THE PREVALENCE AND ECONOMIC IMPORTANCE OF NEMATODE INFECTION IN GOATS IN GWERU DISTRICT, ZIMBABWE

BY

LEONARD MAPOSA

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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.

Leonard Maposa

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Table of Contents

List of appendices

List of tables

List of Figures

The prevalence and economic importance of nematode infection in goats in Gweru District, Zimbabwe

By

Leonard Maposa

Promoter: Prof J. Boomker

Department: Veterinary Tropical Diseases

Degree: MSc

Abstract

A cross-sectional survey was conducted in four areas in the communal area of Gweru District in the Midlands Province, Zimbabwe. The study was conducted at Mkoba, Mangwande, Chiwundura and Nsukamini. The objective of the study was to determine the prevalence of nematode infection in communal goats in Gweru District, and whether or not the prevalence was related to age, sex, breed or the season. The study was important as it would help in evaluating current strategies used in nematode control and designing low cost control strategies.

One hundred and ninety-eight (198) communal goats made up of 49 males and 149 females ranging in age from one month to over twelve months were sampled. Of these, 100 were sampled during the wet season and the remaining 98 during the dry season. One hundred and fifteen (115) or 58% had significant egg counts per gram (epg) of faeces. Among the goats that had significant epg, 31 were males and 84 were females. All age groups were affected. The most common parasites encountered were *Haemonchus, Trichostrongylus, Teladorsagia* and *Oesophagostomum. Haemonchus* was the dominant species during the wet season.

The proportion of goats that had a significant EPG during the wet season was significantly higher than during the dry season (X^2=5.311; P≤0.05). There was no statistical significant difference in prevalence among the different age groups (X^2=1.270; P≤0.05) and between males and females (X^2=0.696; P≤0.05).

Chapter 1: Introduction

1.1 Background

Goat farming is one of the most common livelihood activities in Zimbabwe, and 90% of the over three million goats in Zimbabwe are kept by traditional small-scale farmers (S. Hargreaves, personal communication 2008). The farming system is usually extensive. Animals are reared together irrespective of their age. Feeding is based on grazing natural pastures with minor supplementation using crop residues. Overnight kraaling is generally practised to prevent the goats from straying into crop fields and as a way of protecting them against predators.

Goats play an important role in the culture and economies of the indigent communities in Africa (Boomker, Horak & Ramsay 1994). Their ability to withstand temporary droughts and to provide solutions to cash flow problems makes them a viable economic reserve for the resource-poor farmers. Goat meat and milk constitute arguably the second most common source of proteins after poultry in most communal households in Gweru District. All inhabitants, across religious, cultural and ethnic boundaries in the district consume goat meat. In addition goat manure is used as fertilizer in vegetable gardens. Goats also play an important role in socio-cultural functions such as payment of the bride price (lobola) and for traditional ceremonies. Female- and child-headed households and those families with limited land can easily keep goats. Some Non-Governmental Organisations (NGO) such as Heifer International have initiated goat projects in the district as a way of improving nutrition and generate income, and empowering women and youths.

One of the main challenges in goat production in Zimbabwe is disease of which helminth infection ranks among the highest. Parasites affect their host either directly or indirectly. Those that have direct effects include *Haemonchus*, *Teladorsagia* and *Fasciola* which cause severe damage to tissues or produce anaemia and those that cause indirect damage such as *Trichostronglus*, *Cooperia* and the tapeworms by competing with the host for nutrients. This results in reduced weight gain and poor reproductive performance. Mortalities due to parasite infections are common and have had the effect of lowered productivity and negated the possible benefits of keeping goats. The prevalence of nematode infection in Gweru District is not known but it is thought to be very high (N. Derah, personal communication 2008). Parasitism is endemic in the district although sporadic outbreaks are reported especially during the rainy season.

The limitation of grazing and watering places, which are shared by all farmers, and the fact that helminth control is not coordinated are factors likely to result in environmental contamination with parasitic eggs and the subsequent development of the infective stages of the parasites in any communal set up (Nginyi, Duncan, Mellor, Stear, Wanyangu, Bain & Gatongi 2001). Overstocking and overgrazing of communal pastures exposes the animals to infection with helminths (Pandey, Ndao & Kumar 1994). This increases the infection pressure and the result is the likelihood of a high prevalence of infection. The other school of thought, however, is that overstocking reduces the number of infective larvae consumed by each animal and overgrazed areas provide very little cover for the infective stages. Droughts and overgrazing give the worms as hard a time as it gives the goats and are likely to reduce the rate of infection. The control of nematodes is further complicated by the general unavailability and high cost of anthelmintic drugs in the country due to the decline in the national economy. This makes these remedies beyond the reach of resource-limited farmers who are the major goat owners in the district and the country in general. It becomes apparent that the selection of goats that have adequate resistance or tolerance to worm infection would go a long way in addressing the plight of resource-limited communal farmers. The breeding of animals for resistance appears to have considerable potential as has been shown in Australia and New Zealand where for years sheep have been bred for resistance to nematodes (Coles 2001). Goat farming in Africa is also known to have been practised successfully long before anthelmintics were available resulting in a highly worm resistant goat flock in the continent. Careful selection and avoiding use of anthelmintics can help rebuild such a highly worm resistant flock of goats for the resource-limited communal farmers.

1.2 Aims and Objectives

This study was designed to determine the prevalence of nematode infections and effect of various epidemiological risk factors on that prevalence in communal goats in Gweru District. The specific objectives of the study were;

- To determine the prevalence of nematode infections in communal goats in Gweru district,
- To determine whether the prevalence is related to age, sex, breed or the season and

- To recommend control strategies that communal farmers can use for nematodes in goats.

The Chi-square test for association was used to determine if there was any statistical association between the prevalence of infection and the epidemiological risk factor. The information obtained from this study will help in evaluating current strategies used in nematode control. Designing low cost control strategies requires knowledge of the epidemiological factors that influence the prevalence and intensity of gastro-intestinal nematodes. The results will therefore help in coming up with informed extension messages on how best the problem can be handled. In particular, farmers would be advised on which animals to pay particular attention to and the times of the year when more resources should be put towards worm control. Farmers will also be advised on the types of breeds to choose especially when resources for purchasing anthelmintic remedies are limited.

Chapter 2: Literature Review

2.1 Classification and life cycle of nematodes

Nematodes belong to several genera that fall under class Nematoda of the phylum Nemathelminthes. They are also known as roundworms because of their appearance in cross-section. The basic life cycle of nematodes is that the adult female lays eggs, which hatch into larvae. Depending on the species, eggs may hatch outside the body of the host or after ingestion and is controlled partly by moisture and temperature. In the complete life cycle the larva usually undergoes four moults at intervals shedding its cuticle. The successive larval stages are designated L_1, L_2, L_3, L_4 and after the fourth moult, the pre-adult or juvenile stage. Infection of the host is mostly through ingestion of free-living L_3, which in the majority of ruminant helminths is the infective stage. After going through the third and fourth moults inside the host, it then develops into the mature adult. The sexes are separate and the males are generally smaller than the females.

2.2 Clinical signs of nematode infection

Nematode infection may be peracute, acute or chronic. Clinical signs in goats vary depending on the type of parasite and on whether the disease is peracute, acute or chronic. The signs range from sudden deaths and haemorrhagic gastritis to anaemia, inappetence, diarrhoea, poor growth, rapid or chronic weight loss and varying degrees of oedema of which the submandibular form and ascites are common due to hypoproteinaemia associated with parasitic infection. Reproductive failure may result from poor fertility as a direct result of the poor condition of the animals.

2.3 Epidemiology of nematode infection

The epidemiology of nematode infection depends mainly on one or more of the hosts, the parasite and environmental factors. The ultimate occurrence of parasitic disease is as a result of four basic reasons, namely an increase in the numbers of infective stages, an alteration in host susceptibility, introduction of susceptible stock and the introduction of infection (Urquhart, Armour, Duncan, Dunn & Jennings 1988).

Host factors include such issues as nutritional status, physiological state, age, sex, breed and levels of acquired or innate resistance. The nutritional status of an animal plays an important role in its ability to withstand infection. Poor nutrition increases the host susceptibility to infection and the reverse is true when nutrition is good; adequately fed animals are better able to tolerate the effects of parasitism than those on a poor diet (Faizal & Rajapakse 2001). For example, animals infected with blood-sucking parasites such as *Haemonchus* will maintain their haemoglobin levels for as long as their iron intake is adequate (Urquhart *et al*. 1988). This is usual the case especially end of/after winter when the quality of food is such that animals do not ingest sufficient iron and start to die. Similarly growth rates may not be adversely affected if protein intake is good. Better nutrition during spring and the beginning of summer has been found to result in a decrease in faecal egg count in small ruminants (Papadopoulos, Arsenos, Sotiraki, Deligiannis, Lainas & Zygoyiannis 2002). Trace elements may also be important.

