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A critical evaluation of the causes of carcass condemnations in a South African cattle abattoir

By

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DECLARATION

I hereby declare that this dissertation, submitted for MSc Agric (Animal Production Management) degree at the University of Pretoria, is my own work and has not previously been submitted to any other university or institution of higher education.

Petrus Thabo Tlhapi

DEDICATION

This study is dedicated to:

My father, Johannes Tlhapi, who passed away in September 2006, for his love and encouragement in pursuing studies.

My mother, Elizabeth Tlhapi for her encouragement and support.

My brother Ben Tlhapi for his support.

My wife, Tshepang Tlhapi and Rebone Tlhapi (daughter) for their encouragement, support and for believing in me.

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SUMMARY

A critical evaluation of the causes of carcass condemnation in a South African cattle abattoir

This study was conducted to investigate the causes and the effects of breed, gender and season on carcass condemnations post-mortem in a large South African abattoir. Condemnation of carcasses as a results of animal diseases and conditions has been identified as a problem in the South African beef industry, but the causes and extent of carcass condemnations have not been studied in detail. The importance of cattle management during transportation and pre-slaughter is generally appreciated, but a better understanding of the influence of breed, gender and season on the prevalence of carcass condemnations can help to improve slaughter management at large abattoirs.

Diseases and conditions evaluated during this study were parafilaria, bruising, soiling, fever, peritonitis and pleuritis, abscesses, measles, oedema and intramuscular haemorrhage. Breeds of cattle slaughtered were Friesland, Bonsmara, Brahman, Angus, Afrikander, Hereford and Nguni cattle, grouped as males and females, and the seasonal effects investigated were confined to Autumn, Winter and Summer combined with Spring as it was not easy to distiquish between the two. Data was collected in a Grade A abattoir in South Africa in 2010. The experimental design involved 42 combinations based on their effects and interactions namely 7 breeds x 2 genders x 3 seasons. The model used in this procedure was based on the presence of conditions = (Intercept) x i x j x k where i~breed, j~gender and k~season. The binary response variable was the presence (value = 1) or absence (value = 2) of the respective condition.

Overall, the significant order and extent of causes of bovine carcass condemnations evaluated in this particular abattoir during the period of study were peritonitis and pleuritis at 2.49%, soiling 2.33%, bruising 2.10%, parafilaria 0.54%, while other conditions had a negligible effect. Almost half of these carcass condemnations were due to soiling and bruising, which can be addressed by implementing better abattoir management and better management during transportation.

Peritonitis and pleuritis were prevalent to a greater degree in Autumn, Soiling in Summer, bruising in winter and parafilaria more prevalent in Summer as well. Bonsmara bulls were

more affected by peritonitis and pleuritis, soiling, bruising and parafilari compared to other breeds..

Overall breed, gender and season influenced carcass condemnations in large South African abattoir

It is suggested that proper dehorning should be done at an early stage, especially in bulls of breeds like Bonsmara, Nguni, Friesland and Hereford, which predispose cattle to bruising which increases the number of carcass condemnations. Steps should be taken (i.e. proper handling techniques should be applied) to avoid injuries which may lead to internal bleeding, and eventually bruises (most probably due to fighting during transportation or in lairage), that can be avoided by using improved and upgraded facilities which include enough space per animal. In case of soiling, well-trained slaughter personnel, cattle handlers and cleaners should be hired to prevent bile and soil contamination during evisceration and to avoid mud or manure contamination durinmg lairage. It is recommended that employees be trained to help reduce the high rate of carcass condemnations.

Breeds like Bonsmara and Brahman were more susceptible to peritonitis, pleuritis and parafilaria, so treatrment programmes are advisable for these breeds, especially those from regions where these conditions or diseases are more prevalent.

Key words: Post-mortem; carcass condemnation, cattle; breed; gender; seasonal effects.

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ABBREVIATIONS AND ACRONYMS

AMI	American Meat Institute
AHD	Animal Health Division
ASAS	American Society of Animal Science
AWFS	Animal Welfare and Food Safety
BLV	Bovine Leucosis Virus
BRDC	Bovine Respiratory Disease Complex
BSE	Bovine Sporangium Encephalopathy
DFI	Detained for Further Inspection
Ha	Alternate Hypothesis
HACCP	Hazard Analysis Critical Control Point
Ho	Null hypothesis
HS	Haemophilus Sonmus
HSA	Humane Slaughter Act
I.S.U	Iowa State University
NBQA	National Beef Quality Audit
NFS	National Food Safety
NSBQA	National State Beef Quality Assurance
P.M	Pasteurella Multocida
SPCA	Society for the Prevention of Cruelty to Animals
UNDP	United Nations Development Program
U.S.D.A	United States Department of Agriculture

CHAPTER 1

1. Aims and objectives

The aim of this study was to investigate the critical causes, and the effect of breed, gender and season on carcasses condemnations in large beef abattoirs in South Africa. In doing so, we:

- Identified managerial factors affecting the condemnation of carcasses in the beef industry;
- Measured variations of conditions leading to the condemnation of carcasses in a beef abattoir; and
- Identified different diseases and conditions, from different breeds, males and females in different seasons leading to the condemnation of carcasses.

2. Hypothesis

2.1. The breed of cattle influences the number of carcasses that are condemned. The following breeds were studied:

- Brahman
- Bonsmara
- Nguni
- Afrikander
- Hereford
- Angus
- Friesland

2.2. Gender (male and female cattle) influences the number of carcasses that are condemned.

2.3. Seasons (Summer, Autumn, and Winter) influence the number of carcasses that are condemned.

3. Problem statement

Condemnation of beef carcasses as a result of animal diseases and conditions has been identified as a problem in the South African beef industry, but the extent and types of carcass condemnation have not been studied and analysed to include breed, gender and seasonal impact. The importance of cattle slaughter management is generally appreciated, but a better understanding of the impact of breed, gender and season on types and prevalence of carcass condemnation can aid in improving slaughter management in big abattoirs that contribute the bulk of beef to South African consumers.

4. Motivation of the study

In order to reduce carcass condemnation (carcasses deemed to be unfit for human consumption during inspection), proper managerial skills regarding cattle slaughter production should be applied. Experienced slaughter personnel, experienced workers in the lairages and those who transport cattle should be employed; alternatively, the present workers should be provided with relevant training to avoid problems such as inadequate or incorrect evisceration which can lead to faecal and bile contamination of carcasses. Other factors that result in condemnation of carcasses include the rough handling of cattle before slaughter and overloading of cattle using improper facilities, which can lead to injuries resulting in bruising post-mortem. Well-trained persons (e.g. veterinarians and meat inspectors) should be employed at abattoirs to identify different conditions or diseases present in cattle that are slaughtered.

Improvements in the management of the slaughter process will ensure acceptable and safe meat for human consumption, (Meat Safety Act 40 of 2000) www.rmaa.co.za, which could encourage other countries to import meat from South Africa. This will be beneficial to South Africa's economy and will eventually create more job opportunities.

Meat inspection is an integral part of the production and slaughter process and includes inspection of facilities and the diagnosis of diseases in food-producing animals. It is important that meat inspectors observe proper inspection procedures so that people ultimately consume a product that is safe. Condemned meat products include carcasses and portions of carcasses that, upon inspection or re-inspection, are found to be infected or affected by disease or any abnormal conditions that render them unfit for human consumption. This includes carcasses of animals that have died in the yard or livestock-holding pen (Maja & Bergh, 2007)

Condemned carcasses (carcasses which on inspection deemed to be unfit for human consumtions) or meat products should be monitored carefully; condemned carcasses should never be placed on the slaughter floor. Condemned meat products should not be placed close to or in contact with carcasses that have been approved for human consumption. All equipment that has been in contact with condemned carcasses or meat products should be cleaned and sanitised as required before further use (Meat Safety Act 40 of 2000) www.rmaa.co.za,

Environmental factors influence carcass condemnation because cattle are kept either in intensive or extensive systems. If cattle are kept in extensive systems, they may be exposed to seasonal effects, as well as internal or external parasites, or they may consume unwanted materials that can cause disease and result in carcass condemnation. Veterinarians play a major role in the prevention and management of diseases that affect livestock and they should work closely with meat inspectors in decision making, especially in determining if carcasses need to be totally condemned or trimmed because of conditions such as parafilaria or bruising. Trimmed carcasses are used for deboning and represent a lower financial loss to the meat industry compared to condemned carcasses.

CHAPTER 2

LITERATURE REVIEW

1. Introduction

In the last 20 years, the world's average annual meat production has risen by 3.9%, with beef production rising by 3.4%. The rate of growth of meat production in developing countries was much lower and this low growth of meat and beef production was due to an increase in the number of animals (Smith, 1973).

Beef is produced either intensively (in feedlots), or extensively (in pastures) and both of these environments are influenced by seasonal changes. The dietary effect of animal feeds on carcass and meat quality of cattle has been intensively researched. Studies on varying dietary energy levels (Prior, Kohl-Meier, Cundiff, Dikeman, & Crouse, 1977; Crouse, Anderson and Neumann, 1978) as well as grain- vs. forage-based diets (Bowling, Smith, Carpenter, Dutson, & Oliver, 1977; Young & Kaufman, 1978; Schroeder, Gramer, Bowling & Cook, 1980; Crouse et al 1978; Fortin, Veira, Froehlich, Butler & Proulx, 1985) have appeared in the literature. Studies on pasture vs. feedlot finishing (Schaake, Skelley, Halpin, Grimes, Brown, Cross & Thompson, 1993; Bennett, Hammond, Williams, Johnson, Preston & Miller, 1995; Camfield, Brown Jr, Johnson, Brown, Lewis, & Rakes, 1999) & breed types / frame size (Kock, Dikeman, Allen, May, Crouse & Champion, 1976; Cianzio, Topel, Whitehurst, Beitz & Self, 1982; Dolezal, Tatum & Williams, 1993; Camfield *et al* 1999; Short, Grings, McNeil, Heitschmidt, Williams & Bennett, 1999) are also well documented.

In general, carcasses from feedlot-fed cattle are heavier and contain more fat than carcasses from forage-fed cattle. Beef from forage-fed cattle is also darker and less tender than that from feedlot-fed cattle (Bowling *et al*, 1977). Most of the studies mentioned herein have been conducted in the United States of America (USA) where consumers prefer heavier carcasses exhibiting a substantial degree of marbling. In South Africa, consumers prefer lean meat with little visible fat. Carcasses are produced to suit consumer preferences and are seldom trimmed of excess fat. Within intensive livestock production systems, there is a strong move towards producing animals in fully-controlled environments and to feeding and raising more cattle in feedlots to allow for better disease management and bio-security (Hoffman & Mellet, 2005).

In South Africa, the feedlot industry produces approximately 70-80% of beef in the formal sector, and it is estimated that this sub-sector has a standing capacity of 420 000 head of cattle and a potential output of 1,512 million animals annually. Animals usually enter the feedlot system at a mass of between 200 and 230 kilograms and remain in the feedlot system for approximately 100 to 110 days. The performance of animals in the feedlot is directly linked to breed and genetics. Based on maximum values, an average growth of 1.4 kilograms per day over 110 days equates to a mass increase of 154 kilograms from an initial mass of 230 to 384 kilograms (Schaake *et al*, 1993).

2. Behavioural profile of cattle

Animal behaviour can predispose cattle to injury and thus carcass bruising. A number of intrinsic and extrinsic factors can influence the behaviour of bovines, including anatomical features, production system and environmental factors. The eyes are positioned on either side of the head providing a panoramic view of 330 degrees and binocular vision of 25 to 50 degrees, which allows for good predator awareness. Despite their wide-set eyes, cattle have a blind spot directly behind them (Phillips, 1993). Cattle have slit-shaped pupils and weak eye muscles, which inhibit their ability to rapidly focus on objects that may cause them danger, leading to injuries and eventually bruises. “Cattle can distinguish long wavelength colours (yellow, orange and red) much better than shorter wavelength colours (blue, grey and green), which may have aided their response and survival when a herd member was attacked and blood was spilt.” (Lanier, Grandin, Green, Avery, & McGee, 2000) The limitations in terms of vision (blind spot) and inability to focus quickly often result in rapid responses to escape danger, which makes them more prone to injuries which may result in bruises.

Cutaneous sensitivity may be used to calm cattle and thus avoid physical fights that will lead to injuries. Scratching under the neck and behind the ears, that is, in areas they find difficult to access (Moran, 1993), has been used to calm cattle.

Older cattle, grazing in rangelands will spend less time grazing than younger cattle due to their experience and learned paddock patterns (Krys & Hess, 1993). Within herds consisting of male and female cattle, there are several hierarchies among adult males, adult females and calves. Young males fight adult females, and eventually dominate them. The hierarchy tends to be linear: large herds usually break down into a series of smaller hierarchies. There is evidence that dominance hierarchies in young beef steers are formed soon after weaning and that they remain stable even when the groups are moved to other pens (Stricklin, Graves & Singh, 1980). This is an indication that mob grazing is dangerous, as cattle may infect each other if some are infected with or affected by diseases. The diseases may lead to carcass condemnation during post-mortem.

Although previous research has not shown a relationship between dominance and milk production, recent field observations of ten commercial dairy farms showed that cows yielding a higher amount of milk arrived earlier for milking and those yielding a lower amount of milk arrived later. Aggressive interactions appear to be ritualised and occur in sequence. Approach, threat, physical contact or fighting, once the dominance relationship of any pair of animals is learnt, eliminate the need for further combat. The subordinate animal retreats from the dominant one at the slightest threat. Therefore, physical contact is of minor importance, as long as the animals can recognise each other's position (Beilharz & Zeeb, 1982)

2.1 Grazing behaviour: It is very important to use a system (extensification or intensification) of grazing in cattle so as to avoid physical fights, which may lead to injuries and bruising. Muscular discoloration may also result from injuries and lead to blood clots, causing intramuscular haemorrhage on post-mortem resulting in carcass condemnation. Grazing occupies a large amount of time in both dairy and beef cattle (eight hours per day) and is affected by many factors, including environmental conditions and plant species. Cattle usually stand to graze and the pattern of grazing behaviour of each herd member is relatively similar.

Ruminating hours = 6	Percentage ruminating = 67%
Grazing hours = 9	

The animals move slowly across the pasture with their muzzles close to the ground, biting and tearing at the grass, which is swallowed without much chewing. Therefore it is easy for these cattle to pick up larvae during the process of grazing, resulting in tapeworms. Tapeworms cause a greenish and watery layer on the surface of the carcass during post-mortem. This condition is called parafilaria. Measles are also caused by tapeworms, and result in carcass condemnation and eventually loss of production in post-mortem. Cattle ruminate when resting and the time devoted to ruminating is approximately three quarters of that spent on grazing. This is altered according to the type of pasture. A useful ratio is the R:G (Ruminating:Grazing) ratio, for instance, if grazing is not restricted by management, and is influenced by the abundance of pasture and environmental factors. If pasture is good, ruminating time is short, and the R:G ratio is low (0.4). If the herbage is poor and fibrous, ruminating time is longer and the R:G value is high (1.3) (Reinhart, Mutiso & Reinhart, 1978).

2.2 Group cohesion: In open, trackless areas, free-ranging cattle group into large mobs and the distances between individuals are smaller than in areas with sparse to moderate tree and shrub cover. This puts them at a disadvantage as during grazing these cattle may ingest unwanted materials such as larvae resulting in tapeworms or measles, which results in a many carcass condemnations and eventually, loss of production. This means that the mob is more tightly clumped in open areas, and this affects the grazing pattern (Dudzinki, Muller, Low & Schuh, 1982).

2.3 Resting behaviour: The amount of time cattle spend resting depends on environmental conditions, time spent ruminating and grazing, and on the breed. The consistency with which an animal lies in its resting place is independent of its dominance in hierarchy (Reinhart *et al*, 1978). This indicates that no competitive situation arises with other herd members for particular resting sites, but it is a disadvantage as during that time flies may bite these animals who are easily affected by or infected with diseases resulting in a lot of carcass condemnation during post-mortem and eventually loss of production.

A herd's daily activity involves maintenance behaviour, that is, standing, walking, lying down, feeding, drinking, self-grooming, displaying aggressive behaviour and ruminating. Grazing is affected by temperature. In very high temperatures cattle graze predominantly at night which makes it easy for them to be injured. Cattle that are accustomed to a rotational system of paddock allocation will graze faster than those that are left in paddocks for longer periods. The latter will also tolerate lower feed supply, knowing that feed will be available in the next paddock during the rotation (Krys *et al*, 1993).

Dairy bulls are generally more aggressive and larger than beef bulls. The more aggressive the animals are, the more chance they have of sustaining injuries leading to bruises during post-mortem and eventually carcass condemnation during post-mortem.

2.4 Abnormal behaviour: Cattle that are not healthy will show abnormal behaviour. Healthy cattle appear alert, stretch upon rising, and are vocal, usually in response to pain or stress. Diseased cattle often show little interest in their environment. They usually have dull eyes, sluggish movement, poor grooming patterns and poor appetite. Other indicators of sickness include overstretching of the neck, hunching the back, kicking the belly area, grinding teeth, star-gazing, etc. (Grandin, 1989) Any odd or abnormal behaviour increases the risk of injury and in production animals, injury may have highly detrimental effects on carcass characteristics due to carcass condemnation.

3. Effect of space allowance on the behaviour and bruising of cattle during transportation

The effect that space allowance has on cattle's behaviour during transportation was investigated; here, the investigation was performed regarding the bruising welfare of 48 Hereford steers (mean live weight 400 kilograms). On four occasions, animals from each space allowance low (0.89 meters square per animal) were transported 360 kilometres in the same stock-crate in a standardised manner to slaughter. During transport, the behaviour of the animals was monitored on closed-circuit video. Upon arrival at the abattoir, all animals were placed in liairage in the same yard on each occasion and handled in a standardized manner at slaughter next day. Carcass measurements made at slaughter included bruise, score, muscle, weight, fat depth and muscle score (Grandin, 1981). In the low space allowance the animals made significantly more movements (P-value greater than 0.05) of less than 1m than animals in the medium space allowance; six animals "went down" in the high space allowance, but none did so in the other treatments (Grandin, 1989).

The carcass weight in the low space allowance was significantly lower (P-value greater than 0.05) than that of the medium space allowance, and the bruise scores in the low and high space allowance treatments were four and two times greater respectively, than in the medium space allowance treatment (P-value greater than 0.01). This concluded that space allowance for cattle during road transport can significantly affect the level of bruising, carcass weight and risk of injury of the animals (Grandin, 1989).

4. Cattle behaviour in a sale yard and its potential to cause bruising

It was found that bruising costs the Australian industry at least R252 million each year. At Brisbane abattoirs, drafting and weighing, followed by unloading, had the greatest potential to inflict injury upon the cattle. Aggressive behaviour (butting) showed a significant difference in the initiation rate between horned (0.36 per animal) or hornless (0.91 per animal) cattle. Most butting occurred in the holding yards and involved the neck (47.2 %) and flank (37.8%) regions more often than the hindquarters (25%) (Blackshaw, Kusano & Blackshaw, 1987).

During unloading, drafting and weighing, cattle frequently came into heavy contact with solid objects, particularly on their backs (33.1% of contact) and upper hindquarters (25.4% of contact). Shading behaviour differed between British, Brahman-type cattle and Brahman cattle (41% of British breeds sought shade, whereas only 6.5% of Brahman-type cattle preferred shade). A problem area in the unloading and drafting of cattle was identified in sale and weighing yards where stock handlers and casual labourers moved cattle. Due to the labourer's rough and abusive handling, the cattle exhibited aggravated behaviour which had damaging effects (Blackshaw, *et al*, 1987).

There was no South African data to compare with the above for bruising resulting to condemnation of carcasses.

5. Animal welfare during transportation and slaughter

Good management from the point of pre-loading, throughout the transportation period, to the point of off-loading must be combined with well-designed equipment and carrier interiors for watering, reduction of stressors and avoidance of injuries, to ensure adequate animal wellbeing and their ongoing welfare during the entire transportation process.

5.1 Effect of rest stops on animal welfare

During transportation, rest stops demonstrate an area of controversy in South Africa; one must be careful not to turn rest stops into 'stress stops'. In the USA, practical experience has shown that the health of 250-kilogram Weiner calves, from range land, will be better if they travel non-stop for up to 32 hours (Grandin, 2005). Because of the stress related to loading and unloading, cattle will not be accustomed to close contact with condition if they are unloaded and rested (Grandin, 1989).

Rest stops may be beneficial in other situations; one area that needs to be researched is the use of different stocking densities for long and short trips. It has been observed that, due to extremely hot summer weather, heat builds up rapidly in a stationary vehicle. A solution would be to provide fans to cool the animals during rest stops (Grandin, 2005).

5.2 Animals fit for transportation

A highly critical transportation issue is that of transporting animals that are physically unfit. The National Market Cow and Bull Quality Audit in the USA, indicated that the percentage of dairy cows arriving at a slaughter plant with a poor body score increased from 4.8% in 1994 to 5.4% in 1999 (Smith, Belk, Tatum, Field, Scanga, Roeber & Smith, 2000). The most alarming finding was that the percentage of dairy cows arriving with arthritic leg joints had tripled. In 1993, 4.7% of culled dairy cows had arthritic leg joints, and in 1999 the percentage increased to 14.5%. This increase in lameness may have contributed to the increased incidence of "downers". Producers must put more emphasis on breeding cattle with good limbs, and a little less on production (Smith, *et al*, 2000). The increased number of downers will result in increased number of carcass condemnations post-mortem.

No South African data was available to compare with the above.

5.3 Improving the fitness of animals for transportation

To improve the fitness of cattle that are to be transported, the following steps should be taken:

- Breeding cattle with healthy, strong limbs;
- Farming dairy heifers and gilts more slowly to provide time for the skeleton to develop;
- Culling sick or emaciated animals on the farm;
- Using tranquil handling practices;
- Developing audit systems for monitoring the body condition of dairy and breeding cows as people can manage the things that they measure;
- Avoiding overloading of trucks;
- Marketing old breeding animals when they are still fit to travel;
- Accounting for losses as a means of maintaining breeding stock in better condition; and
- Noting that producers will be motivated to take care of old breeding animals and baby Holstein calves if they have more economic value (Smith *et a*l, 2000).

6. How stressful is slaughter on cattle?

People often wonder if animals are afraid of slaughter. It was observed that cattle and pig behaviour during handling and stunning is the same on the farm and at the plant. Extensively raised cattle often become highly agitated and vocal at the slaughter plant because they are restrained and held for ear tagging and vaccination, which takes longer than stunning. Animal handling on the farm and in the slaughter plant cause physiological measures of stress to increase. When animals become agitated during handling, it is most likely caused by fear. The fear circuits in the animals' brains are completely mapped (Grandin, 1981). To maintain an adequate level of stress, animals require constant auditing of handling and stunning to prevent people from becoming careless. Economic incentives and accountability for losses such as bruises will also improve welfare, and this is referenced in the fact that cattle sold live weight, where the slaughter plant paid for bruises, had twice as many bruises as cattle sold in the carcass where the producer paid for bruises (Grandin, 1981).

6.1 Improving religious cattle slaughter practices

In the USA, the handling of animals to prepare them for Kosher or Halaal slaughter is exempt from the Humane Slaughter Act (HSA). Stunning is legally required for conventional slaughter, and hoisting of sensitive animals prior to stunning is not permitted. All mammals undergoing conventional slaughter have to be stunned and rendered insensitive while they are either standing in a stunning box, or held in a comfortable, upright position within a restrictive device. However, stunning is not legally required for religious slaughter. Some plants restrain fully sensitive cattle, calves or sheep by hanging them upside down with a chain attached to the ankle. This is a stressful, cruel method of restraint that should be eliminated. It is, however, a legal form of religious slaughter in the USA (Grandin, 2005). In South Africa, the SPCA made specific recommendations to improve the acceptability of Kosher or Halaal slaughter, which includes the use of delayed stunning.

Many meat wholesalers, including supermarkets, restaurants and food services companies, require their suppliers to adhere to the American Meat Institute (AMI) guidelines. These guidelines recommend that animals be held in a comfortable, upright position during slaughter. Shackling and hoisting, dragging, leg clamping and trip floor boxes should never be used (Grandin, 2005).

Plants that shackle and hoist sensitive animals are removed from the approved supplier list of meat wholesalers who audit plants. Any activity during transportation, ante-mortem management and pre-slaughter processing can cause bruising and reduce the value of carcasses. The loss of income due to carcass condemnation can have a crippling effect on the economic aspects of beef production and detract from consumer acceptance of meat products.

6.2 Modifications in cattle slaughter conditions in the USA

Since 2005, most large slaughter plants performing Kosher slaughter of cattle have stopped shackling and hoisting fully sensitive cattle, and have replaced these methods with restraints to hold the animal in an upright position. All religious slaughter plants in the USA owned by large corporations that own multiple plants, have eliminated shackling and hoisting. These changes were implemented due to safety concerns from major meat buying customers, and pressure from animal activist groups (Grandin, 1994).

In the USA, harsh methods of restraint are still used in some small independently-owned plants that perform religious slaughter. They continue to do this because it is cheaper and their customers do not demand that they stop shackling and hosting animals. As the law has a religious exemption, the most effective method to stop these plants from practicing harsh slaughtering methods is to incite their customers into demanding change. Some customers who buy Kosher or halaal meat are very concerned about the treatment of animals, while others show little concern, as long as the meat production adheres to the requirements of the religious law (Grandin, 2005).

There are two main welfare issues to be considered when slaughtering is performed without stunning. These include the animal’s reaction to the restraining method, as well as its reaction to the throat cut. When a stressful restraining method is used, it is impossible to observe animals when the throat is cut. Struggling, caused by stressful restraining methods, masks the animal's reactions to the throat cut. An experiment was performed to determine if slaughter without stunning caused pain. The results were as follows: if the cattle stay completely calm while Kosher slaughter is performed, they flinch slightly at the beginning of the cut. There is no other movement until convulsions begin when sensitivity is lost. Immediately after the cut, the head restraint is loosened as are the body restraints. Most cattle studied looked around for five seconds to a minute, until they collapsed. They did not seem aware that their throats had been cut. Waving hands in front of the animal's face caused a much bigger reaction than the Kosher cut (Grandin, 1994).

Another principle to consider in this study is that calm cattle lose sensitivity faster than agitated ones. Quiet handling and low-stress restraint conditions help produce a rapid onset of insensitivity. Animals should not be held in fully restrained positions for more than ten seconds. Immediately after the throat has been cut, the head and body restraints should be loosened (Grandin, 1994).

In the USA, the most effective way to encourgae smaller plants to stop shackling and hoisting prior to ritual slaughters, is to educate meat buyers about slaughtering practices, so that they insist on the use of low-stress restraining devices (Grandin, 1994).

7. Animal welfare and humane handling

7.1 The link between animal welfare and carcass quality

Animal welfare is not merely a legislative requirement. Farm animals are sentient creatures and humans have a moral and ethical responsibility to treat them humanely when in their care, up to and including the slaughter process. Abattoirs and producers can help minimize the amount of stress on animals prior to slaughtering by creating and maintaining a comfortable, quiet and stress-reduced environment (Grandin, 2005).

Scientific evidence suggests that there is a connection between animal wellbeing, carcass quality and food safety; for example, stress can weaken an animal's immune system (Grandin, 1989). There is evidence that endocrine changes occur when animals are stressed, and prolonged levels of stress can make animals more vulnerable to infectious disease. This may actually place the meat at a greater risk of contamination, impacting food safety of the final product. Poor animal welfare may also lead to a higher incidence of disease and bacterial shedding. Evidence has shown that overcrowding can lead to increased disease transmission within groups of animals. It also suggests that overcapacity and stress caused by various factors can increase the shedding of Escherichia coli in both cattle and pigs. This indicates that reducing stress levels of animals during transportation and prior to slaughter can directly reduce the risk of meat contamination (Grandin, 1989).

Minimising the amount of stress can also help increase carcass and meat quality. The energy required for muscle activity in live animals is obtained from sugars (glycogen) in the muscles. In healthy and well-rested animals, the glycogen content of the muscles is high. After the animal has been slaughtered, the glycogen in muscles is converted into lactic acid, and the muscle and carcass becomes firm (rigor mortis). Lactic acid is necessary to produce flavourful and tender meat of good keeping quality and colour. If the animal is stressed before and during slaughter, its glycogen is used up and the lactic acid level that develops in the meat after slaughter is reduced; this can have serious adverse effects on meat quality (Grandin, 1994).

The links between animal welfare and food safety are now being acknowledged by various government policies and regulations. Some researchers believe it is important to develop animal welfare and food-safety standards to ensure a smoother integration between animal welfare and food safety in the future. The inhumane treatment of animals, whether intentional or not, can occur throughout the slaughter process from the point of receiving live animals to the point of slaughter. While intentional abuse of animals should never be tolerated, most incidents of unintentional abuse can easily be corrected through proper education and training of employees. It is the abattoir owner's responsibility to educate staff about proper, humane handling procedures. Animal welfare and the humane handling of animals should be a priority in any facility (Grandin, 2005).

7.2 Transportation of animals

All animals should be transported in vehicles or containers that are properly designed and maintained to ensure that they do not cause injury or sickness. Animal transportation vehicles should be designed so that:

- There is enough height for animals to stand in a natural position, in appropriate groups, without touching the roof and with adequate spacing between adjacent animals;
- Floors are constructed of non-slip material or evenly covered with straw for secure footing;
- No part of any animal protrudes from the vehicle nor are there any projections within the vehicle that may cause injury; and
- There is sufficient airflow and ventilation, especially in Summer, to prevent suffocation and/or heat stroke and/or frostbite (Grandin, 1989).

The vehicle should also be cleaned and sanitized prior to loading to prevent the spread of disease from previous loads, and to reduce the risk of carcass contamination from debris/dirt deposited into the vehicle from previous loads (Grandin, 1989).

7.3 Handling of live animals at the abattoir

Animal behaviour can be affected by:

- Natural instincts;
- Individual differences; and
- Previous experience (Cattle have a natural propensity toward a more brightly lit area, provided that they are not subjected to glares or shadows. To encourage an animal to move forward, the handler should be familiar with the animals' natural flight zone).

