Meat condemnation in slaughtered bovine species in the Eastern Cape Province, South Africa

BY

JAJA ISHMAEL FESTUS

A dissertation submitted in partial fulfilment of the requirement for the degree in Masters of Science in Agriculture (Meat Science)
Department of Livestock and Pasture Science
Faculty of Science and Agriculture
University of Fort Hare

University of Fort Hare
Together in Excellence

Supervisor:

Dr. Borden Mushonga

Co-supervisors:

Prof. Voster Muchenje

Dr. Ezekiel Green

November, 2014

Declaration

I, Jaja Ishmael Festus, vow that this dissertation has not been submitted to any University and that it is my original work conducted under the supervision of Prof. V. Muchenje, Dr B Mushonga and Dr E Green. All assistance towards the production of this work and all the references contained herein have been fully acknowledged.

___________________________ ___________________________

Jaja Ishmael Festus Date

Approved as to style and content by:

___________________________ ___________________________

Prof. V Muchenje Date

___________________________ ___________________________

Dr B Mushonga Date

___________________________ ___________________________

Dr E Green Date

Abstract

Causes of meat condemnation and associated financial implication in slaughtered bovine species in the Eastern Cape Province South Africa

By

Jaja Ishmael Festus

A study was conducted in three abattoirs represented by the acronym ANA, QTA and EBA, to determine the causes of meat condemnation and to ascertain monetary losses associated with such condemnation. *Ante-mortem* and active abattoir surveys were conducted on 229, 458 and 687 cattle from the three abattoirs respectively and abattoir slaughter records (n=51, 302) was obtained from 2010 to 2012. The abattoir records showed that the liver was the most frequently condemned (56.9%), followed by the lung (24.1%), then the heart (7.4%), kidney (6.9%), spleen (4.0%), tongue (0.4%) and carcass (0.3%). An assessment of the abattoir secondary data revealed that the major cause of condemnation of the liver at ANA, QTA and EBA was fasciolosis (5.59, 4.48, 2.68), spleen (abscess, 0.35, 0.94, 0.17) kidney (inflammation, 0.94, 1.01, 1.18), heart (inflammation, 0.9, 1.85, 0.75), tongue (abscess, 0.08, 0.03, 0.05) and lungs (emphysema, 1.12, 1.14, 1.16). Disease/conditions recorded during *ante-mortem* inspection of animals at the lairage were diarrhea, lameness, emaciation, blindness, orchitis, mastitis, skin conditions, and respiratory symptoms corresponding to 8, 1, 13, 2, 3, 6, 9, and 11 percent, respectively. The percentage of condemned organs was higher during the active abattoir meat inspection than in the previous records from the abattoir. Additional losses of tongue due to gunshot injury and the heart due to cysticercosis were recorded. Prevalence of fasciolosis was calculated and seasonal occurrence was determined based on monthly assortment. From the retrospective data, the prevalence of fasciolsis was 2.9 percent (n = 78728) while the annual (2011, 2012, 2013) prevalence of Fasciola infection for AB1 was (3.2, 2.2 and 2.0%), AB2 (6.4, 4.6 and 3.5%) and AB3 (14.4, 6.9 and 9.5%). Higher prevalence was obtain in summer (AB1 = 10.4%, AB2 = 12.8% and AB3 = 10.9%) and autumn (AB1 = 11.2%, AB2 = 10.8% and AB3 = 8.6%) than in winter (AB1 = 9.8%, AB2 = 6.5% and AB3 = 5.9%) and spring (AB1 = 8.2%, AB2 = 7.8% and AB3 = 5.9%). Monetary loss associated with carcass/offal condemnations in the three abattoirs from 2010 to 2012 was 630, 456 South African Rand (ZAR) or 59, 244 United States Dollars (USD), while the summation of losses due to condemnation during the 6 month active meat inspection revealed a higher loss of ZAR 111, 337.5 (10, 383.8 USD) . Monetary losses associated with carcass weight loss, whole and partial liver condemnation due to infection with Fasciola was calculated as ZAR 917, 921.5 (83, 447 USD), ZAR 31, 661.5 (2, 878 USD) and ZAR 19, 112.3 (1, 737 USD) respectively. In conclusion, organs and carcasses were condemned for several disease and non-disease factors and this led to significant financial loss.

Keywords: Cattle, fasciolosis, abattoir, carcass condemnation, financial loss, post mortem, meat inspection season

Dedication

In memory of my late Father, Senibo, Festus (Fubara) Aaron Jaja (chief and head of Aaron Jaja's Compound).

Acknowledgements

I want to appreciate the Almighty God for granting me the ability to further and improve my academic knowledge. I am also thankful to my supervisors, Prof. Voster Muchenje, Dr Borden Mushonga and Dr Ezekiel Green for their support throughout my study. I want to thank Dr. Peter Fayemi, Mr. D. Pepe (Bra Dumza), Mr Mandla, Miss Noluvuyo Moko, my colleagues and members of Rock of Ages International. To my mother (Mrs Florence Jaja), my siblings Kalanne (Victoria), Ibiwangi (Eudora) and Idarefaa (Aaron) thank you for your prayers. My special gratitude goes to abattoirs, for allowing me to do my research at their premises, the Department of Agriculture, the National Research Foundation (NRF) and Govan Mbeki Research and Development Center (GMRDC) provided financial support that enabled me to finish my Master`s degree.

To my best friend, soul mate and wife Chinwe “words cannot express my depth of gratitude” I thank you so much for your love and patience. I am also indebted to Dr and Dr Mrs Nnamdi Chigor, Bro Nebo, Kela, Obum and Eche, Monday, Falowo, Lizwell and Carlos Nantapo who made my stay in South Africa less boring. I will also like to thank Amb (Mrs) Mfon Akwaisua, Mr, Sotonye Goodhead, Deborah Akwaisua, Mr and Mrs Tony Manga, my in-laws and everyone who was part of this story. I thank you all.

Table of Contents

List of Tables

List of Figures

List of abbreviations

BCS	Body condition score
SAMIC	South African Meat Industry Corporation
IMQAS	International Meat Quality Assurance Service
Abacor	Abattoir Commission
WHO	World health organisation
UN	United Nation
FAO	Food and Agricultural Organisation
ARC	Agricultural Research Council
HACCP	Hazard Analysis and Critical Control Points (HACCP)
ISO	International Organization for Standardization
HMS	Hygiene Management System
HAS	Hygiene Assessment syStem
FCI	Food Chain Information
MBTC	Mycobacterium Tuberculosis Complex
TB	Tuberculosis

CHAPTER ONE: Introduction

1.0 Background

South Africa can best be described as a meat consuming country, thus the meat industry in South Africa has grown and continues to make concerted effort to make meat as a source of protein for its growing population (Scholtz *et al*., 2008); Several factors however pose a threat to efficient livestock production and these factors includes diseases of both zoonotic and non-zoonotic origin. Diseases are the main reasons why meat get condemned condemned at the abattoir. Studies have shown that a large quantity of meat (carcass/offal) is wholly or partially condemned due to zoonotic diseases such as brucellosis, leptospirosis, echinococosis, faciolosis, tuberculosis, anaplasmosis, cysticercosis, toxoplasmosis, etc, (Mellau *et al*., 2011). Also worrisome is the high number of carcasses condemned due to non infectious diseases like abcessation of various organs, bruises, hydronephrosis, nephritis, emaciation, emphysema, pneumonia, anthracosis, etc (Cadmus *et al.*, 2009).

Tuberculosis (TB) also contributes significantly to meat condemnation. Today it is one of the world's most important infectious diseases that still accounts for high morbidity and mortality among adults (Shamsher, 2012). It is caused by a pathogenic organism of the genus Mycobacterium. Bovine tuberculosis results from infection by *Mycobacterium bovis*, a Gram positive, acid-fast bacterium that belongs to the Mycobacterium tuberculosis complex (MTC) which includes: *M. africanum, M. tuberculosis*, *M. bovis* BCG, *M. canetti*, *M. microti* (Tara, 2013), *M. caprae and M. pinnipedii* (Cousins *et al*., 2003) and the more recently *M. mungi* (Alexander *et al*., 2010). Bovine tuberculosis (BTB) is a disease characterized by the progressive development of characteristic tubercles, in the lungs, lymph nodes, and/or other organs, which affects the health of the individual animal and has a harmful effect on animal production (Dungworth, 1992). Affected animals experience chronic weight loss, variable appetite, and pyrexia. Tuberculosis may also cause enlargement of other lymph nodes throughout the body, causing pathological conditions like bloat, intestinal ulceration, and/or diarrhea (Miller, 1997). Respiratory signs are regular, but are sometimes subtle and mild. Abnormal lung sounds and breathing difficulties are obvious only in the late stages of the disease (Miller, 1991).

Bovine tuberculosis (BTB) has a severe zoonotic impact (Radostits *et al*., 2000; Pollock *et al*., 2005) and can infect a wide range of animal species. The Office International des Epizootics (OIE) classifies BTB as a list B disease; a disease which poses great threat to public health (Tara, 2013). Currently, the number of people dying of tuberculosis is more than that of any other infectious diseases, 6% human deaths per annum world wide is attributed to tuberculosis (Parthiban *et al*., 2007). Death from tuberculosis comprises 25% of all avoidable deaths in developing countries (Ramachandran and Parmasivan, 2003).

World Health Organization reports estimates an over 1.7 million deaths in year 2006 and 9 million new cases of tuberculosis (WHO, 2008). Work-related groups that are in contact with *M. bovis* infected cattle are likely to develop pulmonary and alimentary TB (O'Reilly and Daborn, 1995). People that are in contact with animals in the dairy industry or in slaughter houses and slabs are especially at risk (Pande *et al*., 1995; Tara 2013; Jha *et al*., 2007). Hunters, animal and zoo care personnel that are in contact with infected free-ranging or captive wildlife may also be at significant risk (Rhyan *et al*., 1995, Miller 1997; O'Reilly and Daborn, 1995).

Tuberculosis, faciolosis, cystercercosis, cystic echinococosis and indeed other zoonotic has severe implications for animal health since they cause decreased productivity and premature death in cattle in affected farms (Moro and Schantz, 2006; Adams, 2001; Taylor *et al*., 2001), causing severe economic losses in the form of reduced milk production and carcass condemnation (Suazo *et al*., 2003; Krauss *et al*., 2003).

1.1 Statement of the problem

The demand for protein far outweighs the capacity of farmers to meet; this is especially the case in developing countries where hunger and poverty is widely reported. Meat condemnation (MI) reduces the capacity of both the meat producer to recoup his capital and at the same time reducing the quantity of meat available to the consumer in the market. Even though MI reduces the quantity of meat available for consumption, it is a very useful tool in study of epidemiology to monitor trends in disease prevalence and transmission. A number of these diseases are a threat to public health and significantly contribute to meat condemnation at slaughter. Diseases affect animal productivity as milk, meat and reproduction is greatly reduced (Dungworth, 1992), cows are culled in the aftermath and infected meat condemned (Suazo *et al*., 2003; Krauss *et al*., 2003) leading to huge economic losses for both the farmer, government and the populace. In developed countries the control of zoonotic and non-zoonotic disease has gained a measure of success, however in developing nations most of these disease are commonly seen (Gibson *et al*., 2004; Collins and Grang, 1983; Cosivi *et al*., 1998).

Hydatidosis, tuberculosis, fasciolosis has been reported worldwide, and it represents a serious human and animal health concern in many rural and grazing areas (Moro and Schantz, 2006; Ernest *et al*., 2008 Megard, 1978; Radostits *et al*., 2000, Pollock *et al*., 2005). South Africa is listed as a country with high TB burden in the world (USAID, 2009; Chen *et al*., 2009; Green *et al*., 2010a; Silaigwana, 2012). The Eastern Cape Province is high on the list (Green et al., 2010a; Silaigwana, 2012). In South Africa reports on hydatidosis is scarce, however Vester *et al.,* (1965) investigated the prevalence of cystic echinococosis in livestock at abattoirs nationwide. It was noted that the prevalence varied greatly between regions and species, for cattle, prevalence ranged from 1.2% to 13.8% with highest prevalence in the Eastern Cape Province. Faciolosis has been reported to be a leading cause of meat condemnation in abattoirs with huge economic implication for farmers (Usip *et al* 2014; Megard, 1978; Cadmus et al., 2009).

It is on this premise that a need arises for a study to be carried out to ascertain the status of disease and factors incriminated in meat condemnations, and to assess it prevalence in the slaughtered cattle's in Eastern Cape Province and also to take into account other causes of meat condemnation in slaughtered cattle and associated financial implication in the Province.

1.2 Justification of the study

The meat industry in South Africa has continuously strived to provide the populace with a ready source of animal protein, however there is a need for improvement in the availability and quality of meat sold to the public. This improvement should begin with identifying diseases that lead to meat condemnation, and the deployment of modern diagnostic techniques in the detection, prevention, control and eradication of diseases; that causes huge economic losses to animal producers as well as having a public health implication on it consumers. The traditional meat inspection exercise carried out by the veterinary doctors is currently being performed by international meat quality assurance service, a private outfit approved by the department of agriculture in South Africa. While the veterinary officials play a supervisory role and offer diagnostic solution to suspicious cases. This is to allow for a more proactive meat inspection exercise. Farmers over time have improved their management of farms animal using latest available drugs and techniques. Presumably, this should produce animals that are disease free or with minimal conditions necessitating condemnation of animals when presented for slaughter at the abattoir. However, this doesn't seem to be the case, as more meat tends to be rejected for various reasons.

It was therefore, necessary to study the rate of meat condemnation in cattle presented for slaughter at the abattoir and document the various factors and diseases related to the condemnation of meat. The study quantified the factors over the period under review. It also evaluated the money implication for these condemnations, while also highlighting the public health implication involving some of the reason for the condemnation. The study is useful to government agencies, farmers and other stakeholders in taking proactive measures in curtailing the trend in meat condemnation.

1.3 Objectives of the study

The main aim of the study was to identify causes of carcass/offal condemnation in slaughtered cattle in abattoirs in the Eastern Cape Province and determine financial loss associated with such condemnation.

The specific objectives of the study were:

1. To identify causes of meat condemnation in selected abattoirs and assess the monetary loss associated with such condemnation in Eastern Cape.

2. To determine the contribution of faciolosis to meat condemnation, it seasonal variation and economic implication.

1.4 Hypothesis

1. Carcass/offal condemnation rate of cattle slaughtered in the Eastern Cape is negligible.

2. Condemnation of carcass/offal slaughtered cattle's in the Eastern Cape has little or no financial implications.

1.5 References

Adams, L. G. 2001. In vivo and in vitro diagnosis of Mycobacterium bovis infection. Review of. Science Technique**. 20:** 304-324.

Alexander, K.A, Laver P.N, and Micheletal A.L. 2010. Novel Mycobacterium tuberculosis complex pathogen, M. mungi," Emerging Infectious Diseases. **16:** 1296–1299.

Cadmus, S.I.B., Adesokan, H.K. 2009. Causes and implications of bovine organs/offal condemnations in some abattoirs in Western Nigeria Tropical Animal Health Production, 41 **7:** 1455-63.

Chen Y., Chao Y., Deng Q., Liu T., Xiang J., Chen J., Zhou J., Zhan Z., Kuang Y., Cai H., Chen H., Guo A. 2009. Potential challenges to the stop TB plan for humans in China; cattle maintain *M. Bovis* and *M. tuberculosis*. Tuberculosis **89:** 95–100.

Collins C H, Grang E J M. 1983. The bovine tubercle bacillus. Journal of Applied Bacteriology **55:** 13–29

Cosivi O., Grange J.M., Daborn C.J., Raviglione M.C., Fujikura T., Cousins D., Robinson R.A., Huchzermeyer H.F.A.K., de Kantor I and Meslin F, X. 1998. Zoonotic tuberculosis due to Mycobacterium bovis in developing countries. Emerging Infectious Diseases. 4 **1:** 59-68.

Cousins, DV, Bernardelli A and Bastida R. 2003. Tuberculosis in seals caused by a novel member of the Mycobacterium tuberculosis complex: Mycobacterium pinnipedii sp. nov. International journal of Systematic Bacteriology **53:** 1305–1314.

Dungworth, D.L. 1992. The respiratory system, In Pathology of domestic animals, Vol. 2, 4th Ed. (K.V.F. Jubb, P.C. Kennedy & N.C. Palmer, eds). Academic Press Inc., San Diego, pp 632-655.

Ernest, E. 2004. Studies on the epidemiology of echinococcosis/hydatidosis in Ngorongoro district, Arusha region, Tanzania. MSc thesis Sokoine University of Agriculture, Morogoro, Tanzania.

Gibson, A.L., Hewinson G., Goodchild T., Watt B., Story A., Inwald J and Drobniewski F.A. 2004. Molecular epidemiology of disease due to Mycobacterium bovis in humans in the United Kingdom. Journal of Clinical Microbiology. 42 **1:**431-434.

Green E., Samie A., Obi L.C., Bessong O.P and Ndip R, N. 2010. Inhibitory properties of selected South African medicinal plants against Mycobacterium tuberculosis. Journal of Ethnopharmacology. **130:** 151-157.

Jha, V C., Monta Y., Dhakal M., Besnet B., Sato T., Nagai A., Kato M., Kozawa K., Yamamoto S, and Kimura H. 2007. Isolation of Mycobacterium spp. In milking buffaloes and cattle in Nepal. J Vet Med Sci, 69 **8:** 819–825.

Krauss H, Weber A, Appel M, Enders B, Isenberg HD, Schiefer HG, Slenczka W, von Graevenitz A, & Zahner H., 2003. Zoonoses Infectious Diseases Transmissible from Animals to Humans. (Third edition), Washing ASM Press. American Society for Microbiology, Washington DC., USA

Megard, J.P. 1978. Fasciolosis in Black Africa. Paris: Merck, Sharp and Dohme Research Development. Paris, France.

Mellau, B. L., Nonga H. E and Karimuribo E.D. 2011. Slaughter stock abattoir survey of carcasses and organ/offal condemnations in Arusha region, northern Tanzania. Tropical Animal Health Production, 43 **4:** 857-864

Miller J., Allen J., Rhan J., Dennis S and David S. 1991 Bovine tuberculosis in a captive elk herd in Colorado: Epizootiology, diagnosis, and management In Proc 95th Ann Mtg US Animal Health Association 533-542.

Miller J., Allen J., Rhan J., Dennis S and David S. 1997. Detection of Mycobacterium bovis in formalin-fixed, paraffin embedded tissues of cattle and elk by PCR amplification of an IS6110 sequence specific for Mycobacterium tuberculosis complex organisms. Journal of veterinary diagnostics, **9:** 244.

Moro, P. L and Schantz P. M. 2006. Echinococcosis: historical landmarks and progress in research and control. Annal of Tropical Medicine and Parasitology 100 **8:** 703-14

O'Reilly, L M and Daborn C J. 1995. The epidemiology of Mycobacterium bovis infections in animals and man: a review. Tuberculosis and Lung Disease 76 **1:**146.

Pande, T.K., Hiran S and Rao V.V. 1995. Primary lingual tuberculosis caused by M. bovis infection. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics. **80:** 172–174.

Parthiban, M, R., Jaiganesh, W. S K., Aruni, S. M and Ramadass P. 2007 Rapid detection of Mycobacterium bovis in clinical samples using thp-1 cells. Veterinary Archive **77:** 265-270.

Pollock, J M., Welsh, M D., and McNair J., 2005. Immune responses in bovine tuberculosis: Towards new strategies for the diagnosis and control of disease. Veterinary Immunology and Immunopathology, 108 (**1-2):** 37-43.

Radostits, O M., Gay, C C., and Blood, D C. 2000. Veterinary Medicine. Book Power Co Ltd, pp 909-934.

Ramachandran R and Parmasivan C.N. 2003. What is new in the diagnosis of tuberculosis? Part I: Techniques for diagnosis of tuberculosis. Indian Journal of Tuberculosis **50:** 133-141.

Scholtz, M.M, Bester J, Mamabolo, J.M, and Ramsay K.M. 2008. Results of the national cattle survey undertaken in South African, with emphasis on beef applied animal husbandry and rural development, **1:** 1-9

Shamsher, S. K. 2012. Diagnostic Methods for Mycobacterium tuberculosis and Challenges in Its Detection in India, Understanding Tuberculosis - Global Experiences and Innovative Approaches to the Diagnosis (Ed.), in tech, 51000 Rijeka, Croatia.

Silaigwana Blessing, 2012. "Molecular detection and drug susceptibility of Mycobacterium tuberculosis complex in raw milk from a major dairy farm in the Nkonkobe region, Eastern Cape Province, South Africa. MSc biochemistry and microbiology thesis, University of Fort Hare. www.netd.ac.za. Accessed 17 July 2013.

Suazo, F M., Escalera, A M and Torres, R M. 2003. A review ofM.bovis BCG protection against TB in cattle and other animal species. Preventive Veterinary Medicine **58:** 1–13.

Tara, N. G and Durga, D J. 2013. Epidemiological study of zoonotic bovine tuberculosis: Neglected emerging diseases of Nepal. International Research Journal of Medicine and Medical Sciences 1 **1:**1-7.

Taylor, M. J., Hughes, M. S., Skuce, R. A and Neill, S. D. 2001. Detection of Mycobacterium bovis in bovine clinical specimens using real-time fluorescence and fluorescence resonance energy transfer probe rapid-cycle PCR. Journal of Clinical Microbiology **39:** 1272-1278.

United States Agency for International Development (USAID), 2009. South Africa Tuberculosis profile. Pages 1-3.

Usip, L. P. E.; Ibanga, E. S.; Edoho, H. J.; Amadi, E. C. and Utah E. 2014. Prevalence of Fascioliasis and the economic loss of condemned liver due to Fasciola infection in Cattle slaughtered at three abattoirs in Eket Urban, Akwa Ibom State of Nigeria. Global Advanced Research Journal of Food Science and Technology 3 **2:** 054-075.

Verster A, and Collins M. 1966. The incidence of hydatidosis in the Republic of South Africa. Onderstepoort Journal Veterinary Research **33:** 49–72.

World Health Organisation (WHO), 2008. Global tuberculosis control: surveillance, planning, financing. WHO report 2008. WHO/HTM/TB/2008.393. Geneva.

CHAPTER TWO: Literature review

2.0. Introduction

Meat is one of the most highly-priced food commodities in South Africa (Hagen *et al*., 2011). The total meat consumption rate is estimated at 41.0 kg per capita per year, which is the second highest in Africa and closely mirrors the global meat consumption estimates of 41.2 kg per capita per year (FAO, 2009; Taljaard *et al*., 2006). The world population is growing and the demand for meat products continues to rise in almost all regions of the globe, especially in developing countries (Delgado, 2003), thus putting the burden of catering for the meat need of the populace on the meat industry. The ability to meet this demand is threatened by disease, especially infectious disease. Evidence suggests that insecure access to nutritious food remains a significant global problem and according to the Food and Agriculture Organization's State of Food Insecurity in the World (2011), 850 million people were undernourished worldwide during the period from 2006–2008.

Fitzpatrick, (2013) describes diseases as the main constraint of biologically efficient livestock production and both endemic and exotic disease results in mortality and morbidity in livestock. Hence less food than should ideally be available in current farming systems. A significant proportion of diseases affect the safety of food supplies, in addition to their effect on volume and quality of food products. Parasitic diseases including those caused by internal and external parasites have widely differing effects on meat, milk and meat production (Fitzpatrick, 2013).

Food and waterborne infections have received considerable attention in the last decade, while some are considered emerging because they have recently become more common (Dorny *et al*., 2009). Each year, millions of people worldwide suffer from foodborne diseases, according to Notermans *et al*. (1995) illnesses resulting from the consumption of contaminated food have become one of the most widespread public health problems in contemporary society. It is estimated that 75% of emerging human pathogens are zoonotic (Woolhouse, 2002). Therefore effort at sustainable production of sufficient amounts of high quality, affordable, safe food required to underpin health and wellbeing of human populations world-wide, entails proper farm management practices, meat inspection, hygiene control and favourable government regulatory activities (Fitzpatrick, 2013).

The need for effective food safety program in every country is crucial, in order to protect its citizen from intoxicant. According to the united nation, consumer protection and the prevention of food borne disease are very essential elements of a food safety program and are usually the shared responsibility of national governments, the food industry and consumers (UN, 2003). Abattoir meat inspection is one of such measures put in place to ensure the quality of food consumed by man. It is definitely not the desire of producers to loss their livestock and profits, but these diseases do happen at any time, especially with poor farm management programmes. Meat is rich in nutrient and offers favourable conditions for the growth of micro-organisms, which leads to meat spoilage (Subratty and Gurib, 2003). Thus meat is traditionally known to be a vehicle for a significant proportion of human food-borne disease. In South Africa, the government implements the hygiene management system (HMS) and hygiene assessment system (HAS) system at the abattoir as a food safety procedure (SA, 2004) in order to ensure that meat consumed by the public is safe and hygienic.

2.1 Meat inspection

Meat inspection (MI) is a process of screening animals and meat for fitness for human consumption and is one of the most widely implemented and longest running systems of surveillance (Stark *et al*., 2014). The traditional or risk based approach may be used and it covers the whole slaughter process that begins with the ante mortem inspection to stunning and ends at the step where the carcass is placed in the cooler. MI is recognized as a suitable source of data collection and for monitoring a broad spectrum of diseases and conditions concerning animal health and welfare. Therefore, MI contributes information on notifiable diseases and zoonoses, endemic production diseases and animal welfare (Stark *et al*., 2014). According to Van Llogtestijn (1993), abattoir meat inspection is necessary to remove gross abnormalities from meat and its products, so as to prevent distribution of infected meat, assist in detecting and eradication of certain livestock diseases.

In areas where diseases such as tuberculosis, Cysticercosis, fascioliasis, and other infectious/zoonotic are prevalent, the traditional approach of meat inspection involving incision and palpation has been the best means of revealing these diseases. However, there is a widespread recognition of the limitations of the traditional approaches and the possibility of introducing or spreading contamination as they involve detailed inspection of tissues, particularly lymph nodes, through multiple incision and palpation (Nesbakken *et al*., 2003). In most abattoirs, it is standard practice to condemn diseased carcasses or organs wholly or partially for health and aesthetic reasons. Condemnation of this sort varies from one abattoir to the other depending on the farming system in which the animals were managed. However, contaminated meat may still find its way to the market for public consumption, a situation which exposes humans to eating unsound and unwholesome meat (Mellau *et al*., 2010)

The decision as to whether meat is fit for human consumption will involve many skills of observation and evaluation. This will include considering the results of *ante-mortem* inspection, as well as any available information on the disease history of the herd or region of origin of the animals. This explains why the MI personnel must undergo routine competency checks by supervisors to assess their knowledge regarding these diseases. Records of these checks must be kept for auditing purposes as required by the Red Meat Regulations (No 1072 of 2004) (SA, 2000). Carcasses that require further inspection by a veterinarian must be diverted into the detention room where further inspection by the meat inspector, or veterinarian will be carried out as required by the Red Meat Regulations (No 1072 of 2004) (MSA, 2000). The veterinarian makes the final decision on whether or not the carcass should be passed or condemned and decides if laboratory tests may be required and in terms of the Red Meat Regulations (No 1072 of 2004) (SA, 2004). This aspect of the process is can be seen in Sections C of the HAS checklist under the heading "Meat inspection and marking" (MSA, 2000).

2.1.1 Meat inspection: A South African perspective

The responsibility of meat safety at abattoirs resided with the Department of Health up to 1967, but with the introduction of "The Animal Slaughter, Meat and Animal Products Hygiene Act, 1967" (Act No. 87 of 1967), the Department of Agriculture became the responsible authority for regulating meat safety at abattoirs within the country. The Department in conjunction with the Local Municipalities became the sole service providers of meat inspection services within the country but the mandate of ensuring meat safety beyond the abattoir remained the responsibility of the Department of Health. Meat Inspection involves the inspection of animals at slaughtering facilities that were owned or managed by either municipalities or by the Abattoir Commission (Abacor). The deregulation of the agricultural commodities in the early 90s, led to the initiative of private meat inspection service. This resulted in meat inspection services being performed by private organizations such as the Meat Board. Government meat inspection services were only retained and continued at selected exporting facilities until October 2011. The political change in South Africa in 1994, and the introduction of the new Constitution (Constitution of the Republic of South Africa), (No. 108 of 1996), led to some changes in the operations of abattoirs. The responsibility of monitoring the abattoirs became that of the provinces. This change affected the approaches in regulating meat safety and meat inspection in the country. Meat Inspection personnel that were primarily in the employment of the government were either absorbed into private companies, reassigned other functions within the government or sack.

The deregulation of the abattoir industry and the shift in ownership of abattoirs from being owned or operated by Municipalities or abattoir corporation (ABACOR), to fully privately owned businesses presented the industry with significant challenges. The South African government made several changes to its meat inspection protocols and authority. These change led to the abolishment of the Meat Board at the end of 1997 and South African Meat Industry Corporation (SAMIC) took over some aspect of meat inspection. SAMIC handed its meat inspection services over to the International Meat Quality Assurance Service (IMQAS) company in the year 2000.

Table 1 Abattoir categories and slaughter units as described in the Meat Safety Act and Regulations

	Red meat	Poultry	Ostriches	Game
High throughput	21-	2001-	21-	21-
Low throughput	3-20	51-2000	3-20	3-20
Rural	1-2	1-50	1-2	1-2
1 Slaughter unit =	1 bovine	1 fowl	2 ostriches	1 medium game
	6 sheep	1 duck		6 small game
	4 porkers	1 pheasant		Large game to be determined by the PEO
	2 baconers	1 guinea fowl		
	1 sausage pigs	½ goose		
		¼ turkey		

Adapted from RMMA (2011) report

Today meat inspection is performed by inspectorate in the employ of abattoirs, IMQAS, closed corporations or private individuals. The Abattoir Hygiene Act, 1992 was substituted by the Meat Safety Act, 2000 (Act 40 of 2000). By the establishment of this act, all meat inspection service must be independent of the abattoir. Section 11 of the Act stipulates the following:

1. The owner of an abattoir must procure a meat inspection service for that abattoir.

2. Meat inspection services may only be performed by the national executive officer, a provincial executive officer, an authorized person or an assignee, which must perform that function independently from the abattoir.

3. A person contemplated in the paragraph above must be a veterinarian, meat inspector, meat examiner, animal health technician or such other duly qualified person as may be prescribed

2.1.2 Red meat hygiene in South Africa

When the privatization of the meat inspection functions in the late 1980's took place, the Meat Board became responsible for meat inspection duties in South Africa (National Agricultural Marketing Council, 2001). Government regulatory role over privately owned abattoirs were lax and several abattoir began sprouting in many parts of the country. Hygiene control at abattoirs deteriorated as the only method used by government in ensuring hygiene at abattoirs was routine weekly inspections. Microbiological testing for pathogens was not compulsory, and so meat safety could not be appropriately measured except through slaughtering in an approved and registered abattoir. However, due to the fact that meat inspection involved visual only and palpation method, the meat inspector merely focused on removing diseased carcasses from the human food chain (Agricultural Research Council, 2000).

Originally, only government abattoirs were allowed to legally slaughter animals in South Africa. But many abattoirs had to shut down due to high cost of operation. Government legislation preventing private enterprise contributed to their closure (National Agricultural Marketing Council, 2001). The loss of municipal control over abattoirs and the privatization of the meat inspection and private enterprise of abattoirs, government health inspectors were employed at these abattoirs by the Meat Board until 1997, in order to ensure meat hygiene. The control of meat hygiene was gradually taken over by non-governmental inspectors, The Meat Safety Act, Act 40 of 2000 (MSA, 2000), was an attempt to reestablish government control over hygiene standards in the meat industry.

2.1.3 Ante mortem inspection

The possibility for microbial contamination begins on the farm. To ensure these risks are mitigated, control strategies must be put in place (Demarchelier, *et al*., 2008). Ante mortem inspection consists of two investigations. On the one hand, the physical examination is to prevent obvious disease or grossly dirty animal entering into a slaughterhouse. On the other hand, the check of the Food Chain Information (FCI) is to help to evaluate the health status of the flock to be slaughtered (Lupo *et al*., 2013). Ante mortem inspection is useful in avoiding the introduction of clinically diseased animals in to slaughterhouse and also serves to obtain information that will be useful in making thorough post mortem inspection (Teka, 1997).

Part VI, 79(2) (d) and (e) of the Red Meat Regulations (No 1072 of 2004) (MSA, 2000) stipulate the full documentation of health status of animals and medication used on animals, including withdrawal periods and dates of administration respectively. Livestock owners should provide the abattoir owner with this information for storage and safe keeping. This information is later used for audited by the state (SA, 2000). All animals must undergo ante mortem inspection before slaughter. Injured animals must be penned separately and must undergo emergency slaughter as soon as possible. There should be communication between the inspector working on the production floor and the employees receiving animals into the abattoir (Gracey, 1990). This aspect of the process is found in Sections A4, 5 and 6 of the HAS checklist under the heading "Ante mortem inspection" (MSA, 2000).

2.2 Diseases that lead to meat condemnation in abattoirs

2.2.1 Mycobacterium tuberculosis complex (MBTC)

Mycobacterium tuberculosis complex are the etiological agents that cause tuberculosis (TB) in both humans and animals. Members belonging to the MTBC include *M. tuberculosis*, *M. bovis* including the vaccine strain BCG, *M. africanum*, *M. microti*, *M. canettii*, *M. pinnipedii* and *M. caprae* (LoBue *et al*., 2010). A more recent member was added to the complex *M. mungi* (Alexander *et al*, 2010). These organisms have identical genetic similarity close to 99%, however they differ in phenotypic traits such as host preference, virulence and epidemiology (Waters *et al*., 2010).