The physiological status of the host, such as pregnancy and lactation, especially if nutrition is not increased to meet foetus and milk requirements, may increase susceptibility to parasitic infection. Under these circumstances even low worm burdens can have detrimental effects on the food conversions of the dam, ultimately affecting foetal or neonate growth. Goats in particular are more susceptible during pregnancy and early lactation (Urquhart *et al*. 1988).

Age is well known to have significant influence on the susceptibility to infection. This has been attributed to increased resistance to infection and/or re-infection with age due to immunity as a result of intake of small numbers of larvae early in life (Assoku 1981). Even though these animals develop immunity with age, the majority remain susceptible until such time as they have been exposed to infection, for instance if they are moved to an endemic area. Most animals become more resistant to primary infection with internal parasites as they become older but adults not previously exposed to the helminths are at high risk if moved into an endemic area (Urquhart *et al*. 1988). Boomker *et al*. (1994) in their study also found an inverse relationship between the ages of goats and the mean nematode burden. Very young kids were, however, noted to have low burdens and this was attributed to a diet consisting mainly of milk and only small amounts of vegetation containing infective larvae. In contrast, Magona & Musisi (2002) in their study did not find age to have a significant influence on the faecal egg count.

Some breeds may be more resistant to helminth infection than others with the variability being genetically determined (Urquhart *et al*. 1988). For example it has been shown that the Red Masaai sheep, indigenous to East Africa, is more resistant to *Haemonchus contortus* than exotic breeds such as the Dorper (Nginyi *et al*. 2001). The selection of resistant animals and culling of poor responders could be of great importance especially among resource-poor communities who might not be able to afford anthelmintics. There is also some evidence that entire male animals are more susceptible than females to some helminth infections (Urquhart *et al*. 1988). This could be important in communities were castration is not routinely practised.

Little attention has been given to the variability between different strains of parasites in terms of their ability to infect their hosts or their pathogenicity. Parasites are, however, generally highly adaptable and it will remain important in animal health and production to conduct further investigations along these lines (Coles 2001). Numerous parasites have developed severe resistance to anthelmintic drugs (Coles 2001). Special attention therefore need to be paid on the choice of anthelmintic to use in any situation based on available information and informed research.

The environment plays a crucial role in the epidemiology of helminth infections. Development of infective stages is dependent on temperature and moisture, with levels of pasture contamination fluctuation in relation to rainfall (Nginyi *et al*. 2001). Similarly, the total gastro-intestinal nematode burden (Pandey *et al*. 1994) and the faecal egg counts (Specht 1982; Yadav & Tandon 1989; Nwosu, Madu & Richards 2007) were also found to be positively related to climatic conditions, especially rainfall. Boomker *et al*. 1994 found that *H. contortus,* which was the most prevalent nematode, followed the expected pattern of summer abundance. The recovery of small numbers of adults and 4th stage larvae during winter (Boomker *et al*. 1994) suggests that limited arrested development occurred in the northern Transvaal, currently Limpopo Province. The microclimatic humidity is also dependent upon other elements such as soil structure, vegetation type and drainage. In humid areas, the prevalence does not show a marked seasonal pattern because favourable conditions exist throughout the year (Yadav & Tandon 1989).

The influence of global warming may play an important role in the occurrence of parasitic diseases. An increase in temperature may permit development of parasites where previously ambient temperatures were too low to allow for it (Coles 2001) or eradicate parasites should the temperature increase above tolerable levels.

A single female parasite generally produces thousands of eggs under favourable climatic conditions such as those in autumn for *Teladorsagia* and *Trichostronglus* and spring and summer for *Haemonchus.* This results in contamination of the environment with eggs of the parasite. The intensity of infection with nematodes has been related to stocking rates in goats (Cabaret & Gasnier 1994) and for it to have an impact, all or most of the animals must be susceptible. This makes the immune status of the host animal very important.

The introduction of new stock can play an important role in the spread of parasitic infections. Today the introduction of a resistant worm population is probably the most important epidemiological consideration.

2.4 Control of Nematodes

Control of parasitic helminths in domestic animals is largely dependent on the use of anthelmintic drugs, but they should be integrated with methods for reducing selection for anthelmintic resistance. Effective anthelmintics remain indispensable to profitable worm control (Van Wyk, Hoste, Kaplain & Besier 2006). Most of the drugs work by interfering with essential biochemical process of the parasite. A good anthelmintic should be efficient against all stages of the particular parasite and be easy to administer. It should be easily metabolized and excreted and not toxic to the host or the environment. The cost must be reasonable to justify its use. Most of the anthelmintics can be used for prophylaxis and therapy. When used for prophylaxis it is necessary that it does not interfere with development of acquired immunity (Van Wyk *et al*. 2006).

Control strategies for parasitic nematodes are complicated by the problem of anthelmintic resistance. The high prevalence of anthelmintic resistance makes it necessary to adopt alternative control strategies or greatly modify the existing ones (Papadopoulos *et al*. 2002). Anthelmintic resistance involving particularly the gastrointestinal nematodes of small ruminants is escalating globally, to the extent that in certain countries, such as South Africa, it has already reached alarming proportions, and is affecting practically all the anthelmintics (Van Wyk 2001). Van Wyk (2001) further argues that the high levels of resistance in nematodes of veterinary importance indicate that the drugs have been used incorrectly. The development of drug resistance depends on the percentage contribution that parasites surviving chemotherapy make to the next generation (Coles 2001). Resistance may be partial or complete. Of all the factors, which predispose to the rapid selection of anthelmintic resistance, intensive treatment has been shown to be the most important (Waller, Echevarrhia, Eddi, Maciel, Nari & Hansen 1996). Resistance has in some cases been attributed to continual use of remedies with the same chemical composition and mode of action (Urquhart *et al*. 1988). In the case of some anthelmintics, partial resistance may temporarily be overcome by increasing the dosage.

2.5 The FAMACHA System.

A clinical assay for the assessment and subsequent treatment of *Haemonchus contortus* in sheep to slow down the development of anthelmintic resistance, the FAMACHA system, has been developed, tested and validated in South Africa (Vatta, Letty, Van der Linde, Van Wijk, Hansen & Krecek 2001). The system is based on a colour chart with five colour categories depicting varying degrees of anaemia that are compared with the colour of the mucous membranes of the eyes of sheep. Only animals showing significant levels of anaemia (levels 4 and 5) are treated.

Vatta *et al.* (2001) tested this system in goats farmed under resource-poor conditions in South Africa and found it to have a sensitivity of 76-85% and specificity of 52-55%. The low specificity means that a large proportion of those animals that would not require treatment would in fact be treated. However, when the use of the FAMACHA system is compared with conventional dosing practices where all the animals are treated, using the FAMACHA system would result in a large proportion of the animals being left untreated.

The concept of refugia, which is the proportion of the population of a given parasite that escapes exposure to control measures, is important in delaying the development of resistance. They are available to dilute both the progeny of resistant parasites, which survive treatment and following maturation within the host, to mate with resistant worms that have survived treatment (Van Wyk *et al.* 2006).

Van Wyk & Van Schalkwyk (1990) demonstrated the control of a resistant strain of *Haemonchus* on pasture through introduction of sheep infected with a susceptible strain. By balancing drug application with maintenance of refugia, the accumulation of anthelmintic resistant alleles in worm populations can be delayed considerably, while still providing good levels of control (Van Wyk & Van Schalkwyk 1990). The use of the FAMACHA system in goats would therefore reduce the selection pressure for anthelmintic resistance.

2.6 Coprological examination in the diagnosis of nematodes infection.

Parasite eggs, larvae, proglottids and sometimes, whole parasites are shed in faeces of infected livestock. Faecal worm egg counts (FECs) and differential larval counts can be used as a guide to determine the parasite burden. It is, however, impossible to calculate from the eggs per gram the precise size of worm population in the host (Thienpont, Rochette & Vanparijs 1986). Far too many factors influence both the egg production and the number of eggs found per gram of faeces (Thienpont *et al.* 1986). The number of helminth eggs laid and passed per gram of faeces depends on such factors as genus of worm, faecal consistency and bulk, host resistance, stage of pregnancy, effects of lactation and whether the worm burden consists of sexually mature parasites. The animal's nutritional condition and the use of certain anthelmintics also influence the egg production. The egg production of most worms does not seem to occur continuously but at regular intervals (cyclic) (Thienpont *et al.* 1986).