Animal handlers should be calm and patient when moving animals, and allow them time to adjust to the new environment and situation. A handler's impatience is the leading cause of inhumane treatment of farm animals. Their lack of patience can lead to frustration which is often taken out on the animals (Grandin, 1989).

7.4 Pre-slaughtering procedures at the abattoir

Meat-inspection regulations require that animals not be held in a pen for more than 24 hours without adequate feeding, watering and bedding. Watering facilities should be present in all livestock holding pens. Animals awaiting slaughter must have access to cool fluid potable water within a reasonable amount of time, depending on the needs per species of animal and time of the year. In cold weather, heaters must be provided to prevent the drinking-water from freezing. In abattoirs where animals are to be housed for 24 hours, feeding must also be provided. Feed and water withdrawal should be kept to a minimum, and be consistent with good processing practices. When assessing how long an animal has gone without feed or water, transportation time must be taken into account, as extended periods without food and particularly water may also have a negative impact on the quality of the meat produced from these animals (Grandin, 1989).

7.5 Unloading of animals

Animals should be unloaded as soon as possible upon arrival at the abattoir. To ensure a smooth transition for the animals and prevent unnecessary delays, farmers and/or truckers should consult with the abattoir operator to schedule their deliveries timeously.

To facilitate humane handling and minimize the chance of animals being injured during unloading, the abattoir must:

- Provide immediate shelter for all animals arriving for slaughter;

- Accommodate safe unloading of different species of animals of variable ages and weights;
- Provide separate space for animals that are injured during transportation;
- Ensure injured animals are handled with extra care and given more time to unload to prevent further injury,
- Ensure that defective animals that cannot be moved in a conscious state without causing additional suffering are dealt with on the vehicle and not forced off; and
- Ensure that after unloading, sick animals are segregated from other animals and tagged (Grandin, 1989).

8. Dark cutting beef

8.1 Management of cattle to reduce dark cutting beef

The first step in managing cattle to reduce the incidence of producing dark cuts of meat, is to maximize the level of glycogen in the animals' muscles. High blood glycogen enables a beef animal to better protect itself when exposed to the effects of stress. The nutrition of the animal determines the level of glycogen in the muscles, which acts as an energy storage bank. The higher the metabolic energy intake of the animal (through feeding), the higher potential the animal has to store glycogen (Prior *et al*, 1977).

There are many different factors (from the paddock to the slaughter floor) which may cause stress and deplete body glycogen. Therefore, the severity of these stressors is directly related to the management of cattle. Livestock handling is a major cause of muscle glycogen depletion. During normal handling, cattle experience two forms of stress:

- Psychological stress (restraint, handling or novelty); and
- Physical stress (hunger, thirst, fatigue, injury, illness, and extremes in temperature).

By managing the process from the paddock to the slaughter ground well, producers can minimize the level of stress experienced by the animal (Prior *et al*, 1977).

8.2 Avoiding social regrouping or mob mixing of animals

Mixing mobs of animals, or social regrouping presents a major stress factor for cattle. Cattle form tight social bonds within a group or a mob. Mixing mobs or introducing a small number of animals to a mob close to slaughter time greatly increases the risk of producing dark cuts of beef. Social regrouping causes physical and psychological stress to an animal. In most instances, an increase in activities may cause a rapid decline in muscle glycogen. These activities may include fighting which causes injuries, and internal bleeding resulting in bruising, so that those activities can establish social dominance, mounting, mock fighting and chin resting (Phillips, 1993).

8.3 Safe transportation of stock

There is no magic formula for predicting the effect of transportation on animals. Neither the distance travelled nor the time in transit can be used to predict the final pH level of the carcass. Transporting stock on rough roads can increase stress, therefore increasing carcass condemnations post mortem as the meat will not be normal. To minimize stress, farmers should take stock to their final destination via the shortest, smoothest routes, and avoid travelling in severe hot or cold weather conditions (Grandin, 1989).

8.4 Avoiding feeding of animals

Starving cattle shows a gradual decline in muscle glycogen levels. Providing some form of fibrous food, such as hay, before dispatch can assist in slowing the animal's rate of digestion (Grandin, 1989).

9. Ante-mortem/ pre-slaughter inspections at the abattoir

In order to obtain the maximum benefit during slaughter, a properly-conducted, thorough inspection is essential. It is the plant management's responsibility to ensure that only those animals that have received ante-mortem inspection, as required under the regulations, are permitted to proceed to the slaughter floor.

Ante-mortem inspection serves the following purpose:

- Identifying animals that show clear evidence of being infected with a disease or condition that could render the carcass unfit for human consumption. This aspect is extremely important in that clinical signs that are detectable in ante-mortem inspection may not be reflected in obvious macroscopic evidence in post-mortem inspection. Therefore, the disease or condition could remain undetected. This is also important as it permits the interception of diseased animals which, if permitted to enter the slaughterhouse floor, could be responsible for contamination of facilities and equipment (Clark, 1993).

- Separating infected animals and slaughtering them separately. Ante-mortem inspection also serves as an adjunct to post-mortem inspection, and enables the veterinarian to carry out his or her disposition based on scientific information.

- Identifying animals which could pose a threat to the health of the personnel who handle the carcass.

- Identifying animals that are suspected of containing chemical residues after having been treated with veterinary drugs such as antibiotics.

- Identifying diseased animals that may have been shipped for slaughter along with other members of the same flock or herd. In this instance, it enables the personnel conducting post-mortem inspections to be alert to the possible existence of the same disease in other members of the herd or flock.

- Identifying heavily contaminated animals. This enables early action to be taken to resolve potential problems associated with this contamination in the slaughter and dressing processes.
- Identifying animals that are suspected of having a reportable or exotic disease.

- Making a disposition regarding the suitability of animals for slaughter.

- Identifying animals requiring delicate handling for humanitarian reasons.
  It may therefore be perceived that ante-mortem inspection findings can play an important part in influencing opinions and actions in later operations. In order for this to happen, it is essential that there is a good system of communication for relaying information, to inspection-staff conducting post-mortem inspections, obtained in ante-mortem inspections (Clark, 1993).

The United States Department of Agriculture (USDA) indicated that, Westland issued the largest beef recall in history (143 million pounds of meat and now recalls have been issued for retail food; items containing traces of banned food). In 2004, the USDA tightened regulations to prohibit the slaughter of all “downer” cows, [animals that cannot stand (non-ambulatory)] after a case of Bovine Spongiform Encephalopathy (BSE), or Mad Cow Disease, was discovered in Washington State. Following this discovery, the United States Department of Agricultural Food Safety and Inspection Services, prohibited the slaughter of cattle that were unable to stand or walk when presented for pre-slaughter inspection (Taylor, 2008).

The inability of cattle to stand or walk may be a clinical sign of BSE. The New York Times recently reported that though the disease is extremely rare in the USA, of the 15 cases documented in North America (most of them in Canada) the major cause of BSE has been traced to “downer” cattle. BSE could be a reasonable motivation to keep defective animals out of the slaughter process (Taylor, 2008).

Another positive effect of the 2004 incomplete “downer” ban was that it could reduce other illnesses as well. A USDA study, published in August 2004, found that “downer” cows had three times more deadly Escherichia coli 0157: H7 bacterium than other cows. Salmonella also seemed to be more prevalent. According to a recent report by the Chicago News Tribune, “downer” cows have typically been milked for several years, leaving their bodies without the muscle, fat and calcium of grazing, well-fed beef cattle. In addition, dairy cows may carry common maladies including mastitis (a bacterial infection of the udder) and foot rot, which they may develop from standing in manure, mud and damp straw (Taylor, 2008). This is an indication that many of the diseases or conditions found should be managed properly to avoid loss of production, and ultimately loss of profit.

The long-awaited USDA Inspector General’s report on humane treatment of non-ambulatory animals, at the Westland/Hallmark meat-packing company, was published. It revealed a weakness in the USDA’s enforcement of humane handling at cull cow plants. It also displayed the USDA’s inability to verify that specified risk material was handed in compliance with agency regulations. The USDA agreed to adopt recommendations made in the Inspector General Report (Schuff, 2008).

The audit focused on what had gone wrong with the USDA's pre-slaughter inspection of animals at the Westland plant in China. An undercover video, taken at the plant years before by the Humane Society of the United States investigator, exhibited the abuse of non-ambulatory animals. This led to outrage from the cattle industry and the general public. The USDA's Food Safety and Inspection Services' performance at Westland and ten other cull cow plants were studied as part of the audit. The Inspector General's report concluded that:

- The Food Safety and Inspection Service (FSIS) could not demonstrate that the resources assigned to its offline inspection (such as inspection of live animals pre-slaughter) were sufficient to adequately perform the task assigned.
- The FSIS did not have a formal, structured developmental programme and system in place to ensure that all its inspection and supervisory staff received both formal and on-the-job training for mission critical functions (Schuff, 2008).

These have been identified as serious shortcomings in the deployment of FSIS personnel, proper training and utilization and adequacy of the USDA food safety budget resources. The Inspector General's investigation determined that there were "deliberate actions by Westland personnel to bypass required inspections, as well as non-compliance with required inspections procedure by the FSIS inspections and in plant staff " (Schuff, 2008). It has become clear that the USDA's optimistic assumption regarding the effectiveness of both ante-mortem inspection and SRM removal to protect human health from higher risk Canadian cattle are baseless, as is the agency's understated risk of BSE spreading (Taylor, 2008).

R-CALF Chief Executive Officer, Bill Bullard, said that the R-CALF statement issued on December 6 about 1.4 million Canadian cattle that were imported into the USA was exceptional. This includes almost 190 000 older cows and bulls that were imported for slaughter in USA facilities. These older Canadian cattle were known to present a higher risk of BSE as they were part of the same Canadian cattle population in which nine of Canada's 16 BSE cases were detected (Schuff, 2008).

In America, the beef industry is undergoing a rapid and dramatic change. Over 20% of the gross return to American agriculture was derived from beef enterprises. This economic impact was further enhanced by income from subsidiary industries, those that engaged in transportation, marketing, feeds, supplies, vaccines, antibiotics, and some financial agencies that survived because of the beef industry. In case of infection, the treatment can be the difference between condemnation and an average market return. In the case of anaplasmosis, some follow the practice of annual blood tests of mature cattle by subsequently inoculating the minority that is negative (Mary & Dyer, 1995).

A series of landmark studies, called the National Beef Quality Audit (NBQA), has taken a closer look at the quality and consistency of production practices. The 1991 NBQA demonstrated that American beef consisted of too much fat, was too tough and too inconsistent to be competitive with pork and poultry in the marketplace. Significant progress has been made by all segments of the beef industry to improve the overall acceptance of beef carcasses that enter the fabrication section of processing facilities (McKenna, Roebert, Bates, Schmidt, Hale, Griffin, Savell, Brooks, Morgan, Montgomery, Belk & Smith, 2000).

The National Beef Quality Audit of 2000 was conducted to assess the current status of the quality and consistency of American-fed steers and heifers. Between May and November 2000, survey teams assessed hide conditions; hide colours were black (45.1%), red (31%), yellow (8%), Holstein (5.7%), gray (4%), white (3.2%), brown (1.7%) and brindle (1.3%). Body parts to be condemned included the liver (30.3%), lungs (13.8%), intestines (11.6%), heads (6.2%), tongues (7%) and carcasses (0.1%).

Evaluation of the carcasses revealed these traits and frequencies: Steer (67.9%), heifer (31.8%), and bullock (0.3%) sex–classes; dark-cutters (2.3%); A (96.6%), B (2.5%), and C or older (0.9%) overall maturities; and native (90.1%), dairy-type (6.9%), *Bos indicus* (3%) breed-types. Mean USDA yield grade traits were USDA yield grade (3.0), carcass weight (356.9), adjusted fat thickness (1.2cm), and longissimus muscle area (84.5cm^2), and kidney, pelvic, and heart fat (2.4%). USDA yield grades were yield grade 1 (12.2%), yield. This information will help the beef industry measure progress compared to the past two surveys and will provide a benchmark for future educational and research activities (McKenna *et al*, 2000).

(There was no South African data available to compare with the above aspects).

10. National beef and carcass quality audit: 2005

10.1 Offal and carcass condemnation

Prevalence rates for the USDA Food Safety and Inspection Services viscera and carcass condemnation were livers (24.7%), lungs (11.5%), tripe (11.6%), heads (6%), tongues (9.7%) and whole carcasses (0%). Liver condemnations were for abscesses (54.2%), flukes (18.5%), animals older than 30 years (0.3%), contamination (6.7%), and other reasons (20.3%). Lung condemnation causes and percentages were: pneumonia (40.6%), contamination (20.5%), abscesses (2.9%), animals older than 30 years (0.4%), and other reasons (35.6%). Tripe condemnation causes and percentages were: abscesses (28.5%), contamination (23.9%), ulcers (2.8%), animals older 30 years (0.8%), and other reasons (43.9%). Head condemnation causes and percentages were: inflamed lymph nodes (19.3%), contamination (9%), animals older than 30 years (3.2%), abscesses (0.4%), and other reasons (68.1%).

Tongue condemnation causes and percentages were: "hair sore" (27.8%), "cactus tongues" (22.5%), inflamed lymph nodes (12.3%), contamination (2.5%), animals older than 30 years (0.3%), and other reasons (34.6%). "Hair sores" are lesions on the surface of the tongue that contain feed and hair particles (Greer, Gill & Dilts, 1994), and "cactus tongue" appears when cactus spines have penetrated the tongue in cattle that have consumed cacti, especially prickly pears. In general, condemnation rates for livers and lungs were numerically less than presented in the NBQA-2000. However, incidence rates for tripe, head, and tongue condemnations were similar to the ones presented in the NBQA-2000; but they were definitely greater than those documented in the NBQA-1991 (Lorenz, Oor & Brown, 1994) and in the NBQA-1995 (Bolenman, Boleman, Morgan, Hale, Griffin, Sawell, Ames, Smith, Tatum, Field, Smith, Gardner, Morgan, Northcutt, Dolezal, Gill & Ray, 1998). (There is currently no published comparative data available for South Africa.)

10.2 Carcass bruising

It was found that 64% of the carcasses had no bruises, 25.8% had just one bruise, 7.4% had two bruises, 1.6% had three bruises, 0.4% had four bruises and none had more than four bruises. Compared to the NBQA-1995 and NBQA-2000 statistics, there was a reduction in bruising incidents (Bolenman, *et al* 1998). The attention paid to the way animals are handled by livestock and meat industries in recent years may have led to the reduced bruising found in the current audit (American Society of Animal Science, 2008). (There is currently no published comparative data available for South Africa.)

11. Harvest floor assessment

11.1. Harvest floor assessment before animal hide removal

50% of the cattle from each production lot were sampled, for a maximum total of 49 330 animals for the harvest floor assessments. Hide colour was classified based on primary visual colour or breed type (black, white, yellow, brindle, red, brown, grey, and Holstein). Animal identification was recorded as follows: no identification, electronic tag, barcode tag, individual visual tag, lot visual tag, metal-clip tag, or other. Prevalance of hide brands was recorded based on location and approximate size. “Butt” brands were those located on the rump and round region; “side” brands were those located on the loin or rib-plate region or both; and “shoulder” brands were located on the shoulder (chuck) or neck region or both. Cattle were assessed visually for the presence of mud or manure based on body location (Hanson, 2000).

11.2. Harvest floor assessment after animal hide removal

Offal (liver, lung, tripe and whole intestinal tract), head, tongue and whole carcasses were evaluated for wholesomeness by the USDA’s Food Safety and Inspection Service personnel. The number of condemnations and the reasons thereof were recorded. Carcass bruises were assessed based on the number, location and the severity of bruises (Hanson, 2000).

11.3 Mud or manure evaluation

Mud or manure is of great concern regarding the contamination of carcasses, especially when it is present on the legs and belly of the animal, where a hide opening may introduce this contamination to the carcass inadvertently. Percentages of animals with or without (including parts that were not visible, mud or manure on specific body locations were: legs (61.4%), belly (55.9%), side (22.6%), and top line (10%). Percentages of cattle with mud or manure were: one location (43.6%), two locations (30.8%), three locations (17.7%), four locations (5%), and five locations (2.9%). Finally, percentages of hide-on cattle with various amounts or severity scores of mud or manure were: none (25.9%), small (56.1%), moderate (14.8%), large (3%), and extreme (0.2%) (Hanson, 2000). (There is currently no published comparative data available for South Africa.)

11.4 Meat Quality

Meat production is actually a sequence that demands intense care in each step. Its production depends on the growth of animals, which is governed by a variety of factors like genetics, sex, nutrition and climatic conditions. These factors do not only affect the growth of the animals, but also influence the nature and amount of various tissues in the carcass and therefore, play an important role in the ultimate quantity and quality production of meat (Shahzad & Sarwar, 2006).

The value of meat is ultimately judged by the degree of acceptability by the consumer. Meat quality is determined by the combination of physical and chemical characteristics that establish its demand from a standpoint of appearance and its ability. Characteristics of good quality meat may include its composition, texture, tenderness, aroma and flavour. Meat palatability is generally referred to as the tenderness, juiciness and flavour of a cooked product. These three characteristics are what consumers desire when ingesting meat, and what the beef industry is trying to supply on a consistent and uniform basis (Shahzad *et al*, 2006).

Post-mortem management is divided in two variables: the rate of cooling and the rate of post-mortem glycolysis. For example, when the cooling rate of a carcass is rapid, the acceleration of glycolysis and early rigor development results in improved tenderness; but when the carcasses are cooled slowly, accelerated glycolysis can result in appreciable toughening. Any effort to improve tenderness must be balanced with efforts to maintain and improve product safety. Existing research information suggests that management of early post-mortem conditions requires simultaneous consideration of cooling and glycolytic rates to produce the desired tenderness of meat. (Shahzad *et al*, 2006)

It was found that today's supermarkets sell beef which is 85-95% lean. A high proportion of this lean product comes from cow/bull meat. A high percentage of 100% visual lean ends up in restructured products that are sold in sandwiches. Most beef producers do not realize that many sub-primal cuts from cows and bulls are now sold in the same manner as the sub-primal cuts from grain-fed fat cattle. It was found that the carcasses of white or high quality cows have a significant covering of white fat, good body conformation and high muscle quality (Smith, 1973).

During the pre-rigor period there is an increase in membrane permeability that facilitates the movements of ions thereby decreasing the impedance and increasing the conductivity of meat. There is also a transient increase in impedance soon after slaughter. This is probably due to the muscle fibres that initially take up extra-cellular fluid as their internal osmotic pressure rises at the start of post-mortem glycolysis (Swatland, 2000).

An audit of liver condemnation on beef cattle was done at Western United State. Liver condemnation at the slaughter section causes direct economic losses for cattle producers and packers. These condemnations are primarily due to abscesses and liver fluke infections. Liver abscesses account for a few condemnations (approximately 12-32%) of livers of cattle slaughtered in the USA. Liver fluke infection represents 5% of liver condemnations from US-fed cattle (Boleman *et al*, 1998).

It has been almost 20 years since *Escherichia coli* outbreaks were first documented and most have involved hamburger or ground meat products (Boleman, *et al* 1998). In 1992, two outbreaks of haemorrhagic colitis (bloody diarrhea and abdominal cramps without fever) occurred in consumers of beef patties (Cassin, Lammerding and Toddle, 1988). In chain food restaurants in Michigan and Oregon, four people in Montreal and Quebec, and 33 in Nepean and Ontario suffered from the diseases after eating hamburgers in a fast-food facility (Lorenz *et al*, 1994).

The first fatality associated with pathogens occurred when four residents were hospitalized and one died. In 1993, a major cause of haemolytic urenic syndrome was linked to verocytotoxins, also known as shiga toxins. (Siegler, Griffin & Barrent, 1993) It was found that certain diarrheagenic *Escherichia coli* can produce a cytotoxin capable of killing vero cells and this became known as verotoxin or verocytotoxins. Verocytotoxins producing *Escherichia coli* became nationally recognized in 1990 with an incidence of infections. (Konomakhuk, Speirs & Stavric, 1997).

The illnesses and deaths that occurred in the USA, due to beef infection changed American policies towards disease. In 1994, the Food Safety and Inspection Services and the USDA declared that ground beef with *Escherichia coli* is harmful, and must be further processed to kill the pathogen, or be destroyed. This was the first time the presence of bacteria in raw meat products was defined as an adulterant. The President of National Food Safety intimated that there should be more surveillance, research and control procedures for food-borne pathogens (Cassin *et al*. 1988).

12. Animal diseases that cause carcass condemnations

12.1 Bovine respiratory diseases

Studies show that 65% of disease-associated losses in the feedlot are due to Bovine Respiratory Disease Complex (BRDC). The percentage of cattle that get sick varies between 0 and 100%, with mortalities ranging from 0 to 35% or higher. Respiratory disease is "shipping fever", and similar conditions can occur at any time during the feedlot period, but the highest incidence occurs during the first 28 days in the feedlot. Many cases of “sudden-death syndrome” can actually be attributed to pneumonia that is easily diagnosed when examination is performed. Costs of BRDC vary significantly. The effect of BRDC on feed efficiency is difficult to monitor because cattle are fed in individual pens. Lung infections due to respiratory diseases present a major cause of lung condemnations at abattoirs and this represents a major economic loss since lungs are an important part of the fifth quarter.

Bovine Respiratory Disease is caused by a complex interaction of animals, environmental factors and stress; it is commonly summarised as follows: stress + virus + bacteria = BRDC. Stress is more difficult to define, but from a cattle health perspective, stress is often the result of changing conditions. Changing conditions include alterations in:

- Diet;
- Environment;
- Air-quality factors;
- Fatigue;
- Pain;
- Fear and excitement;
- Confinement;
- A lack of access to water;
- Rapid diet change;
- Acidosis;
- Mud;
- Heat and
- Dust

(Faber, Hartwig, Busby & Bredahl, 1999)

Major bacterial pathogens include:

- *Pasteurella haemalytica*: a common cause of fibrinous pneumonia, which is a major target of antibiotic therapy in many episodes of bovine respiratory diseases. It is the first bacterial organism to invade the lungs after viral infections have been established.
- *Pasteurella multocida*: invades and causes pneumonia.
- *Haemophilus somnus*: causes pneumonia and infects the central nervous system (Faber *et al*, 1999).

12.2 Brucellosis

It is very unlikely that animals affected with brucellosis will be recognized through clinical signs or post-mortem lesions. The only evidence of brucellosis is in animals licensed to be slaughtered by the Animal Health Division. Contact with these slaughtered animals was identified as dangerous because of the serious injurious consequences they could cause to the personnel that handled carcasses.

12.3 Trichnosis

In the event that trichina is uncovered, through trichinoscopic examination, at the abattoir, the infected carcass should be confined and condemned after laboratory confirmation.

12.4 Tuberculosis

Meat inspection systems play a very important role in the eradication programme for bovine tuberculosis. All granulomas and any tuberculosis-like lesions found elsewhere in the bovine carcass, including single mesenteric lesions, must be forwarded for laboratory analysis. It is imperative that all forms of identification associated with carcasses bearing these lesions be recorded on the HA831 to facilitate herd trace backs. (www.inspection.gc.ca/English/anim/meavia/mmopnnhv/chap9/9.1)

The above diseases are some of those diagnosed in the abattoir that can lead to carcass condemnations resulting in a loss of production and eventually loss of profit.

Successful treatment of diseases involves recognition of sick animals, diagnosis; appropriate therapy, conducting follow-up checks, and accurate appropriate record-keeping. Clinical signs of disease include depression (head down, slow gait), gaunt appearance, reduced appetite, nasal discharge, rapid respiration, and fever.

It is obvious, that in order to reduce the morbidity and mortality associated with diseases, exposure and resistance to infectious organisms must be minimized. Treatment of internal and external parasites should be implemented. Castration and dehorning should be carried out, if not previously done.

Carcass condemnation, trimming of lesions, abscesses, adhesion and systemic effective infection, potential for drug residues, and injection site lesions are all important issues that arise as a result of disease.

Other key points to keep in mind on this subject include:

- Injection technique: Use only one needle of appropriate gauge at least 1-inch long. Make sure needles are discarded when they become dull, bent or damaged; no injection should ever be made into the hip or rear leg area, directions should be followed when using pharmaceuticals or vaccines; injection equipment (syringes, needles and other equipment) should be sterilized; any disinfectants, including alcohol, if used, must be thoroughly rinsed from equipment.
- Drug residue avoidance: Observe label directions and withdrawal times carefully.
- Drug and vaccine storage: purchase new vaccines and store them in a refrigerator; drugs should be stored in a cool, dry area.
- Records: Consistent accurate records should be kept of all treatments and vaccinations. These should include the date, product used, dosage, route of admiration and withdrawal date. These records are useful when analysing disease and implementing strategies.

  (www.inspection.gc.ca/English/anim/meavia/mmopnnhv/chap9/9.1)

With reference to comparisons of quality parameters of beef from cattle that were conventionally fattened compared to cattle produced in free-range conditions, researchers concluded that it was doubtful that the small differences in beef quality observed were related to husbandry practices. Interactions between pre-slaughter handling of steers, and low voltage electrical stimulation of the carcasses were studied, as they affected beef quality. It was concluded that:

- The stress from trucking a relatively short distance, and a 24-hour fast prior to slaughter was sufficient to slow down the rate of post-mortem pH decline and avoid toughening of the beef; and
- Steers kept on feed until slaughter had a sufficiently rapid rate of glycolysis so that low voltage electrical stimulation of the carcass was not necessary to increase the rate of post-mortem decline therefore, and avoid toughening of the beef.

Microbiological surveys conducted on beef carcasses and ground beef in slaughter and processing plants have shown that very few carcasses are contaminated. Long-term prevention strategies are being developed and implemented by beef producers, processors and retailers. The Hazard Analysis Critical Control Point system (HACCP) is a means for developing food safety programmes. This system consists of identifying hazards that can create food safety problems and developing steps to prevent, control or eliminate these hazards in each phase of the food production process.

Pre-operational inspection is a very important aspect of this. This involves inspection of every room and area in which animals are slaughtered, carcasses being dressed or meat products prepared for human consumption or animal food, being carried out in registered establishments and domestic plants on a daily basis. The purpose of such inspections is to examine the production facilities, including all equipment, and to determine if the clean-up and maintenance procedures are carried out in a satisfactory manner.

The pre-operational inspection is an essential part of the quality control programme in all slaughter and processing establishments. Plant management is responsible for all aspects of quality control including the pre-operational inspection of all production areas and equipment within the establishment. It is the inspectors' duty to monitor the effectiveness of the pre-operational inspections carried out by plant management. Inspectors should regularly carry out monitoring of effectiveness of pre-operational inspection especially of complex equipment and other critical meat contact surface. Plants with less than satisfactory records should be monitored frequently.

It is the responsibility of inspectors to ensure that slaughter personnel are dressed appropriately and follow hygiene procedures. Any unsatisfactory clean-up or lack of maintenance should be immediately brought to the attention of plant management for correction. The slaughter of food animals, the dressing of carcasses and the processing of meat products should not commence in any room or area in the registered establishment until appropriate and adequate sanitary conditions exist. The state of cleanliness of work clothes and cleanliness of personal working equipment such as knives, scabbards, hooks, mesh gloves and aprons is also important. Room temperatures and ventilation must be closely monitored. Plant employees who carry out pre-operational inspection and inspectors who monitor such inspections should use their training and experience as well as their senses of sight, smell and touch to determine the effectiveness of the clean-up.

The following may be used as a guide in carrying out pre-operational inspection or monitoring of such inspection:

- Inspect all meat contact surfaces for cleanliness:
  - ✓ Complex equipment must be inspected before it is assembled.
  - ✓ Conveyer belts and scrapers - often installed in connection with such belts, pipelines used for conveying meat, etc, must be inspected.
  - ✓ Small tools such as knives and hooks, as well as protective equipment such as gloves, aprons etc, must be inspected.
  - ✓ Flashlights (torches) should be used when inspecting grinders, emulsifier, suffers and other complex equipment.
  - ✓ Areas of equipment and facilities that do not come into contact with meat product must be inspected for cleanliness, e.g. underside of equipment, ceilings, walls, floors, overhead rails and equipment frames.

- ✓ Personnel should lift drain covers, check hand-washing facilities, sanitizers etc., and confirm that hand-washing facilities are functional and supplied with soap, towels and waste containers (disposal bins).
- ✓ Potential sources of condemnation located above meat products are generally more critical because of the possibility of contaminants falling onto the product. Walls, floors, undersides of equipment etc., pose less of a threat.

- Inspect equipment and facilities for their state of maintenance. Any cracks, peeling paint, rust and loss of galvanization, and any other wear and tear can best be seen during the pre-operational inspection. This is due to the absence of meat products, and because equipment is not in motion and cannot therefore be carefully observed. Pre-operational inspection can divulge actual and potential problems.
- Check temperatures of production areas and sanitizers:
  - ✓ Ventilation and air flow in production areas should be observed.
  - ✓ Air should not be flowing from relatively contaminated areas to cleaner areas (livestock holding areas to kill floor or kill floor to meat processing areas).
  - ✓ All pieces of equipment should be covered with protective mineral oil after cleaning.

The Food Safety and Inspection Services of the USA and the Department of Agriculture has established new requirements for slaughter and processing plants. Plants are required to adopt and implement HACCP systems over a three-year period. Large plants are required to have such a programme in place. De-contamination processes have been developed for beef carcasses, and are being established in beef processing plants. This process includes carcass washing with organic acid, steam vacuuming, steam pasteurization and the use of antimicrobial agents such as chlorinated water. One or more methods to reduce microbial contamination are used on the majority of beef carcasses. The problem of microbial safety of beef is contamination that may occur during slaughter (Bogh-Sorensen, 1980).

Slaughter and processing procedures can also enhance cross-contamination from the hide, gastrointestinal tract and other surfaces of the animal during slaughter and dressing. At the slaughter and processing plant, official meat inspection procedures are inadequate to deal with the hazard of human pathogens in the gut of healthy animals. To minimize public health hazards from these pathogens, it is necessary to involve industry in a process of pathogen reduction (Bogh-Sorensen, 1980).