2.2.2 Prevalence of tuberculosis

Mycobacterium tuberculosis is the predominant cause of human TB worldwide (Angela *et al*., 2006). The pathogen remains one of the significant causes of mortality and morbidity globally due to infectious diseases (Palomino, 2009). The prevalence of *M. tuberculosis* in bovine herds from countries such as Algeria and Sudan is estimated at 6.2% and 7.4% respectively; this high prevalence is attributed to the elevated incidence of *M. tuberculosis* infection amongst the people in these countries and other less developed nations in Asia (Cosivi *et al*., 1998). *M. bovis* is the etiological agent of TB in cattle, which are the natural hosts to the pathogen (Harrington *et al*., 2008).

Mycobacterium bovis remains a significant zoonotic pathogen accounting for approximately 30% of the entire TB burden (Waters *et al*., 2010). The prevalence of *M. bovis* in cattle still remains high with more than 50 million cattle worldwide estimated to be infected with the pathogen (Lyashchenko *et al*., 2004). The prevalence of *M. bovis* which accounted for 16% human infection in the U.K alone has been greatly reduced in most developed countries over the last two decades (Gibson *et al*., 2004). This is due to effective animal TB control measures such as tuberculin skin test and slaughter strategy of all infected cattle. Pasteurization of raw milk has also greatly reduced cattle to human transmission of *M. bovis* in milk products meant for human consumption (Gibson *et al*., 2004).

2.2.3 Treatment, prevention and control of tuberculosis

Tuberculosis in human beings is treated effectively by using drugs like Isoniazid and streptomycin (Silaigwana, 2012). But in cases of animals, the treatment of tuberculosis cannot be safely advocated in view of public health and economic factors (Singh, 2007). It is risky for human beings to remain in contact with animals infected with TB (Singh, 2007). Cattle with lesions in the lungs kidneys and other organs do not show quick response to treatment and usually die (Singh, 2007). The standard control measure applied to TB in animals is test and slaughter (Singh, 2007; CDC, 2010).

Disease eradication programs include: post mortem meat inspection, intensive surveillance including on-farm visits, systematic individual testing of cattle, removal of infected and in-contact animals and movement control (OIE, 2013). Post mortem meat inspection of animals looks for the tubercles in the lungs and lymph nodes (OIE, 2013). Detecting infected animals prevents unsafe meat from entering the food chain which allows veterinary services to trace-back to the herd of the origin of the infected animal which can then be tested and eliminated if needed (Mellau, 2011). Pasteurization of milk of infected animals to a temperature sufficient to kill the bacteria has prevented the spread of disease in humans (Silaigwana, 2012; CDC, 2010).

Treatment of infected animals is rarely attempted because of high cost, lengthy time and larger goal of eliminating the disease (Singh, 2008). Vaccination is practiced in human medicine, but it is not widely used as a preventive measure in animals (CDC, 2010; Singh 2008). The efficacy of existing animal vaccines is variable and it interferes with testing to eliminate the disease. A number of new vaccines are currently being evaluted (OIE, 2013). People in contact with body fluids or tissue from a wild bison or cervid should promptly seek medical attention and inform their healthcare providers about the exposure to a wild animal that might carry M. bovis. People who spend extended periods in close contact with cattle or other animals that might carry M. bovis, such as dairy workers, should promptly seek medical attention for any illness with symptoms of TB disease (Rhyan *et al*., 1995; Tara., 2013; Jha *et al*., 2007).

2.3 Fasciolosis

Bovine fasciolosis is a disease of economic importance in farmed animals caused by trematodes of the genus Fasciola. The two most important species are *Fasciola hepatica* which is found in temperate area and in cooler areas of high altitude, in the tropics and subtropics and *Fasciola gigantica*, which preponderate in tropical area. *Fasciola hepatica* is found in areas above 1800 meters above sea level. In these areas, both species coexists where ecology is conductive for both snail hosts, and mixed infections prevailed (Yilma and Malones, 1998; Malone *et al*., 1998). The life cycle of these trematodes involves snail as an intermediate host (Walker *et al.*, 2008). Fasciola has a two-host life cycle. Its asexual stages develop in intermediate hosts, which in nature are mostly freshwater snails (Mas-Coma *et al*., 2009). The snail of the genus *Lymnae natalensis* and *Lymnae truncatula* are known as intermediate host in life cycle of fasciolosis. Infection with *Lymnea truncatula* is usually associated with herds and flocks grazing on wet marshy land.

On the other hand, *Fasciola gigantica* is found in fresh water snail and infection with this species is associated with livestock that drink from snail infected water and stream as well as with grazing wetland, which may be seasonally swamped (Mas-Coma *et al*. 2009). In South Africa the most common intermediate hosts are *L. trunculata* (*F. hepatica*), *L. natalenis* (*F.gigantica*) and *L. columella* (*F. hepatica* and *F.gigantica*). Other documented *Lymnaea* vectors which have been found to harbor *F. hepatica* are *L. tomentosa* (Australia, New Zeeland), *L. columella* (North America, Australia, and New Zeeland), *L. bulimoides* (Southern USA and the Caribbean), *L. humilis* (North America), *and L. vector* (Southern America), *L. diaphena* (South America). Other important *Lymnaea* vectors of *F. gigantica* are *L.auricularis* (Europe, USA. Middle East, Pacific islands), *L. rufescens* and *L. acuminta* (India, Pakistan) and *L. rubiginosa* (Malaysia) (Magalhaes *et al*., 2004; Mas-Coma *et al*. 2009; Loyacano *et al*., 2002).

2.3.1 Economic losses due to Fasciolosis

The disease is responsible for considerable economic losses in the cattle industry, mainly through mortality, liver condemnation, reduced production of meat, milk, and wool, expenditures for anthelmintics (Mason, 2004) Clinical disease is usually characterized by weight loss, anaemia and hypoproteinaemia. The world-wide losses in animal productivity due to fasciolosis were estimated at US $200 million per annum, to rural agricultural communities and commercial producers with over 600 million animals infected (Ramajo *et al*., 2001). According to Malone *et al* (1998) economic losses can also be due to morbidity, reduced growth rate, increased susceptibility to secondary infections and the expense of control measures. Apart from its veterinary and economic importance, fasciolosis has recently been shown to be a re-emerging and widespread zoonosis (World Health Organisation, 1995).

Studies conducted on losses due to fasciolosis in the United Kingdom and Ireland reveal that more than £18 million a year is lost to this disease at the abattoir (Mulcahy and Dalton, 2001).

Swiss study estimated the economic loss due to bovine fasciolosis, largely attributable to sub-clinical infection, as €52 million a year or €299 per infected animal (Schweitzer *et al*., 2005). Kithuka *et al.* (2002) reported up to 0.26 million USD annual losses attributable to fasciolosis-associated liver condemnations in cattle slaughtered in Kenya. Similarly, a study conducted by Keyyu *et al.* (2006) reported up to 100% liver condemnation rates in some slaughter slabs in Iringa region in Tanzania due to liver flukes in cattle. Fasciola hepatica is generally distributed in Europe, the Americas, and Australia while F. gigantic is more prevalent in tropical countries, although both species have been recorded in Africa and Asia (Mas-Coma *et al*., 2005).

The prevalence of fasciolosis in many parts of Africa has been determined mainly at slaughter. However estimation of economic loss due to fasciolosis at national or regional level in these countries is limited due to lack of accurate estimation of the prevalence of disease (Phiri *et al*., 2005). The presence of fasciolosis due to F. hepatica and F. gigantica in some African countries have been well documented, in Ethiopia its prevalence and economic significance have been reported by several workers (Tadelle and Worku 2007; Ephrem *et al*., 2011).

2.3.2 Diagnosis of fasciola infection

Diagnosis is based primarily on the clinical signs and seasonal occurrence in endemic areas but previous examination, haematological tests and examination of faeces for fluke eggs are useful. Coprological analysis is still commonly employed to diagnose bovine fasciolosis despite the fact that eggs cannot be detected until after the latent period of infection, when much of the liver damage has already occurred (Rokni *et al*., 2003). Several improvements have been made at diagnosing faciolosis including serology (ELISA) and polymerase chain reaction (PCR) tests. PCR methods used for detecting Faciola antigen may include multiplex PCR and real-time PCR, and it use has been helpful in immunology and epidemiology (Magalhaes *et al*., 2004). Treatment of infected animals largely depends on the correct use of appropriate and registered anthelminthics (Mas-Coma *et al*., 2005).

2.4 Cysticercosis

Bovine cysticercosis is a parasitic zoonosis caused by *Cysticercus bovis*, it is of immense socioeconomic and public health importance (OIE, 2006; Lucas *et al*., 2009). It induces the development of *Taenia saginata* (adult tapeworm) in the human small intestine. Taeniosis, which is the infestation in humans, is a food-borne disease which occurs as a result of consumption of meat containing a viable cysticercus (Neva and Brown, 1994; Dorny and Praet, 2007). This may lead to the development of a tapeworm and patients are frequently asymptomatic, however, they may present with mild symptoms of nausea, abdominal discomfort, flatulence, epigastric pain, diarrhoea, vitamin deficiency, excessive or loss of appetite, weakness, loss of weight, digestive disturbances, and intestinal blockage (Dorny and Praet, 2007).

Variably adult tapeworms release motile distal segments containing eggs and their independent motility is the reason for various disorders such as appendicitis, biliary tract obstruction and anal pruritus (Neva and Brown, 1994; Dorny and Praet, 2007). Although this disease has been reported to seldom produce symptoms in humans, it can have a negative impact on consumer confidence in the food industry (Cabaret *et al*., 2002). The life cycle and transmission of *T. saginata* occurs most commonly in environments exemplified by poor livestock husbandry practices, poor sanitation, and inadequate meat inspection and control. The beef tapeworm is found almost all over the world, albeit at very low prevalence in developed countries. Moderate prevalence levels are seen in Southern Asia. High prevalence rates occur in Sub-Saharan Africa, especially in Eastern Africa where it causes high economic loss as a result of meat condemnation (Cabaret *et al*., 2002). After the ingestion of tape worm eggs by cattle, the cysticerci develop in their muscles tissues and advances through a viable stage with a visible single invaginated scolex. It then passes into a degenerated stage with the calcification of cysticerci (Scientific Committee on Veterinary Measures relating to Public Health, 2000).

Humans, who are the final host, can be infested only by viable cysticerci through the consumption of raw or undercooked meat (Scientific Committee on Veterinary Measures relating to Public Health, 2000). The adult worm reaches sexual maturity in approximately 3 months, producing gravid proglottids that are shed in faeces (Dorny and Praet, 2007). Proglottids contain between 50,000 and 80,000 eggs (Flisser *et al*., 2005). Since the symptoms are mild in humans, the public health risk of *T. saginata* in humans is considered to be low. Currently, taeniosis in humans is not notifiable in the countries that make up the European Union (EU), and the prevalence in these areas is said to be unknown (Dorny *et al*., 2010). But in many developing countries, this disease constitutes a serious but sometimes less recognized public health problem (Minozzo *et al*., 2002).

2.4.1 Prevalence and diagnosis of Cysticercosis

Globally, there are 77 million human carriers of *Taenia saginata* out of which about 40% live in Africa (Bekele *et al*., 2010). In kenya a study to estimate the prevalence of *T. saginata*, *Echinococcus granulosus* and *Fasciola gigantica* using meat inspection and serology from different districts showed that the highest prevalence of cysticercosis was recorded for Narok District, where 31.47% and 80.42% of the animals were detected using meat inspection and Ag-ELISA, respectively; while only 9.09% of these animals were detected using Ab-ELISA (Onyango-Abuje *et al*., 1996a, b). Consumer protection from bovine cysticercosis has relied on post-mortem examination of slaughtered cattle by incision and visual inspection even though this method has been questioned in terms of accuracy and efficiency (Webber *et al*., 2012).

The surveillance system for *T. saginata* cyticercosis based on post-mortem inspection has been reported to be unreliable (Abuseir *et al*., 2007). The development and validation of a sero-diagnostic test for bovine cysticercosis to be used as a routine surveillance tool has been recommended (EFSA, 2010). This will improve the accuracy of detecting cysticercosis, as identification currently relies on the morphological appearance of lesions as T. saginata cysticerci. False identifications may occur with other cestode larvae (e.g. hydatid cysts), tissue parasites (e.g. Sarcocystis spp.) and occasionally with neoplastic or non-infectious lesions (Gonzalez *et al*., 2006). Similarly, laboratory confirmation based on gross, stereoscopic and histological examinations has drawbacks as results are equivocal in degenerated cysts (Gonzalez *et al*., 2006). Studies have indicated that antigen detection by ELISA (Ag-ELISA) is 2–10 times more sensitive than routine meat inspection and that this technique may therefore be recommended for epidemiological surveys (Onyango-Abuje *et al*., 1996a,b; Dorny *et al*., 2002).

A more recent study conducted to compare of bovine cysticercosis prevalence detected by antigen ELISA and visual inspection in the North East of Spain proved that sero-prevalence was about 50 times higher than the prevalence obtained by visual inspection within the same period: Nineteen positive animals of 90,891 slaughtered animals (0.02%) in the same slaughterhouses. None of the animals with positive result in the Ag-ELISA was detected by meat inspection (Allepuz *et al.*, 2012). The indication for effective prevention and control has become necessary as economic losses may be high. In addition, due to the condemnation of heavily infected carcasses and the necessity to freeze or boil infected meat losses may also occur from restriction of exports (Bekele *et al*., 2010).

2.5 Summary of literature review

Today hunger and poverty is wide spread globally, with developing nations most of which are characteristic of African nations being the hardest hit. Attempt to resolve food insecurity through animal production is severely being hampered by several diseases which causes whole or parts of meat to be condemned at the abattoir. Meat condemnation further worsens food insecurity and leads to huge economic waste as both the farmer and the government cannot recoup it invested capital. Several part of the animal which constitute meat eg liver, spleen, lungs, kidney, heart and the head are regularly being rejected at the abattoir due to several diseases including cysticercosis, hydatidosis, fasciolosis, actinomycosis, actinobaccilosis etc. Also several non disease factors like emphysema, abscess, inflammation and faulty evisceration contribute to meat condemnation. The need for public enlightenment on the dangers of eating poorly processed meat food product, farmer education on the improvement of animal husbandry is key to reversing of the prevalence of disease that contribute to meat condemnation. Knowledge about the dangers of zoonosis and its implication on human health will protect the public from infection.

2.6 References

Abuseir S., Kuhne M., Schneider T., Klein, G and Epe, C. 2007. Evaluation of a serological method for the detection of Taenia saginata cysticercosis using serum and meat juice samples. Parasitology Research **101:** 131–137.

Alexander, K.A, Laver, P.N and Micheletal, A.L. (2010). Novel Mycobacterium tuberculosis complex pathogen, M. mungi," Emerging Infectious Diseases. **16:** 1296–1299.

Allepuz A, Gabriël S, Dorny P, Napp S, Jansen F, Vilar M.J, Vives L, Picart L, Ortuño A, Gutiérrez J and Casal J. 2012. Comparison of bovine cysticercosis prevalence detected by antigen ELISA and visual inspection in the North East of Spain Research in Veterinary Science **92:** 393–395.

Angela, D.P., Giuseppina C., Tony F.V., Bijo B., Fatmira S and Giuseppina T. 2006. Detection of *Mycobacterium tuberculosis* complex in milk using polymerase chain reaction (PCR). Food Control. **17:** 776-780.

Bekele M., Eliyas T., Alemayehu R., Rahmeto A., Fufa A. 2010. Bovine cysticercosis in Cattle Slaughtered at Jimma Municipal Abattoir, South western Ethiopia: Prevalence, Cyst viability and Its Socio-economic importance. Veterinary World 3 **6:** 257-262.

Cabaret J., Geerts, S., Madeline, M., Ballandonne, C., Barbier D. 2002. The use of urban sewage sludge on pastures: the cysticercosis threat. Veterinary .Research. **33:** 575–597.

Center for Disease Control and Prevention, 2003. Food-borne illness: ten least wanted food-borne pathogens [Online]. S.I.:s.n. Available from:
http://www.cdc.gov/nczved/dfbmd/disease_listing/stec_gi.html.

Cosivi O., Grange J.M., Daborn C.J., Raviglione M.C., Fujikura T., Cousins D., Robinson R.A., Huchzermeyer H.F.A.K., de Kantor I and Meslin F. X. 1998. Zoonotic tuberculosis due to *Mycobacterium bovis* in developing countries. Emerging Infectious Diseases. 4 **1:** 59-68.

Delgado, C. L 2003. Rising consumption of meat and milk in developing countries has created a new food revolution. Journal of Nutrition, **133:** 3907S-3910S.

Desmarchelier P., Fegan N., Smale N and Small, A. 2007. Managing safety and quality in the red meat chain. Meat Science, **77:** 28-35.

Dorny P., Phiri I., Gabriel S., Speybroeck N., Vercruysse, J. 2002. A sero epidemiological study of bovine cysticercosis in Zambia. Veterinary Parasitology. **104:** 211–215.

Dorny P. and Praet N. 2007. Taenia saginata in Europe. Veterinary Parasitology. **149:** 22–24.

Dorny P., Praet N., Deckers N and Gabriel S. 2009. Emerging food-borne parasites Veterinary Parasitology **163:** 196-206

EFSA, 2010. Development of harmonised schemes for the monitoring and reporting of Cysticercus in animals and foodstuffs in the European Union. Available from: http://www.efsa.europa.eu.

Ephrem T., Feyisa B., and Shiferaw M. 2011. Prevalence of Bovine Fasciolosis and its Economic Significane in and Around Assela, Ethiopia. Global Journal of Medical research. **11:** 2249-4618

Fitzpatrick J.L., 2013. Global food security: The impact of veterinary parasites and parasitologists Veterinary Parasitology **195:** 233– 248

Flisser A., Correa D., Avilla G., Marvilla P. 2005. Biology of Taenia solium, Taenia saginata and Taenia saginata asiatica. In: Murrell, K.D., Dorny, P., Flisser, A., Geerts, S., Kyvsgaard, N.C., McManus, D.P., Nash, T.E., Pawowski, Z.S. (Eds.), WHO/FAO/OIE Guidelines for the Surveillance, Prevention and Control of Taeniosis/Cysticercosis. World Health Organization for Animal Health (OIE), Paris, 1–9.

Food and Agriculture Organization, 2009. The state of food and agriculture. Rome: FAO

Food and Agriculture Organization, 2011. The State of Food Insecurity in the World, 2011. Food and Agriculture Organization of the United Nations, Rome.
Available from:http://www.fao.org/publications/sofi/en/.

Gibson, A.L,, Hewinson G., Goodchild T., Watt B., Story A., Inwald J and Drobniewski, F.A. 2004. Molecular epidemiology of disease due to *Mycobacterium bovis* in humans in the United Kingdom. Journal of Clinical Microbiology. 42 **1:**431-434.

Gonzalez, L.M., Villalobos, N., Montero, E., Morales, J., Sanz, R.A., Muro, A., Harrison, L.J.S., Parkhouse, R.M.E and Garate, T. 2006. Differential molecular identification of Taeniid spp. and Sarcocystis spp. cysts isolated from infected pigs and cattle. Veterinary parasitology. **142:** 95–101.

Gracey, J.F. 1981. Thornton's meat hygiene. 7th Ed. United Kingdom: Bailliere Tindall.

Gracey, J.F. 1990. *Meat Science*. USA: McGraw.

Hagen-Zanker, J., Morgan, J., and Meth, C. 2011. South Africa's social security system: Expanding coverage of grants and limiting increases in inequality. London: Overseas Development Institute.

Harrington N.P. Surujballi O.P., Prescott J.F., Duncan J.R., Waters W.R., Lyashchenko K and Greenwald R. 2008. Antibody responses of cervids (*Cervus elaphus*) following experimental *Mycobacterium bovis* infection and the implications for immunodiagnosis. Journal of Clinical and Vaccine Immunology. 15 **11:**1650-1658.

Keyyu, J D., Kassuku, A A., Msalilwa, L P., Monrad, J and Kyvsgaard, N C. 2006. Cross-sectional prevalence of helminth infection in cattle on traditional, small-scale and large-scale dairy farms in Iringa district, Tanzania. Veterinary Research Communications **30:** 45- 55.

Jha, VC., Monta Y, Dhakal M, Besnet B, Sato T, Nagai A, Kato M, Kozawa K, Yamamoto S and Kimura H. 2007. Isolation of Mycobacterium spp. In milking buffaloes and cattle in Nepal. J Veterinary Medical Science, 69 **8:** 819–825.

Kithuka, J M., Maingi N., Njeruh, F M and Ombui, J N. 2002. The prevalence and economic importance of bovine fasciolosis in Kenya-an analysis of abattoir data. Journal of Veterinary Research **69:** 255–262.

LoBue, P. A., Enarson, D.A and Thoen C.O. 2010. Tuberculosis in humans and animals: an overview. Journal of Tuberculosis and Lung Disease. 14 **9:**1075-1078.

Loyacano, A F., Williams, J C., Gurie J, DeRossa, A. A. 2002. Effect of gastrointestinal nematode and liver fluke infections on weight gain and reproductive performance of beef heifers. Veterinary Parasitology 107 **3:**227-34.

Lucas, L. A., Phillip, M. K., Peter, B. G., Mark, O. N., Gerald M and Esther S. 2009. A survey of bovine cysticercosis/human taeniosis in Northern Turkana District, Kenya. Preventive Veterinary Medicine **89:** 197–204

Lupo, C. S., Bouquin L E., Balaine L., Michel V., Péraste J., Petetin I., Colin P., Jouffe L. and Chauvin C. 2013. Bayesian network as an aid for Food Chain Information use for meat inspection. Preventive Veterinary Medicine **109:** 25– 36

Lyashchenko K., Whelan A.O., Greenwald R., Pollock, J.M., Andersen P., Hewinson R.G and Vordermeier H.M. 2004. Association of tuberculin-boosted antibody responses with pathology and cell-mediated immunity in cattle vaccinated with *Mycobacterium bovis* BCG and infected with *M. bovis*. Journal of Infection and Immunity. 72 **5:** 2462-2467.

Magalhaes, K G., Jannotti Passos L K and Dos Santos Carvalho. 2004. Detection of *Lymnaea columella* Infection by *Fasciola hepatica* through Multiplex-PCR. *Mem Inst Cruz*, Rio de Janeiro, 99 **4:** 421-424.

Malone, J. B., Gommes, R., Hansen, J., Yilma, J. M., Slingenberg, J., Snijders, F., Nachet, O. F. and Ataman, E. 1998. A Geographic Information System on the potential distribution and abundance of Fasciola hepatica and F. gigantica in East Africa based on food and agriculture organization databases, Veterinary Parasitology, **78:** 87–101.

Mas-Coma S, Bargues M D., Valero M A. 2005. Fascioliasis and other plant-borne trematoda zoonoses. International Journal of Parasitology **35:**1255–1278

Mas-Coma S., Valero M A and Bargues M D. 2009. Fasciola, lymnaeids and human fascioliasis, with a global overview on disease transmission, epidemiology, evolutionary genetics, molecular epidemiology and control. Advance Parasitology **69:** 41–146

Mason, C. 2004. Fasciolosis associated with metabolic disease in a dairy herd, and its effects on health and productivity. *Cattle Practice* **12:** 7-13.

Mellau L.S.B., Nonga H.E and Karimuribo E.D. 2010. A slaughterhouse survey of lung lesions in slaughtered stocks at Arusha, Tanzania Preventive Veterinary Medicine **97:** 77–82

Minozzo, J.C., Gusso, R.L.F., De Castro, E.A., Lago, O and Soccoi, V.T. 2002. Experimental bovine infection with Taenia saginata eggs: recovery rates and cysticerci location. Braz. Arch. Biol. Technol. **45:** 4–10.

Mulcahy, G and Dalton, J P. 2001. Cathepsin L proteinases as vaccines against infection with *Fasciola hepatica* (liver fluke) in ruminants. *Research Veterinary Science* **70:** 83-86.

Nesbakken, T., Eckner, K., Hoidal, H. K., and Rotterud, O. J. 2003. Occurrence of Yersinia enterocolitica and Campylobacter spp. in slaughter pigs and consequences for meat inspection, slaughtering, and dressing procedures. International Journal of Food Microbiology, **80:** 231e240.

Neva, A.F and Brown, W.H. 1994. Basic Clinical Parasitology, 6th edn. Prentice-Hall international Inc. pp 181–200.

Notermans, S., Gallhoff, G., Zweitering, M and Mead, G. 1995. Identification of critical control points in the HACCP system with a quantitative effect on the safety of food products. Food Microbiology, **12:** 93–98.

OIE, 2013. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. OIE Terrestrial Manual, Paris, France, http://www.oie.int/eng/normes/mmanual/A_summry.htm.

Onyango-Abuje, J.A., Hughes, G., Opicha, M., Nginyi, J.M., Rugutt, M.K., Wright, S.H and Harrison, L.J.S. (1996a). Diagnosis of Taenia saginata cysticercosis in Kenya cattle by antibody and antigen ELISA. Veterinary. Parasitology. **61:** 221–230.

Onyango-Abuje, J.A., Nginyi, J.M., Rugutt, M.K., Wright, S.H., Lumumba, P., Hughes, G., and Harrison, J.S. (1996b). Seroepidemiological survey of Taenia saginata cysticercosis in Kenya. Veterinary. Parasitology. **64:** 177–185.

Palomino J.C. 2009. Molecular detection, identification and drug resistance detection in *Mycobacterium tuberculosis*. Journal of Immunology and Medical Microbiology. **2:**1-3.

Phiri, A M., Phiri I K., Sikasunge C S and Monrad J. 2005. Prevalence of fasciolosis in Zambian cattle observed at selected abattoirs with emphasis on age, sex and origin. Journal of veterinary Medicine. B, **52:** 414-416.

Ramajo V., Oleaga A., Casanueva P., Hillyer G V and Muro A. 2001. Vaccination of sheep against Fasciola hepatica with homologous fatty acid binding proteins. Veterinary Parasitology. 97 **1:** 35-46.

Red Meat Regulations No. 1072 of 17 September 2011.

Rhyan T. 1995. Discovery of bovine tuberculosis in free-ranging mule deer and results of continued wildlife surveillance in the area, p 1B-2 - 1B-4 InProc V

Rokni, M. B., Massoud, J. and Kia, E. B. 2003. Comparison of adult somatic and cysteine proteinase antigens of Fasciola gigantica in Enzyme Linked Immunosorbent Assay for diagnosis of bovine fasciolosis, OIE seminar on biotechnology, Proceeding, November 9–13, Tehran, Iran.

Schweitzer, G, Braun, U, Deplazes, P, Torgerson, P. 2005. Estimating the financial losses due to bovine fasciolosis in Switzerland. Veterinary Research. **13:** 188-193.

Scientific Committee on Veterinary Measures relating to Public Health, 2000. Opinion of the Scientific Committee on Veterinary relating toMeasures to Public Health on the Control of taeniosis/cysticercosis inman and animals. European Commission, pp. 31.

Silaigwana Blessing, 2012. Molecular detection and drug susceptibility of Mycobacterium tuberculosis complex in raw milk from a major dairy farm in the Nkonkobe region, Eastern Cape Province, South Africa. MSc microbiology thesis. University of Fort Hare, South Africa. www.netd.ac.za. Accessed august 2013.

Singh, U.B., Arora J., Suresh N., Pant H., Rana T., Sola C., Rastogi N and Pande J.N. 2007. Genetic biodiversity of *Mycobacterium tuberculosis* isolates from patients with pulmonary tuberculosis in India. Infection, Genetics and Evolution. **7:** 441–448.

Stark, K.D.C., Alonso S., Dadios N., Dupuy C., Ellerbroek L., Georgiev M., Hardstaff J., Huneau-Salaün A.., Laugier C., Mateus A., Nigsch A., Afonso A. and Lindberg A. 2014.

Strengths and weaknesses of meat inspection as a contribution to animal health and welfare surveillance. Food Control **39:** 154e162

Subratty, A.H and Gurib, F.B.H. 2003. Consumers' concern about meat and meat products quality offered for sale in Mauritius. Nutrition & Food Science 33 **2:**80-83.

Tadelle, T and Worku, T. 2007. The prevalence and economic significance of bovine fasciolosis at Jimma, Abattoir, Ethiopia, The Internet Journal of Veterinary Medicine, **3:** 15

Taljaard, P. R., Jooste, A and Asfaha, T. A. 2006. Towards a broader understanding of South African consumer spending on meat. Agrekon, **45:** 214e224.

Tara, N G and Durga D J. 2013. Epidemiological study of zoonotic bovine tuberculosis: Neglected emerging diseases of Nepal. International research journal of medicine and medical Sciences. **1:** 1-7.

Teka, G. 1997. Meat hygiene In: Food Hygiene Principles and Methods of Food Borne Diseases Control with Special Reference to Ethiopia, 99–113.

United Nations-WHO. 2003. Assuring Food Safety and Quality: strengthening National food control systems. WHO: Geneva [Online]

http://www.who.int/foodsafety/publications/fs_management/guidelines_foodcontrol/en

Van Llogtestijn, J.G. 1993. Integrated quality of meat safety. A New Approach. Meat Focus International. **2:** 123–128.

Waters, W.R., Whelan A.O., Lyashchenko, K.P., Greenwald R, Palmer M.V., Harris, B.N., Hewinson R.G., Vordermeier, H.M. 2010. Immune responses in cattle inoculated with *Mycobacterium bovis*, *Mycobacterium tuberculosis* or *Mycobacterium kansasii*. Journal of clinical and vaccine immunology. 17 **2:** 247-252.

Webber J., Dobrenov B., Lloyd J and Jordan D. 2012. Meat inspection in the Australian red-meat industries: past, present and future. Austrialian veterinary journal. **90:** 363–369.

Woolhouse, M.E, 2002. Population biology of emerging and re-emerging pathogens. Trends in microbiology. 10 **S3:** 7.

World Health Organisation, (1995). Control of foodborne trematode infections. WHO. Technical Report, WHO, Geneva, Series 849

Yilma J and Malones J B. (1998). A geographical information system forces model for strategic control of fasciolosis in Ethiopia. Veterinary parasitology 78 **2:** 103-127.

CHAPTER THREE: Causes of carcass/offal condemnation and associated financial loss in three abattoirs in the Eastern Cape Province.

Abstract

A study was conducted in three abattoirs represented by the acronym ANA, QTA and EBA, to determine the causes of meat rejection and to ascertain monetary losses associated with such condemnation. *Ante-mortem* and active abattoir surveys were conducted on 229, 458 and 687 cattle from the three abattoirs respectively from 2010 to 2012. Secondary data of abattoir record on 51, 302 cattle's was collected from the Department of Agriculture. The secondary data showed that the liver was the most frequently condemned (56.9%), followed by lung (24.1%), then the heart (7.4%), kidney (6.9%), spleen (4.0%), tongue (0.4%) and carcass (0.3%). An assessment of the abattoir secondary data revealed that the leading cause (%) of rejection for liver in the 3 abattoir was (fasciolosis, 5.59, 4.48, 2.68), spleen (abscess, 0.35, 0.94, 0.17) kidney (inflammation, 0.94, 1.01, 1.18), heart (inflammation, 0.9, 1.85, 0.75), tongue (abscess, 0.08, 0.03, 0.05) and lungs (emphysema, 1.12, 1.14, 1.16). Disease/conditions recorded during *ante-mortem* inspection of animals at the lairage were diarrhea, lameness, emaciation, blindness, orchitis, mastitis, skin conditions, respiratory symptoms corresponding to (8, 1, 13, 2, 3, 6, 9, 11) percent respectively. The rate of condemnation was more during the active abattoir meat inspection than in the previous records from the abattoir. Additional losses of tongue due to gunshot injury and the heart due to cysticercosis were recorded. Furthermore, there was significance association (P<0.05) among the various risk. Monetary loss associated with carcass/offal condemnations in the three abattoir from 2010 to 2012 was 630, 456 South African Rand (ZAR) or 59, 244 United States Dollars (USD), while the summation of losses due to condemnation during the 6 month active meat inspection revealed a higher loss of ZAR 111, 337.5 (10, 383.8 USD) .

Keywords: Cattle, abattoir, carcass condemnation, financial loss, post mortem, meat inspection

3.0 Introduction

Meat is a valuable food commodity in South Africa (Hagen *et al*., 2011). Meat consumption rate is estimated at 41.0 kg per capita per year and is rated the second highest in Africa (FAO, 2009). Livestock production activity aimed at providing meat for the populace has seen the South African national cattle herd increase by about 6 million head since the 1970s and currently stands at about 14 million (Palmer and Ainslie, 2006). Over two-thirds of the 14.1 million cattle in South Africa are found in communal areas (National Department of Agriculture Directorate, 2008) and the estimated number of cattle in the Eastern Cape is over 3.2 million (Tada *et al*., 2013). Despites these improvement, livestock production is hindered by various factors such as diseases and non disease factors. According to Fitzpatrick (2013) diseases are the main constraint to efficient livestock production and both endemic and exotic diseases result in mortality and morbidity and hence less food than should ideally be available in current farming systems.

When animals are produced they end up at the slaughterhouse which is focal point in the farm to fork chain for meat product (Celine *et al*., 2014). The need for food safety and disease control necessitates meat inspection (MI) at the abattoir. Meat inspection is a process of screening animals and meat for fitness for human consumption and is one of the most widely implemented and longest running systems of surveillance (Stark *et al*., 2014). It can follow traditional or risk based approaches and it covers the whole slaughter process that begins with the ante mortem inspection to stunning and ends at the step where the carcass is placed in the cooler. Meat inspection is essential to remove gross abnormalities from meat and its products, to prevent distribution of contaminated meat and to assist detection and eradication of certain livestock diseases (Van Llogtestijn, 1993). The proportion of cattle with offal, partial or whole carcass condemnation could be a useful indicator for animal health syndromic surveillance purposes (Dupuy *et al*., 2014) as well as for detecting emerging disease (Dupuy *et al*., 2013). Offal include: the liver, heart, kidneys, trachea, spleen, brain, pancreas, trotters (feet), tongue, tail, thymus glands or sweetbreads and tripe or stomach lining (Fayemi and Muchenje, 2012). Cattle condemnations are commonly classified into three levels:

(i) Whole carcass condemnations that mainly reflect a widespread infection, an acute stage of infection or any disorder that can have an impact on the whole carcass,

(ii) Partial carcass condemnations that mainly characterized by chronic infection of a localized phenomenon,

(iii) Offal condemnations that is mainly due to localized parasitic infection or any infection with a dedicated offal tropism (Dupuy *et al*., 2014).