Despite the above factors, the faecal examination and egg count are still of value in the interpretation of clinical investigations. Comparable results are obtained when examination is done under the same conditions and the same method is applied.

An egg count of 500 eggs per gram is generally considered high enough to require treatment in order to limit pasture contamination and subclinical disease (Anonymous, 2005). The egg laying capacity of *Teladorsagia* and *Nematodirus species* is poor and severe clinical signs may be seen before appreciable numbers of eggs are present in the faeces.

Infections with one parasite only are rarely seen and the additive effects of mixed infections will require assessment. The pathogenicity of immature stages not indicated by egg count should always be considered. This is of particular significance with *Nematodirus*, *Teladorsagia* and *Oesophagostomum* (Anon., 2005).

2.7 Chi-square test for association

Chi-square (X^2) tests for association examine two or more variables to determine if they are statistical independent or dependent (Canhao, 1989). The X^2 analysis is a useful statistical tool that can be used to enumerative data conforming to both quantitative and qualitative data. The test can be used to determine the presence or absence of association between epidemiological risk factors and occurrence of a disease within a population. The idea is that if the variables are independent of each other then the observed frequency should not significantly deviate from the respective expected values. The table which summarises the counts for each of the various categories is known as a contingency table.

A significant association occurs when the computed value of X^2 exceeds the critical value for the degrees of freedom and level of confidence. The degrees of freedom are determined by (C-1)(R-1), where C represents the number of columns and R the number of rows of the contingency table (Canhao, 1989). X^2 is computed using the formula;

$$X^2 = \sum[(f_o-f_e)^2/f_e)];$$

Where, f_o is the observed frequency and f_e the expected frequency

The expected frequency for each cell of the contingency table is determined by the formula;

$$\text{Expected frequency for cell} = \frac{\text{(Row total)(Column total)}}{\text{Grand total}}$$

The decision rule is that the null hypothesis is not rejected if the computed value of X^2 is less or equal to the critical value, and reject the null hypothesis and accept the alternative hypothesis if the computed value of X^2 is greater than the critical value.

Chapter 3: Materials and Methods

3.1 Experimental design

This study was an observational study and specifically a cross-sectional study where faecal egg counts as an ante-mortem means of diagnosing gastrointestinal nematode infections of goats was used. This technique has been practised for many years and has provided very good indicative results (Vercruysse 1983).

3.2 Study area

Gweru District is situated in the Midlands Province of Zimbabwe, 19 - 20^0 S; 29 - 30^0 E. The Midlands Province is located centrally in the country, as shown on Figure 3.1 and is made up of eight districts namely Gokwe North, Gokwe South, Kwekwe, Gweru, Chirumanzu, Shurugwi, Zvishavane and Mberengwa. Gweru District falls into the agro-ecological zone, region III, which is characterized by an average annual rainfall of between 650-800 mm, distributed between November and March. The summers are generally wet and hot and winters are cold and dry with occasional frost. The vegetation is generally grassveld with scattered trees and thorny bushes. Livestock farming, fodder crops and some cash crops production are among the major agricultural activities in the district.

Gweru District rural area is divided into large-scale commercial and communal farming areas. This study focussed only on the impact of nematode infection on goat farming in the communal part of the district. Goat farming is one of the most common livelihood and income generating activities among communal farmers in the district.

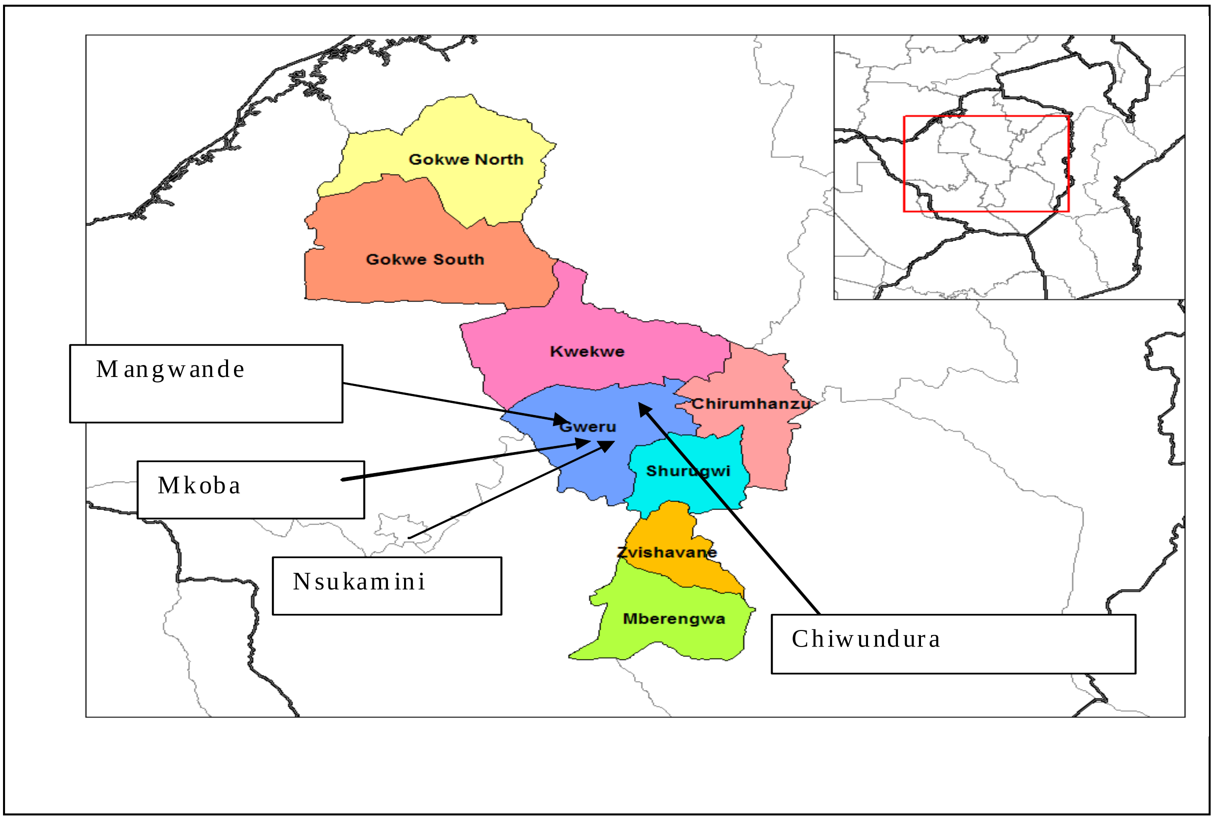

Fig 3.1: Maps of Zimbabwe and the Midlands Province showing location of Gweru District and study areas

For the purposes of this study, the communal area of Gweru District was divided into 4 clusters namely Nsukamini, Chiwundura, Mkoba and Mangwande based on geographical location and common grazing and watering areas as shown of Fig 3.1. Farmers willing to participate were identified from each cluster and participation was on voluntary basis. The number of farmers who participated in the study from each cluster ranged from 9 to 11.

3.3 Experimental animals

The population under study was the communal goats in Gweru District. One hundred and ninety-eight (198) communal goats of various breeds, age groups and sexes belonging to 41 farmers from the communal sector of the district were selected for inclusion in the survey. Of these goats, 100 were sampled during the wet season while 98 were sampled during the dry season. The number of goats sampled per each cluster area is shown in Table 3.1.

Table 3.1: Number of goats sampled in each cluster area.

Cluster area	Number of goats sampled		Total
	Wet season	Dry season	
Nsukamini	20	20	40
Chiwundura	27	26	53
Mkoba	32	30	62
Mangwande	21	22	43
Total	100	98	198

Goats for inclusion in the research were selected using a systematic random sampling technique. In this method, goats were selected at predetermined interval for sampling depending on the total sampling population and sampling size. For example if a hundred goats were available and we wanted to sample twenty goats then samples were collected from every fifth goat from the group.

The animals were divided into three age groups, namely kids (< 4 months), young goats (5-12 months) and mature goats (> 12 months). The breeds were categorized as indigenous and exotic while the sexes were male and female. The goats were kept under extensive communal system of management, feeding mainly on natural pasture with occasional supplementation with crop residues and forage tree leaves. The selection of goats was not based on whether or not the goats had been treated for internal parasites.