Meat industries in developed countries are committed to producing high quality, wholesome products to maintain consumer confidence. HACCP systems with examinations especially at critical points throughout the slaughter procedure are increasingly applied to replace or supplement traditional meat inspection and end-point sampling. Various studies have indicated that the temperatures of raw beef meat and other chilled foods are less well-controlled during retail display than at other stages of their distribution. (Bogh-Sorensen, 1980) Despite the recognized need for good temperature-control of displayed meat, little improvement appears to have occurred within 20 years up to the mid-1990s (James, 1996).

In Canada, the temperatures determined for displayed meat in 1994 were similar to those found in 1978 (Greer *et al*, 1994), However the latter study involved only a few display cases. Moreover, growing concerns in recent years, about the microbiological safety of raw beef and other meats may have prompted retailers to actions aimed at the improvement of control over the temperatures of displayed products. Therefore, a study was undertaken to better define temperatures currently experienced by retail packs of beef that are displayed in retail stores in Canada, as well as to identify the amount of time that beef remains on retail display at these stores (Likes, 1996).

A stochastic stimulation model was used to assess the benefit of measures implemented in the pre-slaughter period aimed at reducing the contamination of beef carcasses with Shigella-like toxin-producing *Escherichia coli*. The scenario studied was based on an abattoir processing 1 000 heads of lot-fed cattle per day. Input assumptions were described using probability distributions to reflect uncertainty in their values. Control measures that were assessed were based either on a reduction in herd prevalence of infection, reduction in opportunity for cross-contamination in the processing plant by re-ordering of the slaughter queue, reduction of concentration of *Escherichia coli* in fresh faeces, or a reduction in the amount of faeces, mud and bedding transferred from the hide to the carcass. Some control measures evaluated were hypothetical in nature, and were included to assist with the planning of research priorities (Dargartz, Wells, Thomas, Hancock & Garber, 1997).

Simulations suggested that the greatest potential impact is associated with vaccination and with an agent that reduces shedding *Escherichia coli* in faeces. Knowledge of herd-tests obtained by testing a sample of animals from the herd, provides only a minor advantage in control programmes, although the application of a rapid test on all animals in all lots might be of some benefit. In most scenarios, there is ample opportunity for cross-contamination to occur within the slaughter plant as a result of early entry of cattle contaminated with *Escherichia coli* (Dargartz *et al*, 1997).

An industry-wide reduction in the amount of tags attached to hides and addition of a source of cattle having a prolonged average fasting time were not predicted to have a large impact on mean amount of carcasses contamination with *Escherichia coli*. *Escherichia coli* occur in the gut of healthy cattle and are a well-known cause of enteric illnesses in humans. Serotypes expressing the H7 flagella antigen are usually the focus of research – since the H-antigen type is not regarded as a good indicator of human pathogenicity (Dargartz *et al*, 1997). It is more useful from the perspective of population studies to refer to the collective group of all *Escherichia coli* regardless of the H-antigen type (Hancock, Rice, Thomas, Dargartz & Besser, 1997).

Escherichia coli are widespread in cattle populations, but are generally at a low prevalence (Armstrong, Hollingsworth & Morris, 1996), because carcasses are often contaminated by faecal micro flora during slaughter. It is inevitable that some of this contamination includes *Escherichia coli*. Cross-contamination becomes possible with further processing and handling of carcasses. Large quantities of product can become tainted particularly when there is pooling of raw ingredients from multiple sources (as happens in the manufacture of comminute meat products, e.g. hamburger patties, fermented sausage) (Armstrong *et al.* 1996).

The organism may multiply in beef products if it is subjected to atypical temperatures during storage. Ordinarily, the health risk due to *Escherichia coli* is contained by hygienic processing, persistently low storage temperatures, and by adequate cooking of meats (Armstrong *et al.* 1996). Occasionally, these precautions are not observed or fail leading to problems ranging from sporadic cases of illness to large-scale outbreaks. The occasional failure of post-slaughter controls has encouraged a belief that there should be greater emphasis on prevention during the pre-slaughter phase of meat production. This was the conclusion reached in reviews of large outbreaks of *Escherichia coli*-related illnesses in the USA and Scotland (Pennington Group, 1997). Attempts to minimize the entry of faecal pathogens into the food chain have traditionally been based on inspection of carcasses in abattoirs for visible evidence of faecal contamination. These practices are regarded as too insensitive to adequately protect consumers from illness, and there is a need for a new system of control (Berends, Snijders & Van Logtestijn, 1993). Recommendations have focused on a vertically intergraded approach to safety, such as that prescribed by the Hazard Analysis and Critical Control Point system where control is exerted at all stages of beef production (Baird-Parker, 1994).

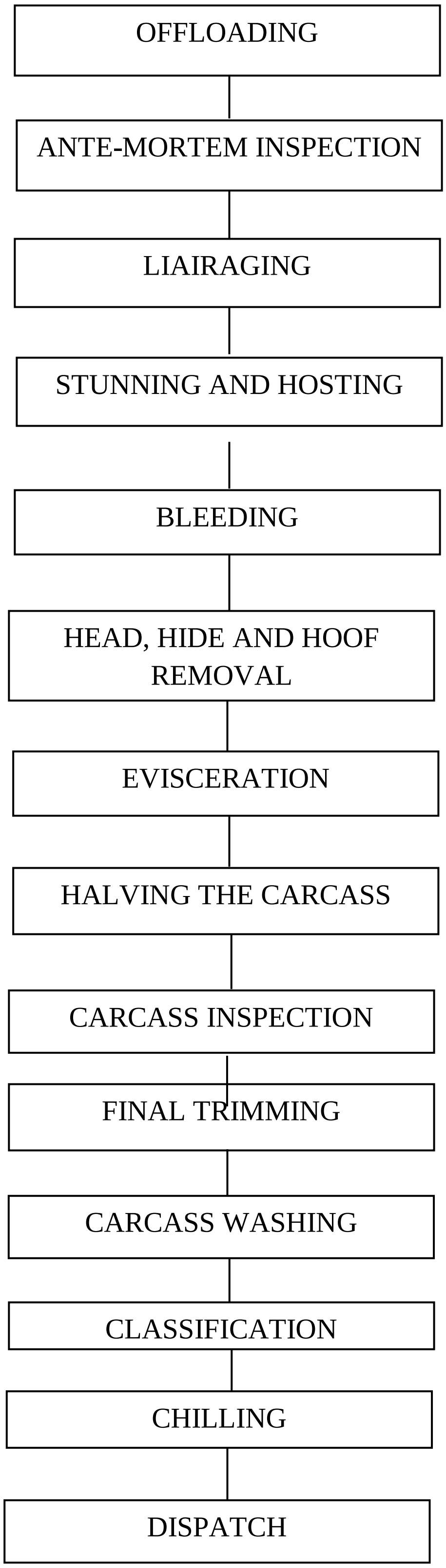
13. The abattoir

An abattoir is a slaughter facility at which animals are slaughtered or intended to be slaughtered. This includes areas in adjacent to such facilities, which will be where carcasses are chilled or meat or animal products are handled (Meat Safety Act 40 of 2000).

13.1. Animal slaughter process

The slaughtering process is defined as killing an animal (and the performance of the usual accompanying acts in connection therewith), in order to obtain meat and animal products (Bekker, 1998).

13.2 Sequence of animal slaughter operations



(Reviewed by www.rmaa.co.za, 15 November 2004)

14. Dubai animal slaughter procedure

In Dubai, the idea of an establishment of abattoirs was raised in 1984. The municipality of Dubai requested the United Nations Development Programme (UNDP), to send abattoir experts to prepare the required preliminary studies at a modern abattoir containing sophisticated equipment in the field of animal slaughtering, carcass and meat preparation to meet the public demand for meat. Abattoirs in Dubai ensure that livestock slaughtering operations are done under direct supervision of qualified veterinary doctors and in accordance with Islamic Shariah. In 2007, Dubai abattoirs were certified for ISO 9001:2000 (quality management system), ISO 14001:2004 (environmental management system), and ISO 18001 (health and safety system). (www.dubaimun.com, 2009).

All slaughter operations lie under direct supervision of qualified veterinarians to ensure that all animals delivered to the abattoir are inspected before and after slaughter; diseased animals are condemned. Abattoirs implemented hygiene programmes to ensure efficient control over slaughter operation procedures. The level of cleanliness at this abattoir was equal to the best abattoirs in most advanced countries. The slaughter halls, tools and equipment were always kept sanitized and disinfected. Slaughter tools and equipment were continuously sterilized before, during and after slaughtering was completed, while microbiological tests were conducted in the abattoir laboratory, samples taken from meat surfaces, meat cut, equipment, flat surfaces, water and checked microscopically to ensure that they were not contaminated.

Animals from trades and companies were held for 18-24 days while those from their feedlots were kept for 18-24 hours before being presented for slaughtering and after being inspected by a qualified veterinary doctor. After the whole process carcasses were kept inside the chiller at 4° C to prevent microbial growth. After the carcass passed the post-mortem inspection and the meat was deemed fit for human consumption, it was stamped with the abattoir official stamp for traders and companies (www.dubaimun.com, 2009).

14.1 Educational and awareness campaign on food safety and animal slaughter

The Dubai abattoir section aims to increase public awareness about the importance of abattoirs and widespread risk of animal disease. The abattoir section is implementing an education campaign in cooperation with the public relation section.

It includes the following:

- Arranging seminar and lectures in cooperation with public health services section in rural areas about the importance of the abattoirs and the risk of slaughtering outside the abattoirs;
- Public health and scientific articles about disease and meat production in local newspapers and magazines in Arabic and English;
- Printing scientific posters in Arabic and English; and
- Inviting school students to visit the abattoir and familiarizing them with its activities.

14.2 Risks associated with slaughtering cattle outside the abattoir

Slaughtering outside the abattoir exposes families to the risk of health problems due to:

- Absence of ante-mortem and post-mortem inspection;
- Inadequate cleaning, sanitation and hygiene practiced where animals are slaughtered allow rapid microbial growth, and leading to contamination of carcasses and meat;
- Illegal butchers not medically certified and maintaining poor personal cleanliness and behaviour likely to cause cross contamination; and
- Improper disposal of byproducts from slaughtering operations posing high risks to public health (www.dubaimun.com, 2009).

15. Methods used for killing and bleeding animals

It is very important to sterilize knives at 82° C in between cuts of different animals (www.rmaa.co.za, November 2005: Meat Safety Act 40 of 2000). Bovine respiratory tracts were examined for blood following shechita without stunning, hold slaughter without stunning, and captive bolts stunning with sticking. In all three methods the cattle were in the upright (standing) position at the start of bleeding. Those that had not been stunned continued to breathe during the early part of bleeding whilst those that were stunned were not breathing. 19% of the shechita, 58% of Halaal and 21% of the stunned plus stuck cattle had a lining of blood on the inner aspect of the trachea. 36%, 69% and 31% had blood in the upper bronchi, respectively.

It was concluded that concerns about suffering from airway irritation by blood could apply, and that cattle are either not stunned before slaughter or do not lose consciousness rapidly enough, and blood is present in the respiratory tract (www.rmaa.co.za: November 2005: Meat Safety Act 2000:18).

15.1 Animal skinning and deheading

Machines or knives are used for skinning and deheading. This means that the skin and the head are completely removed by trained personnel without damaging the carcass or contaminating the meat.

16. Carcass contamination

Contamination is the effect exerted by an external agent on food so that it does not meet food hygiene standards or consumer norms and standards and is therefore deemed unfit for human consumption.

16.1 Contamination on live slaughter animals

Animals are examined at the abattoir. This is the first opportunity to recognize animals that may act as a potential source of contamination, or those suspected of being infected by a disease as well as injured animals, therefore eliminating them from slaughter. If the slaughter is not done within 24 hours, the examination must be repeated (Van der Walt, 2005).

The surfaces of healthy live animals are naturally contaminated with a large number (organisms per cm^2 of hide) of organisms of many varieties. Slaughter stocks are therefore a major source of carcass contamination. Soil (ground) is also a major source of micro-organisms and has a comparable amount (10^7) of bacteria per gram of soil. Faeces are about 100 times more contaminated and have an aerobic plate count and coliforms of about nine to ten per gram of faeces (reviewed by the National Department of Agriculture, February 2005).

It can therefore be concluded that all of these serve as a source of microbial contamination of meat. Skinning and evisceration is a major site of contamination. If these procedures are conducted in the correct manner, the degree of contamination can be reduced.

16.2 Contamination during animal slaughter

The instruments used in dressing and killing (such as knives, saws, etc.) may act as a source of contamination during slaughter. Hygiene practices, including frequent hand-washing and knife sterilization, must be followed by the removal of the hide. Contact between the carcass and the hide must be prevented. Dirty hand, hooks, rollers, and protective clothing can contaminate the carcasses while removing the hide and this must be prevented at all costs. (Van Der Walt, 2005)

17. Carcass condemnation

17.1 Prevention of carcass condemnation

Prevention of drug residues and injection-site lesions should be implemented by ensuring proper administration and observance of meat withdrawal times for all animal health products. The following guidelines should be taken into account:

- Don’t market treated animals before the drug-withdrawal time for meat has expired;
- Don’t market significantly lame cattle;
- Don’t market animals that are emaciated;
- Do cull disabled cattle and those with advanced terminal conditions;
- Do market animals with physical disorders in a timely way to avoid condemnations; and
- Do improve beef safety by implementing practices that reduce bacteria.

17.2 Prevention of carcass bruising

In order to prevent bruising, the following should be kept in mind:

- Dehorn cattle at an early age;
- Correct deficiencies in facilities and transportation equipment; and
- Use proper cattle-handling techniques.

18. Animal hide damage

The following should be kept in mind to avoid hide damage:

- Use external parasite (lice, grub, etc.) control practices; and
- Use proper approved branding methods or permanent identification alternatives.

19. Primary inspection on carcasses at the abattoir

The purpose of primary meat inspection is to identify abnormalities and to detain such carcasses or organs for secondary meat inspection. Carcasses that are normally marked with "passed" stamps; this is done by a meat inspector to make sure that the product is not dangerous for human consumption, but will be beneficial. The inspector oversees the whole process of slaughter to ensure it will run smoothly. Conditions that are considered during post-mortem inspections of beef carcasses in South Africa are summarised in Table 19.1.

Table 19.1

Conditions considered during routine inspection of beef carcasses in South African abattoirs

The carcass	• Abscesses. • Icterus. • Immaturity. • Omphalophlebitis. • Arthritis. • Measles. • Blood splashing. • Tuberculosis. • Bruising. • Emaciation. • Oedema. • Soiling. • Fever. • Septicaemia. • Gangrene. • Lymphadenitis. • Melanosis. • Melanoma. • Parafilaria. • Pleuritis and peritonitis. • Pyemia.
The head	• Abscesses. • Tuberculosis. • Soiling. • Actinomicosis. • Measles.
The limbs	• Arthritis. • Abscesses.

	• Bruising.
The lungs	• Abscesses. • Pneumonia. • Pleuritis. • Melanosis. • Rumen contents aspiration. • Tuberculosis. • Echinococcus cysts. • Emphysema.
The heart	• Pericarditis. • Epicarditis. • Measles. • Blood splashes. • Measles.
The liver	• Abscesses. • Fasciolae. • Telangiectasis.
The kidneys	• Nephritis. • Hydronephrosis.
The spleen	• Infarcts. • Splenomegaly.
The stomach	• Peritonitis.
The intestines	• Tuberculosis. • Enteritis. • Peritonitis. • Tenuicollis.
The reproductive organs	• Metritis. • Mastitis.

19.2 Personal hygiene

The following precautions should be taken when handling meat/carcasses:

- Keep fingernails and hair short and use gloves and hair-nets.
- Hands and arms should be thoroughly and frequently washed with soap and warm water.
- Wash hands immediately after using the toilet.
- Wash hands immediately after contact with diseased meat, offal, blood or dirt and use protective clothing, changing contaminated clothing when necessary.
- Cover cuts and abrasions with waterproof dressings and protective gloves.
- Do not pick your nose.
- Never cough or sneeze near meat – always use clean handkerchiefs and face-masks.
- Do not spit anywhere in the abattoir.
- Do not use tobacco, take snuff or eat in any area where meat and meat products are handled.
- Take daily showers.
- Be neat and tidy at all times.

As a general rule, it is recommended that: people who are suffering from contagious diseases or are carriers of an infectious condition, or who have even been in contact with a source of contagion, should not work in any part of the abattoir where edible products are handled. This includes slaughter area, rough offal area, processing area, storage facilities, cold storage, deboning areas, offloading areas, etc. Workers with suppurating sores on any part of their heads, necks, arms or hands may not come into contact with edible products (Maja et al, 2007).

19.3 Personal equipment

The following equipment is used during slaughter:

- Knives (two-knife or three-knife system may be used);
- Scabbard with chain;
- Sharpening steel;
- Meat hook; and

- Safety gloves.

20. Secondary inspection on carcasses at the abattoir

All suspicious carcasses marked “detained” are subject to secondary inspection. This is done by a veterinarian in an area isolated for this purpose called the DFI area (Detained for Further Inspection), and it is performed by identifying the following:

- The organs/carcass;
- The species/sex;
- The condition of the carcass; and
- The cause followed by a final judgment.

20.1 Carcass classification

The price of meat is determined by classifying the carcasses, which is done by observing the quality of meat. Carcass classification in South Africa is based on age (dentition), fat code and conformation.

20.2 Carcass washing

This step comes after the final inspection. The carcass is sprayed with cold water to remove all blood, visible soil, slight blood marks, bone dust and marrow (Bekker, 1998), before going to the cold room for chilling. It is generally recommended that only approved, uncontaminated carcasses be washed with running water in order to remove any bone splinters or blood that might be present, thus improving the appearance of the carcass (Crouse *et al,* 1978).

CHAPTER 3

MATERIALS AND METHODS

The study was conducted to investigate the causes and the effects of breed, gender and season on carcass condemnation during post-mortem in a large South African abattoir. The seven breeds used in the study were: Afrikander, Bonsmara, Brahman, Nguni, Hereford, Friesland and Angus. These were grouped according to gender, that is, male and female. Seasonal evaluation was confined Autumn, Winter, Summer and Spring pulled together as it was not easy to distinguish between the two in 2010. The study design included the interactions between the seven breeds, two genders and three seasons. The nine condemnation conditions evaluated (as sufficient data was available), from the 18 measured were: Parafilaria, bruising, soiling, fever, peritonitis and pleuritis, abscesses, measles, oedema, intramuscular haemorrhage. A pneumatic stunner was used with a backup of a stun gun during slaughter. Daily inspections and observations of carcasses were performed, and diseases/conditions diagnosed and the incidences were recorded. PROC CATMOD of SAS® V9.2 under Windows XP (SP3) was employed to perform a Generalised Logistic Regression). The binary response variable was the Presence (value = 1) and Absence (value =2) of the condition. (SAS Institute Inc, 1999).

1. Collection of data

Data was collected in one of the largest grade-A beef abattoirs in South Africa, with the assistance of a trained meat inspector and veterinarian. About 25 590 beef carcasses from different breeds were evaluated during the Autumn Winter, Summer and Spring combined as it was not easy to distinguish between the two of 2010.

The following data was recorded: the number of beef cattle slaughtered per day, date of slaughter including season, breed type, number of bulls and heifers slaughtered, condition and diseases diagnosed.

2. Data analysis

Data was analysed in consultation with the Department of Statistics at the University of Pretoria. PROC CATMOD SAS® V9.2 under Windows XP (SP3) was employed to investigate the Generalized Logistic Regression. The procedure was applied to analyse the data with the model presence of conditions equal to the breed, gender and season, using 42 samples (7 breeds x 2 genders x 3 seasons). The model used in this procedure was based on the presence of conditions = (Intercept) x i x j x k, where i ~ breed, j ~ gender and k ~ season. The binary response variable was the presence (value = 1) and absence (value = 2) of the condition (SAS Institute Inc, 1999).

$$Log(\frac{P}{1-P})_{ijk} = u + a_i + \beta_j + \gamma_k + \varepsilon_{ijk}$$

Where:

P = Probability of the PRESENCE of the $(ijk)^{th}$ level of Condition

μ = Intercept

α_i = i^{th} level of Breed

βj = j^{th} level of Season

γk = k^{th} level of Gender

μ = Intercept

εijk = Error term for the i^{th} level of Breed and j^{th} level of Season and k^{th} level of Gender

Note:

If $Log_{Base} A = x$

then $A = Base^x$

(SAS Institute Inc, 1999)

3. Ante-mortem, techniques, methods, slaughter process and carcass inspection

3.1 Ante-mortem inspection of slaughter animals

On animals' arrival in liairage before proceeding to the abattoir, two meat inspectors and a veterinarian conducted ante-mortem inspections on every bovine that was slaughtered during the research project. Diseases diagnosed during pre-slaughter were recorded and those cattle were handled upon entry into the stunning area as those people who were working there were advised not to handle them roughly as it may lead to stress and eventually unnecessary conditions of prevalence post-mortem.

3.2 Techniques and methods used during animal slaughter

Cattle that went into the stunning area stood in an upright position during slaughter. A pneumatic stunner was used with the backup of a stun gun during slaughter for every animal. The aim of stunning was to render the animal unconscious as soon as possible so as to prevent pain and suffering during the killing process. The person responsible for stunning was standing above and behind the head of the cow. The point of stunning was at an intersection of imaginary lines drawn from the eyes to the horns. The stun gun was pressed against the forehead, angled slightly in the direction of the spine and fired. After stunning, the stunning box was opened to allow the animal to roll out into the dry landing area. After the animal was stunned, it was positioned over the bleeding trough, the bleeding knife was removed from the sterilizer and the bleeding incision was done. Bleeding took 60 seconds.

3.3 Animal slaughter processes at the abattoirs

Deheading and skinning (whereby the head and skin were completely removed) was done and the animal was then eviscerated. This was done by slaughter personnel using a knife.

3.4. Carcass inspection

Primary inspection was conducted by six meat inspectors on a rotational basis so that each could have a one-hour break, keeping their assessments as accurate as possible. Observation of carcasses was done visually and palpation was also done where necessary. Other conditions and diseases were referred for secondary inspection which was conducted by a veterinarian. Some carcasses were partially condemned and some were totally condemned. All prevalances and conditions or diseases diagnosed were recorded daily. The following diseases and conditions were diagnosed during this study:

- Parafilaria: A greenish and watery layer was observed on the surface of carcasses. It was removed with a sharp knife. In other cases the greenish, watery layer was seen deeper on the bones of the carcasses, which were partially or totally condemned. This disease is a nematode infestation of cattle normally characterized by haemorrhages on the skin and damage to the subcutaneous tissue. It is transmitted by flies that become infected when they feed on lesions in cattle and ingest parasite eggs or free larvae.

- Bruising: A discoloration at the site of injury was observed which was bright red and watery. Usually within 24 hours of the incident it became dark red. This is often referred to as a congestion of blood. A carcass that is bruised may be totally or partially condemned. Bruises can be caused by inappropriate handling, improper use of sticks by handlers and violent impact against facilities, equipment or other animals.
- Soiling: Contaminated part of the surface of the carcass was seen caused by faeces during evisceration.
- Fever: The carcass was observed with pink to red swellings of the tissues and with an elevated body temperature which was detected using a thermometer. Furthermore, excessive pinkish-coloured fluid was observed in the joints, blood-stained fluid in the heart, the spleen was enlarged to several times its normal size, the liver was swollen, and the meat appeared darker in colour than usual. Poor out-bleeding was observed, which is a cardinal sign of acute inflammation caused by a noxious agent.
- Peritonitis and pleuritis: Inflammation of the membrane surrounding the lung (pleura) and heart and inner lining of the abdomen (peritoneum) was diagnosed after cutting the carcass longitudinally into two halves. Blood clots were seen as well.
- Abscess: A viscous, cream-coloured fluid with a dry, friable appearance like cottage cheese, and an offensive smell was observed within the areas called abscesses. The abscesses differed in size and were seen in the body of the carcasses, the head, the liver and the tongue. An abscess can be further described as a collection of disintegrated tissue cells. The type of pus in an abscess usually varies in colour, odour and consistency, but is generally encapsulated (separated from surrounding tissue) by a layer of fibrous connective tissue.
- Measles: Visible muscle damage (meat) in a carcass caused by larvae of the tapeworm was observed during incision in specific areas such as the carcass

shoulder and diaphragm, during primary inspection. One or two cysts were diagnosed; the carcass was kept for 72 hours at a temperature of -18° C or ten days at -10° C.

- Oedema: An excessive accumulation of fluids in the intercellular spaces and body cavities was observed during inspection. The surface layer of the meat was watery, probably as a result of malnutrition or internal parasites.
- Intramuscular haemorrhage: These are blood clots observed in the muscle on the surface of the carcass and in the deeper muscle layers during post-mortem.

CHAPTER 4

RESULTS AND DISCUSSION

Carcass condemnations due to parafilaria are summarized in Table 4.1, bruising in Table 4.2, soiling in Table 4.3, fever in Table 4.4, peritonitis and pleuritis in Table 4.5, abscesses in Table 4.6, measles in Table 4.7, oedema in Table 4.8, and intramuscular haemorrhage in Table 4.9. The Maximum Likelihood Analysis of Variance for the presence/absence of parafilaria in different breeds, genders and seasons is presented in Tables 4.1.1, 4.1.2 and 4.1.3, and that for bruising in Tables 4.2.1, 4.2.2 and 4.2.3. Soiling is presented in Tables 4.3.1, 4.3.2 and 4.3.3 and fever in Tables 4.4.1, 4.4.2 and 4.4.3. Peritonitis and pleuritis are presented in Tables 4.5.1, 4.5.2 and 4.5.3, abscesses in Tables 4.6.1, 4.6.2 and 4.6.3, measles in Tables 4.7.1, 4.7.2 and 4.7.3, oedema in Tables 4.8.1, 4.8.2 and 4.8.3, and intramuscular haemorrhage in Tables 4.9.1, 4.9.2 and 4.9.3. Results for Population Profiles determined for parafilaria can be referred to in Appendix 1, bruising in Appendix 2, soiling in Appendix 3, fever in Appendix 4, peritonitis and pleuritis in Appendix 5, abscesses in Appendix 6, measles in Appendix 7, oedema in Appendix 8, and intramuscular haemorrhage in Appendix 9.

4.1. Parafilaria: The effects of breed, gender and season on parafilaria in cattle carcasses

The prevalence of parafilaria in bovine carcasses during the period of study in this particular abattoir was about 0.54%. Overall there were no significant seasonal or gender effects on the prevalence of parafilaria (p=0.8354) in cattle slaughtered at the abattoir. The highest number of cases of parafilaria was recorded in bulls in Summer (n=77) which represented 55.4% of the total number of cases of parafilaria. Only 6.5% of heifers slaughtered were condemned due to parafilaria in Summer. The effects of season and gender on the prevalence of parafilaria in cattle slaughtered at this particular abattoir is summarised in Table 4.1.1.

The prevalence of parafilaria was numerically the highest in Summer, but it did not differ significantly between bulls (62.6%) and heifers (56.3%) in this season (Table 4.1.1). The fewest cases of parafilaria occurred in Winter, but again no differences were observed between bulls (13.01%) and heifers (12.5%) (Table 4.1.1). In Summer it is very hot and generally more humid and such conditions favour parafilaria organisms.

Parafilaria was found in Asia (Philippines, Japan, Russia, and India), Europe (Bulgaria, Romania and France) and in Africa (Morocco, Tunisia, Rwanda, Namibia, Botswana, South Africa and Zimbabwe). Parafilaria has been identified as a source of considerable economic loss to the beef industry in South Africa and Sweden despite the climatic differences between these countries. This disease occurs in the savannah areas in South Africa mostly in Summer as indicated, while in Sweden it has emerged as a problem in cattle following Spring turn out to pasture after Winter housing. (www.merchmanuals.com/vet/integumen)

Table 4.1.1 Frequency distribution of parafilaria based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	77	9	86	
	%	55.40	6.47		61.87
	Row%	89.53	10.47		
	Col%	62.60	56.25		
Autumn	**Freq**	30	5	35	
	%	21.58	3.60		25.18
	Row%	85.71	14.29		
	Col%	24.39	31.25		
Winter	**Freq**	16	2	18	
	%	11.51	1.44		12.95
	Row%	88.89	11.11		
	Col%	13.01	12.50		
Total		123	16	139	
%		88.49	11.51		100

Chi-square statistics for the interaction between season and gender on parafilaria

Statistics	DF	Value	Prob(p<F)
Chi-square	2	0.3597	0.8354
Likelihood Ratio - Chi-Square	2	0.3458	0.8412

Table 4.1.2 Frequency distribution of parafilaria based on the effects of season and breed (FREQ Procedure)

		Afrikander	**Angus**	**Bonsmara**	**Brahman**	**Friesland**	**Hereford**	**Nguni**	**Total**	**%**
Summer	**Freq**	3	0	38	18	0	0	27	86	
	%	2.16	0	27.34	12.95	0	0	19.42		61.87
	Row%	3.49	0	44.19	20.93	0	0	31.4		
	Col%	50	0	70.37	66.67	0	0	64.29		
Autumn	**Freq**	3	2	10	0	4	2	14	35	
	%	2.16	1.44	7.19	0	2.88	1.44	10.07		25.18
	Row%	8.57	5.71	28.57	0	11.43	5.71	40		
	Col%	50	100	18.52	0	80	66.67	33.33		
Winter	**Freq**	0	0	6	9	1	1	1	18	
	%	0	0	4.32	6.47	0.72	0.72	0.72		12.95
	Row%	0	0	33.33	50	5.56	5.56	5.56		

	Col%	0	0	11.11	33.33	20	33.33	2.38		
Total		6	2	54	27	5	3	42	139	
%		4.32	1.44	38.85	19.42	3.6	2.16	30.22		100

Chi-square statistics for the interaction between season and breed on parafilaria

Statistics	DF	Value	Prob(p<F)
Chi-square	12	44.5031	<.0001
Likelihood Ratio - Chi-Square	12	52.2993	<.0001

There was a high significant interaction between season and breed on the prevalence of parafilaria ($p<0.0001$) in cattle slaughtered (Table 4.1.2). The highest number of cases of parafilaria was observed in Summer (n=38) in Bonsmara cattle which represent 27.3% of total number of cases in Summer.