Data on cattle condemnation provide information on the epidemiology of livestock diseases and are an indication of the extent of public is exposure to certain zoonotic diseases. The data can also be used to estimate the direct financial losses incurred through condemnation of affected organs and carcasses (Van Llogtestijn, 1993; Nfi and Alonge, 1987).

Currently MI is carried out by International Meat Quality Assurance Service (IMQAS), a subunit in each abattoir created by the Department of Agriculture, Forestry and Fisheries (DAFF) and registered as a private company for the purpose of meat inspection. The IMQAS must report daily condemnation records to a veterinary officer, who from time to time visits the abattoir to ascertain that inspections are properly carried out. The South African government implements the hygiene management system (HMS) and hygiene assessment system (HAS) system at the abattoir as a food safety procedure (Meat Safety Act, 2000). The hygiene assessment system is a nationally standardized evaluation system that quantifies the standard of hygiene management and operation in an abattoir. The decision as to whether meat is fit for human consumption or not will utilize many skills of observation and evaluation, and should take into consideration the results of *ante-mortem* inspection, as well as any available information on the disease history of the herd or region of origin of the animals. Despite the improvement in animal husbandry, condemnation represents a draw back at efforts in resolving food insecurity.

In several African countries, there have been reports of huge wastages of carcass or offal due to condemnation at the abattoir (Cadmus and Adesokan, 2009; Dupuy *et al*., 2014), however, there is scarcity of information in this regards in South Africa. Thus as human population increases and there is pressure on limited food resources, the need to document the various causes of meat condemnation becomes crucial. The implication of zoonotic and emerging zoonotic disease further makes information obtained MI very vital. Losses due to condemnation affect the farmer directly and the economy indirectly (Bekele *et al*., 2010; Ramajo *et al*., 2001). Therefore, this study is aimed at identifying and documenting the major causes of organ and carcass condemnation and the financial loss associated with ANA, QTA and EBA in the Eastern Cape Province.

3.1 Materials and methods

3.1.1 Study area

The study was carried out in the Eastern Cape (E.C) province, which is located in the south-east of South Africa. It is bordered on the north by the Free State and Lesotho, KwaZulu-Natal in the north-east, the Indian Ocean along its south and south-eastern borders, and Western and Northern Cape in the west (Bradshaw *et al*., 2003). It is the second largest province in the country stretching approximately 169 580 km2, i.e. 13.9% of the total land area of South Africa. It has a high population density which is estimated at 41 persons per square km. About 63% of the province's population lives in rural areas (Bradshaw *et al*., 2000). It has the highest unemployment rate in the country with poverty index showing approximately 47% of households living well below the poverty line (Bradshaw *et al*., 2003).

3.1.2 Study sites

The study was conducted at three abattoirs, which are all located in the Eastern Cape Province. Due to ethical and legal considerations the abattoirs were refered to by the acronyms ANA, QTA and EBA. Low through-put abattoir was represented by the acronym (ANA), while the high through-put abattoirs were QTA and EBA. ANA is located 32`80 S and 26`.90 E in the Amathole District of the Eastern Cape Province, RSA. The QTA abattoir is located 31°54′S 26°53′E in the Chris Hani district, while the EBA abattoir is situated at 32.97°S and 27.87°E in the Buffalo City Metropolitan Municipality of the Eastern Cape province. The place receives approximately 480 mm of rainfall per year of which mostly it is during the summer months and is averagely situated 586 - 2371 metres above sea level, high enough to be occasionally covered in snow. The temperatures in the Eastern Cape during the period of study ranged from 18°C to

39°C with mean temperatures of 20.5ºC. It has vegetation that ranges from grasslands and thicket to forests and bushveld with *Acacia karroo*, *Themeda triandra* and *Digitaria eriantha* being the most dominant plant species.

Figure 3.1: Map of the Eastern Cape Province of South Africa showing the location of abattoirs where the study was carried out.

Courtesy: South African accommodation directory and bookings

3.1.3 Study animals

Male and female animals of different ages were included in the retrospective, *ante-mortem* and active meat inspection survey. Where retrospective implies the study of abattoir record from 2010 to 2012, *ante-mortem* the survey cattle for signs of diseases and the active meat inspection means post-mortem inspection of slaughtered cattle. Young animal's use as veal were not included in the study as these were not expected to records diseases that causes meat rejection at the abattoir. These animals were brought from different location in the Eastern Cape.

3.1.4 Sample size determination and sampling

Sample size was calculated based on the formula given by Thrusfield, (2005) with 95% confidence interval, 50% expected prevalence, and 5% desired absolute precision. The sample size was determined to be 382 for the high through put abattoirs and 176 for low through put abattoir. The sizes were however adjusted to 1146 and 229 (almost three times of calculated sample size) respectively; this adjustment became necessary to increase precision and also to account for the large number of animals slaughtered at the abattoir during the years in retrospect from which the secondary data was obtained. The number of cattle slaughtered in the three abattoirs varied and the sample size was maximized proportionally to ANA (229), QTA (458) and EBA (687).

The sampling procedure was conducted using a typical case sampling technique of purposeful sampling for ANA and also for carcass condemnation during the active abattoir survey, while systematic random sampling was used for QTA and EBA (Thrusfield, 2005). Sampling units for ANA involved the selection of rejected meat/offal's and recording case as per unit, while sampling units for QTA and EBA were selected at equal intervals with the first animal being selected randomly. The total number of animals slaughtered during the preceding year (2012) was obtained from the abattoir records as 26, 401 cattle corresponding to 520, 4078, 21803 for ANA, QTA and EBA respectively. The ante-mortem and active meat inspection was carried out for six months in 2013 and during this time the number of slaughtered animal was calculated to be 20, 791 cattle, corresponding to 322, 3788, and 16, 681 representing ANA, QTA and EBA respectively. Sampling interval was thus computed as the total number of animals slaughtered during the study period divided by the required sample size (Regassa *et al*., 2013). Therefore, the sampling intervals for the QTA was 8 (3785/458) and EBA 24 (16, 681/687). While the first cattle, was chosen randomly from the first 8 and 24 animals, respectively. Subsequently, every 8 and 24 cattle were included in the sample during the slaughter operation.

3.1.5 Study types

Cross sectional type of study was employed involving the use of retrospective abattoir records as secondary data from 2010 to 2013 and information regarding the slaughter of 51, 302 cattle was obtained. Active meat and *ante mortem* inspections were also conducted in conjunction with authorized meat inspectors at the various abattoirs. Records of condemnation of liver, spleen, heart, kidney and lungs were obtained in order to ascertain the causes of meat/offal condemnation. However due to poor recording system, data was found to be incomplete with regards to causes of carcass condemnation but same record indicated the number of carcass condemned. It was thus difficult to state the cause of carcass condemnation but direct financial loss was estimated using average cattle carcass weight of five different breeds and multiplying the average weight with current market price.

The *ante-mortem* and active meat inspections were done in accordance with the procedure specified by the Meat Safety Act, (2000) using palpation of organs and visual inspection, with inspectors cutting at various suspicious and disease focal point to ascertain the health status of the meat/offal. The *ante-mortem* pre-slaughter inspection was performed while the animal was at the lairage. Data regarded animal age, sex, breed, body condition score, distance travelled from farm to abattoir were recorded in order to assess the contributing risk factors. Estimating cattle age was done according to FSIS, (2013) and Torell *et al*. (1998). Body condition score (BCS) was carried out using the method described the by NRC, (2000). The BCS was classified into four categories which includes, thin (1-3), borderline (4), optimum (5-7) and fat (8-9). For ease of data analysis these classes were split into 3 groups namely, poor (1-4), moderate (5-7) and good (8-9). Cattle breeds were identified using phenotypic appearance and information obtained from the abattoir.

During the *ante-mortem* inspection, sick and anorexic animals were detained for further investigation and healthy ones were passed for slaughter. Condemned organs upon slaughter were passed through a condemn chamber to the condemn room from where was treated and disposed. During the active meat inspection, cattle included in the inspection were thoroughly screened, disease lesions were detected and organs separated, classified and recorded in line with the guidelines for meat inspection in developing countries (Herenda *et al*., 1994). The inspector's decision regarding carcass or offal was classified as conditionally approved, partially approved, totally approved, in which case was further processed as fit for human consumption and totally condemned as unhealthy for human consumption. Meat classified as totally condemned were rejected and destroyed to avoid human consumption. In cases of partial condemnation, trimmed offal and carcass were estimated based on kilogram weight of daily total trimmed organ. Trimmed organs and carcasses were collected into condemnation drum, thereafter were sorted into different groups such as liver, kidney, spleen, lung, heart and carcass. These were measured using a digital measuring scale Ansutek M1/M2 Portable Crane Scale (Ansutek Commercial Ltd, New Zealand) and the weight of the condemnation drum subtracted in order to get the accurate kilogram weight of condemned organ or carcass. The record of partial condemnation was taken on the days the abattoirs were visited during the six month of the research and the monetary loss was calculated based on current market price per kilogram of organ or carcass.

3.1.6 Animal age estimation

Age determination was done by examining the eruption of permanent incisors. Dentition can reliably be used as an indication of cattle age from 30 up to 48-60 months, when the permanent dentition is complete (FSIS, 2013). After this period, the rate of wear of tooth provides a more useful measure for age estimation. At birth calves have their two deciduous middle incisors and by one year of age, all the deciduous incisors are in place and will show evidence of wear (FSIS, 2013). After one year of age, cattle are aged according to, whether or not, their permanent incisors have erupted and, whether or not, they have come into wear. The eruption of the two central permanent incisors, when the third permanent incisor is not above the gum line, is an indication that the animal is between one and two years of age.

By two years of age, they are in full wear, the two permanent middle incisors have erupted and the second set of permanent incisors has started to erupt (FSIS, 2013). Cattle are considered to be about the 36 to 48 months when the lateral permanent incisors erupt and the corner incisors or canine teeth erupt presenting a total of eight permanent incisors. When both lateral incisors are in wear, the animal is considered to be five years of age, or older. A full mouth means a complete set of permanent incisors is present and indicates that the age of the animal is over 48-60 months (Torell *et al*., 1998). In adult cattle from five to six years, tooth development is complete; the border of the incisors has been worn away, a little below the level of the grinders or molars (FSIS, 2013).

3.1.7 Direct financial loss

Monetary losses were calculated based on the current market price of whole organ or carcass in South African Rand (ZAR), while the prices for trimmed organ and carcass was estimated based on the price per kilogram of condemned organ or carcass using the South African rand (ZAR). The prevailing exchange rate at the time the study was conducted was 1.00 United State dollar (USD) to 10.7257 ZAR or 1.00 ZAR = 0.0932637 USD. Average weight of organs; liver, spleen, kidney, heart, tongue and lungs was taken and the measurement recorded as 5.8, 1.9, 3.0, 2.4, 2.2, and 7.8 kilograms respectively. The average carcass weight of 267.3 was derived by dividing the weight of all slaughtered cattle by the total number of cattle slaughtered for the first day the study.

Prices for whole organ/carcass were obtained from the three abattoirs and averages in rand obtained as the following; 55, 35, 10, 40, 20 and 38 representing prices for liver, spleen, kidney, heart, tongue and lungs, respectively. The corresponding prices in USD were 5.1, 3.3, 0.9, 3.7, 1.9 and 3.5, respectively for the various organs in-view. The average price for whole carcass (weight = 267.3) was calculated based on price per kilogram as ZAR 28 (2.6 USD). Financial losses associated with meat condemnation were in form of losses due to whole or partial meat rejection. For partial condemnation, certain kg of meat was cut off accounting for that part of organ being condemned, otherwise the whole organ is condemned, and in which case losses will be according to the size or weight of the condemned carcass/organ. Abattoirs bore the losses in terms of partial condemnation, while losses accruing from whole condemnations of organ and carcass were referred to the farmers.

3.1.8 Data analysis

Data extracted from retrospective records, *ante-mortem* and active abattoir meat inspection were entered into Microsoft excel (MS Excel 2007) spread sheet. Carcass and organ condemnation rates were determined using simple descriptive statistics. Condemnation rate for retrospective data was defined as the proportion of organs and carcasses condemned to the total number of carcass and organs slaughtered in a year. While the rate of condemnation for active meat inspection, was calculated as the proportion of organs and carcasses condemned to the total number of carcass and organs examined during the study period (Regassa *et al*., 2013). Monetary loss was calculated using current abattoir market prices of organ and carcass (loss in kg). Association between various risks factors during the *ante-mortem* inspection was identified using Chi-square test for proportion of SAS (2003). The possible risk factors were age, sex, breed, and body condition score and distance travelled by the animal from the farm to the abattoir, while the outcome variable was dermatitis, respiratory sign, diarrhea and emaciation

3.2 Results

3.2.1 Causes of offal's rejection during the retrospective study (2010 to 2012)

An assessment of slaughter records from 2010 to 2012 revealed that the liver and lung were the most frequently condemned organs followed by the heart, kidney, spleen and tongue. Condemnation from the three abattoirs were summed up into 2010, 2011 and 2012 and the result show that the quantity of liver that was condemned was 13%, 13% and 8%, while the condemnation rate of the lung were 4%, 6%, and 3.6%, respectively for the three years assessed (Table 3.1). The major cause of liver condemnation was fasciolosis with condemnation rate of 6%, 5% and 3%, this was followed by fibrosis with condemnation rate of 3%, 2.4% and 1%. The condemnation of liver due to abscess was 1%, 3%, and 2% for year 2010, 2011 and 2012, respectively (Table 3.3).

The lungs were mostly thrown away due to pneumonia with condemnation rate of 1%, 2% and 1%, followed by emphysema with 1% condemnation rates across the 3 years under study. Other contributing factors to lungs condemnation were abscess, cyst, pleurisies and improper evisceration (Table 3.4). The heart were mostly condemned due to inflammation (1%, 2% and 1%), followed by cyst (0.2%, 0.4% and 0.2%), the kidney were condemned due to nephritis (1%, 1% and 1%) and cyst (0.1%, 0.2% and 0.2%), spleen were mostly condemned due to splenomegaly (0.2%, 1% and 0.2%), and Abscess (0.4, 1%, and 0.2%), while the tongue was mainly condemned due to abscess with a condemnation rate of 0.1%, 0.03% and 0.1%, respectively, for the years being studied (Table 3.2).

The total calculated weight loss due to carcass/organ condemnation for the year 2010 to 2012 for 51, 302 slaughtered animals was 59, 424.6 kg. The organ and carcass weight lost in the three abattoir for the three years were (15,400.3, 21,418.4, 22,605.9) kilograms for 10, 276, 14, 625, 26, 401 slaughtered cattle respectively (Table 3.1). Monetary losses due to carcass/organ condemnation were estimated and for the organs, the liver recorded the higher losses of 75, 515, 101, 035 and 113, 950 ZAR representing a loss in USD of 7, 058, 9, 443 and 10, 651, respectively, for 2010, 2011 and 2012, respectively.

The loss associated with the condemnation of the lung was ZAR 15, 770 for 2010, ZAR 33, 516 for 2011 and ZAR 35, 872 for 2012. The kidney and spleen recorded losses in ZAR (3120, 1632.8) for year 2010, ZAR (5430, 7630) for year 2011 and ZAR (10590, 3500) for year 2012. The loss associated with carcass condemnation estimated to be ZAR 97297.2, 59875.2, 37422 in the year 2010, 2011 and 2012 respectively. Over all, the direct monetary loss associated with carcass and organ condemnation for 2010 to 2012 were calculated to be ZAR 211, 704 (USD 19, 887.5) and the number of animal slaughtered during the same period was 51, 302 (Table 3.5).

Table 3.1 Number of affected organs and carcasses, and weight loss due to condemnation in cattle slaughtered during from 2010 to 2012.

	2010 (n = 10276)			2011 (n = 14625)			2012 (n = 26401)			
	(n = 502, 2127, 7647)			(n = 437, 4414, 9774)			(n = 520, 4078, 21803)			
Organ affected	ANA(kg)	QTA(kg)	EBA(kg)	ANA(kg)	QTA(kg)	EBA(kg)	ANA(kg)	QTA(kg)	EBA(kg)	Total(Kg)
Tongue	1(2.2)	1(2.2)	8(17.6)	0(0)	0(0)	5(11)	1(2.2)	3(6.6)	14(30.8)	33(72.6)
Spleen	4(7.6)	42(79.8)	12(22.8)	2(3.8)	199 (378.1)	17(32.3)	12(22.8)	30(57)	58(110.2)	376 (714.4)
Heart	0(0)	39 (93.6)	78 (187.2)	1(2.4)	207 (496.8)	116 (278.4)	0(0)	100 (240)	150 (360)	691 (1658.4)
Liver	99 (574.2)	241 (1397.8)	1033 (5991.4)	110 (638)	477 (2766.6)	1250 (7250)	92 (533.6)	310 (1798)	1670 (9686)	5282 (30635.6)
Lung	11 (85.8)	63 (491.4)	341 (2659.8)	31 (241.8)	261 (2035.8)	590 (4602)	27 (210.6)	129 (1006.2)	788 (6146.4)	2241 (17479.8)
Kidney	12(36)	23(69)	69(207)	10(30)	99(297)	72(216)	22(66)	121(363)	210(630)	638(1914)
Carcass	2 (534.6)	11 (2940.3)	0(0)	0(0)	6 (1603.8)	2 (534.6)	2 (534.6)	0(0)	3 (801.9)	26 (6949.8)
Total	129 (1240.4)	420 (5074.1)	1541 (9085.8)	154 (916)	1249 (7578.1)	2052 (12924.3)	156 (1369.8)	693 (3470.8)	2893 (17765.3)	9287 (59424.6)
Total no Loss in 3 abattoirs			15400.3			21418.4			22605.9	59424.6
Total loss in Kg	1240.4	5074.1	9085.8	916	7578.1	12924.3	1369.8	3470.8	17765.3	59424.6
% loss in kg	8	33	59	4	35	60	6	15	79	
compared % loss in kg	2	9	15	2	13	22	2	6	30	100

ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

Table 3.2 Causes of tongue, spleen, heart, kidney and carcass loss due condemnation in cattle slaughtered during from 2010 to 2012.

Organ affected	**Causes of condemnation**	**Number of condemned organs (condemnation rate) during the three years**											
		2010 (n = 10276)				2011 (n = 14625)				2012 (n = 26401)			
		(n = 502, 2127, 7647)				(n = 437, 4414, 9774)				(n = 520, 4078, 21803)			
		ANA	QTA	EBA	Total (%)	ANA	QTA	EBA	Total (%)	ANA	QTA	EBA	Total (%)
Tongue	Abscess	1	1	6	8(0.08)	0	0	5	5(0.03)	1	2	9	12(0.05)
	Actinobaccillosis	0	0	2	2(0.02)	0	0	0	0(0)	0	1	5	6(0.02)
	Total	1	1	8	10(0.1)	0	0	5	5(0.03)	1	3	14	18(0.07)
Spleen	Abscess	3	29	4	36(0.35)	2	127	9	138(0.94)	7	11	28	46(0.17)
	Splenomegaly	1	13	8	22(0.21)	0	72	8	80(0.55)	5	19	30	54(0.2)
	Total	4	42	12	58(0.56)	2	199	17	218(1.49)	12	30	58	100(0.38)
Heart	Cyst	0	8	17	25(0.24)	1	23	29	53(0.36)	0	19	33	52(0.2)
	Inflammation	0	31	61	92(0.9)	0	184	87	271(1.85)	0	81	117	198(0.75)
	Total	0	39	78	117(1.14)	1	207	116	324(2.22)	0	100	150	250(0.95)
Kidney	Cyst	1	0	7	8(0.08)	0	21	12	33(0.23)	3	15	24	42(0.16)
	Nephritis	11	23	62	96(0.94)	10	78	60	148(1.01)	19	106	186	311(1.18)
	Total	12	23	69	104(1.01)	10	99	72	181(1.24)	22	121	210	353(1.34)
Carcass		2	11	0	13(0.13)	0	6	2	8(0.05)	2	0	3	5(0.02)
Total		129	420	1541	2090(20.36)	154	1249	2052	3455(23.62)	156	693	2893	3742(14.17)

ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

Table 3.3 Causes of liver condemnation in cattle slaughtered during from 2010 to 2012.

Organ affected	Causes of condemnation	Number of condemned organs (condemnation rate) during the three years											
		2010 (n = 10276)				2011 (n = 14625)				2012 (n = 26401)			
		(n = 502)	(n = 2127)	(n = 7647)		(n = 437)	(n = 4414)	(n = 9774)		(n = 520)	(n = 4078)	(n = 21803)	
		ANA	QTA	EBA	Total (%)	ANA	QTA	EBA	Total (%)	ANA	QTA	EBA	Total (%)
Liver	Abscess	19	39	56	114(1.11)	10	42	355	407(2.78)	13	51	342	406(1.5)
	Fasciolosis	44	90	477	611(5.95)	63	281	311	655(4.48)	36	187	484	707(2.7)
	Fibrosis	8	41	232	281(2.74)	13	45	288	346(2.37)	9	32	225	266(1.0)
	Hepatitis	11	32	105	148(1.44)	12	41	130	183(1.25)	20	19	266	305(1.2)
	Cyst	4	9	38	51(0.5)	5	11	48	64(0.44)	0	11	22	33(0.12)
	Melanosis	5	15	71	91(0.89)	7	32	77	116(0.79)	5	0	149	154(0.6)
	Telangietasis	8	15	54	77(0.75)	0	25	41	66(0.45)	9	10	182	201(0.8)
Total		99	241	1033	1373(13)	110	477	1250	1837(13)	92	310	1670	2072(8)
Loss in ZAR		5445	13255	56815	75515	6050	26235	68750	101035	5060	17050	91850	113960
Total loss in USD					7, 058				9, 443				10, 651

N/B: ZAR means South African rand, ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

Table 3.4 Percentage of lung condemned in cattle slaughtered from 2010 to 2012.

Organ affected	**Causes of condemnation**	**Number of condemned organs (condemnation rate) during the three years**											
		2010 (n = 10276)				2011 (n = 14625)				2012 (n = 26401)			
		(n = 502)	(n = 2127)	(n = 7647)		(n = 437)	(n = 4414)	(n = 9774)		(n = 520)	(n = 4078)	(n = 21803)	
		ANA	QTA	EBA	Total (%)	ANA	QTA	EBA	Total (%)	ANA	QTA	EBA	Total (%)
Lung	Abscess	3	12	58	73(0.71)	6	23	126	155(1.06)	11	20	172	203(0.77)
	Cyst	0	5	12	17(0.17)	2	15	29	46(0.31)	0	4	41	45(0.17)
	Pneumonia	4	20	88	112(1.09)	9	96	218	323(2.21)	10	31	88	129(0.49)
	Emphysema	3	11	101	115(1.12)	7	66	94	167(1.14)	5	38	263	306(1.16)
	Pleuritis	1	5	34	40(0.39)	3	45	83	131(0.9)	0	11	109	120(0.45)
	Lung worm	0	2	16	18(0.18)	4	16	21	41(0.28)	1	8	29	38(0.14)
	Imp Env	0	8	32	40(0.39)	0	0	19	19(0.13)	0	17	86	103(0.39)
Total		11	63	341	415(4.04)	31	261	590	882(6.03)	27	129	788	944(3.58)
Loss in ZAR		418	2394	12958	15, 770	1178	9918	22420	33, 516	1026	4902	29944	35, 872
Total loss in USD					1, 474				3, 132				3, 353

ZAR means South African rand. Imp. Env means improper eviscereation, ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

Table 3.5 Monetary loss associated with organs and carcasses condemnation of cattle slaughtered in 2010, 2011 and 2012.

Organ affected	Monetary loss (ZAR) associated with condemnation at each of the abattoirs											
	2010 (n = 10276)				2011 (n = 14625)				2012 (n = 26401)			
	(n = 502)	(n = 2127)	(n = 7647)		(n = 437)	(n = 4414)	(n = 9774)		(n = 520)	(n = 4078)	(n = 21803)	
	ANA	QTA	EBA	Total	ANA	QTA	EBA	Total	ANA	QTA	EBA	Total
Tongue	20	20	160	200	0	0	100	100	20	60	280	360
Spleen	140	1470	420	1632.8	70	6965	595	7630	420	1050	2030	3500
Heart	0	1560	3120	4680	40	8280	4640	12960	0	4000	6000	10000
Liver	5445	13255	56815	75515	6050	26235	68750	101035	5060	17050	91850	113960
Lung	418	2394	12958	15770	1178	9918	22420	33516	1026	4902	29944	35872
Kidney	360	690	2070	3120	300	2970	2160	5430	660	3630	6300	10590
Carcass	14968.8	82328.4	0	97297.2	0	44906.4	14968.8	59875.2	14968.8	0	22453.2	37422
Total	21351.8	101717.4	75543	198215	7638	99274.4	113633.8	220546.2	22154.8	30692	158857.2	211704
Total loss in ZAR	21351.8	101717.4	75543	198215	7638	99274.4	113633.8	220546.2	22154.8	30692	158857.2	211704
Total loss in USD	1995.4	9505.8	7059.8	18632.4	713.8	9277.3	10619.0	20724.2	2070.4	2868.2	14845.2	19887.5
% loss in USD	3	16	12	31	1	16	18	35	3	5	25	34

ZAR means South African rand, USD means United States dollar, ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

3.2.2 Analysis of risk factors obtained during *ante-mortem* inspection

During the *ante-mortem* inspection attention was paid to variables that were likely to contribute to the overall outcome of disease and conditions during meat inspection at the abattoir. Exactly 229, 458 and 687 animals were inspected at ANA, QTA and EBA and these represents 66, 46 and 54 percent respectively. The number of animals aged less than two years was 41, 59 and 55 percent for ANA, QTA and EBA respectively. More males were slaughtered than females and the assessment of the body condition score (BSC) revealed that animal that were poorly scored were 76, 89, 113, moderately scored were 81, 105, 249 while those with good BSC were 72, 264, 325 for ANA, QTA and EBA respectively.

Animals were transported from different farm locations as far as >60 km, 61-120km and <120km and Simmentaler was highest slaughtered during the study period for ANA and QTA (45 and 31 percent). While, a greater percentage of non-descript (22%) was slaughtered at EBA (Table 3.6). In decreasing order the disorders noted at ante-mortem for the 3 abattoirs were emaciation, respiratory sign, skin conditions and diarrhea. While ochitis, lameness and blindness were the lowest disorder recorded at the abattoir, the total recorded abnormalities during ante-mortem for ANA (66), QTA (46) and EBA (54) percent respectively during the time of the study (Table 3.7).

3.2.3 Causes of offal's and carcass condemnation during active abattoir inspection and post mortem inspection

Post mortem examination of organ and carcass showed that the liver was the most condemned followed by the lungs. The liver recorded a total condemnation rate of 52.4%, 60.5% and 66.4% for the various abattoir studied (Table 3.8).

Table 3.6 Chi-square analysis of ante-mortem occurrence with various potential risk factor during the active abattoir survey (July to December 2013)

Number (%) of affected animal (n = 229) (n = 458) (n = 687) during active abattoir meat inspection (July to December 2013)						
Risk Factors	Number affected (%)			X^2		
	ANA	QTA	EBA	ANA	QTA	EBA
Age						
<1-2 year	95(41)	271(59)	379(55)	6.6**	15.4***	7.3**
≥ 2 year	134(59)	187(41)	308(45)			
Sex						
Male	155(68)	293(64)	419(61)	28.7***	35.8***	33.2***
Female	74(32)	165(36)	268(39)			
BSC						
Poor	76(33)	89(19)	113(16)	0.5NS	122.6***	100.8***
Moderate	81(35)	105(23)	249(36)			
Good	72(31)	264(58)	325(47)			
Distance Travelled						
<60 Km	172(75)	305(67)	121(18)	57.8***	230.8***	162***
60-120 Km	57(25)	91(20)	184(27)			
>120 Km	0(0)	62(14)	382(56)			
Breed						
Beef master	3(1)	18(4)	122(18)	639.2***	625.4***	471.6***
Nguni	7(3)	73(16)	97(14)			
Angus	5(2)	9(2)	19(3)			
Simmentaler	103(45)	143(31)	135(20)			
Non-descript	85(37)	133(29)	151(22)			
Brahman	3(1)	13(3)	24(3)			
Bonsmara	5(2)	19(4)	68(10)			
Hereford	2(1)	10(2)	13(2)			
Brangus	2(1)	19(4)	30(4)			
Holstein	10(4)	14(3)	17(2)			
Jersey	4(2)	7(2)	11(2)			

BSC means body condition score, ANA means low through put abattoir, QTA and EBA means High through put abattoirs, ** means significant at p<0.01, *** means significant at p<0.001, ^{NS} means not significant at p>0.05

Table 3.7 Summary of disease/condition identified during ante-mortem inspection

(July to December 2013)

Number (%) of affected animal (n = 229)(n = 458) (n = 687) during active abattoir meat inspection (July to December 2013)							
Disease/condition	Number affected (%)				X^2-value for 3 abattoirs		
	ANA	QTA	EBA	Total			
Diarrhea	22(10)	27(6)	59(9)	108(8)	149.5	356.4	471.3
Lameness	2(1)	5(1)	13(2)	20(1)	0.0	438.2	636.0
Emaciation	46(20)	52(11)	86(13)	184(13)	82.0	273.6	386.1
Blindness	3(1)	9(2)	18(3)	30(2)	217.2	422.7	616.9
Ochitis	7(3)	11(2)	20(3)	38(3)	201.9	415.1	609.3
Mastitis	15(7)	29(6)	33(5)	77(6)	172.9	349.3	561.3
Skin condition	27(12)	32(7)	64(9)	123(9)	133.7	338.9	454.8
Respiratory sign	28(12)	46(10)	79(12)	153(11)	130.7	292.5	407.3
Total	150(66)	211(46)	372(54)	733(53)			

The leading cause of condemnation at ANA and QTA was fasciolosis, while at EBA, improper evisceration contributed to a loss of 27.1% of liver. Abscess (8.7%), *Cysticercosis bovis* (2.4%) and fibrosis (9.2%) were some other causes of liver condemnation at ANA, QTA and EBA respectively (Table 3.8). The lung were mostly condemned for emphysema at ANA but was mostly condemned for improper evisceration at QTA and EBA respectively. Pneumonia, pleuritis, haemorrhage and lung worm were other reasons for lung condemnation at ANA, QTA and EBA abattoirs respectively (Table 3.9). The tongue were condemned due abscess, gunshot injury and pigmentation, the spleen were due to abscess, infarct and splenomegaly, the heart was mostly condemned due to cysticercosis, haemorrhage, calcification and peri-carditis and the kidney were rejected due to cyst, infarct and hydronephrosis (Table 3.10). The carcass was either trimmed for bruises, abscess or improper evisceration at ANA (90%), QTA (87%) and EBA (82%) respectively (Table 3.11).

Monetary losses associated with liver condemnation were estimated to be (ZAR 7,488, 18, 067, 33, 673,) for total kilogram loss of (416, 1003.7, and 1870.7) for ANA, QTA and EBA respectively. Fasciolosis was the chief contributor to liver condemnation (Table 3.8). Total kilogram loss for the lung stood at (568, 2263, and 3619) for the 3 abattoir and a monetary consequence of ZAR 29, 025 (Table 3.9). The tongue contributed losses in (ZAR 166,742, 368), spleen (ZAR 375, 1851.5, 3157), heart (ZAR 692, 4876, 5516) and kidney (ZAR 476, 2286, 2580) for the various abattoirs respectively (Table 3.10). Trimmed carcass was measure and weight lost recorded for ANA, QTA and EBA (117, 233.6, and 576.9 in kg) with related monetary loss put at (ZAR 3264.8, 6540.8, 16153.2), (Table 3.11).

