TICK INFESTATION AND UDDER AND TEAT DAMAGE IN SELECTED CATTLE HERDS OF MATABELELAND SOUTH, ZIMBABWE

BY

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Submitted in partial fulfilment of the requirements for the degree

MASTER OF SCIENCE (VETERINARY TROPICAL DISEASES)

in the

Department of Veterinary Tropical Diseases

Faculty of Veterinary Science

University of Pretoria

Submitted: 2008

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Declaration

I hereby declare that this dissertation, submitted by me to the University of Pretoria for the Master of Science (Veterinary Tropical Diseases) has not previously been submitted for a degree at any other University.

Daud Nyosi Ndhlovu

Acknowledgements

I would like to express my deepest gratitude to the following people:

Prof Banie L. Penzhorn my promoter for his guidance especially during the write up. Dr Pious V. Makaya my supervisor in Zimbabwe for his guidance and making it possible for me to utilise the Central Veterinary Laboratory and staff for tick identification and Dr D. M. Pfukenyi of the Faculty of Veterinary Science for the assistance in statistical calculations .The Director of the Division of Veterinary Field Services for giving me the material resources to conduct the study. Dr Msongelwa Mangena the Provincial Veterinary Officer of Matabeleland South, who availed all the resources that I needed to successfully conduct the study and for his moral support and faith in me. The communal and commercial farmers at the various dip-tanks and farms for allowing me access to their animals and their time. Prof I. G. Horak and Dr Maxime Madder for the insightful tick practical course. Prof J.A.W. Coetzer who through the Department of Veterinary Tropical Diseases, Faculty of Veterinary Science, University of Pretoria, sponsored the MSc program. My wife and colleague Felistas, my three children Phumuzile, Mkhululi and Siphosenkosi who put up with my busy schedule.

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Abbreviations used

CS	Commercial sector
CSO	Central Statistics Offices
DVFS	Department of Veterinary Field Services
ECF	East Coast fever
GOZ	Government of Zimbabwe
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics.
SH	Small-holder
S.I.	Statutory Instrument
TR	Total Replenishment
WP	Wettable powder

Tick infestation and udder and teat damage of selected cattle herds of Matabeleland South, Zimbabwe

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Abstract

A cross-sectional survey was conducted at six properties in the small-holder and commercial sector in Gwanda district of Matabeleland South Province, Zimbabwe. The study was conducted at Sivume and Nyandeni communal dip-tanks, at Blanket, Double cross, Judds and at Timber farms. The objective of the study was to ascertain the tick infestations, tick species and udder and teat damage of milking cows and heifers from selected cattle herds. The study was important as it would help animal-health decision makers and farmers in knowing the prevailing tick genera and species in the study area and hence the potential for the occurrence of diseases associated with these ticks.

Two hundred and eighty-six cattle were sampled and ticks were collected and sent to the Central Veterinary Laboratory for further characterisation.

A total of eight tick species, comprising of *Amblyomma hebraeum*, *Hyalomma truncatum*, *Hyalomma marginatum rufipes*, *Rhipicephalus evertsi evertsi, Rhipicephalus (Boophilus) decoloratus, Rhipicephalus appendiculatus, Rhipicephalus zambeziensis* and *Rhipicephalus simus* were identified. 53 % of the sampled cattle had some degree of udder and teat damage but very few farmers (2.6 %) treated their cattle for these conditions.

Chapter 1: Introduction

Tick infestations and tick-borne diseases (TBDs) are important conditions affecting livestock health and productivity in Zimbabwe (Norval 1979; Lawrence, Foggin & Norval 1980) and in large areas of sub-Saharan Africa (Norval, Donachie, Meltzer, Deem & Mahan 1995). In Matabeleland South Province, particularly, some recent work done by VEDMA Consulting group (2005) confirmed that tick infestation and TBDs are some of the most important conditions affecting livestock productivity.

Ticks are responsible for direct damage to livestock skins/hides through their feeding habits. The damage is manifested as hide damage, damage to udders, teats, scrotum and myiasis due to infestation of damaged sites by maggots and secondary microbial infections (Norval 1983b; Meltzer & Norval 1993; Dreyer, Fourie & Kok 1998b). Productivity losses that can occur (Norval, Sutherst, Kurki, Gibson & Kerr 1988b; Norval, Sutherst, Jorgensen, Gibson & Kerr 1989; Stachurski, Musonge, Achu-Kwi & Saliki 1993; Meltzer, Norval & Donachie 1995; Jonsson 2006) are not usually obvious to the communal or small-holder farmer but are important if raising of cattle is to be done at a commercial level.

Control of ticks and TBDs in the smallholder sector has been one of the major activities of the Department of Veterinary Field Services (DVFS) (Norval, Perry & Hargreaves 1992). Like most departments in Zimbabwe, DVFS has faced budgetary constraints. The budget has decreased in real terms year after year. This decrease in budgetary allocation has also affected dipping-service delivery leading to frequent disruptions of dipping activities. This has had an effect on the tick dynamics in the affected areas**.** Coupled to this has been the agrarian reform that started in full force in the year 2000. The reform has seen movement of livestock into former commercial farms and the breakdown of fences between these commercial farms and communal areas. Also, movement of livestock has taken place within and between districts in the country. This scenario has implications as regards tick dynamics and tick distribution in Matabeleland South Province.

The objective of the study was to characterize tick species, their distribution and their impact on cattle with special emphasis on udder and teat damage at selected dip-tanks and farms of Matabeleland South Province. Results from the study will add to the already existing knowledge and also lay a foundation for further research on ticks and TBDs in Matabeleland South.

Chapter 2: Literature review

2.1 Historical preamble

2.1.1 Ticks and tick-borne- disease control in Zimbabwe

Ticks and tick-borne diseases (TBDs) are recognized as some of the major health constraints to cattle production in Zimbabwe, and their control has been the long-term commitment of the Department of Veterinary Services since its inception (Norval *et al.* 1992).

In areas free from tsetse fly, ticks and TBDs present the most serious threat to livestock production (Norval 1979). The importance of ticks and TBDs came into prominence in this country as a result of importing TBD-infected cattle after serious losses of cattle due to the Rinderpest epidemic towards the end of the 19th century. A shipment of cattle from East Africa in 1901 was implicated in the introduction of East Coast fever (ECF), a TBD, into Zimbabwe, which devastated existing cattle herds (Norval 1979; Norval 1983b; Norval *et al.* 1992). This led to the introduction of compulsory cattle dipping in 1914. ECF was subsequently eradicated in 1954 (Norval 1979; Lawrence *et al.* 1980).

2.1.2 Management of dipping services in Zimbabwe

Management of dip tanks was devolved to the communities in 1995. Dipping committees were set up to manage and maintain the dip tanks and collect the dipping fees, while the Department of Veterinary Field Services (DVFS) was to provide overall supervision and procurement of the acaricide. Currently, the major stakeholders in dip-tank management include the following: (i) dipping committee, (ii) community (stockowners), (iii) dip attendant and (iv) the DVFS (VEDMA Consulting Group 2005).

The DVFS procures and supplies acaricide to all the communal dip tanks in the country. Since 1997, the DVFS operated a partial cost-recovery program, where communities contributed towards the cost of acaricides through dipping fees. Currently, the stockowners contribute Z$500,000 per beast per year. It is estimated that, on average, the cost recovery on dipping has contributed approximately 15 % towards the DVFS dipping budget since its inception in 1997 (VEDMA Consulting Group 2005).

Currently the DVFS uses the acaricide Amitraz at 25.50 % m/m ("Tickbuster® WP"-Zimbabwe Phosphate Industries) for all the communal dip tanks. Tickbuster WP used following the total replenishment (TR) method of dipping, was specifically developed for the DVFS and is only authorised for exclusive use by the DVFS at communal dip-tanks.