3.4 Sample collection

The goats were individually sampled. Faecal samples were taken per rectum with a plastic glove on. As soon as a sufficient quantity of faeces had been collected, the glove was turned inside out and served as a container. The glove was carefully tied and correctly labelled, carried on ice and stored in a fridge before being sent to the laboratory at the Midlands State University. Samples were collected during two distinct different times of the year that is during the wet/rainy season (January - March) and during the dry season (July - October) of 2008.

3.5 Data collection.

In this study both primary and secondary data was collected. Primary data was in form of egg counts and answers to questionnaires, while secondary data was collected from veterinary records of farmers and reports, mainly from the Department of Veterinary Services. Farmers were asked to provide answers to two questionnaires (Appendix A and B). The first was to collect information on the farmer's management practices while the second collected information about the individual goat.

The questionnaire was used to gather all relevant current and historical information on the goats. The questionnaire also captured the status of the animal such as body condition or any other observed signs of ill health and the FAMACHA rating of the mucous membranes as well as any treatments administered to the animals. The epidemiological risk factors captured were age, sex, breed and season.

3.6 Counting the number of eggs per gram of faeces

The presence of nematode eggs was detected with the modified McMaster's technique (Thienpont *et al.* 1986) and expressed as number of eggs per gram of faeces. Two grams of weighed fresh faeces were weighed into a glass beaker and saturated sodium chloride was added up to the 60 ml mark. The suspension was stirred to get a homogeneous distribution of eggs in the liquid. Using a Pasteur pipette, the counting chambers were filled, tilting a little to let air bubbles escape and left for a few minutes. The eggs in each counting chamber were counted under low magnification.

The number of eggs per gram (epg) was calculated using the formula;

$$\text{Epg} = \frac{\text{Total number of eggs}}{\text{Total number of counting cells}} \times 200$$

An EPG of 1 000 and above was considered significant taking into consideration the mixed nature of infection.

3.7 Determining the most prevalent helminth species

The most common helminth species in terms of prevalence were determined by the number of goats that had eggs of that particular species regardless of the number of eggs. In this study, no larval culture was done. Identification of the different species was based on the morphology of the eggs.

3.8 Data analysis

The chi-square test was used to evaluate statistical significance of the association between the risk factors and prevalence and/or the existence of clinical signs of parasitic infection. The test hypotheses used was stated as follows;

H_0: There is no relationship between the prevalence of nematode infection and the risk factors

H_1: There is a relationship between the prevalence of nematode infection and the risk factors

Data was presented in form of contingency tables showing the observed frequency per risk factor. The expected frequency for each cell of the table was determined by the formula and Chi-square (X^2) was then calculated with $P \leq 0.05$ as the acceptable level of significance

Chapter 4: Results

4.1 Prevalence of nematode infection in Gweru communal areas

4.1.1 Overall prevalence

In this survey 198 communal goats made up of 49 males and 149 females were sampled. Of these, 100 were sampled during the wet season and 98 during the dry season. The goats belonged to 41 households. The number of goats owned per household ranged from one to 20 with an average of six. Seventy-eight percent of the goats were owned by women.

Of the 198 goats sampled, 115 (58%) had significant egg counts per gram of faeces (Appendix C). Among the goats that had significant epg, 31 were males and 84 were females. All age groups were affected. The most common parasites encountered were *Haemonchus, Trichostrongylus, Teladorsagia* and *Oesophagostomum. Haemonchus* was the dominant species during the wet season. One striking feature was the abundance of coccidia in the majority of the goats.

4.1.2 Prevalence by season

The prevalence of nematode infection during each of the two seasons (wet and dry) was calculated by determining the proportion of all goats sampled during that particular season, which had significant epg and expressed as a percentage. The prevalence of nematode infection during the wet and dry seasons is summarised in table 4.1 below

Table 4.1: Prevalence of nematodes infection by season

Season	Total number of goats sampled	No. of goats with significant EPG	No. of goats with insignificant EPG	Prevalence (%)
Wet season	100	66	34	66
Dry season	98	49	49	50
Totals	198	115	83	58

The proportion of goats that had a significant EPG during the wet season was significantly higher than during the dry season (X^2 = 5.311; P ≤ 0.05) hence it can be concluded that the prevalence of nematode infection was higher during the wet season as compared to the dry season. This is consistent with previous findings (Boomker *et al* 1994, Pandey *et al* 1994, Nwosu, Madu & Richards 2007; Yadav & Tandon 1989; Specht 1982)

4.1.3 Prevalence by age.

For the purposes of this project, the ages of the goats were classified into three categories namely, kids (0-4 months), young goats (5-12 months) and adult goats (>12 months). Table 4.2 summarises the prevalence in each age group.

Table 4.2: Age distribution of the prevalence of nematodes.

Age	Total no. sampled	Total no. positive	Total no. Negative	Prevalence (%)
0 - 4 months	40	23	17	57.5
5 – 12 months	59	31	28	52.5
>12 months	99	61	38	61.6
Total	198	115	83	58

The prevalence of nematode infection in the table in absolute figures reflects a higher occurrence in the adults followed by the kids with the young goats having the least. However there was no statistical significant difference in prevalence among the different age groups (X^{2} = 1.270; P ≤ 0.05). In this study there was therefore no defined pattern of prevalence relating to the age of the goats.

4.1.4 Prevalence by sex

Of the 198 goats sampled, 49 were males and 149 were females. About 22% of the households most of whom owned less than six goats did not have a billy goat in their flock. Thirty-one (31) males and 84 goats had significant epg. The prevalence of nematode infection in the sampled goats is summarised in table 4.3 below.

Table 4.3: Prevalence of nematode infection by sex.

Sex	Total number sampled	No. positive	No. negative	Prevalence %
Males	49	31	18	63.3
Females	149	84	65	56.4
Total	198	115	83	58

While the absolute figures indicate a higher prevalence of infection in male goats, there was no statistical significant difference of the prevalence of nematode infection between males and females ($X^2 = 0.696; P \leq 0.05$).

4.1.5 Prevalence by breed

All the goats sampled were of mixed breed with a bias towards the indigenous breeds. They could therefore not be classified differently hence no analysis of prevalence was carried out in respect of the breeds.

4.2 Clinical manifestation of nematode infection

Of the 198 goats sampled, 68 goats (12 males and 56 females) had clinical signs suggestive of nematode infection. All age groups were affected. The signs included diarrhoea, emaciation, general body weakness and submandibular oedema. Fifty-six or 82% of the 68 clinically affected goats had significant epg levels, an indication that the parasites could have been the primary cause of the clinical signs. Eighty percent of the farmers reported a higher prevalence of clinical signs during the wet season.

However, the overall body condition of the goats was significantly better during the wet season when compared to the dry season. The presence of coccidian oocysts especially during the wet season could also have been responsible for some of the clinical cases.

4.3 FAMACHA assay.

In this research the FAMACHA clinical assay was used and assessed for its value as a means for determining the goats that requires treatment. Overall 63 goats of the 115 with a significant faecal count scored four and five on the FAMACHA scale. This represents a sensitivity of 54.8%. The sensitivity was increased to 80% when FAMACHA scores three, four and five were considered as significant to warrant treatment. The specificity was relatively high at 90.4% when score four and five were considered, and 86.7% when a score of three was factored respectively.

4.4 Control of nematode infection

This research collected information on the common practices within the community that are used in the control of internal parasites. Of the 41 farmers included in this research, only 18 or 44% treated their goats against internal parasites. Two (4.9%) of these treat their goats twice a year, four (9.8%) once a year and the remaining 12 (29.3%) treat only those that show signs of illness. Parasite control strategies are often haphazard and the timing largely depends on when the farmer has resources to purchase the anthelmintics. Anthelmintic choice is largely governed by the price and availability. In a number of cases, under-dosing was detected which has the potential of increasing anthelmintic resistance. The practice of controlling internal parasites was closely related to the farmer's level of education with those farmers who have gone beyond primary education being more conscious of the need to treat their goats against internal parasites and other common diseases prevalent in the area.

One interesting finding in this study was that, although not statistically significant ($X^2 = 2.163$; $P \leq 0.05$), the prevalence of nematode infection among the farmers who dewormed their goats (60.5%) was higher than among those who did not practice any controls (54.4%). This clearly shows that the control measures being practised in the study area had no significant bearing on the prevalence of nematodes infection.

4.5 Age distribution of goats

This research also looked at age distribution of goats among the farmers included in the survey. The ratio of kids: young goats: adults was 21:39:61. This is almost 1:2:3. When asked why there was such a trend of having more adults than kids and young goats, most of the respondents indicated that a lot of kids and young goats had died during the period of continuous heavy rains that occurred in the area between December 2007 and January 2008. The causes of the high mortality could not be verified as no autopsies had been conducted, however the local veterinary technician strongly suspected stress related infections mainly pasteurellosis and also coccidiosis.