Table 3.8 Conditions that led to the condemnation of liver and associated monetary loss (in ZAR) during the active abattoir survey (July to December 2013)

Number (%) of condemned liver (n = 229)(n = 458) (n = 687) during active abattoir meat inspection										
Causes of condemnation	Number affected (Loss in %)			Loss in Kg			Monetary Loss (ZAR)			
	ANA	QTA	EBA	ANA	QTA	EBA	ANA	QTA	EBA	Total
Abscess	20(8.7)	17(3.7)	33(4.8)	63	78.6	171.4	1134	1415	3085	5634
Calcification	19(8.3)	31(6.8)	22(3.2)	72.2	119.8	97.6	1300	2156	1757	5213
Fasciolosis	30(13.1)	65(14.2)	61(8.9)	114	217	253.8	2052	3906	4568	10526
Fibrosis	4(1.7)	48(10.5)	63(9.2)	12.2	208.4	215.4	220	3751	3877	7848
Hepatitis	19(8.3)	23(5)	35(5.1)	58.2	73.4	113	1048	1321	2034	4403
C. bovis	4(1.7)	11(2.4)	9(1.3)	23.2	60.8	42.2	418	1094	760	2272
Melanosis	6(2.6)	14(3.1)	34(4.9)	18.8	71.2	157.2	338	1282	2830	4450
Imp Ev	11(4.8)	57(12.4)	186(27.1)	33.8	130.6	778.5	608	2351	14013	16972
Telangiectasis	7(3.1)	11(2.4)	13(1.9)	20.6	43.9	41.6	371	790	749	1910
Total	120(52.4)	277(60.5)	456(66.4)	416	1003.7	1870.7	7488	18067	33673	59227

Imp. Env means improper evisceration, C.bovis means *Cysticercus bovis.* ZAR means South African rand, ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

Table 3.9 Conditions that led to the condemnation of lung and associated monetary loss (in ZAR) during the active abattoir survey (July to December 2013)

Number (%) of condemned lung (n = 229)(n = 458) (n = 687) during active abattoir meat inspection								
	Number affected (Loss in %)			Loss in Kg			Monetary Loss	
Causes of condemnation	ANA (%)	QTA (%)	EBA (%)	ANA	QTA	EBA	Kg	ZAR
Abscess	4(2)	12(3)	13(2)	23.2	63.6	81.4	168.2	757
Haemorrhage	7(3)	48(10)	36(5)	41.6	254.4	170.8	466.8	2101
Pneumonia	21(9)	41(9)	82(12)	113.8	229.8	429.6	773.2	3479
Emphysema	34(15)	69(15)	155(23)	225.2	418.2	909	1552.4	6986
Calcification	3(1)	7(2)	11(2)	13.4	24.6	75.8	113.8	512
Pleuritis	5(2)	13(3)	84(12)	19	80.4	445.2	544.6	2451
Lung worm	8(3)	5(1)	17(2)	32.4	27	68.6	128	576
Imp Env	23(10)	175(38)	287(42)	99.4	1165	1438.6	2703	12164
Total	105(46)	370(81)	685(100)	568	2263	3619	6450	29025

Imp. Env means improper evisceration, ZAR means South African rand, ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

Table 3.10 Conditions that led to the condemnation of other organs (tongue, spleen, heart and kidney) and associated monetary loss (in ZAR) during the active abattoir survey (July to December 2013)

Number (%) of condemned organ (n = 229) (n = 458) (n = 687) during active abattoir meat inspection (July to December 2013)										
Organ condemned	Cause of condemnation	Number affected (Loss in %)			Loss in Kg			Monetary Loss (ZAR)		
		ANA	QTA	EBA	ANA	QTA	EBA	ANA	QTA	EBA
Tongue	Abscess	1	4	5	2	8	10	42	164	196
	Gunshot injury	2	11	0	4	23	0	78	458	0
	Pigmentation	0	1	2	0	2	5	0	38	92
	Actinobaccillosis	1	2	2	2	4	4	46	82	80
	Total (%)	4 (2)	18(4)	9(1)	8.3(4)	37.1(8)	18.4(3)	166	742	368
Spleen	Abscess	2	6	10	5	10	18	158	364	630
	Infarct	1	13	27	3	26	51	112	900	1768
	Splenomegaly	2	8	12	3	17	22	105	588	760
	Total (%)	5 (2)	27(6)	49(7)	10.7(5)	52.9(12)	90.2(13)	375	1851.5	3157
Heart	Cysticercus bovis	1	3	1	2	6	2	88	244	80
	Haemorrhage	2	32	28	5	78	69	188	3124	2740
	Calcified cyst	0	2	5	0	5	16	0	212	640
	peri-carditis	4	13	21	10	32	51	416	1296	2056
	Total (%)	7(3)	50(11)	55(8)	17.3(8)	121.9(27)	137.9(20)	692	4876	5516
Kidney	Cyst	3	27	42	11	83	128	111	826	1280
	Infarct	9	31	25	29	109	81	290	1090	810
	Hydronephrosis	2	11	14	8	37	49	75	370	490
	Total (%)	14(6)	69(15)	81(12)	47.6(21)	228.6(50)	258(38)	476	2286	2580

ZAR means South African rand, ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

Table 3.11 Conditions that led to the partial condemnation of carcass and associated monetary loss (in ZAR) during the active abattoir survey (n = 229) (n = 458) (n = 687) from July to December 2013

Cause of condemnation	Number affected (Loss in %)			Loss in Kg			Monetary Loss (ZAR)		
	ANA (%)	QTA (%)	EBA (%)				ANA	QTA	EBA
G. bruises	33(14)	85(19)	117(17)	37	60.6	159.9	1022	1696.8	4477.2
L. bruises	112(49)	146(32)	165(24)	42.2	78.3	173.5	1181.6	2192.4	4858
Abcess	17(7)	28(6)	96(14)	11.3	16.2	97.4	316.4	453.6	2727.2
Imp. Env	44(19)	141(31)	186(27)	26.6	78.5	146.1	744.8	2198	4090.8
Total	206(90)	400(87)	564(82)	117	233.6	576.9	3264.8	6540.8	16153.2

G. bruise means generalized bruises, L. bruises means localized bruises, Imp. Env means improper evisceration, ZAR means South African rand, ANA means low through-put abattoir, QTA and EBA means high through-put abattoir

3.3 Discussion

Abattoir meat inspection and slaughter records contribute to disease surveillance and control. Meat inspection assist in monitoring diseases in the national herd and flock by providing feedback information to the veterinary service to control or eradicate diseases, produce wholesome products as well as protect the public from zoonotic hazards (Van Llogtestijn, 1993; Regassa *et al*., 2013). Information obtained from such inspection can reveal causes of meat condemnation even in apparently health animals and as such be communicated back to the farmer in order to improve farm management and husbandry. Slaughtering of sick animals detected during the ante-mortem inspection was delayed, while organ/carcass suspected cysticercosis were detained for further confirmation by veterinary authority in charge of the abattoir.

3.3.1 Analysis of outcome variables on risk factor

The high through-put abattoirs slaughtered more young animals than low through-put abattoir. The age at slaughter in the former may not be unconnected with the fact that younger animals are usually less predisposed to diseases that lead to meat condemnation at inspection point (Mohammed *et al.,* 2012; Pihler *et al*., 2013), But a number of scientists (Abunna et al., 2008; Phiri et al., 2005a; Tadesse et al., 2014) have demonstrated a lack of relationship between disease prevalence and age of animal. Again, the high through put abattoir are export abattoirs and are less inclined to purchase older animals due to its meat quality characteristics upon slaughter and bearing in mind its consumers preferences. This point is supported by Chulayo and Muchenje (2013) who reported that Animal-related factors affecting meat quality include age, breed and the sex of the animal. In addition, Du Plessis and Hoffman, (2007) reported that various meat quality attributes (colour, pH, drip loss, cooking loss, juiciness, tenderness, residue, flavor, shear force and aroma) of Simmentaler cross, Bonsmara cross and Nguni steers raised on natural sweet veld pastures and slaughtered at 18 or 30 months of age were affected by age. Some other characteristics like live weight, carcass weight dressing percentage, carcass compactness and fat content have also been noted to be affected by animal age (Ali *et al*., 2011). It is also worth mentioning that the abattoirs purchase most of their animals at auctions and as such age estimation is done by dentition and weight estimate is done by body condition score (BSC), this makes error of estimate possible. The percentage of old cattle slaughtered at the low throughput abattoir (ANA) may be due to the fact that most of it animals are sourced from local farmers in the community. A greater percentage of these farmers are involved in the farming of local breeds such as Nguni and crosses of local and exotic breeds (Tada *et al*., 2013).

More males were slaughtered across the three abattoirs than female. The differences between sexes at slaughter may be due to the fact that female animals are usually reserved for breeding and reproductive purposes and the males sent early for slaughter (Hughes, 2013). Sex-related abnormalities recorded during the ante-mortem investigation were mastitis and ochitis. A study on the major causes of slaughtering of female cattle by Gebrekidan *et al*. (2009) revealed that reproductive tract abnormalities and mastitis had considerable impact on the productive and reproductive performance of female cattle and were the major reasons why female animals were culled and sent to abattoir for slaughter. The duration and economic implication of the treatment of bovine mastitis often favors slaughter rather than the treatment and management of mastitis (Halasa *et al*., 2007). Similarly, spent bulls are culled due to decline in reproductive performance and diseases. Although across the three abattoir body condition score (BCS) was moderate to good, a significant proportion (%) of animals presented for slaughter at ANA (33), QTA (19) and EBA (16) had poor BCS (Table 3.6). Several factors could have been responsible for the poor BCS and these may include nutrition, disease, environmental stress etc. Specifically and in relation to the present study, fasciolosis was responsible for a sizeable number of liver condemnations. Animals infested with Fasciola are characterized by loss of weight and in chronic late stages show severe emaciation (Tsegaye *et al*., 2011). It can be safe to posit that emaciation and poor BCS noted in these animals may have been due to parasitic infection due to Fasciola.

Out of the total animals inspected during ante mortem 10% (ANA), 6% (QTA) and 9% (EBA) had diarrhea. The cause of the diarrhea was not ascertained in this study; however there are many causes of diarrhea in cattle and these may include type of nutrition, stress parasitic infestation such as helminth and fasciola, bacteria, virus (Brownlie et al., 1986; Komba et al., 2012; Mas-Coma et al., 2005; Torgerson and Macpherson, 2011). Low percentage of lameness was seen in this study (see table 3.6) and may be associated with the method of animal transportation to the abattoir and distance travelled from the farm to the slaughter facility as reported by Mohammed *et al.* (2012). Animals were transported long distance to the high throughput abattoirs and this may expose the animal to stress.

According to a study by Mounier *et al*. (2014) during transfer to the slaughter plant, animals can be exposed to various stressors such as fasting or forced exercise. Other forms of stressors may be due to breakdown of social grouping and the familiar environment, handling (e.g., during loading and unloading), and novelty, which may lead to physical exhaustion or psychological stress and can negatively affect meat quality (Mounier *et al*., 2014). About 20% of the animals seen during the ante-mortem at ANA were emaciated, while 11% and 13% had similar condition at QTA and EBA respectively. Emaciation in animals may be due to malnutrition or disease etiology. Similar study by Mohammed *et al*. (2012) on major cause of liver condemnation and associated financial foss at Kombolcha Elfora Abattoir, South Wollo, Ethiopia, revealed that the most common abnormalities during ante mortem inspection were emaciation, fever, localized swelling, lameness, branding and rough hair coat.

Conditions affecting the skin in the present study were alopecia, bruises, branding, dermatitis and pyoderma. Similar findings by Fekadu *et al*. (2012) and Mohammed *et al*. (2012) supports the current findings. Dermatitis, bruises and severe injury which may lead to alopecia are often caused by disease and poor animal handling. Bruising in slaughter cattle is described as a superficial discoloration due to bleeding of tissue from ruptured blood vessels beneath the surface of the skin (Vimiso and Muchenje, 2013). According to Hernandez *et al*. (2004) and Ndou *et al*. (2011), cattle are prone to repeated rough handling in their lifetime which later on lead to aversive reactions such as stress and bruising during transportation or routine husbandry. Similar finding by Edwards *et* *al*. (1997) and Tlhapi, (2013), reveals that bruises may be due to animals fighting during transportation, which may affect carcass value leading to carcass rejection at slaughter. Bruises indicates poor handling of animals prior and during transportation and decreases beef quality due to increased level of creatine kinase (Mpakama *et al*., 2014). Respiratory signs noticed at the lairage were in the form of nasal discharge, wheezing sound, labored breathing and epistasis (Table 3.7). A lower prevalence (1.11%) of respiratory signs was found in a related study by Fekadu *et al*. (2011) in cattle, but high prevalence (53.6% and 48.8%) of respiratory sign was reported by Regassa *et al*. (2013) in goat and sheep. Generally, it is suggested that animal brought to low thorough put abattoir for slaughter are sourced from rural location/farms and often lack the appropriate veterinary care and good husbandry expected of commercial and large scale cattle farms (Musemwa *et al*., 2008).

Breeds that were identified during the ante-mortem were beef master, Nguni, Angus, Simmentaler, Non-descript, Brahman, Bonsmara, Hereford, Brangus, Holstein and Jersey. The highest breed slaughtered was simmentaler (Table 3.6). This may be due to abattoir preferences or available cattle at the auction market. Again the number of simmentaler recorded in this study is due to sampling methods and errors as the abattoir were only visited on certain days. But finding by Du Plessis and Hoffman, (2007) observed a significance difference between live weight, carcass weight and carcass compactment of Simmentaler steers, Bonsmara and Nguni crossses finished on natural pastures in the arid subtropics of South Africa, and this may also be responsible for the high number of slaughtered Simmental cattle. The number of Nguni slaughtered during this period, was however low, and this may be related to the fact that Nguni cattle are reared for traditional and ceremonial purposes in the Eastern Cape and as such are not regularly slaughtered. There were other cattle that had phenotypic semblance with those of the Nguni and according to Mapiye *et al*. (2009), crossbreds and Nguni were the common cattle breeds in the smallholder areas and these were considered as part of the non-descript animals brought for slaughter. Other possible reason for this can be the need for genetic upgrade of the breed as Nguni cattle are known for being hardy and resistance to tick and diseases (Marufu *et al*., 2011; Musemwa *et al*., 2008) and are generally not known for good performance as a beef breed. This fact is also related to the findings of Muchenje *et al*. (2008) who noted that the Nguni had the highest average daily gain but bonsmara and Angus steers had higher carcass weight and dressing percentage when raised on natural pasture in the Eastern Cape, South Africa.

The use of phenotypic traits in the identification of breed may have limitation as most of the local as rural farmers do not keep accurate breeding records of their animal reproductive activity and thus cannot accurately tell the genetic makeup of the crosses. The result of this study has not indicated an improvement or success of the government Nguni cattle development projects which were initiated in South Africa to improve livelihood of communal farmers. However, those brought for slaughter may be as a result of government sponsored fattening programme which is part of the Nguni cattle development projects which was on going as the time of this study. Conversely, since Nguni cattle are reared by rural farmers with several constraints such as limited access to transportation, market and abattoir facility (Musemwa *et al*., 2008). It can be safe to say that most Nguni cattle are slaughtered informally bearing in mind their use as traditional and ceremonial animals (Mapiye *et al*., 2009). This view is supported by Musemwa *et al*. (2008) who posited that the simplest and the most popular option for nguni sales, especially amongst smallholder livestock owners, is private sales directly to the ultimate consumer, who are individuals buying livestock for different reasons; which may include slaughter, investment or socio-cultural functions such as funerals, weddings, customary and religious celebrations.

3.3.2 Liver condemnations at the three abattoirs

In both the retrospective and the active meat inspection, the liver was the most frequently condemned organ. From the retrospective record a total of 30635.6 kg weight of liver was lost over the period 2010 to 2012 (Table 3.1). The record indicates that a significant percentage of liver were lost due to abscess (Tables 3.3 and 3.8). An abscess is a localized collection of pus (dead neutrophils) separated from the surrounding tissue by a fibrous capsule formed following an infection. Grossly, it is an enlarged palpable lesion with fluctuating fluid. The most common pyogenic bacteria which cause abscess in animals include *Arcanobacterium* (Actinomyces) *pyogenes*, Streptococcus spp., Staphylococcus spp., and *Fusobacterium* (Sphaerophorus) *necrophorum* (Mellau *et al*., 2010a).

In comparing the obtained result, Cadmus and Adesokan, (2009a) recorded similar observed losses of 2.9%, during an investigation into the causes of organ/offal condemnation in some abattoir in western Nigeria. Similarly, studies by Ahmedullah *et* *al*. (2007 and Mohammed *et al*. (2012) also supported the result obtained during the active meat inspection. Lower rate of condemnation due to abscess, was however reported by Fekadu *et al*. (2012). In the present study there was a high rate of condemnation of liver (8.7%) at ANA and these were not similar to other study earlier reported. Small through put abattoirs such as ANA which are owned and managed by middle income people in the society are likely to attract cattle supplies from the rural communities and according to Musemwa *et al*. (2008), disease represent a limitation to improve livestock production for rural farmers. Also liver abscesses are caused by bacteria and the infection occurs due to migrating intestinal parasite which predisposes and pre-optimizes the conditions necessary for secondary bacteria to flourish (Mellau *et al*., 2010b).

Fasciolosis was responsible for liver condemnation of (5.95%), (4.48%) and (2.68%) for ANA, QTA and EBA for year 2010, 2011 and 2012 during the retrospective study respectively (Table 3.3). A greater percentage of condemnation was seen during the active abattoir inspection corresponding to ANA (13.1), QTA (14.2), and EBA (8.9). This result is in agreement with the findings of Mellau *et al*. (2010). But higher proportion of condemnation was reported by Bekele *et al*. (2010), Fekadu *et al*. (2012) and Mohammed *et al*. (2012). Parasitic disease such as Fasciola infection has been associated with changes in season vis-s-vis seasonal rainfall pattern (Phiri *et al*., 2005b). Some affected liver was slightly swollen and appeared pale in color with round edge, the capsule was thick, rough with whitish or reddish discoloration. Fibrosis of the bile ducts which indicated subacute form of infection was also seen. Some parts of bile ducts had cystic appearance due to dilatation. While in others, the liver was greatly enlarged with presence of a few small irregular whitish areas indicating fibrosis over the parietal surface and parenchyma was hard due to fibrous tissue which was thought to be due to healing of migratory tracts of immature parasites. The presence of numerous small and large patches scattered over the parietal surface of some livers could be the indication of transperitoneal route of migration of young flukes. The damage of hepatic cells near these tracts might have resulted from feeding habit of these premature parasites (Fekadu *et al*., 2012).

In the present study, a combined percentage of liver lost due to fibrosis was (5.95), (4.48), (2.68) for the 3 years being studied, the active abattoir meat inspection indicates that less percentage (2.74), (2.37), (1.01) of liver were rejected at the abattoir due to this reason. Generally, fribrosis is consequent upon the migratory activity of parasites such as Fasciola through the bile duct/canals thereby eliciting inflammatory responses which progress to fibrotic or granulomatous formation of tissues along the billary tract (Ahmedullah *et al*., 2007; Alton *et al*., 2012). The result obtained in this study can therefore be associated with the high prevalence of Fasciola infection in animals brought for slaughter (Table 3.3).

Liver enlargement is commonly associated, with inflammatory changes manifested by gross rounding edges (hepatomegaly) and sometimes adhesions to peritoneal membrane. The results obtained in this study, was similar to that of Degheidy and Al-malki, (2012) and Denbarga *et al*. (2011) who recorded a 1.9% and 1.0% hepatitis in slaughtered cattle, respectively. While Fekadu *et al*. (2012) reported a lesser prevalence of 0.4% in cattle slaughtered in Southwestern Ethiopia. Several reason are attributed to hepatitis and these may include parasitic (Fasciola Spp, and *Dicrocoelium dendriticum*) invasion and tunneling of the bile duct, virus and bacteria such as Hepatitis E virus, and Streptococcus spp. (S. agalactiae/dysgalactiae/ pyogenes/zooepidemicus) (Blagojevic and Antic, 2014).

Records from abattoir indicate that cyst was responsible for condemnation of 0.5, 0.44 and 0.12 percent of liver in 2010, 2011 and 2012 respectively. The cause and nature of the cyst were not documented in the abattoir records, but during the active meat inspection it was however detected that *Cysticercus bovis* which is a larval stage of *Taenia saginata* was responsible for liver condemnation. It is global in distribution but is rare or absent in high income countries, the main endemic regions include Latin America, China, South East Asia and sub-Saharan Africa (Torgerson and Macpherson, 2011). *Cysticercus bovis* infection is said to be a faecal-water contaminated helminthiases in which rates of transmission and exposure has been associated with conditions such as human behaviour, occupation, social practices and cultural beliefs together with poor human hygiene, unsanitary animal husbandry and economic activities (Nithiuthai *et al*., 2004).

It is an infection of public health significance as eating of raw or undercooked beef results in taeniasis in human population and an important cause of economic loss mainly due to condemnation, refrigeration and downgrading of infected carcasses (Kumar and Tadesse, 2011). In West Africa, studies have shown epilepsy to be associated with neurocysticercosis in human and was further suggested that it is prevalent in low or middle income endemic countries in which approximately 30% of epilepsy may be attributable to neurocysticercosis (Torgerson and Macpherson, 2011). In the present study results show that the prevalence was lower than what was obtained by Kebede *et al*. (2009a) and Tadesse *et al*. (2014) but was similar to the finding of Borji *et al*. (2012). Losses are incurred when a meat inspectors discover an abnormality on a carcass, it is detained for further processing of the carcass if possible (e.g. freezing) or the condemnation of all or part of the carcass. These measures have a direct financial impact for farmers as a large amount of meat is condemned and price of the carcass is significantly decreased (Dupuy *et al*., 2014a). Information regarding the status of cysticercosis in the Eastern Cape Province is sparse as studies conducted in this area is over 40 years (Phiri, 2006; Phiri *et al*., 2003) but the human cases of cysticercosis appears to be most prevalent in Eastern Cape Province particularly in the poor, rural areas of Ciskei and Transkei, home to black South Africans where pigs are allowed to roam freely and sanitation facilities are inadequate or nonexistent (Carabin *et al*., 2006; Phiri *et al*., 2003)

Melanosis is an abnormal accumulation of melanin pigments in various organs which causes dark pigmentation of the tissues resulting from a disorder of pigment metabolism (Mellau et al., 2010b). The retrospective study revealed that pigments were seen in 0.89%, 0.79% and 0.58% of liver in years under review and in the three abattoirs respectively. There were differences in the result obtained from the active meat inspection as condemnation due to melanosis stood at (2.6%), (3.1%) and (4.9%) for the

3 abattoirs studied. Report by Alton *et al*. (2012) showed a 2.07% condemnation rate of liver due to pigmentation in a provincial abattoir in Canada. This was very similar to what was obtained during the active abattoir inspection in ANA, but it was lesser than the finding in the other abattoirs. Melanin is a natural pigment, which occurs in the skin, hair, nails and membranes. But aberrant migration during embryogenesis does occur (Oruc, 2007) and when it is in excess the meat/offal is condemned for esthetic reasons.

Non disease factor such as improper evisceration lead to huge wastages of the liver especially through trimming and which in most instance were largely over trimmed by the meat inspectors. During the study the precentage of liver trimmed and condemned for faecal and blood splash were 4.8, 12.4 and 27.1 for ANA, QTA and EBA respectively (Table 3.8). Similar study carried out by Regassa *et al*. (2013) on small ruminant, posted results which were in line with our finding at ANA, but was less compared to the number of liver condemned at the QTA and EBA. Evisceration problem which is largely ignored by researchers led to the trimming and rejection of many livers as indicated by this study. A possible reason for lesser rejection at ANA may be the small number of animals brought for slaughter and the fact that it is a small throughput abattoir with some levels of slaughter operation done manually. The higher percentage noted at the high throughput abattoir may be linked to the speed and shortness of time require by each slaughter-man to perform his own function. Such speed and haste may contribute to faecal and blood spillage and soiling of clean offal's. This point was supported by Dupuy *et al*. (2013) who link the faecal contamination of heart and lungs to the failure of quality slaughter processes.

Telangiectasis was a common cause of liver rejection at the slaughter houses, it etiology however remains unknown. It is seen as visible as dark purple red sunken areas of the liver and lesions do not lead to any clinical symptoms (Atasever, 2002). In this study, liver rejection rate for this condition was recorded as 0.75%, 0.45% and 0.76% for the respective years and abattoir being studied (Table 3.3). The percentage (3.1, 2.4, and 1.9) condemnation rate during the active meat inspection was higher than the retrospective study (Table 3.8). Report of higher incidence rate of 2.6% by Atasever, (2002) corresponds to the findings during the active meat inspection.

Several pathologic reasons have thought to be the cause of telangietasis and include but not limited to focal necrotizing hepatitis, metabolic disturbance, high levels of vitamin A, and ischemic injury of the hepatocytes from the hepatic portal vein occlusions (Atasever, 2002). Other are dilatation of the space of Disse by glycogen extruded from hepatocytes with endothelial rupture and subsequent erosion of the hepatocytes, reduced density of the reticulin framework with a reduction of the trabecular resistance to the intrasinusoidal pressure, and a primary alteration of the sinusoidal barrier as increased deposition of basement membrane components in the perisinusoidal region, and fibrosis (Atasever, 2002). It is also believed to be associated with hepatic abscesses (Dupuy *et al*., 2013). The high rate of liver condemnation recorded in this work also suggest that more could have been condemn given the human error due to inspectors oversight and also due to the fact that inspection was only done with visual only appraisal.

3.3.3 Lung condemnations at the three abattoirs

An estimated 17479.8 kilogram weight of lungs was lost in the period covered for the retrospective study. Several factors were responsible for the loss and these include: abscess, cyst, pneumonia, emphysema, pleuritis, lung worm, improper evisceration and calcification. Pneumonia and emphysema were the leading cause of condemnation and an overall percentage condemnation of 4.04, 6.03 and 3.58 of lungs were lost in the 3 year under review (Table 3.4). Abscess formation contributed to a 0.71, 1.06 and 0.77 percent loss of lungs in ANA, QTA and EBA respectively. Similar results were obtained by Fekadu *et al*. (2012), Lat-lat *et al*. (2006) and Phiri (2006) who reported losses of 1.11, 0.5 and 0.8 percent respectively. But higher losses of 8.2% cattle lungs were recorded by Mellau *et al*. (2010a). Generally, abscesses are indicative of the presence of bacteria and most often than not and in the present instance are due to secondary bacterial infection. Lung abscess may originate from infected emboli in the blood coming from other septic organs or areas as in case of endocarditis, lymphadenitis, mastitis and metritis. It has been documented that *Pasteurella spp*. and *Actinimyces pyogenes* are the main causes of lung abcesses in cattle (Mellau *et al*., 2010a).

The retrospective study did not indicate the nature and location of the cyst and thus a percentage of lung condemnation due to cyst was 0.17%, 0.31% and 0.17%. High prevalence (4.4%, 47% and 16.3%) of cyst of cysticercosis reported among slaughtered cattle at Ethiopia by Megersa *et al*. (2010), Tadesse *et al*. (2014) and Tolosa *et al*. (2009) respectively. During the active meat inspection no viable cyst was detected but calcifications of parts of lungs were noticed and these were suspected to be hydatid cyst.

Accurate data on the prevalence of cystic echinococcosis, an important helminth infection in man, has not been reported. This is partly due to poor reliability of the available diagnostic tests and high costs of performing these tests under field conditions. Most of the prevalence studies have relied on slaughter data (Njoroge *et al.*, 2002). Some rural farmers in the Eastern Cape allow dogs to freely roam with their livestock; this can promote the dog to domestic animal interphase, and according to Ernest *et al*. (2009) dogs are the definitive host for E. granulosus, the possibility for environmental contamination is high and the disease can easily be transmitted to ruminants and humans. The non viability of the cyst may be due to medication already administered or animal immune system defense against invading parasitic conditions. The result seen in this work was similar to what was obtained by Abunna *et al*. (2008) during an investigation of bovine cysticercosis at Awassa municipal abattoir Ethiopia. The difference seen among these studies might be due to several factors such as the differences in the agro-climatic conditions of the study areas, culture of eating raw or under cooked meat, probability of incision made at inspection site from abattoir to abattoir, dose and viability of eggs and or larvae consumed (Tadesse *et al*., 2014).

Higher prevalence of cysticercosis in developing countries is associated with poor sanitary infrastructure, low awareness and improper disposal of sewage (Tolosa *et al*., 2009). These conditions clearly depict the sanitary conditions in the rural locations of the Eastern Cape and may be liable for the prevalence seen in cattle brought at slaughter. It is also possible that the method of meat inspection, the expertise and precision of the meat inspector to identify the cases, difference in the management, sampling method, the number and location of cuts, and other factors can significantly contribute to the variation of prevalence of bovine cysticercosis.

During the retrospective study, pneumonia (1.09%), (2.21%), (0.49%) and emphysema (1.12%), (1.14%), (1.16%) contributed significantly to lung wastages at ANA, QTA and EBA. Similar condemnation of lung due to pneumonia was reported by Alawa *et al*. (2011), Lat-lat *et al*. (2006) and Swai *et al*. (2013) and for emphysema by Lat-lat *et al*. (2006) and Mellau *et al*. (2010a). The active meat inspection revealed that the following numbers (%) of lungs were lost due to pneumonia 21(9), 41(9) and 82(12) and emphysema 34(15), 69(15) and 155(23). findings similar to those obtain in this work were studies conducted by Alton *et al*. (2010), Cadmus and Adesokan, (2009b), Denbarga *et al*. (2011) and Mellau *et al*. (2010a) and for emphysema by Fekadu *et al*. (2012) and Kambarage *et al*. (1995).

Pneumonia in ruminants is a complex condition which involves the interaction between the host (i.e. immunological and physiological), multiple agents (e.g. bacterial, viral, mycoplasma) and environmental factors. Poor housing and overcrowding which may subject the animals to various stresses like cold, wind, rain and dust, as a result opportunistic bacteria like Pasteurella spp. and A. pyogenes are likely to attack the lungs (Mellau *et al*., 2010a). In South Africa, temperature in winter (June to August) season can get to an all time low and as much as 0°C in certain parts of the Eastern Cape. This condition may predispose animals to pneumonia. Other stress factors responsible for pneumonia are penetration of lung by foreign body (Fekadu *et al*., 2012), parasitism such as massive infestations of the respiratory tract with ascarid larvae and lungworm, feed contaminated with moulds fed to the animals in trucks during transportation or in cattle markets and exposure to dust either in their environments or fatigue during long treks in search of pastures (Cadmus and Adesokan, 2009) this conditions are very similar to what may be obtained in this study area as most farmer are small holders and without the capacity for feed supplementation, thus cattle such as Nguni and crosses trek long distances in search of food. It is important to mention also that change in weather condition i.e from autumn to spring and to winter is associated with windy and dusty atmosphere and a precursor to several respiratory diseases which may contribute to variation in number of lungs rejected due to pneumonia.

Pulmonary emphysema in animals is normally secondary to some respiratory disease conditions like infectious bovine rhinotracheitis, pneumonic pasteurellosis, malignant catarrhal fever, mycoplasmal infection, leptospirosis and some different cases of septicaemia and endocardiasis. Due to a well-developed interlobular septa and lack of collateral ventilation, sheep, pigs, and particularly cattle are susceptible to interstitial emphysema. Some cases of emphysema have been recorded in slaughter animals due to extensive gasping respiration during slaughter especially when animals are slaughtered without stunning (Mellau *et al*., 2010a). A number of cattle both at ANA and QTA were not stunned but shot due to the owner's inability to restrain the cattle for onward transportation to the abattoir. For ANA they were shot while at the abattoir because these animals were already aggressive and could not be controlled, the others were shot at the farms and then brought to the abattoir for inspection. Situations such as this could promote emphysematous lung and consequent increase the percentage of lungs thrown away.

Furthermore age of the animal be been shown to have association with emphysema, as very old cows is reported to be prone to emphysema when slaughtered (Mellau *et al*., 2010a). A hypersensitivity pneumonia also called “farmer slung” has been noted to be associated with lung emphysema. This disease affects mainly adult dairy cattle; which develops this condition as a result of exposure to hay with high moisture content (Dupuy *et al*., 2013). Stress factors including fatigue during long treks in search of pastures and exposure to polluted air in their environments which predispose animals to several respiratory distresses, has been shown to promote lung emphysema (Regassa *et al*., 2013).

The presence of worms in the lung observed in this study (Tables 3.4 and 3.9) is similar to what was observed by Lat-lat *et al*. (2006) in cattle and buffalo and Regassa *et al*. (2013) in sheep and goat, but were higher in earlier study by Regassa *et al*. (2010). Several lung worm species have been reported to occur very sporadically in the high lands of tropical and sub-tropical regions, and occurrence has been commonly and widely seen in cattle of temperate regions around the world, others may undergo hypobiosis in adverse climatic conditions such as dryness or drought, and in which case larvae may become inhibited in the lung tissue for up to 150 days (Lat-lat *et al*., 2006). South Africa do experience dry conditions especially during winter and wet season in spring and partly summer, evidence from the slaughter records reveal that most worms were detected during the summer and may be associated with seasonal prevalence and mode of action of the parasite. Activities of these parasite is characterized by irritative bronchitis associated with adult worms, allergic condition, pneumonia associated with massive infestations of the respiratory tract and calcified cyst which is associated with lung worms of *Dictyocaulus viviparous*, *Dictyocaulus filarial* and *Mullerius capillaries* (Lat-lat *et al*., 2006; Mellau *et al*., 2010a; Regassa *et al*., 2013).

Generally, worms can cause extensive intestinal and duodenal erosions, ulceration, haemorrhage, abscesses and catarrhal inflammation (Mas-Coma *et al*., 2005) and helminth infection can result in losses in productivity through a reduction of feed intake and feed conversion efficiency, loss of blood and even death. Farmers in the rural area lack access to latest and adequate information regarding the seriousness of helminth infection, and further lack the relevant skills on how to treat and control internal parasites. According to Tsotetsi and Mbati, (2003), Cattle on communal grazing play an important role in the culture and economics of small scale farmers living in villages or townships in South Africa and these cattle are seldom, if ever, treated for internal parasites. This perhaps gives an explanation to the number of lung condemnation seen in ANA when compared to the number of animals examined during the study and relation to the QTA and EBA (Table 3.9).

Pleurisy (pleuritis) is an inflammation of the pleural membrane that surrounds and protects the lungs. It is a condition normally associated with pneumonia and at a certain stage it may lead to fibrinous adhesions between the parietal pleura and the lung surface

(Mellau *et al*., 2010a). Pleurisy in adult cattle may sometimes be a legacy of respiratory disease contracted as intensively reared calves (Edwards *et al*., 1997). A similar result was obtained by Regassa *et al*. (2013) in ruminants at Ethiopia, while Kambarage *et al*. (1995) and Lat-lat *et al*. (2006) findings corroborate that of the active meat inspection. This difference may be due to differences in geographical locations, aetiologies, different definitions used (Mellau *et al*., 2010a) or due to personal assessments, season and definitive diagnosis of pleurisy between the different studies.

