liquids are applied as lotions. Powders are used by sprinkling. Ointments and unaltered plant material are also used. These dosage forms are easy to prepare without specialised equipment and reflect the low level of technological sophistication in EVM.

2.7 Threats to ethno veterinary knowledge

As compared to orthodox veterinary medicine, indigenous traditional animal health care was developed and practised through trial and error methods, and not through deliberate experimentation. As a result the findings were not documented, and for these reasons it has not been universally recognized (Mathias et al., 2004).

Traditional veterinary medicine knowledge like all other traditional knowledge systems is handed down in oral storage format from generation to generation and it may disappear because of rapid socioeconomic, environmental, technological changes leading to loss of cultural heritage. This knowledge is decaying and disappearing rapidly worldwide mainly due to hindered transfer of ethnoveterinary knowledge to younger generations who are unwilling to inherit from their ancestry what they regard ungodly, ineffective and/or witchcraft. Documentation has to be done, and systematic studies have to be conducted for conservation of this valuable asset (Kokwaro, 2009; Zuberi, 1999; Longuefosse & Nossin, 1996; Toyang et al., 1995; Principe, 1989).

Since ethnoveterinary medicine has its roots embodied in ethnobotany mainly, there is need to judiciously harvest, process, store, preserve and utilize the botanical preparations and establish botanical gardens of particularly endangered medicinal plants (Lotschert & Beese, 1999; Cumberbatch, 1992), so that a sustainable system of conservation and utilization of medicinal plants is achieved and maintained (Kasonia & Ansay, 1997). Growth in market and public demand is manifested at the expense of plant species extinction as a result of environmental degradation and the death of true or genuine custodians of the required traditional knowledge (Plotkin, 1988).

Lastly ethnopractices are severely endangered by the lack of a clear policy and regulatory information regarding the use and promotion of pesticidal plants in Zimbabwe and most other African countries. There is no protection of intellectual property rights (Mathias, 2004).

The objective of this study is to assess indigenous traditional tick control strategies in Tsholotsho and to document the various traditional tick remedies used by farmers in the study area. The study also seeks to assess the efficacy of selected indigenous tick control products for efficacy considered environmentally friendly remedies.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This section presents the study area, the research and sampling methods as well as the data collection and analysis methods applied in this research. The research methods presented in the subsections that follow were used to gather information required to accomplish the aims and objectives presented above. These methods include:

- reviewing of secondary data (literature review), and
- empirical research.

Empirical research included both:

- observational, and
- experimental study designs.

3.2 Study area

The study was conducted in Tsholotsho one of the seven districts in the Matabeleland North Province in south-western Zimbabwe. It is located in the heart of Natural Farming Region IV on coordinates: 19°45′59.77″S 27°45′00.00″ E, about 117km north-west of Bulawayo.

Districts around Tsholotsho shown in **Figure 3.1** below include, Lupane, Hwange, Umguza and Mangwe in Matabeleland South Province. Tsholotsho district is 775556 ha large and is inhabited by three ethnic communities, the Ndebele, Kalanga and San. However the principal language spoken by over 80% of the population is Ndebele.

Kalahari sands cover 70% of the overgrazed communal land area while 30% is made up of red and black clays of basalt origin. The rich black clay soils on either side of Gwayi River form “The Gwayi River flood plain” shared by rural Tsholotsho and expropriated game parks, forests, and private farms in Lupane and Umguza districts (**Figure 3.1**).

Norval et al., (1981) described the region as characterized by semi-arid climatic conditions and annual uni-modal rainfall of between 450 mm and 650 mm. The duration of the rainy season is from October/November to March/ April sometimes resulting in sporadic, heavy rainstorms, with periodic dry spells, followed by cool to warm dry season from May to September.

Other climate data for Tsholotsho are as follows:

- mean daily maximum temperature of 28.7ºC with a range 24.0-32.6ºC,
- mean daily minimum temperature of 6.4-17.3ºC,
- 55 rain days per year.

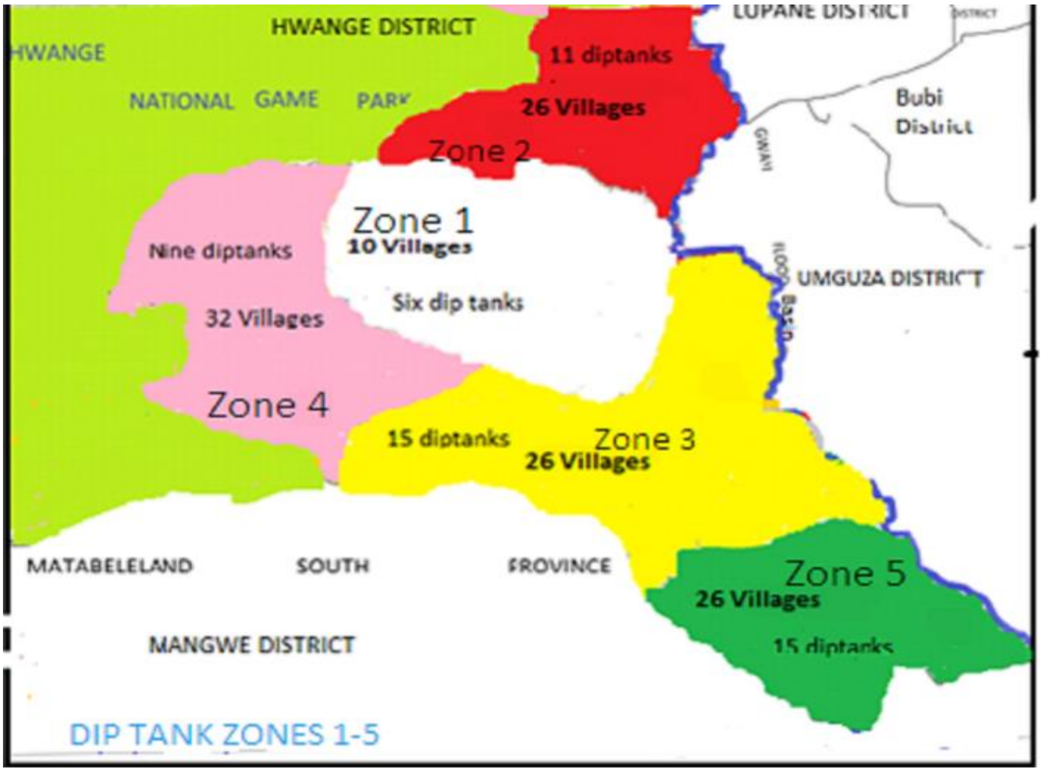

Figure 3.1: Tsholotsho district map showing location of the Dip Tank Zones (Tsholotsho Livestock and Veterinary Services 2013)

The clays are home to the thorny acacia and extensively covered grassland areas forming into very dense vegetation types towards the farms and parks acquired during the land reform. The Kalahari sands nurture larger tree species.

These sands can only support semi-extensive farming involving the breeding of goats, sheep, donkeys, cattle, wildlife and cultivation of drought resistant crops within inland areas.

The Department of Veterinary Field Services is responsible for providing strategic dipping services to 56 dip tanks that are divided into 5(five) dip tank zones or Animal Health Management Centres (AHMC) for ease of management. The 56 dipping structures (dip tanks) service the 120 villages administered through the 5 dip tank zones or AHMCs by Animal Health Assistants (**Figure 3.1)**.

The communal livestock producers pay a levy that goes towards procurement of the acaricide. Weekly dipping is practised during the wet summer months of November to March, while fortnightly dipping is done during the remainder of the year.

The effectiveness of this dipping programme mainly depends on:

a) availability of foreign currency to import the acaricides,

b) availability of dipping water,

c) staff establishment, and

d) state of the dip tank.

The main tick control practice in the study area is by plunge dipping. This is practised in 54 of the dip tanks using Amitraz 25.50% m/m ("Tickbuster® WP", Zimbabwe Phosphate Industries). The other two use pour-ons and tick greases due to cracked walls and siltation of dip tanks in the areas. The livestock populations by zone from which the sample was taken per dip tank is presented on **Table 3.1** below.

Table 3.1: Livestock population in Tsholotsho (Tsholotsho District Animal Health Centre 2012)

Tsholotsho District		Bulls	Steers	Oxen	Heifers	Cows	Calves	Cattle	Sheep	Goats	Donkeys
Zone No.	Zone name										
1	Dlamin	822	3452	4590	6873	12471	5232	33328	356	43077	14263
2	Sipepa	377	1343	3232	2695	7718	1550	21454	236	12972	8787
3	Tsholotsho	1603	3168	4296	5026	5730	2830	21088	60	7438	3333
4	Pumula	461	2307	1731	2627	4049	2980	14151	115	14001	1686
5	Nkunzi	308	1252	4784	2496	5813	1591	16244	400	11206	1971
	District Total	3571	11522	18633	19699	35676	14183	106257	1167	88688	30000

3.3. Materials and methods

3.3.1 Literature review

Literature review is a less costly and less time consuming method for gathering facts. Therefore the researcher in the present study relied upon literature review to meet the requirements of this study. Literature review was used to cultivate the required depth of knowledge necessary for the writing up of this study. Literature review is also necessary for planning of projects and to avoid repeating work already done by others

Literature review was achieved through doing the following:

- An extensive literature review of published and unpublished sources was done in order to present the findings and explanations by others on related topics of interest. This was then used to develop the present research study.
- Existing literature on preferences for traditional remedies among goat producers in Tsholotsho was sourced and reviewed to get an understanding of what has been done on the subject of usage of EVAs in the study area.

- Annual, monthly and weekly updates on livestock population, dip tanks, villages and livestock ownership from the district office files of the Division of Livestock and Veterinary Services (DVLS) were reviewed in order to gain understanding of what government is doing to assist livestock owners with their needs and requirements.

3.3.2 Empirical research

Empirical research is a way of gaining knowledge by means of direct and indirect observation or experience. The main advantage of using empirical evidence is that it can be analyzed quantitatively and/ or qualitatively (Gordon 2005).

3.3.2.1 Study Design

A cross-sectional study design was considered suitable for this research for the following reasons (William 2006; Bradley & Sean 2007; McCrindle 2009):

1. it is quick to apply and conduct,
2. its cost variables can be controlled against the number of subjects and their dispersion,
3. it is more time saving than the longitudinal study,
4. it can be used to administer a structured questionnaire,
5. there are no risks to the subjects because it does not control their variable behaviours, and
6. it is possible to demonstrate causal relationships using Odds ratio.

3.3.2.2 Sampling frame, design and sample size

This section explains how data on respondents' demographic profiles and the various remedies as well as the experimental units (ticks) were found and collected for analysis and experimentation.

Sampling frame

The sample frame for this study consisted of the following:

1. all village clusters,
2. all stock owners in Tsholotsho, and
3. All ticks species on cattle in Tsholotsho.

Sampling design and sample size

Simple random sampling was employed to select the villages to be studied. The district was divided into villages located in the five dip tank zones or (AHMC) (Figure 3.2) and numbered one (1) through 120 on pieces of paper that were put into a hat and agitated. A total of 21 villages out of 120 were randomly sampled by blindly picking out numbered papers from the hat as follows:

- zone 1: five (5) villages,
- zone 2: one (1) village,
- zone 3: six (6), zone 4: five (5) villages and
- zone 5: four (4) villages.

From the 21 villages, a proportionate simple random sample of 300 cattle owners was selected by computer using the random number generator as follows:

- 24 from zone1,
- 67 from zone 2,
- 65 from zone 3,
- 66 from zone 4 and
- 78 from zone 5**.**

Data on tick control strategies used by 300 respondents (registered in a Veterinary stock book) selected from villages (n = 21) was collected using a structured questionnaire.

Two compounds; (one plant and one animal extract) indicated as ethnoveterinary acaricide during the interview were subjected to laboratory analysis to determine their efficacy. The criterion for selection of the ethnoveterinary acaricide was that it had to be environmentally friendly.

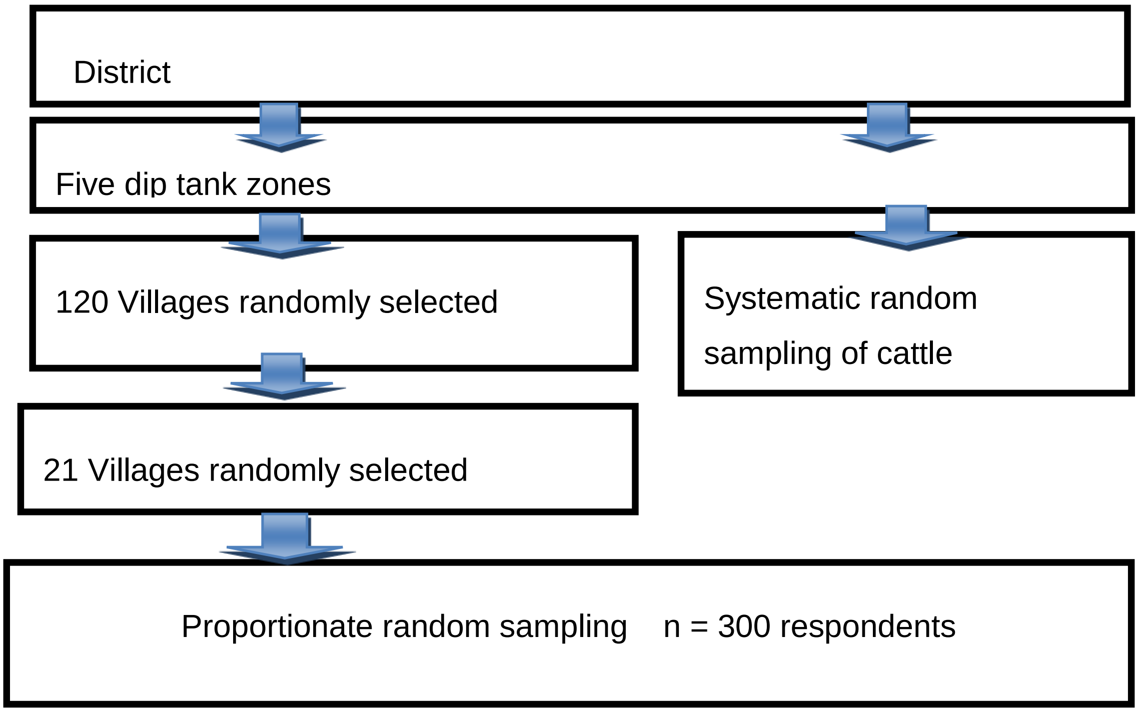

Figure 3.2: Framework of sampling strategy adopted in the present study

Systematic random sampling of ticks was done in 15 physical dip tank structures divided into five administrative dip tank zones (or AHMC) as follows:

- in **zone I,** five (5) dip tanks were visited,
- two (2) in **zone 2**,
- six (6) in **zone 3,**
- one (1) in **zone 4,** and
- zone **5** one (1) dip tank.

A total of 759 ticks were collected from the 15 dip tanks that had been chosen conveniently depending on whether or not there was dipping and ease of access to the dip tanks. The first animals were sampled randomly and thereafter every fifth Animal was sampled till when the required number of at least 120 ticks per dip tank was reached.

Pregnant ticks were collected and sent to the laboratory to test for the effects of EVA extracts on oviposition. Any other adult and nymph stages of all ticks found attached on chosen stock were collected as well and used to test for mortality and repulsion effect of the ethnoveterinary acaricide. The ticks were held in small transport vials supported with moist Whitman filter paper (Whitman International Limited, USA) and fresh green grass. They were kept at 75% relative humidity and temperature of 27°C (±1.5°C), to mimic the environment that is conducive for the survival of ticks (Thorsell et al., 2006).

3.4 Collecting ticks

Sampling of ticks was done between the first and the last week of August. Fortnightly dipping is practiced during this time of the year. However since there was no dipping in some dip tanks because of water shortage at the time of tick collection, only zones where dipping took place during the sampling stage were considered for sampling.

The ticks were collected at the dip tanks from host stock in the morning before dipping. The purpose of the study was first explained to the farmers, who had to give consent by signing the consent form (Annexure B) before this sampling commenced.

Predilection sites for tick attachment were targeted to speed up the process of tick collection and avoid delaying the cattle and the farmers. Blunt tweezers were used to pull ticks off the animal and methylated spirits was used for sterilizing the area to prevent sepsis and possibilities of opportunistic infection on the animal.

Initially, as has been described by various authors, ticks were sorted in labelled plastic containers depending on whether or not they were (Olivo et al., 2009):

- engorged,
- nymphs and
- unclassed.

The ticks were then transported to Bulawayo Provincial Veterinary Laboratory. Thorough species identification under a stereoscopic microscope was done.

Pregnant ticks (engorged) were used in the pregnancy test. Nymphs and any other unclassed tick stages were used in the controlled mortality and repellence tests.

3.5 Interviews & questionnaire survey

Before interviews were conducted, the purpose of the research was also explained to each farmer selected to participate in the study. Consent to participate in the study was confirmed by signing of the consent form (Annexure B) by the participants. Participants who could not read and write verbal consent were considered sufficient. To be able to determine the extent of remedy usage the respondents were asked the three basic questions among others:

- How do you control ticks?
- Which remedies do you use?
- How do you prepare it? (Annexe A).

3.6 Experimental study design

All the formulations tested for efficacy against ticks were selected based on the answers by the respondents' to the question:

- How do you prepare the remedy? (Annexure A).

The selected usage forms per zone were ranked and the marula remedy ranked as best, so it was chosen for testing. The remedies were then prepared according to the respondents' answers in the questionnaire.

An experimental study design was used to collect data on the efficacy of two indigenous Marula formulations considered popular and bio-friendly. Three methods:

- egg laying,
- controlled mortality and
- repellence bioassaysdiscussed below were used to assess the efficacy of the selected indigenous Marula formulations.

The formulations that were tested included:

- marula fruit in animal fats smears,
- marula pulp infusion and decoction dips
- marula seed oil decoction dips and

- marula alcohol extracts

3.6.1 The egg laying bioassay

This is also referred to as the **pregnancy test** (egg laying test). It measures the ability of a remedy to hinder engorged ticks from laying viable eggs when applied.

Engorged female ticks collected from predilection sites of naturally infested animals were washed with water and dried with paper towels to remove chemical residues and any dirt films.

The ticks were then randomly allocated to treatment and control groups. After allocation to the two groups, both groups were weighed equally in tens (10s) using a sensitive balance and the masses recorded before treatment. Marula fruit in animal fats smear and marula pulp water infusion dip were tested on two samples of ticks from zones 1 and 2. The sample from zone 3 was treated with marula seed oil decoction dip only due to unavailability of enough engorged females at the time of collection. While the sample of engorged ticks from zone 4 was divided in two and the animal fats smear was then tested in comparison with marula seed oil decoctions dip and the control. Tick samples from zone 5 were subjected to marula alcohol sediments dip only because respondents in this zone did not use any other plant animal extract remedy.

The smear was applied by hand dressing the tick, and distributing the acaricides over the tick gently using the tip of a finger from the capitullum to the posterior festoons. The legs were not smeared to allow ticks free movement during incubation.

The dipping treatment was done by immersing the ticks for 10 minutes in a specified dipping remedy. After treatment, the ticks were left to dry at room temperature for 10 minutes and reweighed to note any increments in mass due to the compounds applied on ticks before they were incubated.