2.1.3 Milestones of ticks and tick-borne-disease control in Zimbabwe.

Compulsory short-interval dipping of cattle for the control of ticks and TBDs has been enforced in Zimbabwe since the early part of this century (Norval 1979; Norval 1983b; Norval *et al*. 1992).

Initially, intensive dipping was introduced for the control of ECF following its introduction from East Africa in 1901/1902 during the restocking that followed the Rinderpest pandemic of 1896 and the Anglo-Boer war of 1899-1902 (Norval 1979; Lawrence *et al.* 1980; Norval 1983b; Norval *et al.* 1992). During this period, the ox-wagon was the main mode of transportation and, as such, the pandemic had disastrous consequences.

In 1903, cattle brought into Zimbabwe from Australia contracted ECF while quarantined in a camp that had previously been occupied by cattle affected by the disease (VEDMA Consulting Group 2005). The ECF outbreak saw the construction of the first dip tank in Zimbabwe in 1910 (Norval *et al.* 1992), with dipping initiated in 1911. By 1912, a total of 215 dip tanks had been constructed to service the then national herd of 500,000 cattle.

A policy of compulsory dipping of cattle in acaricide was made into law in 1914 (Norval 1979) for the control of ECF. This policy led to the eradication of the disease in Zimbabwe in the 1950s. As a result of compulsory dipping, other TBDs were brought under control and eradicated from large areas of the country (Lawrence *et al.* 1980; Norval *et al.* 1992).

The eradication of ECF and the general reduction of TBDs resulted in a rapid increase in cattle population from 4,1 million to 5,6 million. This increase was attributed, among other animal-health activities, to the control of TBDs; cattle deaths attributed to TBDs amounted to only 886 per annum (Norval 1983b). This healthy situation continued up to the early 1970s, when the liberation war began. The liberation war had the effect of disrupting dipping services and other disease-control activities in the country (Lawrence *et al.* 1980; Norval 1983b).

Norval (1979) reported that as conflict escalated between 1973 and 1978 dipping was disrupted in more and more areas to the extent that by the end of 1978 the state was regularly dipping only *ca.* 20 % of the 3.2 million tribal cattle. Effective dipping ceased, which led to the death of an estimated one million cattle from TBDs (Lawrence *et al.* 1980). Disruption of dipping services during this period was also occasioned by the reluctance of communal farmers to pay dipping fees, their resentment of the compulsory dipping and the apparent lack of disease threat (Norval 1979).

During the early 1980s it was known that endemic stability existed as a result of disruption in dipping services due to civil strife. Arguments for integrated control strategies in the control of ticks and TBDs were presented, which showed that in the long term, intensive dipping was uneconomic and it reduced enzootic stability to TBDs (Norval 1983b). Recommendations were made to Government not to introduce intensive dipping. Despite these recommendations, however, intensive dipping was reintroduced (Norval *et al*. 1992).

Currently, the department practises strategic dipping at communal dip-tanks: weekly dipping during the wet months of December to March and then monthly or fortnightly dipping, depending on tick infestation levels, for the rest of the year, to end up with a total of 26 dippings per year. Some farmers in the commercial sector practise intensive dipping while others use an integrated approach that uses a combination of indigenous tick-resistant cattle, immunisation against some TBDs and acaricides to control the direct effects of ticks (Lawrence 1997; Perry, Chamboko, Mahan, Medley, Minjauw, O'Callaghan & Peter 1998).

2.2 Legislation for the control of ticks and tick-borne diseases in Zimbabwe

Legislation is in place for the control of ticks in Zimbabwe. The Animal Health (Cattle Cleansing) Regulations of 1993, Government of Zimbabwe (GOZ) (1993), give guidelines on issues related to tick control. These regulations define obligations of the stockowners and the DVFS vis-à-vis tick and TBD control.

The Animal Health (Cattle Cleansing) Regulations, 1993, Statutory Instrument (S.I.) 250 of 1993, defines among other things: what a tick is, what dipping is and what constitutes tick infestation.

According to the Animal Health Act (Cattle Cleansing) regulations GOZ (1993) three tick genera of importance in Zimbabwe are classified as specified pests. The tick genera are: *Amblyomma*, *Rhipicephalus* and the *Rhipicephalus (Boophilus)* group. The state has the mandate to control these ticks.

National tick surveys were conducted in Zimbabwe in 1988-1991 and again in 1996 (Peter, Perry, O'Callaghan, Medley, Shumba, Madzima, Burridge & Mahan 1998b). These surveys and previous work (Norval 1981; Norval 1983a; Chatikobo, Kusina, Hamudikuwanda & Nyoni 2001) identified the genera *Amblyomma* and *Rhipicephalus* and the subgenus *Rhipicephalus (Boophilus)* as the most important ticks associated with major TBDs.

The most important species in the genus *Amblyomma* include *Amblyomma hebraeum* and *Amblyomma variegatum*.

In Zimbabwe the most commonly occurring *Amblyomma* species is *A. hebraeum*, which in the adult stage is parasitic on cattle and other medium and large-sized ungulates, leopards and ostriches; immature stages feed on ungulates, carnivores and tortoises (Norval 1983a; Horak, MacIvor, Petney & de Vos 1987; Dower, Petney & Horak 1988). *Amblyomma hebraeum* is replaced by *A. variegatum* in the northern parts of the country (Norval, Perry, Meltzer, Kruska & Booth 1994). The distribution of *A. hebraeum* is from central Zimbabwe southwards into South Africa, eastern Swaziland, southern Mozambique and eastern Botswana. *Amblyomma hebraeum* is the principal vector of heartwater in Zimbabwe.

Amblyomma variegatum is a three-host tick. All stages of the tick infest cattle, sheep and goats. The distribution of this tick extends from north-western Zimbabwe, the central highveld and on the eastern border of the country, to central and northern Mozambique (Norval 1983a; Peter, Perry, O'Callaghan, Medley, Shumba, Madzima, Burridge & Mahan 1998a). Adults of this tick are present throughout the year on cattle and buffalo although infestations are heavier during the wet warm months of September to May, while nymphs of this tick are only found between June and December (Petney, Horak & Rechav 1987).

Of importance when considering *A. hebraeum* and *A. variegatum* in Zimbabwe is the fact that these two species have an area of overlap (Peter *et al.* 1998a). It is reported that in an area of overlap *A. variegatum* completely replaces *A. hebraeum* over a period of three years (Norval *et al.* 1994). In these areas of overlap there is interspecific mating with the production of sterile hybrids. The survival of *A. hebraeum* is also favoured by the presence of alternative wildlife hosts for the adult stage while this is limited to buffalo for *A. variegatum* (Norval *et al.* 1994).

The other *Amblyomma* species found in Zimbabwe are *A. nuttalli*, *A. marmoreum*, *A. rhinocerotis*, *A. sparsum* and *A. tholloni* (Norval 1983a).

Members of genus *Rhipicephalus* are brown to black ticks with well-developed mouthparts. There are two- and three-host ticks in this genus. The important species include *Rhipicephalus appendiculatus*, *Rhipicephalus zambeziensis*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus (Boophilus) decoloratus* and *Rhipicephalus (Boophilus) microplus* as described by Walker, Bouattour, Camicas, Estrada-Peña, Horak, Latif, Pegram & Preston (2003).

Adult and immature ticks of the species *Rhipicephalus appendiculatus* infest cattle, goats, buffaloes and a number of other game animals.

Some adults and large numbers of immature forms can also feed on smaller antelopes and scrub hares (Walker *et al.* 2003). In southern Africa this tick is confined to the moister regions, which includes the highveld of Zimbabwe (Mooring & Mazhowu 1995). This tick survives best in woodland and woodland savannah regions with good vegetation cover. Droughts and overgrazing have an adverse effect on this tick's survival such that in properly managed properties this three-host tick can be found in abundance (Norval 1979).