The other highest numbers of parafilaria cases were seen in Nguni and Brahman cattle which were recorded in Summer as well, while the lowest number of cases in cattle was recorded in Winter. Overall, very few cases of parafilaria were recorded for Afrikander (4.3%) Angus (1.44%), Friesland (3.6%) and Hereford cattle (2.16%), because these breeds represented numerically a small proportion of the total number of cattle slaughtered at this abattoir. The prevalence of parafilaria was highest in the Bonsmara-, Nguni-and Brahman-types as these types represented the largest proportion of cattle slaughtered and generally originate from areas where parafilaria parasites are endemic. Nguni cattle generally come from areas that are more infested with parafilaria, and parafilaria is less controlled on Nguni cattle due to the perception that they are more resistant to external parasites.

Table 4.1.3 Frequency distribution of parafilaria based on the effects of gender and breed (FREQ Procedure)

		Afrikander	Angus	Bonsmara	Brahman	Friesland	Hereford	Nguni	Total	%
Male	**Freq**	2	2	51	25	2	1	39	123	
	%	2.16	1.44	36.69	17.99	1.44	0.72	28.06		88.49
	Row %	2.44	1.63	41.46	20.33	1.63	0.81	31.71		
	Col%	50.00	100.0	94.44	92.59	40.00	33.33	92.86		
Female	**Freq**	3	0	3	2	3	2	3	16	
	%	2.16	0.00	2.16	1.44	2.16	1.44	2.16		11.51
	Row %	18.75	0.00	18.75	12.50	18.75	12.50	18.75		
	Col%	50.00	0.00	5.56	7.41	60.00	66.67	7.14		
Total		6	2	54	27	5	3	42	139	
%		4.32	1.44	38.85	19.42	3.60	2.16	30.22		100

Chi-square statistics for the interaction between gender and breed on parafilaria

Statistics	DF	Value	Prob(p<F)
Chi-square	6	32.6012	<.0001
Likelihood Ratio - Chi-Square	6	21.3506	0.0016

There was a highly significant interaction between gender and breed on the prevalence of parafilaria (p<0.0001) in cattle slaughtered. The highest number of cases of parafilaria was recorded for bulls in Bonsmara cattle which represented 36.7% of the total number of cases, followed by Nguni (28.1%), Brahman (18%), Afrikander (2.2%), Angus (1.4%), Friesland (1.4%) and Hereford cattle (0.7%). It was found that significantly more cases of parafilaria (38.9%) were reported in Bonsmara compared to Nguni, Brahman, Afrikander, Angus, Friesland and Hereford cattle.

Although Bonsmara, Nguni and Brahman-types represented the highest number of parafilaria cases due to the higher number of animals slaughtered from these types, the Friesland (Chi^2=8,47; p<0,0036) and Nguni types (Chi^2=28,76; p<0,0001) were more likely to be affected by parafilaria based on the maximum likelihood analysis (Table 4.1.4).

Based on the maximum likelihood analysis, bulls were more likely to be affected by parafilaria compared to heifers. Overall, cattle were also more likely to be affected by parafilaria in Summer (Chi^2=57, 48; p<0,0001), followed by Winter (Chi^2=13,16; p<0,0003) and Autumn (Chi^2=4,08; p<0,0433). The differences in the likelihood of bulls or heifers to be affected by parafilaria are also indicated in Table 4.1.4.

Table 4.1.4 Analysis of Contrasts of Maximum likelihood Estimates for parafilaria based on the CATMOD PROCEDURE.

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.00365	0.0070555	846.35	0.0001	0.00250	0.00533
Afrikander	0.5241	0.2040	2.75	0.0970	0.2443	1.1241
Angus	0.4294	0.2664	1.86	0.1731	0.1272	1.4490
Bonsmara	0.5690	0.1153	7.74	0.0054	0.3825	0.8464
Brahman	0.5329	0.1265	7.03	0.0080	0.3346	0.8485
Friesland	0.3774	1.4121	8.47	0.0036	1.4883	7.6644
Hereford	1.3824	0.7299	0.38	0.5397	0.4911	3.8913
Nguni	3.1395	0.6697	28.76	<.0001	2.0667	4.7691
Male	1.8137	0.2441	19.57	<.0001	1.3932	2.3611
Female	0.5514	0.0742	19.57	<.0001	0.4235	0.7178
Summer	2.6016	0.3281	57.48	<.0001	2.0318	3.3311
Autumn	0.7349	0.1120	4.08	0.0433	0.5452	0.9908
Winter	0.5230	0.0934	13.16	0.0003	0.3685	0.7423

A comparison of the likelihood of parafilaria between breeds is presented in Table 4.1.5.

Table 4.1.5 Contrasts of Maximum Likelihood Estimates based on breed on the presence of parafilaria in carcasses based on the PR0C CATMOD (DF = 1)

Contrast	Chi-Square	Pr > ChiSq	Estimate	Standard error	LCL	UCL
Intercept	846.35	<0.0001	0.00365	0.000705	0.00250	0.00533
Afrikander	2.75	0.0970	0.5241	0.2040	0.2443	1.1241
Angus	1.86	0.1731	0.4294	0.2664	0.1272	1.4490
Bonsmara	7.74	0.0054	0.5690	0.1153	0.3825	0.8464
Brahman	7.03	0.0080	0.5329	0.1265	0.3346	0.8485
Friesland	8.47	0.0036	0.3774	1.4121	1.4883	7.6644
Hereford	0.38	0.5397	1.3824	0.7299	0.4911	3.8913
Nguni	28.76	<0.0001	3.1395	0.6697	2.0667	4.7691
Afr/Ang	0.06	0.8085	1.2206	1.0038	0.2435	6.1181
Afr/Bon	0.03	0.8529	0.9211	0.4084	0.3863	2.1963
Afr/Bra	0.00	0.9714	0.9835	0.4568	0.3958	2.4439
Afr/Fri	9.13	0.0025	0.1552	0.0957	0.0463	0.5198
Afr/Her	1.77	0.1834	0.3791	0.2764	0.0908	1.5828
Afr/Ngu	16.55	<0.0001	0.1669	0.0735	0.0705	0.3955
Ang/Bon	0.15	0.6968	0.7546	0.5452	0.1831	3.1098
Ang/Bra	0.09	0.7695	0.8057	0.5938	0.1901	3.4158
Ang/Fri	5.99	0.0144	0.1271	0.1071	0.0244	0.6628
Ang/Her	1.61	0.2043	0.3106	0.2861	0.0511	1.8893
Ang/Ngu	7.48	0.0062	0.1368	0.0995	0.0329	1.8893
Bon/Bra	0.08	0.7835	1.0677	0.2546	0.6691	1.7039
Bon/Fri	13.89	0.0002	0.1685	0.0805	0.0660	0.4298
Bon/Her	2.13	0.1444	0.4116	0.2503	0.1250	1.3555
Bon/Ngu	62.00	<0.0001	0.1812	0.0393	0.1185	1.3555
Bra/Fri	13.69	0.0002	0.1578	0.0787	0.0593	0.4196
Bra/Her	2.29	0.1302	0.3855	0.2428	0.1121	1.3250
Bra/Ngu	47.63	<0.0001	0.1697	0.0436	0.1026	0.2809
Fri/Her	1.44	0.2308	2.4431	1.8211	0.5668	10.5299
Fri/Ngu	0.02	0.8799	1.0758	0.5200	0.4171	2.7743
Her/Ngu	1.76	0.1847	0.4403	0.2723	0.1310	1.4795
Male	19.57	<0.0001	1.8137	0.2441	1.3932	2.3611
Female	19.57	<0.0001	0.5514	0.0742	0.4235	0.7178
Summer	57.48	<.0001	2.6016	0.3281	2.0318	3.3311
Autumn	4.08	0.0433	0.7349	0.1120	0.5452	0.9908
Winter	13.16	0.0003	0.5230	0.0934	0.3685	0.7423
Sum/Aut	34.48	<0.0001	3.5399	0.7621	2.3214	5.3980
Sum/Win	35.54	<0.0001	4.9742	1.3385	2.9355	8.4291
Aut/Win	1.23	0.2681	1.4052	0.4317	0.7696	2.5658

Breed

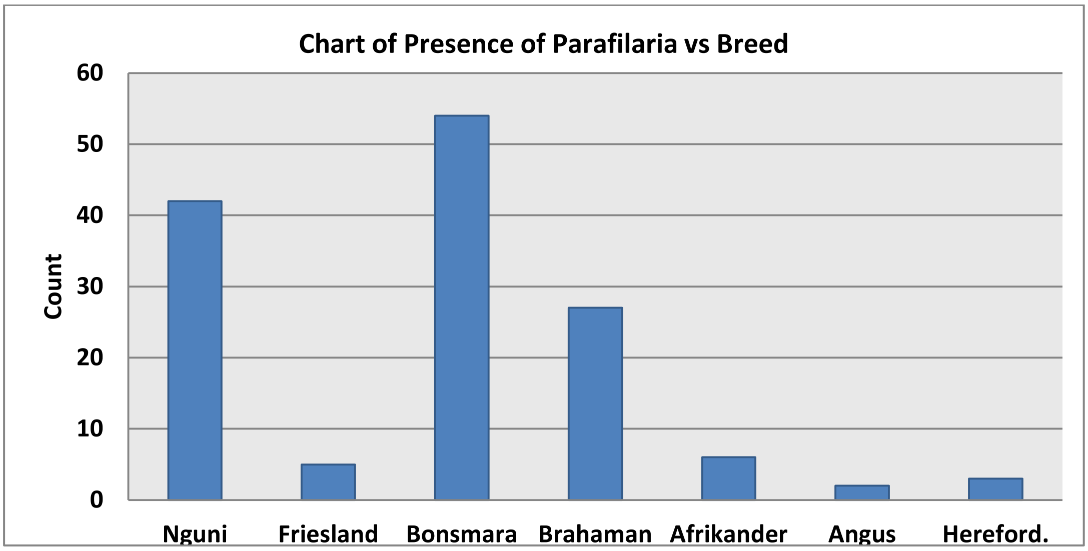


Chart 4.1.1 The effect of breed on the presence of parafilaria

If the presence vs. absence of parafilaria is considered, there was a highly significant breed effect ($p<0.0001$) in cattle slaughtered at the abattoir. Of the seven breeds investigated in this study the order of significance for the prevalence of parafilaria in different breeds was Nguni ($p<0.0001$), Friesland ($p=0.0036$), Bonsmara ($p=0.0054$), Brahman ($p=0.0080$) and Afrikander ($p=0.0970$), while no effect was evident for Angus ($p=0.1731$) or Hereford ($p=0.5397$).

The difference in prevalence of parafilaria in Bonsmara compared to Friesland cattle (Chi^2=13, 89; $p=0.0002$) was significant, which shows that Friesland cattle (Chi^2=8.47; ($p=0.0036$) was significantly more affected by parafilaria compared to Bonsmara cattle (Chi^2=7.74; $p=0.0054$). This observation seems logical given the known resistance of Bonsmara cattle to external parasites as opposed to Friesland cattle that generally have a very poor resistance to external parasites as evidenced on the classic work by Bonsma (1980).

The difference in prevalence of parafilaria in Brahman compared to Friesland cattle was highly significant (Chi^2=13, 69; $p=0.0002$), which indicates that Friesland cattle (Chi^2=8.47; $p=0.0036$) were more susceptible to parafilaria compared to Brahman cattle (Chi^2=7.03;

p=0.008), which are known to have strong hair and hide characteristics that deter external parasites (Bonsma, 1980).

The difference in prevalence of parafilaria between Bonsmara compared to Nguni cattle (Chi^2=62.00; p<0.0001) was significant, with Nguni cattle (Chi^2=28.76; p<0.0001) being much more prone to parafilaria compared to Bonsmara cattle (Chi^2=7.74; p=0.0054) (Table 4.5). The results show that Nguni cattle were more affected compared to Bonsmara. This is probably because Nguni cattle generally come from areas that are more infested with parafilaria, and parafilaria is less controlled in Nguni cattle due to the perception that they are more resistant to external parasites.

It is interesting to note that the difference in prevalence of parafilaria in Afrikander compared to Nguni cattle (Chi^2=16.55; p<0.0001) was significant, with Afrikander cattle (Chi^2=2.75; p=0.0970) being less prone to parafilaria compared to Nguni cattle (Chi^2=28.76; p<0.0001). Afrikander cattle are known to have a short, shiny hair coat and strong skin which provides better protection against external parasite infestation like parafilaria and ticks.

The above contrasts are those which are critical; others can be referred to Table 4.1.5.

Gender

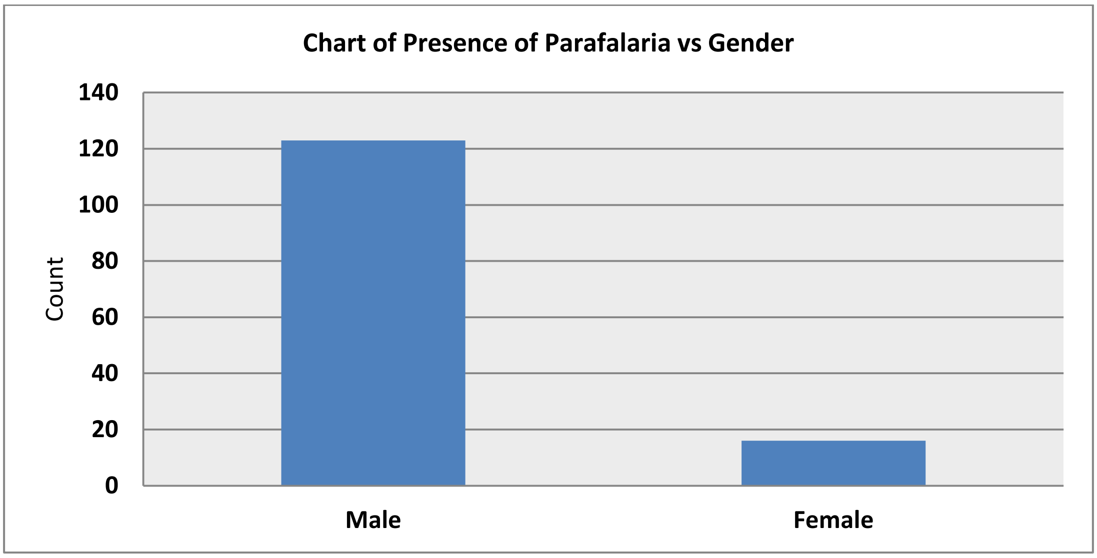


Chart 4.1.2 The effect of gender on the presence of parafilaria

There was a highly significant gender effect on the likelihood of parafilaria ($p<0.0001$) in cattle slaughtered at the abattoir. Bulls were more likely to be affected by parafilaria ($Chi^2=19.57$; $p<0.0001$) compared to heifers ($Chi^2=19.57$; $p<0.0001$) as summarised in Table 4.1.5.

Season

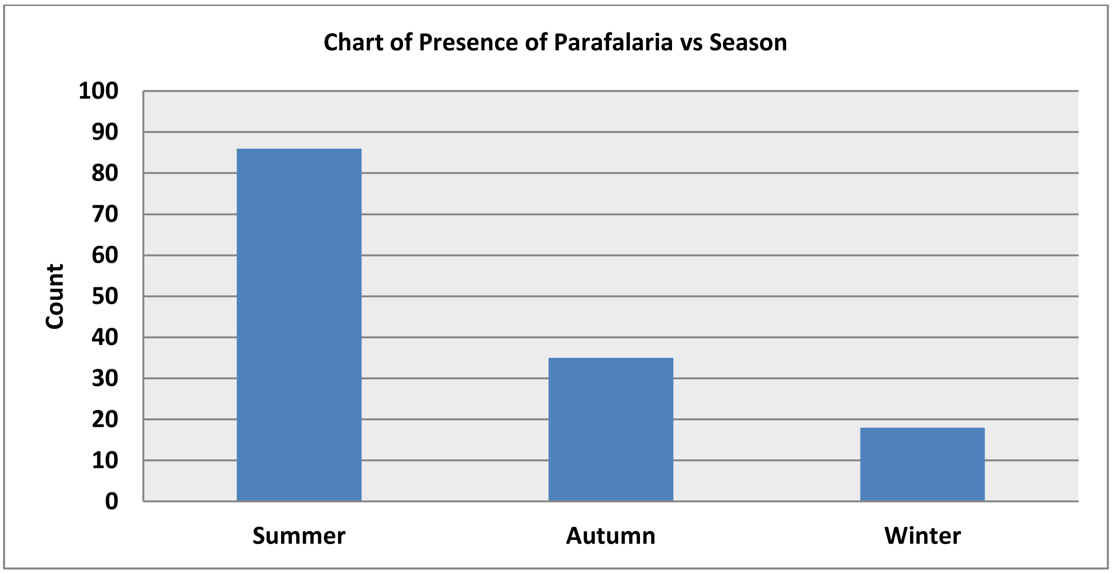


Chart 4.1.3 The effect of season on the presence of parafilaria

There was a significantly high seasonal effect on the prevalence of parafilaria ($p<0.0001$) in cattle slaughtered at the abattoir. The difference in prevalence of parafilaria in Winter ($Chi^2=13.16$; $p=0.0003$) was significant, and when Winter is compared to Summer a high significant effect was seen ($Chi^2=35.54$; $p<0.0001$), indicating that Winter ($Chi^2=13.16$; $p=0.0003$) was less affected by parafilaria compared to Summer ($Chi^2=57.48$; $p<0.0001$). This shows that even though there was a high significant effect on their contrast, Summer shows a higher effect on parafilaria compared to Winter, as Summer is very hot and a lot of effects prevails mostly in that season.

The difference in prevalence of parafilaria in Summer compared to Autumn was highly significant ($Chi^2=34.48$; $p<0.0001$), with more effects seen in Summer ($Chi^2=57.48$; $p<0.0001$) compared to Autumn ($Chi^2=4.08$; $p=0.0433$). The prevalence of parafilaria was significantly lower in Winter and Autumn compared to Summer as when it is very hot, more of these effects prevail (Table 4.1.5).

4.2. Bruising: Effects of breed, gender and season on bruising of carcasses

The overall prevalence of bruising in carcasses observed during the period of study in the Grade A abattoir was about 2.10% of cattle slaughtered during the period monitored. There was a significant seasonal and gender effect on the prevalence of bruising (p=0.0031) in cattle slaughtered.

The highest number of cases of bruising reported for bulls in summer was (n=165) which represents 30.8% of the total number of cases of bruising, while only 4.9% of heifers slaughtered were condemned in that season. The effects of season and gender on the prevalence of bruising in cattle slaughtered is summarised in Table 4.2.1.

In Australia it has been suggested that in beef cattle, external factors (i.e. source, transport and handling) may be responsible for the site where bruises are located in the body of the animal whereas animal factors such as presence of horns, sex class and temperature determine the severity of bruising and may cause deeper lesions (Anderson and Horder, 1979).

Table 4.2.1 Frequency distribution of bruising in bovine carcasses based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	165	26	191	
	%	30.84	4.86		35.70
	Row%	86.39	13.61		
	Col%	38.37	24.76		

Autumn	**Freq**	103	41	144	
	%	19.25	7.66		26.92
	Row%	71.53	28.47		
	Col%	23.95	39.05		
Winter	**Freq**	162	38	200	
	%	30.28	7.10		37.38
	Row%	81.00	19.00		
	Col%	37.67	36.19		
Total		430	105	535	
%		80.37	19.63		100

Chi-square statistics for the interaction between season and gender on bruising

Statistics	DF	Value	Prob(p<F)
Chi-square	2	11.5720	0.0031
Likelihood Ratio - Chi-Square	2	11.3247	0.0035

The period prevalence of bruising was numerically higher in Winter compared to other seasons, and there was a significant difference between bulls (37.7%) and heifers (36.2%) in Winter (Table 4.1). There was a significant difference in Summer between the bulls (38.4%) and heifers (24.8%) as well. Fewer cases were observed in Autumn with a significant difference between bulls (24%) and heifers (39.1%) as well. Generally the higher prevalence was observed in Winter, which suggests that bulls were more aggressive in Winter when grazing, or engaged more in fighting activities causing injuries and more bruising of carcasses.

Table 4.2.2 Frequency distribution of bruising based on the effects of season and breed (FREQ Procedure)

		Afrikander	Angus	Bonsmara	Brahman	Friesland	Hereford	Nguni	Total	%
Summer	**Freq**	9	8	49	81	8	2	34	191	
	%	1.68	1.50	9.16	15.14	1.50	0.37	6.36		35.70
	Row%	4.71	4.19	25.65	42.41	4.19	1.05	17.80		
	Col%	18.00	24.24	28.82	50.63	27.59	18.18	41.46		
Autumn	**Freq**	29	22	48	8	11	3	23	144	
	%	5.42	4.11	8.97	1.50	2.06	0.56	4.30		26.92
	Row%	20.14	15.28	33.33	5.56	7.64	2.08	15.97		
	Col%	58.00	66.67	28.24	5.00	37.93	27.27	28.05		
Winter	**Freq**	12	3	73	71	10	6	25	200	
	%	2.24	0.56	13.64	13.27	1.87	1.12	4.67		37.38
	Row%	6.00	1.50	36.50	35.50	5.00	3.00	12.50		
	Col%	24.00	9.09	42.94	44.38	34.48	54.55	30.49		
Total		50	33	170	160	29	11	82	535	
%		9.35	6.17	31.78	29.61	5.42	2.06	15.33		100.0

Chi-square statistics for the interaction between season and breed on bruising

Statistics	DF	Value	Prob(p<F)
Chi-square	12	102.3421	<.0001
Likelihood Ratio - Chi-Square	12	110.2497	<.0001

A highly significant interaction between season and breed on the prevalence of bruising ($p<0.0001$) in cattle slaughtered was observed (Table 4.2.2). The highest number of cases of bruising observed in Summer was (n=81) Brahman cattle representing 15.1% of the total cases in Summer.

Other cases of bruising were observed in Bonsmara, Nguni, Afrikander, Friesland, Angus and Hereford cattle in Summer, while in Autumn the highest recorded cases of bruising were Bonsmara, Afrikander, Nguni and Angus and the fewest cases observed that season were in Friesland Brahman and Hereford. The overall highest reported cases were in Bonsmara, Brahman, Nguni, and Afrikander while the overall fewest cases were seen in Angus, Friesland and Hereford, as these three represent a small proportion of the total number slaughtered. A large number of cases were observed probably because of improper handling methods or facilities and presence of horns in some breeds during transportation which caused injuries and bruising.

Table 4.2.3 Frequency distribution of bruising based on the effects of gender and breed (FREQ Procedure)

		Afrikander	**Angus**	**Bonsmara**	**Brahman**	**Friesland**	**Hereford**	**Nguni**	**Total**	**%**
Male	**Freq**	23	24	148	147	4	7	77	430	
	%	4.30	4.49	27.66	27.48	0.75	1.31	14.39		80.37
	Row%	5.35	5.58	34.42	34.19	0.93	1.63	17.91		
	Col%	46.00	72.73	87.06	91.88	13.79	63.64	93.90		
Female	**Freq**	27	9	22	13	25	4	5	105	
	%	5.05	1.68	4.11	2.43	4.67	0.75	0.93		19.63
	Row%	25.71	8.57	20.95	12.38	23.81	3.81	4.76		
	Col%	54.00	27.27	12.94	8.13	86.21	36.36	6.10		
Total		50	33	170	160	29	11	82	535	
%		9.35	6.17	31.78	29.91	5.42	2.06	15.33		100.0

Chi-square statistics for the interaction between gender and breed on bruising

Statistics	DF	Value	Prob(p<F)
Chi-square	12	149.8737	<.0001
Likelihood Ratio - Chi-Square	12	125.6495	<.0001

A highly significant interaction between gender and breed was observed in the prevalence of bruising in cattle slaughtered in the abattoir ($p<0,0001$). The highest number of recorded cases of prevalence on bruising for bulls were (148) Bonsmara which represented 27.7% of the total number of cases, followed by Brahman (27.5%), Nguni (14.4%), Angus (4.5%), Afrikander (4.3%), Hereford (1.3%) and Friesland cattle (0.8%), while highest cases of bruising in heifers were in (27) Afrikander which represent 5.1% followed by Friesland (4.7%), Bonsmara (4.1%), Brahman (2.4%), Angus (1.7%), Nguni (0.9%) and Hereford (0.8%), but the overall significant effect due to bruising was seen in the Bonsmara bull as indicated above, that may be because of the aggressiveness of the bulls leading to physical fights resulting in injuries and eventually in bruising.

The overall highly significant effect was seen in Winter (Chi^2=20.72; p<0, 0001) followed by Autumn (Chi^2=29.05; p<0, 0001) and Summer (Chi^2=2.08; p=0.1495). Based on the maximum likelihood analysis (Table 4.4) breeds mostly affected by bruising were Bonsmara cattle (Chi^2=97.24; p<0, 0001), followed by Friesland (Chi^2=41.80; p<0, 0001), while Brahman, Nguni, Angus, Afrikander and Hereford were less affected. No significant difference was observed between bulls (Chi^2=19.90; p<0, 0001) and heifers (Chi^2=19.90; p<0, 0001; Table 4.2.4).

Table 4.2.4 The CATMOD procedure: analysis of Contrasts of Maximum likelihood Estimates of Bruising

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.0255	0.00183	2608.20	<.0001	0.0221	0.0293
Afrikander	0.9717	0.1399	0.04	0.8421	0.7329	1.2885
Angus	1.2479	0.2047	1.82	0.1770	0.9048	1.7212
Bonsmara	0.3937	0.0372	97.24	<.0001	0.3271	0.4738
Brahman	0.9547	0.0940	0.22	0.6379	0.7872	1.1579
Friesland	3.1927	0.5733	41.80	<.0001	2.2456	4.5394
Hereford	0.4920	0.1320	6.99	0.0082	0.2908	0.8325
Nguni	1.3967	0.1636	8.13	0.0044	1.1101	1.7572
Male	1.2884	0.0732	19.90	<.0001	1.1527	1.4402
Female	0.7761	0.0441	19.90	<.0001	0.6944	0.8675
Summer	1.0974	0.0708	2.08	0.1495	0.9671	1.2454
Autumn	0.6800	0.0487	29.05	<.0001	0.5911	0.7824
Winter	1.3400	0.0861	20.72	<.0001	1.1813	1.5199

A comparison of the likelihood of bruising between breeds is presented in Table 4.2.5.

Table 4.2.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1) for bruising

Contrast	Chi-Square	Pr > ChiSq	Estimate	Standard error	LCL	UCL
Intercept	2608.20	<.0001	0.0255	0.00183	0.0221	0.0293
Afrikander	0.04	0.8421	0.9717	0.1399	0.7329	1.2885
Angus	1.82	0.1770	1.2479	0.2047	0.9048	1.7212
Bonsmara	97.24	<.0001	0.3937	0.0372	0.3271	0.4738
Brahman	0.22	0.6379	0.9547	0.0940	0.7872	1.1579
Friesland	41.80	<.0001	3.1927	0.5733	2.2456	4.5394
Hereford	6.99	0.0082	0.4920	0.1320	2.2908	0.8325
Nguni	8.13	0.0044	1.3967	0.1636	1.1101	1.7572
Afr/Ang	1.15	0.2842	0.7787	0.1819	0.4926	1.2308
Afr/Bon	27.38	<.0001	2.4681	0.4262	1.7595	3.4622
Afr/Bra	0.01	0.9187	1.0178	0.1760	0.7252	1.4285
Afr/Fri	22.84	<.0001	0.3044	0.0758	0.1869	0.4957
Afr/Her	3.88	0.0488	1.9751	0.6821	1.0037	0.4957
Afr/Ngu	3.90	0.0483	0.6957	0.1278	0.4854	0.9972
Ang/Bon	35.12	<.0001	3.1697	0.6171	2.1642	4.6422
Ang/Bra	1.82	0.1765	1.3071	0.2590	0.8864	1.9274
Ang/Fri	12.51	0.0004	0.3909	0.1038	0.2322	0.6578
Ang/Her	6.92	0.0085	2.5365	0.8974	1.2679	5.0743
Ang/Ngu	0.28	0.5962	0.8935	0.1899	0.5891	1.3551
Bon/Bra	60.52	<.0001	0.4124	0.0470	0.3299	0.5155
Bon/Fri	95.25	<.0001	0.1233	0.0264	0.0810	0.1877
Bon/Her	0.50	0.4813	0.8002	0.2532	0.4304	1.4879
Bon/Ngu	80.23	<.0001	0.2819	0.0398	0.2137	0.3719
Bra/Fri	31.02	<.0001	0.2990	0.0648	0.1955	0.4573
Bra/Her	4.28	0.0386	1.9406	0.6218	1.0355	3.6366
Bra/Ngu	7.14	0.0075	0.6836	0.0973	0.5171	0.9035
Fri/Her	26.47	<.0001	6.4895	2.3590	3.1827	13.2321
Fri/Ngu	13.07	0.0003	2.2859	0.5227	1.4603	3.5785
Her/Ngu	10.00	0.0016	0.3523	0.1162	0.1845	0.6726
Male	19.90	<.0001	1.2884	0.0732	1.1527	1.4402
Female	19.90	<.0001	0.7761	0.0441	0.6944	0.8675
Summer	2.08	0.1495	1.0974	0.0708	0.9671	1.2454
Autumn	29.05	<.0001	0.6800	0.0487	0.5911	0.7824
Winter	20.72	<.0001	1.3400	0.0861	1.1813	1.5199
Sum/Aut	15.88	<.0001	1.6138	0.1938	1.2753	2.0422
Sum/Win	3.47	0.0623	0.8190	0.0877	0.6639	1.0103
Aut/Win	32.08	<.0001	0.5075	0.0608	0.4013	0.6418

Breed

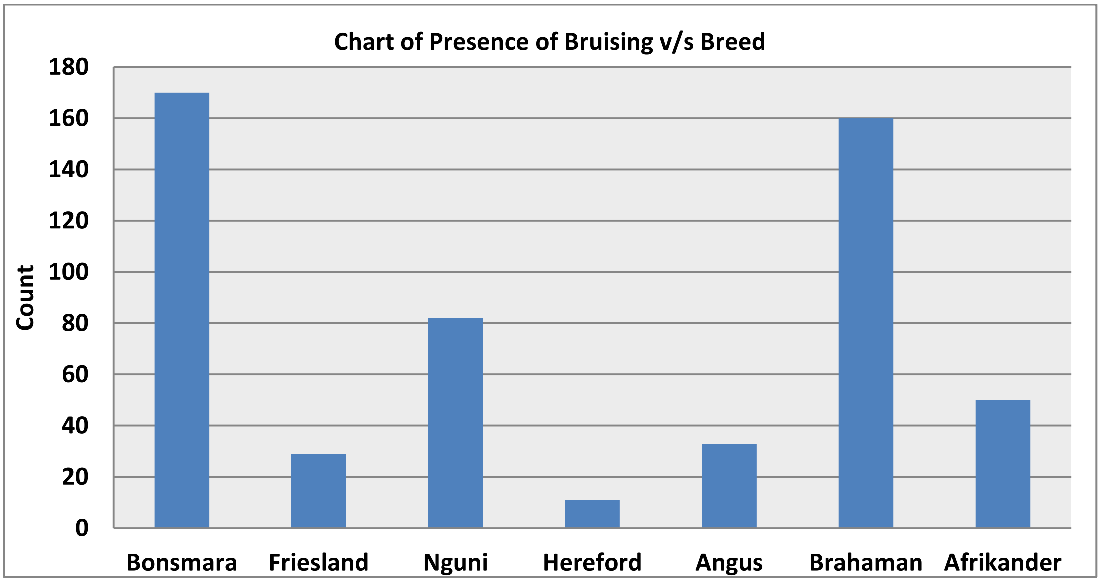


Chart 4.2.1 The effect of breed on the presence of bruising

There was a highly significant breed effect on the prevalence of bruising ($p<0.0001$) in cattle slaughtered at the abattoir. The order of significance in terms of the prevalence of bruising was Bonsmara ($p<0.0001$), Friesland ($p<0.0001$), Nguni ($p=0.0044$), Hereford ($p=0.0082$), Angus ($p=0.1770$), Brahman ($p=0.6379$), and Afrikander ($p=0.8421$), which indicates that the Bonsmara breed was more susceptible to bruising compared to Friesland, Nguni, Hereford, Angus, Brahman, and Afrikander cattle.