Another contributing factor was that the general condition of the goats prior to the rain season was not so good due to the drought that affected the area in the previous season. This could have contributed to reduced goat fertility resulting in the low kidding rate. The twinning rate was also reported to have gone down over the years.

4.6 Secondary data

4.6.1 Causes of goat mortalities

Information obtained from the local Government Veterinary office records showed that most goats in the area die of pulpy kidney disease and infection with internal parasites. Heartwater came close as the third most important cause of goat mortality. Kids and young goats are especially affected and mortalities in these categories of goats were very common. Mortalities in these categories of goats are estimated to be over 50% and that another 25-30% suffered from reduced growth rate as a direct result of nematode infection. On the basis of these findings, it was estimated that a farmer owning six female goats could be losing up US$500 (about R5 000) per year as result of nematode infection.

4.6.2 Veterinary services provision in the area.

Traditionally the Government Veterinary Department was the sole provider of veterinary services in the area. They provided free consultancy services and veterinary drugs at highly subsidised prices. Due to the economic hardship prevailing in the country the department is no longer able to provide the services. The farmers seem to have developed some dependency in that they are unwilling to pay for services and veterinary drugs at market price. The community now depends largely on Non Governmental Organisations (NGO) operating in the area for the supply of veterinary drugs but the supply has not been constant. One NGO has of late helped the community with the training of community based animal health workers (CAHWs) and this has resulted in improved delivery of veterinary services although the benefits are still to be realised on the ground.

Chapter 5: Discussion

5.1 Nematode infection of communal goats in Gweru in relation to epidemiological factors

Although faecal egg counts (FECs) are generally considered inaccurate indicators of worm burden, they are nevertheless often used for this purpose, particularly where necropsy for worm recovery is not feasible or practical, as in the present study. This study showed that the prevalence of nematode infection among communal goats in Gweru district of Zimbabwe was high (69.7%). The most common parasites encountered were *Haemonchus, Trichostrongylus, Teladorsagia* and *Oesophagostomum.* This agrees with the findings in another communal area in the eastern part on the country (Pandey *et al.* 1994).

There was a definite seasonal variation in the occurrence of nematode infection as reflected by the FECs. The prevalence was higher during the wet season as compared with the dry season. The relative humidity and warm temperatures seemed to provide condition favourable for the development of pre-parasitic stages. This is in agreement with previously published findings that the total gastro-intestinal nematode burden (Pandey *et al.* 1994) and the faecal egg counts (Specht 1982; Yadav & Tandon 1989; Nwosu *et al.* 2007) were positively related to climatic conditions, especially rainfall. Boomker *et al.* (1994) also found that *H. contortus,* which was the most prevalent nematode in their study, followed the expected pattern of summer abundance. The presence of infection in the goats even during the dry season when environmental conditions preclude the development and survival of their pre-parasitic stages could be an indication of persistence of the adult stage within the host.

While the absolute figures might seem to indicate otherwise, the prevalence of nematode infection in this study did not show any statistical significant trend related to the age of the goats. This is in contrast with the findings of Boomker *et al.* (1994) and Assoku (1981) who found that the prevalence was inversely related to age. The findings of this study, however, agree with those of Magona & Musisi (2002), who also found age not to play a major part. In this study there were generally fewer kids and young goats as compared to adults and most of the younger goats belonged to farmers who treated their goats against internal parasites. This could have created some bias in the results and hence the undefined trend. The majority of the kids were still very young especially during the wet season (< 2 months) so the low worm burdens could be attributed to a diet consisting mainly of milk and only small amounts of vegetation containing infective larvae

The study also looked at the effect of sex on the prevalence of nematode infection. While the absolute figures indicate a higher prevalence of infection in male goats (63.3% against 56.4% for females), there was no statistical significant difference of the prevalence of nematode infection between males and females. This contradict the finding of Urquhart *et al.* (1988), who reported the existence of some evidence that entire male animals were more susceptible than females to some helminth infections. This certainly was not reflected among the parasitic species that were common in the area under study

5.2 Clinical manifestation, body condition and nematode control

Most farmers reported a higher incidence of clinical signs during the wet season. This coincided with the period of high internal parasitic challenge as well as other pests such as ticks. However the body condition was better during the wet season despite the high challenge. Body condition is an indication of nutritional status, with poorer scores corresponding to poorer food intake and/or greater metabolic need. It is probable that the effects of the worm burden were masked during the wet season because of sufficient browse being available. Since no autopsies were conducted during this study, this researcher was not able ascertain that nematodes alone were the causes of the clinical signs observed. However the positive correlation between the high epg and manifestation of clinical signs was suggestive of the fact that nematodes played a significant part. In this study the ratio of kids to adults may reflect a combination of reproductive inefficiencies as well reduced survival rates of kids.

The haphazard nature of nematode control also brought into question its effectiveness even among those farmers who treated their goats. This was supported by the fact that there was no significant difference in prevalence between the farmers who dewormed their goats and those who did not. The contamination of the environment remained high, especially at communal watering points which means that treated goats would quickly pick up infective larvae unless anthelmintics with a long residual effect were used. A coordinated effort that considers epidemiological parameters to determine the appropriate times for collective dosing against internal parasites could yield better results. The choice of dosing remedies also needs to be guided by proper scientific analysis of the anthelmintic resistance prevailing in the area. Alternatively farmers in the study area and other communal areas in Zimbabwe should encouraged to select for resistance to nematodes and other common infections within their areas as a long term cost cutting measure especially in the face of the current economic challenges prevailing in the country.

5.3 FAMACHA clinical assay

The use of the FAMACHA system to determine which animals require dosing with anthelmintics to prevent mortalities and minimise development of resistance to anthelmintics would be a powerful tool in the study area. From the results it is safe to say that the FAMACHA clinical assay may be used with a sensitivity of over 80% provided that animals in categories three, four and five are treated. Based on these finding, this author is in agreement with Vatta *et al*. (2001) that the cut -off for anaemia in goats should be taken as FAMACHA category three. Comparing the two seasons, both sensitivity and specificity were marginally higher during the wet season as compared to the dry season. This also coincided with a higher incidence of infection with *Haemonchus,* which generally is attributed to the development of the anaemic condition.

For the resource-limited farmers, like the communal farmers in Gweru District targeted by this study, the use of the FAMACHA system represents an attractive tool to be employed in implementing integrated internal parasite control on the farm. The use of the system provides a method by which tremendous savings in the use of anthelmintics can be realized. The teaching of the FAMACHA system as part of an integrated approach to worm control within participatory rural extension programmes can go a long way in the sustainable control of helminths in goats within the communal sector.

The use of the FAMACHA ensures that only those animals requiring treatment are treated hence the farmer saves money by avoiding blanket treatment of all animals. The reduced mortalities will equally imply improved productivity and potentially more income for the farmer. A training need was identified for the community in this regard.

5.4 Veterinary service provision

The study revealed the inadequacy of veterinary service provision in the communal areas of Gweru District. The state veterinary services can no longer be relied upon due to underfunding and lack of resources. This calls for other players to come in and bridge in the gap. There is a great opportunity now for strengthening community based animal health programmes and build the capacity of the community to address animal health problems collectively. The few CAHWs, who have been trained, courtesy of an international NGO operating in the area, are providing invaluable services to the community and the farmers expressed their appreciation for the services. Farmers can also cut cost by purchasing drugs as a group in bulk and use their collective voice to lobby for better service delivery.

5.5 Economic losses related to nematode infection

The study revealed that communal goat keepers in Gweru District are suffering huge economic losses due to goat morbidities, mortalities, reduced growth rates, reproductive inefficiencies and the high cost of uninformed nematode control strategies. While the contribution of nematodes infection to these losses could be established, authoritative information from the Department of Veterinary Services indicates that this could be very high. The cost of controlling nematode especially with the incorporation of the FAMACHA system will be insignificant when compared with the production losses suffered by the goat keepers. Integrated approaches to worm control within participatory rural extension programmes need to be designed for use among resource-limited rural communities to improve production efficiency.

5.6 Conclusion

Infection with gastrointestinal nematodes is probably the single most important constraint to goat production in the communal areas of Gweru District. The prevalence is high and has been characterised by high mortalities. The species of gastrointestinal nematodes found in these areas were generally similar to those reported in the eastern parts of Zimbabwe (Pandey *et al*. 1994). The prevalence had a defined seasonal trend with higher prevalence during the wet season. There was however no evidence to suggest that age and sex had any influence on the prevalence of infection.