In Zimbabwe and other countries within the region, the different instars of *R. appendiculatus* exhibit a strict pattern of seasonal occurrence (Latif, Hove, Kanhai, Masaka & Pegram 2001) with one generation occurring each year. Adults are mostly active and abundant in the rainy season (mid-December to May), larvae in the cool season (March to October) and nymphs in the dry months of June to October (Latif *et al.* 2001).

Rhipicephalus zambeziensis is morphologically similar to *R. appendiculatus* and has the same host range and disease relations (Walker *et al.* 2003). This tick replaces *R. appendiculatus* in the hot dry river valley systems of south-eastern Africa. In Zimbabwe *R. zambeziensis* is found in the semi-arid regions of the country (Mooring & Mazhowu 1995) and in the drainage basins of the Zambezi, Limpopo and Save rivers. Madder, Speybroeck, Bilounga, Helleputte & Berkvens (2005) stated that survival of *R. zambeziensis* was better than that of *R. appendiculatus* under more extreme conditions of humidity and temperature. As such, *R. zambeziensis* was more adapted to hotter and drier areas while *R. appendiculatus* was more adapted to cooler and wetter conditions.

Distributions of *R. appendiculatus* and *R. zambeziensis* overlap where there are gradual transitions between wet and dry areas. Competitive displacement of one species by the other occurs where *R. zambeziensis* and *R. appendiculatus* overlap (Mooring & Mazhowu 1995).

Rhipicephalus evertsi evertsi is a two-host tick. Both adult and immature forms occur on both domestic and wild ungulates, but the immature forms can also be found on small mammals. Its preferred hosts are horses, donkeys and zebras (Norval 1981). *Rhipicephalus e. evertsi* occurs in all parts of Zimbabwe, except the Zambezi valley (Norval 1981). This tick can tolerate a wide range of climatic conditions (Hamel & Gothe 1978) and some strains can cause paralysis in sheep.

Ticks belonging to subgenus *Rhipicephalus (Boophilus)* are one-host tick species. The two most important species of this subgenus are *Rhipicephalus (Boophilus) decoloratus* and *Rhipicephalus (Boophilus) microplus*.

Cattle, and to a lesser extent horses and donkeys, are the main hosts of *R. (B.) decoloratus* (Londt, Horak & de Villiers 1979). This tick can also be found on a large number of wild ungulates, which include impalas, bushbuck and kudu (Horak, Potgieter, Walker, de Vos & Boomker 1983). The species is distributed through most of the wetter regions of South Africa and is also present in the eastern parts of Zimbabwe (Norval *et al*. 1992; Walker *et al*. 2003)

The preferred host of *R. (B.) microplus* tick is cattle. Distribution of this tick in Zimbabwe is in the eastern region (Chimanimani, Chipinge, Mutare, Rusape and Wedza), northern and north-eastern region and the north-western region (Katsande, Mazhowu, Turton & Munodzana 1996).

2.4 Physical damage and economic losses due to ticks

Ticks are associated with important animal-health problems and cause severe economic losses to the livestock industry worldwide. In addition, as ecto-parasites they contribute to reduced productivity in cattle (Young & Haantuba 1997). The economic losses inflicted due to damage to skins and hides are very high. Furthermore, there is widespread consensus among animal-health professionals and livestock owners that ticks are major causes of udder damage, a predisposing factor to mastitis (Regassa 2001). Tick feeding can reduce live-mass gain, milk yield and hide quality, provide portals of entry for secondary bacterial infections and for myiasis-inducing larvae (Dreyer, Fourie & Kok1998b).

Tick-induced diseases and productivity losses have inflicted large costs on African beef and dairy producers (Young & Haantuba 1997). Norval (1983b) argued that while it was accepted that ticks caused direct damage to cattle, that damage had to be considered rationally in the light of assessing the economic costs of damage compared to the costs of controlling the ticks. In essence the point is that damage should not be looked at in isolation but the economic scenario has to be considered also.

Research has been conducted to assess the productivity effects of various ticks, particularly *Rhipicephalus (B.)* spp., *Amblyomma* spp. and *R. appendiculatus* (Norval *et al.* 1988; Norval *et al.* 1989; Meltzer & Norval 1993; Starchurski *et al.* 1993; Meltzer *et al.* 1995; Jonsson, Mayer, Matschoss, Green & Ansell 1998; Jonsson 2006). Parallel to the research on productivity losses has been the development of concepts such as economic damage threshold (Meltzer & Norval 1993) and economic threshold (Young & Haantuba 1997).

Working in Zimbabwe, Meltzer & Norval (1993) defined the economic damage threshold for *A. hebraeum*-infested cattle as the minimum average weekly standard female tick burden sufficient to cause damage equal in dollar value to the cost of applying tick control. This figure can be changed due to damage to udders and teats, infestation of cattle by screwworms and the nutritional condition of the animal.

According to Young & Haantuba (1997), the economic threshold is defined as the lowest pest population that causes a reduction in profit, or equivalently the pest population where the benefits of control equal the costs of eliminating the pest. In their study Young & Haantuba (1997) found that the economic threshold for *R. appendiculatus* differed between infectious and non-infectious ticks. When infectious ticks were considered, then the economic threshold was reached even when only a single tick was present. In Sanga calves, the threshold of non-infectious *R. appendiculatus* was three ticks per calf. This figure varies depending on the prevailing beef prices. The model used to derive the figure can also be used for other breeds of cattle.

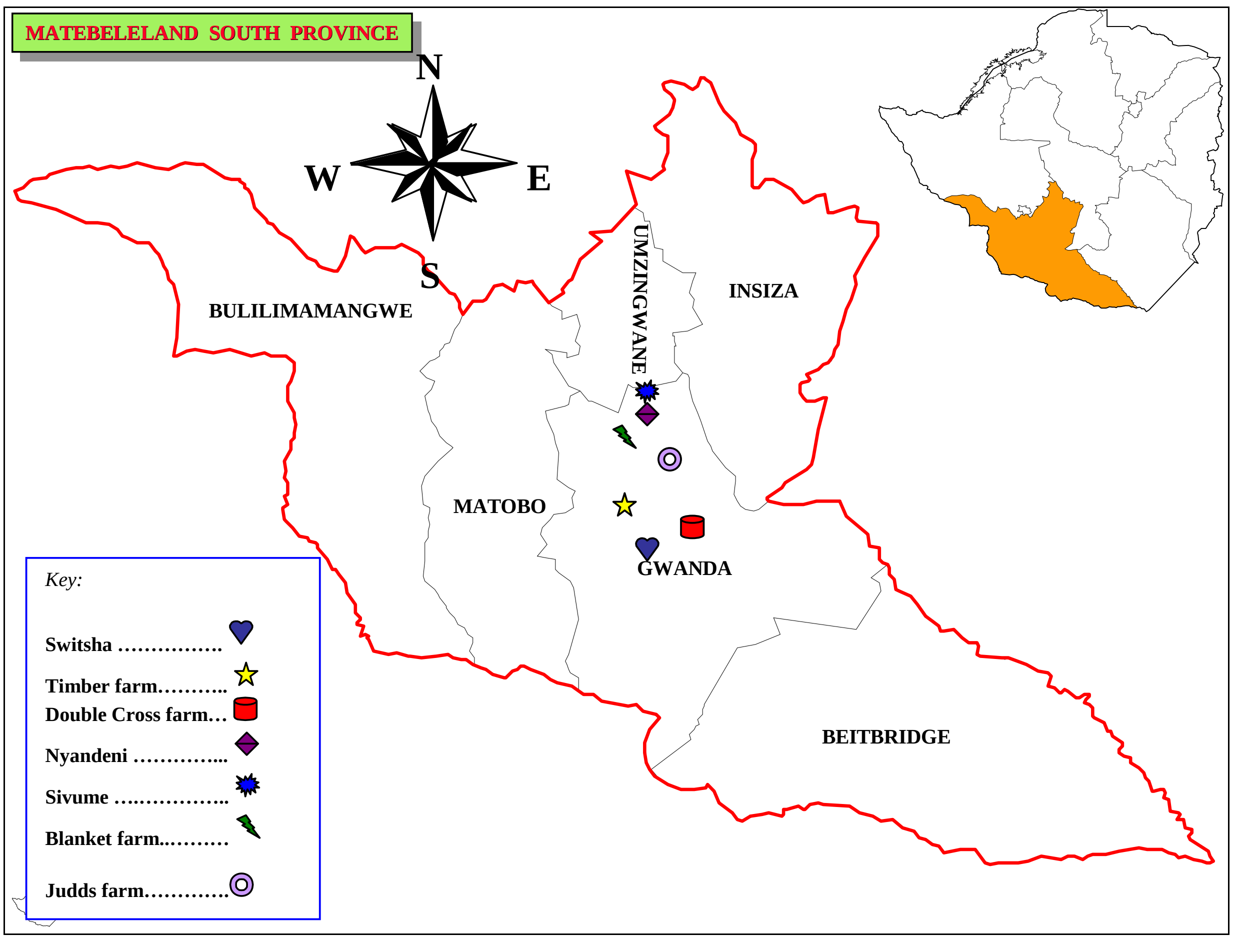
These two concepts of economic damage threshold and economic threshold can be used by animal-health decision makers to make prudent choices on whether to use an acaricide or when to use it (Meltzer & Norval 1993; Young & Haantuba 1997).