Improper evisceration accounted for percentage partial condemnation of (0.39), (0.13) and (0.39) from the abattoir slaughter data, while (10), (38) and (42) percent of lung of animals slaughtered within this period were trimmed (Table 3.9). A total 2703 kilogram weight of lung was loss to improper evisceration, and contributed a significant economics loss to the abattoir. Improper evisceration has been attributed to a failure in the slaughtering process (Dupuy *et al*., 2013) and compromises meat quality and hygiene by contaminating carcass/organ with highly pathogenic organism like salmonella and verotoxin-producing Escherichia coli (VTEC) which are found in the stomach and intestine (Blagojevic and Antic, 2014). Findings in relation to improper evisceration was by Regassa *et al*. (2013) and loses were in term of the kidney and tongue. In the present study evisceration problem may be due to use of sharp knife, unskilled and inappropriately trained workers. In addition, less number of eviscerating staff puts pressure on them to work faster to deliver and achieve the daily slaughter target. The impatience of the slaughter or eviscerating worker may also contribute in the number of lungs soiled by blood and faeces.

3.3.4 Tongue condemnations at the three abattoirs

Several conditions such as abscess, actinobacillosis, pigmentation and gunshot injury affected the tongue which lead to it rejection. Abattoir slaughter records revealed a small number of losses due to abscess and actinobaccillosis, but during the active survey a higher percentage of tongue were seen with abscess (1, 4 and 5) and actinobaccillosis (1, 2 and 2) in the 3 abattoir studied (Tables 3.2 and 3.10). Similar finding was recorded by Alton *et al*. (2012) but higher condemnations were recorded by Dupuy *et al*. (2013), Kambarage *et al*. (1995), Phiri, (2006), Regassa *et al*. (2013) and Tlhapi, (2013). Tongues with pigments were also condemned and others were as a result of gunshot injuries. The reason for tongue pigmentation was not ascertained but may not be unassociated with keratinization of the epithelial surface of the tongue. Agitated and aggressive cattle at ANA were shot at the abattoir upon arrival, haven tried to restrain without success, also some cattle were shot at the farm for similar reason and later brought to QTA for inspection and processing.

3.3.5 Spleen condemnations at the three abattoirs

There was a low occurrence of abscess (0.35), (0.94) and (0.17) and splenomegaly (0.21), (0.55) and (0.2) and these were the main reason for spleen rejection during the retrospective study however, higher occurrence were recorded during the active meat inspection for same reason in ANA, QTA and EBA and corresponds to (2, 6 and 10) and (2, 8 and 12). In addition spleen infarcts led to percentage condemnation of (1, 13 and 27) of spleen during the active meat inspection. Phiri, (2006) reported a higher condemnation of spleen in studies in three provinces of Zambia and (Tlhapi, 2013) indicated that fever was the cause of splenomegaly during a study on the causes of carcass condemnation in South African abattoir. Most studies (Blagojevic and Antic, 2014; Gajadhar *et al*., 2006; Kebede, 2008; Kebede *et al*., 2009b; Megersa *et al.*, 2010; Tolosa *et al*., 2009) found cyst of either *Cysticercus bovis* and *Ecchinococus granulosus* as the major cause of spleen rejection. But in the present study abscess, splenomegaly and infarct were the main cause of condemnation in the 3 abattoir studied. This outcome may be due to location, efficiency of veterinary care on the farm and lack of adequate inspection. It may also be due to the low prevalence of cysticercosis and hydatidosis in the study. Generally, apart from fever earlier mentioned, infection with *Baccillus anthracis* has been noted to cause liver enlargement, while bacteria organism like *Staphylococcus aureus* and Streptococcus spp. (S. agalactiae/dysgalactiae/ pyogenes/zooepidemicus) are notable causes of abscess in cattle (Blagojevic and Antic, 2014).

3.3.6 Heart condemnations at the three abattoirs

The percentage of Cyst recorded from abattoir slaughter data revealed that (0.24, 0.36 and 0.2) of heart was lost, while (1, 3 and 1) percent heart was thrown away due to the cyst of cysticercosis bovis. This was identified as lesions consisting of cysticerci 5–8 mm by 3–5 mm, translucid and filled with brownish fluid (Abunna *et al*., 2008) further diagnosis for confirmation was not done. Live cattle having C. bovis shows no symptoms, however, in cases of heavy infestation, larvae may cause myocarditis or heart failure (Kumar and Tadesse, 2011). Several studies (Cadmus and Adesokan, 2009a; Fekadu *et al*., 2012; Komba *et al*., 2012; Tadesse *et al*., 2014) obtained similar result as with this study, while higher figures were obtained by Kambarage *et al*. (1995), Kebede *et al*. (2009b) and Tolosa *et al*. (2009). Cysticerci can remain alive in cattle anywhere from days to years and has public health implication in humans as the consumption of infected raw or undercooked beef causes taeniasis in human (Kumar and Tadesse, 2011). In live cattle, cysts grow slowly, between 1 and 5 cm in diameter per year, and it may take many years before clinical symptoms appear, usually as the result of dysfunction of the organ in which the cyst develops. When and if the cyst ruptures, the sudden release of its contents can precipitate allergic reactions ranging from mild to fatal anaphylaxis (Dorny *et al*., 2009).

Inflammatory conditions like pericaditis and endocarditis were responsible for the condemnation of (0.9), (1.85) and (0.75) percent of heart from the retrospective records, while endocarditis was responsible for the condition of (4, 13 and 21) percent heart. Several studies (Alawa *et al*., 2011; Dupuy *et al*., 2013; Fekadu *et al*., 2012) supports the finding of this work, but Denbarga *et al*. (2011), Kambarage *et al*. (1995) and Phiri, (2006) reported higher condemnation due to inflammation. Several conditions may lead inflammation of the heart and may include diseases caused by bacteria spp such as Streptococcus spp. and Arcanobacterium pyogenes (Blagojevic and Antic, 2014) and Erysipelothrix rhusiopathiae (Hill *et al*., 2013). Haemorrhages such as those from poorly bleed animal or blood clothing in the heart, may lead to its condemnation (Table 3.10).

3.3.7 Kidney condemnations at the three abattoirs

The kidney can be seen as an indicator of the health and fitness of the animal, due to its sensitivity to insult from infection or toxin. In the present study, cyst (0.08), (0.23) and

(0.16) and nephritis (0.94), (1.01) and (1.18) were the major reasons for kidney condemnation in the 3 years studied in retrospect, while higher percentage (3, 27 and 42) of cyst was identified during the active meat inspection (Tables 3.2 and 3.10). Furthermore, infarct (9, 31 and 25) and hydronephronesis (2, 11 and 14) were also reasons why the kidney was condemned in ANA, QTA and EBA, during the active meat survey. Findings regarding nephritis and hydronephrosis were supported by Fekadu *et al*. (2012); Hajimohammadi *et al*. (2014) and Tadesse *et al*. (2014), cyst formation (Abunna *et al*., 2008), infarct (Kambarage *et al*., 1995) and haemorrahage (Phiri, 2006). Higher rate of occurrence of cyst and nephritis was reported by Alton *et al*. (2012), Edwards *et al*. (1997) and Tolosa *et al*. (2009). According to Edwards *et al*. (1997), some cyst may be congenital in nature but condemnation purposes are geared towards aesthetic reason and not necessarily public health.

Adult parasites have been shown to affect the kidney as they tunnel through small veins around the bladder and ureter and release high numbers of eggs which are deposited in the bladder wall predisposing the kidney to chronic disease which may be characterized by haematuria, dysuria, hydronephrosis (Van Der Werf *et al*., 2003). According to Dupuy *et al*. (2013) there may be an association between kidney condemned due to nephritis and bronchopneumonia. When calves are affected by bronchopneumonia and left untreated, it secondarily induces lesions on heart, kidneys and thymus. In the present study haemorahagic condition of the heart may be due to improper bleeding or existing heart problem, whereas the cause of the infarct was not identified, it may be due to infection with tick-borne disease which is endemic in the Eastern Cape. Similar view was reported by Kambarage *et al*. (1995) who considered infarct as due to the infection with Theileria parva in Tanzania.

3.3.8 Carcass condemnations at the three abattoirs

A carcass may be totally or partially condemned; in this study a total of 26 carcasses were totally condemned from the abattoir records from 2010 to 2012 corresponding to an estimated 6949.8 kilogram loss of weight during this period (Table 3.1). During the active meat inspection, there were no whole carcass condemnations but partial trimming of carcass for various reasons. Generalized bruises was responsible for the loss of (37), (60.6) and (159.9) kg of carcass while (42.2), (78.3) and (173.5) kg were lost to partial trimming (Table 3.11). Generally, bruises are indicative of the pre-slaughter stress the animal undergoes and is a maker for good management and care on the animal (Strappini *et al*., 2009). Apart from the animal welfare implications, bruising affects carcass value (Edwards *et al*., 1997). Bruises are associated with rough handling, violent impact of the animals against sharp-edged surfaces, aggression between animals and also mechanical damage to animal tissue (Chulayo, 2012; Strappini *et al*., 2009).

Cattle from the market were said to have more bruises than cattle sold directly from the farm, while sex breed and age correlated with occurrence of bruises in animal (Jarvis *et al*., 1995; Mpakama *et al*., 2014). In the present study bruises may be due to the fact that some animal were agitated and uncontrollable evidence by the fact that some were shot. It can also be due to poor handling facility at the farm and abattoir during loading and offloading. Furthermore, it may also be due to mode and distance of transportation, as transportation has been shown to have an impact on the bruise score of animal to be slaughtered.

Abscess formation was also present in some carcass and affected carcass was trimmed. The percentage/kilogram weight of trimmed carcass were (7/11.3), (6/16.2) and (14/97.4) for the 3 abattoirs (Table 3.11). It was observed that most of the abscesses were located on the hip area and on the neck fold and these are two popular sites for administration of injections. Abscesses pose a problem in terms of contamination should the abscess be ruptured during slaughter, it will contaminate clean carcass/offal, including the slaughter environment. Also in live animal, abscessation can develop into more generalized pyaemia. According to Edwards *et al*. (1997) abscess formation on carcass relates directly to husbandry practice on the farm. The incidence of post-injection abscesses indicates poor hygienic practice by the farm operator whether administering therapeutic medication or immunization. Improper evisceration such as fecal contamination was responsible for percentage/kilogram loss of (19/26.6), (31/78.5), (27/146.1) weight of carcass to trimming. Faulty slaughter process may lead to meat contamination as faecal and blood splash might lead to contamination (Blagojevic and Antic, 2014; Dupuy *et al*., 2014a) and reduction in meat quality and hygiene.

3.3.9 Financial implications of carcass/organ condemnations in the three abattoirs

Whole sale prices were used for the estimation of the financial loss associated with condemnation, thus it is very likely that higher monetary loss is possible if real market prices are used. Again the condemnations were made by meat inspectors and the likelihood of human error such as missing some disease case is possible. In the present study, estimate made from the abattoir data indicate that a total of 59424.6 kg weight of carcass/offal's were lost in the 3 abattoir (Table 3.1). The least being ANA (1240.4, 916, 1369.8 kg), followed by QTA (5074.1, 7578.1, 3470.8 kg) and EBA (9085.8, 12924.3, 17765.3 kg), the difference noted among the abattoir may be due to slaughter capacity and meat inspector efficiency. Table 3.5 indicates that during the same period a total of ZAR 630465.2 (59244.1 USD) was monetary estimate that was lost due carcass/offal condemnation and were in the following order in (ZAR/USD); 2010 (ZAR 198215/18632.4 USD), 2011 (ZAR 220546.2/20724.2 USD) and 2012 (ZAR 211704/19887.5 USD).

Currently, information on the quantity and financial implication of meat condemnation in the Eastern Cape is scarce, therefore we cannot compare between this study and any other within our locality. But elsewhere in Africa studies of this nature have shown various percentages of financial losses (Denbarga *et al*., 2011; Fekadu *et al*., 2012; Kithuka *et al*., 2002; Mwabonimana *et al*., 2010). In the present study the liver was the most condemned and attracted the highest loss of (ZAR 75515, 101035, 113960), while the tongue was the least condemned and also attracted the least financial loss of (ZAR 200, 100, 360) for the three years studied. The active abattoir meat inspection has the following losses associated with meat condemnation from the liver, lung, heart, spleen, kidney and tongue in a decreasing order (ZAR 59227, 29025, 11084, 5383.5, 5342, and 1276). Several studies (Borji *et al*., 2012; Regassa *et al*., 2013; Tadesse *et al*., 2014; Torgerson and Macpherson, 2011) have indicated that disease and non disease factors lead to carcass/offal condemnation, in which the resultant effect is the financial losses accrued to it and the burden of these losses are those of the farmer and the abattoirs involved.

3.4. Conclusion

The study identified abscessation, inflammatory conditions of the heart, faciolosis, cysticercosis, calcification, splenomegaly, bruises, improper evisceration, and actinobacillosis were found to be major causes of organs/carcass condemnation resulting in considerable direct financial loss to the farmer and abattoir. The sum total of financial losses associated with these condemnations for the years in retrospect (2010-2012) and the active abattoir survey (July to December 2013) was ZAR 1, 027630.7 (95810 USD).

3.5 References

Abunna, F., Tilahun, G., Megersa, B., Regassa, A and Kumsa, B. 2008. Bovine cysticercosis in cattle slaughtered at Awassa municipal abattoir, Ethiopia: prevalence, cyst viability, distribution and its public health implication. Zoonoses and public health, 55 **2:** 82–8.

Ahmedullah F, M., Akbor, M. G., Haider, M. M., Hossain, M. A. H. N. A. Khan, M.I. and Shanta I.S. 2007. Pathological Investigation of Liver of the Slaughtered Buffaloes in Barisal District, Bangladesh journal veterinary, 5 No. 5 **(1 & 2):** 81–85.

Alawa, C.B.I., Etukudo-Joseph, I. and Alawa, J.N. 2011. A 6-year survey of pathological conditions of slaughtered animals at Zango abattoir in Zaria, Kaduna State, Nigeria, Tropical Animal Health and Production, 43 **1:** 127–131.

Ali, M.M., Hossain, M.M., Akhter, S., Islam, M.S. and Hashem, M.A., 2011. Effect of age on slaughterhouse by-products of indigenous cattle of Bangladesh, Bangladesh journal of animal science, 42 **1:** 3–7.

Alton, G.D., Pearl, D.L., Bateman, K.G., McNab, W.B. and Berke, O. 2010. Factors associated with whole carcass condemnation rates in provincially-inspected abattoirs in Ontario 2001-2007: implications for food animal syndromic surveillance. BMC veterinary research, **6:** 42.

Alton, G.D., Pearl, D.L., Bateman, K.G., McNab, W.B. and Berke, O. 2012. Suitability of bovine portion condemnations at provincially-inspected abattoirs in Ontario Canada for food animal syndromic surveillance. BMC veterinary research, BMC Veterinary Research, 8 **1:** 88.

Grandin, T. 1997. Assessment of stress during handling and transport. Journal animal Science **75:** 249–257

Atasever, A. 2002. Incidence and Pathologic Studies on Liver Telangiectasis in Beef Cattle, Turkish Journal of veterinary animal science, **26:** 235–238.

Bekele, M., Tesfay, H. and Getachew, Y. 2010. Bovine Fasciolosis : Prevalence and its economic loss due to liver condemnation at Adwa Municipal Abattoir , North Ethiopia, EJAST, **1:** 39–47.

Blagojevic, B. and Antic, D. 2014**.** Assessment of potential contribution of official meat inspection and abattoir process hygiene to biological safety assurance of final beef and pork carcasses, Food Control, Elsevier Ltd, 36 **1:** 174–182.

Borji, H., Azizzadeh, M. and Kamelli, M. 2012. A retrospective study of abattoir condemnation due to parasitic infections: economic importance in Ahwaz, southwestern Iran." The Journal of parasitology, 98 **5:** 954–7.

Bradshaw D, Nannan N, Laubscher R, Groenewald P, Joubert J, Nojilana B, Norman R, P.D.& S.M. 2000**.** Mortality estimates for Eastern Cape Province, South African National Burden of Disease Study, 3–10.

Bradshaw, D., Groenewald, P., Laubscher, R., Nannan, N., Nojilana, B., Norman, R., Pieterse, D., et al. 2003. Initial burden of disease estimates for South Africa, 2000. South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde, Vol. 93 No. **9:** 682–688.

Brownlie, J., Mc, C. and Cj, H. 1986. Pathogenesis and Epidemiology of Bovine Virus Diarrhoea Virus Infection of Cattle, Annal Rech Veterinary, **18:** 157–166.

Cadmus, S.I.B. and Adesokan, H.K. 2009. Causes and implications of bovine organs/offal condemnations in some abattoirs in Western Nigeria, Tropical Animal Health and Production, 41 **7:** 1455–1463.

Carabin, H., Krecek, R.C., Cowan, L.D., Michael, L., Foyaca-Sibat, H., Nash, T. and Willingham, A L. 2006. Estimation of the cost of Taenia solium cysticercosis in Eastern Cape Province, South Africa. Tropical medicine & international health : TM & IH, 11 **6:** 906–16.

Chulayo Amanda Yucca. 2012. Effects of pre-slaughter sheep handling and animal-related factors on Creatine Kinase levels and physico-chemical attributes of mutton, M.Sc dissertation, University of Fort Hare. Alice, South Africa.

Degheidy, N.S. and Al-malki, J.S. 2012. Epidemiological Studies of Fasciolosis in Human and Animals at Taif, Saudi Arabia, World Applied Sciences Journal, 19 **8:** 1099–1104.

Denbarga, Y., Demewez, G. and Sheferaw, D. 2011. Major causes of organ condemnation and financial significance of cattle slaughtered at Gondar ELFORA abattoir, northern Ethiopia. Global Veterinaria, IDOSI Publications LA - English, 7 No. **5:** 487–490.

Dorny, P., Praet, N., Deckers, N. and Gabriel, S. 2009. Emerging food-borne parasites. Veterinary parasitology, 163 **3:** 196–206.

Dupuy, C., Demont, P., Ducrot, C., Calavas, D. and Gay, E. 2014. Factors associated with offal , partial and whole carcass condemnation in ten French cattle slaughterhouses, MESC, 97 **2:** 262–269.

Dup**uy, C., Morignat, E., Maugey, X., Vinard, J.-L., Hendrikx, P., Ducrot, C., Calavas, D.,** 2013. Defining syndromes using cattle meat inspection data for syndromic surveillance purposes: a statistical approach with the 2005-2010 data from ten French slaughterhouses. BMC veterinary research, **9:** 88.

Edwards, D.S., Johnston, a M. and Mead, G.C. 1997. Meat inspection: an overview of present practices and future trends. Veterinary journal 154 **2:** 135–47.

Ernest, E., Nonga, H.E., Kassuku, A.A. and Kazwala, R.R. 2009. Hydatidosis of slaughtered animals in Ngorongoro district of Arusha region, Tanzania, Tropical Animal Health and Production, 41 **7:** 1179–1185.

FAO. (2009), "The state of food and agriculture", Food and Agriculture Organization of the United Nations: Rome, FAO.

Fayemi, P.O. and Muchenje, V. 2012. Meat in African context: From history to science", African Journal of Biotechnology, 11 **6:** 1298–1306.

Fekadu, A., Legesse, E. and Tesfaye, D. 2012. The Cause, Rate and Economic Implication of Organ Condemnation of Cattle Slaughtered at Jimma Municipal Abattoir , Southwestern Ethiopia, Global Veterinaria 9, **4:** 396–400.

Fitzpatrick, J.L. 2013. Global food security: the impact of veterinary parasites and parasitologists. Veterinary parasitology, 195 **3-4:** 233–48.

FSIS. (2013), "Using dentition to age cattle", Food Safety Inspection Service: U.S. Department of Agriculture, Washington, D.C. Accessed online at http://www.fsis.usda.gov/ofo/tsc/bse_information.htm on May 1, 2013.

Gajadhar, A.A., Scandrett, W.B. and Forbes, L.B. 2006. Overview of food- and water-borne zoonotic parasites at the farm level Toxoplasmosis. Review of scientific technique, Office of international Epizootics. 25 **2:** 595–606.

Gebrekidan, B., Yilma, T. and Solmon. 2009. Major causes of slaughtering of female cattle in Addis Ababa Abattoir Enterprise, Ethiopia. Indian Journal of Animal Research, Agricultural Research Communication Centre LA - English, 43 **4:** 271–274.

Hagen-Zanker, J., Morgan, J., & Meth, C. 2011. South Africa's social security system: Expanding coverage of grants and limiting increases in inequality, Over-seas Development Institute, London.

Hajimohammadi, B., Oryan, A., Zohourtabar, A., Ardian, M., Shokuhifar, M. and Eslami, G. 2014. Rate of Carcass and Offal Condemnation in Animals Slaughtered at Yazd Slaughterhouse, Central Iran, Journal of Food Quality and Hazards Control, **1:** 61–64.

Halasa, T., Huijps, K., Østerås, O. and Hogeveen, H. 2007. Economic effects of bovine mastitis and mastitis management: A review. The Veterinary quarterly, 29 **1:** 18–31.

Herenda, D., Chambers, P.G., Ettriqui, A., Seneviratnap, P., DaSilvat, T.J.P. 1994. Manual on Meat Inspection for Developing Countries. Food and Agricultural Organization of the United Nations (FAO), Rome, Italy.

Hernandez, P., Aliaga, S., Pla, M. and Blasco, A. 2004. The effect of selection for growth rate and slaughter age on carcass composition and meat quality traits in rabbits. Journal of animal science, 82 **11:** 3138–3143.

Hill, A., Brouwer, A., Donaldson, N., Lambton, S., Buncic, S. and Griffiths, I. 2013. A risk and benefit assessment for visual-only meat inspection of indoor and outdoor pigs in the United Kingdom, Food Control, 30 **1:** 255–264.

Hughes, H. 2013. Raised replacement heifers: Some economic considerations, Veterinary Clinics of North America. Food Animal Practice, 29 **3:** 643–652.

Jarvis, A.M., Selkirkb, L. and Cockrama, M.S. 1995. The influence of source, sex class and pre-slaughter handling on the bruising of cattle at two slaughterhouses, Livestock Production Science, 43 **95:** 215–224.

Kambarage, D.M., Kimeraa, S.I., Kazwalaa, R.R. and Mafwereb, B.M. 1995, Disease conditions responsible for condemnation of carcasses and organs in short-horn Zebu cattle slaughtered in Tanzania, Preventive Veterinary Medicine **22:** 249–255.

Kebede, N. 2008. Cysticercosis of slaughtered cattle in northwestern Ethiopia. Research in veterinary science, 85 **3:** 522–6.

Kebede, N., Tilahun, G. and Hailu, A. 2009. Current status of bovine cysticercosis of slaughtered cattle in Addis Ababa Abattoir, Ethiopia, Tropical Animal Health and Production, 41 **3:** 291–294.

Kithuka, J.M., Maingi, N., Njeruh, F.M. and Ombui, J.N. 2002. The prevalence and economic importance of bovine fasciolosis in Kenya--an analysis of abattoir data. The Onderstepoort journal of veterinary research, 69 **4:** 255–262.

Komba, E.V.G., Komba, E. V., Mkupasi, E.M., Mbyuzi, A.O., Mshamu, S., Mzula, A. and Luwumba, D. 2012. Sanitary practices and occurrence of zoonotic conditions in cattle at slaughter in Morogoro Municipality, Tanzania: implications for public health, Tanzania Journal of Health Research, **14:** 2

Kumar, A. and Tadesse, G. 2011. Bovine cysticercosis in Ethiopia : a review Prevalence of bovine cysticercosis in Ethiopia, Ethiopian veterinary journal, 15 **1:** 15–35.

Lat-lat, H., Sani, R.A. and Sheikh-omar, A.R. 2006. Condemnation of lungs in abattoirs in peninsular Malaysia due to parasitic infection from 1998 - 2004, Tropical Biomedicine, 23 **1:** 61–68.

Mapiye, C., Chimonyo, M., Dzama, K., Raats, J.G. and Mapekula, M. 2009. Opportunities for improving Nguni cattle production in the smallholder farming systems of South Africa, Livestock Science, 124 **1-3:** 196–204.

Marufu, M.C., Chimonyo, M., Mapiye, C. and Dzama, K. 2011. Tick loads in cattle raised on sweet and sour rangelands in the low-input farming areas of South Africa, Tropical Animal Health and Production, 43 **2:** 307–313.

Mas-Coma, S., Bargues, M.D. and Valero, M.A. 2005. Fascioliasis and other plant-borne trematode zoonoses, International Journal for Parasitology, 35 **11-12:** 1255–1278.

Meat Safety Act. 2000. Act No. 40, Government Gazette Notice No. 1106. Parliament of the Republic of South Africa, Menlopark 0102 Pretoria South Africa: Sourced from the South African Meat Industry Company.

Megersa, B., Tesfaye, E., Regassa, A., Abebe, R. and Abunna, F. 2010. Bovine cysticercosis in Cattle Slaughtered at Jimma Municipal Abattoir, South western Ethiopia: Prevalence, Cyst viability and Its Socio-economic importance, Veterinary World, 2 **2:** 257.

Mellau, L.S.B., Nonga, H.E. and Karimuribo, E.D. 2010. A slaughterhouse survey of lung lesions in slaughtered stocks at Arusha, Tanzania. Preventive veterinary medicine. 97 2**:** 77–82.

Mellau, L.S.B., Nonga, H.E. and Karimuribo, E.D. 2010. A Slaughterhouse Survey of Liver Lesions in Slaughtered Cattle, Sheep and Goats at Arusha, Tanzania, Research Journal of Veterinary Sciences, 3 **3:** 179–188.

Mohammed, N., Hailemariam, Z., Mindaye, S., Medicine, V., Box, P.O. and Dewa, D. 2012. Major Cause of Liver Condemnation and Associated Financial Loss at Kombolcha Elfora Abattoir , South Wollo , Ethiopia, 4 **4:** 140–145.

Mounier, L., Dubroeucq, H., Andanson, S., Veissier, I. and Etoile, M.L. 2014. Variations in meat pH of beef bulls in relation to conditions of transfer to slaughter and previous history of the animals The online version of this article, along with updated information and services, is located on the World Wide Web at: Variations, Journal of animal science, **84:** 1567–1576.

Mpakama, T., Chulayo, A.Y. and Muchenje, V. 2014. Bruising in Slaughter Cattle and Its Relationship with Creatine Kinase Levels and Beef Quality as Affected by Animal Related Factors, 27 **5:** 717–725.

Muchenje, V., Dzama, K., Chimonyo, M., Raats, J.G. and Strydom, P.E. 2008. Meat quality of Nguni, Bonsmara and Aberdeen Angus steers raised on natural pasture in the Eastern Cape, South Africa. Meat science, 79 **1:** 20–8.

Musemwa, L., Mushunje, A., Chimonyo, M., Fraser, G., Mapiye, C. and Muchenje, V. 2008. Nguni cattle marketing constraints and opportunities in the communal areas of South Africa : Review, 3 **4:** 239–245.

Mwabonimana, M.F., Kassuku, A.A., Ngowi, H.A., Mellau, L.S.B., Nonga, H.E. and Karimuribo, E.D. 2010. Prevalence and economic significance of bovine fasciolosis in slaughtered cattle at Arusha abattoir, Tanzania. Tanzania Veterinary Journal, 22**, 2:** 2009.

National Department of Agriculture Directorate. (2008), "Agricultural Statistics of the National Department of Agriculture, Republic of South Africa.", http://www.nda.agric.za: accessed 04 April 2011.

Ndou, S.P., Muchenje, V. and Chimonyo, M. 2011. Animal welfare in multipurpose cattle production systems and its implications on beef quality. African Journal of Biotechnology 10 **7:**1049-1064

Nfi, A.N. and Alonge, D.O. 1987. An economic survey of abattoir data in Fako division of the south west province, Cameroon (1978-1980). Bulletin of Animal Health and Production in Africa, **35:** 239–242.

Nithiuthai, S., Anantaphruti, M.T., Waikagul, J. and Gajadhar, A. 2004. Waterborne zoonotic helminthiases. Veterinary parasitology, 126 **1-2:** 167–93.

Njoroge, E.M., Mbithi, P.M.F., Gathuma, J.M. and Wachira, T.M. 2002. Short communication A study of cystic echinococcosis in slaughter animals in three selected areas of northern Turkana, Kenya, **104:** 85–91.

Oruc, E. 2007. Short Communication Melanosis in a Holstein Heifer, **503:** 501–503.

Palmer, T. and Ainslie, A. 2006. Country Pasture/Forage Resource Profiles, Country profiles, Zimbabwe. Food and Agriculture, 1–28.

Phiri, a M. 2006. Common conditions leading to cattle carcass and offal condemnations at 3 abattoirs in the Western Province of Zambia and their zoonotic implications to consumers, Journal of the South African Veterinary Association, 77 **1:** 28–32.

Phiri, A.M., Phiri, I.K., Sikasunge, C.S. and Monrad, J. 2005a. Prevalence of fasciolosis in Zambian cattle observed at selected abattoirs with emphasis on age, sex and origin, Journal of Veterinary Medicine Series B: Infectious Diseases and Veterinary Public Health, 52 **9:** 414–416.

Phiri, A.M., Phiri, I.K., Sikasunge, C.S. and Monrad, J. 2005b. Short Communication Prevalence of Fasciolosis in Zambian Cattle Observed at Selected Abattoirs with Emphasis on age, Sex and Origin, Journal veterinary medicine. 416 **52:** 414–416.

Phiri, I.K., Ngowi, H., Afonso, S., Matenga, E., Boa, M., Mukaratirwa, S., Githigia, S. 2003. The emergence of Taenia solium cysticercosis in Eastern and Southern Africa as a serious agricultural problem and public health risk, Acta Tropica, 87 **1:** 13–23.

Pihler, I., Maksimović, N. and Stanisic, N. 2013. Influence of slaughter age on Meat Quality of Goat, 15th International Feed Technology Symposium -Feed-to-Food / Cost Feed for Health joint Workshop 284–289.

Du Plessis, I. and Hoffman, L. 2007. Effect of slaughter age and breed on the carcass traits and meat quality of beef steers finished on natural pastures in the arid subtropics of South Africa, South African Journal of Animal Science, 37 **3:** 143

Ramajo, V., Oleaga, A., Casanueva, P., Hillyer, G. V. and Muro, A. 2001. Vaccination of sheep against Fasciola hepatica with homologous fatty acid binding proteins, Veterinary Parasitology, 97 No. **1:** 35–46.

Regassa, A., Moje, N., Megersa, B., Beyene, D., Sheferaw, D., Debela, E., Abunna, F. 2013. Major causes of organs and carcass condemnation in small ruminants slaughtered at Luna Export Abattoir, Oromia Regional State, Ethiopia. Preventive veterinary medicine. 110 2: 139–48.

Regassa, A., Toyeb, M., Abebe, R., Megersa, B., Mekibib, B., Mekuria, S., Debela, E. 2010. Lungworm infection in small ruminants: prevalence and associated risk factors in

Dessie and Kombolcha districts, northeastern Ethiopia, Veterinary parasitology. 169 **1-2:** 144–8.

SAS. 2003. SAS/STAT®Software Release 6.12. SAS Institute Inc., Cary, NC, USA.

Stark, K.D.C., Alonso, S., Dadios, N., Dupuy, C., Ellerbroek, L., Georgiev, M., Hardstaff, J., et al. 2014. Strengths and weaknesses of meat inspection as a contribution to animal health and welfare surveillance, Food Control, Elsevier Ltd, **39:** 154–162.

Strappini, A.C., Metz, J.H.M., Gallo, C.B. and Kemp, B. 2009. Origin and assessment of bruises in beef cattle at slaughter, Journal of animal, 3 **05:** 728.

Swai, E., Mwezimpya, I., Ulicky, E., Mbise, A., Moshy, W. and Litamoi, J. 2013. An abattoir survey of contagious bovine pleuropneumonia lesions in slaughtered cattle in selected districts in Northern Tanzania., Asian Pacific journal of tropical biomedicine, 3 **4:** 303–6.

Tada, O., Muchenje, V. and Dzama, K. 2013. Effective population size and inbreeding rate of indigenous Nguni cattle under in situ conservation in the low-input communal production system, South African Journal of Animal Science 2013, 43 **2:** 138–142.

Tadesse, B., Birhanu, T., Sultan, A., Ayele, G. and Ejeta, E. 2014. Prevalence , Public Significance and Financial Loss of Hydatid Cyst on Cattle Slaughtered at Nekemte

Municipal Abattoir , Western Ethiopia Department of Medical Laboratory Sciences , College of Medical, Acta Parasitologica Globalis, 5 **3:** 151–159.

Thrusfield, M. 2005, Surveys In Veterinary Epidemiology, (Edition, 3rd, Ed.), Blackwell Science Ltd, London, pp 228–246.

Tlhapi, P.T. 2013. A critical evaluation of the causes of carcass condemnations in a South African cattle abattoir, M.Sc dissertation University of Pretoria. Pretoria South Africa

Tolosa, T., Tigre, W., Teka, G. and Dorny, P. 2009. Prevalence of bovine cysticercosis and hydatidosis in Jimma municipal abattoir, South West Ethiopia. The Onderstepoort journal of veterinary research, 76 **3:** 323–6.

Torell, R. Bruce, B., Kvasnicka, B., Coney, K. 1998. Methods of determining age in cattle, Cattle Producer's Library: CL712. University of Nevada, Reno, NV. [http://www.unce.unr.edu/publications/files/ag/other/cl712.pdf]. Access July 4, 2013.

Torgerson, P.R. and Macpherson, C.N.L. 2011. The socioeconomic burden of parasitic zoonoses: global trends. Veterinary parasitology, Elsevier B.V., 182 **1:**79–95.

Tsegaye, E., Mulugeta, B.S. and Begna, F. 2011. Prevalence of Bovine Fasciolosis and its Economic Significane in and Around Assela, Ethiopia Shiferaw Mulugeta, Feyisa Begna, Ephrem Tsegaye, **11:** 3.

Tsotetsi, A.M. and Mbati, P.A. 2003. Parasitic helminths of veterinary importance in cattle, sheep and goats on communal farms in the northeastern Free State, South Africa, Journal of the South African Veterinary Association, 74 **2:** 45–48.