In all the cases, nothing was done to the control group. After the second weighing both the treated and untreated (control) ticks were incubated at room temperature and 70-80% relative humidity as suggested by Drummond et al. (1973). The groups of ticks from zones 4-5 comprising of *Rhipicephalus* species only were incubated for 21-22 days since in these ticks oviposition is completed within 22 days. However, ticks collected from zones 1-3 comprising *Amblyomma, Rhipicephalus* and *Hyalomma* ticks, were incubated for 48 to 52 days in order to allow all the ticks time to complete egg laying. The control groups were incubated separately to avoid contamination with acaricide.

The weight of both groups was monitored and recorded at intervals from day 1, 7, 14, and then daily from the 18th to 22nd day for *Rhipicephalus* since the heavier eggs of these ticks were laid towards the end of oviposition (Dipeolu et al., 1991). The weighing continued until the end of the experiment on day 52 for *Hyalomma* and *Amblyomma.* The mean mass variations in experimental units that could be attributed to:

- oviposition efficiency,
- blood mass conversion rate,
- growth and
- death were then used to ascertain efficacy using the formula below;

$$\% \text{ Efficacy} = \frac{\text{Mass of treated ticks} + \text{laid eggs}}{\text{Mass of untreated ticks} + \text{laid eggs}} \text{X } 100$$

The overall average % efficacy of the pregnancy tests were obtained by averaging up the individual efficacies calculated each day when changes in mass were taken. Experimental efficacy was gotten from the final mass of eggs and ticks. The mean of means % efficacy was then calculated by averaging the two means.

3.6.2 The *in vitro* repellence test

The *in vitro* repellence test is a simulative measurement of the capacity of an acaricide to cause the ticks to move away from the focal point of application of the acaricides with or without inflicting mortality.

[redacted]

The method described by Thorsell et al., (2006) was used in the in *vitro repellence* assay. Only the nymph stages of local tick species were used to test the repellence properties of ethno-veterinary materials. According to this method, two Whitman No.1 filter papers (Whitman International Limited) were placed inside separate Petri-dishes with an inner diameter of 9.5 cm. The smear and immersion were applied along the periphery of the filter papers. The filter papers were then air dried for 2 minutes. A maximum of ten nymphs were placed at the centre of each treated filter paper each time and their movement with regard to avoiding the treated area were observed. If the nymph continued its motion beyond the periphery of the treated area within 5 minutes, the tick was recorded as non-repelled. But if the nymph reversed its direction before reaching the periphery of the treated area the tick was considered as repelled. The Petri dishes were left uncovered and exposed to the air from the start up to the end of the experiment.

On each occasion, the number of nymphs avoiding the treated area within five (5) minutes was recorded. The repellence was expressed as number of nymphs avoiding the treated area to the total number of nymphs at each occasion. Thus 10 nymphs avoiding out of a total of 10 is recorded as 100% repellence. The repellence was calculated using the formula below suggested by Thorsell et al., (2006):

$$R = \left(\frac{a}{\mathrm{n}}\right) \times 100$$

Where R= repellence

a=the number of nymphs avoiding the treated area

n= total number of nymphs put in the centre of the filter paper on each occasion.

3.6.3 The mortality test

This is an *in vitro* mortality test used as a measure of death due to the effect of the remedy. It is a simulation of how a remedy would perform if and when applied *in vivo* (Zurlo 2011)

[redacted]

Here unclassed adult ticks and nymphs were dipped or smeared and incubated for a maximum of up to 14 days (Pirali-Kheirabadi & Razzaghi-Abyaneh, 2007). This test was carried out with ticks and remedies from zones1-4.The smear remedy was used in three (3) samples while the dip was used in four (4) .Equal numbers of randomly selected unclassed adult ticks and nymphs per tick species were allocated to each of 3 groups (smear, dip and control categories). The number of ticks allocated to each group depended on their prevalence in different zones.

Each treatment group was immersed for 10 minutes in a specific extract prepared as per the instructions provided by the farmer. Meanwhile nothing was done to the control group. After dipping/smearing in the respective extracts, each group was placed for 10 minutes into separate petri dishes containing moist Whitman No. 1 filter papers (Whitman International Limited) measuring 62.63cm^2 with pieces of green grass to provide an environment conducive for tick survival (Theorell et al. 2005). The tick samples were then incubated for a maximum of 14 days at prevailing room temperature and 75-80% relative humidity in the dark as described by Pirali-Kheirabadi et al., (2007). The incubators were examined during the 1st, 2nd , 3rd , 6th and 24th hour after treatment, and then on the 5th, 7th and 14th day. At each checking the number of ticks was countered and the dead ticks were removed. Ticks were considered alive if they exhibited normal behaviour when they were aroused by breathing upon them or physically stimulated with a wooden stick. Ticks that were incapable of:

- moving,
- maintaining a normal posture,
- normal leg coordination,
- the ability to right themselves, or
- exhibiting any signs of life were considered moribund or dead.

This was especially if they showed cuticular darkness, haemorrhagic skin lesions, a lack of Malpighian tubes and stillness. The tick mortality rate was calculated as by using the formula below (Chungsamarnyart et al., 2003; Abbott, 1925):

$$1 - \left(\frac{n\ in\ T\ after\ treatment}{\text{n in Co after treatment}}\right) \times 100$$

n = the number of ticks in sample

T = the treatment

Co = the control

3.7 Data analysis

The results of the interview and questionnaire survey were analysed using the SPSS® version 21(IBM Corp), USA and Microsoft Excel® (Microsoft Corp), USA. One Microsoft/Redmond, WA 98052-6399 was used to run descriptive statistics.

To rank the indigenous knowledge based remedies in terms of the most used and therefore most popular remedy, the **average percentage usage** of the remedy was considered. The verification was done using all the 300 participants; but the statistical analysis was done on a sample of 20 drawn from the 300. Details of how it was done can be found in **Annexure C**. The central limit theorem requires a sample of 30 and above to assume the normal distribution. This assumption was not done here and a sample of 20 is more amenable to mathematical manipulation than a sample of 300 yet the sample of 20 would still produce the same ranking and efficacy results. In order to avoid the requirement of the central limit theorem no normal distribution was assumed and the non-parametric Wilcoxon rank test was used to ascertain the ranks and efficacy.

The Wilcoxon Rank Sum Test is a hypothesis test.

In general the Null and Alternate Hypotheses formulated for all the samples tested can be summarised as follows:

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in mass/

number killed or repelled after application of the marula formulation is not statistically significant at a given level of significance and could have arisen by chance.

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change in mass/ number killed or repelled after application of the Marula formulation is statistically significant at a confidence level that was determined using the Wilcoxon rank-sum test and it is not by chance.

Two groups of samples (in this case it is the same population sample before and after the application of a treatment) were identified and then the following characteristics of each group were calculated:

- **n_1**– Sample size of the 1st group -Number of samples in the group
- **n_2**– Sample size of the 2nd group -Number of samples in the group
- N_1, N_2 -Sum of the ranks of all samples in the 1st and 2nd groups.
- R – The Rank Sum Computed value (test /research statistic) for this study was obtained from (N_1 and N_2) whichever had the smaller value.
- Using n (the number of samples) and the required degree of accuracy in this case $\alpha = 0.05$ and $\alpha = 0.2$, critical values were then obtained from tables of values. The critical values and the research (test) statistics were then used to accept or reject the null hypothesis.

Wilcoxon Rank Sum Test for Small Samples in Excel

"Small samples" occur when the sample size of both groups is less than 10. In this case, **n_1** and **n_2**are both less than 10.

The data shown in each excel table attached in Appendix C was obtained using the following procedure:

- **Step 1:** The samples counted were equal in both groups for this experiment i.e. **n_1- n_2**
- **Step 2:** All samples were ranked according to sample size (mass or numbers) in Excel. MONDAY and TUESDAY were used to designate the sample before

and the same sample after the application of the treatment. The day designation would make it easier to sort the samples according to day.

- **Step 3:** The before and after samples were combined in order statistics and ranked. If any samples had the same values, they were assigned the rank that would be the average of the ranks each would get if they weren't equal.
- **Step 4 :** The samples were then sorted in rows according to days so that all the **before** samples whose day designation was MONDAY would be on top and constitute sample 1 and the **after** ones whose day designation was TUESDAY went below and constituted sample 2.
- **Step 5:** The sum of the ranks (**N_1 and N_2**) for each sample group were then calculated.
- **Step 6:** The Wilcoxon Rank Sum Small Sample Charts (Annexure C) to determine the **Critical values** for which the Lower value is less than the smaller rank sum and the Upper value is less than the greater rank sum. The critical values gave the confidence level for which to reject the **Null Hypothesis** in favour of the **Alternate Hypothesis.** The **Null Hypothesis** was not rejected for all critical values in which the calculated rank sums fell within the Lower and Upper values

CHAPTER 4

RESULTS

In this section, results from the interview of 300 farmers from the five dip tank zones and the 21 villages from these zones are presented. Results from the experiments carried out in the laboratory using the three different bioassays namely pregnancy test, repellence and controlled mortality tests are also presented.

4.1 Demographic profile of the respondents

4.1.1 Participant age descriptive statistics

The ages of the participants ranged from 20 years of age to 91 years of age, with a range of 71 years. The mean age of the participants was 59.44 years of age (Table 4.1).

Table 4.1: Age distribution of participants

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Age of Participant	300	20-91	20	91	59.44	18.492	341.953

4.1.2 Participant gender distribution

Table 4.2: Gender distribution of participants

	Frequency	Percent	Cumulative Percent
Female	73	24.3	24.3
Male	227	75.7	100.0
Total	300	100.0	

The gender distribution in **Table 4.2** above shows that there were more male respondents (227/300=75.7%) as compared to females (73/300=24.3%).

4.1.3 Participant distribution by Zone

The largest number of participants came from Zone 5. Zones 2, 3and 4had almost an equal number of participants each and the smallest or the least number of participants came from Zone 1 which had 24 participants out of the 300 that were interviewed.

Table 4.3 : Participant distribution by zone

	Frequency	Percent	Cumulative Percent
Zone 1	24	8.0	8.0
Zone 2	67	22.3	30.3
Zone 3	65	21.7	52.0
Zone 4	66	22.0	74.0
Zone 5	78	26.0	100.0
Total	300	100.0	

4.1.4 Participants distribution by marital status

Table 4.4: Distribution participants by marital status

Marital status	Frequency	Percent	Cumulative Percent
Married	209	69.7	69.7
Divorced	26	8.7	78.3
Single Parent	19	6.3	84.7
Widow	38	12.7	97.3
Widower	8	2.7	100.0
Total	300	100.0	

With respect to marital status, the majority (69.7%) of respondents were married followed by widows who made up 12.7% of the respondents.

4.2 Livestock ownership in Tsholotsho

Findings of the present study (**Table 4.5**), showed that the types of animals reared by respondents in Tsholotsho included:

- cattle,
- sheep,
- goats and
- donkeys**.**

Farmers either reared a single species of livestock or had more than one species.

Table 4.5: Distribution participants by marital status

	Frequency	Percent	Cumulative Percent
Cattle	73	24.3	24.3
Goats	40	13.3	37.7
Donkeys	25	8.3	46.0
Goats/donkeys	41	13.7	59.7
Goats/Cattle	73	24.3	84.0
Cattle/donkeys	26	8.7	92.7
Cattle/Goats/donkey	18	6.0	98.7
cattle/goats/sheep	2	.7	99.3
cattle/sheep	1	.3	99.7
sheep/goats/donkeys	1	.3	100.0
Total	300	100.0	

The livestock species that was reared by the majority of respondents was cattle and the goats/cattle combination, which were reared by just over 24% (n=73) of the respondents. Goats were also popular (reared by 13.3 %; n= 40) as were the goats/donkeys combination (13.7%; n = 41). The least popular combination of livestock kept was the cattle/sheep and the sheep/goats/donkeys combination.

4.2.1 Livestock ownership by age distribution

Cattle were quite popular among the 50 to 80 year age group. The goats/cattle combination was the next popular group of animals reared by this same age group. However goats were most popular within the 20 to 30 year old age group (**Figure 4.1).**

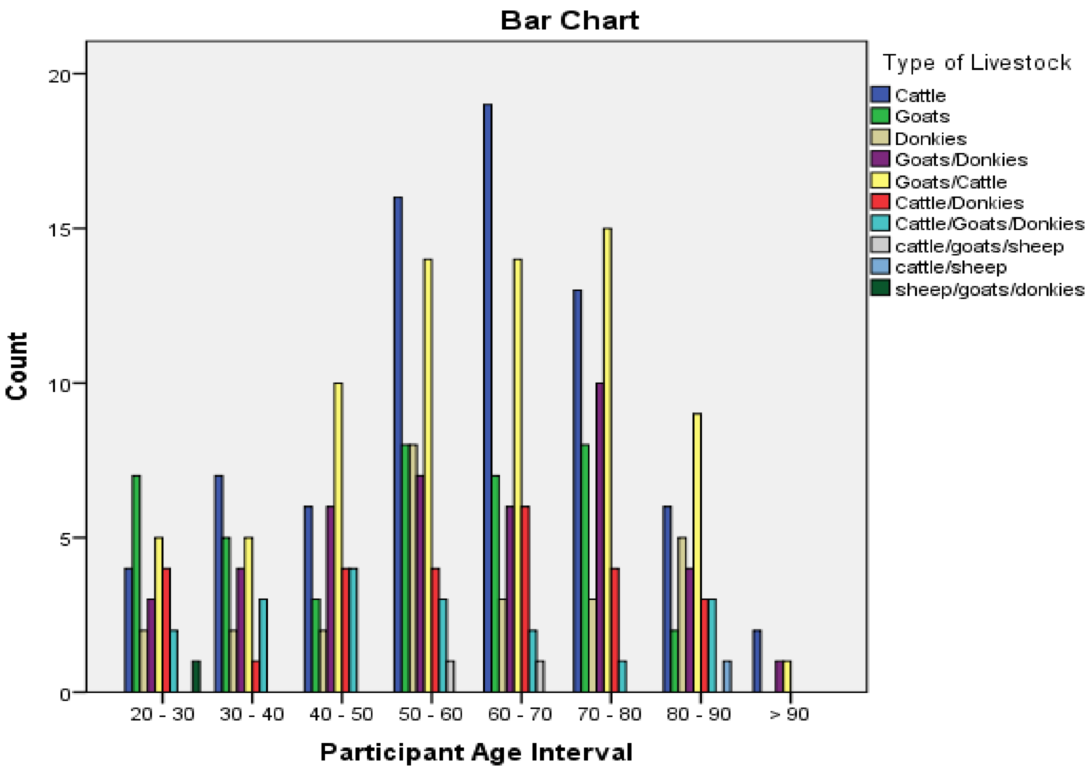

Figure 4.1: Livestock ownership based on age

4.2.2 The livestock ownership by gender of the participants

Amongst the male respondents, the goats/cattle combination was the most popular livestock combination followed by the cattle only. Among the female participants, the goats' only, were reared by the largest number of respondents followed by cattle only (**Figure 4.2**).

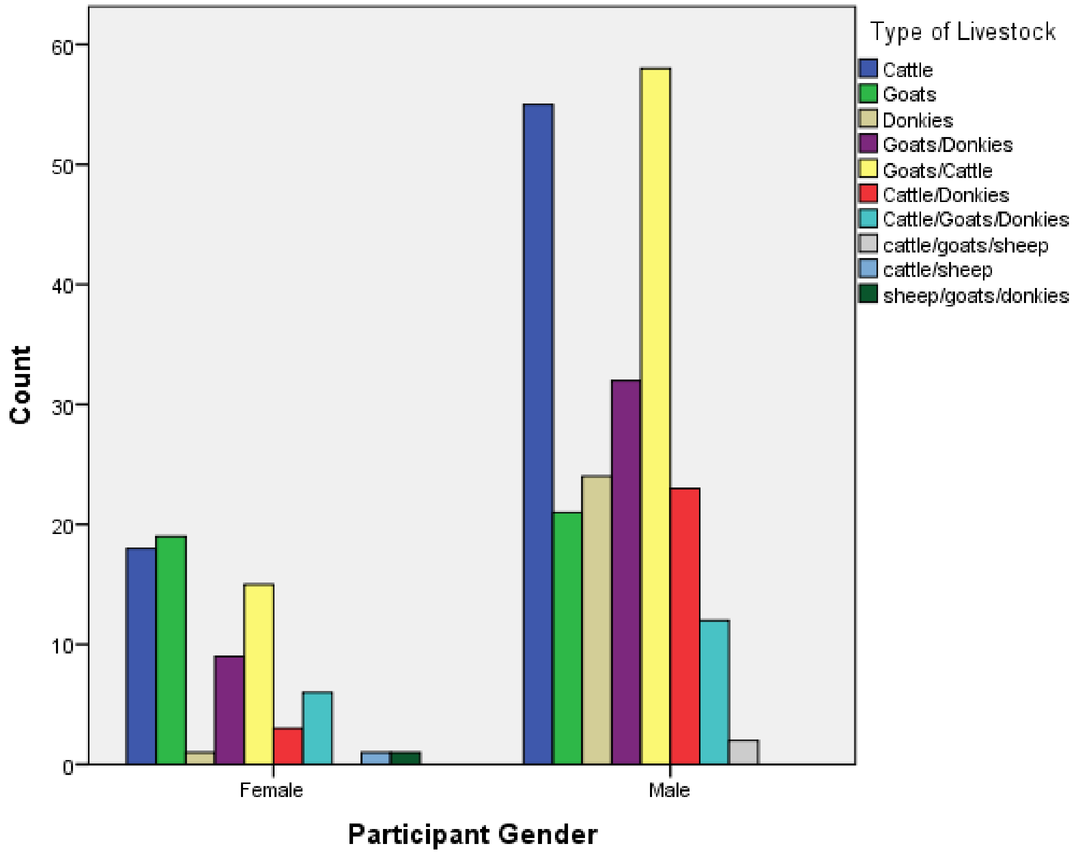

Figure 4.2: Livestock ownership based on gender of respondents

4.2.3 Livestock ownership by marital status

The married respondents owned most of the livestock combinations as shown in **Table 4.6**.They owned the most cattle (74%), the most goats (48%), and the number of goats/cattle (74%). Widows owned the next most number of cattle after the married group (**Table 4.6**).

The single parents tended to rear goats more as compared to other livestock types. Meanwhile, fewer widowers reared each of the livestock combination (**Table 4.6**).

Table 4.6: Livestock ownership by marital status of participants

Type of Livestock	Marital Status					
	Married n (%)	Divorced n (%)	Single Parent n (%)	Widow n (%)	Widower n (%)	Total
Cattle	54(74%)	5 (7%)	2 (3%)	11 (15%)	1 (1%)	73
Goats	19(48%)	2 (5%)	10/40 (25%)	9/40(23%)	0	40
Donkies	20(80%)	3(12%)	0	0	2(8%)	25
Goats/donkies	30(73%)	4(10%)	3(7%)	4(10%)	3(7%)	41
Goats/Cattle	53(74%)	8(11%)	3(4%)	6(8%)	2(3%)	73
Cattle/donkies	20(77%)	2(8%)	0	2(8%)	0	26
Cattle/Goats/donkies	12(67%)	1(6%)	1(6%)	4(22%)	0	18
cattle/goats/sheep	1(50%)	1(50%)	0	0	0	2
cattle/sheep	0	0	0	1(100%)	0	1
sheep/goats/	0	0	0	1(100%)	0	1

4.2.4 Livestock ownership by zone

In terms of number of animals, zone 5 had the highest number of animals reared followed by zones 2, 4 and 3. Zone 4 had the least number of animals (Table 4.7).