Chapter 3: Materials and methods

3.1 Study Area

The study was conducted in Gwanda district, which is in Matabeleland South Province, Zimbabwe. The area is bordered by Beitbridge district to the south, Matobo district to the west, Umzingwane district to the north-west and Insiza, Mberengwa and Mwenezi districts to the east and south-east respectively (Fig. 1).

Fig. 1: Maps of Zimbabwe and Matabeleland South Province showing study areas in Gwanda district



The study was conducted during the months of January, March and April 2007. The properties at which the study was done fall under the two main categories or sub-sectors. One is the small-holder sector (SH) in which access to grazing land and natural resources is communal. The other is the commercial sector (CS) in which access to grazing and natural resources is not communal (Tawonezvi 2005). The SH comprises the communal areas, small-scale commercial farming areas, old resettlement and the new resettlement areas, the latter being formally called A1 properties. The CS is made up of the original large-scale commercial farms before the land reform, and the A2 farms that were redistributed to prospective commercial farmers after the land reform.

A total of seven properties were sampled. The first property, Switsha dip-tank (21°10′ S, 29°07′E), a communal-area dip-tank, was used as a pilot survey site to assess the completeness of the data-capture forms and to assess the ability to identify ticks by officers involved in the study. The other properties were Timber farm (21°01′S, 29°09′E) and Double cross farm (21°10′S, 29°09′E), these two properties being A2 farms. New farmers who were formerly communal farmers own these two farms. The two commercial farms were Judds farm (20°53′S, 29°39′E) and Blanket farm (20°05′S, 28°27′E), which are owned and managed by the original farmers from before the land reform. The CS properties were chosen in such a way as to include established commercial farmers and the “new” farmers (A2). In addition to Switsha diptank, two communal dip-tanks were sampled, these being Sivume (20°36′S, 28°31′E) and Nyandeni (20°40′S, 28°55′E).

The study properties are all found in natural regions 4 and 5 of Zimbabwe (Tawonezvi 2005; International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (2007). This region is characterised by low and erratic rainfall below 450mm in region 5 and between 450 mm and 650 mm in region 4 (ICRISAT 2007). This area is therefore suitable for extensive cattle and game ranching (Central Statistical Office 2000; Tawonezvi 2005). Generally, in these regions, the year can be divided into three seasons: a warm, wet season from mid-November until April, a cool dry season from April to August and a hot dry season from September up to mid-November (Colborne, Norval & Spickett 1981).

According to ICRISAT (2007), the common vegetation type in Gwanda district is comprised of *Colophospermum mopane*, *Combretum* spp., *Acacia* spp., *Boscia* and *Grewia* spp. woodlands. The common grass species are *Aristida* and *Panicum* spp.

The control of ticks and TBDs differs in the two sub-sectors. The DVFS is responsible for providing strategic dipping services in the SH sector, with the small-holder farmers paying a dipping levy that goes towards procurement of the acaricide. In this sector strategic dipping is practised mainly aimed at the control of adult ticks. Weekly dipping is conducted during the wet season from November to March, while fortnightly dipping is done during the other eight months. Adherence to this program is dependent on the availability of foreign currency to purchase some components of the acaricide by the local manufacturers. Plunge-dipping is practised in the communal areas through the use of Amitraz 25.50 % m/m (“Tickbuster® WP”, Zimbabwe Phosphate Industries).

In the CS, the farmers are responsible for the control of ticks and TBDs, and they usually practise intensive dipping regimens, as long as acaricide is available. This is characterised by weekly dipping to ensure that cattle are tick-free.

3.2 Experimental animals

A total of 286 female cattle (lactating cows and heifers) were sampled. This does not include the 17 cattle that were sampled at Switsha diptank during the pilot survey. The properties were chosen through convenient sampling, while the sample animals were sampled systematically (Thrusfield 1995) at the dip-tanks and farms. The numbers of cattle sampled at each property are indicated in Table 1.

As absolute ages of individual animals were unknown, parity (i.e., number of calves borne) was used as an indicator of age.

Table 1: Location, number of cattle sampled and geo-references

Farm or diptank	**Sector**	**Number sampled**	**Latitude**	**Longitude**
Blanket	Commercial	34	20°05′S	28°27′E
Double cross	Commercial	46	21°10′S	29°09′E
Judds	Commercial	39	20°53′S	29°39′E
Timber	Commercial	21	21°01′S	29°09′E
Nyandeni	Communal	55	20°40′S	28°55′E
Sivume	Communal	91	20°36′S	28°31′E

3.3 Tick infestation

Tick infestation was defined according to the Animal Health Act (Cattle Cleansing) Regulations, 1993 (Government of Zimbabwe 1993). The Statutory Instrument 250 of 1993 of the Animal Health Act among other things defines a tick, dipping and tick infestation. According to the Act a herd of cattle will be deemed to be tick infested if any of the following conditions are met: ten or more live ticks are found on each of a number of cattle amounting to more than ten per centum of the herd; ten or more engorged ticks on any one animal in the herd; or five or more engorged ticks on each of at least five herd of cattle in that herd. However, for the purposes of this study, tick infestation was defined as occurring when an animal had ten or more live ticks on it.

3.4 Tick index

The tick index of each farming sector was defined as the number of ticks per animal. This was calculated by dividing the total number of ticks counted at each farming sector by the total number of cattle sampled.

3.5 Experimental procedure

3.5.1 Tick counts

Tick counts were done on systematically selected animals at the farms or dip tanks. Based on the knowledge that they cause most of the physical damage and are associated with productivity losses (Norval *et al.* 1988; Norval *et al.* 1989; Starchurski *et al.* 1993; Jonsson 2006), only adult ticks were counted. No attempt was made to identify immature stages or to classify ticks according to male or female in the field. Counting of ticks was done on one side of the animal while on the udder all ticks were counted. The tick-counting method according to Londt, Horak & de Villiers (1979), which targets counting of ticks at their predilection sites on the live animal (Baker & Ducasse 1967), was used to count the ticks. Ticks were counted from six sites: the pinna, neck, leg, tail, upper and lower perineum.