Vimiso, P. and Muchenje, V. 2013. A survey on the effect of transport method on bruises, pH and colour of meat from cattle slaughtered at a South African commercial abattoir, South African Journal of Animal Science, 43 **1:** 110–121.

Van Der Werf, M.J., De Vlas, S.J., Brooker, S., Looman, C.W.N., Nagelkerke, N.J.D., Habbema, J.D.F. and Engels, D. 2003. Quantification of clinical morbidity associated with schistosome infection in sub-Saharan Africa, Acta Tropica. **86:** 125–139.

Van Llogtestijn J.G. 1993. Integrated quality of meat safety. A New Approach, Meat Focus International, 2 **2:** 123–128.

CHAPTER FOUR: Prevalence, seasonal changes and economic importance of Fasciola parasite in liver of slaughtered cattle in selected abattoirs in the Eastern Cape Province South Africa.

Abstract

The objective of this study was to determine the prevalence, seasonal changes and economic importance of Fasciola parasite in liver of slaughtered cattle in two high throughput abattoirs (AB1 and AB2) and one low throughput abattoir (AB3). Retrospective information regarding the number of cattle slaughtered and number of liver condemned due Fasciola infection for the years 2011, 2012 and 2013 was obtained from the Department of Agriculture for analysis. Survey data was also collected during active abattoir inspection (AB1, n= 500, AB2, n= 400, and AB3, n= 220) and animals were selected using systematic random sampling and were monitored from stunning through to evisceration and inspection point. Occurrence of Fasciola in the liver was observed grossly, while palpation and incisions were made to further confirm its presence. Prevalence of fasciolosis was calculated and seasonal occurrence was determined based on monthly assortment. From the retrospective data, the prevalence of fasciolsis was 2.9 percent (n = 78728) while the annual prevalence of Fasciola infection from 2011-2013 for AB1 was (3.2, 2.2 and 2.0%), AB2 (6.4, 4.6 and 3.5%) and AB3 (14.4, 6.9 and 9.5%). Higher prevalence was obtain in summer (AB = 10.4%, AB2 = 12.8% and AB3 = 10.9%) and autumn (AB = 11.2%, AB2 = 10.8% and AB3 = 8.6%) than in winter (AB = 9.8%, AB2 = 6.5% and AB3 = 5.9%) and spring (AB = 8.2%, AB2 = 7.8% and AB3 = 5.9%). Cattle with poor body condition score (BCS) were more affected across the different levels of severity and there was a significant difference between BCS and the level severity at each abattoir ($p<0.05$). The percentage prevalence of fasciolosis was high in young animals at AB1, AB2 and AB3 (30.8, 23.2 and 18.2%) than in old animal (8.8, 14.5 and 14.1%). The monetary losses associated with carcass weight loss, whole and partial liver condemnation was estimated to be ZAR 917, 921.5 (83, 447 USD), ZAR 31, 661.5 (2, 878 USD) and ZAR 19, 112.3 (1, 737 USD) respectively. In conclusion, the prevalence of fasciola infection was high in warm season than in cold season, a seasonal pattern of infection was observed and infection led to monetary losses.

Keyswords: Fasciolosis, season, cattle, abattoir, economic loss

4.0 Introduction

Fasciolosis is a disease caused by trematode Fasciola, which is predominantly a disease of ruminants and is responsible for huge direct and indirect economic loses to the livestock industry (Bekele *et al*., 2010; Theodoropoulos *et al*., 2002; Zeleke *et al.*, 2013). The need to curtail waste is in meat product evidently clear given the rate at which the world population is rapidly expanding. Currently, the population of South Africa is estimated to be a little above 52 million and is projected to reach 73 million in 2050 (SSA, 2013). Infection by fasciola is highly pathogenic and can lead to severe morbidity and even death of the host and has in recent times become a reoccurring problem challenging the livestock sector thereby limiting the ability of the sector to provide enough protein for the ever growing population (Radfar *et al.*, 2013).

Economic loses to rural agricultural communities and commercial producers from Fasciola infection world-wide is estimated to be US $200 million per annum, (Boray, 1985), with over 600 million animals infected (Ramajo *et al*., 2001). In developing economies, the incidence of F. hepatica can reach up to 77% while in tropical nations; fasciolosis is considered the single most important helminthosis of cattle, with reported prevalence of 30-90% (Tsegaye *et al*., 2011a). Economic losses recorded due to the disease are mainly through abattoir liver rejection, reduced production of milk, meat, and wool, veterinary care, metabolic disease and mortality (Bekele *et al*., 2010; Khanjari *et al*., 2014; Kithuka *et al*., 2002; Mohammed *et al*., 2012; Terefe *et al*., 2012).

Fasciolosis apart from being a disease of veterinary importance, has also been pointed as emerging zoonosis of great public health concern with an increasing number of human cases being reported; It is estimated that 75% of emerging human pathogens are zoonotic (Esteban and Bargues, 1999; Fitzpatrick, 2013; Mas-Coma *et al*., 2005). Emerging zoonoses have been defined as zoonoses that are freshly recognised or recently evolved, or that have occurred in the past but demonstrate an enhancement in incidence or expansion in geographical, host or vector range (Dorny *et al*., 2009; Fitzpatrick, 2013). Recent studies by Dorny *et al*. (2009) and Torgerson and Macpherson, (2011a) indicates that 2.5 million people world-wide were infected with fasciolosis. Clinical signs of fasciolosis are caused by the migration of the young flukes through the liver causing abdominal pain, indigestion, weight loss, mild fever and malaise (Dorny *et al*., 2009).

Studies have also shown the reality of aberrant migrations of parasitic entities including Fasciola (Dorny *et al*., 2009; Nithiuthai *et al*., 2004; Torgerson and Macpherson, 2011). The recognition that the majority of emerging diseases affecting humans worldwide are zoonotic in origin has raised interest in improving disease surveillance in domestic animals and wildlife (Thomas-Bachli *et al*., 2012). Socio-economic impact of zoonotic disease is increasingly being experienced by many countries, but most particularly by the developing nations. In these countries, the poor and marginalised populations bear a disproportionately high share of the burden that such diseases are creating (Seimenis, 2012).

While *Fasciola hepatica* is mostly found in Europe, the Americas, and Australia, Fasciola gigantic is more prevalent in tropical countries, although both species have been recorded in Africa and Asia (Mas-Coma *et al*., 2005). It has a two-host life cycle, with the asexual stages developing in intermediate hosts, which in nature are mostly freshwater snails of the genus Lymnaea (Mas-Coma *et al*., 2005). Fasciola hepatica has a regular occurrence in temperate area and in cooler areas of high altitude in the tropics and subtropics while Fasciola gigantica, is predominately seen in tropical area (Dawa *et al*., 2013). The water snail of the genus *Lymnae natalensis* and *Lymnae truncatula* are known as intermediate host in life cycle of fasciolosis. *Lymnea truncatula* is usually associated with herds and flocks grazing in wet water logged marshy land.

While *Lymnae natalensis* infection is associated with livestock drinking from snails infected water as well as with grazing wetland, which may be swampy atimes (Fitzpatrick, 2013; Terefe *et al*., 2012; Tsegaye *et al*., 2011a; Zeleke *et al*., 2013). In South Africa the most common intermediate hosts are *L. trunculata (F. hepatica), L. natalenis (F.gigantica)* and *L. columella (F. hepatica* and *F.gigantica).* Encystment takes place in the intestine and the juvenile fluke pass across the peritoneum and arrive at the liver. After migrating through the parenchyma, the trematode reach the bile ducts and attain sexual maturity, at this point most pathological damage start to occur leading to the release of antigens (Keyyu *et al*., 2006; Khan *et al*., 2010; Sánchez-Andrade *et al*., 2002; Tsotetsi and Mbati, 2003)

Pathogenesis depends primarily on the two different stages of development of the parasite in the liver of the host, the level of parasitaemia, and if it is an acute, sub acute or chronic infection. The clinical signs of acute disease are characterised by sudden acute deaths, weakness, anaemia and dyspnoea. Sub acute and chronic fasciolosis is characterized by progressive loss of condition, anaemia, hypoalbuminaemia, emaciation, pallor of the mucous membranes, submandibular oedema and ascites (Degheidy and Al-malki, 2012; Keiser and Utzinger, 2009; Mwabonimana *et al*., 2010; Phiri *et al*., 2005a, 2005b). In cattle, infection remain untreated as the immune response does not provide adequate protection, thus the animals remain prone to re-infection each year (McLeod, 2011).

Abattoirs have played an important role in the surveillance of a variety of diseases of human and animal health significance. Inspection at the abattoir allows for all animals passing into the human food chain to be examined for abnormal signs, lesions or specific diseases (Alton *et al*., 2010). This study was intended to determine the seasonal prevalence of fasciolosis in cattle slaughtered at two high through put and one low through put abattoirs and to comparatively assess the economic impact of fasciolosis due to liver condemnation in these abattoirs.

4.1 Materials and methods

4.1.1 Description of study area

Refer to chapter three, section 3.1 sub-section 3.1.1

4.1.2 Study site

Refer to chapter three, section 3.1 sub-section 3.1.2

4.1.3 Study population and Sample size Determination

Study animals were those brought to the abattoir for slaughter and included male and females of different ages, transported from different locations. In order to establish the prevalence and economic significance of fasciolosis, the sample size was determined at 90% confidence interval and 5% margin of error and an expected prevalence of 50% by using the formula given by Thrusfield, (2005) and was validated using a sample size calculator (Raosoft Inc USA see www.raosoft.com).

$$n = \frac{1.96^2 \cdot P_{exp}(1-Pexp)}{d^2}$$

Where n = required sample size

Pexp = expected prevalence= 50%

d = desired absolute precision=5%

Hence, d = 0.05 and p= 0.5 (50%).

Accordingly 268, 256 and 179 animals belonging to abattoirs (AB1, AB2 and AB3) were supposed to be sampled but in order to increase the precision, a total of 500, 400 and 220 study animals were used (Regassa *et al*., 2013). The animal numbers were maximally adjusted to minimize the margin of error below the 5% mark and to further improve statistical precision.

4.1.4 Study Design and Sampling Method

A cross sectional study was conducted in the 3 abattoir used for this study. Abattoir slaughter record was obtained from the Veterinary department from 2010 to 2012 and data was extracted to assess seasonal pattern. Also a prospective study was conducted from March 2013 to march 2014, with aim to also ascertain seasonality of Fasciola infection and to also estimate the liver condemnation due to Fasciola and its associated economic losses. Ante mortem inspection was carried to document relevant risk factor and generally animal welfare indicators.

4.1.5 Abattoir survey

Daily condemnation records for cattle in the abattoir were used as the sources of data. Records of number of animals slaughtered and the organs/offal condemned were collected. Routine meat inspection is carried out by International Meat Quality Assurance Service (IMQAS), who are qualified meat inspectors who had undertaken special training in meat inspection, processing, disease identification and pathology of farm animals. The inspectors carry out their work under occasional supervision by state veterinarians.

Ante-mortem examination of all animals presented for slaughter was done a day before or shortly prior to slaughter by meat inspectors. This was followed by postmortem meat inspection involving visual examination, palpation, and incisions at notable disease points on liver according to procedures described by Alembrhan and Haylegebriel, (2013) and

Mellau *et al*. (2011). Fasciola parasite was detected grossly and diagnosed based on pathological changes, i.e. colour, size, morphology, consistence, presence of lesions or parasites. During the active meat inspection, the liver of the slaughtered cattle were grossly inspected to detect the presence of flukes. Prominent billary tract and ducts were opened with knife. Adult and immature Fasciola flukes were collected and sorted. Affected livers were classified in to three groups.

1. Mildly affected livers: - If the quarter of the liver was affected or if one bile duct was prominently enlarged on the ventral surface of the liver.

2. Moderately affected: - If half of the organ was affected or if two or more bile passages were hyper plastic.

3. Severely affected: - If the entire organ was involved or if the was cirrhotic and triangular in outline and when the right lobe was atrophied (Equar and Gashaw, 2012).

4.1.6 Direct loss and indirect loss economic loss associated with liver condemnation

Economic losses were estimated both from the total number of liver rejected from the retrospective and active meat survey data. All livers infected with Fasciola were not condemned; some were partially condemned while the contaminated part was trimmed. Annual slaughter rate was estimated from the retrospective abattoir record of the three years being reviewed, while the average price for liver was obtained from the abattoir's marketing department. The current foreign exchange rate of 1 United State Dollar (USD) for 10.7 South African Rand (ZAR) was used for conversion. Information gathered was then computed mathematically using the method set by Ogunrinade and Ogurinade 1980 as cited by Equar and Gashaw, (2012).

(a) Total Annual liver condemnation (ALC) = MCS X MLC X P

Where ALC = Annual loss from liver condemnation

MCS = Mean annual cattle slaughtered at Abattoirs (AB1, AB2 and AB3)

MLC = Mean cost of one liver at the abattoirs

P = Prevalence of fasciola in cattle liver at the abattoirs

(b) Annual Partial liver condemnation (PLC)

Where: PLC = Annual loss from partial liver condemnation

MCS = Mean annual cattle slaughtered at Abattoirs (AB1, AB2 and AB3)

½ MLC = Mean cost of half liver at the abattoirs

P = Prevalence of fasciola in cattle liver partially condemned at the abattoirs

(c) Carcass weight loss due to fasciolosis: An average carcass weight loss due to bovine fasciolosis was then assessed using the following formula.

Annual loss from carcass weight loss (ACW) = CSR X CL X BC X P

Where: ACW = Annual loss from carcass weight loss.

ACS = Average number of cattle slaughtered per Annum at the Abattoirs (AB1, AB2 and AB3).

CWL = Carcass weight loss in individual cattle due to fasciolosis

CBL = Average price of 1kg beef at the abattoirs.

P = Prevalence of fasciola in cattle liver at the abattoirs

Total annual economic loss = a + b + c

4.1.7 Statistical analysis

The data was captured into Microsoft excel 2007 and was analyzed quantitatively and statistical inferences were drawn. It was later imported into the Statistical Package for Social Sciences (SPSS) version 22 for analysis. Descriptive statistics were used for analysis, while chi-square (X^2) measures were employed to assess the association between risk factors and occurrence of Fasciola parasite. The prevalence of fasciolosis was calculated as the number of Fasciola infected animal divided by the total number of slaughtered animals and was then multiplied by 100. A 5 % significant level was used to determine the differences in the prevalence of fasciolosis among different abattoirs, P-value was significance when less than 0.05.

4.2 Results

4.2.1 Monthly and yearly prevalence of fasciola infection in liver of cattle slaughtered from 2010 to 2011 in two high throughput and one low throughput abattoir

Information regarding slaughter condemnation of livers was extracted from abattoir slaughter records (schedule 8), and summarized into monthly and yearly prevalence as shown in Table 4.1 and 4.2. The highest monthly prevalence was seen between September and March (Table 4.1) and the lowest around May to August. The month with the lowest prevalence was June (1.2%). A total of 1,406 livers were condemned for Fasciola infection, which represent 2.3% prevalence for AB1 as against a total of 684 livers condemned at AB2 for same reason and represent 4.6% prevalence. While at the low throughput abattoir, a total of 159 livers were rejected by the meat inspector Fasciola representing 10% prevalence. Overall and across the three abattoirs, number/prevalence of Fasciola in slaughtered cattle stood at 78728 (2.9%). The annual prevalence of Fasciola for 2010, 2011 and 2012 for AB1 was calculated to be 3.2, 2.2, and 2.0 percent respectively. While the prevalence of Fasciola for AB2 and AB3 stood at 6.4, 4.6, 3.5 and 14.4, 6.9, and 9.5 percent for the same period respectively.

4.2.2 Association between body condition score (BCS) and seasonal prevalence of Fasciola in various abattoir studied from July 2013 to June 2014.

There was a strong association between BCS and the prevalence of Fasciola in the two through put abattoir; however the association was not strong for the low through put abattoir (Table 4.3). Out of 500 cattle examined at AB1, 32.2% of these were had poor BCS and recorded the highest prevalence (21.6%) of fasciolosis. Whereas, 41.8% and 26% had moderate and good BCS, and prevalence of 10.4 and 7.6 percent respectively (Table 4.3). However, the result for poor, moderate and good BCS of cattle at AB2 were 38.2%, 36.5%, 25.2% with Fasciola prevalence of 18.5, 13.0 and 6.2% respectively. While the number, percentage and prevalence of Fasciola in relation to BCS of cattle at AB3 was calculated for poor as (60, 27.3 and 7.3), moderate (97, 44.1 and 15.9) and good (63, 28.6 and 9.1).

Seasonal variation were noted in all abattoirs, but were not significant ($p<0.05$) in AB1 and AB3 as compared to AB2. Seasonal prevalence of Fasciola during the study at AB1 was recorded for winter as (9.8%), spring (8.2%), summer (10.4%) and autumn (11.2%). Result for AB2 showed the following prevalence for winter (6.5), spring (7.8), summer (12.8) and autumn (10.8). While at AB3 prevalence for various seasons was seen for winter as (5.9), spring (6.8), summer (10.9) and autumn (8.6) percent respectively (Table

4.4). There was a strong association between BCS and severity of Fasciola infection for AB1 ($P<0.05$) and result indicated the following for mild infection; poor 23 (11.6), moderate 67 (33.9) and good 15 (7.6). Animals with moderate infection had poor 39 (19.7), moderate 9 (4.5) and good 5 (2.5) BCS. Whereas, more animals with poor and moderate (10.1% each) BCS were severely affected, while no catte with good BCS was affected at AB1 (Table 4.5).

At AB2 more animals with poor BCS indicated mild, moderate and severe (16.6, 19.9 and 17.9 percent) infection as compared with animals with good body condition score (6.6, 6.6 and5.3 percent). The results showed a strong association ($p<0.05$) between BCS and severity of infection (Table 4.5). A stronger associated ($p<0.05$) was noted at AB3 between BCS and severity of infection as result indicates that for poor BCS, severity of infection was: mild (0%), moderate (36.6%) and severe (28.2%) whereas results obtained for good BCS, indicates that the severity of infection were mild (8.5%), moderate (0%) and good (0%).

4.2.3 Association between various risk factors and prevalence of bovine fasciolosis in study animals

Result from AB1 showed that out of 500 slaughtered animals, 355 were young and 145 were old. The prevalence of Fasciola in the two groups was 30.8 and 8.8 percent respectively. The odds of Fasciola infection occurring were higher in young animals than in older ones. But the association between age related risk factor was less as compared to sex. However, even though the association between the risk factors age and sex differ, the

Table 4.1 Summarized monthly number (prevalence) of Fasciola in liver of slaughtered cattle (n = 62, 420, n = 14, 719, n = 1, 589) during the year 2011-2013 in two high through put abattoirs (AB1 and AB2) and one low throughput abattoir (AB3)

Month	**AB1**	**AB2**	**AB3**
January	160(0.3)	86(0.6)	23(1.4)
February	152(0.2)	78(0.5)	17(1.1)
March	173(0.3)	64(0.4)	16(1)
April	115(0.2)	51(0.3)	6(0.4)
May	82(0.1)	32(0.2)	5(0.3)
June	104(0.2)	31(0.2)	5(0.3)
July	84(0.1)	42(0.3)	10(0.6)
August	64(0.1)	36(0.2)	7(0.4)
September	97(0.2)	44(0.3)	11(0.7)
October	99(0.2)	71(0.5)	20(1.3)
November	140(0.2)	64(0.4)	16(1)
December	136(0.2)	85(0.6)	23(1.4)
Total	1406(2.3)	684(4.6)	159(10)

AB1 and AB2 means high through put abattoirs, AB3 means low throughput abattoir

Table 4.2 Prevalence rate of liver condemnation due to fasciolosis in slaughtered cattle from 2010 to 2012 in the 3 abattoirs

Abattoir	Year	No slaughtered	No positive	Prevalence (%)
AB1	2011	9774	311	3.2
	2012	21803	484	2.2
	2013	30843	611	2.0
AB2	2011	4414	281	6.4
	2012	4078	187	4.6
	2013	6227	216	3.5
AB3	2011	437	63	14.4
	2012	520	36	6.9
	2013	632	60	9.5
Total		78728	2249	2.9

AB1 and AB2 means high through put abattoirs, AB3 means low throughput abattoir

Table 4.3 Prevalence of bovine fasciolosis based on body condition score (BCS) of study animals (n= 500, n=400, and n= 220) representing abattoirs (AB1, AB2 and AB3) from July 2013 to June 2014.

Abattoir	**BCS**	**No examined**	**%**	**Prevalence (%)**	**X^2**	**Sig**
AB1	Poor	161	32.2	21.6	75.6	***
	Moderate	209	41.8	10.4		
	Good	130	26	7.6		
AB2	Poor	153	38.2	18.5	14.9	***
	Moderate	146	36.5	13		
	Good	101	25.2	6.2		
AB3	Poor	60	27.3	7.3	1.5	NS
	Moderate	97	44.1	15.9		
	Good	63	28.6	9.1		

N/B: AB1 and AB2 means high through put abattoirs, AB3 means low throughput abattoir, BCS means body condition score, Prevalence of faciolosis, X^2: chi-square, Sig: significant level, ***: significant at $p<0.001$ for AB1 and $p<0.01$ for AB2. NS: not significant

Table 4.4 Seasonal prevalence of bovine fasciolosis based on study animals (n= 500, n= 400, and n= 220) representing abattoirs (AB1, AB2 and AB3) from July 2013 to June 2014.

Abattoir	Season	No examined	No positive	Prevalence (%)	X^2	Sig
AB1	Winter	125	49	9.8	0.9	NS
	Spring	113	41	8.2		
	Summer	129	52	10.4		
	Autumn	133	56	11.2		
AB2	Winter	100	26	6.5	19.5	***
	Spring	104	31	7.8		
	Summer	96	51	12.8		
	Autumn	100	43	10.8		
AB3	Winter	53	13	5.9	5.5	NS
	Spring	57	15	6.8		
	Summer	56	24	10.9		
	Autumn	54	19	8.6		

N/B: AB1 and AB2 means high through put abattoirs, AB3 means low throughput abattoir, X^2 means chi-square, Sig: significiance level, ***: significant at p<0.001, NS: not significant

Table 4.5 Association between body condition score and severity of Faciola in slaughtered (n= 198, n= 151, n= 71) cattle from July 2013 to June 2014 in the 3 abattoirs (AB1, AB2 and AB3)

		Classification by the level of severity					
Abattoir	BCS	Mild	Moderate	Severe	Total	X^2	Sig
AB1	Poor	23 (11.6)	39 (19.7)	20 (10.1)	82 (41.4)	45.4	***
	Moderate	67 (33.9)	9 (4.5)	20 (10.1)	96 (48.5)		
	Good	15 (7.6)	5 (2.5)	0 (0)	20 (10.1)		
	Total (%)	105 (53.0)	53 (26.8)	40 (20.2)	198 (100)		
AB2	Poor	25 (16.6)	30 (19.9)	27 (17.9)	82 (54.3)	17.6	***
	Moderate	21 (13.9)	20 (13.2)	0 (0)	41 (27.2)		
	Good	10 (6.6)	10 (6.6)	8 (5.3)	28 (18.5)		
	Total (%)	56 (37.1)	60 (39.7)	35 (23.2)	151 (100)		
AB3	Poor	0 (0)	26 (36.6)	20 (28.2)	46 (64.8)	51.5	***
	Moderate	5 (7)	14 (19.7)	0 (0)	19 (26.8)		
	Good	6 (8.5)	0 (0)	0 (0)	6 (8.5)		
	Total (%)	11 (15.5)	40 (56.3)	20 (28.2)	71 (100)		

N/B: AB1 and AB2 means high through put abattoirs, AB3 means low throughput abattoir, X^2: means chi-square, Sig: significant level, ***: significant at $p<0.001$

odds of Faciola occurring in male and females did not differ significantly. Less number of local breeds (185) was slaughtered at AB1 as compared to crosses (315). The prevalence of Fasciola was however higher (22.6%) in the local breed in contrast to the fewer number of slaughtered local breed and when compared to the prevalence of crosses (17%). The study noted a 14.8% prevalence of Fasciola on diarrheic cattle and 24.8% prevalence on non-diarrheic animal. The odds of fasciolosis were greater in diarrheic animals than non-diarrheic animals. 18.6% of 500 sampled animals were emaciated and were associated with a Fasciola prevalence of 10.4% as against 29.2% prevalence in non-emaciated animals. The odds were however still higher in emaciated animals than in non-emaciated animals (Table 4.6).

Fasciola infection was found to be higher in young animal at AB2 than in old animals with a prevalence rate of 23.2% and 14.5% respectively. The weak odd of the disease occurring in both young and old was established. There was association between age variable such as young and old and the prevalence of Fasciola although the association was not so strong when compared with that of sex. But the odd of disease occurring in both sexes did not differ significantly. A prevalence of 22.2% was recorded for local breed, while crosses had a prevalence rate of 15.5%. A strong association was noted for the breed and the odd of the disease happening was more for local breed. Diarrhea was present in 85 animals and absent in 315 animals and a corresponding prevalence of 11.0 and 26.8 percent was recorded. While 7.5% prevalence was seen in emaciated cattle and 30.2% was seen in non-emaciated cattle, the odds of having Fasciola is higher in non-emaciated than in emaciated animals (Table 4.7).

At the low through put abattoir (AB3) unlike in the high through put abattoirs (AB1 and AB2) older animals was slaughtered more than young animals (Table 4.8). Prevalence rate of Fasciola was calculated to be 18.2 and 14.1 percent for young and old respectively. A chi-square value of 13.9 was calculated and the odds of disease were estimated at 1.7 and 5.4. The prevalence rate of 29.1 and 3.2 percent was noted for male and female with an odd of disease higher in males than in female. Cattle with diarrhea with had 15.0% prevalence and non-diarrheic animals had a prevalence of 17.3, this was also what was obtained for emaciated and non-emaciated animals (Table 4.8) but the chi-square (15.0 and 33.7) differ significantly and the odds of Fasciola infection was seen to be more for emaciated animal than in non emaciated animals.

4.2.4 Financial losses associated with whole, partial liver condemnation and carcass weight loss due to Fasciola infection in two high through put abattoir and a low throughput abattoir

Summary of monetary losses associated with carcass weight loss, whole and partial liver condemnation was calculated as ZAR 917, 921.5 (83, 447 USD), ZAR 31, 661.5 (2, 878 USD) and ZAR 19, 112.3 (1, 737 USD). The breakdown shows that a total of ZAR 25, 160 was lost at AB1, 4, 082 at AB2 and 2, 419.5 at AB3 (Table 4.9). Higher losses were incurred for partial condemnation of liver at AB1 (ZAR 15, 407), AB2 (ZAR 3, 354) and (ZAR 351.3) (Table 10). An estimated monetary losses associated with carcass weight loss was put at ZAR 76, 0847.5 for AB1, ZAR 14, 4468, and ZAR 12, 606 for the low throughput abattoir AB3 (Table 4.11).

Table 4.6 Association between various risk factors and prevalence of bovine fasciolosis in study animals (n= 500) of abattoir AB1 from July 2013 to June 2014.

Risk factors		**No examined**	**%**	**Prevalence (%)**	X^2	**Sig**	**Odd ratio**	
							Lower limit	Upper limit
Age	Young	355	71	30.8	7.3	*	1.2	2.7
	Old	145	29	8.8				
Sex	Male	323	64.6	19.8	30.6	***	0.2	0.5
	Female	177	35.4	19.8				
Breed	Local	185	37	22.6	56.7	***	2.9	6.2
	Crosses	315	63	17				
Diarrhoea	Present	119	23.8	14.8	33.3	**	2.2	5.2
	Absent	381	76.2	24.8				
Emaciation	Yes	93	18.6	10.4	12.7	NS	1.4	3.6
	No	407	81.4	29.2				

N/B: AB1 means high through put abattoir, prevalence of fasciolosis, X^2: chi-square, Sig: significant level, *: significant at $p<0.05$, **: significant at $p<0.01$, ***: significant at $p<0.001$, NS: not significant

Table 4.7 Prevalence of bovine fasciolosis by sex, age, breeds, diarrhea and emaciation score of study animals (n= 400) in abattoir AB2 from July 2013 to June 2014.

Risk factors		**No examined**	**%**	**Prevalence (%)**	**X^2**	**Sig**	**Odd ratio**	
							Lower limit	Upper limit
Age	Young	274	68.5	23.2	5.4	*	0.4	0.9
	Old	126	31.5	14.5				
Sex	Male	219	54.8	11.2	60.9	***	0.1	0.3
	Female	181	45.2	26.5				
Breed	Local	134	33.5	22.2	70.5	***	4.1	10.3
	Crosses	266	66.5	15.5				
Diarrhoea	Present	85	21.2	11	9	**	1.3	3.4
	Absent	315	78.8	26.8				
Emaciation	Yes	66	16.5	7.5	2	*	0.9	2.5
	No	334	83.5	30.2				

N/B: AB2 means high through put abattoir, prevalence of fasciolosis, X^2: chi-square, *: significant at p<0.05, **: significant at p<0.01, ***: significant at p<0.001

Table 4.8 Prevalence of bovine fasciolosis by sex, age, breeds, diarrhea and emaciation score of study animals (n= 220) in abattoir AB3 from July 2013 to June 2014.

Risk factors		**No examined**	**%**	**Prevalence (%)**	X^2	**Sig**	**Odd ratio**	
							Lower limit	Upper limit
Age	Young	85	38.6	18.2	13.9	***	1.7	5.4
	Old	135	61.4	14.1				
Sex	Male	145	65.9	29.1	27.4	***	3.3	17.9
	Female	75	34.1	3.2				
Breed	Local	69	31	14.5	9.1	**	1.4	4.5
	Crosses	151	68.6	17.7				
Diarrhoea	Present	64	29.1	15	15.4	***	1.8	6.1
	Absent	156	70.9	17.3				
Emaciation	Yes	50	22.7	15	33.7	***	3.4	13.4
	No	170	77.3	17.3				

N/B: AB3 means low through put abattoir, prevalence of fasciolosis, X^2: chi-square, Sig: significant level, **: significant at p<0.01, ***: significant at p<0.001

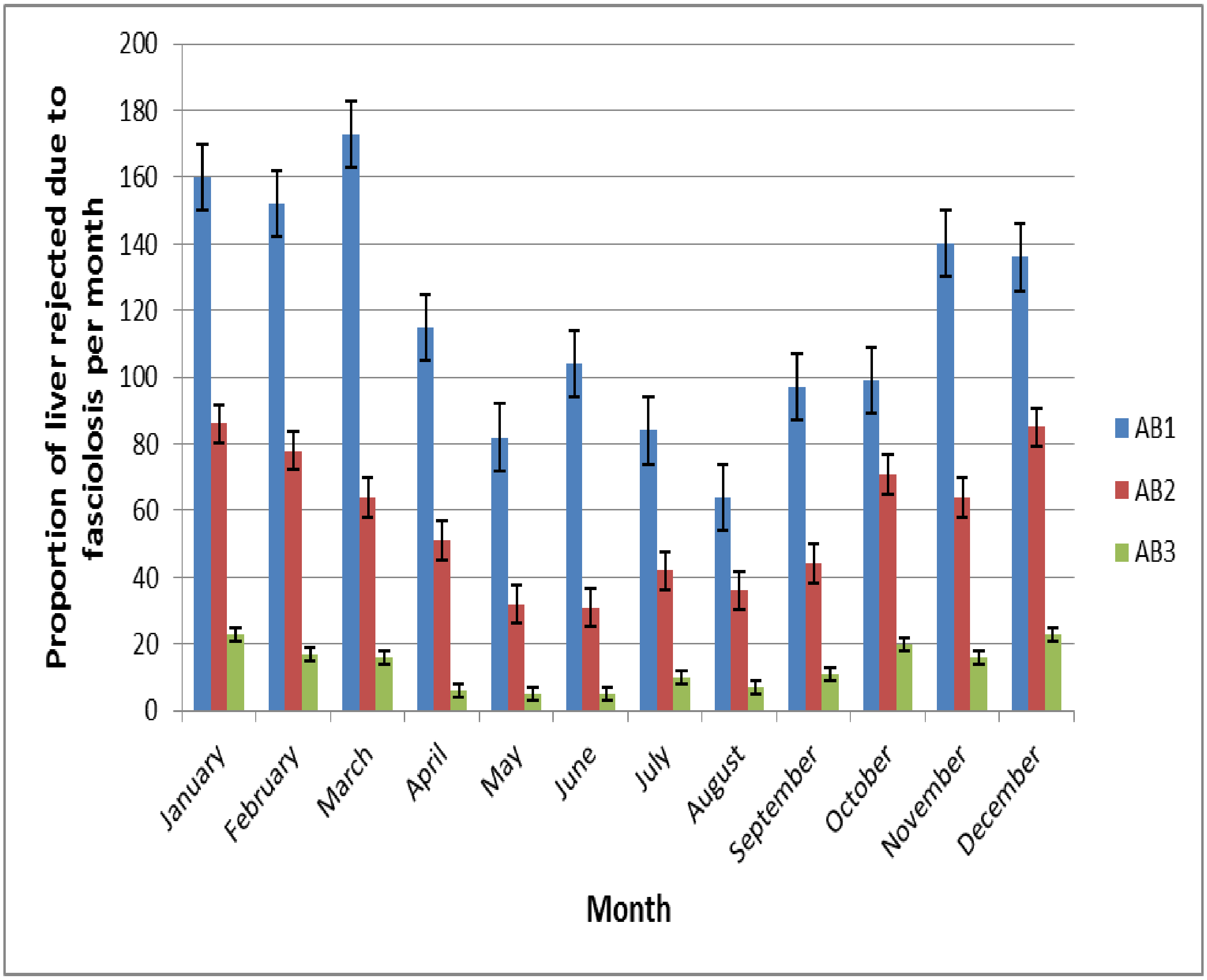

Figure 4.1 Summarized monthly proportion of Fasciola in liver of slaughtered cattle during the year 2011-2013 in two high through put abattoirs (AB1 and AB2) and a low throughput abattoir (AB3).