In terms of cattle, again Zone 5 had the highest number of cattle (40%), followed by zone 4(23%). Zone 2 had the highest number of goats (38%) reared, while zone 3 had the highest number of goats/donkeys combination (39%). Zone 4 had the highest number of goats/cattle combination reared (37%) followed by zone 5 and then in zone 3 (**Table 4.7**).

Table 4.7: Livestock ownership by zone

Type of Livestock	Participant Zone					Total
	Zone 1	Zone 2	Zone 3	Zone 4	Zone	
	n (%)	n (%)	n (%)	n (%)	n (%)	
Cattle	6(8%)	13(18%)	8(11%)	17(23%)	29(40%)	73
Goats	3(8%)	15(38%)	11(28%)	4(10%)	7(18%)	40
Donkeys	3(12%)	11(44%)	6(24%)	1(4%)	4(16%)	25
Goats/Donkeys	3(7%)	10(24%)	16(39%)	3(7%)	9(22%)	41
Goats/Cattle	2(3%)	6(8%)	17(23%)	27(37%)	21(29%)	73
Cattle/Donkeys	2(8%)	7(27%)	3(16%)	8(31%)	6(23%)	26
Cattle/Goats/Donkeys	4(22%)	5(28%)	3(17%)	5(28%)	1(6%)	18
cattle/goats/sheep	1(50%)	0	0	1(50%)	0	2
cattle/sheep	0	0	0	0	1(100%)	1
sheep/goats/donkeys	0	0	1(100%)	0	0	1

4. 3 Tick Control strategies used by farmers in Tsholotsho

In this section the results of the various ticks control methods and the extent of usage of the various tick control practices in the study area are presented.

4.3.1 The commercial dips

The commercial dips that were identified included tick remedies registered with the medicines council of the Government of Zimbabwe (GOZ).The respondents indicated that they had used the following commercial dipping chemicals:

- Triatix (formamidine),
- Deadline (pyrethroid),
- Amitraz (formamidine),
- Frontline (pyrethroid), and
- tick greases (deltamethrin).

4.3.2 The indigenous tick control strategies and remedies

The indigenous knowledge based methods of tick control used by the farmers were summarized as follows:

- physical tick control methods,
- control using industrial and domestic chemicals, and
- the use of plant and animal extracts.

4.3.2.1 Physical methods of tick control

The physical methods of tick control refer to the removal of ticks manually from livestock. Physical control methods (**Table 4.8**) can be any one or a combination of the following methods:

- pick and crush,
- cut (with scissors),
- pricking,
- pick and crush/cut,
- cut/pricking/ pick & crush/cut/pricking.

Table 4.8: The distribution of the physical methods of tick control

Tick control method used	Frequency	Percent
None Done	206	68.7
Pick&crush	68	22.7
Cut(Scissors)	1	0.3
Pricking	2	0.7
Pick&crush/Cut	2	0.7
Pick&crush/Pricking	9	3.0
Cut/Pricking	8	2.7
Pick&crush/Cut/Pricking	4	1.3

Out of the 300 respondents who indicated that they used physical methods of tick control, the majority (22.7 %) used the pick and crash method. Very few of the respondents admitted to using the other methods (**Table 4.8**)

Table 4.9: Proportion of respondents who used the physical methods of tick control by gender

Physical means of tick control	Participant Gender	
	Female n=29	Male n=65
Pick&crush	18(62%)	50(77%)
Cut(Scissors)	0	1(1.5%)
Pricking	1(3%)	1(1.5%)
Pick&crush/Cut	2 (7%)	0 (0%)
Pick&crush/Pricking	4(14%)	5(8%)
Cut/Pricking	1(3%)	7(11%)
Pick&crush/Cut/Pricking	3(10%)	1(1.5%)

Most females 18 of 29 (62%) who admitted to using physical methods of tick control, preferred to pick and crush ticks. Another 4/29 (14%) indicated they either picked & crushed or simply picked and pricked them. Few of them 3/29 (10%) either picked & crushed or picked and cut or possibly picked and pricked them.

As for the males, 50 of 65 (77%) the majority like their counter parts the females indicated that they used the pick& crush method. However, not many of them used the other physical methods of tick control methods (**Table 4.9**).

4.3.2.2 The use of physical methods of tick control by participants' age group

In all age groups the majority did not use the physical methods. However among those who indicated that they used physical methods of tick control the most commonly used method was the pick and crash. Few of the respondents indicated that they used the other methods (**Figure 4.3**).

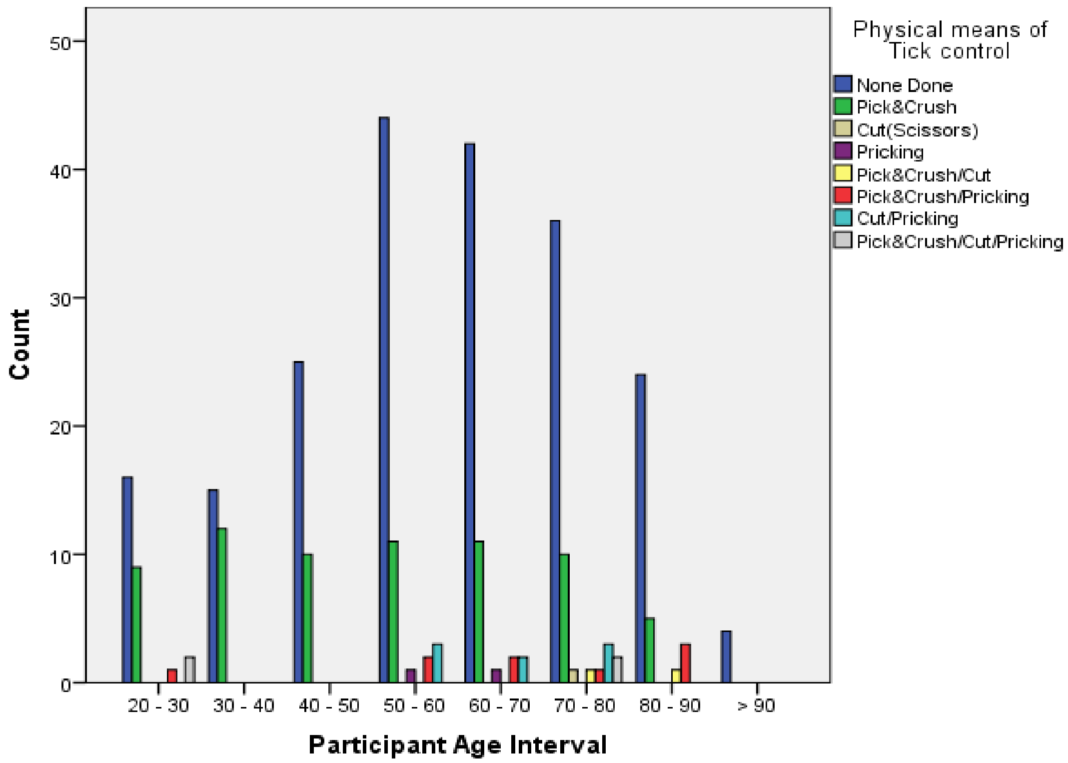

Figure 4.3: Usage of physical methods based on the age of the participants

4.3.2.3 The use of physical methods based on the marital status of the participants

Married couples use of physical methods was significantly lower (**Figure 4.4**). However among those who opted to use physical methods of tick control the most commonly used method was the pick and crash. Few of the respondents indicated that they used the other methods

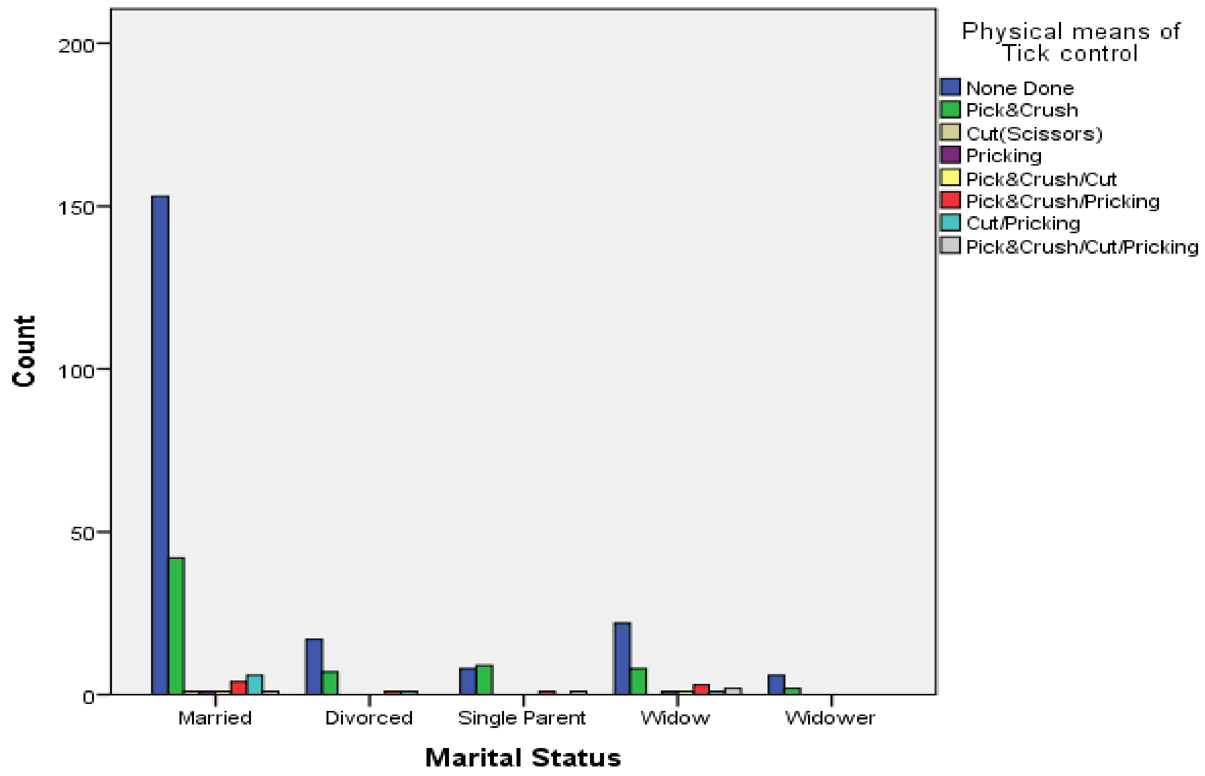

Figure 4.4: Use of the physical methods of tick control based on marital status

4.3.2.4 Physical methods of tick control by zone of origin of respondents

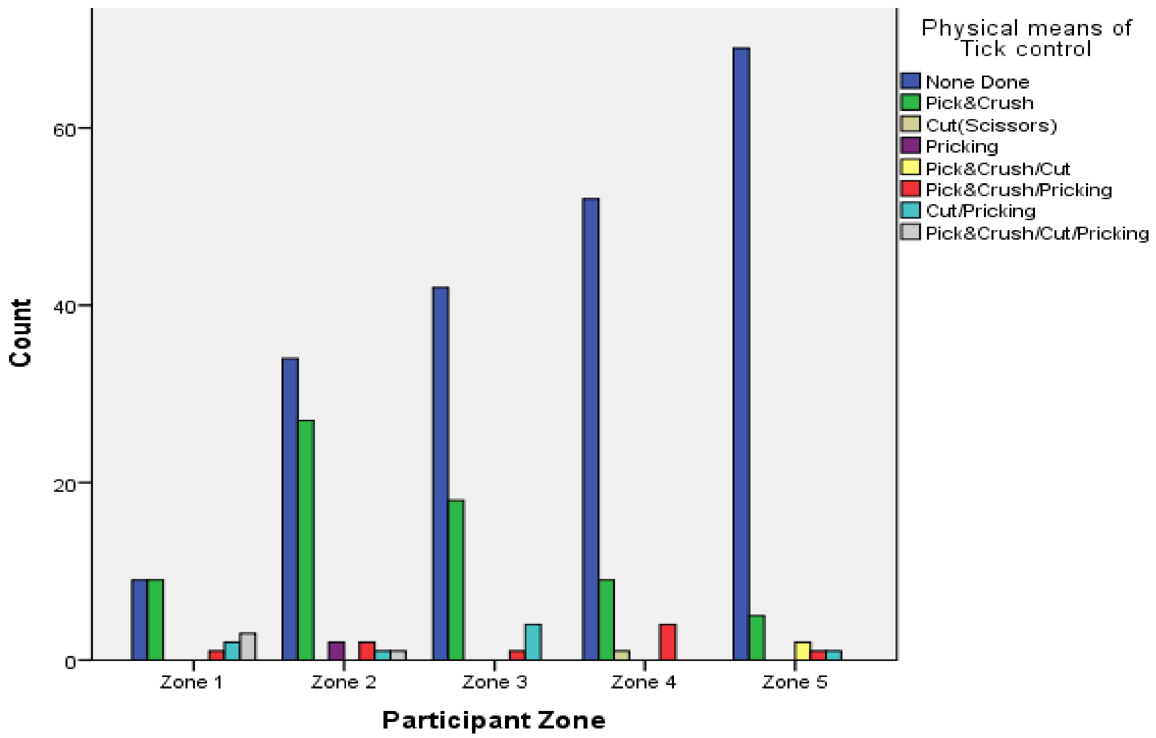

Figure 4.5: Physical methods by participants

The majority of people in each of the zones did not use physical methods of tick control (**Figure 4.5**). However among the different physical methods of tick control, the method most commonly used by the majority of people in the different zones is pick and crush. The pick and crush or prick method was also represented in all zones though by much smaller numbers.

4.3.2.5 Types of extracts used and extent of usage by demographic profile

Respondents indicated that they made use of both plant and animal extracts or a combination of the twoto control ticks (**Figure 4.6**). Plant extracts were obtained from plant roots, leaves, woody stems, barks, fruits and seeds, while animal extracts consisted of animal fats, body fluids and excretory waste products.

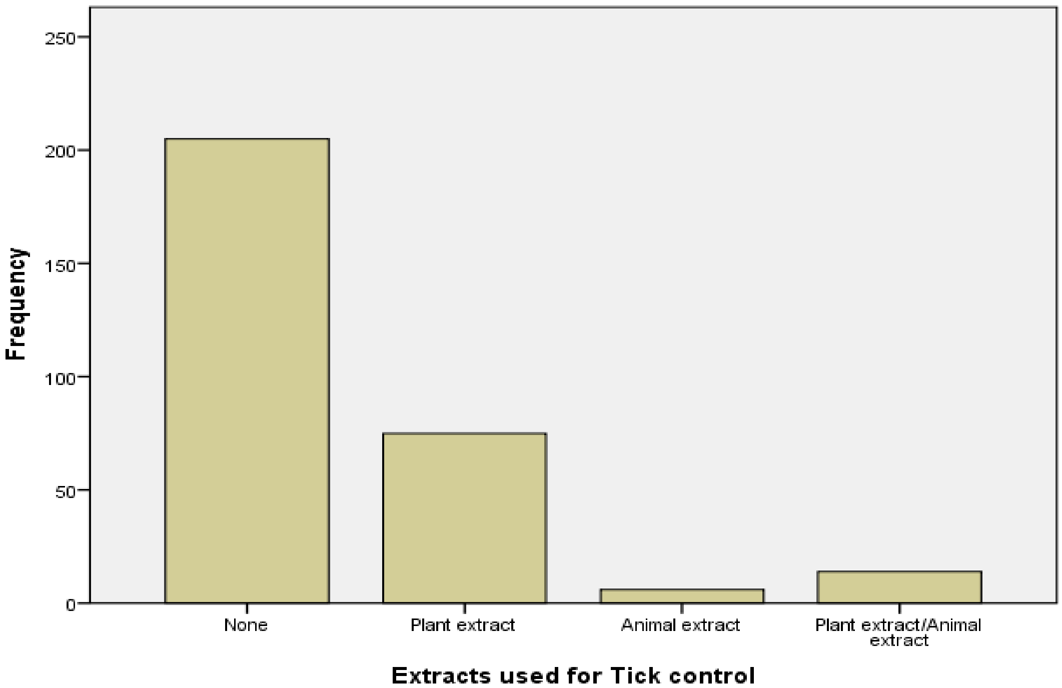

Figure 4.6: Comparative proportion of plant and animal extract used.

As shown in **Figure 4.6**, the practice of using extracts to control ticks was not wide spread as the majority of respondents indicated that they do not make use of extracts (category shown as none in **Figure 4.6**). Few people as demonstrated in **Figure 4.6** make use of the animal extracts or even a combination of the two. Respondents who admitted to making use of extracts use mainly plant extracts.

4.3.2.6 The proportion of animal and plant extracts used to control ticks

Table 4.10: Proportion of animal extracts used by respondents

Names of extracts used	Form in which remedy is used	%Use (n=6)
Arrow poison worm (*Diamphidia nigroonata*)	beetle fluid in whey dip	2(33%)
Donkey manure	plant parts and fresh dung	1(17%)
	dung in petroleum product smear	4(67%)
Sheep fats	fats in plant extract smears	2(33%
Cattle tallow	fats in plant smears	3(50%)

The most commonly used animal extract was donkey dung in petroleum products (67%) which is used as a smear. The second most commonly used extract was cattle fats in plant smears (50%), and it was also used in plant smears.

As shown in **Figure 4.8**, extract usage tended to vary with the ages of participants. In each group the majority do not make use of extracts. Among those who indicated that they made use of extracts, they tended to prefer plant extracts over animal extracts.

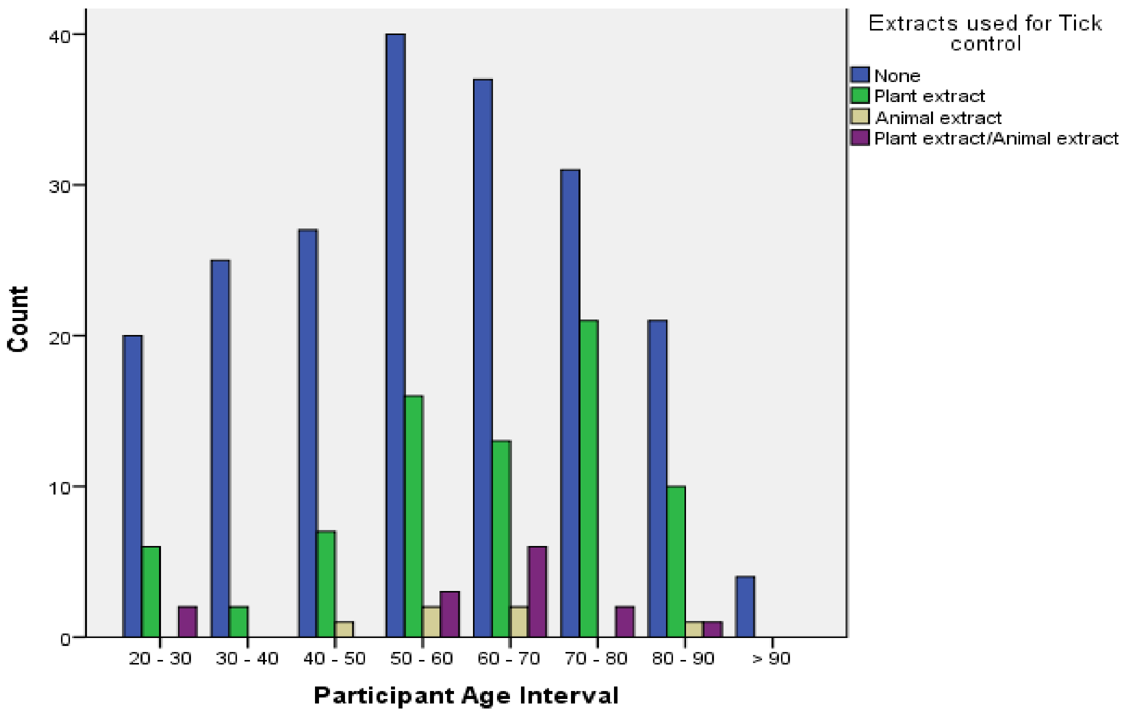

Figure 4.7: Proportion of plant and extract use based on age interval

Based on age groups, in all the age groups the majority did not make use of the extracts to control ticks. However among those who indicated that they made use of the extracts, plants extracts were the most commonly used across the age groups that were studied (**Figure 4.7**). This was followed by the plant/animal extract combination.