For the resource-poor farmer wanting to control nematode infection especially haemonchosis in goats, the use of the FAMACHA system represents an attractive tool to be employed in implementing integrated internal parasite control. An advantage of the clinical assay is the fact that a large proportion of the animals are left untreated and is able to contaminate the pasture with the eggs of anthelmintic-susceptible worms. The principle on which the FAMACHA method is based, namely the treatment of only those animals that are in categories three, four and five, provides a method by which tremendous savings in the use of anthelmintics can be realised. The method should be taught as part of an integrated approach to worm control within participatory rural extension programmes. It can be used in combination with a systematic culling process which select for resistance to internal parasites.

Chapter 6: References

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Appendices

Appendix A

Questionnaire for survey of helminth infection of goats in Gweru district

A. Respondent and farming practice information.

1. Respondent's name…………………………………………
2. Information collected on (Date)……………………………
3. Is respondent…………owner/relative/employee.
4. Gender…………………Male/female
5. Level of education………Nil/Primary/Secondary/Tertiary
6. Identification of animals sampled ………………………………………………

………

……………………………..

7. How many goats do you have?

    i. 0-4 months Males………. Females……….

    ii. 5-12 months Males………. Females……….

    iii. > 12 months Males………. Females……….

8. Where do your goats graze?

	Always	Sometimes	Never
Zero grazing			
Backyard/Tethering			
Communal grazing			

9. Do you give supplementary feed to your goats?……..YES/NO

10. If yes, what type?

Hay	
Crop residues	
Forage leaves	
Concentrate	
Other	

B. Worm control Information

11. Do you treat goats against worms? YES/NO

12. If yes, how often per year?

Once	
Twice	
Thrice	
More than three times	
When sick	

13. Where do you get your drugs and comment on availability?

Source	Readily available	
	Yes	No
Vet department		
Open market		
Other farmers		
Other (state)		

14. When do you think the health of the goats deteriorates?

	Always	Sometimes	Never
Wet season			
Dry season			
All year round			

15. Who takes care of the health of your goats?

Self	
CAHW	
Vet Department	
Private Practitioners	
NGOs	
Traditional healer	

Appendix B

Goat information sheet

1. Goat identity/name……………………………………
2. Sample number………………………………………..
3. Sex……………………………
4. Breed…………………………..
5. Age

0-4 months	5-12 months	>12 months

6. Is there any of the following signs of illness?

	YES	NO
Diarrhoea		
Coughing		
Emaciation		
General weakness		
Bottle jaw		

7. Rating of the colour of the mucus membranes on the FAMACHA scale of 1-5…………………..

8. Comments on any treatments received ……………………………………………

……

……

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Appendix C

Feacal egg count results for communal goats in Gweru District

Summary of egg count results- Wet season

Farmer	Gender	Level of Education	Worm control	Sample No.	Sex	Breed	Age	Signs of illness	FAMACHA Rating	Egg Count/ g	Comments
V Maphosa	F	Primary	Nil	VM 1	F	Cross	>12 mths	Nil	2	400	-Respondent was the owner -Total flock size 7 (All F) -3 deaths recently recorded in th flock -Experience animal health probl in wet season -Service provision- Self, CAHW, V Dept, NGO (Heifer) -Supplement with crop residues
				VM 2	F	Cross	0-4 mths	Nil	3	1100	
				VM 3	F	Cross	>12 mths	-Emaciation	4	1400	
				VM 4	F	Cross	5-12 mths	Nil	1	300	
				VM5	F	Cross	>12 mths	-Emaciation -General weakness	5	1500	
S Moyo	F	Secondary	Twice a year	SM 1	F	Cross	>12 mths	-Diarrhoea -General weakness	2	600	-Respondent was the owner -Total flock 13 (3M, 10F) -Animal health problems commo wet season -Service provision- Self, CAHW, N (Heifer) -Crop residues and forage leaves used for supplementation
				SM 2	F	Cross	>12 mths	Nil	2	1000	
				SM 3	M	Cross	5-12 mths	Nil	3	1100	
				SM 4	F	Cross	>12 mths	-Emaciation	2	1100	
				SM 5	F	Cross	5-12 mths	Nil	2	400	
				SM 6	F	Cross	0-4 mths	Nil	2	300	
				SM 7	F	Cross	>12 mths	Nil	2	300	
				SM 8	F	Cross	5-12 mths	Nil	3	4500	
				SM 9	F	Cross	>12 mths	Nil	3	3800	
S Mlilo	F	Primary	Once a	SML 1	M	Cross	5-12 mths	-emaciation	2	300	-Respondent was an aunt to the

			year								owner
				SML 2	F	Cross	0-4 mths	Nil	2	400	-Flock size 16 (2M, 14F) -Was not sure about when probl are most prevalent as well as the major service providers -Crop residues used for supplementation
				SML 3	M	Cross	5-12 mths	Nil	1	300	
				SML 4	F	Cross	>12 mths	-Emaciation -General weakness	4	1200	
				SML 5	F	Cross	5-12 mths	Nil	3	1580	
				SML 6	F	Cross	>12 mths	-Emaciation	2	600	
				SML 7	F	Cross	>12 mths	-Emaciation -General weakness	5	3450	
S Khoza	M	Secondary	When sick	SK 1	F	Cross	>12 mths	-Nil	2	700	-Respondent was owner -Flock size 5 (1M, 4F) -Problems common in wet seaso -Services provided by self, CAHW and NGO -Supplement with crop residues
				SK 2	F	Cross	>12 mths	Nil	4	2250	
				SK 3	F	Cross	>12 mths	Nil	4	3700	
				SK 4	M	Cross	5-12 mths	Nil	4	3750	
				SK 5	F	Cross	0-4 mths	Nil	2	2800	
Q Zulu	F	Primary	Nil	QZ 1	F	Cross	>12 mths	-Emaciation -General weakness	4	3000	-Respondent was owner -Flock size 4 (2M, 2F) -Problems sometimes in both we and dry seasons -Service provision by CAHW and NGO -Supplementation with crop residues
				QZ 2	F	Cross	>12 mths	-Emaciation -General Weakness	2	300	
				QZ 3	M	Cross	5-12 mths	Nil	2	400	
				QZ 4	M	Cross	5-12 mths	Nil	2	300	
M Hlongwane	F	Secondary	Nil	MH 1	F	Cross	5-12 mths	Nil	1	300	-Respondent was owner -Flock size 2 (both F) -Animals always tethered -Problems always in wet season -Service provided by CAHW and NGO -Supplement with crop residues forage leaves
				MH 2	F	Cross	0-4 mths	-General weakness	2	500	

M Dube	F	Primary	Nil	MD 1	M	Cross	>12 mths	Nil	2	1000	-Respondent was owner
				MD 2	M	Cross	0-4 mths	Nil	3	2000	-Flock size 4 (2M, 2F)
				MD 3	F	Cross	>12 mths	Nil	3	900	-Problems always in wet season sometimes in dry -Supplement with crop residues forage leaves -Service by CAHW and NGO
M Ncube	F	Secondary	When Sick	MN 1	F	Cross	>12 mths	-Emaciation -General weakness	3	1300	-Respondent was owner -Flock size 8 (all F) Problems always in wet season -Supplement with crop residues forage leaves Service by CAHW and NGO
				MN 2	F	Cross	5-12 mths	Nil	2	300	
				MN 3	F	Cross	>12 mths	Nil	2	400	
				MN 4	F	Cross	5-12 mths	-Emaciation -General weakness -Bottle jaw	5	1900	
				MN 5	F	Cross	>12 mths	Nil	2	400	
J Dube	F	Secondary	Nil	JD 1	M	Cross	5-12 mths	Nil	3	1200	-Respondent was a relative of ov
				JD 2	F	Cross	>12 mths	Nil	2	400	-Flock size 4 (2M, 2F)
				JD 3	M	Cross	5-12 mths	-Diarrhoea -Emaciation	4	2700	-Problems sometimes in dry sea -Supplement with crop residues
				JD 4	F	Cross	>12 mths	Nil	2	400	-Service by self
J Ndlovu	F	Nil	Nil	JN 1	F	Cross	5-12 mths	Nil	2	400	-Respondent was owner -Only one female goat -Sometimes tethered/communa grazed -Problems sometimes in dry sea -Service by CAHW -No supplementation
L Banda	F	Primary	Nil	LB 1	F	Cross	>12 mths	-Emaciation	5	2800	-Respondent was owner
				LB 2	F	Cross	>12 mths	-Emaciation	4	1000	-Flock size 3 (All F)
				LB 3	F	Cross	0-4 mths	Nil	5	2200	Problems always in wet season -Supplement with crop residues forage leaves