On the pinna, which is the predilection site for all stages of *R. appendiculatus* and immature stages of *R. (B.) decoloratus*, ticks were counted on both surfaces. The neck region, a predilection site for all stages of *R. (B.) decoloratus* and *R. appendiculatus* larvae, was sampled by counting all the ticks found on one side of the neck and the dewlap. On the leg, an important site for all stages of *R. (B.) decoloratus*, immature stages of *Ambylomma hebraeum* and *R. appendiculatus* and adult *Hyalomma* species, only the forelimb was sampled and ticks were counted from the axilla down to the foot. The tail, a predilection site for adult stages of *Rhipicephalus simus*, *Hyalomma truncatum* and *A. hebraeum*, was sampled by palpating and searching for the ticks on the tail brush only. All ticks from the upper perineum, an area extending from the base of the tail to about 10 cm below the anus were counted. This is the predilection site for the adult stages of *Rhipicephalus e. evertsi*, *A. hebraeum* and *Hyalomma marginatum rufipes*. The lower perineum, an important site for adult *A. hebraeum* ticks, included an area extending from below the upper perineum to include the whole udder; all ticks found at this site were counted.

3.5.2 Tick collection

At least two ticks of each species were collected manually ~~by hand~~ ("manually" means "by hand") from their predilection sites (Baker & Ducasse 1967; Londt *et al.* 1979) for laboratory identification. Collection of ticks for identification was done on the same site as for the tick counts. Ticks collected from the same site on one animal for each dip-tank or farm were placed in a labelled universal bottle containing 70% alcohol as a preservative for further laboratory identification.

Ticks which could be easily identified visually were identified *in situ* in the field and those which could not be identified visually were sent to the Central Veterinary Laboratory in Harare for further identification and confirmation under a stereomicroscope. Ticks were identified to genus and species level according to their morphological features, colour and predilection site using the key of Walker *et al.* (2003).

3.5. 3 Characterising udder and teat damage

In this study udder damage was defined as conditions that affected the udder such as induration of one or more quarters, abscessation and open wounds. Udder damage was assessed by visual inspection, palpation and from the clinical history given by the owner. Further, it was also checked whether one or more quarters were affected.

Teat damage was defined to include blocked teats, lost teats and teats that expressed milk with pus on manipulation. The damage to teats was assessed by visual inspection, manual palpation and milking of all quarters to check for blockages.

3.5.4 Information on the treatment or non-treatment of udders and teats

Farmers were verbally questioned on how they managed conditions affecting udders and / or teats. The only respondents targeted were those farmers whose cattle had the conditions of interest.

3.6. Data capture

The information on tick numbers, tick species, udder damage, teat damage, treatment or non-treatment and parity of the animal were entered into two data-capture forms. One of the forms captured information on udder damage and teat damage, treatment or non-treatment and also tick counts at the various predilection sites. The other form captured information on tick species and their numbers (see annexures 1 and 2). Udder and teat damage was characterised as either absent, that is no damage and coded as N: where there was damage, coding was Y for yes. The same coding applied for teat damage. Treatment for udder and or teat damage was also coded; as Y for treatment and N for no treatment. The date of the last dipping before the survey was also recorded.

After field collection, the data were entered into Excel spreadsheet (Microsoft 2000). These data were also transformed into a database in Microsoft Access 2000.

3.7 Statistical analysis

The overall number of tick infested cows and heifers was calculated from the total number of animals sampled and expressed as a percentage. Tick infestation was evaluated in relation to the farming sector, predilection site and parity of the animal. Udder and teat damage was assessed in relation to farming sector, parity and tick infestation status of the animal. Farming sector, predilection site and parity of the animal categories were generated as follows: three for farming sector (communal, A2 and commercial), six for predilection site (pinna, neck, leg, tail, upper and lower perineum) and three for parity (1-3, 4-6 and ≥7).

The Two-Sample Proportion-Test and Two-Sample T-test for independent groups in Statistix (Analytical Software, 1996 version 1.0) was used to measure differences in proportions between categories and to evaluate the differences in mean number of tick counts for the different categories, respectively. Values of $P < 0.05$ were considered as significant.

Association between tick infestation and the potential putative risk factors and that between udder and teat damage and the potential putative risk factors was evaluated using Epi-Info Version 6. For tick infestation, the analysis focused on two risk factors, namely farming sector and parity of animal, while that for udder and teat damage focused on farming sector, parity and tick infestation status of the animals. The association was assessed by calculating the chi-square (χ^2) test for association, the relative risk (RR) and 95% confidence intervals (Thrusfield 1995). An RR greater than 1 indicates a positive statistical association between factor and outcome, while that less than 1 indicates a negative statistical association and an RR of 1 suggests no association (Thrusfield 1995).

Chapter 4: Results

4.1 Tick infestation according to farming sector, predilection site and parity of animals

Of the 286 cows and heifers sampled, 233 (81.5%) were infested with ticks (Table 2). The communal (93.8%) and A2 (85.1%) sectors recorded a significantly higher (P<0.05) prevalence compared to the commercial farming sector and there was no significant difference between the former two farming sectors (Table 2). Occurrence of tick infestation was significantly associated with the communal sector (χ^2 = 47.8, P<0.001) and the A2 sector (χ^2 = 14.8, P<0.001) compared to the commercial sector. Tick infestation was found to be approximately 2 times more likely to occur on the communal sector (RR = 1.8, 1.4<RR<2.2) and the A2 sector (RR = 1.6, 1.3<RR<2.02) compared to the commercial farming sector.

Table 2: Number of cattle infested with ticks and the prevalence of tick infestation according to farming sector

Farming sector	Number of cattle sampled	Number of cattle infested	Prevalence (%)
Communal	146	137	93.8[a]
A2	67	57	85.1[a]
Commercial	73	39	53.4[c]
Total	286	233	81.5

Figures with a different superscript in a column are significantly different at P<0.05

Of the 8792 ticks counted *in situ*, the following species and groups were identified, in descending order of prevalence (Table 3): *Amblyomma hebraeum* (36%), *Hyalomma truncatum/H. m. rufipes* (29%), *Rhipicephalus evertsi evertsi* (17.7%), *Rhipicephalus (B.) decoloratus* (6.5%), *Rhipicephalus simus* (5.4%) and *Rhipicephalus zambeziensis/appendiculatus* (5%).

Table 3: Total tick counts according to tick species identified by visual inspection

Tick species	Total tick count	%
A. hebraeum	3165	36.0
*H. truncatum**	2575	29.3
R. e. evertsi	1559	17.7
R. (B). decoloratus	574	6.5
R. simus	477	5.4
*R. zambeziensis***	442	5.0
Total	8792	

* includes *H. m. rufipes*

** includes *R. appendiculatus*

Of the 8792 ticks counted, the communal sector (70%) contributed the highest percentage with the A2 and commercial sectors together contributing 30% (Table 4). The tick index varied among the farming sectors with the communal sector (42.2) recording the highest index followed by the A2 (19.4) and the commercial sector recording the lowest (Table 4). Similarly, the mean tick counts varied significantly ($P<0.05$) among the farming sectors (Table 4); irrespective of the tick species, the communal sector recorded a significantly overall higher mean tick count compared to the A2 and commercial sectors. However, there was no significant overall mean tick count difference between the A2 and commercial sectors. *Amblyomma hebraeum, H. truncatum* and *R. e. evertsi* recorded significantly ($P<0.05$) higher mean tick counts for the communal sector compared to the A2 and commercial farming sectors (Table 4). However, *A. hebraeum* mean tick count was significantly higher for the A2 sector compared to the commercial sector while that for *R. e. evertsi* was significantly higher for the commercial sector compared to the A2 sector. There was no significant difference in the mean tick count of *H. truncatum* between the two sectors. There was no significant difference in the mean tick count of *R. (B). decolaratus* among all the farming sectors. *Rhipicephalus simus* recorded a significantly lower mean tick count for the A2 sector compared to the commercial and communal sectors while that for *R. zambeziensis* was significantly lower for the commercial sector compared to the A2 and communal sectors.