Table 4.11: Usage of plant and animal extract based on marital status of participants

	Extracts used for Tick control			
Marital Status	Plant extract (%)	Animal extract (%)	Plant/Animal extract (%)	Total
Married	57/75(76%)	4//6(67%)	11/14(79)%	72
Divorced	3/75(4%)	0	1/14(7%)	4
Single Parent	4/75(5%)	0	0	4
Widow	8/75(11%)	2/6(33%)	2/14(14%)	12
Widower	3/75(4%)	0	0	3

Use of extracts differed across the marital status variable. For example the married group (**Table 4.11**) tended to use both plant, and a combination of animal and plant extracts compared to the rest of the other groups, while the widows only used plant extracts. In general more respondents from the married group indicated that they made use of extracts (n=72) as compared to the rest of the other groups.

4.3.2.7 Extracts usage by gender

Table 4.12: Proportion of plant and animal extract use by different Gender

Extracts used for Tick control	Participant Gender	
	Female (n = 20)	Male (n = 75)
Plant extract	15/20(75%)	60/75(80%)
Animal extract	2/20(10%)	4/75(5%)
Plant extract/Animal extract	3/20(15%)	11/75(15%)
Total	20/95(21%)	75/95(79%)

According to results presented in Table 4.12, more males 75/95 (79%) than females 20/95 (21%) responded yes to making use of extracts. The plant extracts were used by the majority of males (80%) and females (75%). The number of male and female respondents who indicated that they made use of the plant/animal extract combinations showed no significant difference.

4.3.2.8 Plant and animal extracts used in different Zones

The use of plant extract was the most popular method in all the five zones (**Table 4.13**). In zone 5 all the respondents 31/31(100%) indicated that they made use of plant extracts only. In zone 3 the majority of respondents (82%) indicated that they used plant extracts, while no one made use of animal extracts only. In other zones (**1**, **2** and **4**) the use of the different types of extracts did not vary greatly.

Table 4.13: Comparative proportion of plant and animal extracts used in different Zones

	Participant Zone					
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n
Plant extract	5(63%)	12(67%)	13(82%)	14(64%)	31(100%)	75(79%)
Animal extract	1(13%)	3(17%)	0	2(9%)	0	6(6%)
Plant extract/Animal extract	2(25%)	3(17%)	3(19%)	6(27%)	0	14(15%)
Total	8(8%)	18(19%)	16(17%)	22(23%)	31(33%)	95

4.3.3 Chemical based tick control methods and their usage

This section shows how farmers attempt to address the problem of tick challenge using synthetic chemicals. Some of these chemicals are originally intended for tick control like commercial acaricides but others are manufactured for kitchen and toilet microbes.

4.3.3.1 Chemical based tick control methods

In the present study, chemicals not normally used for controlling ticks but had been adopted by farmers as acaricides were considered to be chemical based indigenous knowledge remedies. These are presented in **Figure 4.8** and **Table 4.14**.

Chemical based local knowledge acaricides included the following:

- petroleum products and compounds derived by combining petroleum products with other chemicals,
- household chemicals and
- compounds derived from mixing petroleum products like spent engine oil with household chemicals products ,
- mixtures of household chemicals and conventional dips.

Spent engine oil, automobile brake fluid and gear box oil were used by farmers as acaricides mixed with conventional dips or household chemicals. However, in some instances respondents indicated that they used household chemicals as plain remedies for tick control purposes (**Table 4.14**).

Some of the household chemicals that were identified included carbolineum, jays' fluid, and mosbar. Carbolineum is a commercial chemical designed for cleaning toilets. However, as the present study shows, farmers buy and use this compound to kill ticks on their cattle. According to the results of the present study, this chemical was either used as a plain remedy (not mixed with anything else) or as a mixture with petroleum products. Jayes fluid is another commercial chemical designed for cleaning toilets that farmers indicated that they use as a mixture with petroleum products and conventional dips to control ticks. As for mosbar a commercial mosquito repellent was used plain and as a mixture with petroleum products.

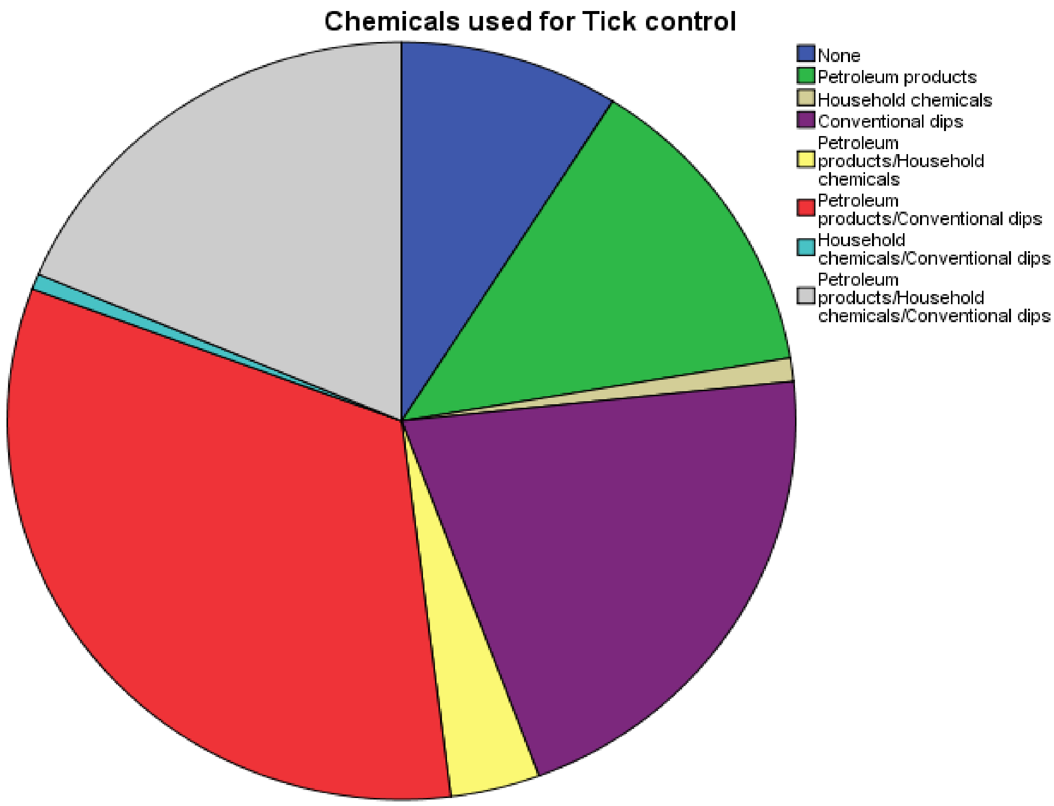

Figure 4.8: The proportion of the various chemicals methods of tick control

The majority of respondents 273/300 (91%) admitted to making use of chemicals in their different forms. The different forms and the extent of their usage are presented in **Figure 4.8**. Most respondents tended to use the mixture of petroleum products and conventional dips. This was, followed by the use of conventional dips, and then the petroleum products and household chemicals and conventional dips combination.

As shown in **Table 4.14**, 31/273 (11%) of the participants confirmed that they had used petroleum plain products, while (18%) indicated that they used petroleum products mixed with conventional dips. The other 58/273 (21%) indicated that they added household chemicals to conventional dips for use as a tick control remedy.

Table 4.14: Proportion of chemical remedies and their usage forms

Name of remedy	**Form in which remedy is used**	**Number of users n=273**
Carbolineum	mixed with petroleum products	3(1%)
	plain*	1(0.3%)
Jayes fluid	mixture of petroleum /dip	3(1%)
Mosbar	Mixed with petroleum products	5(2%)
Spent engine oil	plain*	31(11%)
	mixed with conventional dips	50(18%)
	mixture with conventional dip & household chemicals	58(21%)
Brake fluid	plain*	4(2%)
	mixes with conventional dips	30(11%)
Gear box oil	plain*	5(2%)
	mixes with conventional dip	18(7%)
Commercial dips#	plain*	63(23%)

*Plain = not mixed with anything else; #Deadline, Triatix, Frontline and Amitraz

Out of 273 participants who indicated that they made use of chemicals as acaricides, only 23% admitted to using commercial dips.

4.3.3.2 Chemical methods of tick control based on demographic profiles

The distribution of these chemicals methods by participants' age group is dealt with in bar chart **Figure 9** below.

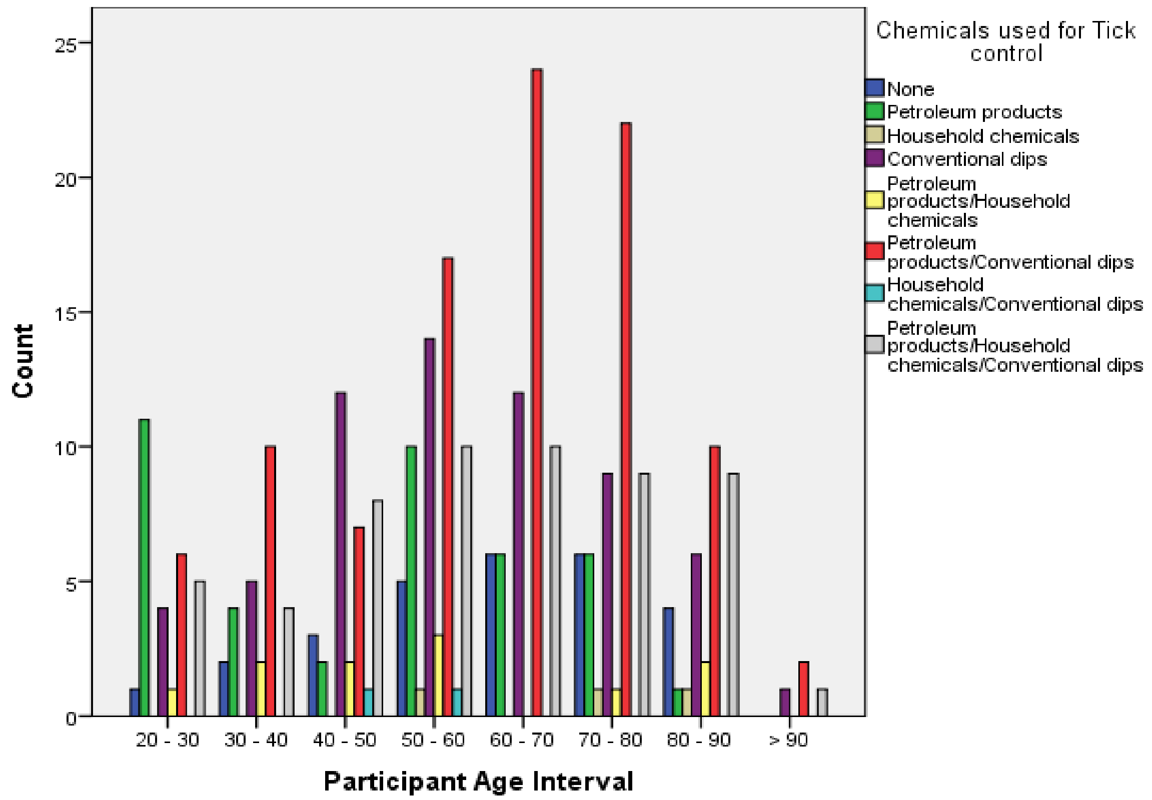

Figure 4.9: Distribution of the chemical methods by age interval

Across the age groups, the mixture of petroleum products and commercial dips were used by more people as compared to any other. The next most popular remedy across the various age groups was the conventional commercial dips. These were followed in popularity by the plain petroleum products. Of note, petroleum products seemed to be very popular with the 20-30 age group, and the 50-60 age group respectively (**Figure 4.9**).

4.3.3.3 The use of chemicals by gender

Table 4.15: Assessment of preference for chemical remedies based on gender of the respondents

	Participant Gender	
Chemicals used as acaricides	Female n = 67	Male n = 206
Petroleum products	7(10%)	33(16%)
Household chemicals	1(1.5%)	2(0.03%)
Conventional dips	18(27%)	45(22%)
Petroleum products/Household chemicals	5(7.5%)	6(3%)
Petroleum products/Conventional dips	24(36%)	74(35.9%)
Household chemicals/Conventional dips	0	2(0.03%)
Petroleum products/Household chemicals/Conventional dips	12(18%)	44(21%)

The use of conventional dips blended with petroleum products was the most common practice among both males and females. The second commonly used chemical remedy by both male and female respondents was conventional dips. Petroleum products/household chemicals/conventional dips mixture was the third most popular form in which the local knowledge based chemicals were used for tick management by both genders.

4.3.3.4 The use of chemicals by zones

Table 4.16: Proportion of participants who used chemicals by zones

	Participating Zones					
Chemicals used	Zone 1 n=22	Zone 2 n=53	Zone 3 n=57	Zone 4 n=65	Zone 5 n=67	Total n=217
1	3(14%)	13(24.5%)	18(31.5%)	3(4.6%)	3(4.5%)	40(18%)
2	2(8%)	0	0	0	1(1.5%)	3(0.04 %.)
3	22(16.7%)	16(30%)	17(30%)	17(26%)	9(13%)	63(29%)
4	1(4%)	4(7.5%)	4(7%)	0	2(2.9%)	11(0.05%)
5	7(29%)	15(28%)	8(14%)	26(40%)	42(63%)	98(45%)
6	1/22(4%)	0	0	1/65(1.5%)	0	2(0.009%)
7	**4(16.7%)**	**5(9%)**	**10(17.5%)**	**18(27.7%)**	**10(14.9%)**	**56(26%)**

1. Petroleum products; **2**. Household chemicals;

3. Conventional dips; **4**. Petroleum products/Household chemicals;

5. Petroleum products/Conventional dips; 6. Household chemicals/Conventional dips;

7. Petroleum products/Household chemicals/Conventional dips

In zones **1**, **4**, and **5** the most commonly used chemical was conventional dips blended with petroleum products. Conventional dips were the most popular in zone **2**. The conventional dips ranked second in zone **3** and third in zones **1**, **4** and **5**. The conventional dips/petroleum products/household chemicals mixture was not used at all in some zones and was thus considered to be the least popular remedy used by only two (2) people in zones **1** and **4**. Overall, chemicals were a very popular remedy in all the zones.

4.3.3.5 Chemical use based on participant marital status

Because of their status and higher numerical proportion the married were expected to use more chemicals than any other marital category.

Table 4.17: Different chemicals used in all the zones based on marital status

Chemicals used	Marital Status				
	Married	Divorced	Single Parent	Widow	Widower
	n=192	n=22	n=17	n=34	n=8
1	30(14%)	3(13.6%)	4(24%)	2(5.9%)	1(12.5%)
2.	2(0.9%)	0	0	1/ (3%)	0
3	41(19.6%)	8(36%)	4(24%)	8(24%)	2(25%)
4	5(2%)	0	3(18%)	2(5.9%)	1(12.5%)
5	69(33%)	6(27%)	5(29%)	14(41%)	4(50%)
6	2(0.9%)	0	0	0	0
7	43(20.5%)	5(23%)	1(6%)	7(21%)	0

1. Petroleumproducts
2. **Householdchemicals**
3. Conventionaldips
4. Petroleum products/Household chemicals
5. Petroleum products/Conventional dips
6. Household chemicals/Conventional dips
7. Petroleum products/Household chemicals/Conventional dips

Blended conventional dips with petroleum products was the most commonly used method among the widows (41%), married group (33%) and the widowers 4/8 (50%) (**Table 17**). The mixture of petroleum products/conventional dips/household chemicals, were the second most common method among the married respondents (20.5%). Plain household chemicals and mixtures of household chemicals with conventional dips were the least commonly used 2/192 (0.9%) among the married and 1/34 (3 %) among the widows. Other groups such as the divorcees tended to prefer the use of conventional dips.

4.4 Ranking of tick control strategies based on number of usage forms and average usage percentage.

Ranking of chemicals, plant and animal extract remedies used by farmers showed that marula was used in many more forms compared with the other methods. This was followed by castor oil bush, and the remedy that was ranked lowest was garlic (ranked number 13) (Table 4.18).

Table 4.18: Ranking of remedies based on the number of forms they were used and average usage percentage

Name of remedy	Number of usage forms	Average usage percentage	Rank
Umganu (Marula fruit)	5	35%	**1**
Umnhlakuva (Castor-oil bush)	3	30%	**2**
Igwayi (N. tobaccum)	3	25%	**3**
Donkey manure	3	17%	**4**
Iminyela (Forest corkwood)	3	13.33%	**5**
Spent engine oil	2	45%	**6**
Isinhlonhlwana (Rhino thorn)	2	33%	**7**
Commercial dips	2	30%	**8**
Uthangazana (Wild cucumber)	2	8%	**9**
Mosbar (mosquito repellent)	1	50%	**10**
Carbolineum	1	30%	**11**
Poison arrow beetle	1	10%	**12**
Garlic	1	5%	**13**

4.4.1 Ranking the physical use methods in percentages of users

Details of the different physical methods of tick control were discussed in section**4.3.2.1** of this chapter. In this section, the various physical methods of tick control are ranked based on the frequency with which they were used in the study area.

Table 4.19: Ranking physical methods in percentages of users.

Name of method	Remedy use(n= 94)	Rank
pick & crush	68(72%)	1
pick &crush or prick	9(10%)	2
cut/pricking	8(9%)	3
pick & crush or cut	4(4%)	4
pick&crush/prick/cut	2(2%)	5
pricking	2(2%)	6
cut	1(1%)	7

Ranking of physical control methods in **Table 4.19** showed that most participants 68/94(72%) preferred to pick the ticks and crush them. Therefore in the present study this form of physical tick control ranked number 1. Picking and crushing or pricking ranked number 2, while cutting ticks with scissors off the animal was ranked last.

4.4.2 Results of the test of selected ethno-veterinary compounds

This section deals with results of efficacy tests for selected remedies (**Table 4.20**). The section also presents the Wilcoxon Rank – Sum Test results.