It is interesting to note that the difference in prevalence of bruising in Angus compared to Bonsmara cattle ($Chi^2=35.12$; $p<0.0001$) was highly significant, showing that Angus cattle ($Chi^2=1.82$; $p=0.1770$) were less susceptible to bruising compared Bonsmara ($Chi^2=97.24$; p<.0.0001). The difference in prevalence of bruising in Brahman compared to Friesland cattle ($Chi^2=31.02$; $p<0.0001$) was significantly high, showing that Brahman cattle ($Chi^2=0.22$; $p=0.6379$) were less prone to bruising compared to Friesland cattle ($Chi^2=41.80$; $p<0.0001$). The difference in prevalence of bruising in Afrikander compared to Bonsmara ($Chi^2=27.38$; $p<0.0001$) was significantly high as well, which is an indication that Afrikander cattle ($Chi^2=0.04$; $p=0.8421$) were less prone to bruising compared to Bonsmara cattle ($Chi^2=97.24$; p<.0.0001) (Table 4.2.5).

The difference in prevalence of bruising in Friesland compared to Hereford cattle (Chi^2=26.47; p<0.0001), was highly significant, showing that Friesland cattle (Chi^2=41.80; p<0.0001) were more prone to bruising compared Hereford cattle (Chi^2=6.99; p=0.0082) and the difference in prevalence of bruising in Afrikander compared to Friesland cattle (Chi^2=12.51; p<0.0001) was significantly high, indicating that Afrikander cattle (Chi^2=0.04; p=0.8421) were less susceptible to bruising compared to Friesland cattle (Chi^2=41.80; p<0.0001).

These are contrasts of breeds that were critical during the study; other contrasts can be referred to table 4.2.5.

Gender

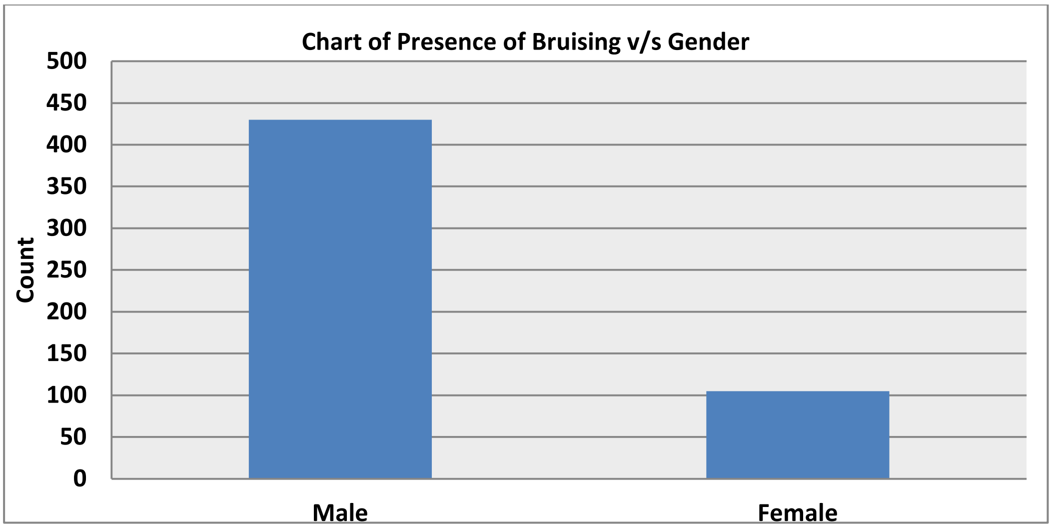


Chart 4.2.2 The effect of gender on the presence of bruising

There was a significant gender effect on prevalence of bruising (p<0.0001) in cattle slaughtered at the abattoir. The prevalence of bruising in bulls (Chi^2=19.90: p<0.0001) and heifers (Chi^2=19.90: p<0.0001) were both significant, showing that bulls were more likely to be affected by bruising probably because of the well-known aggressiveness and use of horns when fighting leading to internal bleeding and eventually bruising during post-mortem (Table 4.2.5).

Season

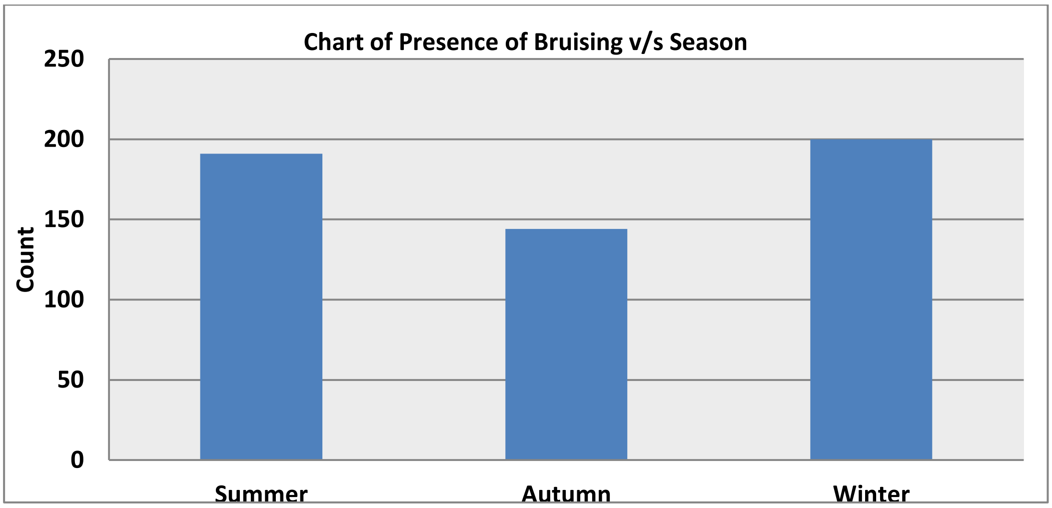


Chart 4.2.3 The effect of season on presence of bruising

There was a highly significant seasonal effect on bruising (p<0.0001) in cattle slaughtered in the abattoir. Carcasses were more likely to be condemned due to bruising in Winter (Chi^2 =20,72; p<0.0001) compared to Summer and Autumn (Table 4.2.5).

The difference in prevalence of bruising in Autumn compared to Winter (Chi^2=32.08: p<0.0001) was highly significant, an indication that in Autumn (Chi^2=25.05: p<0.0001), carcasses were more likely to be condemned due to bruising compared to Winter (Chi^2=20.72: p<.0001).

The difference in prevalence of bruising in Summer compared to Autumn (Chi^2=15.88p<0.0001) was highly significant as well, indicating that in Summer (Chi^2=2.08: p=0.1495) carcasses were less likely to be condemned due to bruising compared to Autumn (Chi^2=29.05: p<0.0001). The difference in prevalence of bruising in Summer compared to Winter was significant (Chi^2=3.47: p=0.0623), which indicates that in Summer (Chi^2=2.08: p=0.1495) carcasses were less likely to be condemned due to bruising than in Winter (Chi^2=20.72p<.0001) as shown in Table 4.2.5.

4.3. Soiling: Effects of breed, gender and season on soiling of carcasses

The overall prevalence of soiling in bovine carcasses during the process of this study in the abattoir was about 2.33%. Overall there were no seasonal and gender effects on the prevalence of soiling (p=0.3119) in cattle slaughtered in the abattoir. The highest number of cases of soiling recorded for bulls in Summer was (n=186) representing 31.2% of the total number of cases of soiling, while heifers (n=38) represented 6.4%. The effect of season and gender on the prevalence of soiling in beef carcasses is summarised in Table 4.3.1.

According to researchers in Ethiopia, visceral contents are not significant sources of carcass contamination; however punching viscera by inexperienced slaughter personnel normally causes soiling of carcasses. Transfer of contamination from hides to carcass surfaces is effectively unavoidable due to the nature of the skinning and removal process (www.borlang-tamu-edu.wpengine.net-dna).

Table 4.3.1 Frequency distribution of soiling based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	186	38	224	
	%	31.16	6.37		37.52
	Row%	83.04	16.96		
	Col%	38.59	33.04		
Autumn	**Freq**	142	42	184	
	%	23.79	7.04		30.82
	Row%	77.17	22.83		

	Col%	29.46	36.52		
Winter	**Freq**	154	35	189	
	%	25.80	5.86		31.66
	Row%	81.48	18.52		
	Col%	31.95	30.43		
Total		482	115	597	
%		80.74	19.26		100

Chi-square statistics for the interaction between season and gender on soiling

Statistics	**DF**	**Value**	**Prob(p<F)**
Chi-square	2	2.3304	0.3119
Likelihood Ratio - Chi-Square	2	2.2916	0.3180

The prevalence of soiling was numerically higher in Summer, with no differences as such between bulls (38.6%) and heifers (33.0% in that season), followed by Winter while in Autumn fewer cases were observed with no big difference between bulls (29.5%) and heifers (36.5%).

Table 4.3.2 Frequency distribution of soiling based on the effects of season and breed (FREQ Procedure)

		Afrikander	**Angus**	**Bonsmara**	**Brahman**	**Friesland**	**Hereford**	**Nguni**	**Total**	**%**

Summer	**Freq**	7	3	87	97	4	0	26	224	
	%	1.17	0.50	14.57	16.25	0.67	0.00	4.36		37.52
	Row%	3.13	1.34	38.84	43.30	1.79	0.00	11.61		
	Col%	21.21	13.04	37.18	52.72	36.36	0.00	29.89		
Autumn	**Freq**	17	12	72	19	2	16	46	184	
	%	2.85	2.01	12.06	3.18	0.34	2.68	7.71		30.82
	Row%	9.24	6.52	39.13	10.33	1.09	8.70	25.00		
	Col%	51.52	52.17	30.77	10.33	18.18	64.00	52.87		
Winter	**Freq**	9	8	75	68	5	9	15	189	
	%	1.51	1.34	12.56	11.39	0.84	1.51	2.51		31.66
	Row%	4.76	4.23	39.68	35.98	2.65	4.76	7.94		
	Col%	27.27	34.78	32.05	36.96	45.45	36.00	17.24		
Total		33	23	234	184	11	25	87	597	
%		5.53	3.85	39.20	30.82	1.84	4.19	14.57		100

<u>Chi-square statistics for the interaction between season and breed on soiling</u>

Statistics	DF	Value	Prob(p<F)
Chi-square	12	92.8081	<.0001

Likelihood Ratio - Chi-Square	12	106.6176	<.0001

There was a significantly high interaction between season and breed on the prevalence of soiling (p<0.0001) in cattle slaughtered (Table 4.2). The highest number of cases of soiling observed in Summer was (n=97) in Brahman cattle representing 16.3% of the total cases in Summer. Other cases of soiling were observed in Bonsmara, Nguni, Afrikander, Friesland and Angus cattle, while no effects were seen in Hereford cattle in Summer. Autumn had the highest number of recorded cases of soiling in Bonsmara, Nguni, Brahman, and Afrikander cattle. The fewest cases in Autumn were observed in Hereford, Angus and Friesland cattle. The overall highest number of reported cases were in Bonsmara, Brahman, Nguni and Afrikander cattle while the overall fewest cases were seen in Hereford, Angus and Friesland. According to my observation during the study, unskilled labourers were used for evisceration which resulted in poor evisceration and more problems with soiling carcasses.

Table 4.3.3 Frequency distribution of soiling based on the effects of gender and breed (FREQ Procedure)

Chi-square statistics for the interaction between gender and breed on soiling

Statistics	DF	Value	Prob(p<F)
Chi-square	6	123.0945	<.0001
Likelihood Ratio - Chi-Square	6	101.2191	<.0001

A high significant interaction between gender and breed was observed for the prevalence of soiling in cattle slaughtered in the abattoir (p<0,0001). The highest number of recorded cases of prevalence in soiling for bulls was (n=206) Bonsmara which represented 34.5.% of the total number of cases, followed by Brahman (27.5%), Nguni (12.2%), Afrikander (2.9%), Angus (2.4%), Hereford (1.5%) with no effect seen in Friesland. The highest number of cases of soiling in heifers was in Bonsmara (n=28) which represent 4.7% followed by Brahman (3.4%), Afrikander (2.9%), Hereford (2.7%), Nguni (2.4%), Friesland (1.8%) and Angus (1.5%).

Table 4.3.4 The CATMOD procedure: Analysis of Contrasts of Maximum Likelihood Estimates for soiling

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.0250	0.00184	2513.93	<.0001	0.0216	0.0289
Afrikander	0.5662	0.0952	11.45	0.0007	0.4073	0.7871
Angus	0.9478	0.1815	0.08	0.7795	0.6512	1.3795
Bonsmara	0.6189	0.0562	27.97	<.0001	0.5180	0.7393
Brahman	1.1692	0.1142	2.56	0.1096	0.9655	1.4159
Friesland	1.2324	0.3319	0.60	0.4377	0.7270	2.0893
Hereford	1.4533	0.2766	3.86	0.0495	1.0009	2.1103
Nguni	1.4378	0.1684	9.61	0.0019	1.1429	1.8089
Male	1.2266	0.0654	14.67	0.0001	1.1048	1.3617
Female	0.8153	0.0435	14.67	0.0001	0.7344	0.9051
Summer	0.9006	0.0579	2.65	0.1034	0.7940	1.0215
Autumn	1.0233	0.0645	0.13	0.7143	0.9044	1.1579

Winter	1.0851	0.0651	1.85	0.1734	0.9647	1.2204

A comparison of the likelihood of soiling between breeds is presented in Table 4.3.5.

Table 4.3.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1 for soiling

Contrast	**Chi-Square**	**Pr > ChiSq**	**Estimate**	**Standard error**	**LCL**	**UCL**
Intercept	2513.93	<.0001	0.0250	0.00184	0.0216	0.0289

Afrikander	11.45	0.0007	0.5662	0.0952	0.4073	0.7871
Angus	0.08	0.7795	0.9478	0.1815	0.6512	1.3795
Bonsmara	27.97	<.0001	0.6189	0.0562	0.5180	0.7393
Brahman	2.56	0.1096	1.1692	0.1142	0.9655	1.4159
Friesland	0.60	0.4377	1.2324	0.3319	0.7270	2.0893
Hereford	3.86	0.0495	1.4533	0.2766	1.0009	2.1103
Nguni	9.61	0.0019	1.4378	0.1684	1.1429	1.8089
Afr/Ang	3.44	0.0638	0.5974	0.1660	0.3465	1.0300
Afr/Bon	0.21	0.6478	0.9149	0.1781	0.6247	1.3400
Afr/Bra	13.50	0.0002	0.4843	0.0956	0.3289	0.7130
Afr/Fri	4.74	0.0294	0.4594	0.1641	0.2282	0.9250
Afr/Her	11.36	0.0007	0.3896	0.1089	0.2252	0.6740
Afr/Ngu	20.15	<.0001	0.3938	0.0817	0.2622	0.5915
Ang/Bon	3.68	0.0551	1.5315	0.3403	0.9908	2.3674
Ang/Bra	0.86	0.3541	0.8107	0.1836	0.5200	1.2638
Ang/Fri	0.50	0.4815	0.7690	0.2869	0.3702	1.5978

Ang/Her	2.09	0.1484	0.6522	0.1929	0.3652	1.1645
Ang/Ngu	3.03	0.0816	0.6592	0.1577	0.4124	1.0536
Bon/Bra	39.07	<.0001	0.5293	0.0539	0.4336	0.6462
Bon/Fri	4.75	0.0293	0.5021	0.1587	0.2702	0.9330
Bon/Her	15.26	<.0001	0.4258	0.0931	0.2775	0.6535
Bon/Ngu	40.66	<.0001	0.4304	0.0569	0.3322	0.5577
Bra/Fri	0.03	0.8688	0.9487	0.3027	0.5076	1.7729
Bra/Her	0.93	0.3347	0.0845	0.1814	0.5171	1.2516
Bra/Ngu	2.29	0.1300	0.8132	0.1111	0.6222	1.0628
Fri/Her	0.20	0.6561	0.8480	0.3139	0.4105	1.7518
Fri/Ngu	0.22	0.6381	0.8572	0.2809	0.4510	1.6292
Her/Ngu	0.00	0.9643	1.0108	0.2420	0.6322	1.6159
Male	14.67	0.0001	1.2266	0.0654	1.1048	1.3617
Female	14.67	0.0001	0.8153	0.0435	0.7344	0.9051
Summer	2.65	0.1034	0.9006	0.0579	0.7940	1.0215
Autumn	0.13	0.7143	1.0233	0.0645	0.9044	1.1579
Winter	1.85	0.1734	1.0851	0.0651	0.9647	1.2204
Sum/Aut	1.29	0.2552	0.8800	0.0988	0.7062	1.0967

Sum/Win	3.02	0.0821	0.8300	0.0890	0.6727	1.0240
Aut/Win	0.31	0.5765	0.9431	0.0989	0.7679	1.1583

Breeds

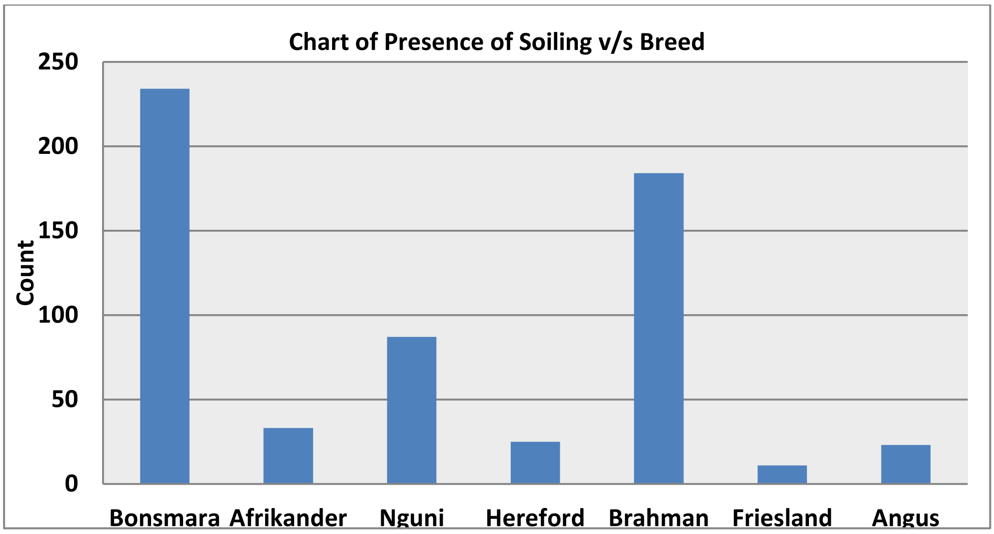


Chart 4.3.1 The effect of breed on presence of soiling

There was a significant high breed effect on the prevalence of soiling (p=<0.0001) in cattle slaughtered at the abattoir. The order of significance in prevalence of soiling in cattle slaughtered are Bonsmara (p<0.0001), Afrikander (p=0.0007), Nguni (p=0.0019), Hereford (p=0.0494), Brahman (p=0.1096), Friesland (p=0.4377) and Angus (p=0.7795), indicating more susceptibility of soiling to Bonsmara compared to Afrikander, Nguni, Hereford, Brahman, Friesland and Angus.

The difference in prevalence of soiling in Bonsmara compared to Nguni cattle (Chi^2=4.66: p<0.0001) was highly significant, which indicates that Bonsmara (Chi^2=27.97:p<0.0001) were more susceptible to soiling compared to Nguni cattle (Chi^2=9.61:p=0.0019). The difference in prevalence of soiling in Bonsmara compared to Brahman (Chi^2=39.07:p<0.0001) was highly significant as well, showing Bonsmara cattle (Chi^2=2797:p<0.0001) as more prone to soiling compared to Brahman cattle (Chi^2=2.56:p=0.1096) (Table 4.3.5).

The difference in prevalence of soiling in Afrikander compared to Nguni (Chi^2=20.15:p<0.0001) was highly significant, which indicates that Afrikander cattle (Chi^2=11.45:p=0.0007) were more susceptible to soiling compared to Nguni cattle (Chi^2=9.61:p=0.0019). The difference in prevalence of soiling in Bonsmara compared to Hereford cattle (Chi^2=15.26:p<0.0001) was highly significant, with Bonsmara (Chi^2=27.97:p<0.0001)) showing as more prone to soiling compared to Nguni cattle (Chi^2=9.61:p=0.0019. The difference in prevalence of soiling in Angus compared to Bonsmara (Chi^2=3.68: p=0.0551) was significant, with Angus cattle being less susceptible to soiling (Chi^2=0.08: p=0.7795) compared to (Chi^2=27.97:p<0.0001 as shown in Table 4.3.5.

Gender

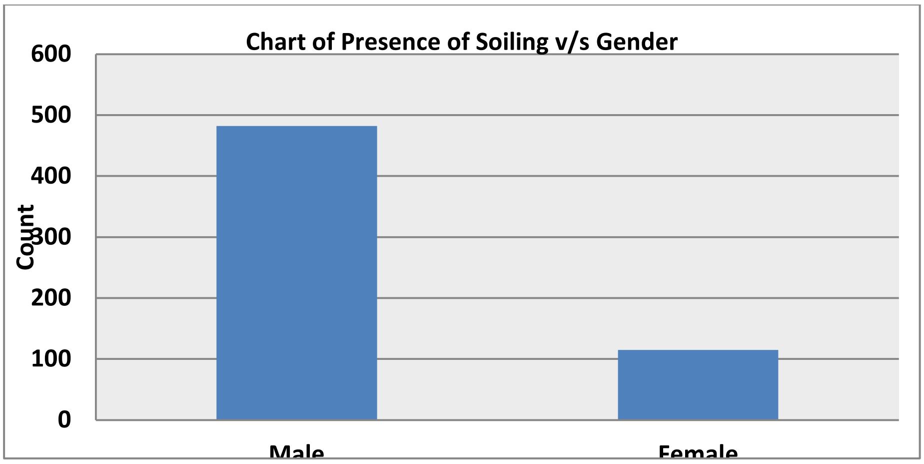


Chart 4.3.2 The effect of gender on the presence of soiling

There was a significantly high gender effect on prevalence of soiling (p<0.0001) in cattle slaughtered at the abattoir. Bulls were more likely to be affected by soiling (Chi^2=14.67; p<0.0001) compared to heifer (Chi^2=14.67; p<0.0001) as summarised in Table 4.3.5.

Season

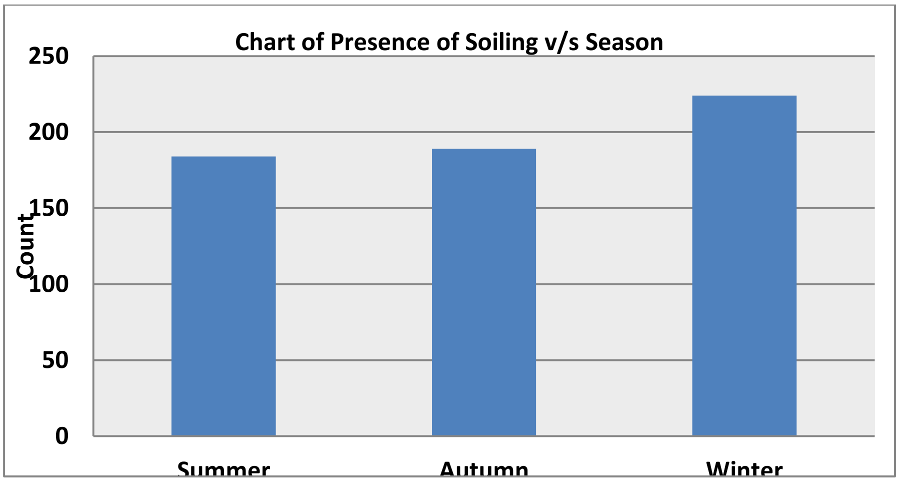


Chart 4.3.3 The effect of season on the presence of soiling

Carcasses were more likely to be condemned due to soiling in Summer (Chi^2 =2.65; p=0.1034) compared to Winter (Chi^2 =1.85; p=0.1734) and Autumn (Chi^2 =0.13; p=0.7143) (Table 4.3.5).

4.4 Fever: The effect of breed, gender and season on fever in cattle

The overall prevalence of fever in bovine carcasses during the process of this study in the abattoir was about 0.07%. Overall there was no seasonal or gender effect on prevalence of fever (p=0.6547) in cattle slaughtered at the abattoir. The highest number of cases of fever recorded for bulls in summer was n=(9) representing 50% of the total number of cases of fever recorded. Only 5.6% of heifers slaughtered were condemned due to fever in Summer. The effect of season and gender on prevalence of fever in beef carcasses is summarised in Table 4.4.1

In the United Kingdom, meat hygiene service figures in 2005 indicated that 3.5 of whole carcasses in every 1 000 slaughtered are condemned as a result of fever, abscess and oedema (White, 2006) (www pvj.com).

Table 4.4.1 Frequency distribution of fever based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	9	1	10	
	%	50.00	5.56		55.56
	Row%	90.00	10.00		
	Col%	52.94	100.00		
Autumn	**Freq**	5	0	5	
	%	27.78	0.00		27.78
	Row%	100.00	0.00		
	Col%	29.41	0.00		
Winter	**Freq**	3	0	3	
	%	1667	0.00		16.67
	Row%	100.00	0.00		
	Col%	17.65	00.0		
Total		17	1	18	
%		94.44	5.56		100

<u>Chi-square statistics for the interaction between season and gender on fever</u>

Statistics	**DF**	**Value**	**Prob(p<F)**

Chi-square	2	0.8471	0.6547
Likelihood Ratio - Chi-Square	2	0.2225	0.5427

The prevalence of fever was high in Summer but there was a difference in Summer between bulls (52.9%) and heifers (100%) (Table 4.4.1), while fewer cases occurred in Autumn and Winter in bulls with no significant effects in heifers.

Table 4.4.2 Frequency distribution of fever based on the effects of season and breed (FREQ Procedure)

		Bonsmara	**Brahman**	**Nguni**	**Total**	**%**
Summer	**Freq**	5	4	1	10	
	%	27.78	22.22	5.56		55.56
	Row%	50.00	40.00	10.00		
	Col%	45.45	66.67	100.0		
Autumn	**Freq**	3	2	0	5	
	%	16.67	11.11	0.00		27.78
	Row%	60.00	40.00	0.00		
	Col%	27.27	33.33	0.00		
Winter	**Freq**	3	0	0	3	
	%	16.67	0.00	0.00		16.67
	Row%	100.00	0.00	0.00		

	Col%	27.27	0.00	0.00		
Total		11	6	1	18	
%		61.11	33.33	5.56		100

Chi-square statistics for the interaction between season and breed on fever

Statistics	DF	Value	Prob(p<F)
Chi-square	4	2.9455	0.5670
Likelihood Ratio - Chi-Square	4	4.2015	0.3794

There was no significant interaction between season and breed on prevalence of fever (p=0.5670) in cattle slaughtered in the abattoir. The highest number of reported cases of fever in Summer was five in Bonsmara cattle representing 27.8% of the total cases in that season. Other cases reported were in Brahman and Nguni cattle. The highest number of cases reported in Autumn were in Bonsmara and Brahman with no significant effect on Nguni cattle, while in Winter reported cases of fever were observed in Bonsmara with no significant effect on Brahman or Nguni (Table 4.4.2).

Table 4.4.3 Frequency distribution of fever based on the effects of gender and breed (FREQ Procedure)

		Bonsmara	Brahman	Nguni	Total	%
Male	**Freq**	10	6	1	17	94.44
	%	55.56	33.33	5.56		
	Row %	58.82	35.29	5.88		

	Col%	90.91	100.0	100		
Female	**Freq**	1	0	0	1	5.56
	%	5.56	0.00	0.00		
	Row %	100.0	0.00	0.00		
	Col%	9.09	0.00	0.00		
Total		11	6	1		100.0
%		61.11	33.33	5.56	18	

Chi-square statistics for the interaction between gender and breed on fever

Statistics	DF	Value	Prob(p<F)
Chi-square	2	0.6738	0.7140
Likelihood Ratio - Chi-Square	2	1.0221	0.5999

No significant interaction between gender and breed was observed on prevalence of fever in cattle slaughtered in the abattoir (p=0.7140).