Table 4: Total tick counts, mean tick counts and tick index according to farming sector and tick species identified by visual inspection

	Farming sector					
	Communal		A2		Commercial	
Tick species	*TTC	Mean ± s.e.	*TTC	Mean ± s.e.	*TTC	Mean ± s.e.
A. hebraeum	2198	$16^{a} \pm 1.2$	621	$9.9^{b} \pm 0.8$	346	$5.9^{c} \pm 0.7$
H. truncatum	1938	$15^{a} \pm 0.9$	297	$5^{b} \pm 0.5$	340	$7^{b} \pm 0.9$
R. e. evertsi	1169	$11^{a} \pm 0.8$	84	$3.7^{b} \pm 0.8$	306	$5.8^{c} \pm 0.3$
R. (B). decolaratus	511	$8^{a} \pm 1.2$	4	$2^{a} \pm 0.9$	59	$4^{a} \pm 0.9$
R. simus	227	$6^{a} \pm 0.8$	41	$2^{b} \pm 0.3$	209	$7^{a} \pm 1.1$
R. zambeziensis	119	$7^{a} \pm 1.6$	252	$6^{a} \pm 0.7$	71	$3^{b} \pm 0.5$
Overall	6162	$12.5^{a} \pm 0.5$	1299	$6.4^{b} \pm 0.4$	1331	$5.8^{b} \pm 0.3$
Total cattle sampled	146		67		73	
Tick index	42.2		19.4		18.2	

Mean tick counts with a different superscript in a row for each tick species are significantly different at $P < 0.05$

*TTC = Total tick count

The upper perineum recorded the highest percentage (34.3%) of the ticks counted *in situ*, followed by the lower perineum (26.9%) with the leg (6.2%) recording the lowest percentage (Table 5). Mean tick counts varied significantly (P<0.05) according to the predilection site (Table 5) and irrespective of the tick species the upper and lower perineum recorded significantly higher mean tick counts compared to the other sites. The tail and the pinna also recorded significantly higher mean tick counts compared to the neck and the leg.

Table 5: Total, percent and mean tick counts of ticks identified visually according to predilection site on sampled animals

Predilection site	Total tick count	% of total	Mean ± s.e
Upper perineum	3016	34.3	$11.8^{a} \pm 0.6$
Lower perineum	2358	26.9	$10.1^{a} \pm 0.6$
Tail	1252	14.2	$7.6^{b} \pm 0.6$
Pinna	952	10.8	$6.7^{b} \pm 0.5$
Neck	669	7.6	$4.8^{c} \pm 0.5$
Leg	545	6.2	$4.2^{c} \pm 0.3$
Total	8792		

Mean tick counts with a different superscript in a column are significantly different at $P < 0.05$

Tick samples that were sent to the Central Veterinary Laboratory (Table 6) revealed that *R. appendiculatus* was present at three properties; with *R. zambeziensis* present at all sampled properties. Other tick species, which were confirmed at the laboratory, were *H. m. rufipes*, which was identified from all the sites but Sivume dip tank, and *H. truncatum,* which was identified at four sites but not at Judds farm.

Table 6: Specimens identified by the Central Veterinary Laboratory

	Diptank/farm					
Tick species	Switsha	Double cross	Judds	Nyandeni	Sivume	Total
A. hebraeum	26	4	2	*	1	33
R. evertsi evertsi	*	2	1	*	3	6
R. appendiculatus	0	0	1	1	11	13
R. zambeziensis	11	20	3	5	2	41
R. (B.) decoloratus	0	0	18	0	17	35
R. simus	1	11	5	3	6	26
H. truncatum	6	5	0	5	11	27
H. marginatum rufipes	6	3	2	5	0	16
Total ticks counted	50	45	32	19	51	197

** Not submitted*

The highest percentage of *A. hebraeum* and *R. appendiculatus* was recorded on the lower perineum while that of *R. e. evertsi* and *H. m. rufipes* was on the upper perineum, that for *R. (B). decoloratus, R. simus* and *H. truncatum* was on the tail and that for *R. zambeziensis* was on the pinna (Table 7).

Table 7: Predilection site of laboratory identified tick species

	Tick species								
Predilection site	*A. hebraeum (%)*	*R.. e. evertsi* (%)	*R.. zambeziensis* (%)	*R.. appendiculatus* (%)	*R.. (B). decoloratus* (%)	*R.. simus* (%)	*H. truncatum* (%)	*H. rufipes* (%)	Total (%)
Upper perineum	3 (9.1)	5 (83.3)	2 (4.9)	0	6 (17.1)	0	3 (11.1)	14 (87.5)	33 (16.8)
Lower perineum	18 (54.5)	0	1 (2.4)	9 (69.2)	3 (8.6)	1 (3.8)	4 (14.8)	0	36 (18.3)
Tail	5 (15.2)	1 (16.7)	4 (9.8)	1 (7.7)	11 (31.4)	23 (88.5)	14 (51.9)	2 (12.5)	61 (31.0)
Pinna	0	0	21 (51.2)	1 (7.7)	1 (2.9)	0	0	0	23 (11.7)
Neck	1 (3)	0	13 (31.7)	2 (15.4)	6 (17.1)	0	2 (7.4)	0	24 (12.2)
Leg	6 (18.2)	0	0	0	8 (22.9)	2 (7.7)	4 (14.8)	0	20 (10.2)
Total	33	6	41	13	35	26	27	16	197

There was no significant difference in the prevalence of tick infestation according to parity (Table 8).

Table 8: Number of cattle infested with ticks and the prevalence of tick infestation according to parity

Parity	Total sample	Number infested	Prevalence (%)
1-3	199	162	81.4^a
4-6	80	65	81.3^a
≥7	7	6	85.7^a
	286	233	

Figures with a different superscript in a column are significantly different at $P<0.05$

4.2 Udder and teat damage according to farming sector and parity of animals

The communal sector recorded a significantly higher ($P<0.05$) prevalence of udder and teat damage compared to the A2 and commercial farming sectors and there was also a significant difference between the latter two farming sectors (Table 9). Occurrence of udder damage was significantly associated with the communal sector ($\chi^2 = 21$, $P<0.001$; $\chi^2 = 49$, $P<0.001$) compared to the A2 and commercial sectors. Similarly, teat damage was significantly associated with the communal sector ($\chi^2 = 22.3$, $P<0.001$; $\chi^2 = 64.8$, $P<0.001$) compared to the A2 and commercial sectors and teat damage was also significantly associated with the A2 sector ($\chi^2 = 8.6$, $P=0.003$) compared to the commercial sector.

Table 9: Number and proportion of cows and heifers with udder and teat damage according to farming sector

Farming sector	Total sampled	Udder damage (%)	Teat damage (%)
Communal	146	108 (74.0[a])	111 (76.0[a])
A2	67	27 (40.3[b])	28 (41.8[b])
Commercial	73	17 (23.3[c])	13 (17.8[c])
Total	286	152 (53.1)	152 (53.1)

Figures with a different superscript in a column are significantly different at P<0.05

Udder damage was found to be approximately 2 times and 3 times more likely to occur on the communal sector (RR = 1.8, 1.4<RR<2.5; RR = 3.2, 2.1<RR<4.9) compared to the A2 and commercial farming sectors, respectively. Similarly, teat damage was found to be approximately 2 times and 4 times more likely to occur on the communal sector (RR = 1.8, 1.4<RR<2.5; RR = 4.3, 2.6<RR<7.1) compared to the A2 and commercial farming sectors, respectively. Teat damage was also found to be approximately 2 times more likely to occur on the A2 sector (RR = 2.4, 1.3<RR<4.1) compared to the commercial sector.