4.4.3 Marula formulations tested for efficacy

Table 4.20: Proportions of marula formulations from each zone

Zone	Marula pulp water infusion dip (n=10)	marula seed oil decoction dip (n=12)	marula pulp water decoction dip (n=3)	marula alcohol sediments dip (n=5)	Marula fruit in animal fats smear n=5
1	4(40%)	2(17%)	1(33%)	0(0)	1(20%)
2	6(60%)	3(25%)	2(67%)	0(0)	1(20%)
3	0(0%)	2(17%)	0(0)	0(0)	1(20%)
4	0(0%)	5(41%)	0(0)	0(0)	2(40%)
5	0(0%)	0(0)	0(0)	5(100%)	0(0%)

All the respondents in zone **5** indicated that they use only marula as an alcohol sediment dip. Respondents from zones **3** and **4,** used marula in two forms only (marula seed oil decoction and marula in animal fats smear).The other two zones tended to use the marula in several forms (**Table 4.20**).The formulation which was more popular in that it was used in most zones (n=4) was marula in animal fats smear followed by marula seed oil decoction. This was followed by marula pulp infusion dip that was used inzones**1** and **2**. Marula alcohol sediments were used only in one zone. In zones **1** and **2** the infusions of marula pulp was more popular than decoction and the seed oil decoction.

4.4.4 Test for efficacy of various marula formulations on egg laying

A total of 759 ticks were collected from five zones and used in efficacy tests

(**Table 21**)

Table 4.21: Number of ticks collected from different zones

Zone	Number of ticks
1	224
2	142
3	180
4	183
5	30
Total	759

Tables 4.2.2- 4.2.6 present the effects of marula in animal fats smear, marula pulp extract dips (marula pulp infusion &decoction, marula seed oil decoction and marula alcohol sediments) on 130 pregnant (engorged) *Amblyomma, Rhipicephalus* and *Hyalomma* females.

A total of 30 engorged female ticks from zone 1 were used for the egg laying bioassay **(pregnancy test).**

Engorged *Rhipicephalus zambeziaensis* made the bulk of the 30 ticks sampled in **zone 2** during the second week of August for use in the pregnancy test.

The engorged ticks obtained from zone 3 were not sufficient for testing both the smear and dip. Therefore, ONLY the marula seed oil decoction dip was tested. A sample of 20 ticks consisting of *Hyalomma* and *Rhipicephalus* females with an initial mass of 4.90 grams per group were used.In zone 4 the pregnancy test for efficacy of the marula seed oil decoction dip and marula in animal fats was carried out. The 30 engorged ticks of average mass 0.42 gm. per tick collected from the dip tanks within zone 4 were *Rhipicephalus zambeziaensis* only.

The pregnancy test in zone 5 was done using the marula alcohol sediments dip only because the farmers did not use any other extract forms.

Test results for marula formulations (marula smear in animal fats and marula fruit pulp decoction) used in zones **1** are presented in the **Table 4.22** below. Oviposition (corresponding with increase in the weight of ticks) in tested ticks was observed from the 19^{th} to 21^{st} day in *Rhipicephalus*, while in *Hyalomma and Amblyomma it was observed* between day 33^{rd} to 50^{th} of incubation

Table 4.22: Pregnancy Test for marula in animal fats and marula fruit pulp decoction dip used in zone 1

Time in days	Dip form						Control	
	Marula smear in animal fats			Marula pulp decoction				
	Treatment mass (gm)	Δ mass	% efficacy	Treatment mass (gm)	Δ mass	% efficacy	Tick mass (gm)	Δ mass
0	6.2 gm			6.2 gm			6.2 gm	
7	5.69	-0.51	99.12	5.68	-0.52	98.96	5.74	-0.46
14	5.53	-0.67	96.85	5.3	-0.9	92.8	5.71	-0.49
16	5.48	-0.72	98.74	5.2	-1	93.7	5.55	-0.65
19	5.43	-0.95	100	5.16	-1.04	98.3	5.25	-0.95
20	5.53	-0.67	96.85	5.3	-0.9	92.81	5.71	-0.49
21	5.16	-1.04	99.4	5.11	-1.09	98.46	5.19	-1.01
22	5.13	-1.27	100	5.04	-1.16	98.25	5.13	-1.07
*23	5.31	-0.8	*104	4.95	-1.25	97.82	5.06	-1.14
*28	5.23	-0.97	*108	4.83	-1.37	100	4.8	-1.4
37	4.35	-1.85	99.8	4.42	-2	100	4.36	-1.84
40	4.39	-1.81	101	4.14	-2.06	95.17	4.35	-1.85
48	3.74	-2.46	93.03	3.72	-2.48	92.53	4.02	2.18
50	3.59	-2.61	90.89	3.6	-2.6	91.13	3.95	-2.25
52	3.01	3.19	91.18	3.2	-3	97.6	3.28	-2.92
Overall average % efficacy			96.5	Overall average % efficacy		95.99		
Mean of means % efficacy			93.84	Mean of means % efficacy		96.8		

*Laying eggs by *Rhipicephalus* treated with smears was observed by day 23.

Δ mass = cumulative change in mass

On day 0 of the experiment, the mass of the ticks in both treatments and the control was 6.2 gm. each. After seven (7) days of incubation the mass of ticks in the group treated with marula fat smear decreased by 0.51 gm. to 5.69 gm. Therefore using the formula mentioned in section 3.7.1, at this stage, the efficacy of the marula in animal fats smear was 99.12%. However, the mass decreased to 5.13 gm by day 22 and continued to fall by1.27 gm. There was a slight increase in the weight of ticks between day 23 and 28.From day 52 of incubation ticks lost weight by 3.19 gm and the efficacy of the smear was 91.18% (Table 4.22).

The mass of the ticks in the marula pulp decoction dip gradually fell from 6.2 gm to 3.2 gm after 52 days of incubation. Ticks in the control group also showed a decrease from the initial mass of 6.2 gm to 3.28 gm at the close of the experiment. Again using the formula for calculating efficacy described in section 3.7.1, the average efficacy of the dipping remedy remained at 95.99%.

Table 4.23: Pregnancy Test for efficacy of marula pulp in water infusion dip and animal fats smear used in Zone 2

Time(days)	Treatment group						Control group	
	Marula in animal fats smear			Marula pulp water infusion dip				
	Mass (gm)	Δ Mass (gm)	% efficacy	Mass (gm)	Δ Mass (gm)	% efficacy	Mass (gm)	Δ Mass (gm)
0	1.6			1.6			1.6	
1	1.13	-0.47	100	*1.2	-0.4	*106	1.13	-0.47
7	1.23	-0.37	97.62	1.25	-0.35	99	1.26	-0.34
14	1.19	-0.41	98.3	1.21	-0.38	100	1.21	-0.39
16	1.15	-0.45	100	1.15	-0.45	100	1.15	-0.45
19	1.09	-0.51	98.2	1.11	-0.49	100	1.11	-0.49
20	1.08	-0.52	99.1	0.9	-0.7	82.5	1.09	-0.51
21	0.92	-0.68	94.9	0.79	-0.81	81	0.97	-0.63
22	0.74	-0.86	94.9	0.67	-0.93	85	0.78	-0.82
23	0.6	-1	96	0.52	-1.08	81	0.64	-0.96
28	0.45	-1.15	84	0.41	-1.19	75.9	0.54	-1.06
37	0.44	-1.16	100	0.31	-1.29	70.5	0.44	-1.16
40	0.28	-1.32	93	0.19	-1.3	63.3	0.3	-1.3
48	0.14	-1.46	87.5	0.1	-1.46	62.5	0.16	-1.44
52	0.16	-1.44	88.9	0.11	-1.48	64.7	0.18	-1.42
Experimental % efficacy			88.9	Experimental % efficacy		64.7		
Overall average % efficacy			95.2	Overall average % efficacy		82		
Mean of means % efficacy			92.8	Mean of means % efficacy		75		

Δmass (gm.) = change in mass

The initial mass of ticks in each of the three test groups was 1.6 gm. After 52 days, the mass of ticks in the smear test decreased to 0.16 gm after 52 days incubation (Table 4.23). The mean average efficacy of the remedy was 92.5%.

The weight of the ticks in the marula pulp infusion reduced by 1.48 gm and the final mass was 0.11 gm (Table 4.23). Ticks in the control had a final mass of 0.18 gm which was a drop by1.42 gm. Therefore using the formula in section 3.7.1 the mean average % efficacy of the infusion remedy was 75%.

Table 4.24: Pregnancy Test for marula seed oil decoction dip done in zone 3

	Treated with marula seed oil decoction dip			Control	
Time (days)	Tick mass (gm)	Δ mass (gm)	%efficacy	Tick mass (gm)	Δ mass (gm)
0	4.9 gm.			4.9 gm.	
6	4.81	-0.09	98.8	4.87	-0.03
7	4.81	-0.09	99.6	4.83	-0.07
8	4.8	-0.1	100	4.8	-0.1
9	4.77	-0.13	99.4	4.76	-0.14
14	4.44	-0.46	98	4.59	-0.31
23	4.07	-0.83	94	4.31	-0.59
26	4.06	-0.84	95	4.26	-0.64
34	3.67	-1.23	90.6	4.05	-0.85
36	3.62	-1.28	90.3	4.01	-0.89
39	3.52	-1.38	90	3.91	-0.99
42	3.62	-1.28	94.5	3.83	-1.7
48	3.57	-1.33	95.7	3.73	-1.17
	Experimental %efficacy		95.7		
	Average overall %efficacy		95.5		
	Mean of means %efficacy		96		

Ticks from zone **3** that were used in the treatment and control groups for the pregnancy test weighed 4.9 gm on day 0.At the end of the experiment on day 48, ticks in the treatment weighed 3.57gm while the control ticks weighed 3.73 gm. The mean average efficacy of the marula seed oil decoction was determined to be 96% (Table 4.24).

In zone **4** all engorged ticks collected and used to test the effects of marula seed oil decoction and marula in animal fats smear at the end of August were *Rhipicephalus zambeziaensis*. At the beginning of the test the ticks weighed 2.42 gm. The mass of the ticks in smear treatment after 21 days incubation was 1.42 gm and the final mass of ticks in the control was 1.47gm. Therefore the mean mass efficacy of the smear was determined to be 94% (**Table 4.25**).

Ticks subjected to the decoction remedy weighed 2.42 gm at the start and 1.03 gm at the end. The mean average efficacy of this remedy was computed to be 81% (**Table 4.25**).

Table 4.25: Pregnancy Test for efficacy of marula seed oil decoction dip and marula in animal fats smear used in zone 4

Time (days)	**Dip form**							
	Marula in animal fats smear			marula seed oil decoction dip			Control	
	Treatment mass gm	∆mass(gm)	% efficacy	treatment mass (gm)	∆mass (gm)	% efficacy	Tick mass (gm)	∆mass (gm)
0	2.42			2.42			2.42	
1	1.85	-0.57	90	1.93	0.37	94	2.05	0.37
7	1.6	-0.82	94.5	1.44	-0.73	85	1.69	-0.73
14	1.37	-1.05	82.5	1.4	-0.86	84	1.66	-0.86
16	1.37	-1.05	87.3	1.18	-0.85	75	1.57	-0.85
19	1.3	-1.12	91	1.15	-0.99	80.4	1.43	-0.99
20	1.43	-0.99	96	1.09	-0.93	73.2	1.49	-0.93
21	1.42	-1	97	1.03	-0.95	70	1.47	-0.95
Experimental % efficacy			97	Experimental %efficacy		70		
Overall average % efficacy			91.2	Overall average %efficacy		80.23		
Mean of means % efficacy			94	Mean of means %efficacy		81		

The initial mass of ticks in both treatment and control was 2.75 gm. The mass of the ticks in alcohol sediments after 22 days was 1.4 gm. and for the control groups the mass was 1.65 gm. The mean average efficacy was 89% (**Table 4.26**).

Table 4.26: Pregnancy Test for marula alcohol sediments used in zone 5

	Marula alcohol sediments in seed oil decoction dip			Control	
	Mass (gm)	∆ Mass (gm)	% Efficacy	Mass (gm)	∆Mass (gm)
0	2.75 gm.	0		2.75gm	0
3	2.55	-0.2	97	2.61	0.14
8	2.03	-0.72	96.67	2.1	-0.65
10	1.91	-0.84	95.98	1.99	-0.76
13	1.86	-1.06	90.86	1.86	-0.89
22	1.4	-1.35	84.85	1.65	-1.1
Experimental % efficacy			84.85		
Overall average % efficacy			93.07		
Mean of means % efficacy			89		

4.4.5 The efficacy of marula remedies as a repellent of tick nymphs

Tables 4.27-30 present the repellent effects of marula in animal fats smear and Marula pulp extract dips (marula pulp infusion & decoction and marula seed oil decoction on *Amblyomma* (n=45)*, Rhipicephalus* (n=56) and *Hyalomma* (n=25) nymphs.

Two samples of ticks from zones 1 and 2 were divided into two for treatment with marula fruit in animal fats smear and marula pulp water infusion dip. One sample from zone 3 was treated with marula seed oil decoction dip and the smear. The sample of nymphs from zone 4 was subjected to the repellent effect of marula seed decoction dip only.

The **repellence tes**t in zone 1 measured the repellent ability of marula in animal fats smear and marula pulp infusion dip on nymph ticks. Twentynymphs of three tick species, *Hyalomma* (n=6), *Rhipicephalus* (n=7) and *Amblyomma* (n=7) were used in this test.

The repellence bio-assay in **zone 2** used a total of *Amblyomma (*n=5), *Hyalomma (*n=9) and *Rhipicephalus (*n=12) nymphs. The nymphs were put at the centre of separate filter papers treated with marula pulp infusion dip and marula in animal fats smear.

The marula seed oil decoction extract and marula in animal fats smear used in zone 3 were tested on (n = 49) tick nymphs consisting of *Amblyomma* (n=18), *Rhipicephalus* (n = 25) and *Hyalomma (*n = 5). Twenty nine of the ticks were used to test the repellent ability of the smear and 20 were used with the dip treatment.

Thirty two nymph samples consisting of *Amblyomma (*n = 15), *Rhipicephalus (*n = 12) and *Hyalomma (n* = 5) nymphs were treated with marula seed oil decoction remedies used in zone 4.

Table 4.27: Repellence Test for marula fruit in animal fats smear and marula infusion dip used in zone 1

Time in minutes	Dip Form									
	Marula in animal fats smear				marula pulp water infusion dip					
	Repelled ticks			Ticks not repelled	Repelled ticks			Ticks not repelled		
	Amblyomma	R/cephalus	Hyalomma		Amblyomma	R/cephalus	Hyalomma	Amblyomma	R/cephalus	Hyalomma
1	3	1		-		1				
2	1	2		-	1	1	1			
3				-						
4			2	-						
5				-				2	2	3
Total repelled	4	3	2	-	1	2	1	2	2	3
% efficacy	100	100	100		33	50	25			
Total repelled		9				4				
Tick total		9					11			
Average % efficacy		100					36			

Nine (9) ticks were used in the smear and 11 in the infusion dip. After five minutes exposure to the smear all the nine (9) nymphs were repelled showing that the smear had a 100% repellent ability. The dip repelled only 4/11(40 %).Therefore, using the formula described by Thorsell et al. (2006) (**see section3.7.2**), the percentage product of dividing the number of nymphs repelled by the nymphs not repelled showed that it was 36% efficacious.

Table 4.28: Repellence Test for marula pulp infusion dip and marula in animal fats smear done on tick nymph from zone 2

Time (minutes)	Marula in animal fats smear			Marula pulp water infusion dip					
	Repelled ticks		Ticks not repelled	Repelled ticks			Ticks not repelled		
	Amblyomma	Hyalomma	Amblyomma	Amblyomma	R/cephalus	Hyalomma	Amblyomma	R/cephalus	Hyalomma
1	3	1	1	1	2				
2		1			5	3			
3					1				
4								4	3
Species total	3	2	1	1	8	3		4	3
% efficacy against species	75	100		100	66.7	50			
Total repelled	5			12					
Tick total	6					19			
Average % efficacy	85.4					67.7			

The average efficacy of the marula smear in animal fats against the nymphs of three different tick species was 85.4% but that of the dip was only 67.7%.

The test for repellence in zone **3** was performed against 49 nymphs as illustrated by **Table 4.29**.After the five minutes test the smear proved to have an average repellence effect of 97.4% while the decoction dip was only 44% efficacious.

Table 4.29: Repellence Test for efficacy of marula seed oil decoction dip and marula in animal fats smear from zone 3

Time (min)	dip form									
	Marula in animal fats smear				Marula seed oil decoction					
	repelled ticks			ticks not repelled	ticks repelled			ticks not repelled		
	Amblyomma	Rhipicephalus	Hyalomma	Rhipicephalus	Amblyomma	Rhipicephalus	Hyalomma	Amblyomma	Rhipicephalus	Hyalomma
1	3		1	1	1					
2	3		1		1	1				
3						1				
4		4				3		4	4	3
5	6	10				1	1			
species total	12	14	2	1	2	6	1	4	4	3
% efficacy	100	93.3	100		33	60	33.3			
total repelled	28				9					
tick total	29				20					
average %efficacy	97.4				44					

Table 4.30: Repellence Test for efficacy of marula seed oil decoction dip obtained from zone 4

Time in minutes	Repelled ticks			Ticks not repelled		
	Amblyomma	R/cephalus	Hyalomma	Amblyomma	Hyalomma	
1	1		2	8	4	5
2	5	2	3			
3	1	5				
4	-	-	-	-	-	**-**
5	-	-	-	-	-	**--**
Species total	7	7	5	8	4	5
Tick total	36					
Total repelled	19					
% efficacy against species	47	58.3	55.56			
Average % efficacy	53					

The total number of ticks repelled was 19 out of 36. However, the dip repelled 47% *Amblyomma*, 58.3% of *Rhicephalus* nymphs, and 55.7% *Hyalomma*in five (5) minutes. It was 53% efficacious against all ticks nymphs used (**Table 4.30**)

4.4.6 The efficacy of marula remedies on tick mortality

This subsection including **Tables 4.31-4.34** deal with the ability of either marula pulp decoction, infusion or marula seed oil decoction or marula in animal fats to kill *Amblyomma* (n=168), *Hyalomma* (n= 80) and *Rhipicephalus* (n=238) within 168 hours.

The **mortality test** for efficacy of marula fruit pulp decoction dip and marula in animal fats smear used in zone 1 was tested against *Amblyomma* (n = 93), *Hyalomma (*n = 48) and *Rhipicephalus* (n=33).Each of the three groups received *Amblyomma (*n = 13*)*, *Hyalomma* (n - 16) and *Rhipicephalus* (n - 11)

Rhipicephalus zambeziaensis was 55 % of the 87 ticks sampled from zone 2 during the warmer dry part of August. These ticks consisting of *Amblyomma (*n = 21), *Hyalomma* (n =18) and *Rhipicephalus* (n=48) were used in the controlled mortality test).The two treatment groups and the control were each allocated seven (7)

Amblyomma, six (6) *Hyalomma* and 16 *Rhipicephalus.* This test was run for five (5) days.