The highest number of recorded cases of prevalence of fever for bulls was ten in Bonsmara which represented 55.6% of the total number of cases, followed by Brahman (33.3%), Nguni (1%), and reported cases of fever in heifers was only in Bonsmara, one, which represented 5.6%, with no significant effect seen in Brahman and Nguni.

The overall high significant effect due to fever was observed in Bonsmara bulls (Table 4.4.3)

Table 4.4.4 The CATMOD procedure: Analysis of Contrasts of Maximum Likelihood Estimates for fever

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.000314	0.000168	228.11	<.0001	0.000110	0.000895
Male	2.5065	1.2911	3.18	0.0744	0.9133	6.8788
Female	0.3990	0.2055	3.18	0.0744	0.1454	1.0949
Summer	1.9176	0.6186	4.07	0.0436	1.0189	3.6088
Autumn	0.9176	0.3396	0.06	0.8145	0.4436	1.8947
Winter	0.5688	0.2424	1.75	0.1856	0.2467	1.3115

A comparison of the likelihood of fever between seasons is presented in Table 4.4.5.

Table 4.4.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1) for fever

Contrast	Chi-Square	Pr > ChiSq	Estimate	Standard error	LCL	UCL
Intercept	228.11	<.0001	0.000314	0.000168	0.000110	0.000895
Male	3.18	0.0744	2.5065	1.2911	0.9133	6.8788
Female	3.18	0.0744	0.3990	0.2055	0.1454	1.0949

Summer	4.07	0.0436	1.9176	0.6186	1.0189	3.6088
Autumn	0.06	0.8145	0.9167	0.3396	0.4436	1.8947
Winter	1.75	0.1856	0.5688	0.2424	0.2467	1.3115
Sum/Aut	1.81	0.1785	2.0918	1.1475	07138	6.1299
Sum/Win	3.40	0.0652	3.3710	2.2214	0.9265	12.2651
Aut/Win	0.43	0.5136	1.6116	1.1772	0.3850	6.7458

Breed

There was no significant breed effect on prevalence of fever.

Gender

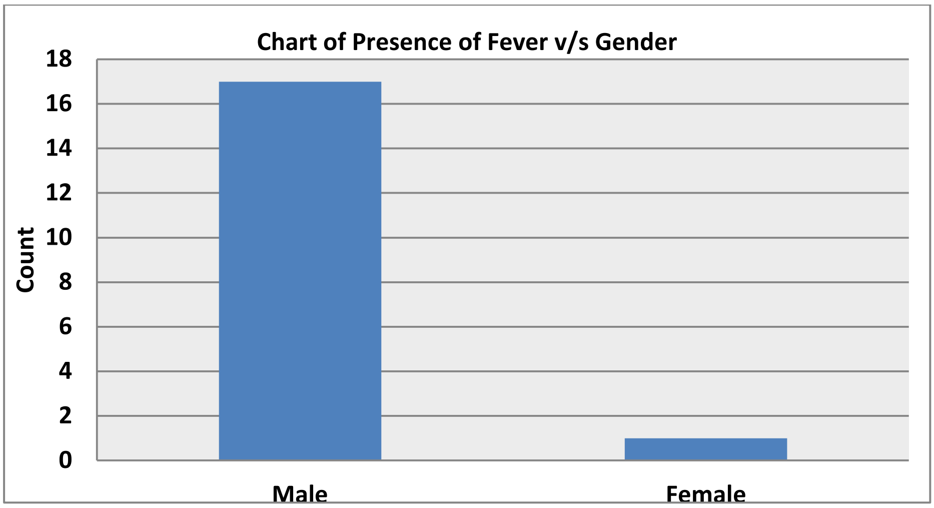


Chart 4.4.1 The effect of gender on the presence of fever

There was a significant gender effect on the prevalence of fever (p=0.0744) in cattle at the abattoir. The prevalence of fever on bulls was (Chi^2=3.18: p=0.0744) estimate (2.5065) and heifers (Chi^2=3.18: p=0.0744) estimate (0.3990) both significant, were an indication of more susceptibility of fever on bulls compared to heifers (Table 4.4.5).

Season

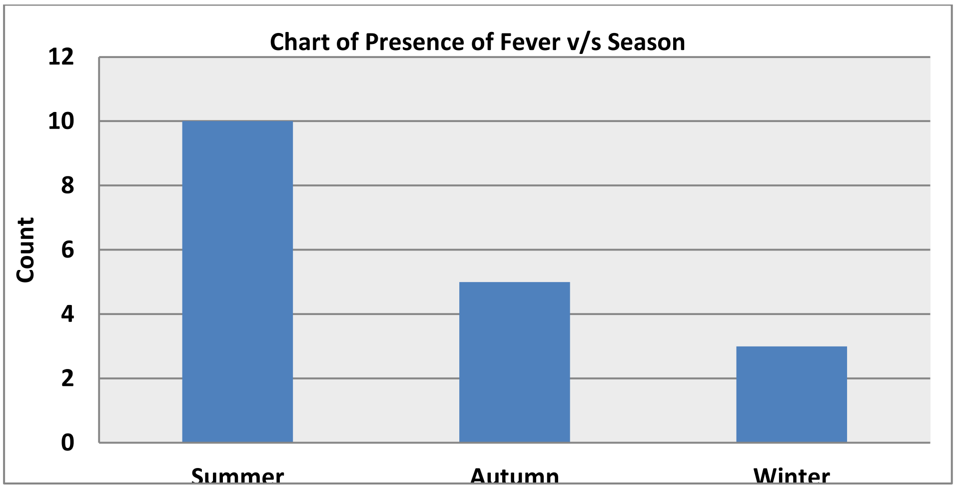


Chart 4.4.2 The effect of season on the presence of fever

There was no statistically significant seasonal effect on fever. Carcasses were more likely to be condemned due to fever in Summer (Chi^2=4.07: p=0.0436) compared to Winter (Chi^2=1.75: p=0.1856) and Autumn (Chi^2=0.06: p=0.8145) as shown in table 4.4.5

4.5. Peritonitis and pleuritis: The effect of breed, gender and season on peritonitis and pleuritis in carcasses

The prevalence of peritonitis and pleuritis in bovine carcasses during the period of study in this particular abattoir was about 2.49%. Overall there were no significant seasonal or gender effects on the prevalence of peritonitis and pleuritis (p=0.6593) in cattle slaughtered at the abattoir (Table 4.5). The highest number of cases of peritonitis and pleuritis was recorded in bulls in Autumn (n=197) which represented 30.9% of the total number of cases of peritonitis and pleuritis . Only 3.9% of heifers slaughtered were condemned due to peritonitis and pleuritis in the same season. The effects of season and gender on the prevalence of peritonitis and pleuritis in cattle slaughtered at this particular abattoir is summarised in Table 4.5.1.

There was no data available in other countries to compare with the above.

Table 4.5.1 Frequency distribution of peritonitis and pleuritis based on the effects of season and gender (FREQ Procedure)

		Male	Female	Total	%
Summer	**Freq**	188	31	219	
	%	29.47	4.86		34.33
	Row%	85.84	14.16		
	Col%	33.75	38.27		
Autumn	**Freq**	197	25	222	
	%	30.88	3.92		34.80
	Row%	88.74	11.26		
	Col%	35.37	30.86		
Winter	**Freq**	172	25	197	
	%	26.96	3.92		30.88
	Row%	87.31	12.69		
	Col%	30.88	30.86		
Total		557	81	638	
%		87.30	12.70		100

<u>Chi-square statistics for the interaction between season and gender on peritonitis and pleuritis</u>

Statistics	DF	Value	Prob(p<F)
Chi-square	2	0.8330	0.6593
Likelihood Ratio - Chi-Square	2	0.8341	0.6590

The prevalence of peritonitis and pleuritis was numerically high in Autumn but no difference was observed in bulls (35.4%) and heifers (30.9%) in this season (Table 4.5.1). The fewest cases of peritonitis and pleuritis were seen in Winter with no difference between bulls (30.9%) and heifers (30.9%).

Table 4.5.2 Frequency distribution of peritonitis and pleuritis based on the effects of season and breed (FREQ Procedure)

		Afrikander	**Angus**	**Bonsmara**	**Brahman**	**Friesland**	**Hereford**	**Nguni**	**Total**	**%**
Summer	**Freq**	0	1	119	71	1	2	25	219	
	%	0.00	0.16	18.65	11.13	0.16	0.31	3.92		34.33
	Row %	0.00	0.46	54.34	32.42	0.46	0.91	11.42		
	Col%	0.00	20.00	28.40	50.35	100.0	40.00	37.88		
Autumn	**Freq**	1	3	158	21	0	2	37	222	
	%	0.16	0.47	24.76	3.29	0.00	0.31	5.80		34.80
	Row %	0.45	1.35	71.17	9.46	0.00	0.90	16.67		
	Col%	100.0	60.00	37.71	14.89	0.00	40.00	56.06		

Winter	**Freq**	0	1	142	49	0	1	4	197	
	%	0.00	0.16	22.26	7.68	0.00	0.16	0.63		30.88
	Row %	0.00	0.51	72..08	24.87	0.00	0.51	2.03		
	Col%	0.00	20.00	33.89	34.75	0.00	20.00	6.06		
Total		1	5	419	141	1	5	66	638	
%		0.16	0.78	65.67	22.10	0.16	0.78	10.34		100.0

Chi-square statistics for the interaction between season and breed on peritonitis and pleuritis

Statistics	**DF**	**Value**	**Prob(p<F)**
Chi-square	12	61.2796	<.0001
Likelihood Ratio - Chi-Square	12	70.1600	<.0001

The highest number of cases in cattle was recorded in Autumn, and in Summer the highest number of cases were Bonsmara (18.7%), Brahman (11.1%) and Nguni (3.9%), while few cases of peritonitis and pleuritis in Summer were recorded for Hereford (0.31%), Angus (0.16%), Friesland (0.16%) and no significant effect was seen in Afrikander. The fewest cases of peritonitis and pleuritis overall were recorded for Angus (0.8%), Hereford (0.8%), Friesland (0.2%) and Afrikander cattle (0.2%) as these represent the smallest amount of cattle slaughtered, while Bonsmara, Brahman and Nguni had the highest prevalence as they represent the largest proportion of cattle slaughtered (Table 4.5.2).

Table 4.5.3 Frequency distribution of peritonitis and pleuritis based on the effects of gender and breed (FREQ Procedure)

		Afrikander	Angus	Bonsmara	Brahman	Friesland	Hereford	Nguni	Total	%
Male	**Freq**	1	4	354	128	1	4	65	557	
	%	0.16	0.63	55.49	20.06	0.16	0.63	10.19		87.30
	Row%	0.18	0.72	63.55	22.98	0.18	0.72	11.67		
	Col%	100.0	80.00	84.49	90.78	100.0	80.00	98.48		
Female	**Freq**	0	1	65	13	0	1	1	81	
	%	0.00	0.16	10.19	2.04	0.00	0.16	0.16		12.70
	Row%	0.00	1.23	80.25	16.05	0.00	1.23	1.23		
	Col%	0.00	20.00	15.51	9.22	0.00	20.00	1.52		
Total		1	5	419	141	1	5	66	638	
%		0.16	0.78	65.67	22.10	0.16	0.78	10.34		100

Chi-square statistics for the interaction between gender and breed on peritonitis and pleuritis

Statistics	DF	Value	Prob(p<F)
Chi-square	6	12.7531	0.0471
Likelihood Ratio - Chi-Square	6	16.8840	0.0097

There was a significant interaction between gender and breed in the prevalence of peritonitis and pleuritis (p=0.0471) in cattle slaughtered. The highest number of cases of peritonitis and pleuritis recorded for bulls in Bonsmara cattle represented 55.5% of the total number of cases, followed by Brahman (20.1%), Nguni (10.2%), Angus (0.6%), Hereford (0.6%), Friesland (0.2%) and Angus cattle (0.2%). It was found that significantly more cases of peritonitis and pleuritis were reported in Bonsmara compared to Brahman, Nguni, Hereford, Angus, Friesland and Afrikander cattle. Although Bonsmara, Brahman and Nguni-types represented the highest number of peritonitis and pleuritis cases due to the higher number of animals slaughtered from these types, Brahman (Chi^2=26,31; p<0,0001) and Nguni types (Chi^2=26,42; p<0,0001) were more likely to affected by peritonitis and pleuritis based on maximum likelihood analysis (Table 4.5.4).

Overall, cattle were affected by peritonitis and pleuritis in Summer (Chi^2=17, 34; p<0,0001), followed by Winter (Chi^2=8.18; p<0,0042) and Autumn (Chi^2=2, 29; p=0.1301) and were more likely to be affected by peritonitis and pleuritis based on maximum likelihood analysis (Table 4.5.4).

Table 4.5.4 The CATMOD procedure: Analysis of Contrasts of Maximum Likelihood Estimates for Peritonitis and Pleuritis

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.00600	0.00135	513.11	<.0001	0.00385	0.00934
Afrikander	0.0510	0.0446	11.57	0.0007	0.00919	0.2833
Angus	0.7450	0.3276	0.45	0.5032	0.3147	1.7638
Bonsmara	4.2914	0.9757	41.04	<.0001	2.7483	6.7009
Brahman	3.3465	0.7881	26.31	<.0001	2.1093	5.3094
Friesland	0.4352	0.3811	0.90	0.3421	0.0782	2.4214
Hereford	1.1800	0.5215	0.14	0.7080	0.4962	2.8061
Nguni	3.5674	0.8828	26.42	<.0001	2.1965	5.7940
Male	1.4565	0.0751	38.65	<.0001	0.00798	0.5875
Female	0.6866	0.0119	38.65	<.0001	0.00167	0.0848
Summer	1.2109	0.0153	10.80	0.0010	0.00213	0.1092
Autumn	0.9331	0.1660	1.44	0.2309	0.00731	1.8811
Winter	0.8850	0.0475	4.18	0.0408	0.00502	0.3723

A comparison of the likelihood of peritonitis and pleuritis between breed and season is presented in Table 4.5.5.

Table 4.5.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1)

Contrast	Chi-Square	Pr > ChiSq	Estimate	Standard error	LCL	UCL
Intercept	513.11	<.0001	0.00600	0.00135	0.00385	0.00934
Afrikander	11.57	0.0007	0.0510	0.0446	0.00919	0.2833
Angus	0.45	0.5032	0.7450	0.3276	0.3147	1.7638
Bonsmara	41.04	<.0001	4.2914	0.9757	2.7483	6.7009
Brahman	26.31	<.0001	3.3465	0.7881	2.1093	5.3094
Friesland	0.90	0.3421	0.4352	0.3811	0.0782	2.4214

Hereford	0.14	0.7080	1.1800	0.5215	0.4962	2.8061
Nguni	26.42	<.0001	3.5674	0.8828	2.1965	5.7940
Afr/Ang	5.98	0.0145	0.0685	0.0751	0.00798	0.5875
Afr/Bon	19.55	<.0001	0.0119	0.0119	0.00167	0.0848
Afr/Bra	17.34	<.0001	0.0152	0.0153	0.00213	0.1092
Afr/Fri	2.29	0.1301	0.1172	0.1660	0.00731	1.8811
Afr/Her	8.18	0.0042	0.0432	0.0475	0.00502	0.3723
Afr/Ngu	17.76	<.0001	0.0143	0.0144	0.00198	0.1031
Ang/Bon	15.03	0.0001	0.1736	0.0784	0.0716	0.4208
Ang/Bra	10.78	0.0010	0.2226	0.1019	0.0908	0.5458
Ang/Fri	0.24	0.6243	1.7118	1.8791	0.1991	14.7174
Ang/Her	0.52	0.4694	0.6313	0.4014	0.1816	2.1948
Ang/Ngu	11.28	0.0008	0.2088	0.0974	0.0837	0.5209
Bon/Bra	6.13	0.0133	1.2823	0.1288	1.0532	1.5614
Bon/Fri	5.20	0.0226	9.8607	9.8959	1.3794	70.4924
Bon/Her	8.10	0.0044	3.6367	1.6495	1.4950	8.8467
Bon/Ngu	1.78	0.1826	1.2029	0.1668	0.9167	1.5786
Bra/Fri	4.11	0.0426	7.6896	7.7373	1.0701	55.2570

Bra/Her	5.12	0.0236	2.8359	1.3064	1.1497	6.9952
Bra/Ngu	0.17	0.6791	0.9381	0.1450	0.6930	1.2699
Fri/Her	0.82	0.3638	0.3688	0.4051	0.0428	3.1754
Fri/Ngu	4.34	0.0373	0.1220	0.1232	0.0168	0.8833
Her/Ngu	5.54	0.0186	0.3308	0.1555	0.1316	0.8312
Male	38.65	<.0001	1.4565	0.0881	1.2936	1.6397
Female	38.65	<.0001	0.6866	0.0415	0.6099	0.7730
Summer	10.80	0.001	1.2109	0.0705	1.0803	1.3573
Autumn	1.44	0.2309	0.9331	0.0539	0.8332	1.0450
Winter	4.18	0.0408	0.8850	0.0529	0.7873	0.9949
Sum/Aut	6.86	0.0088	1.2977	0.1292	1.0678	1.5770
Sum/Win	9.29	0.0023	1.3682	0.1407	1.1184	1.6737
Aut/Win	0.27	0.6042	1.0543	0.1076	0.8632	1.2878

Breed

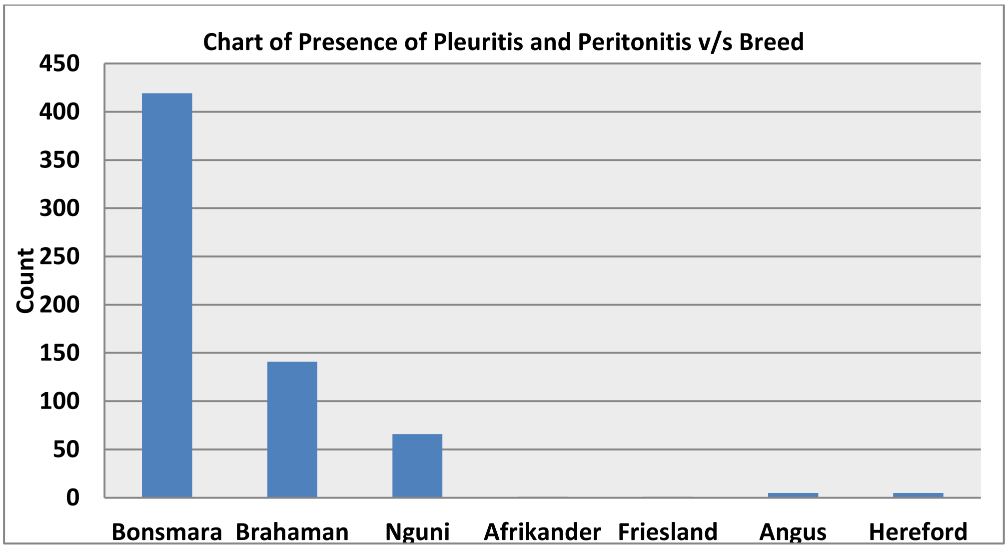


Chart 4.5.1 The effect of breeds on presence of pleuritis and peritonitis

Then prevalence of peritonitis and pleuritis ($p<0.0001$) in cattle slaughtered at the abattoir was significant. The order of significance in prevalence of peritonitis and pleuritis are Bonsmara ($p<0.0001$), Brahman ($p<0.0001$), Nguni ($p<0.0001$), Afrikander ($p=0.0007$), Friesland ($p=0.3421$), Angus ($p=0.5032$) and Hereford cattle ($p=0.7080$). This is as an indication that Bonsmara cattle were more susceptible to pleuritis and peritonitis compared to Brahman, Nguni, Afrikander, Friesland, Angus and Hereford cattle.

The difference in prevalence of peritonitis and pleuritis in Afrikander compared to Bonsmara (Chi^2=1955:$p<0.0001$) was significant, with Afrikander cattle (Chi^2=11.57p<.0007) being less prone to peritonitis and pleuritis compared Bonsmara cattle (Chi^2=41.04:$p<0.0001$). The difference in prevalence of peritonitis and pleuritis in Afrikander compared to Nguni (Chi^2=17.76:$p<0.0001$) was highly significant, indicating that Afrikander cattle (Chi^2=11.57;p<.0007) were less susceptible to peritonitis and pleuritis compared to Nguni cattle (Chi^2=26.42:$p<0.0001$).

The difference in prevalence of peritonitis and pleuritis in Afrikander compared to Brahman (Chi^2=17.34: $p<0.0001$) was significantly high, with Afrikander cattle (Chi^2=11.57: p<.0007) being less prone to peritonitis and pleuritis compared Brahman cattle (Chi^2=26.31:p<0.0001) (Table 4.5.5).

Gender

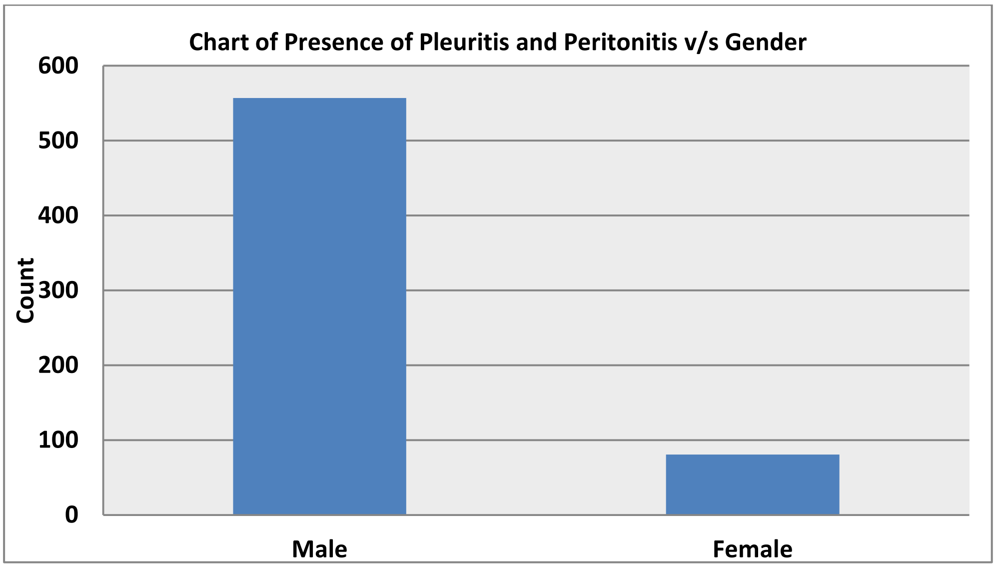


Chart 4.5.2 The effect of gender on the presence of pleuritis and peritonitis

There was a significantly high gender effect on the prevalence of peritonitis and pleuritis (p<0.0001) in cattle at the abattoir. Bulls were more likely to be affected by peritonitis and pleuritis (Chi^2=38.65; p<0.0001) compared to heifers (Chi^2=38.65; p<0.0001) as summarised in Table 4.5.5.

Season

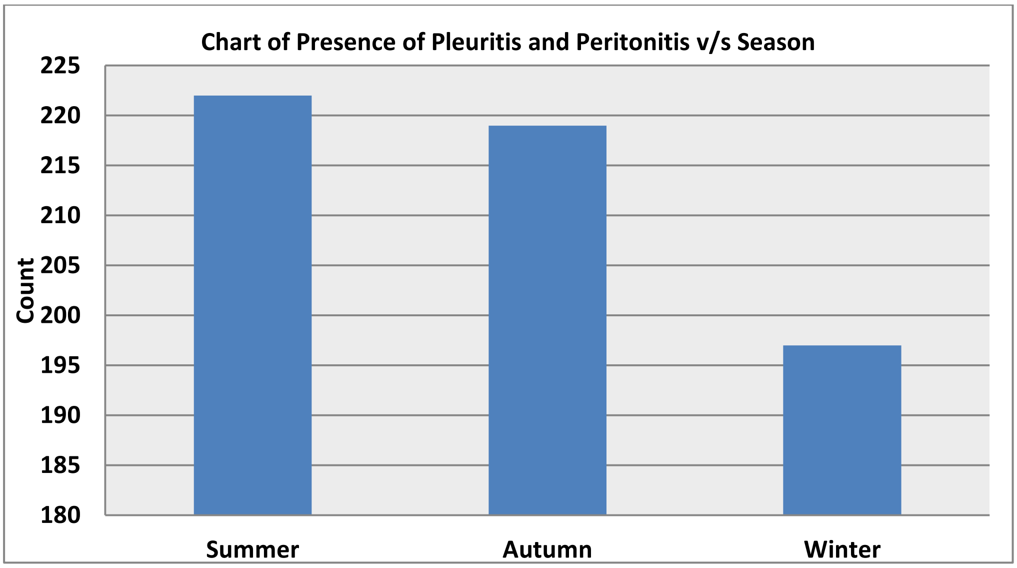


Chart 4.5.3 The effect of season on the presence of pleuritis and peritonitis

There was a significant seasonal effect on prevalence of peritonitis and pleuritis (p=0.0042) in cattle slaughtered at the abattoir. Prevalence of peritonitis and pleuritis in Summer (Chi^2=10.80:p=0.0010), Winter (Chi^2=4.18:p=0.0408) and Autumn (Chi^2=9.29p=0.0023) was more likely to be affected by peritonitis and pleuritis based on the maximum likelihood analysis (Table 4.5.5).

The difference in prevalence of peritonitis and pleuritis in Summer compared to Winter (Chi^2=9.29p=0.0023) was significantly high, with Summer (Chi^2=10.80: p<0.001) having more effects on peritonitis and pleuritis compared to Winter (Chi^2=4.18: p=0.0408) (Table 4.5.5).

4.6. <u>Abscess: The effect of breed, gender and season in abscess on carcasses</u>

The prevalence of abscess in bovine carcasses during the period of study in the abattoir was about 0.38%. Overall there were no significant seasonal or gender effects on the prevalence of abscess (p=0.3389) in cattle slaughtered at the abattoir. The highest number of cases of abscess was recorded in bulls in Winter (n=43) which represented 43.9% of the total number of cases of abscess in that season. Only 1.02% of heifers slaughtered were condemned due to abscess in Winter. The effects of season and gender on the prevalence of abscess in cattle slaughtered at this particular abattoir is summarised in Table 4.6.1. The prevalence of abscess was numerically the highest in Winter, but it did not differ significantly between bulls (45.3%) and heifers (33.3%) in this season (Table 4.6.1). The fewest cases of parafilaria occurred in Autumn, and there was a difference between bulls (25.3%) and no significant effect in heifers.

In 2008, about 7 812 cattle were examined and slaughtered in a Nigerian cattle abattoir, only to find that abscesses were at 4.5%. The number of carcasses partially condemned was 5160, highlighting that there was a need to improve meat inspection practices in the abattoir (www.academicjournals.org).

Table 4.6.1 Frequency distribution of abscess based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	28	2	30	
	%	28.57	2.04		30.61
	Row%	93.33	6.67		
	Col%	29.47	66.67		
Autumn	**Freq**	24	0	24	
	%	24.49	0.00		24.49
	Row%	100.0	0.00		
	Col%	25.26	0.00		

Winter	**Freq**	43	1	44	
	%	43.88	1.02		44.90
	Row%	97.73	2.27		
	Col%	45.26	33.33		
Total		95	3	98	
%		96.94	3.06		100

Chi-square statistics for the interaction between season and gender on abscess

Statistics	**DF**	**Value**	**Prob(p<F)**
Chi-square	2	2.1642	0.3389
Likelihood Ratio - Chi-Square	2	2.5841	0.2747

There was no significant interaction between season and breed in the prevalence of abscess (p=0.1497) in cattle slaughtered (Table 4.6.2). The highest number of cases of abscess was observed in Summer (n=20) in Bonsmara cattle which represented 20.4% of the total number of cases in Summer.

This condition is common in feedlots where cattle are fed a high grain diet producing acidity in the rumen and ulcerative rumenitis. This condition presents with a viscous, coloured cream fluid during post-mortem that has a dry cartage cheese appearance and a bad smell.

Table 4.6.2 Frequency distribution of abscess based on the effects of season and breed (FREQ Procedure)

		Afrikander	Bonsmara	Brahman	Nguni	Total	%
Summer	**Freq**	0	20	4	6	30	
	%	0.00	20.41	4.08	6.12		30.61
	Row%	0.00	66.67	13.33	20.00		
	Col%	0.00	30.77	19.05	53.55		
Autumn	**Freq**	1	16	4	3	24	
	%	1.02	16.33	4.08	3.06		24.49
	Row%	4.17	66.67	16.67	12.50		
	Col%	100.0	24.62	19.05	27.27		
Winter	**Freq**	0	29	13	2	44	
	%	0.00	29.59	13.27	2.04		44.90
	Row%	0.00	65.91	29.55	4.55		
	Col%	0.00	44.62	61.90	18.18		
Total		1	65	21	11	98	
%		1.02	66.33	21.43	11.22		100

Chi-square statistics for the interaction between season and breed on abscess

Statistics	DF	Value	Prob(p<F)

Chi-square	6	9.4514	0.1497
Likelihood Ratio - Chi-Square	6	9.3226	0.1562

The highest number of abscess cases in Bonsmara, Brahman and Nguni cattle were recorded in Winter, and the lowest were recorded in Autumn. Overall, very few cases of abscess were recorded for Afrikander (1.02%) and Nguni cattle (11.2%), because these breeds represented a numerically small proportion of the total number of cattle slaughtered at this abattoir. The prevalence of abscess was high in Bonsmara and Brahman types because these types represented the largest proportion of cattle slaughtered.