											-Service by CAHW and self
B Khoza	F	Secondary	Nil	BK 1	F	Cross	5-12 mths	-Emaciation	2	1000	-Respondent was owner
				BK 2	M	Cross	5-12 mths	Nil	2	400	-Flock size 5 (2M, 3F)
				BK 3	M	Cross	5-12 mths	Nil	2	300	Problems always in wet, sometir
				BK 4	F	Cross	>12 mths	Nil	2	400	dry season
				BK 5	F	Cross	>12 mths	Nil	4	2000	-Supplement with crop residues forage leaves -Services from Vet Dept and self
B Ndlovu	F	Secondary	When sick	BN 1	M	Cross	0-4 mths	Nil	2	300	-Respondent was the owner -Flock size 4(1M, 3F)
				BN 2	F	Cross	0-4 mths	Nil	2	300	-Problems always in wet season,
				BN 3	F	Cross	>12 mths	-Emaciation -General weakness	5	1250	sometimes in dry -Supplement with crop residues
				BN 4	F	Cross	>12 mths	-Emaciation -General weakness	5	500	-Service by CAHW and NGO
D Mbano	F	Primary	When sick	DM 1	M	Cross	0-4 mths	-Diarrhoea -Emaciation -General weakness	5	2800	-Respondent was owner -Flock size 3 (1M, 2F) -Problems always wet, sometim
				DM 2	F	Cross	>12 mths	-Slight emaciation	2	1500	dry season -Supplement with crop residues
				DM 3	F	Cross	>12 mths	-Emaciation	2	1000	-Service by NGO
E Moyo	M	Primary	Nil	EM 1	F	Cross	5-12 mths	Nil	4	3000	-Respondent was owner
				EM 2	F	Cross	>12 mths	Nil	4	1100	-Flock size 7 (1M, 6F)
				EM 3	M	Cross	0-4 mths	-Emaciation -General weakness	4	1300	-No supplementation -Service by CAHW
				EM 4	F	Cross	5-12 mths	Nil	2	500	Problems always during wet sea
E Nkiwane	F	Primary	When sick	EN 1	F	Cross	>12 mths	Nil	2	1300	-Respondent was owner -Flock size 9 (2M, 7F)
				EN 2	F	Cross	>12 mths	-Emaciation	3	2000	-Supplement with hay, crop resi
				EN 3	F	Cross	0-4 mths	Diarrhoea	4	1900	and pods -Always communal grazing

								Emaciation General weakness			-Service by CAHW -Problems always in wet season
				EN 4	F	Cross	0-4 mths	-Emaciation	3	1200	
				EN 5	F	Cross	>12 mths	Nil	4	2500	
				EN 6	M	Cross	0-4 mths	Nil	5	3000	
				EN 7	M	Cross	0-4 mths	Slight emaciation	3	1000	
G Makaza	M	Secondary	Once a year	GM 1	F	Cross	>12 mths	Nil	2	400	-Respondent was owner -Flock size 20 (3M, 17F) -Communal grazing always -Supplement with crop residues -Service by Vet dept/CAHW -Problems always wet season
				GM 2	M	Cross	5-12 mths	Nil	4	1400	
				GM 3	F	Cross	>12 mths	Nil	3	1000	
				GM 4	F	Cross	>12 mths	Nil	1	1100	
				GM 5	F	Cross	>12 mths	Nil	3	1300	
				GM 6	M	Cross	5-12 mths	General weakness	4	700	
				GM 7	M	Cross	0-4 mths	Nil	3	2000	
G Nyoni	F	Primary	Nil	GN 1	F	Cross	>12 mths	Nil	3	1000	-Respondent owner -Flock size 3 (All F) -Supplement with forage leaves -Problems sometimes in wet sea
				GN 2	F	Cross	5-12 mths	Nil	3	900	
				GN 3	F	Cross	>12 mths	Nil	3	1700	
C Ndlovu	M	Primary	Once a year	CN1	F	Cross	0-4 mths	Nil	4	3000	-Respondent was owner -Flock size 7 (2M, 5F) -Supplement with hay, crop resi and pods -Always communal grazing -Service by self -Problems always in wet season
				CN 2	M	Cross	5-12 mths	Nil	5	4500	
				CN 3	M	Cross	5-12 mths	Nil	4	3200	
				CN 4	F	Cross	>12 mths	-Bottle jaw & general body weakness	5	7000	
				CN 5	F	Cross	0-4 mths	Nil	4	2800	
J Maposa	M	Secondary	When sick	JM 1	F	Cross	>12 mths	-Emaciation	4	6000	-Respondent was worker -Flock size 11 (2M, 9F) -Supplement crop residues -Always communal grazing -Service by Vet dept/self
				JM 2	M	Cross	5-12 mths	Nil	2	1100	
				JM 3	F	Cross	0-4 mths	-Loss of condition & general	4	7900	

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								weakness			-Problems throughout the year
				JM 4	M	Cross	>12 mths	Nil	4	3000	
				JM 5	F	Cross	0-4 mths	General weakness	4	5000	
				JM 6	F	Cross	5-12 mths	-Emaciation	4	4500	
F Zhou	M	Primary	When sick	FZ 1	F	Cross	>12 mths	Nil	2	1000	-Respondent was owner -Flock size 14 (4M, 10F) -Supplement crop residues -Always communal grazing -Service by self/neighbours -Problems always in wet season
				FZ 2	M	Cross	0-4 mths	Body weakness and loss of condition	5	9900	
				FZ 3	F	Cross	5-12 mths	Nil	5	2900	
				FZ 4	F	Cross	>12 mths	Nil	5	5000	
				FZ 5	M	Cross	5-12 mths	-Loss of body condition	4	7800	
				FZ 6	M	Cross	5-12 mths	-severe emaciation and bottle jaw	5	8000	
T Nyathi	M	Primary	Once a year	TN 1	F	Cross	>12 mths	Nil	4	3000	Respondent was relative -Flock size 5 (all F) -Animal health problems usually during the wet season -Service by self -supplement with crop residues
				TN 2	F	Cross	>12 mths	Nil	3	2800	
				TN 3	F	Cross	0-4 mths	-Diarrhoea	2	900	

Summary of egg count results- Dry season

Farmer	Gender	Level of Education	Worm control	Sample No.	Sex	Breed	Age	Signs of illness	FAMACHA Rating	Egg Count/g	Comments
S Mlilo	F	Primary	Once a year	SML 1	F	Cross	0-4 mths	Nil	1	400	-Respondent was an aunt to the owner -Flock size 16 (2M, 14F) -Was not sure about when problems are most prevalent as well as the major service providers -Crop residues used for supplementation
				SML 2	F	Cross	5-12 mths	Nil	2	1500	
				SML 3	F	Cross	5-12 mths	-Bottle jaw	4	1600	
				SML 4	F	Cross	0-4 mths	Nil	3	900	
				SML 5	M	Cross	>12 mths	Nil	2	500	
S Ncube	F	Secondary	When sick	SN1	F	Cross	>12 mths	Nil	3	1200	-Respondent was owner -Flock size 8 (2M, 6F) -Supplement with hay, crop residues and pods -Always communal grazing -Service by Vet dept -Problems occur any time of the year
				SN2	F	Cross	0-4 mths	-Diarrhoea & body weakness	3	2000	
				SN3	F	Cross	5-12 mths	Nil		1900	
				SN4	F	Cross	5-12 mths	Nil	2	600	
				SN5	F	Cross	>12 mths	Nil	3	2700	
				SN5	M	Cross	5-12 mths	-Bottle jaw & Emaciation	5	4000	

V Maphosa	F	Primary	Nil	VM1	F	Cross	>12 mths	Nil	2	600	-Respondent was the owner -Total flock size 6 (1M & 5 F) -Experience animal health problems in wet season -Service provision- Self, CAHW, Vet Dept, NGO (Heifer) -Supplement with crop residues
				VM2	M	Cross	5-12 mths	Nil	2	700	
				VM3	F	Cross	5-12 mths	General body weakness	5	2300	
				VM4	F	Cross	>12 mths	Nil	2	1600	
S Moyo	F	Secondary	Twice a year	SM1	M	Cross	5-12 mths	Nil	1	400	-Respondent was the owner -Total flock 15 (4M, 11F) -Animal health problems common in wet season -Service provision- Self, CAHW, NGO (Heifer) -Crop residues and forage leaves used for supplementation
				SM2	F	Cross	>12 mths	Nil	2	700	
				SM3	F	Cross	5-12 mths	Nil		1100	
				SM4	F	Cross	0-4 mths	Body weakness & loss of body condition	3	1600	
				SM5	F	Cross	>12 mths	Nil	2	600	
				SM6	M	Cross	>12 mths	Nil	2	600	
				SM7	F	Cross	>12 mths	Nil	4	800	