The **mortality test** for efficacy of remedies from zone 3 was performed on 105 unclassed ticks of two tick species found in Tsholotsho district. The *Rhipicephalus zambeziaensis* species were 77**%** of the sample consisting of *Amblyomma (n* = 24) and *Rhicephalus (*n = 81). Each of the treatment and control groups received eight (8) *Amblyomma* and *Rhipicephalus (n -27)*. *Hyalomma* ticks were not available at the time of collecting the sample from zone 3.

The **mortality test** for efficacy of seed oil decoction dip was repeated in zone 4. It was done for seven (7) days with (n =117) ticks consisting of *Amblyomma (*n = 30)*, Rhipicephalus (*n = 76)*, Hyalomma* (n = 14). Since unclassed ticks were used in this test some *Rhipicephalus* females that were observed laying eggs during seven days incubation. These ticks could have been in their late engorgement stage at the time of collection.

Table 4.31: Mortality test for marula fruit in animal fats smear and marula pulp decoction used in zone 1

Time (hrs.)	Tick type			Tick type			Tick type		
	Amblyomma (n=93)			*Hyalomma(n*=48)			*Rhipicephalus(*n=33)		
	number of dead ticks			number of dead ticks			number of dead ticks		
	Marula in fats smear	Marula pulp dip	control	Marula in fats smear	Marula pulp dip	control	Marula in fats smear	Marula pulp dip	control
1	16			8					
2									3
6									
24	14	6	10	7	4	4	7		4
120	1	6	3	0	4	2	1	11	0
168	0	7	4	1	4	3	3	0	3
Live total	0	12	14	0	4	7	0	0	2
%efficacy	100	61.3		100	75		100	100	
Average %efficacy	Smear = 100						Dip =78.7		

All the three tick species exposed to marula smear died within 168 hours. Therefore, the average kill percentage for the smear according to the formula in **section 3.7.3** was 100%. Meanwhile, marula pulp decoction killed 19/31 (61.3%) *Amblyomma*, 12/160 (75%) Hyalomma, and 100% *Rhipicephalus.* In this case the average % kill of the decoction was 78.7%

Table 4.32: Mortality Test for marula pulp infusion dip and marula in animal fats smear from zone 2

Time (hours)	Tick type								
	Amblyomma n=21			Hyalomma=18			Rhipicephalus n=48		
	Number of dead ticks			Number of dead ticks			Number of dead ticks		
	Marula in fats smear	Marula pulp infusion	control	Marula in fats smear	Marula pulp infusion	control	Marula in fats smear	Marula pulp infusion	Control
1				2			12	1	1
2	7			1			1		
6							0		
24				1			1	1	2
120	7	1		2			1	1	1
Live total	0	6	7	0	6	6	1	13	12
%efficacy against species	100	14		100	0		92	0	
Total Av. % efficacy	Smear = 97				Infusion dip = 5				

The smear remedy killed all *Amblyomma*, all *Hyalomma*, and (12/13 (92%) of Rhipicephalus within 120 hours of subjection to treatment. The marula infusion killed 1/7(14.3%) *Amblyomma*, none of *Hyalomma* and1/13(7%) *Rhipicephalus*. The average efficacy of the smear was 97% and that of the marula infusion 5%.

The *Amblyomma (*n = 24) and *Rhipicephalus* (n = 81) collected from zone 3 were treated with Marula seed oil decoction and Marula in animal fats .The mortality effects of the remedies are shown in Table 4.33 below.

Table 4.33: Controlled Mortality Test for efficacy of marula seed oil decoction dip and marula in animal fats smear used in zone 3

Time in (hours)	Tick type			Tick type		
	Amblyomma (n = 24)			Rhipicephalus (n = 81)		
	number of dead ticks			number of dead ticks		
	Marula in fats smear	Marula oil decoction dip	Control	Marula in fats smear	Marula oil decoction dip	Control
1	6			18		
2						
6				3		
24	2					
120		3		3	3	
Live total	0	5	8	3	24	27
% efficacy against species	100	38		89	11	
Total Average % efficacy	Smear = 94.5			Dip = 25		

The smear killed all (100%) *Amblyomma* and 15/18 *Rhicephalus* while the decoction killed 3/8 *Amblyomma* and 3/28 *Rhipicephalus.* After exposure for 120 hours of the two remedies, the efficacy of the smear treatment was estimated to be 94.5% while the decoction was only 25% effective according to the formula for finding % mortality.

Table 4.34: Mortality Test for efficacy of marula seed oil decoction dip used in zone 4

	Number of dead ticks					
Time in hours	Amblyomma n= 30		Hyalomma n=14		Rhipicephalus n=76	
	dip	control	dip	control	dip	control
1	1		1		15	8
2						
6					3	
24	2	1			5	
72	1				4	1
168		1	2	1		1
Live total	8	13	4	6	12	27
%efficacy against species	39		33		56	
Total Average %efficacy	42					

At the end of 168 hours of treatment of ticks with marula seed oil decoction, only 50/120 ticks from the three species were killed. This translated into an average efficacy of 42% for the remedy.

4.5 Analysis of performance of various marula extracts (pulp & seed oil dips) and marula in animal fats smears)

To assess the efficacy of the different marula formulations the present study measured the statistical significance of the change caused on a population by an application on a sample of the population. The measurement compares the population to itself before and then after the application (Annexure C).

Table 4.35: Wilcoxon Rank Sum Test Analysis of the performance of marula extracts (pulp& seed oil) dips and marula in animal fats smear remedies

Test analysis	Pregnancy test	
	Marula extracts(pulp and seed oil) dip	Marula in animal fats smear
Average % decline in mass	59%	52%
Rank Sum Computed	[27,51]	[21,34]
Critical Values for which Ho is rejected:	[28,50]	[22,33]
α Value	0.05	0.2
Confidence level of Statistical significance	One sided test =95%	80%
P value	0.0465	-
	(Repellence test)	
Average % Repellence	58%	94.5%
Rank Sum Computed	[6,15]	[6,15]
Critical values for Ho is rejected:	[6,15]	[6,15]
α Value	0.05	0.05
Confidence level of Statistical significance	One sided test =95%	One sided =95%
P value	0.05	0.05
	Controlled Mortality test	
Average % Kill	59%	96.7%
Rank Sum Computed	[6,15]	[6,15]
Critical Values for which Ho is rejected:	[6,15]	[6,15]
α Value	0.05	0,05
Confidence level of Statistical significance	One sided test =95%	One sided test 95%
p value	0.0465	0.0465

The ranks [27,51] for samples on pregnancy test using marula extracts both lie outside these critical limits of the one sided Wilcoxon (6 6 α = 0.05 the lower critical value = 28 and the Upper critical value = 50). Therefore the Null Hypothesis is rejected in favour of the Alternate Hypothesis. There is a 95% confidence in that the change in mass due to the marula extract treatment is statistically significant (P = 0.0465). For the two sided Wilcoxon the ranks [27, 51] lie outside the critical values (6 6 α = 0.01 with critical values [28, 50]) from the Wilcoxon rank-sum tables and therefore the Null Hypothesis can be rejected in favour of the Alternate Hypothesis. We therefore have 90% confidence on the two sided test that the change in mass due to the Marula infusion is statistically significant.

The Rank-Sums [21,34] obtained on the change in mass by the smear test for pregnancy just lie outside the critical values obtained on the Wilcoxon table (5 5 α = 0.2 with critical values [22,33]), This means that with a confidence level of 80% the Null Hypothesis can be rejected in favour of the Alternative Hypothesis. Therefore with an 80% level of confidence, it can said that the change in mass after the application of the smear is statistically significant. Again at that level of confidence, it is acceptable that the change in mass could not have come by chance alone.

On the repellence of marula extracts (pulp and seed oil) dip the Wilcoxon Rank-Sum test produced the following values [6, 15]. These are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 α = 0.05 [6, 15]). That means the Null Hypothesis can be rejected in favour of the Alternative Hypothesis at 95% confidence level. The repelling power of the marula extracts is statistically significant and the repulsion is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6,15] with α = 0.1, it can be stated with 90% confidence that the repelling power of the marula extracts is statistically significant and repulsion was not a result of random phenomenon (P value = 0.05).

The Wilcoxon Rank-Sum test produced the values [6, 15] on repellence by the marula smear. These are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 α = 0.05 [6, 15]) .That means that the Null Hypothesis can be rejected in favour of the Alternate Hypothesis. Therefore it can be inferred with 95% confidence that the repelling power of the smear is statistically significant and it is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6, 15] with α = 0.1 there is a 90% confidence that the repelling power of the smear is statistically significant and was not a result of random phenomenon (P value = 0.05).

Concerning controlled mortality using marula extract dips (marula pulp and seed oil) the Wilcoxon Rank-Sum test produced the following values [6,15] .These are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 α = 0.05 [6,15]) . This means that the Null Hypothesis can be rejected in favour of the Alternate Hypothesis. Thence it can be inferred with 95% confidence that the number of ticks killed after application of the marula extract dips is statistically significant and it is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6,15] with $\alpha = 0.1$ has a 90% confidence that the number killed after the application of the marula extract dips is statistically significant and was not a result of random phenomenon(P value = 0.046)

The Wilcoxon Rank-Sum test for mortality using the smear in animal fats produced the following values [6,15] which are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 $\alpha = 0.05$ [6,15]) .This implies that the Null Hypothesis can be rejected in favour of the Alternate Hypothesis. The number of ticks killed after application of the smear is statistically significant at 95% confidence and it is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6,15] with $\alpha = 0.1$ has 90% confidence that the number killed after the application of the smear is statistically significant and was not a result of random phenomenon (P value = 0.046)

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

This chapter discusses the results from the questionnaire survey on participants' demographic profiles, livestock ownership and control strategies. Results of ranking of tick control strategies and efficacy of marula extracts are also discussed. The chapter also presents the conclusions drawn from the findings and the subsequent recommendations.

5.1 Biographic details of respondents

Gabalibatse (2013) reported that the age range of livestock owners in Ngami land was 15 to 90 years. This is similar to the age range shown by the present study. The age summary statistics show that there was participation from people within the 20-50 age bracket, which suggests that there is a good succession plan, in that as the old people retire from farming, there is a young generation that is willing to take over from them. Sabine et al., (2007) observed that 13.9% sons and 5.9% daughters of farmers in Tsholotsho participated in livestock production, making the young generation prospective custodians of future improved management.

The majority of the participants (69.7%) were married, and male (75.7%) who were over 20 years of age.

The age groups; 50 to 60, 61 to 70 and 71 to 80 owned the highest number of all the livestock and livestock combination in Tsholotsho, which is consistent with findings by Oladele and Rantseo (2010) in Botswana. These age groups are established participants who have built their wealth over the years, and some of this wealth is kept as livestock. In this survey, goats were the most popular within the ages of 20 to 30 years. The effect of age on goat ownership was elaborated as statistically insignificant by Ndebele et al., (2007) in the Gwayi smallholder farming area of Tsholotsho district. According to Ndebele et al., (2007) the age group of 40 years and below is just starting to breed and therefore it would be cheaper for them to own goats and use them to sustain family needs than cattle.

The skewed distribution of livestock wealth with the males owning more of every combination of livestock was expected because they are usually heads of families. This is similar to findings of other authors like Gabalibatse (2013), who also reported a 73.4% male ownership of livestock in their studies. The popular ownership of goats in the female groups (47.5%) is probably due to the fact that goats are cheaper to acquire and look after. The maintenance costs for goats are lower than those of cattle as goats are browsers rather than grazers and are smaller than cattle. The Organization of Rural Associations for Progress (ORAP) (2013) cited by Phiri et al., (2014) articulated that women in Tsholotsho embraced their small livestock programs motivated by the realization that goats are more drought tolerant than cattle and cheaper to feed during periods of stress. Moreover Agriculture and Technical Extension (AGRITEX) services Tsholotsho (2013) cited by Phiri et al., (2014) asserted that the preference for goats among women was influenced by training through Non-Governmental Organizations (NGOs) such as ORAP. However Nsoso et al., (2005) suggests that because of the inability of women to access farmlands that tend to own less livestock and prefer trade instead. This could explain the lower number of females (24.7%) who owned cattle as compared to their male (75%) counter parts.

The married group owned the largest number of each of the livestock categories. For example they owned most cattle, goats, goats/cattle and the other categories. That was expected as marriage offers stability, with females staying home to look after animals, which is conducive for the increase in number of livestock. Marriage also provides for sharing of responsibilities and making decisions pertaining to management of livestock. Widows were next in terms of numbers of cattle owned after the married group. This could be attributed to the fact that they had opportunity to gather cattle during the time when their spouses were still alive and thus inherited the livestock after the death of the spouse, Gabalibatse (2013).

The single parents group had goats (25%) as their most popular possession. This supports the notion that goats are cheaper to procure, easier to look after, and cheaper to maintain.

Negassa and Jabbar (2008) described ownership of livestock in communal areas as part and parcel of the rural people’s livelihoods. However, most rural farmers in Tsholotsho cannot afford maintaining livestock on orthodox medicines and hence resort to indigenous knowledge based methods by default as reported earlier on (ICRISAT, 2008; Homann et al., 2007). In the next section the various local knowledge based tick control methods used by farmers in Tsholotsho are discussed.

5.1.2 The physical methods of tick control

As reported in chapter 4, farmers in the study area employ local knowledge based tick control strategies. These include: physical, chemical and plant & animal extract control methods.

Of the local knowledge based tick control strategies that were identified, the popularity of physical removal (grooming) and the use of extracts for tick control, differed very slightly. These methods are not financially expensive according to Moyo and Masika (2009) and Lorusso et al., (2013), but they are time consuming, labour intensive and tedious as they entail picking, pricking or cutting ticks one by one on each animal. Therefore the method is best suited for the tamest small bodied animals of the herd that are placid enough to allow their owners to touch them. In view of this, it is not possible to apply these methods to all the animals in the herd and to all the parts of the body especially if the herd is large. However, physical tick control methods are commonly used by farmers like the Fulani of Nigeria who were studied by Maina (1986). According to these authors, the Fulani have time on their hands, and are patient, with lots of energy to expend on such activities. Therefore, such methods are more practical with farmers who own few livestock. The number of livestock owned, is therefore a limiting factor when it comes to using of physical methods for controlling ticks. In Tsholotsho the average cattle ownership was high (73%) and therefore this could explain why the method was not popular among the farmers who were studied. Sutherst & Bourne (1977) further questioned their effectiveness when applied on important reproductive organs of the animal. This could also explain why these methods are not so popular in the study area.

There were more males than females in this survey. This could explain why they were over represented in the use of the physical methods compared to females. However, the general trend was that the more livestock one owned, the less likely they are to use physical methods of tick control as the numbers of livestock becomes prohibiting. Sajid et al., (2009) observed that small holder dairy farmers with fewer numbers of livestock relied more on the physical methods as the farmers would be able to manage the fewer livestock. The age group between 40 and 80 years owned the bulk of the livestock and would not have the time to pick ticks on each individual animal they own. The age group above 90 years old would simply not have the energy to do such activities. This explains why among these age groups, very few indicated that they used physical methods of tick control.

The single parents were the only group in which more than half of the respondents (58%) indicated that they made use of the physical methods of tick control. This could be that they used it on goats, given up to 25% of them owned goats. Fewer widowers use physical removal despite them having fewer livestock probably because they simply do not have the time to control ticks physically. The same reasoning applies to the divorcees as well as widows.

However maybe because of low costs associated with this method; especially if the ticks are just hand-picked and crushed, pricked or cut, it was practised by all categories of respondents. It was practised by all age groups, both genders, all marital statuses and in all zones that were sampled in Tsholotsho. However, the method is tedious and unhygienic. Masika et al., (2008) cited by Jonsson (2005), are of the view that it promotes sepsis in animals because when ticks are irritated they tend to regurgitate saliva carrying pathogens into the skin at sites of attachment. This method can reduce tick populations but does not lead to reduced tick borne disease occurrence making it the least effective control method (Masika P.J & Moyo B, 2009).

5.1.3 The use of extracts to control ticks

From the analysis of numbers of livestock owners who use indigenous knowledge based methods, the use of extracts differed slightly with that of physical method. The extract methods are relatively cheap as the plants and animals used are freely available. Time wise however they are more tasking compared to the chemicals methods of tick control as farmers have to devote time to collect and process them. Once processed, their use and application is as easy as the chemical methods, and are less tedious to apply than the physical methods of tick control.

The use of extracts to control ticks is likely to be preferred by farmers with more livestock but cannot afford commercial dips, and in addition have the time and energy to collect, process and apply the concoctions on their animals. The use of pure plants extracts (extracts from a single plant) by farmers in Tsholotsho is preferred to the other two extract form (animal extracts and plant/animal extracts forms), which is in agreement with work done in Ghana and Ngami land-Botswana (Gabalebatse et al., 2013; Awumbila & Bokuma, 1994). The latter showed that in Botswana, farmers tended to use a single plant extensively.

The biggest challenge of using plant remedies is lack of enough research to rule out toxic effects on animals. The only reference to efficacy mentioned by farmers in this study is where they use Bushmen poison arrow worm and the rhino thorn intentionally for their known poison potency. All the same, farmers do this without enough scientific proof of their in vivo performance against ticks (Jackson, 1990).

Unlike in the study area (Tsholotsho), the efficacy of herbal tick remedies used by farmers in Ngami land was investigated and integrated into veterinary extension services by the government of Botswana (Gabalebatse et al., 2013). The author of this study is of the view that the Government of Zimbabwe needs to adopt this approach so as to foster these indigenous knowledge based systems.

In terms of gender preference the number of male and female respondents from each group who indicated that they made use of the plant/animal extract combinations showed no significant difference (Table 4.12). However findings of this study showed that in Tsholotsho 79% males compared to 21% females use plant extracts. This contradicts findings from other studies on ethno veterinary practices that noted that use of plant extracts as remedies was more popular among female respondents as compared to their male counterparts. The former are known to be very proactive and their knowledge is rated to be equal to that of their husbands and sons (Gabalebatse et al., 2013).

The use of herbal tick remedies including the least used animal extract shows a central tendency around the 50-60, 61-70 and 71-80 age groups (Figure 4.7). This pattern of usage conforms to studies done earlier on that showed that usage of local based remedies among the younger generations was low and thus at a risk of extinction following the death of the elderly custodians of the requisite traditional knowledge (Yineger et al., 2008; Hamilton, 2003; Zuberi, 1999).

5.1.4 Chemical methods of tick control

The use of commercial dips is prohibited by affordability and in addition considering the economic situation in Zimbabwe, by availability of the dipping chemical. However, despite this limitation chemical methods of tick control have been shown to be the most preferred way of tick control. This is because in the chemical group of remedies, there are chemicals that the farmers use that are less expensive and are abundantly available.

The use of chemicals is less labour intensive and less time consuming as well. Therefore, many farmers are likely to prefer them to the other two methods of tick control discussed above, more so if they can afford them. The major disadvantage of the chemical method of tick control is that handling of chemicals is associated with accidents. The other weakness associated with this method is that farmers have a habit of adulterating orthodox acaricides to improve their efficacy. Unfortunately, mixing of orthodox commercial dips with other chemicals has not been scientifically proved to improve on their efficacy. Furthermore, prolonged use of petroleum products may pose the risk of lead poisoning in meat and milk products, skin irritation and inflammation (Mbati et al., 2002; Masika et al., 1997) .These writers reported petroleum products especially spent engine oil to contain lead at about 500mg/100 ml.