Animals of parity 1-3 recorded a significantly higher (P<0.05) prevalence of udder and teat damage compared to those of parity 4-6, but there was no significant difference between those of parity 1-3 and parity ≥7 and those of parity 4-6 and parity ≥7 (Table 10). Occurrence of udder (χ^2 = 5.6, P=0.02) and teat (χ^2 = 10.7, P<0.001) damage was significantly associated with parity 1-3 compared to parity 4-6. Udder (RR = 1.4, 1.1<RR<1.9) and teat (RR = 1.6, 1.2<RR<2.2) damage was found to be

1.4 times and approximately 2 times more likely to occur on animals of parity 1-3 compared to those of parity 4-6, respectively.

Table 10: Number and proportion of cows and heifers with udder and teat damage according to parity

Parity	Total sampled	Udder damage (%)	Teat damage (%)
1-3	199	115 (57.8^{a})	117 (58.8^{a})
4-6	80	33 (41.3^{b})	29 (36.3^{b})
≥7	7	4 (57.1^{ab})	4 (57.1^{ab})
Total	286	152 (53.1)	150 (52.4)

Figures with a different superscript in a column are significantly different at $P<0.05$

4.3 Association between tick infestation and udder and teat damage

The percentage of tick-infested animals with udder damage was higher than those with tick infestation but with no udder damage (Table 11).

Table 11: Tick infestation and udder damage situation of sampled animals

Tick infestation and udder damage status	Number of animals (Total animals tick infested/not tick infested)	%
Tick infested animals with udder damage	133 (233)	57.1
Tick infested animals with no udder damage	100 (233)	42.9
Not tick infested animals with udder damage	19 (53)	35.8
Not tick infested animals with no udder damage	34 (53)	64.2

Similarly, the percentage of tick-infested animals with teat damage was higher than those with tick infestation but with no teat damage (Table 12).

Table 12: Tick infestation and teat damage situation of sampled animals

Tick infestation and teat damage status	Number of animals (Total animals tick infested/not tick infested)	%
Tick infested animals with teat damage	135 (233)	57.9
Tick infested animals with no teat damage	98 (233)	42.1
Not tick infested animals with teat damage	17 (53)	32.1
Not tick infested animals with no teat damage	36 (53)	67.9

Occurrence of udder (χ^2 = 5.5, P=0.02) and teat (χ^2 = 10.6, P<0.001) damage was significantly associated with tick infestation compared to no tick infestation. Udder (RR = 1.6, 1.04<RR<2.2) and teat (RR = 1.8, 1.2<RR<2.7) damage was found to be approximately 2 times more likely to occur on tick infested animals compared to those with no tick infestation.

4.9 Treatment for udder and or teat damage

Only four animals were treated out of a total of 152 cattle with udder and teat damage. The properties where treatment was given were Blanket farm and Double cross farm.

Chapter 5: Discussion

5. 1 Tick infestation

According to the Animal Health Act (Cattle Cleansing) regulations GOZ (1993), tick infestation arises when at least 10 % of the cattle have ≥ 10 live ticks on them. In this study, 81.5 % of the cattle met this criterion and thus were regarded as tick infested. Cattle can become tick infested if they are not regularly dipped or if ticks have developed resistance to the acaricide being used. The significant difference in prevalence of tick infestation between the communal and the other sectors as expressed by the mean tick counts and tick index, could be attributed to the different management practises in these sectors. In the communal sector, farmers rely on Government to supply acaricide, which it does erratically due to budgetary constraints. On the other hand, the commercial and A2 farmers are responsible for providing their own dipping services and these farmers are usually better off than communal farmers. The A2 farmers are somewhere in-between established commercial farmers and communal farmers in their provision of dipping services. A2 farmers traditionally are used to Government-provided dipping services and are taking some time in gaining the capacity to provide an efficient tick-control program of their own. Abundance of live ticks on cattle can occur for various reasons, amongst others, development of resistance to the particular acaricide used (Meltzer & Norval 1993), or poor mixing of the acaricide. The latter has been reported from the Eastern Cape Province of South Africa, where farmers complained that the acaricide was not killing ticks. Further investigations revealed that failure of acaricide was due to poor mixing of the acaricide (Mekonnen *et al.* 2002). The other factor that can contribute to increased tick abundance on cattle, even after regular and recent dipping, is the abundance of the free-living stages in the veld that could be due to favourable environmental conditions. As this study was conducted during summer, it would be expected that free-living stages would be in abundance in the veld and the pick-up rate of ticks from the veld would be correspondingly high.

5.2 Tick genera and species infesting cattle

A total of eight species of ticks were found to be infesting cattle at the different study sites (Tables 4, 6 and 7). The ticks belonged to the three genera, namely *Amblyomma*, *Rhipicephalus* (including the subgenus *Boophilus*) and *Hyalomma*. According to Punyua, Latif, Nokoe & Capstick (1991; cited by Hlatshwayo, Mbati & Dipeolu 2002), it is rare to find more than six species infesting their hosts in any one given ecological zone. In this case, eight species of ticks were found infesting cattle, which would mean that the study area comprised of two or more ecological zones. On the other hand, this could be one of those rare instances where more than six tick species are found in one ecological zone, as was evident at Judds farm, Sivume dip tank and Nyandeni dip tanks, where seven tick species were identified at the collection sites. Related species such as *R. appendiculatus* and *R. zambeziensis*, as well as *H. truncatum* and *H. marginatum rufipes*, coexisted at these sites.

The ticks species identified, in descending order of abundance, were *A. hebraeum, Hyalomma* species, *R. e. evertsi*, *R. (B.) decoloratus, R. simus* and the *R. appendiculatus* / *zambeziensis* group. These findings are partly in agreement with those of Bryson, Tice, Horak, Stewart & du Plessis (2002) who found that in some parts of South Africa, particularly in the North West Province, the commonest ticks infesting cattle were *A. hebraeum*, *R. appendiculatus* and *R. e. evertsi* while in Mpumalanga Province the commonest tick was *R. (B.) decoloratus*. These findings are in contrast to those of several workers (Dreyer, Fourie & Kok 1998b; Mekonnen, Hussein & Bedane 2001; Hlatshwayo *et al.* 2002) who found that the commonest tick species infesting cattle was *R. (B.) decoloratus* in some parts of the Free State province of South Africa and in central Ethiopia, while Regassa (2001) found the commonest tick in the Borana province of Ethiopia to be *R. pulchellus* and some other related rhipicephaline species.

5.2.1 Amblyomma hebraeum

The finding of *A. hebraeum* in this part of the country and the absence of *A. variegatum* is in agreement with the findings of Peter *et al.* (1998a), who found that *A. hebraeum* was predominant in the lowveld whilst this tick species was not collected in the northern regions of the highveld of Zimbabwe and further northward. According to Peter *et al.* (1998a) the northern limit of *A. hebraeum* is latitude 17 º South. Above this northern limit it is replaced by *A. variegatum*. The absence of the related species of *A. variegatum* during the study in this lowveld area was expected. *Amblyomma variegatum* is limited to the Zambezi valley and the surrounding dry lowveld areas in the north-western parts of Zimbabwe (Norval *et al.* 1994) while in the east it is found in the Burma valley, which is at the eastern border of Zimbabwe (Norval 1983a).