Table 4.6.3 Frequency distribution of abscess based on the effects of gender and breed (FREQ Procedure)

		Afrikander	**Bonsmara**	**Brahman**	**Nguni**	**Total**	**%**
Male	**Freq**	1	63	20	11	95	
	%	1.02	64.29	20.41	11.22		96.94
	Row%	1.05	66.32	21.05	11.58		
	Col%	100.0	96.92	95.24	100.0		
Female	**Freq**	0	2	1	0	3	
	%	0.00	2.04	1.02	0.00		3.06
	Row%	0.00	66.67	33.33	0.00		
	Col%	0.00	3.08	4.76	0.00		
Total		1	65	21	11	98	
%		1.02	66.33	21.43	11.22		100.0

Chi-square statistics for the interaction between gender and breed on abscess

Statistics	DF	Value	Prob(p<F)
Chi-square	3	0.5837	0.9002
Likelihood Ratio - Chi-Square	3	0.9219	0.8201

There was no significant interaction between gender and breed in the prevalence of abscess (p=0.9002) in cattle slaughtered. The highest number of cases of abscess was recorded for bulls in Bonsmara cattle which represented 64.3% of the total number of cases, followed by Brahman (20.4%), Nguni (11.2%) and Afrikander cattle (1.02%). It was found that significantly more cases of abscess (66.3%) were reported in Bonsmara compared to Brahman, Nguni and Afrikander cattle.

Overall, cattle were affected by abscess in Winter ($Chi^2$6.09; p=0.0136) followed by Autumn (Chi^2=3.80; p=0, 0513) while Summer (Chi^2=0.04; p=0.8460) was not significant but likely to be affected by abscess based on maximum likelihood analysis. There were differences in the likelihood of bulls or heifers to be affected by parafilaria as indicated previously (Table 4.6.5).

Table 4.6.4 The CATMOD procedure: Analysis of Contrasts of Maximum Likelihood Estimates for abscess

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.00149	0.000438	489.00	<.0001	0.000837	0.00265
Male	3.2273	0.9472	15.94	<.0001	1.8156	5.7366
Female	0.3099	0.0909	15.94	<.0001	0.1743	0.5508

Summer	0.9715	0.1444	0.04	0.8460	0.7259	1.3002
Autumn	0.7355	0.1159	3.80	0.0513	0.5400	1.0018
Winter	1.3995	0.1906	6.09	0.0136	1.0717	1.8276

Table 4.6.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1) for abscess

Contrast	**Chi-Square**	**Pr > ChiSq**	**Estimate**	**Standard error**	**LCL**	**UCL**
Intercept	489.00	**<.0001**	0.00149	0.000438	0.000837	0.00265
Male	15.94	**<.0001**	3.2273	0.9472	1.8156	5.7366
Female	15.94	**<.0001**	0.3099	0.0909	0.1743	0.5508
Summer	0.04	0.8460	0.9715	0.1444	0.7259	1.3002
Autumn	3.80	**0.0513**	0.7355	0.1159	0.5400	1.0018
Winter	6.09	**0.0136**	1.3995	0.1906	1.0717	1.8276
Sum/Aut	1.03	0.3106	1.3210	0.3627	0.7713	2.2625
Sum/Win	2.36	0.1245	0.6942	0.1649	0.4358	1.1059
Aut/Win	6.40	**0.0114**	0.5255	0.1337	0.3192	0.8651

Breed

There was no intereaction between the types of breed and abscess as shown in table 4.6.5

Gender

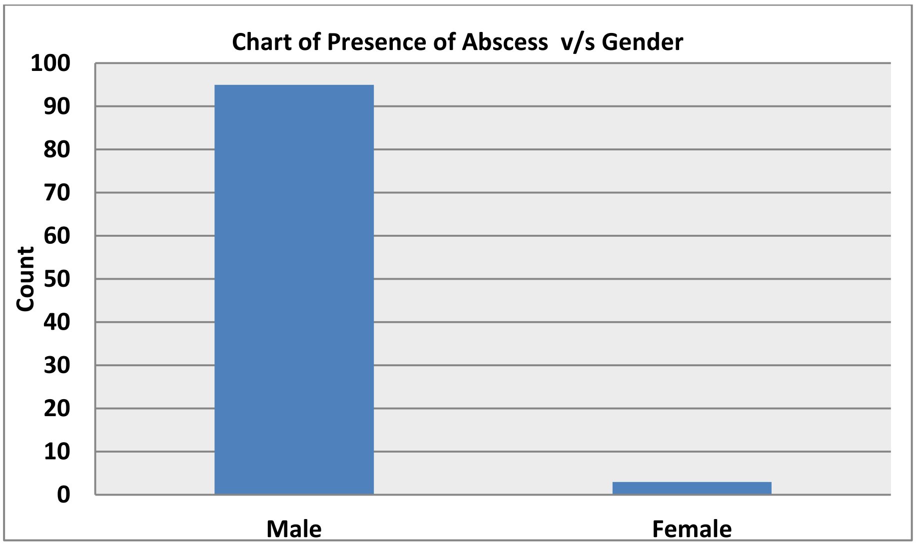


Chart 4.6.1 The effect of breed on the presence of abscess

There was a significant gender effect on prevalence of abscess ($p<0.0001$) in cattle at the abattoir. Prevalence of abscess in bulls ($Chi^2=3.80:p<0.0001$) estimate (3.2273) and heifers ($Chi^2=3.80p<0.0001$) estimate (0.3099) were both significant, indicating that bulls were more prone to abscess compared to heifers (Table 4.6.5).

Season

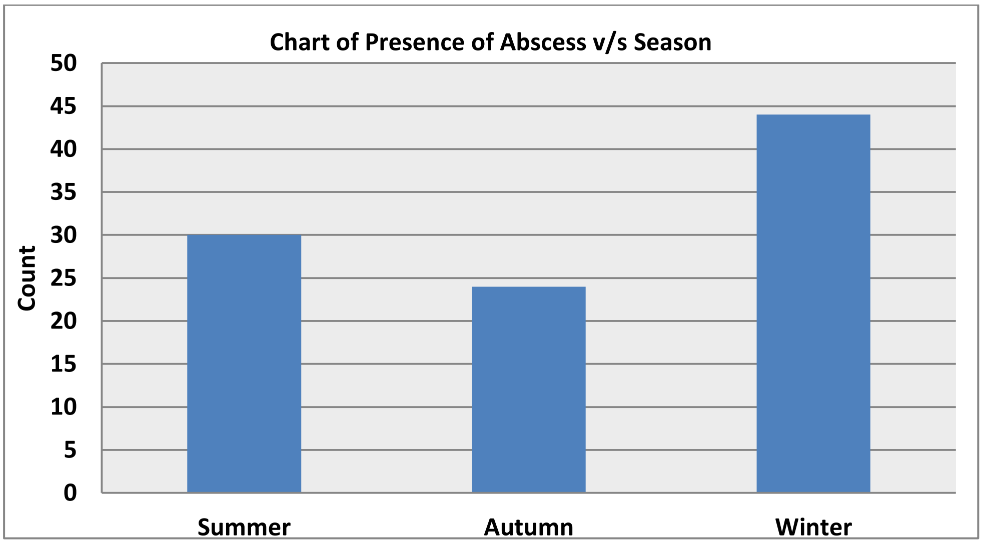


Chart 4.6.2 The effect of season on the presence of abscess

There was a significant seasonal effect on prevalence of abscess ($p<0.0335$) in cattle at the abattoir. Carcasses were more likely to be condemned due to abscess in Winter (Chi^2 =6.09; p=0.0136), Autumn (Chi^2 =3.80; p=0.0513) and Summer (Chi^2 =0.04; p=0.8460) (Table 4.6.5).

The difference in prevalence of abscess in Autumn compared to Winter (Chi^2=6.40: p=0.0114) was significant, showing that in Autumn (Chi^2=3.80:p=0.0513) fewer effects of abscess were seen compared to Winter (Chi^2=6.09:p=0.0136) (Table 4.6.5).

4.7. Measles: The effect of breed, gender and season on measles in carcasses

The prevalence of measles in bovine carcasses during the period of study in this particular abattoir was about 0.08%. Overall there were no significant seasonal or gender effects on the prevalence of measles (p=0.8572) in cattle slaughtered at the abattoir. The highest number of cases of measles was recorded in bulls in Winter (n=16) which represented 72.7% of the total number of measles cases recorded. Only 4.6% of heifers slaughtered were condemned due to measles in Winter. The effects of season and gender on the prevalence of measles in cattle slaughtered at the abattoir is summarised in Table 4.7.1.

The prevalence of measles was numerically the highest in Winter, and there was a significant difference between bulls and heifers in this season. The fewest cases of measles occurred in Summer with a significant difference between bulls (9.5%) and no significant effects observed in heifers. Not many cases were seen in heifers (Table 4.7.1).

No data from other countries was found to compare with the above.

Table 4.7.1 Frequency distribution of measles based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	2	0	2	
	%	9.09	0.00		9.09
	Row%	100.0	0.00		
	Col%	9.52	0.00		
Autumn	**Freq**	3	0	3	
	%	13.64	0.00		13.64
	Row%	100.0	0.00		
	Col%	14.29	0.00		
Winter	**Freq**	16	1	17	
	%	72.73	4.55		77.27
	Row%	94.12	5.88		
	Col%	76.19	100.0		
Total		21	1	22	
%		95.45	4.55		100

Chi-square statistics for the interaction between season and gender on measles

Statistics	**DF**	**Value**	**Prob(p<F)**

Chi-square	2	0.3081	0.8572
Likelihood Ratio - Chi-Square	2	0.5295	0.7674

The effect was seen during Winter when there was a scarcity of food and cattle started grazing even unwanted materials due to insufficient food, especially those that are extensified. Those unwanted materials may have had larvae leading to tapeworms and resulting to muscle damage in the carcass during post-mortem and eventually measles

Table 4.7.2 Frequency distribution of measles based on the effects of season and breed (FREQ Procedure)

		Afrikander	**Bonsmara**	**Brahman**	**Hereford**	**Nguni**	**Total**	**%**
Summer	**Freq**	1	0	0	0	1	2	
	%	4.55	0.00	0.00	0.00	4.55		9.09
	Row%	50.00	00.0	0.00	0.00	50.00		
	Col%	100.0	0.00	0.00	0.00	50.00		
Autumn	**Freq**	0	2	0	0	1	3	
	%	0.00	9.09	0.00	0.00	4.55		13.64
	Row%	0.00	66.67	0.00	0.00	33.3		
	Col%	0.00	18.18	0.00	0.00	50.00		

Winter	**Freq**	0	9	7	1	0	17	
	%	0.00	40.91	31.82	4.55	0.00		77.27
	Row%	0.00	52.94	41.18	5.88	0.00		
	Col%	0.00	81.82	100.0	100.0	0.00		
Total		1	11	7	1	2	22	
%		4.55	50.0	31.82	4.55	9.09		100

<u>Chi-square statistics for the interaction between season and breed on measles</u>

Statistics	**DF**	**Value**	**Prob(p<F)**
Chi-square	8	20.7157	0.0079
Likelihood Ratio - Chi-Square	8	17.1087	0.0290

There was a significant interaction between season and breed in the prevalence of measles (p=0.0079) in cattle slaughtered (Table 4.7.2). The highest number of cases of measles was observed in Winter (n=9) in Bonsmara cattle which represented 40.9% of the total number of cases in Winter. The highest number of measles cases in all seasons was recorded in Winter, while the lowest number of cases in cattle was recorded in Summer, with no cases of prevalence of measles observed for Bonsmara and Brahman in either Summer or Autumn.

Overall, very few cases of measles were recorded for Nguni (9.1%), Afrikander (4.6%) and Hereford cattle (4.6%), as these breeds represented a numerically smaller portion of the total number of cattle slaughtered at this abattoir. The prevalence of measles was highest in the Bonsmara- and Brahman-types because these represented the largest portion of cattle slaughtered. These breeds were probably significantly affected because they were grazing on pastures that were polluted due to unhygienic toilets practices in which the signs of that condition was seen during post-mortem as measles.

Table 4.7.3 Frequency distribution of measles based on the effects of gender and breed (FREQ Procedure

		Afrikander	Bonsmara	Brahman	Hereford	Nguni	Total	%
Male	**Freq**	1	11	7	0	2	21	
	%	4.55	50.00	31.82	0.00	9.09		95.45
	Row%	4.76	52.38	33.33	0.00	9.52		
	Col%	100.0	100.0	100.0	0.00	100.0		
Female	**Freq**	0	0	0	1	0	1	
	%	0.00	0.00	0.00	4.55	0.00		4.55
	Row%	0.00	0.00	0.00	100.0	0.00		
	Col%	0.00	0.00	0.00	100.0	0.00		
Total		1	11	7	1	2	22	
%		4.55	50.00	31.82	4.55	9.09		100.0

<u>Chi-square statistics for the interaction between gender and breed on measles</u>

Statistics	DF	Value	Prob(p<F)
Chi-square	4	22.0000	0.0002
Likelihood Ratio-Chi-Square	4	8.1359	0.0867

There were high significant interaction between gender and breed on the prevalence of measles (p=0.0002) in cattle slaughtered. The highest number of cases of measles were recorded for bulls in Bonsmara cattle which represented 50.0% of the total number of cases, followed by Brahman (31.8%), Nguni (9.1%) and Afrikander cattle (4.6%), no significant effect was seen for bulls in Hereford cattle (Table 4.7.3). It was found that significantly more cases of measles were reported in Bonsmara compared to Brahman, Nguni and Afrikander cattle. Although Bonsmara, Brahman and Nguni-types represented the highest number, Overall cattle were affected by measles in winter (Chi^2=14.24; p=0.0002), followed by summer (Chi^2=2.60; p=0.1070) and autumn (Chi^2=1.05; p=0.3061) not significant but likely to be affected by measles based on maximum likelihood analysis (Table 4.7.5). There were differences in the likelihood of bulls or heifers to be affected by measles. According to my observation during this study lot of the above breeds were not affected by measles as they were from the feedlots (intensification system).

Table 4.7.4 The CATMOD procedure: Analysis of Contrasts of Maximum Likelihood Estimates Measles

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.000280	0.000156	215.95	<.0001	0.000094	0.000833
Male	2.4756	1.2670	3.14	0.0765	0.9079	6.7505
Female	0.4039	0.2067	3.14	0.0765	0.1481	1.1015
Summer	0.4354	0.2246	2.60	0.1070	0.1584	1.1966
Autumn	0.6253	0.2868	1.05	0.3061	0.2545	1.5365
Winter	3.6731	1.2664	14.24	0.0002	1.8687	7.2196

Table 4.7.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1) for Measles

Contrast	**Chi-Square**	**Pr > ChiSq**	Estimate	Standard error	LCL	UCL
Intercept	215.95	**<.0001**	0.000280	0.000156	0.000094	0.000893
Male	3.14	**0.0765**	2.4756	1.2670	0.9079	6.7505
Female	3.14	**0.0765**	0.4039	0.2067	0.1481	1.1015
Summer	2.60	0.1070	0.4354	0.2246	0.1584	1.1966
Autumn	1.05	0.3061	0.6253	0.2868	0.2545	1.5365
Winter	14.24	**0.0002**	3.6731	1.2664	1.8687	7.2196
Sum/Aut	0.16	0.6918	0.6962	0.6359	0.1162	4.1702
Sum/Win	8.13	**0.0044**	0.1185	0.0887	0.0274	0.5136
Aut/Win	7.99	**0.0047**	0.1702	0.1066	0.0499	0.5812

Breed

The results showed no significant effect of measles on breed as indicated in table 4.7.5

Gender

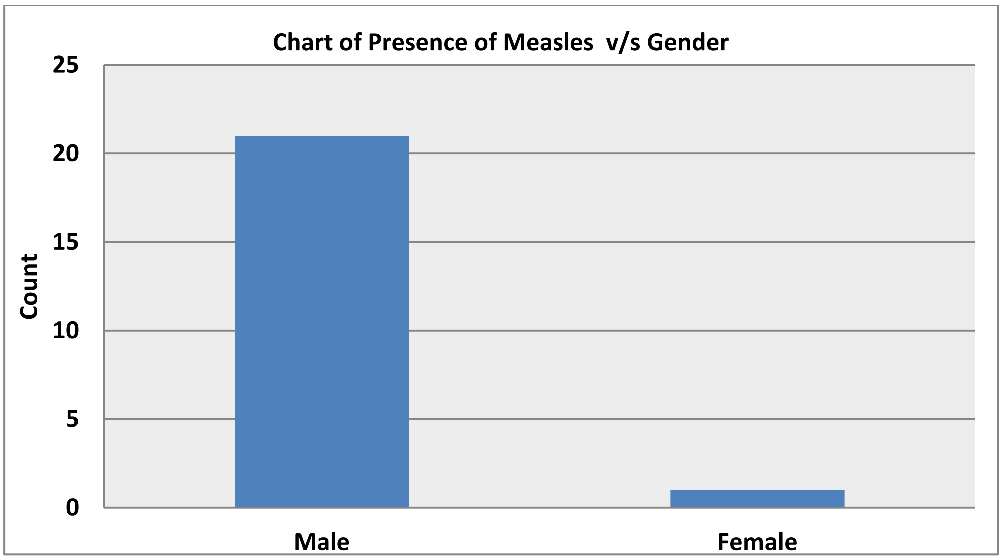


Chart 4.7.1 The effect of gender on the presence of measles

There appears to be a marginal gender effect on prevalence of measles (p=0.0765) in cattle in the abattoir. Prevalence of measles in Bulls (Chi^2=3.14: p=0.0765) estimate (2.4756) and heifers (Chi^2=3.14:p=0.0765) estimate (0.4039) were significant, that is an indication that bulls were more susceptible to measles compared to heifers (Table 4.7.5).

Season

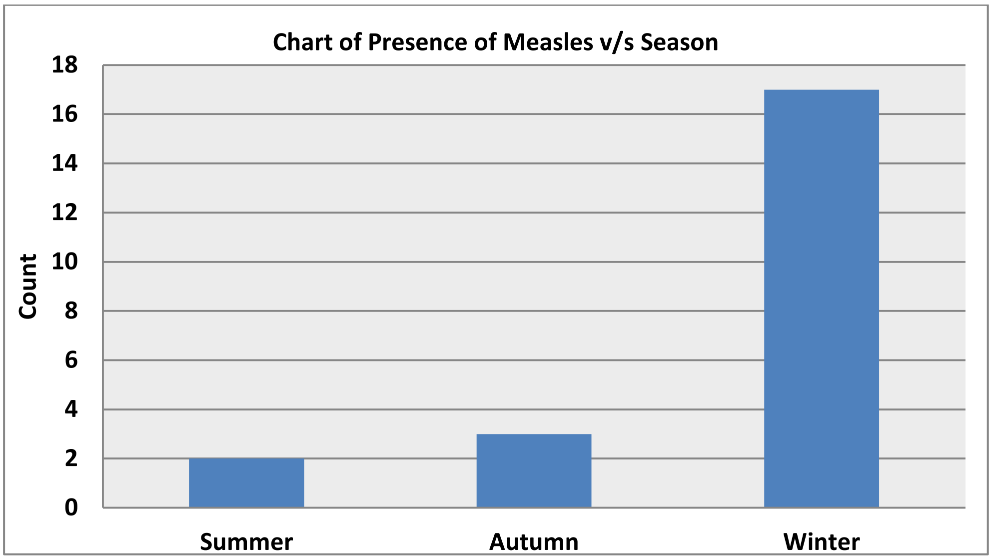


Chart 4.7.2 The effect of season on the presence of measles

There was a significantly high seasonal effect on prevalence of measles (p=0.0008) in the cattle slaughtered at the abattoir. The prevalence of measles in Winter (p=0.0002) was significantly high. No evidence of effects on prevalence of Summer (p=0.1070) and Autumn (p=0.3061) were observed.

The difference in prevalence of measles in Summer compared to Winter (Chi^2=8.13:p=0.0044) was significantly high, with Summer (Chi^2=2.60:p=0.1070) being less affected due to measles compared Winter (Chi^2=14.24:p=0.0002) and the prevalence of measles in Autumn compared to Winter (Chi^2=7.99: p=0.0047) was significant, indicating that Autumn (Chi^2=1.05: p=0.3061) was more affected by measles than Winter (Chi^2=14.24:p=0.0002) as shown in (Table 4.7.5).

4.8. Oedema: The effect of breed, gender and season on oedema on carcasses

The prevalence of oedema in cattle carcasses during the period of study in this particular abattoir was about 0.3%. Overall there were significant seasonal and gender effects on the prevalence of oedema (p=0.0970) in cattle slaughtered at the abattoir. The highest number of cases of oedema was recorded in bulls in Autumn (n=28) representing 35.4% of the total number of cases of oedema recorded. Only 6.3% of heifers slaughtered in Autumn were condemned due to oedema.

The effects of season and gender on the prevalence of oedema in cattle slaughtered at this particular abattoir is summarised in Table 4.8.1. The prevalence of oedema was numerically the highest in Autumn, but did not differ significantly between bulls (41.2%) and heifers (45.5%) in this season. The fewest cases of oedema occurred in Winter, but there was a difference in bulls (27.9%) and no significant effect in heifers (Table 4.8.1). High effect was seen in Autumn as this is the time of shortage of food leading to severe malnutrition, gastrointestinal parasitic infestation, and eventually water on the surface of the carcass during post-mortem which is a sign of oedema.

In the United Kingdom, meat hygiene services in 2005 indicated that 3.5 of the carcasses in every 1 000 slaughtered are condemned as a results of oedema, abscess and fever (White, 2006) and (www.nadis.org).

Table 4.8.1 Frequency distribution of oedema based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	21	6	27	
	%	26.58	7.59		34.18
	Row%	77.78	22.22		
	Col%	30.88	54.55		
Autumn	**Freq**	28	5	33	
	%	35.44	6.33		41.77
	Row%	84.85	15.15		
	Col%	41.18	45.45		
Winter	**Freq**	19	0	19	
	%	24.05	0.00		24.05
	Row%	100.0	0.00		
	Col%	27.94	0.00		
Total		68	11	79	100.0
%		86.08	13.92		

Chi-square statistics for the interaction between season and gender on oedema

Statistics	DF	Value	Prob(p<F)
Chi-square	2	4.6663	0.0970
Likelihood Ratio-Chi-Square	2	7.0902	0.0289

Table 4.8.2 Frequency distribution of oedema based on the effects of season and breed (FREQ Procedure)

		Afrikander	Bonsmara	Brahman	Nguni	Total	%
Summer	**Freq**	3	12	10	2	27	
	%	3.80	15.19	12.66	2.53		34.18
	Row%	11.11	44.44	37.04	7.41		
	Col%	100.0	30.77	35.71	22.22		
Autumn	**Freq**	0	21	6	6	33	
	%	0.00	26.58	7.59	7.59		41.77
	Row%	0.00	63.64	18.18	18.18		
	Col%	0.00	53.85	21.43	66.67		
Winter	**Freq**	0	6	12	1	19	
	%	0.00	7.59	15.19	1.27		24.05
	Row%	0.00	31.58	63.16	5.26		

	Col%	0.00	15.38	42.86	11.11		
Total		3	39	28	9	79	
%		3.80	49.37	35.44	11.39		100

<u>Chi-square statistics for the interaction between season and breed on oedema</u>

Statistics	DF	Value	Prob(p<F)
Chi-square	6	17.7385	0.0069
Likelihood Ratio Chi-Square	6	18.3012	0.005

There was a significant interaction between season and breed in the prevalence of oedema (p=0.0069) in cattle slaughtered (Table 4.8.2). The highest number of cases of oedema was observed in Autumn (n=21) in Bonsmara cattle which represented 26.6% of the total number of cases in Autumn, probably because they have smooth coats and are regarded as a heat and tick tolerant breed.

The overall highest numbers of oedema cases in cattle were recorded in Autumn, with no significant effect observed in Afrikander cattle, while the lowest numbers of cases in cattle were recorded in Winter. Overall, very few cases of oedema were recorded for Nguni (11.4%) and Afrikander (3.8%).

Table 4.8.3 Frequency distribution of oedema based on the effects of gender and breed (FREQ Procedure)

		Afrikander	Bonsmara	Brahman	Nguni	Total	%
Male	**Freq**	1	32	26	9	68	
	%	1.27	40.51	32.91	11.39		86.08
	Row%	1.47	47.06	38.24	13.24		
	Col%	33.33	82.05	92.86	100.0		
Female	**Freq**	3	7	2	0	11	
	%	2.53	8.86	2.53	0.00		13.92
	Row%	18.18	63.64	18.18	0.00		
	Col%	66.67	17.95	7.14	0.00		
Total		3	39	28	9	79	
%		3.80	49.37	35.44	11.39		100

Chi-square statistics for the interaction between gender and breed on oedema

Statistics	DF	Value	Prob(p<F)
Chi-square	3	10.0203	0.0184
Likelihood Ratio - Chi-Square	3	8.8291	0.0317

There was a significant interaction between gender and breed in the prevalence of oedema (p=0.0184) in cattle slaughtered. The highest number of cases of oedema was recorded for bulls in Bonsmara cattle which represented 40.5% of the total number of cases, followed by

Brahman (32.9%), Nguni (11.4%) and Afrikander (1.3%). It was found that overall significantly more cases of oedema (49.4%) were reported in Bonsmara compared to Brahman, Nguni and Afrikander cattle. Bonsmara, Brahman and Nguni types represented the highest number of oedema cases due to the higher number of animals slaughtered for these types.

Overall, cattle were also more likely to be affected by oedema based on maximum likelihood analysis in Autumn (Chi^2=2.48; p=0.1156), followed by Winter (Chi^2=2.52; p=0.1125) and Summer (Chi^2=0.06; p=8138) as indicated in Table 4.8.5. There were differences in the likelihood of bulls or heifers to be affected by oedema as indicated. Bonsmara were highly affected probably due to shortage of pasture, which led to severe malnutrition and gastrointestinal parasitic infestation, eventually causing signs of oedema during post-mortem which is a watery surface of the carcass.

Table 4.8.4 The CATMOD procedure: Analysis of Contrasts of Maximum Likelihood Estimates for Oedema

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.00242	0.00399	1331.79	<.0001	0.00175	0.00334
Male	1.4308	0.2336	4.82	0.0282	1.0391	1.9703
Female	0.6989	0.1141	4.82	0.0282	0.5075	0.9624
Summer	1.0387	0.1673	0.06	0.8138	0.7575	1.4241
Autumn	1.2732	0.1954	2.48	0.1156	0.9424	1.7201
Winter	0.7562	0.1331	2.52	0.1125	0.5355	1.0678

Table 4.8.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1) for Oedema

Contrast	**Chi-Square**	**Pr > ChiSq**	**Estimate**	**Standard error**	**LCL**	**UCL**
Intercept	1331.79	<.0001	0.00242	0.000399	0.00175	0.00334
Male	4.82	0.0282	1.4308	0.2336	1.0391	1.9703
Female	4.82	0.0282	0.6989	0.1141	0.5075	0.9624
Summer	0.06	0.8138	1.0387	0.1673	0.7575	1.4241
Autumn	2.48	0.1156	1.2732	0.1954	0.9424	1.7201
Winter	2.52	0.1125	0.7562	0.1331	0.5355	1.0678
Sum/Aut	0.61	0.4349	0.8158	0.2127	0.4894	1.3600
Sum/Win	1.12	0.2909	1.3735	0.4128	0.7621	2.4753
Aut/Win	3.26	**0.0709**	1.6837	0.4856	0.9566	2.9632

Breed

There was no significant interaction between breed and oedema as shown on table 4.8.5

Gender

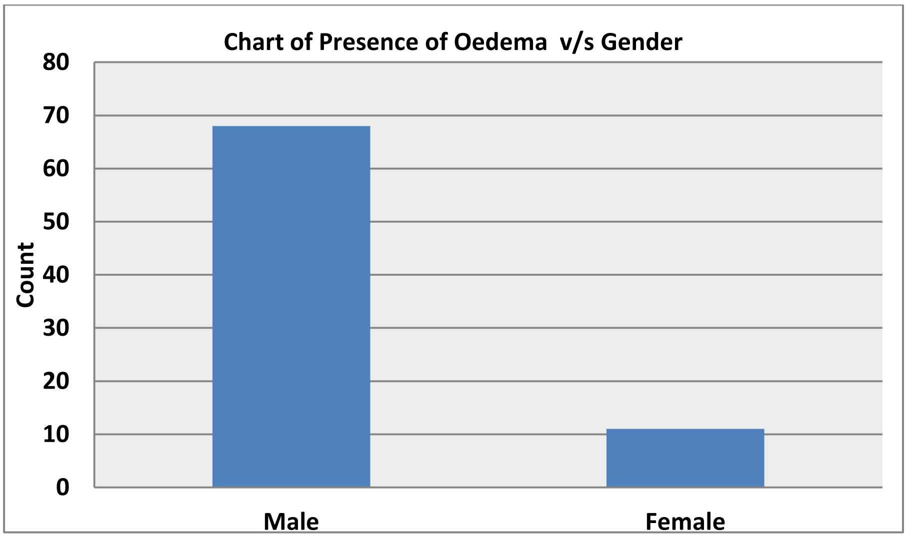


Chart 4.8.1 The effect of gender on the presence of oedema

There was a significant gender effect on the prevalence of oedema (p=0.0282) in cattle at the abattoir. Bulls were more likely to be affected by oedema (Chi^2=4.82:p=0.0282) compared to heifers (Chi^2=4.82:p=0.0282) (Table 4.8.5).

Season

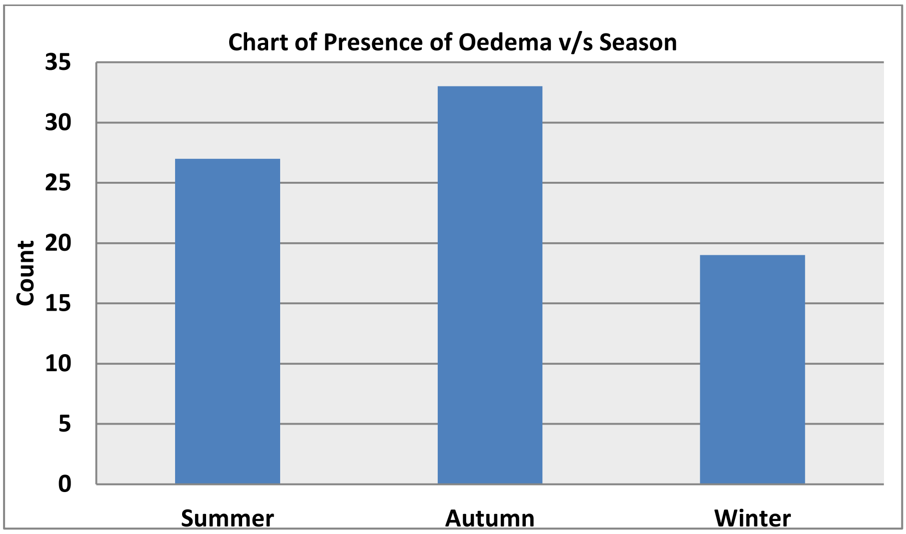


Chart 4.8.2 The effect of season on the presence of oedema

Statistics showed that there was no seasonal effect on the occurrence of oedema (p=19540) but carcasses were more likely to be condemned due to soiling in Winter (Chi^2 =2.52; p=0.1125) compared to Autumn (Chi^2 =2.48; p=0.1156) and Summer (Chi^2 =0.06; p=0.8138) (Table 4.8.5).