The most commonly used combination of chemicals across the age groups was the petroleum products/commercial dips. This is interesting because all the farmers probably prefer using commercial dips but because they are expensive and not readily available, the farmers get whatever they can and mix it with available and affordable petroleum products to increase the quantity. Any combination that includes commercial dips is quite popular for reasons that include the following: ease of preparation, user friendly, reliable performance and long shelf life.This poses a problem in that it compromises dose rates by over dilution of acaricides or using them in high concentrations (Swai et al., 2005; Awumbila & Bokuma, 1994).

The efficacy of any acaricide is lowered by adulteration, dilution and other forms of tempering .The same authors argue that these practices by farmers reduce the concentration of acaricide to non-lethal levels thereby exposing parasites to sub-lethal levels of active ingredients leading to development of resistance in ticks. Over dosing or use of high concentrations is a waste of resources and may lead to poisoning of the animal or human beings and environmental health risks (Addah et al., 2009).

It was observed that persons in the age groups 60 to 70 and 71 to 80 preferred to use chemical methods for controlling ticks in their herds as compared to other age groups. This could be related to the fact that owning large numbers of livestock especially cattle as was observed in the two age groups, requires methods that are less labour intensive and more practical to use compared to the other two methods discussed above.

It was observed that the married group uses the chemicals methods more than the others groups. This could be because they are more represented but also because they also own more livestock than the other groups. The dominance of the use of combinations that include mixtures with commercial dips could be due to reasons already mentioned.

The household chemicals/commercial dips combination, which was used only by the males and not any of the other female respondents, could be due to the fact that females prefer to use their household chemicals for house hold cleaning rather than using them on livestock, while their male counterparts would gladly use them for tick control given their attachment to their livestock as a source of wealth and therefore more important compared to house hold chores.

The difference that exists between males and females in the use of household chemicals to control ticks, shows that farmers need to be educated along the objectives set by ILRAD of redressing tick control approaches and strategies of particular groups of cattle keepers. The methods have to be bio friendly and also accessible to all the communal livestock keepers, including those who are poor and cannot afford transport costs to veterinary and retail outlets as well as the costs of synthetic products.

5.2 Ranking of the different tick control strategies

Ranking of chemicals, plant and animal extract remedies used by farmers in Tsholotsho showed that marula was used in many more forms compared with the other methods. Marula (*Scleorocarpus birrea)*, **Greek σκληρός,**"hard", and **κάρυον**, "nut", is a plant with a stony nut shell inside the fleshy fruit pulp that the farmers in Tsholotsho crush and use in five different forms to control ticks (Table 4.20). The Zulus of KwaZulu Natal (KZN) according to Hutchings et al., (1996) and also use it for controlling ticks on livestock. However, there is no recorded work on efficacy of the remedy. Lombard et al., (2005) and Arnold et al., (1983) stated that "harvesting of fruit from marula does not present any direct environmental risk" and estimated that a single marula tree yields between 2 100 – 9 100 fruits in a season. Gouwakinnou et al., (2011) referred to it as "tree of life" owing to its ability to provide food, shelter, medicine, fuel, ornaments as well as forming an integral part of the spiritual and cultural rituals of indigenous communities. This makes it the best suited bio-friendly plant for use to assess the efficacy of a selected local based tick control remedy as indicated in the objectives of the present study.

The water prepared infusions and decoction extract forms were the most popular in four of the five zones studied. This is consistent with 82% infusion and decoction preparation of EVAs studied by Van der Merwe et al., (2001) among Tswana people in North West of Pretoria. The use of marula alcohol dips was confined in zone 5 only. One major advantage of using marula fruit is that the shelf-life of the fruit extracts is very extensive and can exceed three years when processed into juice, alcoholic beverages (wine and beer) and jam for storage underground in sealed clay or plastic containers. The farmers can therefore store and use the dip in a viable state whenever there is a tick challenge even if it is not the season for the marula fruit. This property makes the alcohol sediments of the dip ideal for trade.

The marula fruits that farmers use for various purposes in different forms are rich in ascorbic acid (168 mg/100 g) Viljoen et al., (2008), and the fruit juice contains sesquiterpene hydrocarbons including caryophyllene, α-humulene, and copaene (Mariod & Abdelwahab, 2012). The fruit kernels contain high amounts of oil (47 mg/g dry weight mostly due to oleic acid), protein (36.4% dry weight), and are a good source of minerals (Cu, Mg, and Zn at 24.8, 4210, and 62.4 μg/g dry weight, respectively) Jama et al., (2008). The oil-rich seeds contain oleic, myristic, and stearic fatty acids and different types of amino acids, with a predominance of glutamic acid and arginine. It is possible that one of these chemicals contain one or more of the active ingredients that make marula a good acaricide.

5.3 Efficacy of marula remedies

In this section, results of the efficacy tests for marula extract dips and smears are presented.

5.3.1 Pregnancy Test

The marula fruit extracts were observed to have a moderate impact on the reproductive capacity of ticks in that it hindered tick oviposition and moderately (59%) affected the mass of pregnant ticks. It has been suggested that a control method that does not wipe out ticks completely is good as it allows for endemic stability. According to Jones et al. (1968) and Paull (1980) cited in AU-IBAR (2013), the advantage of endemic stability is that the animals are continually challenged and hence are able to build and maintain immunity**.**

5.3.2 Repellence Test

The results of the repellence test in zone 1, 2 and 3 showed that marula in animal fats smears were 100; 85.4 and 97.4% efficacious, yielding 94.5% average efficacy (Table 4.35). A high repellence capacity of the remedy with or without the killing of ticks is a welcome property, especially for a smear remedy which can only be applied on specific areas like the predilection site (i.e. the udder and scrotum) to perform a specific function of protecting those specific sensitive areas against tick bite wounds (Rajput, Hu, Chen, Abdullah G. Arijo, et al., 2006; Drummond, 1983). Ticks damage production and reproduction organs especially of cattle. Therefore there is a need for direct protection against tick infestation using effective remedies that can keep ticks away from such important parts of the animal. Based on the findings of the present study, the marula in animal fats smear is therefore most ideal for this purpose. This could be because it concentrates the active ingredients on the area of application unlike the infusion and decoction that diffuse and spread away from the point of application thereby diluting the concentration of the active ingredients on the point of application.

5.3.3 Mortality Test

During the mortality test, the marula smear killed all the ticks (100%)**.**This shows that the marula smear is very effective if used on predilection sites such as the reproductive organs. This is because at such sites a zero tick presence is a necessity. This high kill rate together with its high repellence activity makes the smear an ideal acaricide for application on predilection sites to prevent ticks from attaching on the animal.

On the other hand, the performance of marula dip extract was observed in four zones to have a lower kill rate of 78.7; 5; 25 and 47% consecutively (Tables 4.31-4.34). This notwithstanding, one of its advantage is that as a dip, it is easy to apply on the body Zahid et al., (2006). Based on the results that showed that its average kill was 59% (Table 4.35), the marula dip could be considered to poses a moderate average percentage kill. This moderate average percentage repellence capacity and moderate average percentage anti - tick pregnancy capacity makes it a potential acaricide remedy for the following reasons:

- The percentage kill rate of **60%** is almost the same as the marula dip extracts of **59%**. This does not wipe out the tick population that is susceptible to the remedy which keeps the remedy effective and marketable for a long time. Wiping out the susceptible population results in the multiplication of the resistant population which renders the acaricide useless.
- The moderate per cent kill rate and moderate per cent repellence is ideal as it does not wipe out tick infestation and leave cattle naive. This leaves animals susceptible to tick borne disease on even the slightest exposure.

The qualities mentioned above promote **endemic stability**, whereby the cattle are exposed to adequate tick amounts for their immunity to be constantly exposed to and challenged by moderate levels of tick borne diseases (African, 2013; Coleman et al., 2001; Paull et al., 1980; Jones et al., 1968). The importance and desirability of these characteristics cannot be overemphasized.

5.4 Conclusions and recommendations

Results of the present study showed that farmers in the study area employ both conventional and unorthodox methods of tick control like physical removal of ticks and use of non-conventional chemical remedies that are not commercial dips. Some of the unorthodox practices like mixing commercial dips with other chemicals can have unintended consequences like promoting tick resistance. The present study did not consider whether farmers observe any form of withdrawal periods following treatment of animals with remedies like chemicals. The author is of the view that if withdrawal periods are not observed following the use of chemicals like engine oil or other petroleum products that have a high content of heavy metal, these chemicals could end up in the food chain and hence poison the consumers of products from such animals. In view of this, a study is needed to establish if any form of withdrawal period is observed and if farmers are aware of the dangers of using some of the chemicals that have potential to harm the health of the consumers of products from animals that have been treated.

The preference for the different methods is not uniform across the 5 zones and even age groups and gender even though chemical methods were preferred more by participants than the other two strategies like the use of extracts and physical removal that differed slightly. Blended conventional dips with petroleum products were most popular across three (3) of the five (5) zones, across all age, marital and both gender groups. Single parents who tended to rear goats mostly tended to prefer the use of physical methods. The use of plant extract was the most popular method in all the five zones, across all age and gender groups. However, it was the married group mainly that made use of extracts compared to the other groups.

The ranking score of chemicals, plant and animal extract remedies used by farmers does not preclude their efficacy but is rather a demonstration of their popularity and also bio-friendly considerations. Garlic for instance ranked number 13 and last but has been proven by other researchers to be highly efficacious and so was spent engine oil and jays fluid. The pick and crush method with highest rank status among farmers in this study is also very popular among cattle breeders elsewhere like the Fulani of Nigeria and some pastoralists of Uganda mentioned.

The marula extracts proved to be efficacious in their current forms. They were shown to be able to act as repellents, mortality agents and hinder egg laying in ticks. Based on the findings of the present study, the use of marula as an acaricide is promising. In view of this, the author recommends further studies to be done so as to isolate the active ingredients in the marula extracts used by the farmers in the study area.

5.5 Limitations of the study

The present study depended on farmers indicating the tick control methods that were used in the study area. As Rathore et al, (1997) argued, due to the low level of education of the farmers, it is possible that they were not able to recall all the different methods of tick control used in the study area. It has been shown that local/native healers and animal owners may not be in position to distinguish between the various types of industrial chemicals used as remedies. It is therefore possible that the list of local tick control strategies provided in the present study could have been more exhaustive if the farmers' level of education had been considered.

Ranking of alternative tick control remedies was based on use forms, and did not consider the efficacy of the most popular remedy. For example, although garlic was ranked number 13 and last, it has been proven by other researchers to be highly efficacious and so was spent engine oil and jays fluid. It is therefore possible that if the active ingredients of the remedies was used to rank the remedies, or that the remedies were ranked based on their mode of action, a more efficacious solution could have been found. Therefore since the present study did not consider these, the resultant assessment may not be an accurate estimate of the most efficacious remedy.

To better understand why farmers opt for alternative tick control remedies, more research is needed to find out their level of understanding of how acaricides work. The present work did not consider this aspect and hence, it is not possible to deduct based on the findings of the present study why farmers opt for the various methods of tick control.

Additional work on ingredients of marula fruits needs to be done on specific bio friendly properties such as bio-degradability and residual persistence within and without host animal.

CHAPTER 6

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ANNEXURES

Annexure A: Questionnaire

TICK CONTROL PRACTICES IN COMMUNAL TSHOLOTSHO

Name of Farmer (interviewed)…………………………Dip tank zone………………

Name of Village …………………………Name of dip tank…………………………….

Age range: >20-40 □ 41-60 □ 61-90□ >90□

Sex M □ F □ Cell/Phone No……………………………

Status…………….Owner □ Spouse □ Child □ Guardian □

No of stock owned: cattle □ goats □ sheep □ donkeys □

PART 1.

Commercial □	**Manual □**	**Indigenous □**	**Indigenous Other □ (STATE)**
	□Pick & crush	**□Plant extracts**	**I............................**
	□Cutting with scissors	**□Soil extracts/mixtures**	**Ii............................**
		□Soot	**Iii...........................**
	□Pricking		
		□Animal extracts	**iv............................**
	□Other: state		
		□Petroleum products	
		□Household chemicals	

PART 2 **Answer only if using plant extracts as control methods**

WHICH PART OF THE PLANT DO YOU USE?			**HOW DO YOU PREPARE REMEDY?**			**HOW DO APPLY IT ON THE ANIMAL?**
root	bark	soot	leaves	fruit	□water infusion □oil infusion □fresh □ other..............	□spray □pour □sprinkle □smear□other: State

					□water infusion □oil infusion □fresh □ other.....................	□spray □pour □sprinkle □smear □other: State
					□water infusion □oil infusion □fresh □ other.....................	□spray □pour □sprinkle □smear □other: State

PART 3 Answer only if you are using animal products as control methods

RESPONDENT	INGRIDIENTS OF PRODUCT USED?					HOW DO YOU PREPARE REMEDY?	HOW DO YOU APPLY IT ON ANIMALS?
	blood	fats	bile	faecal waste	Other i........... ii........... iii...........	□water infusion □oil infusion □fresh □ other.........	□spray □pour □sprinkle □smear □ Other.........

						□water infusion □oil infusion □fresh □ other.........	□spray □pour □sprinkle □smear
						□water infusion □oil infusion □fresh □ other.......	□spray □pour □sprinkle □smear

PART 4 **Answer only if you are using petroleum and or household chemicals as control methods**

RESPONDENT		INGRIDIENTS OF PRODUCT USED?					HOW DO YOU PREPARE REMEDY?	HOW DO YOU APPLY IT ON ANIMALS?
1		blood	fats	bile	faecal waste	Other i........... ii........... iii...........	□water infusion □oil infusion □fresh □ other.........	□spray □pour □sprinkle □smear □ Other.........
2							□water infusion □oil infusion □fresh □ other.........	□spray □pour □sprinkle □smear
3							□water infusion □oil infusion □fresh □ other.......	□spray □pour □sprinkle □smear

PART 5

If you answered other to questions above then complete the questions below;

1. What method do you use most?

Ans

____

_____

2. What do you use to prepare your favourite remedy?

Ans:____

____

3. How do you prepare the remedy?

Ans:____

____

4.How do you apply it on livestock?

____

____

PART 6

1. How helpful are your control methods? □doubtful □useful □very useful

2. State any bad effects of the remedies on:

People____

____

____

Livestock____
____
____

Environment____
____
____

3. Would you agree to have your remedies improved to be more user friendly and more effective? Yes □ No □

4. If your answer is yes, which two of the indigenous remedies you have stated would like to have improved?

Remedy A:_______________________Remedy B:______________________________

Interviewer……………………………………………Signature………………………………

Date…………………

Annexure B: Consent form

APPENDIX: INFORMATION LEAFLET AND INFORMED CONSENT FORM

Participant Information and Informed Consent for farmers in Madonna village of Tsholotsho rural district council, Division of Livestock and Veterinary Services, Matabeleland North Province, ZIMBABWE:

PROJECT TITLE:

TICK CONTROL PRACTICES IN COMMUNAL TSHOLOTSHO

Project researcher: Mr Christopher J. Mkhize

Dear Farmer (s),

You are being invited to participate in a research study about effectiveness of indigenous tick remedies. This research project is being conducted by Mr. Christopher J Mkhize, University of South Africa (UNISA) and Florida Campus;

The main objective of this study is to make a contribution by looking at the efficacy of bio-friendly natural acaricides and document the way they are prepared and applied. It will determine also the best preparation and application technique.

There are no known risks if you decide to participate in this research study, nor are there any costs for participating in the study. The information you provide will help me understand how best to satisfy the needs of animal health and production among the communal farmers. The information collected may not benefit you directly, but what I learn from this study should provide general benefits to communal farmers, government, and researchers.

This survey is optional. If you choose to participate, and a decision not to participate will not in any way be used against you. The study will be done with your full participation and your involvement will be throughout the study, you are not obliged to write your name on the questionnaire. No one will be able to identify you, nor will anyone be able to determine which village you come from should you choose so. No one will know whether you participated in this study. Nothing you say on the questionnaire will in any way influence your present or future in the society.

Your participation in this study is voluntary. If you choose to participate, please submit your completed questionnaire to the relevant researcher. Questionnaires are collected by the Researcher. If you prefer, you may email the survey to: Mr. Christopher Mkhize, UNISA Student, Division of Livestock and Veterinary Services Tsholotsho, and Animal Health. If you have any questions or concerns about completing the questionnaire or about being in this study, you may contact me at

2637743535580 or at chris2008mkhize@yahoo.com

The UNISA Research Board has reviewed my request to conduct this project. If you have any concerns

About your rights in this study, please contact Dr J.W. Oguttu of Agriculture and Animal Health, P.O. Box 392 UNISA, 0003, Department of Animal Health and Human EcologyFlorida Campus on

(011) 471-3353or emailjoguttu@unisa.ac.za or contact Dr Francis Babi on francisbabi@gmail.com

1. WHAT YOUR PARTICIPATION IN THE STUDY ENTAILS

If you decide to participate in this study, you will be required to do the following:

- To sign this informed consent form;
- To identify and provide information on ethno veterinary medicines used to control ticks this will be conducted in form of a survey.
- To allow the researcher to collect ticks samples with your assistance on livestock on

the morning before dipping.

- To be present on day of visit at your homestead and assist in answering questions.

2. RISKS INVOLVED IN THIS STUDY

There are no risks associated with this study because what is required is information and ticks; which you will be asked to provide information on during interview for the time it will take to complete a questionnaire. Your cattle will not be affected in any way; they will only be used for collecting tick samples. Your current system and husbandry practices will not be interfered with at any time.

3. POTENTIAL BENEFITS THAT WILL COME FROM THE STUDY

The benefits of participating in this study are:

- You will get to appreciate what other farmers in the communal areas are doing and how broad their knowledge is, based on ethno-veterinary medicines used in cattle diseases and parasites control.
- You'll get a clear picture of the situation of ethno-veterinary medicine uses in tick control.
- You'll form part of a team that will identify research needs that maybe required in the future with regard to ethno-veterinary use in cattle ticks.
- You'll have answers to questions that you may not have had answered as an individual.
- You will know how, what to do or where to go when you want to improve your knowledge and skills.

4. IMPLICATIONS OF THE STUDY

The study will assist in providing a better understanding of ethno veterinary acaricide use in Tsholotsho communal areas, besides identifying other areas that might require research in years to come.

The assessment and documentation of the efficacy of bio-friendly traditional tickicides will empower you as a small holder farmer to make informed decisions on use of EVA remedies, while increasing the chances of consuming safer meat products while reducing environmental hazards.

The study can lead to further investigations on actual chemical properties, mixing measurements, dosage, application sites and techniques, thus investing the efficacy of different prophylactic treatments for various tick species and thus promote the development of novel and innovative products in animal medicine; documenting and validating the appropriate information to ensure that plant and animal extracts are used safely for the benefit of the human and animal population without compromising the environment.

5. COMPENSATION OR INCENTIVES FOR PARTICIPATING IN THIS STUDY

Please note that you will not be paid to participate in the study. There is no financial compensation or incentives that will be given to you for participating in this study.