5.2.2 Hyalomma *species*

Hyalomma truncatum and *Hyalomma m. rufipes* were found to be infesting cattle at some of the study sites. These two tick species occurred together at 80 % of the study sites, as indicated by samples sent to the laboratory.

The upper perineum was the attachment site of 87.5 % of *H. m. rufipes* while 12.5 % were collected from the tail. This tick did not infest the other parts of the animal. This study confirmed the predilection site for *H. m. rufipes* to be the upper perineum, in agreement with Baker & Ducasse (1967) and Londt *et al.* (1979).

The related *Hyalomma truncatum* was collected at 80 % of the study sites. The majority of ticks, *ca.* 52 %, were collected from the tail, while all attachment sites on the animal, except for the pinna, yielded ticks. These findings differ slightly from those of Londt *et al.* (1979) who collected the tick from all the six predilection sites, with most of the ticks being collected from the upper perineum.

Chatikobo *et al.* (2001) collected only *H. m. rufipes* from cattle in the Sanyati smallholder farming area in the northwest part of Zimbabwe. Horak, Swanepoel & Gummow (2001) reported the presence of *H. truncatum*, *H. m. rufipes* and *H. marginatum turanicum* in South Africa. The latter subspecies was not recovered during the current study.

5.2.3 Rhipicephalus evertsi evertsi

Finding of *R. e. evertsi* at all sites was consistent with the findings of Norval (1981) who reported that this tick species occurred in all parts of Zimbabwe except in the

Zambezi valley. Its abundance in an area is also determined by the abundance of its preferred equine hosts such as donkeys, horses and zebras. The current livestock movements onto some former commercial farms have led to the introduction of donkeys by the newly resettled farmers. Donkeys are important in maintaining *R. e. evertsi* populations.

5.2.4 Rhipicephalus (Boophilus) decoloratus

Rhipicephalus (Boophilus) decoloratus was found at all study sites except at Double cross farm. The related *R. (B.) microplus* was not found in this lowveld area. The absence of *R. (B.) microplus* was expected, as it has a limited distribution in Zimbabwe (Katsande *et al.* 1996). The failure to find *R. (B.) decoloratus* at Double cross farm could have been due to the fact that cattle had been dipped three days previously and as such this tick could have been removed by the acaricide.

Other workers (Dreyer *et al.* 1998b; Mekonnen *et al.* 2001; Hlatshwayo *et al.* 2002) have found that *R. (B.) decoloratus* was the species commonly infesting cattle while in this study it was the fourth commonest in abundance.

5.2.5 Rhipicephalus simus

This tick species was collected from all study sites. As was expected, the bulk of the collections (*ca.* 88 %) were from the tail switch. These findings are similar to those of Londt *et al.* (1979), where 100 % of the ticks were collected from the tail switch. Interestingly, *R. simus* was found in large numbers on some properties during this study; in contrast, Bryson *et al.* (2002) indicated that while this tick is widely distributed, it is seldom found in large numbers. The large numbers identified at some study sites would indicate that there is an abundance of murid rodents in the area, which are the hosts for the immature stages of this tick species (Walker *et al.* 2003). The other reason for the abundance would be the dipping method: if farmers do not thoroughly wet the tail switch or ignore it completely, then this tick would thrive.

5.2.6 Rhipicephalus appendiculatus *and* Rhipicephalus zambeziensis

These two ticks were found to co-exist on some properties. It was evident from samples sent to the laboratory, that *R. appendiculatus* and *R. zambeziensis* co-existed at 60 % of the sites (see Table 6). In Zimbabwe *R. appendiculatus* it is confined to the moister regions that include the highveld. The related *R. zambeziensis* replaces *R. appendiculatus* in the hot dry river systems in the lowveld of Zimbabwe (Norval, Walker & Colborne 1982; cited by Mooring and Mazhowu 1995). Competitive displacement between the two species is a possibility (Mooring & Mazhowu 1995). This displacement occurs in those areas where the distributions of the two species overlap. The study areas could have dip tanks and farms where the displacement occurs. Of *R. appendiculatus* specimens collected, 84 % were from Sivume diptank (20º 36' S, 28º 31' E), the northernmost study site, as compared to 4.8 % of *R. zambeziensis* collected at this site. In contrast, *ca.* 49 % of *R. zambeziensis* specimens were collected at Double cross farm (21º 10' S, 29º 09' E), the southernmost study site, but no *R. appendiculatus* were collected at this site. There is an apparent displacement of *R. appendiculatus* by *R. zambeziensis* as one proceeds southward in the study area.

5.3 Udder and teat damage

Tick infestations have been viewed by farmers as causes of teat damage (Masika, Sonandi & van Averbeke 1997; Hlatshwayo & Mbati 2005). They also cause udder damage, predispose to mastitis, abscessation and hide damage (Meltzer & Norval 1993; Dreyer *et al.* 1998a; Dreyer *et al.* 1998b; Tibary & Anouassi 2000).

Of the 286 milking cows and heifers sampled in this study, 53 % had some degree of udder and/or teat damage. This is in agreement with results from Kenya (Meltzer & Norval 1993), where 52 % of the milking cattle surveyed had lost one or more teats. While no teats were reported lost in the current study, teat and udder damage was encountered in the form of blocked teats, pus discharges and induration of quarters. The reason teats not being lost is that farmers on most of the properties surveyed practised some form of regular tick control. If a breakdown in tick control, for whatever reason, were to occur for a prolonged period, then the prevalence of lost teats would emerge as an important issue. There was also a significant association between udder/teat damage and infestation, with most of the ticks being recovered from the upper perineum and lower perineum (Table 5). The latter fact combined with the fact that the location of *A. hebraeum* was significantly associated with the lower perineum which included the udder (Table 7), would result in udder/teat damage. *Amblyomma hebraeum* has large mouth parts which cause extensive inflammation and damage during feeding.

Cows of lower to middle parity were the ones most affected by conditions of udder and teat damage. This differed from findings from Kenya, where it was found that animals ≥ 4 years old were more prone to damage (Meltzer & Norval 1993). The reason for the apparent difference could be due to the method of estimating the age of the animals. In this study, animals were aged according to parity rather than actual years. As such, the lower (1-3) and middle (4-6) parity groups included cows ≥ 4 years old, making comparison with the Kenyan study impossible. Of interest, was the fact that farmers treated only four (2.6 %) of the 152 animals with udder and or teat damage. This low level of treatment was due in part to lack of remedies and also due to the fact that farmers were content as long as there was at least one functional quarter and teat from which a calf could suckle.

5.4 Conclusion

Tick infestation as defined by the Animal Health Act of Zimbabwe was prevalent in milking cattle sampled, especially in communal herds of Gwanda. Such a situation is ideal for the establishment of endemic stability to the various TBDs. On the other hand, higher tick infestations can lead to damaged udders and teats, which seemed not to be important to the farmers in this study, since only a small proportion of farmers treated their affected animals. This attitude would change if communal farmers would become commercially oriented and took into consideration potential productivity losses associated with certain levels of tick infestation and the effect on the growth rates of calves suckling from two or fewer teats and quarters. Tick species such as *R. appendiculatus* and *R. zambeziensis* were found in considerable numbers, but the disease that they transmit, theileriosis, has not been reported from the study area. All the same, these cattle are at risk of contracting the disease should a *Theileria parva*-infected animal be introduced into the area. Currently, these ticks are important in the study area for the direct damage that they cause.

This study has provided some baseline data on tick species prevalent in the study area and set the stage for further research on the economic effects of tick infestations especially in SH cattle herds. The findings of the study will help animal-health decision makers in making appropriate decisions with regard to the control of ticks and TBDs in the study area.

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