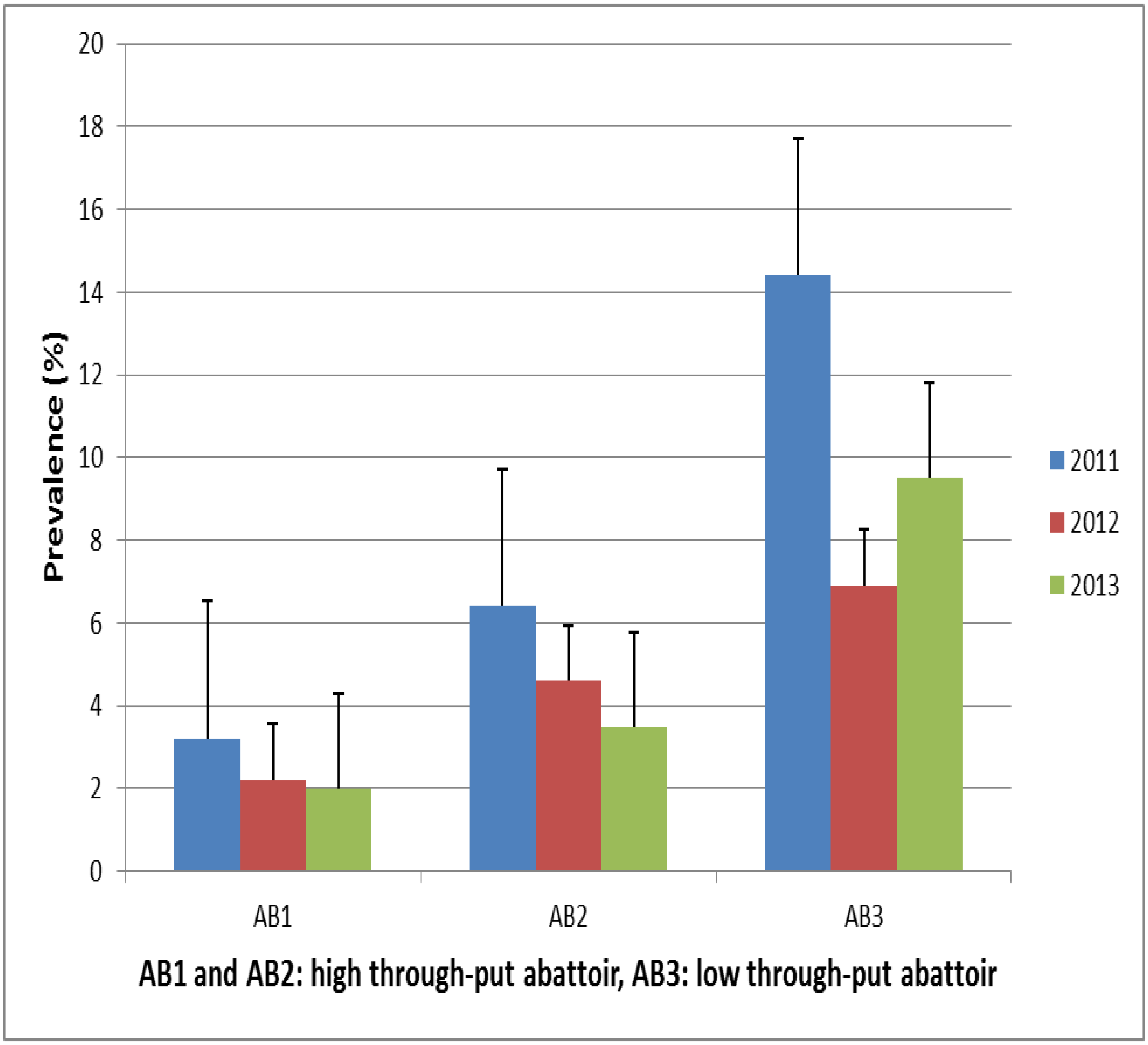

Figure 4.2 Percentage prevalence of liver condemned due to fasciolosis in slaughtered cattle from 2010 to 2012 in the three abattoirs

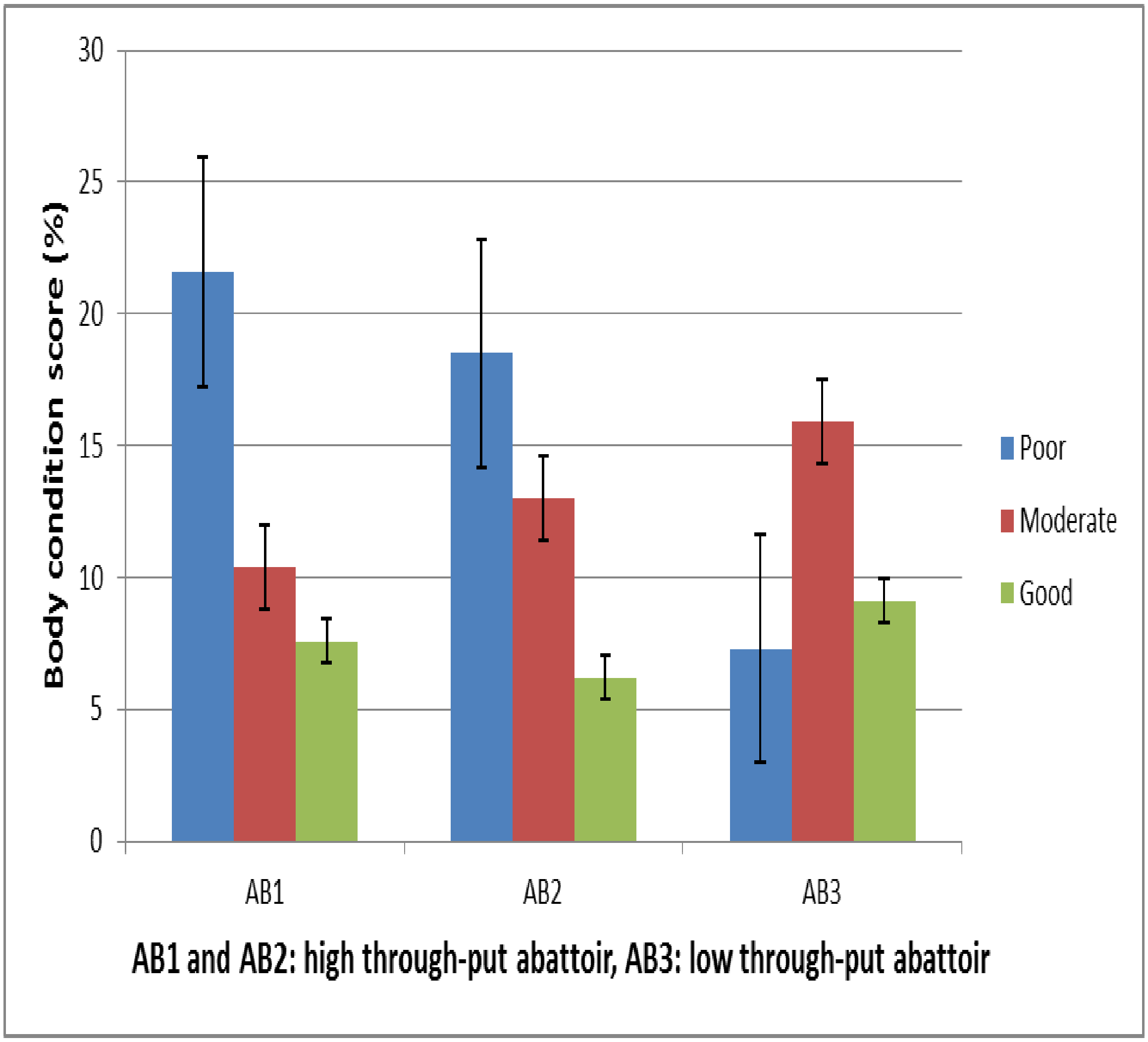

Figure 4.3 Percentage prevalence of bovine fasciolosis based on body condition score (BCS) of study animals in abattoirs (AB1, AB2 and AB3) from July 2013 to June 2014.

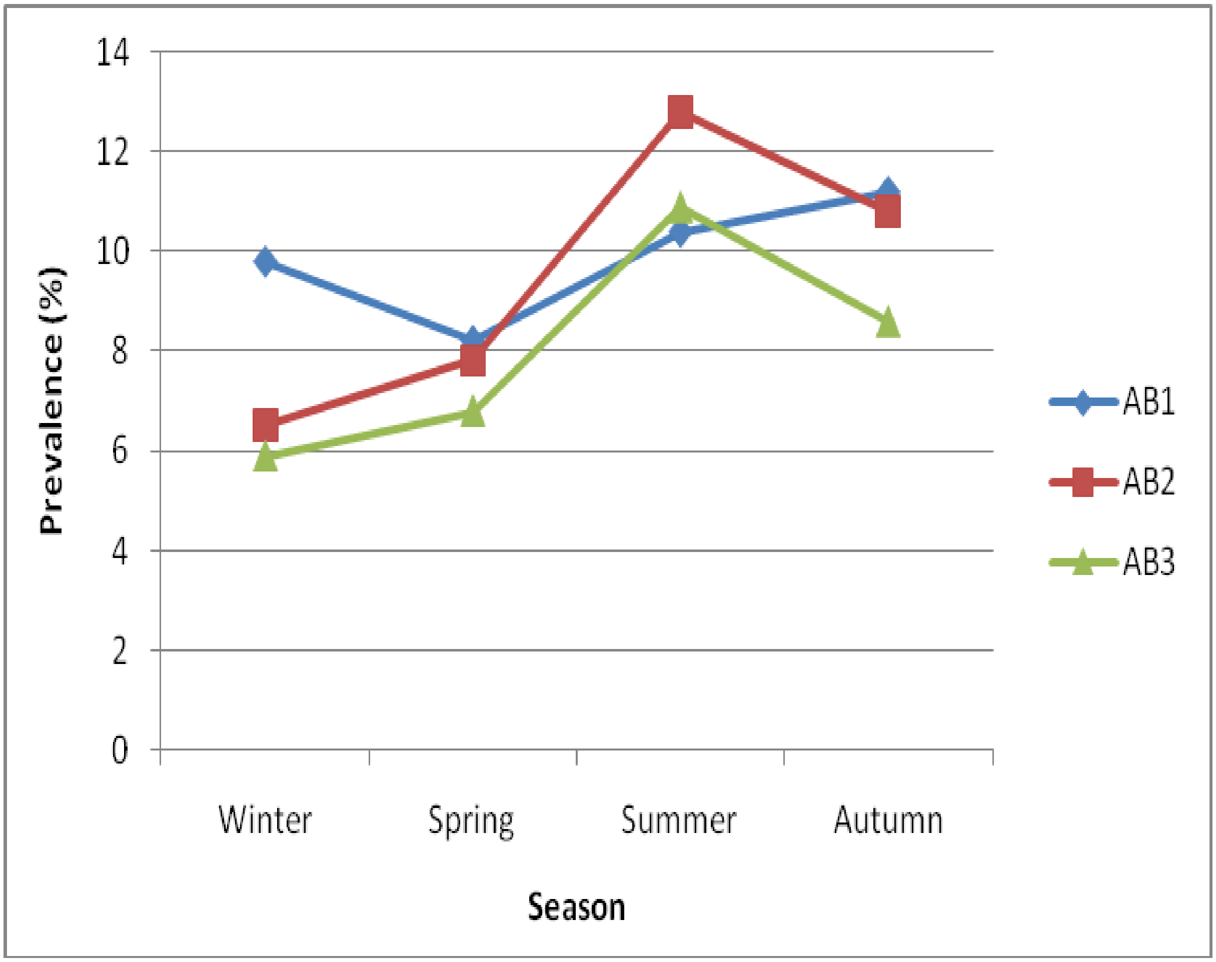

Figure 4.4 Seasonal prevalence of bovine fasciolosis at AB1, AB2 and AB3. N/B: AB1 and AB2 means high through put abattoirs, AB3means low throughput abattoir

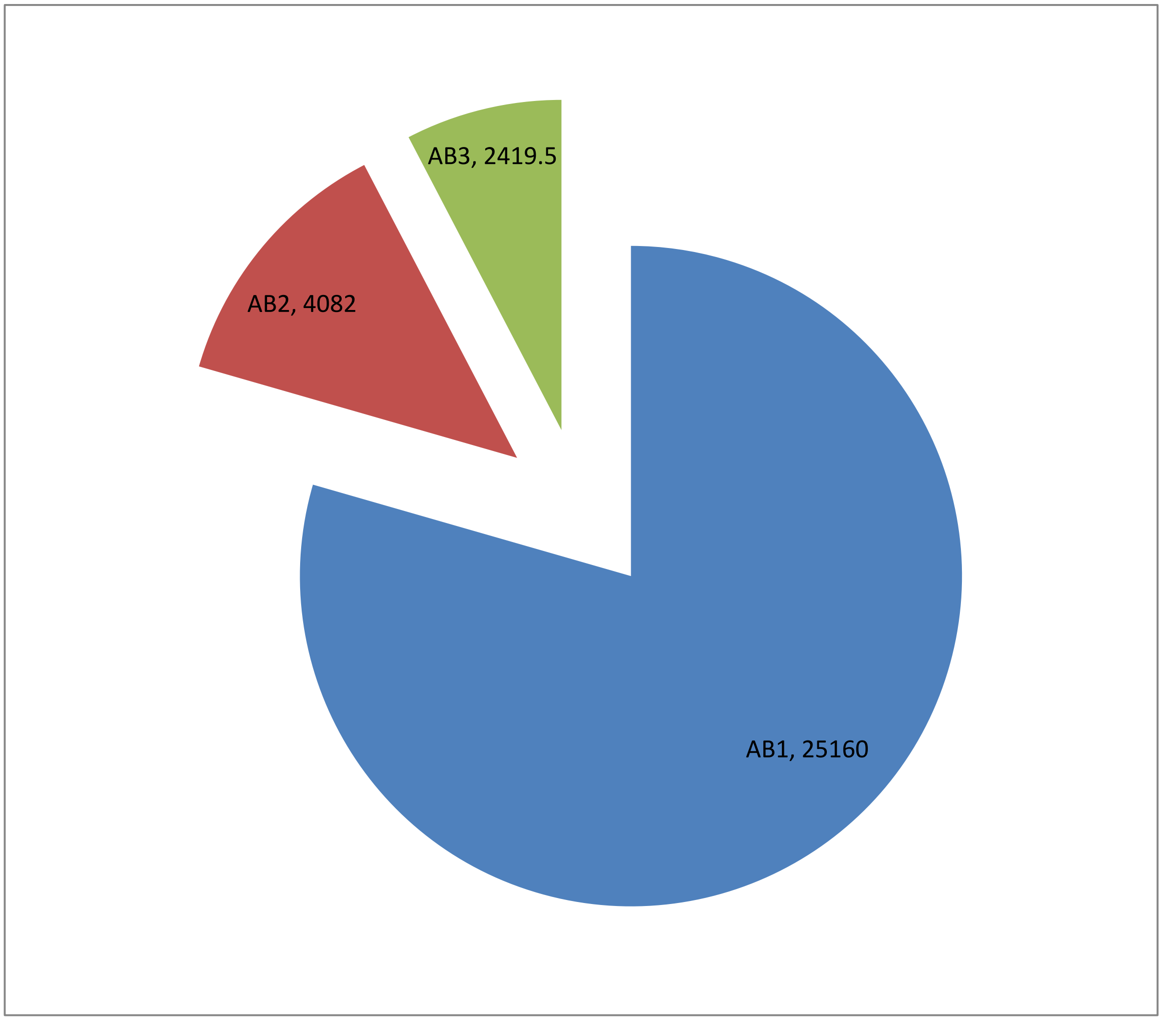

Figure 4.5 Annual financial losses (ZAR) associated with complete liver condemnation due to fasciolosis in various abattoirs (AB1, AB2 and AB3) during the study from July 2013 to June 2014. N/B: AB1 and AB2 means high through put abattoirs, AB3means low throughput abattoir

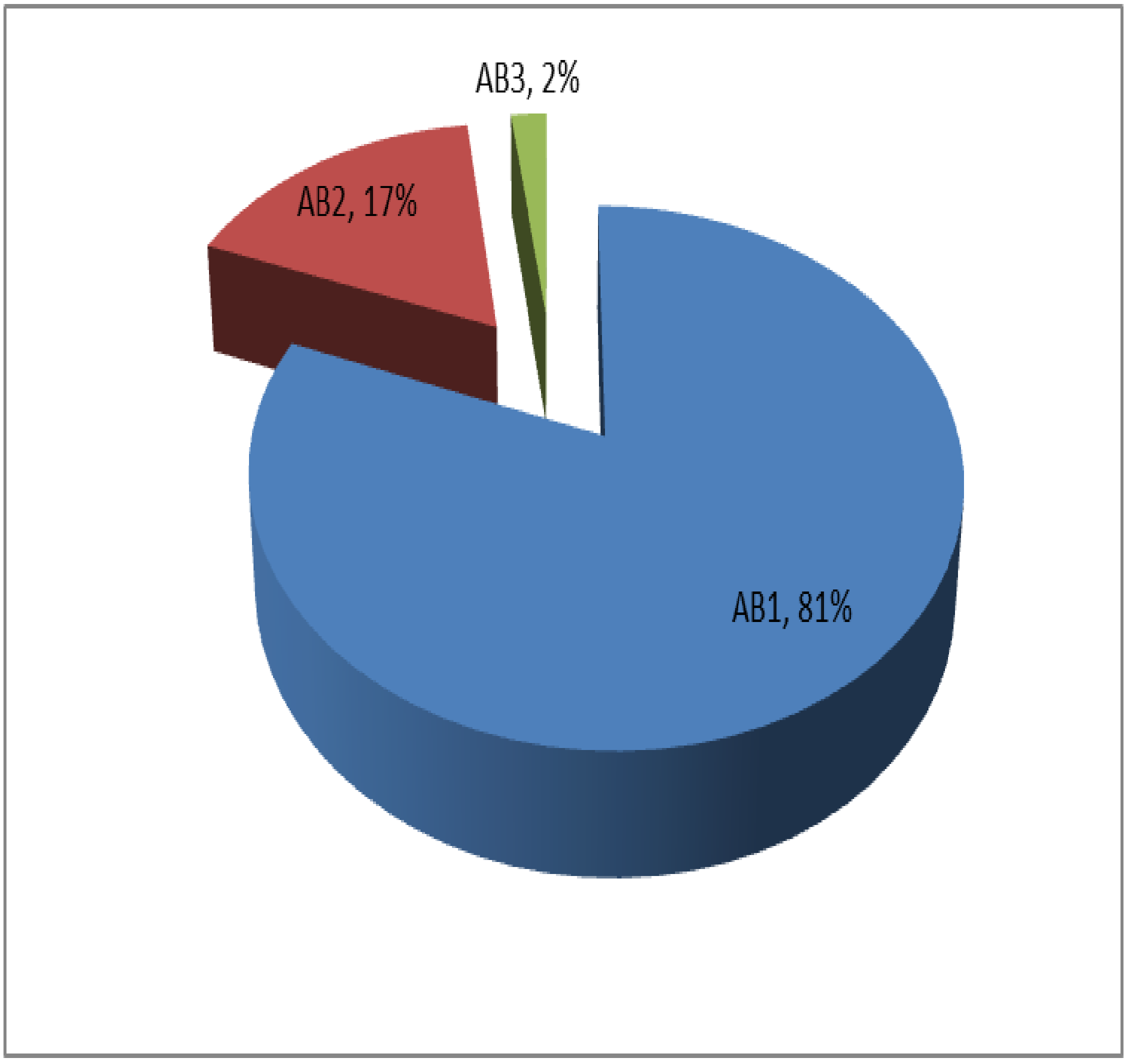

Figure 4.6 Annual financial losses (ZAR) associated with partial liver condemnation due to fasciolosis in various abattoirs (AB1, AB2 and AB3) during the study from July 2013 to June 2014. N/B: AB1 and AB2 means high through put abattoirs, AB3means low throughput abattoir

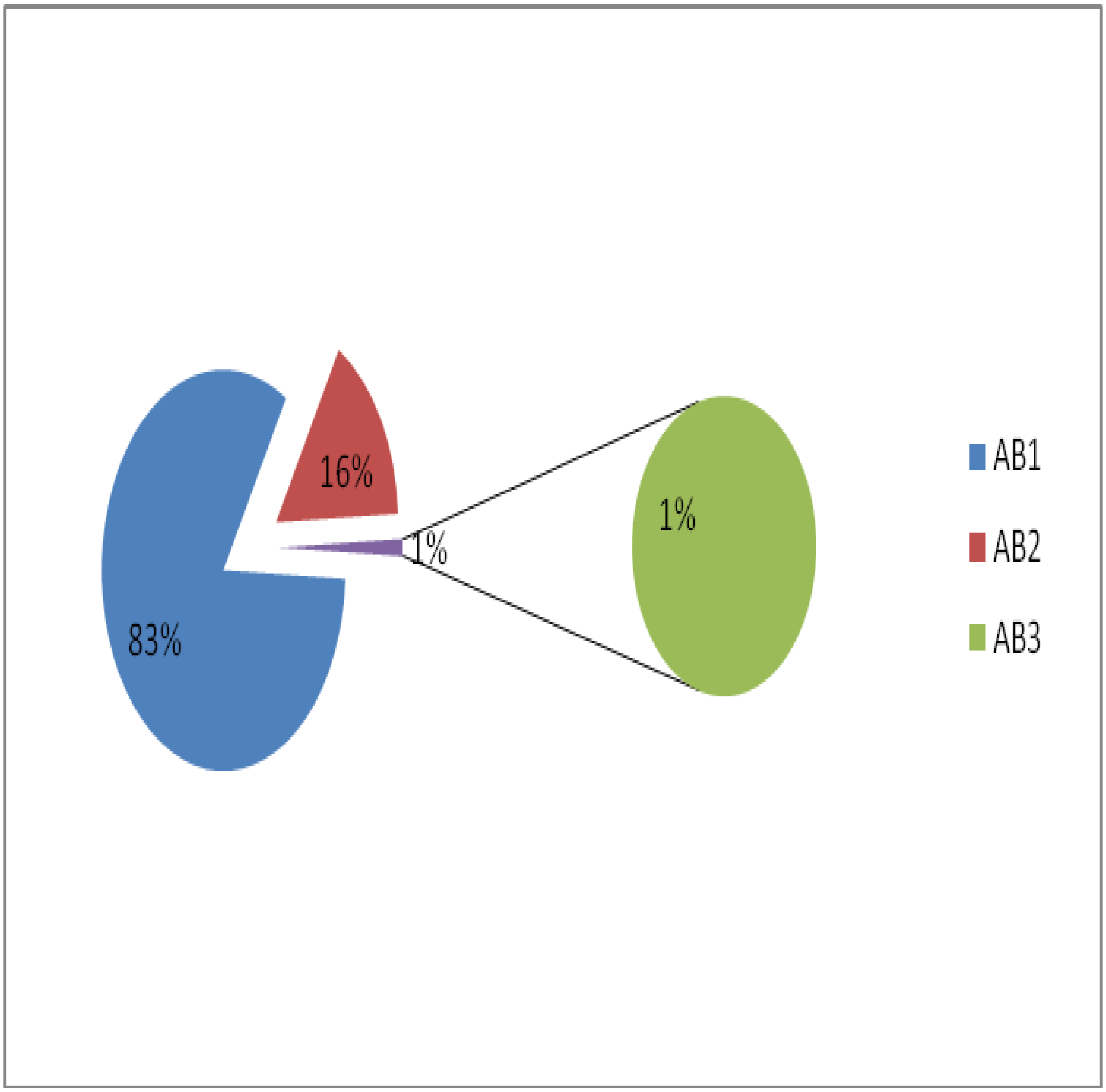

Figure 4.7 Annual financial losses (ZAR) associated with carcass weight loss due to fasciolosis in various abattoirs (AB1, AB2 and AB3) during the study. N/B: AB1 and AB2 means high through put abattoirs, AB3means low throughput abattoir

Table 4.9 Annual financial losses associated with complete liver condemnation due to fasciolosis in various abattoirs during the study from July 2013 to June 2014.

	Abattoirs		
	AB1	**AB2**	**AB3**
No of sample	500	400	220
No condemned	89	57	18
MCS	2570	519	53
MLC (ZAR)	55	55	55
P (%)	17.8	14.3	8.2
ALC (ZAR)	25, 160	4, 082	2, 419.5
USD	2, 287	368	220

N/B: AB1 and AB2 means high through put abattoirs, AB3means low throughput abattoir, MCS means annual loss from liver condemnation, MLC: mean cost of one liver at the abattoirs (AB1, AB2 and AB3), P: prevalence, ALC: annual loss from liver condemnation, ZAR: South African rand, USD: United States Dollar

Table 4.10 Annual financial losses associated with partial liver condemnation due to fasciolosis in various abattoirs during the study from July 2013 to June 2014.

	Abattoirs		
	AB1	**AB2**	**AB3**
No of sample	500	400	220
No trimmed	109	94	53
MCS	2570	519	53
½ MLC (ZAR)	27.5	27.5	27.5
P (%)	21.8	23.5	24.1
ALC (ZAR)	15, 407	3, 354	351.3
USD	1, 401	305	32

N/B: AB1 and AB2 means high through put abattoirs, AB3means low throughput abattoir, MCS means annual loss from liver condemnation, ½ MLC = Mean cost of half liver at the abattoirs (AB1, AB2 and AB3), P: prevalence, ALC: annual loss from liver condemnation, ZAR: South African rand, USD: United States Dollar

Table 4.11 Annual financial losses associated with carcass weight loss due to fasciolosis in various abattoirs during the study from July 2013 to June 2014.

	Abattoirs		
	AB1	**AB2**	**AB3**
No of sample	500	400	220
No condemned	198	151	71
ACS	2570	519	53
CWL (%)	10	10	10
CBL (ZAR)	28	28	28
P (%)	39.6	37.8	32.3
ACW (ZAR)	76, 0847.5	14, 4468	12, 606
USD	69, 168	13, 135	1, 146

N/B: AB1 and AB2 means high through put abattoirs, AB3means low throughput abattoir, ACS: Average number of cattle slaughtered per Annum at the Abattoirs (AB1, AB2 and AB3), CWL: Carcass weight loss in individual cattle due to fasciolosis, CBL: Average price of 1kg beef at the abattoirs, P: Prevalence of Fasciola in cattle liver at the abattoirs ACW: annual loss from carcass weight loss, USD: United States Dollar

4.3 Discussion

Fasciola infection in cattle has been noted to be a major cause of economic loss for the livestock venture (Ansari-Lari and Moazzeni, 2006). Flukes invade the liver and in-turn causes reduce meat and milk yield, reduced reproductive performance and also may lead whole or partial liver condemnation at slaughter point. Although abattoir survey data has its own limitations, it is however a cheaper means of identifying disease prevalence, monitoring and evaluation in disease epidemiology. Thus considering that flukes are endemic in most tropical and sub-tropical climate and contributes negatively to animal production, its overall use is beneficial. According to Ahmadi and Meshkehkar, (2010) an efficient meat inspection service should function as an important tool in the monitoring of animal disease, this is very valuable in the field of chronic and ill-defined conditions which may not be apparent to either the stockowner or his veterinary doctor, but must be of considerable financial and animal health importance. Feedback from the abattoir to the individual farm is of great value in the field of preventive medicine, as it allows a trackback and circulation of information to curtail emerging animal and human health threats.

The current study revealed a 2.9% prevalence of fasciolosis over a three year period (2011 to 2013). Prevalence of Fasciola at AB1 AB2 and AB3 during the same period was 2.3, 4.6 and 10 percent respectively. Currently there is no national established prevalence of Fasciola in South Africa and this may be due to differences in provincial climatic conditions. However, similar studies have been conducted in some southern African countries and elsewhere. In a similar studies conducted by Aragaw *et al*., (2012) and

Phiri, (2006) in Addis Ababa Ethiopia and Zambia, 20% prevalence of fasciolosis was gotten and this was also similar to what was obtained by Alawa *et al*. (2011) and Megersa *et al*. (2010) and Phiri, (2006). During a survey of slaughtered cattle in Saudi Arabia and Kenya, Degheidy and Al-malki, (2012) and Kithuka *et al*. (2002) observed 8.6 and 9.3 percent prevalence of Fasciola infection. Moreover, higher prevalence (49.6-65.9%) has been obtained in other studies in Khuzestan Iran and Ethiopia (Ahmadi and Meshkehkar, 2010; Demssie et al., 2012).

During the active abattoir survey from July 2013 to June 2014, the current study noted that the prevalence of Fasciola was higher across the 3 abattoir during summer and autumn seasons than during the winter and spring. The figure was less in winter and spring. During the retrospective year (2010 to 2012) observed monthly prevalence was higher in November, December and January which are months found within the summer season (Table 4.1). The hatching of fluke eggs and the multiplication of the snail intermediate host require high rainfall, moisture and temperatures and these conditions generally are common features in the spring and autumn, when many fluke eggs hatch, snails multiply and then cercariae develop and are released on wet pastures before encysting onto herbage (Borji *et al*., 2012; Khanjari *et al*., 2014).

During spring, summer and up the autumn there is increase in the amount rainfall in the Eastern Cape Province of South African and this also encourages the number Lymnaea species which are intermediate host responsible of the Fasciola parasite and this consequently lead to the increase in prevalence of Fasciola infection around this period

(Aragaw *et al*., 2012). Infestation with fasciolosis is usually associated with grazing wet land and drinking from the snail infested wet or watery places (Terefe *et al*., 2012). Other possible reason for this level of prevalence is the population of livestock and management practice used in raising livestock in the Eastern Cape. Many of these animals are raised extensively and allowed to walk long distances of grazing farm land drinking from free flowing rivers and dams. According to Phiri *et al*. (2005a) such practice exposes the animal to fasciola eggs and lymnaea intermediate host. Therefore a good environment has been established for the hatching of the eggs and transmission of the metacercariae to cattle as they drink water and feed on the grasses on the watercress. On the other hand, the low prevalence in winter is apparently due to low temperature and insufficient moisture which is necessary for the propagation and maintenance of the life cycle of snail (Phiri *et al*., 2005a). At this point the breeding of snail and the multiplication of Fasciola parasite slows down, the intermediate snail undergo a state of aestivation (Tsegaye *et al*., 2011).

In the two high throughput abattoir (AB1 and AB2), animals with poor body condition recorded the highest prevalence (Table 4.3), while at the low through put abattoir animals with moderate BCS had the highest prevalence rate. Similar findings which have been reported by Dawa *et al*. (2013) and Megersa *et al*. (2010) in Adwa Municipal Abattoir and Dire Dawa Municipal Abattoir, Ethiopia are in agreement with the result seen at AB1 and AB2. However, our report is in contrast with several other studies who found higher prevalence and these were in decreasing order from poor, average to good BCS (Demssie *et al*., 2012; Terefe *et al*., 2012; Wondwosen *et al*., 2012; Zeleke *et al*., 2013). The high prevalence rate as seen with animals with poor body condition may be due to the parasitic activity of flukes, as it may lead to progressive weight loss, lack of appetite and the cattle becoming weak. As the animal continues to lose weight it becomes unable to fight infection as it loses it immunity and homeostasis (Terefe *et al*., 2012; Tsegaye *et al*., 2011b; Wondwosen *et al*., 2012). Since most of the animals with thin or poor BCS had Fasciola, it is possible that they were poorly fed; as animals with nutritional inadequacies are unable to fight infection, as the body is starved of vital nutrient that could nourish and maintain regular functions of the body (Equar and Gashaw, 2012).

At the three abattoirs, there was a higher prevalence of moderate infection with Fasciola in animals with poor BCS (Table 4.4). This was followed by severe infection and then mild infection. This result agrees with the findings of Bekele *et al*. (2010). The moderate to severe infection noted in this study may be due to poor BCS and nutritional status of these animals (Wondwosen *et al*., 2012; Zeleke *et al*., 2013). The prevalence may also be due to the proximity of livestock to streams, rivers and dams which propagates the growth of water snails and enhances the growth fasciola spp (Phiri *et al*., 2005a).

In both AB1 and AB2, young animals had higher prevalence than older ones (Table 4.6 and 4.7) but in AB3 older animals had higher prevalence than young animals. Result from AB3 is in agreement with the findings of Dawa *et al*. (2013), Keyyu *et al*. (2006) and Khan *et al*. (2010) who reported a 19.6 and 25.95 percent prevalence in young and old animals respectively. There is no cogent explanation on the variations in age of prevalence between the abattoirs except with the animal's immunity. As elucidated by

Khan *et al*., (2010), lower prevalence in adults may be due to higher immunogenicity of Gastrointestinal helminths helpful in the stimulation of acquired immunity in older animals. The hypothesis that older animals can acquire immunity against GI parasites has been supported experimentally by different scientists (Khan *et al*., 2010); otherwise there is no other concrete fact in the literatures. It is also essential to state that in the current study, the number of young animals slaughtered was higher than old animals. This is because consumers preferences and the fact these abattoirs are export abattoir and quality check entails soft, tender and meat of high quality. Thus the percentage prevalence of fasciola may have been affected during sampling for the study.

There were no differences in the prevalence of Fasciola for both sexes at AB1, whereas at AB2 a greater prevalence of Fasciola was recorded for female than in males. At AB3, a prevalence of 29.1% for male as against 3.2% for female animals was recorded. A study conducted by Dawa *et al*. (2013) on prevalence and economic significance of fasciolosis in cattle slaughtered at Dire Dawa Municipal Abattoir, Ethiopia revealed higher prevalence of fasciola in female animals and this agrees with the finding at AB2 but is in contrast with the result obtained at AB3. However, in another study by Khan *et al*. (2010) on gastrointestinal helminthiasis, prevalence of Fasciola was generally low but infection with *F. hepatica* was more for males than in female animals. Generally, it is assumed that sex is a determinant that can influence the prevalence of parasitism (Khan *et al*., 2010) and females are more prone to parasitism during pregnancy and peri-parturient period due to increased stress and suppressed immune system (Raza *et al*., 2007).