6. YOUR RIGHTS AS A PARTICIPANT IN THIS STUDY

Your decision to participate in this study is voluntary. You have the right to decide not to participate, or to stop taking part at any time without providing reasons for doing so. Your withdrawal will in no way affect your farm business. You have the right not to disclose the financial records for your livestock enterprises if you do not wish to. Any questions you may feel are too sensitive to answer you have the right not to. You will not be forced to answer any questions.

7. STATEMENT OF CONFIDENTIALITY AND ANONYMITY IN THE STUDY

All documents and information obtained during the course of this study will be kept confidential. Your identity will not be revealed while the study is being conducted. I understand that the results of this study may be published in scientific journals. If any data is published, your name will not be revealed. Access to your data will be strictly limited to the investigators. Also, your data and personal information will be kept and stored in a confidential format which will only be accessible to the investigators. You may give permission for your name to be shown when results are documented and presented if you do not have a problem with it.

8. QUALIFICATIONS OF THE RESEARCHERSTO CARRY OUT THE STUDY

I am a qualified and experienced Livestock production specialist as well as Chemical laboratory technician. I am supervised by qualified and experienced staff employed by theUniversity of South Africa (UNISA), Agriculture, Environmental Affairs and Rural Development; Department of Animal Health and Human EcologyFlorida Campus, Gauteng. We have various and relevant qualifications and experience in Agricultural Science, Extension and Training, which will enable us to carry out this study.

9. ETHICAL APPROVAL

The College Research Committee and the College Research Ethics Committee of the College of Agriculture and Environmental Sciences has approved the project proposal at the moment. Also, EduRite my private sponsor has granted approval and funding to conduct this research in the district.

10. CONTACT FOR ADDITIONAL INFORMATION REGARDING THE STUDY

a. The Project Supervisor: Dr J.W. Oguttu, can be contacted during office hours at (011) 471-3353or emailjoguttu@unisa.ac.za

b. The Co-Supervisor: Dr Francis Babi can be contacted by email francisbabi@gmail.com

c. Should you have any further questions regarding the ethical aspects of this study, you may contact the Chairperson of the College Research Ethics Committee, Prof E. Kempen at kempel@unisa.ac.za.

11. A FINAL WORD

Your co-operation and participation in the study will be greatly appreciated. Please sign the enclosed informed consent below if you agree to participate in the study. In such a case, you will receive a copy of the signed informed consent from the researcher.

WRITTEN CONCENT

I hereby confirm that I have been adequately informed by the interviewer about the nature, conduct, benefits and risks of the study. I have also received, read and understood the above written information. I am aware that the results of the study will be anonymously processed into a research report.

I understand that my participation is voluntary and that I may, at any stage, without prejudice, withdraw my consent and participation in the study. I had sufficient opportunity to ask questions and of my own free will declare myself prepared to participate in the study.

Farmer's name ____
(Please Print)

Farmer's signature: ______________________________

Date of consent: _________________________________

Interviewer's name: ____
(Please print)

Interviewer's signature: ___________________________

Date of interview___________________________________

VERBAL CONSENT (Applicable when participants cannot read or write)

I hereby declare that I have read and explained the contents of the information sheet to the farmer. The nature and purpose of the study were explained, as well as the possible risks and benefits of the study. The farmer has clearly indicated that he/she will be free to withdraw from the study at any time for any reason and without jeopardizing his/her relationship with the health care team.

I hereby certify that the farmer has verbally agreed to participate in this study.

Farmer's name:

____

(Please print)

Interviewer'snames:

____

(Please print)

Interviewer's signature: ___________________________________

Date of interview: _____________________________________

Annexure C: Wilcoxon Ranksum Results

WILCOXON RANK-SUM TEST ANALYSIS FOR CONTROLLED MORTALITY TEST OF THE SMEAR				
SAMPLE NO	**NO BEFORE SMEAR APPLICATION**	**NO REMAINING AFTER SMEAR APPLICATION**	**NO KILLED BY SMEAR**	**PERCENTAGE KILLED**
1	58	0	58	100%
2	29	1	28	97%
3	35	3	32	91%
	Average % Kill =		**96%**	
	SAMPLE SIZES			
	n_1	=	3	
	n_2	=	3	
H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in the number killed after application of the smear is not statistically significant at a given level of significance and could have arisen by chance.				
H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change in the number killed after application of the smear is statistically significant at a confidence level that we will determine using the Wilcoxon rank-sum test and it is not by chance.				
RANK SAMPLE ORDER STATISTICS				
RANK	**SAMPLE**	**DAY**		
4	29	MONDAY		
5	35	MONDAY		
6	58	MONDAY		
1	0	TUESDAY		
2	1	TUESDAY		
3	3	TUESDAY		
MONDAY	=	NO BEFORE SMEAR APPLICATION		
TUESDAY	=	NO AFTER SMEAR APPLICATION		

<table>
<tr><td>N1</td><td>=</td><td>15</td><td>RANK-SUM BEFORE APPLICATION OF SMEAR</td></tr>
<tr><td>N2</td><td>=</td><td>6</td><td>RANK-SUM SUM AFTER APPLICATION OF SMEAR</td></tr>
<tr><td colspan="4">Our Wilcoxon Rank-Sum test produced the following values [6, 15] which are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 α = 0.05 [6, 15]) which means that we can reject the Null Hypothesis in favour of the Alternate Hypothesis meaning that we can with 95% confidence declare that the number killed after application of the smear is statistically significant and it is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6,15] with α = 0.1 we have 90% confidence that the number killed after the application of the smear is statistically significant and was not a result of random phenomenon! P value = 0.0500</td></tr>
</table>

WILCOXON RANK-SUM TEST ANALYSIS FOR REPELLING POWER OF THE MARULA EXTRACT DIPS

SAMPLE NO	NO AT CENTRE BEFORE SMEAR APPLICATION	NO AT CENTRE AFTER SMEAR APPLICATION	NO REPELLED	PERCENTAGE REPELENCE
1	10	6	4	40%
2	25	8	17	68%
3	17	6	11	65%
	Average % Repellence	**=**	**58%**	

SAMPLE SIZES

n_1	=	3
n_2	=	3

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in the number at the centre after application of the Marula infusion is not statistically significant at a given level of significance and could have arisen by chance.

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change in the number at the centre after application of the Marula extract dips is statistically significant at a confidence level that we will determine using the Wilcoxon rank-sum test and it is not by chance.

RANK SAMPLE ORDER STATISTICS)

RANK	SAMPLE	DAY
4	10	MONDAY

5	17	MONDAY	
6	25	MONDAY	
1.5	6	TUESDAY	
1.5	6	TUESDAY	
3	8	TUESDAY	
MONDAY	=	NO AT CENTER BEFORE MARULA INFUSION APPLICATION	
TUESDAY	=	NO AT CENTER AFTER MARULA INFUSION APPLICATION	
N1	=	15	RANK-SUM BEFORE APPLICATION OF MARULA INFUSION
N2	=	6	RANK-SUM SUM AFTER APPLICATION OF MARULA INFUSION

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change of mass due to treatment with the Marula infusion is statistically significant for a given confidence level that we will determine using the Wilcoxon tables.

RANK SAMPLES (RANK SAMPLE ORDER STATISTICS)

RANK	**SAMPLE**	**DAY**
5	1.6	MONDAY
6	2.42	MONDAY
7	2.75	MONDAY
10	4.65	MONDAY
11	4.9	MONDAY
12	6.2	MONDAY
1	0.11	TUESDAY
2	1	TUESDAY
3	1.03	TUESDAY
4	1.4	TUESDAY
8	3.2	TUESDAY

9	3.75	TUESDAY	
MONDAY	=	BEFORE TREATMENT	
TUESDAY	=	AFTER TREATMENT	
N1	=	51	RANK SUM OF BEFORE TREATMENT
N2	=	27	RANK SUM OF AFTER TREATMENT

For the one sided Wilcoxon (6 6 α = 0.05 the lower critical value = 28 and the Upper critical value = 50) Our ranks [27, 51] both lie outside these critical values and therefore we reject the Null Hypothesis in favour of the Alternate Hypothesis: We therefore have 95% confidence that the change in mass due to the Marula infusion treatment is statistically significant P value = 0.0465.

For the two sided Wilcoxon (6 6 α = 0.01 with critical values [28, 50]) our ranks [27, 51] lie outside the critical values from the Wilcoxon rank-sum tables and therefore reject the Null Hypothesis in favour of the Alternate Hypothesis: We therefore have 90% confidence on the two sided test that the change in mass due to the Marula infusion is statistically significant.

Wilcoxon rank-sum test analysis for controlled mortality test of the marula infusion

SAMPLE NO	**NO BEFORE MARULA EXTRACT DIPS APPLICATION**	**NO REMAINING AFTER MARULA EXTRACT DIPS APPLICATION**	**NO KILLED BY MARULA EXTRACT DIPS**	**PERCENTAGE KILLED**

1	58	16	42	72%
2	29	25	4	14%
3	35	3	32	91%
	Average % KILL	**=**	**59%**	
	SAMPLE SIZES			
	n_1	**=**	3	
	n_2	**=**	3	

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in the number killed after application of the marula infusion is not statistically significant at a given level of significance and could have arisen by chance.

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change in the number killed after application of the Marula infusion is statistically significant at a confidence level that we will determine using the Wilcoxon rank-sum test and it is not by chance.

	RANK SAMPLE ORDER STATISTICS)		
RANK	**SAMPLE**	**DAY**	
4	29	MONDAY	
5	35	MONDAY	
6	58	MONDAY	
1	3	TUESDAY	
2	16	TUESDAY	
3	25	TUESDAY	
MONDAY	=	NO BEFORE MARULA EXTRACT DIPS APPLICATION	
TUESDAY	=	NO AFTER MARULA EXTRACT DIPS APPLICATION	
N1	=	15	RANK-SUM BEFORE APPLICATION OF MARULA EXTRACT DIPS
N2	=	6	RANK-SUM SUM AFTER APPLICATION OF MARULA EXTRACT DIPS

Our Wilcoxon Rank-Sum test produced the following values [6, 15] which are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 α = 0.05 [6, 15]) which means that we can reject the Null Hypothesis in favour of the Alternate Hypothesis meaning that we can with 95% confidence declare that the number killed after application of the marula infusion is statistically significant and it is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6,15] with α = 0.1 we have 90% confidence that the number killed after the application of the marula infusion is statistically significant and was not a result of random phenomenon! P value = 0.0500

WILCOXON RANK-SUM TEST ANALYSIS FOR CONTROLLED MORTALITY TEST OF THE SMEAR

SAMPLE NO	NO BEFORE SMEAR APPLICATION	NO REMAINING AFTER SMEAR APPLICATION	NO KILLED BY SMEAR	PERCENTAGE KILLED
1	58	0	58	100%
2	29	1	28	97%
3	35	3	32	91%
	Average % KILL	**=**	**96%**	
	SAMPLE SIZES			
	n_1	**=**	3	
	n_2	**=**	3	

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in the number killed after application of the smear is not statistically significant at a given level of significance and could have arisen by chance.

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change in the number killed after application of the smear is statistically significant at a confidence level that we will determine using the Wilcoxon rank-sum test and it is not by chance.

	RANK SAMPLE ORDER STATISTICS)		
RANK	**SAMPLE**	**DAY**	
4	29	MONDAY	
5	35	MONDAY	
6	58	MONDAY	
1	0	TUESDAY	
2	1	TUESDAY	
3	3	TUESDAY	
MONDAY	=	NO BEFORE SMEAR APPLICATION	
TUESDAY	=	NO AFTER SMEAR APPLICATION	
N1	=	15	RANK-SUM BEFORE APPLICATION OF SMEAR
N2	=	6	RANK-SUM SUM AFTER APPLICATION OF SMEAR

Our Wilcoxon Rank-Sum test produced the following values [6, 15] which are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 α = 0.05 [6, 15]) which means that we can reject the Null Hypothesis in favour of the Alternate Hypothesis meaning that we can with 95% confidence declare that the number killed after application of the smear is statistically significant and it is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6,15] with α = 0.1 we have 90% confidence that the number killed after the application of the smear is statistically significant and was not a result of random phenomenon! P value = 0.0500

WILCOXON RANK-SUM TEST ANALYSIS FOR REPELLING POWER OF THE MARULA EXTRACT DIPS

SAMPLE NO	NO AT CENTRE BEFORE SMEAR APPLICATION	NO AT CENTRE AFTER SMEAR APPLICATION	NO REPELLED	PERCENTAGE REPELENCE
1	10	6	4	40%
2	25	8	17	68%
3	17	6	11	65%
	Average % Repellence	**=**	**58%**	

SAMPLE SIZES

n_1	=	3
n_2	=	3

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in the number at the center after application of the Marula infusion is not statistically significant at a given level of significance and could have arisen by chance.

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change in the number at the center after application of the Marula extract dips is statistically significant at a confidence level that we will determine using the Wilcoxon rank-sum test and it is not by chance.

RANK SAMPLE ORDER STATISTICS)

RANK	**SAMPLE**	**DAY**
4	10	MONDAY
5	17	MONDAY
6	25	MONDAY
1.5	6	TUESDAY
1.5	6	TUESDAY
3	8	TUESDAY

MONDAY	=	NO AT CENTER BEFORE MARULA INFUSION APPLICATION

TUESDAY	=	NO AT CENTER AFTER MARULA INFUSION APPLICATION	
N1	=	15	RANK-SUM BEFORE APPLICATION OF MARULA INFUSION
N2	=	6	RANK-SUM SUM AFTER APPLICATION OF MARULA INFUSION

Our Wilcoxon Rank-Sum test produced the following values [6, 15] which are also the critical values for the One sided Wilcoxon Rank-Sum test (3 3 α = 0.05 [6, 15]) which means that we can reject the Null Hypothesis in favour of the Alternate Hypothesis meaning that we can with 95% confidence declare that the repelling power of the Marula infusion is statistically significant and it is not due to random chance. At the two sided Wilcoxon Rank-Sum test the critical values of [6,15] with α = 0.1 we have 90% confidence that the repelling power of the Marula infusion is statistically significant and was not a result of random phenomenon! P value = 0.0500

	WILCOXON RANK-SUM TEST ANALYSIS FOR REPELLING POWER OF THE SMEAR			
SAMPLE NO	**NO AT CENTRE BEFORE SMEAR APPLICATION**	**NO AT CENTRE AFTER SMEAR APPLICATION**	**NO REPELLED**	**PERCENT REPELLENCE**
1	9	0	9	100%
2	6	1	5	83%
3	28	1	27	96%
	Average % Repellence	**=**	**93%**	
	SAMPLE SIZES			

n_1	=	3
n_2	=	3

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in the number at the centre is not statistically significant at a given level of significance and could have arisen by chance.

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change in the number at the center after application of the smear is statistically significant at a confidence level that we will determine using the Wilcoxon rank-sum test and it is not by chance.

RANK SAMPLE ORDER STATISTICS)

RANK	SAMPLE	DAY
4	6	MONDAY
5	9	MONDAY
6	28	MONDAY
1	0	TUESDAY
2.5	1	TUESDAY
2.5	1	TUESDAY

MONDAY	=	NO AT CENTER BEFORE SMEAR APPLICATION	
TUESDAY	=	NO AT CENTER AFTER SMEAR APPLICATION	
N1	=	15	RANK-SUM BEFORE APPLICATION OF SMEAR
N2	=	6	RANK-SUM SUM AFTER

APPLICATION OF SMEAR

WILCOXON RANK-SUM TEST ANALYSIS OF SMEAR APPLICATION PREGNANCY DATA

SAMPLE NO	MASS BEFORE SMEAR APPLICATION	MASS AFTER SMEAR APPLICATION	CHANGE IN MASS	% DECLINE IN MASS
1	6.2	3.01	3.19	51%
2	1.6	0.16	1.44	90%
3	4.9	3.57	1.33	27%
4	2.42	1.42	1	41%
5	2.75	1.4	1.35	49%
	PERCENTAGE DECLINE MASS	**=**	**52%**	
	SAMPLE SIZES			
	n_1	**=**	5	
	n_2	**=**	5	

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groups i.e. the change in mass due to the application of the smear is not statistically significant but a random phenomenon.

	RANK SAMPLES (RANK SAMPLE ORDER STATISTICS)		
RANK	**SAMPLE**	**DAY**	
4	1.6	MONDAY	
5	2.42	MONDAY	
6	2.75	MONDAY	
9	4.9	MONDAY	
10	6.2	MONDAY	
1	0.16	TUESDAY	
2	1.4	TUESDAY	
3	1.42	TUESDAY	
7	3.01	TUESDAY	
8	3.57	TUESDAY	
MONDAY	=	BEFORE SMEAR TREATMENT	
TUESDAY	=	AFTER SMEAR TREATMENT	
N1	=	34	RANK SUM BEFORE SMEAR APPLICATION
N2	=	21	RANK SUM AFTER SMEAR APPLICATION

WILCOXON RANK-SUM TEST ANALYSIS OF MARULA INFUSION PREGNANCY TEST DATA

SAMPLE NO	MASS BEFORE TREATMENT WITH MARULA EXTRACT DIPS	MASS AFTER TREATMENT WITH MARULA EXTRACT DIPS	CHANGE IN MASS AS A RESULT OF TREATMENT WITH MARULA EXTRACT DIPS	% DECLINE IN MASS
1	6.2	3.2	3	48%
2	1.6	0.11	1.49	93%
3	4.9	3.57	1.33	27%
4	2.42	1.03	1.39	57%
5	4.65	1	3.65	78%
6	2.75	1.4	1.35	49%

	PERCENTAGE DECLINE IN MASS	**=**	**59%**	
	SAMPLE SIZES			
	n_1	=	6	
	n_2	=	6	

H_0 - Null Hypothesis states that the two samples came from the same populations. In other words, there is no difference between the two groupie the change in mass after the treatment with the Marula infusion is not statistically significant but is just a random phenomenon.

H_1 - Alternate Hypothesis states that the two samples do not come from the same populations i.e. the change of mass due to treatment with the Marula infusion is statistically significant for a given confidence level that we will determine using the Wilcoxon tables.

RANK SAMPLES (RANK SAMPLE ORDER STATISTICS)

RANK	SAMPLE	DAY
5	1.6	MONDAY
6	2.42	MONDAY
7	2.75	MONDAY
10	4.65	MONDAY
11	4.9	MONDAY
12	6.2	MONDAY
1	0.11	TUESDAY
2	1	TUESDAY
3	1.03	TUESDAY
4	1.4	TUESDAY
8	3.2	TUESDAY
9	3.75	TUESDAY

MONDAY	=	BEFORE TREATMENT	
TUESDAY	=	AFTER TREATMENT	
N1	=	51	RANK SUM OF BEFORE TREATMENT
N2	=	27	RANK SUM OF AFTER TREATMENT

For the one sided Wilcoxon (6 6 α = 0.05 the lower critical value = 28 and the Upper critical value = 50) Our ranks [27, 51] both lie outside these critical values and therefore we reject the Null Hypothesis in favour of the Alternate Hypothesis: We therefore have 95% confidence that the change in mass due to the Marula infusion treatment is statistically significant P value = 0.0465.

For the two sided Wilcoxon (6 6 α = 0.01 with critical values [28, 50]) our ranks [27, 51] lie outside the critical values from the Wilcoxon rank-sum tables and therefore reject the Null Hypothesis in favour of the Alternate Hypothesis: We therefore have 90% confidence on the two sided test that the change in mass due to the Marula infusion is statistically significant.