M Mbewe	M	Secondary	nil	MM1	F	Cross	0-4 mths	Nil	2	400	-Respondent was a relative -Flock size 9 (2M & 7 F) -Animal problems common in dry season (attributed to shortage of food) -Service provision –self, also uses indigenous remedies -Crop residues used for supplementation
				MM2	F	Cross	5-12 mths	Nil	3	2000	
				MM3	F	Cross	>12 mths	Nil	5	3200	
				MM4	M	Cross	5-12 mths	Nil	2	500	
				MM5	F	Cross	0-4 mths	Nil	1	300	
				MM6	F	Cross	5-12 mths	Nil	4	1100	
L Magwati	F	Secondary	When sick	LM1	F	Cross	>12 mths	-Bottle jaw and loss of body condition	4	3000	-Respondent was owner -Flock size 7 (2 M & 5 F) -Had not de-wormed the goats since beginning of the year -Service provision – usually self or neighbours -Crop residues used for supplementation
				LM2	M	Cross	0-4 mths	-Diarrhoea	4	2400	
				LM3	F	Cross	>12 mths	Nil	3	1800	
				LM4	F	Cross	>12 mths	Nil		900	
				LM5	F	Cross	0-4 mths	Nil	2	500	

E Nkiwane	F	Primary	When sick	EN 1	F	Cross	5-12 mths	Nil	1	200	Respondent was owner -Flock size 9 (2M, 7F) -Supplement with hay, crop residues and pods -Always communal grazing -Service by CAHW -Problems always in wet season -Had de-wormed the goats since the last sampling
				EN 2	M	Cross	5-12 mths	Nil		1000	
				EN 3	F	Cross	>12 mths	Nil	2	900	
				EN 4	F	Cross	0-4 mths	Nil	2	1200	
				EN 5	M	Cross	>12 mths	Nil	2	600	
				EN 6	F	Cross	>12 mths	-Emaciation	2	800	
				EN 7	F	Cross	5-12 mths	Nil	2	300	
L Mkoba	F	Primary	Nil	LMK1	F	Cross	5-12 mths	-Anorexia & loss of body condition	5	2500	-Respondent was the owner -Total flock size 11 (3M & 8 F) -Experience animal health problems in wet season -Service provision- Self -Supplement with crop residues
				LMK2	F	Cross	0-4 mths	Nil	3	1700	
				LMK3	F	Cross	>12 mths	-General body weakness	2	1200	
				LMK4	F	Cross	5-12 mths	-Bottle jaw	5	2900	
				LMK5	M	Cross	0-4 mths	Nil	5	3000	
				LMK6	F	Cross	>12 mths	Nil	4	1900	
L Dube	F	Primary	Nil	LD1	F	Cross	>12 mths	Nil		1400	-Respondent was relative -Flock size 5 (1 M & 4 F) -Communal grazing always
				LD2	F	Cross	0-4 mths	-Diarrhoea	2	900	

				LD3	M	Cross	5-12 mths	Nil		1000	-Supplement with crop residues -Service by Vet dept -Problems always wet season
G Makaza	M	Secondary	Once a year	GM 1	F	Cross	0-4 mths	Nil	1	300	-Respondent was owner -Flock size 22 (3M, 19F) -Communal grazing always -Supplement with crop residues -Service by Vet dept/CAHW -Problems always wet season -Goats had been vaccinated against pulpy kidney and de-wormed since the previous sampling
				GM 2	F	Cross	>12 mths	Nil	2	600	
				GM 3	F	Cross	>12 mths	Nil		1000	
				GM 4	M	Cross	5-12 mths	Nil	4	1300	
				GM 5	F	Cross	>12 mths	Nil	2	800	
				GM 6	M	Cross	0-4 mths	Nil	2	900	
				GM 7	F	Cross	>12 mths	Nil	2	1100	
J Ngulube	F	Secondary	Twice a year	JN1	F	Cross	>12 mths	-Loss of body condition	2	1200	-Respondent was owner -Flock size 15(3M, 12F) -Communal grazing always -Supplement with crop residues -Service by self/CAHW -Animal health problems sometimes observed
				JN2	F	Cross	>12 mths	Nil	5	900	
				JN3	F	Cross	5-12 mths	Nil	2	500	
				JN4	M	Cross	>12 mths	Nil	2	600	

				JN5	F	Cross	>12 mths	Nil	4	2000	during wet season
				JN6	F	Cross	5-12 mths	Nil	2	300	
V Gambiza	F	Primary	When sick	VG1	F	Cross	0-4 mths	Nil	2	1200	-Respondent was owner -Flock size 13(2M, 11F) -Communal grazing always -Supplement with crop residues -Service by self/CAHW -Animal health problems always during wet season
				VG2	F	Cross	>12 mths	Bottle jaw & loss of body condition	4	1900	
				VG3	F	Cross	>12 mths	Nil	2	400	
				VG4	F	Cross	0-4 mths	Nil	2	500	
				VG5	F	Cross	>12 mths	Nil	4	1300	
				VG6	M	Cross	5-12 mths	Nil	2	400	
				VG7	F	Cross	>12 mths	Nil	2	500	
				VG8	F	Cross	>12 mths	-Emaciation & general body weakness	4	2500	
L M Shoko	F	Secondary	When Sick	LMS1	F	Cross	>12 mths	Nil	4	900	Respondent was owner -Flock size 9 (3M, 7F) -Supplement with hay, crop residues and pods -Always communal grazing -Service by CAHW
				LMS2	M	Cross	0-4 mths	Nil	5	1600	
				LMS3	F	Cross	0-4 mths	Nil	2	400	

				LMS4	F	Cross	5-12 mths	Nil	2	400	-Problems can occur any time of the year
				LMS5	M	Cross	>12 mths	-Emaciation -General weakness	4	2000	
				LMS6	F	Cross	>12 mths	Nil	4	1500	
				LMS7	F	Cross	5-12 mths	Nil	2	300	
P Zulu	F	Primary	Nil	PZ 1	F	Cross	>12 mths	Nil	2	1300	Respondent was owner -Flock size 9 (2M, 7F) -Supplement with hay, crop residues and pods -Always communal grazing -Service by CAHW -Problems always in wet season
				PZ 2	F	Cross	>12 mths	Nil	2	900	
				PZ 3	M	Cross	>12 mths	Nil	3	2200	
				PZ 4	F	Cross	>12 mths	Nil	2	200	
				PZ 5	M	Cross	>12 mths	Nil	5	1100	
				PZ 6	F	Cross	0-4 mths	-mild diarrhoea	2	700	
M Sibanda	F	Primary	Nil	MS1	F	Cross	>12 mths	Nil	4	1900	-Respondent was the owner -Total flock size 13 (3M & 10 F) -Experience animal health problems sometimes in wet season -Service provision- Self, CAHW)
				MS2	M	Cross	5-12 mths	Nil	2	400	
				MS3	F	Cross	>12 mths	-Emaciation	4	1400	
				MS4	M	Cross	5-12 mths	Nil	4	2000	
				MS5	F	Cross	>12 mths	Nil	4	800	

				MS6	F	Cross	>12 mths	Nil	3	1800	-Supplement with crop residues
				MS7	F	Cross	>12 mths	Nil	2	400	
B Nyoni	F	Primary	Nil	BN 1	F	Cross	>12 mths	Nil	2	200	-Respondent was the owner -Flock size 4(1M, 3F) -Problems always in wet season, sometimes in dry -Supplement with crop residues -Service by CAHW and NGO
				BN 2	M	Cross	>12 mths	Nil	5	2100	
				BN 3	F	Cross	>12 mths	-Emaciation	2	700	
				BN 4	F	Cross	>12 mths	Nil	2	1400	
M Hlongwane	F	Secondary	Nil	MH 1	F	Cross	5-12 mths	Nil	2	400	-Respondent was owner -Flock size 2 (both F) -Animals always tethered -Problems always in wet season -Service provided by CAHW and NGO -Supplement with crop residues and forage leaves
				MH 2	F	Cross	5-12 mths	Nil	3	1200	
E Tshuma	F	Primary	Nil	ET1	F	Cross	5-12 mths	Nil	4	700	-Respondent was owner -Flock size 3 (All F)
				ET2	F	Cross	>12 mths	Nil	2	300	