4.9. Intramuscular haemorrhage: The effect of breed, gender and season on intramuscular haemorrhage on carcasses

The prevalence of intramuscular haemorrhage in bovine carcasses during the period of study in this specific abattoir was about 0.31%. Overall there were significant seasonal and gender effects on the prevalence of intramuscular haemorrhage (p=0.0546) in cattle slaughtered at the abattoir. The highest number of cases of intramuscular haemorrhage was recorded in bulls in Winter (n=37) which represented 46.3% of the total number of cases of haemorrhage. Only 11.3% of heifers slaughtered were condemned due to intramuscular haemorrhage in that season. The effects of season and gender on the prevalence of intramuscular haemorrhage in cattle slaughtered at this particular abattoir is summarised in Table 4.9.1.

The prevalence of intramuscular haemorrhage was numerically the highest in Winter, but there was no significant difference between bulls (56.9%) and heifers (60%) in this season. The fewest cases of intramuscular haemorrhage occurred in Autumn, but there was a significant difference between bulls (7.7%) and heifers (26.7%) in Autumn (Table 4.9.1).

No data was found in other countries to compare with the above.

Table 4.9.1 Frequency distribution of intramuscular haemorrhage based on the effects of season and gender (FREQ Procedure)

		Male	**Female**	**Total**	**%**
Summer	**Freq**	23	2	25	
	%	28.75	2.50		31.25

	Row%	92.00	8.00		
	Col%	35.38	13.33		
Autumn	**Freq**	5	4	9	
	%	6.25	5.00		11.25
	Row%	55.56	44.44		
	Col%	7.69	26.67		
Winter	**Freq**	37	9	46	
	%	46.25	11.25		57.50
	Row%	80.43	19.57		
	Col%	56.92	60.00		
Total		65	15	80	
%		81.25	18.75		100

Chi-square statistics for the interaction between season and gender on intramuscular haemorrhage

Statistics	**DF**	**Value**	**Prob(p<F)**
Chi-square	2	5.8168	0.0546
Likelihood Ratio - Chi-Square	2	5.4316	0.0662

Table 4.9.2 Frequency distribution of intramuscular haemorrhage based on the effects of season and breed (FREQ Procedure)

		Bonsmara	Brahman	Nguni	Total	%
Summer	**Freq**	16	8	1	25	
	%	20.00	10.00	1.25		31.25
	Row%	64.00	32.00	4.00		
	Col%	26.67	47.06	33.33		
Autumn	**Freq**	9	0	0	9	
	%	11.25	0.00	0.00		11.25
	Row%	100.0	0.00	0.00		
	Col%	15.00	0.00	0.00		
Winter	**Freq**	35	9	2	46	
	%	43.75	11.25	2.50		57.50
	Row%	76.09	19.57	4.35		
	Col%	58.33	52.94	66.67		
Total		60	17	3	80	
%		75.00	21.25	3.75		100

Chi-square statistics for the interaction between season and breed on intramuscular haemorrhage

Statistics	DF	Value	Prob(p<F)
Chi-square	4	4.8796	0.2999
Likelihood Ratio - Chi-Square	4	6.8941	0.1416

There was no significant interaction between season and breed in the prevalence of intramuscular haemorrhage (p=0.2999) in cattle slaughtered (Table 4.9.2). The highest number of cases of intramuscular haemorrhage was observed in Winter (n=35) for Bonsmara cattle which represent 43.8% of total number of cases in Winter.

Overall, the highest number of intramuscular haemorrhage cases was recorded in Winter and the lowest number of cases in cattle slaughtered was recorded in Autumn. Overall, very few cases of intramuscular haemorrhage were recorded for Nguni (3.8%), because that breed represented a numerically smaller portion of the total number of cattle slaughtered at this abattoir. The prevalence of intramuscular haemorrhage was high in Bonsmara- and Brahman-types because these types represented the largest proportion of cattle slaughtered (Table 4.9.2), and probably because there was no enough pasture in Winter; the smaller intake that is why this condition is associated with Vitamin C deficiency (www.encyclopedia2.thefreedictionary.com). The other factor can be improper stunning due to inexperienced personnel resulting in signs of intramuscular haemorrhage during post-mortem.

Table 4.9.3 Frequency distribution of intramuscular haemorrhage based on the effects of gender and breed (FREQ Procedure)

		Bonsmara	Brahman	Nguni	Total	%
Male	**Freq**	52	12	1	65	
	%	65.00	15.00	1.25		81.25

	Row%	80.00	18.46	1.54		
	Col%	86.67	70.59	33.33		
Female	**Freq**	8	5	2	15	
	%	10.00	6.25	2.50		18.75
	Row%	53.33	33.33	13.33		
	Col%	13.33	29.41	66.67		
Total		60	17	3	80	
%		75.00	21.25	3.75		100

<u>Chi-square statistics for the interaction between gender and breed on intramuscular haemorrhage</u>

Statistics	**DF**	**Value**	**Prob(p<F)**
Chi-square	2	6.9454	0.0310
Likelihood Ratio - Chi-Square	2	5.6753	0.0586

There was a significant interaction between gender and breed in the prevalence of intramuscular haemorrhage (p=0.0310) in cattle slaughtered. The highest number of cases of intramuscular haemorrhage was recorded for bulls in Bonsmara cattle (n=52) which represented 65% of the total number of cases, followed by Brahman (15.0%) and Nguni cattle (1.3%). It was found that overall significantly more cases of intramuscular haemorrhage (75%) were reported in Bonsmara compared to Brahman and Nguni cattle (Table 4.9.3).

Overall, cattle affected by intramuscular haemorrhage in Winter (Chi^2=22.91; p<0,0001), followed by Autumn (Chi^2=14.00; p<0,0002) and Summer (Chi^2=0.35; p=0.5525) were not significant but likely to be affected by measles based on maximum likelihood analysis (Table 4.9.4). There were differences in the likelihood of bulls or heifers being affected by parafilaria as indicated previously, probably because of Vitamin C deficiency as there was insufficient pasture during winter.

Table 4.9.4 The CATMOD procedure: Analysis of Contrasts of Maximum Likelihood Estimates for Intramuscular Haemorrhage

Contrast	Estimate	Standard Error	Chi-Square	Pr > ChiSq	LCL	UCL
Intercept	0.00232	0.000384	1348.39	<.0001	0.00168	0.00321
Male	1.1895	0.1713	1.45	0.2284	0.8969	1.5775
Female	0.8407	0.1211	1.45	0.2284	0.6339	1.1150
Summer	1.1136	0.2018	0.35	0.5525	0.7808	1.5884
Autumn	0.4115	0.0977	14.00	0.0002	0.2584	0.6553
Winter	2.1821	0.3557	22.91	<.0001	1.5854	3.0035

Table 4.9.5 Contrasts of Maximum Likelihood Estimates from PROC CATMOD (DF = 1) for intramuscular haemorrhage

Contrast	Chi-Square	Pr > ChiSq	Estimate	Standard error	LCL	UCL
Intercept	1348.39	<.0001	0.00232	0.000384	0.00168	0.00321
Male	1.45	0.2284	1.1895	0.1713	0.8969	1.5775
Female	1.45	0.2284	0.8407	0.1211	0.6339	1.1150
Summer	0.35	0.5525	1.1136	0.2018	0.7808	1.5884
Autumn	14.00	0.0002	0.4115	0.0977	0.2584	0.6553
Winter	22.91	<.0001	2.1821	0.3557	1.5854	3.0035
Sum/Aut	6.53	0.0106	2.7062	1.0542	1.2612	5.8067
Sum/Win	7.24	0.0071	0.5103	0.1275	0.3127	0.8329
Aut/Win	20.93	<.0001	0.1886	0.0688	0.0923	0.3854

Breed

There was insufficient data to determine any statistically significant breed effect on prevalence of intramuscular haemorrhage in cattle slaughtered in the abattoir.

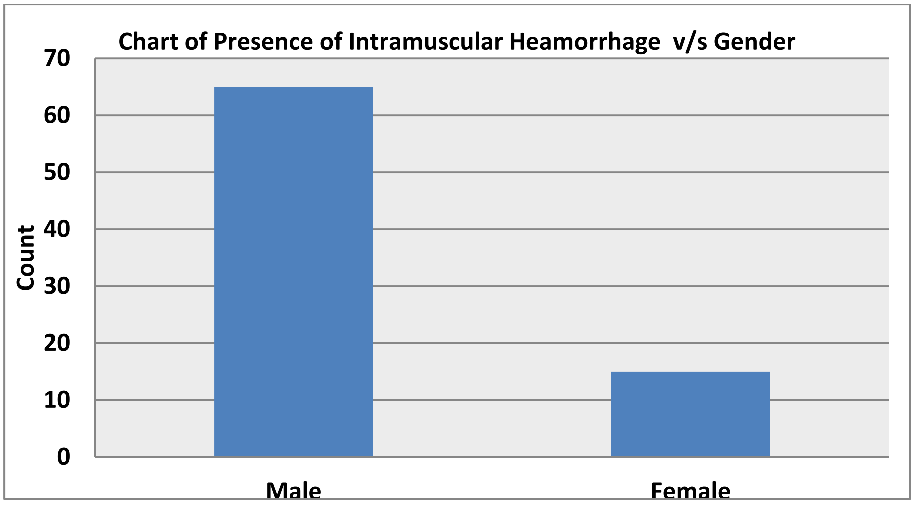


Chart 4.9.1 The effect of gender on the presence of intramuscular haemorrhage

There was no significant gender effect on intramuscular haemorrhage in cattle slaughtered at the abattoir (p=0.2284). Bulls were more likely to be affected by intramuscular haemorrhage (Chi^2=1.45; p=0.2284) compared to heifers (Chi^2=1.45; p=0.2285) as summarised in Table 4.9.5.

Season

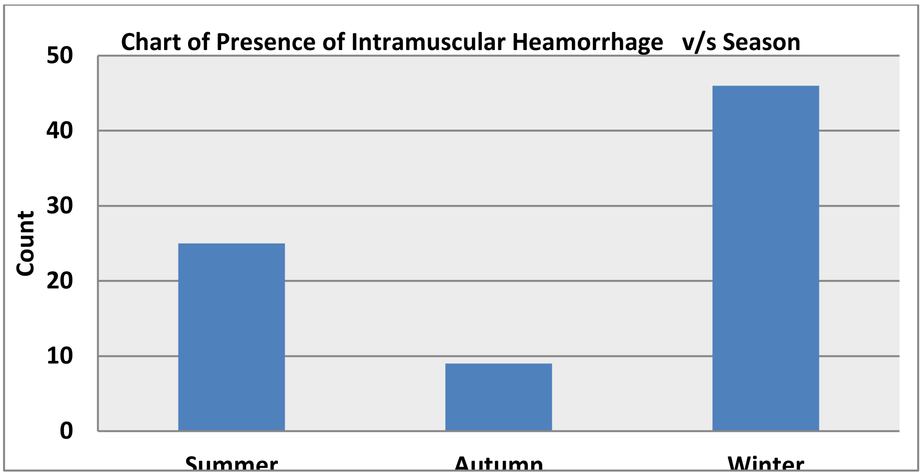


Chart 4.9.2 The effect of season on the presence of intramuscular haemorrhage

There was a significantly high seasonal effect on prevalence of intramuscular haemorrhage (p<0.0001) in cattle at the abattoir. The prevalence of intramuscular haemorrhage in Winter (Chi^2=22.91:p<0.0001) and Autumn (Chi^2=14.00:p=0.0002) were significant and no significant effect observed in Summer (Chi^2=0.35:p=0.5525). Carcasses were more likely to be condemned due to intramuscular haemorrhage in Winter, Autumn and Summer as shown in table 4.9.5.

Prevalence of intramuscular haemorrhage in Autumn compared to Winter (Chi^2=20.93: p<0.0001) was significant. In Autumn (Chi^2=14.00:p=0.0002) fewer effects were observed compared to Winter (Chi^2=22.91:p<0.0001) (Table 4.9.5).

CHAPTER 5

CRITICAL EVALUATION, CONCLUSION AND RECOMMENDATIONS

1. Critical evaluation

According to this study the highest number of cases observed and recorded for parafilaria was in Summer, while fewer cases occurred in Winter. The higher prevalence of parafilaria in Summer was probably because cattle are more predisposed to this condition due to the climatological factors that favour the parafilaria parasites in Summer. Bonsmara, Nguni and Brahman were more likely to be affected while fewer cases of parafilaria were observed in Afrikander, Hereford, Angus and Friesland.

The highest number of cases of bruising was observed in Winter and fewer cases were seen in Autumn. Bonsmara bulls were the most affected as indicated previously, probably due to aggressiveness, stress associated with confinement and poor handling facilities; transportation may also explain some of this bruising, especially in breeds with horns.

Soiling was a critical condition as well especially in Summer compared to other seasons. The most affected animals were Bonsmara bulls compared to other breeds. During the study it was noted that unskilled labourers were used during cattle evisceration (some using only one knife instead of the two-knife and three-knife protocols), improper handling of the cattle occurred and improper washing in the lairages before slaughter was performed, all of which were contributing factors to contamination, resulting in a greater number of partial condemnations and eventually leading to greater loss of production. In the overall effects due to diseases or conditions, soiling was the second most important condition and that could be addressed by better abattoir management.

The highest number of cases of fever was recorded in Summer while fewer cases were seen in Winter compared to other seasons. Most cases of this disease were seen in Bonsmara bulls while fewer cases were seen in Nguni.

Peritonitis and pleuritis were critical in Summer while fewer cases were observed in Winter and that effect was mostly seen in Bonsmara bulls.

The highest number of abscess cases was recorded in Winter while fewer cases were observed in Autumn. The highest number of cases of abscesses was recorded for Bonsmara bulls, while fewer cases were found in the Afrikander cattle.

Measles was mostly diagnosed in Winter while fewer cases in Summer. Bonsmara were more highly affected by measles with fewer cases being seen in Afrikander and Hereford breeds.

Oedema was the only condition that was highly diagnosed in Autumn with fewer cases in Winter. The most affected were the Bonsmara bulls with fewer cases observed in the Afrikander breed.

Intramuscular haemorrhage was observed to be prevalent to a greater degree in Winter as well, with less prevalence in Autumn, and the most affected were Bonsmara bulls as these breed are farmed mostly in tick-born areas.

2. Conclusion

Overall, most conditions such as parafilaria, soiling, fever, peritonitis and pleuritis, and abscesses were prevalent to a greater degree in Summer, while bruising, measles and intramuscular haemorrhage were more prevalent in Winter. The only condition which was more prevalent in Autumn was oedema.

The highest significant order of prevalence of all effects of diseases and conditions during the study were: peritonitis and pleuritis (2.49%), soiling (2.33%), bruising (2.1%), parafilaria (0.54%,) abscess (0.38%), intramuscular haemorrhage (0.31%), oedema (0.3%), measles (0.08%) and fever (0.07%). The 1.4% were due conditions other than those described in this dissertation, but the number of cases were not there to analyse statistically. Almost half of these carcass condemnations are associated with improper cattle slaughter management especially soiling and bruising. As indicated that it was noted that unskilled labourers were used during cattle evisceration (some using a one-knife instead of a two-knife system and so making cross-contamination unavoidable). Inexperienced cattle handlers and cleaners were washing cattle in the lairages before slaughter, contributing to contamination and soiling as a condition, and resulting to increases in partial condemnations and eventually loss of production. With regard to contributory diseases or conditions, soiling was therefore the second most important condition.

The instruments used in dressing and killing (such as knives, saws, etc.) may act as a source of contamination during slaughter. Hygiene practices, including frequent hand-washing and knife sterilization, must be followed by the removal of the hide. Contact between the carcass and the hide must be prevented. Dirty hand, hooks, rollers, and protective clothing can contaminate the carcasses while removing the hide and this must be prevented at all costs (Van Der Walt, 2005).

Cross-contamination becomes possible with further processing and handling of carcasses. Large quantities of product can become tainted particularly when there is pooling of raw ingredients from multiple sources (Armstrong *et al.* 1996). Transporting stock on rough roads can increase stress therefore increasing carcass condemnations on post mortem as the meat will not be normal. To minimize stress, farmers should take stock to their final destination via the shortest, smoothest routes, and avoid travelling in severe hot or cold weather conditions (Grandin, 1989).

The third most importantant condition was bruising (as indicated above). It was noted that improper facilities were used during transportation (e.g. overloading), with some of these breeds having horns, making it easy for them to injure each other, eventually causing bruising. Another contributing factor to bruising was rough handling of these cattle in the lairages (before slaughter). The most affected gender was bulls in all the seasons and the most affected breed due to all of the above diseases and conditions were Bonsmara. That probably might be because they have smooth coats, though they are regarded as a heat and tick tolerant breed.

3. Recommendations

Based on the results of this study, it is confirmed that factors such as breed, gender and season affect the presence or absence of different condemnation conditions in cattle.

It is suggested that proper dehorning should be done at an early stage, especially in bulls of breeds like Bonsmara, Nguni, Friesland and Hereford, which predispose cattle to the condemnation conditions (like bruising) highlighted in this study. Steps should be taken (i.e. proper handling techniques should be applied) to avoid injuries which may lead to internal bleeding, and eventually bruises (most probably due to fighting during transportation or in lairages), that can be avoided by using improved and upgraded facilities which include enough spacing. To avoid animals fighting, those not reared together must not be mixed during transportation and lairaging. Loading and unloading using shallow-stepped rams should be avoided. Trucks should be neither over- nor underloaded. Overloading causes stress and bruising due to crushing. Underloading results in animals being thrown around and falling more than necessary.

In case of soiling, well-trained slaughter personnel, cattle handlers and cleaners should be hired to prevent bile and soil contamination during evisceration and to avoid mud or manure contamination from the lairages. Alternatively they can be taken for relevant courses or training to help reduce the high rate of carcass condemnation due to soiling or bile contamination.

Breeds like Bonsmara, Nguni, Friesland and Brahman were mostly susceptible to parafilaria in all seasons; therefore, vaccination programmes should be followed, accompanied by isolation and purchase of cattle from healthy herds in order to reduce infections. Bonsmara and Brahman cattle were most susceptible to pleuritis and peritonitis and that happened mostly in Autumn. Preventive measures can be applied in the feedlots.

A large number of bulls were affected by parafilaria, bruising, soiling, fever, pleuritis and peritonitis, abscesses, oedema, measles and intramuscular haemorrhage which will help both commercial and small scale farmers to focus on preventative measures mainly in bulls. Inspection and condemnation of beef carcasses require more attention in South African abattoirs and simple slaughter management strategies can be employed to reduce the prevalence of carcass condemnation based on better management of cattle breeds, genders and season.

CHAPTER 6

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CHAPTER 7

APPENDIX

Table 1: Population Profiles determined for parafilaria **: Results for parafilaria**

Sample	Breed	Gender	Season	Present	Absent	Row Totals
1	Afrikander	Male	Summer	1	182	183
2	Afrikander	Male	Autumn	2	1343	1345
3	Afrikander	Male	Winter	0	163	163
4	Afrikander	Female	Summer	2	107	109
5	Afrikander	Female	Autumn	1	414	415
6	Afrikander	Female	Winter	0	38	38
7	Angus	Male	Summer	0	120	120
8	Angus	Male	Autumn	2	198	200
9	Angus	Male	Winter	0	296	296
10	Angus	Female	Summer	0	50	50
11	Angus	Female	Autumn	0	170	170
12	Angus	Female	Winter	0	90	90
13	Bonsmara	Male	Summer	35	3309	3344
14	Bonsmara	Male	Autumn	10	2486	2496
15	Bonsmara	Male	Winter	6	4560	4566
16	Bonsmara	Female	Summer	3	1547	1550
17	Bonsmara	Female	Autumn	0	760	760

31	Hereford	Male	Summer	0	25	25
32	Hereford	Male	Autumn	0	44	44
33	Hereford	Male	Winter	1	331	332
34	Hereford	Female	Summer	0	22	22
35	Hereford	Female	Autumn	2	47	49
36	Hereford	Female	Winter	0	194	194
37	Nguni	Male	Summer	24	325	349
38	Nguni	Male	Autumn	14	1083	1097
39	Nguni	Male	Winter	1	238	239
40	Nguni	Female	Summer	3	188	191
41	Nguni	Female	Autumn	0	248	248
42	Nguni	Female	Winter	0	226	226
			Column Totals	139	25451	25590

Results for Bruising

Table 7.2 Population profiles determined for bruising.

Sample	Breed	Gender	Season	Present	Absent	Row Totals
1	Afrikander	Male	Summer	1	182	183
2	Afrikander	Male	Autumn	10	1335	1345

3	Afrikander	Male	Winter	12	151	163
4	Afrikander	Female	Summer	8	101	109
5	Afrikander	Female	Autumn	19	396	415
6	Afrikander	Female	Winter	0	38	38
7	Angus	Male	Summer	6	114	120
8	Angus	Male	Autumn	18	182	200
9	Angus	Male	Winter	0	296	296
10	Angus	Female	Summer	2	48	50
11	Angus	Female	Autumn	4	166	170
12	Angus	Female	Winter	3	87	90
13	Bonsmara	Male	Summer	43	3301	3344
14	Bonsmara	Male	Autumn	44	2452	2496
15	Bonsmara	Male	Winter	61	4505	4566
16	Bonsmara	Female	Summer	6	1544	1550
17	Bonsmara	Female	Autumn	4	756	760
18	Bonsmara	Female	Winter	12	625	637
19	Brahaman	Male	Summer	78	2051	2129
20	Brahaman	Male	Autumn	8	1377	1385
21	Brahaman	Male	Winter	61	715	776
22	Brahaman	Female	Summer	3	810	813
23	Brahaman	Female	Autumn	0	107	107
24	Brahaman	Female	Winter	10	441	451
25	Friesland	Male	Summer	3	34	37

26	Friesland	Male	Autumn	1	70	71
27	Friesland	Male	Winter	0	41	41
28	Friesland	Female	Summer	5	26	31
29	Friesland	Female	Autumn	10	52	62
30	Friesland	Female	Winter	10	129	139
31	Hereford	Male	Summer	2	23	25
32	Hereford	Male	Autumn	0	44	44
33	Hereford	Male	Winter	5	327	332
34	Hereford	Female	Summer	0	22	22
35	Hereford	Female	Autumn	3	46	49
36	Hereford	Female	Winter	1	193	194
37	Nguni	Male	Summer	32	317	349
38	Nguni	Male	Autumn	22	1075	1097
39	Nguni	Male	Winter	23	216	239
40	Nguni	Female	Summer	2	189	191
41	Nguni	Female	Autumn	1	247	248
42	Nguni	Female	Winter	2	224	226
			Column Totals	535	25055	25590

Results for Soiling

Table 7.3 Population profiles determined for soiling

Sample	**Breed**	**Gender**	**Season**	**Present**	**Absent**	**Row Totals**
1	Afrikander	Male	Summer	7	1338	1345
2	Afrikander	Male	Autumn	9	154	163
3	Afrikander	Male	Winter	0	183	183
4	Afrikander	Female	Summer	10	405	415
5	Afrikander	Female	Autumn	0	38	38
6	Afrikander	Female	Winter	7	102	109
7	Angus	Male	Summer	8	192	200
8	Angus	Male	Autumn	3	293	296
9	Angus	Male	Winter	3	117	120
10	Angus	Female	Summer	4	166	170
11	Angus	Female	Autumn	5	85	90
12	Angus	Female	Winter	0	50	50
13	Bonsmara	Male	Summer	63	2433	2496
14	Bonsmara	Male	Autumn	65	4501	4566
15	Bonsmara	Male	Winter	78	3266	3344
16	Bonsmara	Female	Summer	9	751	760
17	Bonsmara	Female	Autumn	10	627	637
18	Bonsmara	Female	Winter	9	1541	1550
19	Brahaman	Male	Summer	19	1366	1385
20	Brahaman	Male	Autumn	62	714	776
21	Brahaman	Male	Winter	83	2046	2129

22	Brahaman	Female	Summer	0	107	107
23	Brahaman	Female	Autumn	6	445	451
24	Brahaman	Female	Winter	14	799	813
25	Friesland	Male	Summer	0	71	71
26	Friesland	Male	Autumn	0	41	41
27	Friesland	Male	Winter	0	37	37
28	Friesland	Female	Summer	2	60	62
29	Friesland	Female	Autumn	5	134	139
30	Friesland	Female	Winter	4	27	31
31	Hereford	Male	Summer	3	41	44
32	Hereford	Male	Autumn	6	326	332
33	Hereford	Male	Winter	0	25	25
34	Hereford	Female	Summer	13	36	49
35	Hereford	Female	Autumn	3	191	194
36	Hereford	Female	Winter	0	22	22
37	Nguni	Male	Summer	42	1055	1097
38	Nguni	Male	Autumn	9	230	239
39	Nguni	Male	Winter	22	327	349
40	Nguni	Female	Summer	4	244	248
41	Nguni	Female	Autumn	6	220	226
42	Nguni	Female	Winter	4	187	191

			Column Totals	597	24993	25590

Results for Fever

Table 7.4 Population profiles determined for fever.

Sample	Gender	Season	Present	Absent	Row Totals
1	Male	Summer	9	6178	6187
2	Male	Autumn	5	6633	6638
3	Male	Winter	3	6410	6413
4	Female	Summer	1	2765	2766
5	Female	Autumn	0	1811	1811
6	Female	Winter	0	1775	1775
		Column Totals	18	25572	25590

Results for Peritonitis and pleuritis

Table 7.5 Population profiles determined for peritonitis and pleuritis.

Sample	Breed	Gender	Season	Present	Absent	Row Totals
1	Afrikander	Male	Summer	1	1344	1345
2	Afrikander	Male	Autumn	0	183	183
3	Afrikander	Male	Winter	0	163	163
4	Afrikander	Female	Summer	0	415	415
5	Afrikander	Female	Autumn	0	109	109
6	Afrikander	Female	Winter	0	38	38
7	Angus	Male	Summer	2	198	200
8	Angus	Male	Autumn	1	119	120
9	Angus	Male	Winter	1	295	296
10	Angus	Female	Summer	1	169	170
11	Angus	Female	Autumn	0	50	50
12	Angus	Female	Winter	0	90	90
13	Bonsmara	Male	Summer	134	2362	2496
14	Bonsmara	Male	Autumn	98	3246	3344
15	Bonsmara	Male	Winter	122	4444	4566
16	Bonsmara	Female	Summer	24	736	760
17	Bonsmara	Female	Autumn	21	1529	1550
18	Bonsmara	Female	Winter	20	617	637
19	Brahaman	Male	Summer	21	1364	1385
20	Brahaman	Male	Autumn	62	2067	2129
21	Brahaman	Male	Winter	45	731	776

22	Brahaman	Female	Summer	0	107	107
23	Brahaman	Female	Autumn	9	804	813
24	Brahaman	Female	Winter	4	447	451
25	Friesland	Male	Summer	0	71	71
26	Friesland	Male	Autumn	1	36	37
27	Friesland	Male	Winter	0	41	41
28	Friesland	Female	Summer	0	62	62
29	Friesland	Female	Autumn	0	31	31
30	Friesland	Female	Winter	0	139	139
31	Hereford	Male	Summer	2	42	44
32	Hereford	Male	Autumn	2	23	25
33	Hereford	Male	Winter	0	332	332
34	Hereford	Female	Summer	0	49	49
35	Hereford	Female	Autumn	0	22	22
36	Hereford	Female	Winter	1	193	194
37	Nguni	Male	Summer	37	1060	1097
38	Nguni	Male	Autumn	24	325	349
39	Nguni	Male	Winter	4	235	239
40	Nguni	Female	Summer	0	248	248
41	Nguni	Female	Autumn	1	190	191
42	Nguni	Female	Winter	0	226	226
			Column Totals	638	24952	25590

Results for Abscess

Table 7.6. Population profiles determined foraAbscess.

Sample	Gender	Season	Present	Absent	Row Totals
1	Male	Summer	28	6159	6187
2	Male	Autumn	24	6614	6638
3	Male	Winter	43	6370	6413
4	Female	Summer	2	2764	2766
5	Female	Autumn	0	1811	1811
6	Female	Winter	1	1774	1775
		Column Totals	98	25492	25590

Results for Measles

Table 7.7. Population profiles determined for measles

Sample	Gender	Season	Present	Absent	Row Totals
1	Male	Summer	2	6185	6187
2	Male	Autumn	3	6635	6638
3	Male	Winter	16	6397	6413
4	Female	Summer	0	2766	2766
5	Female	Autumn	0	1811	1811
6	Female	Winter	1	1774	1775
		Column Totals	22	25568	25590

Results for Oedema

Table 7.8. Population Profiles determined for Oedema

Sample	Gender	Season	Present	Absent	Row Totals
1	Male	Summer	21	6166	6187
2	Male	Autumn	28	6610	6638
3	Male	Winter	19	6394	6413
4	Female	Summer	6	2760	2766
5	Female	Autumn	5	1806	1811
6	Female	Winter	0	1775	1775
		Column Totals	79	25511	25590

Results for Intramuscular haemorrhage

Table 7.9. Population profiles determined for intramasular haemorrhage

Sample	Gender	Season	Present	Absent	Row Totals
1	Male	Summer	23	6164	6187
2	Male	Autumn	5	6633	6638
3	Male	Winter	37	6376	6413
4	Female	Summer	2	2764	2766
5	Female	Autumn	4	1807	1811
6	Female	Winter	9	1766	1775
		Column Totals	80	25510	25590