However, some scientists recorded higher prevalence in male animals than females as most of the males were kept under grazing practice while the females were not grazed during pregnancy (Khan *et al*., 2010). Furthermore, the likelihood that female animals stay alive longer due to reproductive purposes may contribute to the prevalence shown for AB2, while the number of males brought for slaughter which was larger than female may also play a role in the outcome of the prevalence at AB3.

In both AB1 and AB2 the prevalence of Fasciola was more for the South African local breeds than the crosses; but in AB3 the reverse was seen. The predominant local breed in the Eastern Cape Province is the Nguni and is widely adapted to the harsh climate and topography of the area. But in terms of production, the Nguni has been said to be poor due to challenges with poor management and disease control strategy (Musemwa *et al*., 2008; Scholtz *et al*., 2008; Seimenis, 2012). Livestock are central in supporting the livelihoods of deprived farmers, consumers and traders throughout the developing world; and the animals of poor populace are particularly susceptible to disease because of costs, absence or inappropriateness of the animal health sector (Seimenis, 2012). This perhaps can be a contributing factor to the high prevalence of Fasciola infection among local breeds as compared to the crosses. Poorly fed and managed animals stand little chance of fighting of infection and are easily susceptible to illness.

In all three abattoirs the diarrhea was inversely related to the prevalence of fasciolosis and may be due to other causes. Similarly, the prevalence of Fasciola was seen more among animals that we not emaciated. This therefore supports the general knowledge that

Fasciola infection can only lead to cachexia in late and chronic stages of infection (Tsegaye *et al*., 2011).

Disease burden is the impact of a disease on society measured by financial cost, mortality, morbidity, or other indicators (Torgerson and Macpherson, 2011b). Fasciola infection is associated with economic losses as the cattle experiences weight loss, reduction in milk production and reproductive performance, the farmer also incurs additional cost in veterinary care (Aragaw et al., 2012; Equar and Gashaw, 2012; Khoramian et al., 2014; Radfar et al., 2013).

The present study revealed a total 31, 661 ZAR, (2, 875 USD) was lost due to whole liver condemnation for the 3 abattoir (Table 4.9), while 19, 112.3 ZAR (1, 735 USD) was lost due to partial liver condemnation (Table 4.10). Associated monetary loss due cattle weight loss is put at 917, 921.3 ZAR (83, 449 USD) (Table 4.11). Financial loss associated with liver condemnation in this is lower than what was obtain in similar study by (Tsegaye *et al*., 2011b) but was higher than the result obtained by Cadmus and Adesokan, (2009), Equar and Gashaw, (2012), Khoramian *et al*. (2014) and Mohammed *et al*. (2012). However as indicated by Khoramian *et al*. (2014) to be able to properly evaluate economic loss due to fasciolosis, very important parameters such as mortality rates due to disease, chronic ill effects (weight gain, feed conversion efficiency, inter-current disease, poor carcass conformation, malnutrition, decreased fertility and milk yield), anthelmintic treatment costs should be available and consulted. Indeed if all these were taken into account, a higher financial loss would have been documented.

4.4 Conclusions

The cooler season had less Fasciola infection than the warmer seasons. There was a strong association between body condition scores and the prevalence of fasciolosis in abattoir AB1 and AB2. On classification of Fasciola based on the severity of infection, there was more moderate infection of Fasciola than severe and mild infection. Animals with poor body condition were highly affected by all class of Fasciola than animals with moderate and good body condition. Young and local breeds of cattle had higher prevalence than old and animals of different crosses. Annual financial impact of fasciolosis and seasonal prevalence in this study is high and if allowed to remain cannot make a sustainable livestock venture.

4.5 References

Abunna, F., Asfaw, L., Megersa, B. and Regassa, A. 2010. Bovine fasciolosis: coprological, abattoir survey and its economic impact due to liver condemnation at Soddo municipal abattoir, Southern Ethiopia, Tropical animal health and production, 42 **2:** 289–92.

Ahmadi, N.A. and Meshkehkar, M. 2010. Prevalence and Long Term Trend of Liver Fluke Infections in Sheep, Goats and Cattle Slaughtered in Khuzestan , Southwestern Iran, Journal of Paramedical Sciences (JPS), 1 **2:** 26–31.

Alawa, C.B.I., Etukudo-Joseph, I. and Alawa, J.N. 2011. A 6-year survey of pathological conditions of slaughtered animals at Zango abattoir in Zaria, Kaduna State, Nigeria. Tropical animal health and production, 43 **1:** 127–31.

Alembrhan, A. and Haylegebriel, T. 2013. Major causes of organ condemnation and economic loss in cattle slaughtered at Adigrat municipal abattoir, northern Ethiopia, Veterinary World, 6 **10:** 734–738.

Alton, G.D., Pearl, D.L., Bateman, K.G., McNab, W.B. and Berke, O. 2010. Factors associated with whole carcass condemnation rates in provincially-inspected abattoirs in Ontario 2001-2007: implications for food animal syndromic surveillance, BMC veterinary research, **6:** 42.

Ansari-Lari, M. and Moazzeni, M. 2006. A retrospective survey of liver fluke disease in livestock based on abattoir data in Shiraz, south of Iran, Preventive veterinary medicine, 73. **1:** 93–6.

Aragaw, K., Negus, Y., Denbarga, Y. and Sheferaw, D. 2012. Fasciolosis in slaughtered cattle in Addis Ababa abattoir, Ethiopia, Global Veterinaria, 8 **2:** 115–118.

Bekele, M., Tesfay, H. and Getachew, Y. 2010. Bovine Fasciolosis : Prevalence and its economic loss due to liver condemnation at Adwa Municipal Abattoir , North Ethiopia, EJAST, 1 No. **1:** 39–47.

Boray, J.C. 1985. Flukes of Domestic Animals. In: **Gaafar, S.M., Howard, W. S., Marsh, R. E.,** (Eds.), Parasites, Pests and Predators., Elsevier,, New York, pp 178–218.

Borji, H., Azizzadeh, M. and Kamelli, M. 2012. A retrospective study of abattoir condemnation due to parasitic infections: economic importance in Ahwaz, southwestern Iran, The Journal of parasitology, 98 **5:** 954–7.

Cadmus, S.I.B. and Adesokan, H.K. 2009. Causes and implications of bovine organs/offal condemnations in some abattoirs in Western Nigeria, Tropical Animal Health and Production, 41. **7:** 1455–1463.

Dawa, D., Abattoir, M., Mebrahtu, G. and Beka, K. 2013. Prevalence and Economic Significance of Fasciolosis in Cattle Slaughtered at Dire Dawa Municipal Abattoir, Ethiopia, Journal of veterinary Advancement, 3 **12:** 319–324.

Degheidy, N.S. and Al-malki, J.S. 2012. Epidemiological Studies of Fasciolosis in Human and Animals at Taif, Saudi Arabia, World Applied Sciences Journal, 19 **8:** 1099–1104.

Demssie, A., Birku, F. and Biadglign, A. 2012. An Abattoir Survey on the Prevalence and Monetary Loss of Fasciolosis in Cattle in Jimma Town, Ethiopia, Global Veterinaria 8, **4:** 381–385.

Dorny, P., Praet, N., Deckers, N. and Gabriel, S. 2009. Emerging food-borne parasites." Veterinary parasitology, 163 **3:** 196–206.

Equar, Y. and Gashaw, A. 2012. Prevalence of Bovine Fasciolosis, Amplitude of Liver Condemnation and its Economic Impact in Slaughtered Cattle at Municipal Abattoir of Mekelle, North Ethiopia, International Journal of Current Agricultural Research, 1 **1:** 10–14.

Esteban, J.G. and Bargues, M.D. 1999. The traditional epidemiological picture of human fascioliasis has changed markedly in recent years, as outlined below, 77 **4:** 340–346.

Fitzpatrick, J.L. 2013. Global food security: the impact of veterinary parasites and parasitologists. Veterinary parasitology. 195 **3-4:** pp. 233–48.

Gebrekidan, B., Yilma, T. and Solmon. 2009. Major causes of slaughtering of female cattle in Addis Ababa Abattoir Enterprise, Ethiopia. Indian Journal of Animal Research, Agricultural Research Communication Centre LA - English, 43 **4:** 271–274.

Keiser, J. and Utzinger, J. 2009. Food-borne trematodiases. Clinical microbiology reviews, 22. **3:** 466–83.

Keyyu, J.D., Kassuku, a a, Msalilwa, L.P., Monrad, J. and Kyvsgaard, N.C. 2006. Cross-sectional prevalence of helminth infections in cattle on traditional, small-scale and large-scale dairy farms in Iringa district, Tanzania, Veterinary research communications, 30 **1:** 45–55.

Khan, M.N., Sajid, M.S., Khan, M.K., Iqbal, Z. and Hussain, A. (2010. Gastrointestinal helminthiasis: prevalence and associated determinants in domestic ruminants of district Toba Tek Singh, Punjab, Pakistan.", Parasitology research, 107 No. **4:** 787–94.

Khanjari, A., Bahonar, A., Fallah, S., Bagheri, M., Alizadeh, A., Fallah, M. and Khanjari, Z. 2014. Prevalence of fasciolosis and dicrocoeliosis in slaughtered sheep and goats in Amol Abattoir, Mazandaran, northern Iran, Asian Pacific Journal of Tropical Disease, 4 **2:** 120–124.

Khoramian, H., Mohsen A., Mahmood M O., Mahdi D., Hossein H and Asgari M. 2014 Prevalence of ruminants' fascioliasis and their economic effects in Kashan, center of Iran, Asian Pacific Journal of Tropical Biomedicine, 4. **2:** S585–S589.

Kithuka, J.M., Maingi, N., Njeruh, F.M. and Ombui, J.N. 2002. The prevalence and economic importance of bovine fasciolosis in Kenya--an analysis of abattoir data. The Onderstepoort journal of veterinary research, 69 **4:** 255–262.

Mas-Coma, S., Bargues, M.D. and Valero, M.A. 2005. Fascioliasis and other plant-borne trematode zoonoses, International Journal for Parasitology, 35 **11-12:** 1255–1278.

McLeod, A. 2011. World Livestock 2011 Livestock in food security World, World, United, Nations Food and Agriculture Organization. Rome, 130.

Megersa, B., Tesfaye, E., Regassa, A., Abebe, R. and Abunna, F. 2010. Bovine cysticercosis in Cattle Slaughtered at Jimma Municipal Abattoir, South western Ethiopia: Prevalence, Cyst viability and Its Socio-economic importance, Veterinary World, 2 **2:** 257.

Mellau, B.L., Nonga, H.E. and Karimuribo, E.D. 2011. Slaughter stock abattoir survey of carcasses and organ/offal condemnations in Arusha region, northern Tanzania, Tropical Animal Health and Production.

Mohammed, N., Hailemariam, Z., Mindaye, S. and Dewa, D. 2012. Major Cause of Liver Condemnation and Associated Financial Loss at Kombolcha Elfora Abattoir , South Wollo , Ethiopia, **4:** , 140–145.

Musemwa, L., Mushunje, A., Chimonyo, M., Fraser, G., Mapiye, C. and Muchenje, V. 2008. Nguni cattle marketing constraints and opportunities in the communal areas of South Africa : Review, African Journal of Agricultural Research. 3 **4:** 239–245.

Mwabonimana, M.F., Kassuku, A.A., Ngowi, H.A., Mellau, L.S.B., Nonga, H.E. and Karimuribo, E.D. 2010. Prevalence and economic significance of bovine fasciolosis in slaughtered cattle at Arusha abattoir, Tanzania, Tanzania Veterinary Journal, 22**, 2:** 2009.

Nithiuthai, S., Anantaphruti, M.T., Waikagul, J. and Gajadhar, A. 2004. Waterborne zoonotic helminthiases, Veterinary parasitology, 126 **1-2:** 167–93.

Phiri, A M. 2006. Common conditions leading to cattle carcass and offal condemnations at 3 abattoirs in the Western Province of Zambia and their zoonotic implications to consumers, Journal of the South African Veterinary Association, 77 **1:** 28–32.

Phiri, A.M., Phiri, I.K., Sikasunge, C.S. and Monrad, J. 2005a. Prevalence of fasciolosis in Zambian cattle observed at selected abattoirs with emphasis on age, sex and origin, Journal of Veterinary Medicine Series B: Infectious Diseases and Veterinary Public Health, 52 **9:** 414–416.

Phiri, A.M., Phiri, I.K., Sikasunge, C.S. and Monrad, J. 2005b. Short Communication Prevalence of Fasciolosis in Zambian Cattle Observed at Selected Abattoirs with Emphasis on Age, Sex and Origin, Journal veterinary Medicine, 416 **52:** 414–416.

Radfar, M.H., Nourollahi-Fard, S.R. and Mohammadyari, N. 2013. Bovine fasciolosis: prevalence, relationship between faecal egg count and worm burden and its economic impact due to liver condemnation at Rudsar abattoir, Northern Iran, Journal of Parasitic Diseases, doi:10.1007/s12639-013-0389-z.

Ramajo, V., Oleaga, A., Casanueva, P., Hillyer, G. V. and Muro, A. 2001 Vaccination of sheep against Fasciola hepatica with homologous fatty acid binding proteins, Veterinary Parasitology, 97 **1:** 35–46.

Raza, M.A., Iqbal, Z., Jabbar, A. and Yaseen, M. 2007. Point prevalence of gastrointestinal helminthiasis in ruminants in southern, Journal of Helminthology **81:** 323–328.

Regassa, A., Moje, N., Megersa, B., Beyene, D., Sheferaw, D., Debela, E., Abunna, F. 2013. Major causes of organs and carcass condemnation in small ruminants slaughtered at Luna Export Abattoir, Oromia Regional State, Ethiopia, Preventive veterinary medicine, Elsevier B.V., 110 **2:** 139–48.

Sanchez-Andrade, R., Paz-Silva, a, Suárez, J.L., Panadero, R., Pedreira, J., Lopez, C., Díez-Baños, P. 2002. Influence of age and breed on natural bovine fasciolosis in an endemic area (Galicia, NW Spain). Veterinary research communications, 26 **5:** 361–70.

Scholtz, M.M., Bester, J., Mamabolo, J.M. and Ramsay, K.A. 2008. "Results of the national cattle survey undertaken in South Africa, with emphasis on beef", Applied Animal Husbandry & Rural Development. **1:**1–9.

Seimenis, A. 2012. Zoonoses and poverty - a long road to the alleviation of suffering. Veterinaria italiana, **48:** 5–13.

SSA. 2013. Statistics South Africa: Mid-year population estimates, Embargoed until: 14 May 2013, 10:30. Accessed: July 2014. Published by SSA, Pretoria.

Terefe, D., Wondimu, A. and Gachen, D.F. 2012. Prevalence , gross pathological lesions and economic losses of bovine fasciolosis at Jimma Municipal, Journal of Veterinary Medicine and Animal Health, **4:** 6–11.

Theodoropoulos, G., Theodoropoulou, E., Petrakos, G., Kantzoura, V. and Kostopoulos, J. 2002. Abattoir condemnation due to parasitic infections and its economic implications in the region of Trikala, Greece. Journal of veterinary medicine. B, Infectious diseases and veterinary public health, 49 **6:** 281–4.

Thomas-Bachli, A.L., Pearl, D.L., Friendship, R.M. and Berke, O. 2012. Suitability and limitations of portion-specific abattoir data as part of an early warning system for emerging diseases of swine in Ontario, BMC Veterinary Research. **7:**185

Thrusfield, M. 2005 Surveys In: Veterinary Epidemiology, (Edition, 3rd, Ed.), Blackwell Science Ltd, London, pp 228–246.

Torgerson, P.R. and Macpherson, C.N.L. 2011. The socioeconomic burden of parasitic zoonoses: global trends. Veterinary parasitology. 182 **1:**79-95

Tsegaye, E., Mulugeta, B.S. and Begna, F. 2011. Prevalence of Bovine Fasciolosis and its Economic Significane in and Around Assela, Ethiopia Shiferaw Mulugeta, Feyisa Begna, Ephrem Tsegaye, **11:** 3.

Tsotetsi, A.M. and Mbati, P.A. 2003. Parasitic helminths of veterinary importance in cattle, sheep and goats on communal farms in the northeastern Free State, South Africa, Journal of the South African Veterinary Association, 74 **2:** 45–48.

Wondwosen, E., Addis, M. and Tefera, M. 2012.An Abattoir Survey on the Prevalence and Monetary Loss of Fasciolosis among Cattle in Wolaita Sodo Town, Ethiopia, Advances in Biological Research 6 **3:** 95-100

Zeleke, G., Menkir, S. and Desta, M. 2013. Original article Prevalence of ovine fasciolosis and its economic significance in basona worana district, central Ethiopia, Scientific Journal of Zoology, 2 No. 2 **8:** 81–94.

CHAPTER FIVE: General discussion, conclusion and recommendation

5.1 General discussion

The broad objective of this study was to identify causes of carcass and offal condemnation in slaughtered cattle in abattoirs in the Eastern Cape province of South Africa and to determine the financial loss associated with such condemnation. Abattoirs have played an important role in the surveillance of a variety of diseases of human and animal health significance. Inspection at the abattoir allows for all animals passing into the human food chain to be examined for abnormal signs, lesions or specific diseases (Alton *et al*., 2010; Dupuy *et al*., 2013; Thomas-Bachli *et al*., 2014). Animals' daily interaction with the ecosystem, its feeding habit and physiological dynamics expose them several infectious and non-infectious diseases. These disease and conditions have been referred to as a major constraint of efficient livestock production and negatively impacting on the wellbeing of livestock and resulting in poor productivity.

A significant proportion of diseases affect the safety of food supplies, and affect the volume and quality of food products (Fitzpatrick, 2013). Cattles in this study were condemned at the slaughter for various reasons; some due to disease while others were conditions underpinning the presence of disease and faulty abattoir slaughter processes. Some of the diseases identified as the leading cause of carcass and offal's condemnation are classified as zoonotic or emerging zoonotic disease. It is estimated that 75% of emerging human pathogens are zoonotic (Dorny *et al*., 2009).

Indeed in all three abattoirs studied factors responsible for meat and offal rejection were similar except the quantity condemned which varied and may have been due to the size and capacity of the abattoir. The presence of this disease and conditions could have been possible due to poor or improper use of anthelmintics, farmer's lack of knowledge on appropriate method and dosage of therapeutics and inadequate knowledge on seasonal variability in disease etiology. In addition, faulty evisceration problems such as faecal and blood splashes are consequent upon operational anomaly in the slaughter. Time allocated for each animal during slaughter may be inadequate and will thus encourage rush, leading to spillage to faecal matter in the clean areas of the abattoir. It is also important to mention that the experience of the abattoir slaughter men may also affect the number and rate of contamination of offal's and carcass with faeces and blood. Meat condemnations in this study lead to high financial losses for the farmer and the abattoir and by implication affecting the socio-economic wellbeing of farmers concerned.

The prevalence of fasciolosis studied in chapter four was generally low when compared with results obtained from other African countries, but a seasonal pattern of infection was established suggestive that warmer and wet seasons (spring, summer and autumn) and breed contributed to higher prevalence in the various abattoirs studied. Cooler seasons generally experience less liver condemnation due to fasciola infection. The severity of infection was more at a moderate infection level of fasciola than severe and mild infection. Animals with poor body condition were more highly affected by fasciola than animals with moderate and good body condition. Young and local breeds of cattle had higher prevalence than older ones and animals of different crosses. Most of the local breeds are kept by local and poor resourced farmers; and according to (Scholtz *et al*., 2008; Seimenis, 2012) animal's belonging to poor people are particularly vulnerable to disease because of inability to cover all production costs, and absence or unsuitability of the animal health sector. Significant monetary loss was recorded as a result of liver rejection due fasciolosis at the three abattoir studied.

5.2 Conclusion

Livestock are important in supporting the livelihoods of poor farmers, consumers and traders throughout the developing world. The purpose of animal production is to produce meat and milk and other animal related product available for human and animals use, as well as to make profit to sustain the social economy of the farmer. In view of this and the fact that implementation of adequate measures, especially against emerging and re-emerging zoonotic and foodborne diseases, has also proven to be very difficult, the control and prevention of fasciola should be the primary concern of public and private institutions including farmers. Its recent trend and inclusion as an emerging zoonosis further buttress the point that urgent steps need to taken to break the cycle of fasciola infection. It has been noted that endemic infectious diseases, including zoonoses, together with emerging and re-emerging diseases, are mostly shouldered by poor and vulnerable populations.

5.3 Recommendations

- Therefore, effort should be geared towards educating farmers on how to improve animal husbandry in order to reduce parasitic diseases that lead to condemnations;

farmers also need to be trained on animal handling and transportation in order to reduce stress and bruises at slaughter.

- ❖ The general public (farmers, abattoir workers, customers, animal attendants and butchers) need to be aware of the public health significance of diseases of animal origin and the related losses.
- ❖ The abattoir should also intensify efforts at identifying diseased animal and take serious precaution regarding the selection of the animals for slaughtering. Such effort should be directed at understanding the animal origin, husbandry practice at the farms, seasonal variation in parasite demography and general physical characteristic indicative of good health, so that such financial loses can be minimized.
- ❖ There should be an office for the veterinary doctor at the abattoir to enforce the meat safety act of 2000 regarding lairage time, ante-mortem and post-mortem inspection. Animals to be slaughter must be rested 24 hours before slaughter, which will allow ample time for quality inspection.
- ❖ Adequate and proper disposal/ treatment of the condemned offal's are strongly advocated in order to control and break the cycle of infecting agents. Furthermore, butchers and eviscerators should be increased in number at the abattoir and allowed more time per animal slaughtered in order to reduce the rush which usually leads to spillage of fecal material on the carcass/organs and which may predispose the public to infection as well as the contamination of abattoir clean areas.

- ❖ Animal bruises can be prevented by a more humane way of handling which includes careful, quiet handling, dehorning at a young age and use of modern equipment and avoid traditional ways of animal husbandry. Proper means of animal transportation and restrain should be used and animal abuse eschewed.
- ❖ Animal grazing on wet land and drinking from open rivers need to be avoided. Farmers are also encouraged to do stall feeding; this will limit the contact between cattle and *lymnaea spp* or encysted metacercariae was cattle grazes.
- ❖ Implementation of on-farm control measures to eliminate the contamination of agricultural water by water snail, which are the intermediate host, is a key factor in the control of many zoonotic diasease. Finally, Appropriate and potent anthelmintics should be given to communal farmers to aid treatment and prophylaxis.
- ❖ Farmers need to be educated on the need to understand the seasonality of fasciola parasite and adequate steps taken to avoid its propagation.
- ❖ There is a need for adequate laboratory investigation on the prevalence of fasciolosis in animals at the farms and those brought to the abattoir for slaughter, such investigation may employ the use of modern diagnostic tools such as serology and molecular techniques.

5.4 Future research

We recommend that further studies should be carried out in this area to identify the causes of meat condemnation in other abattoir as well as livestock species such as sheep and goat. Such research should adopt modern serological techiques like the polymerase chain reaction (PCR) etc. A more adept, integrated and conputerised slaughter approach should implementated to allow for easier collection of data by scientist and realtime up to date availability of information should be ensured by abattoir owners and relevant government department.

5.5 References

Alton, G.D., Pearl, D.L., Bateman, K.G., McNab, W.B. and Berke, O. (2010. Factors associated with whole carcass condemnation rates in provincially-inspected abattoirs in Ontario 2001-2007: implications for food animal syndromic surveillance, BMC veterinary research, **6:** 42.

Dorny, P., Praet, N., Deckers, N. and Gabriel, S. 2009. Emerging food-borne parasites. Veterinary parasitology, 163 **3:** 196–206.

Dupuy, C., Morignat, E., Maugey, X., Vinard, J.-L., Hendrikx, P., Ducrot, C., Calavas, D., et al. 2013. Defining syndromes using cattle meat inspection data for syndromic surveillance purposes: a statistical approach with the 2005-2010 data from ten French slaughterhouses. BMC veterinary research, **9:** 88.

Fitzpatrick, J.L. 2013. Global food security: the impact of veterinary parasites and parasitologists. Veterinary parasitology, Elsevier B.V., 195. **3-4:** 233–48.

Scholtz, M.M., Bester, J., Mamabolo, J.M. and Ramsay, K.A. 2008. Results of the national cattle survey undertaken in South Africa, with emphasis on beef, Applied Animal Husbandry & Rural Development 2008, **1:**1–9.

Seimenis, A. 2012. Zoonoses and poverty - a long road to the alleviation of suffering. Veterinaria italiana, **48:** 5–13.

Thomas-Bachli, A.L., Pearl, D.L., Friendship, R.M. and Berke, O. 2014. Exploring relationships between whole carcass condemnation abattoir data, non-disease factors and disease outbreaks in swine herds in Ontario (2001-2007). BMC research notes, BMC Research Notes, 7. **1:** 185.

Appendix

MONTHLY REPORT ON CONDEMNATIONS ABATTOIR.................................. Province...Eastern Cape

MONTHLY SLAUGHTER FIGURES: Bovine..2880..Calves...135... Sheep..3126..goats........... Pigs..3304..horses.......... MONTH...May.....YEAR..2014

Condition /Disease	BOVINE (NUMBERS ONLY - NOT KILOGRAMS)		CALVES (NUMBERS ONLY - NOT KILOGRAMS)		SHEEP (NUMBERS ONLY - NOT KILOGRAMS)		GOATS (NUMBERS ONLY - NOT KILOGRAMS)		PIGS (NUMBERS ONLY - NOT KILOGRAMS)		HORSES (NUMBERS ONLY - NOT KILOGRAMS)	
	CARCASS TRIMMED OR PARTS OR ONLY ORGANS AFFECTED	TOTALLY CONDEMNED (CARCASS AND ORGANS)	CARCASS TRIMMED OR PARTS OR ONLY ORGANS AFFECTED	TOTALLY CONDEMNED (CARCASS AND ORGANS)	CARCASS TRIMMED OR PARTS OR ONLY ORGANS AFFECTED	TOTALLY CONDEMNED (CARCASS AND ORGANS)	CARCASS TRIMMED OR PARTS OR ONLY ORGANS AFFECTED	TOTALLY CONDEMNED (CARCASS AND ORGANS)	CARCASS TRIMMED OR PARTS OR ONLY ORGANS AFFECTED	TOTALLY CONDEMNED (CARCASS AND ORGANS)	CARCASS TRIMMED OR PARTS OR ONLY ORGANS AFFECTED	TOTALLY CONDEMNED (CARCASS AND ORGANS)
Abscessation	99	-	-	-	91	-			-	-		
Actinomycosis	1	-	-	-	-	-			-	-		
Anaemia	-	-	-	-	-	-			-	-		
Arthritis	-	-	-	-	-	-			-	-		
Brucellosis	-	-	-	-	-	-			-	-		
Bruising/Injuries	-	-	-	-	-	-			-	-		
Cachexia (emaciation)	-	-	-	-	-	-			-	-		
Contamination	3	-	-	-	-	-			-	-		
Cysticercosis		1	-	-	-	-			-	-		
Degeneration	-	-	-	-	-	-			-	-		
Edema		-	-	-	-	-			-	-		
Emphysema	47	-	-	-	-	-			-	-		
Enteritis	-	-	-	-	-	-			-	-		
Erysipelas	-	-	-	-	-	-			-	-		
Fascioliasis	206	-	-	-	-	-			-	-		
Fever	-	-	-	-	-	-			-	-		
Gangrene	-	-	-	-	-	-			-	-		
Hydatid Cysts	53	-	-	-	13	-			-	-		
Jaundice	-	-	-	-	-	-			-	-		
Leptospirosis	-	-	-	-	-	-			-	-		
Lumpy Skin Disease	-	-	-	-	-	-			-	-		
Lymph adenitis (Caseous)	-	-	-	-	-	-			-	-		
Neoplasms	-	-	-	-	-	-			-	-		
Nephritis	-	-	-	-	-	-			-	-		
Oesophagostomum	-	-	-	-	-	-			-	-		
Parasitic	-	-	-	-	-	-			19	-		
Pericarditis	23	-	-	-	-	-			-	-		
Peritonitis/Pleuritis	39	-	-	-	-	-			-	-		
Pigmentation	-	-	-	-	-	-			-	-		
Pneumonia	5	-	-	-	-	-			-	-		
Sarcosporidia	-	-	-	-	-	-			-	-		
Septicaemia	-	-	-	-	-	-			-	-		
Steatosis Hepatica	6	-	-	-	-	-			-	-		
Swine Fever	-	-	-	-	-	-			-	-		
Telangiectasis	14	-	-	-	-	-			-	-		
Tox/Tail bite pyaemia	-	-	-	-		-						
Tuberculosis									26	-		
OTHER -	39	-	-	-	-	-						
Measles	4	-										

MONTHLY ~~APPLICAT~~ ATTENTION: DR. I. JAJA

Daily condemnation cattle/sheep/goat/pig/game meat Please code with c/s/g/p/m for different animals Date: JANUARY 14

		BOVINES	PORCINES	OVINES
HEAD	Abscess	02	01	03
	Actinomycosis			
	Others	9		
TONGUE	Abscess			
	Actibacillosis			
	Others			
LUNGS	Abscess	3	[illegible]	
	Pneumonia	7	[illegible]	17
	Blood aspiration	12	[illegible]	
	Faecal aspiration			
	Lung worm/cyst			
	Pleuritis	6		
	Emphysema	12	[illegible]	
	Necrosis			
	Contamination			
	Others		24	
LIVER	Abscess	15		
	Faciola hepatica	11		
	Stilesia hepatica			
	Necrosis			14
	Fibrosis			
	Hepatitis	7		
	Icterus			
	Peritonitis			
	Telangiectasis			
	Contamination			
	Cyst			
	Others	20		
HEART	Pericarditis	29	05	17
	Endocarditis			
	Myocarditis			
	Contamination			
	Others			
PLUG	P.p.p			
	Abscess	9		
	Septicaemia	08		
	Pyaemia			
	Contamination			
	Others			
STOMACH	Abscess	03		
	Peritonitis			
	Ulcer			
	Inflammation	14		
	Contamination			
	Others	10		
SPLEEN	Abscess			
	Infarcts			
	Splenomegaly			
	Peritonitis	5		
	Others			
INTESTINE	Abscess			
	Peritonitis			
	Pimply gut (knoppiesderm)			08
	Inflammation			
	Contamination			
	Others			
CARCASS	Septicaemia			
	Pyaemia			
	Icterus/unaplacmosis			
	Lymphadenitis			
	P.p.p			
	Odema/ fat atrophy	2		
	Uraemia			
	Others			

TEETH COUNTED BY MEAT INSPECTOR ON CATTLE SLAUGHTERED. NAME:

DATE										
NO	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH	TOTAL TEETH
1	8	4	8	8 351	87648	8	8	8	8	2
2	8	8	8	5	8	8	8	8	8	4
3	8	8	8	5	6	8	8	8	8	2
4	8	8	8	6	8	8	8	8	8	2
5	6	8	8	6 936	8	21	41198	8	8	0
6	6	8	2	2	6	2	84613	8	6	8
7	8	8	8	2	8	6	21928	6	2	8
8	8	8	8	0	6 115	1	87493	6	8	8
9	2	6	5	8 47	87100	6	81667	6	8	8
10	4	8	8	8 43	212061	6	87407	6	8	8
11	2	8	8	8 520	86079	4	81962	8	6	8
12	4	4	8	8 558	89070	6	8 [illegible]	4	8	8
13	8	8	8	8 49	88729	6	61489	6	8	8
14	6	8	6	8 744	87176	3	86[illegible]	6	8	8
15	2	6	6	8 484	88137		87946	6	8	6
16	4	4	8	8 71	80641		81[illegible]	6	6	8
17	6	8	4	8 654	212023		89673	4	2	8
18	2	8	8	8 710	86123		85[illegible]	4	8	8
19	4	8	8		8		21[illegible]	6	8	8
20	2	8	8		8 A81		8	6	8940	3
21	5	4	8		[illegible]		6	4	8	8
22	2	6	6		89306			8	4023	8
23	2	8	8		87323			4	89350	8
24	2	8	8		88405			8	8547	4
25	3	3	8		8 [illegible]			4	6	8
26	4	4	8		4			5	8	8
27	4	2	8		2			8	8766	3
28	2	2	8		2			4	4	8
29	5	4	8		6			8	4	2
30	2	2	8		0			6	2	2
31	4		8		2			6	6	3
32	2		8		4			4	2	4
33	4		41198		0			6	8	2
34	2		21150[illegible]		2			5	[illegible]	[illegible]

DIRECTORATE OF VETERINARY SERVICES
DAILY STATISTICAL RETURNS OF RED MEAT ABATTOIRS (ACT 40/2000)
MONTH : SEPTEMBER 2013

	CATTLE	CALVES	PIGS	SHEEP/~~GOATS~~	HORSES	OSTRICHES	GAME
1							
2	21		186	112			
3	27		236	105			
4	83		144	8			
5	67		205	15			
6	11		342	29			
7							
8							
9	29		294	32			
10	53		251	79			
11	5		245	28			
12	19		00	80			
13	22		191	9			
14							
15							
16	22		194	00			
17	42		202	10			
18	18		226	38			
19	32		[illegible]0	15			
20	11		205	00			
21							
22							
23	00		442	00			
24	00		00	00			
25	13		268	61			
26	84		334	123			
27	37		269	00			
28							
29							
30	26		199	6			
31							
TOTAL	522	83	4349	728			

COMMENTS :

NONE !!!!

[illegible signature]
SIGNATURE : MEAT INSPECTOR

OWNER/MANAGER

03/10/2013
DATE