Feedlot performance of the Drakensberger in comparison with other cattle breeds: A Meta-analysis

by

Mia Niemand

Submitted in partial fulfilment of the requirements for the degree

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Department of Animal and Wildlife Sciences

Faculty of Natural and Agricultural Sciences

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INDEX

CHAPTER 1:

CHAPTER 2:

CHAPTER 3:

CHAPTER 4:

CHAPTER 5:

CHAPTER 6:

CHAPTER 7:

DECLARATION

I declare that this dissertation for the degree of MSc (Agric) Animal Science: Animal Nutrition at the University of Pretoria has not been submitted by me for a degree at any other University.

M. Niemand

Pretoria

February 2013

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SUMMARY

Feedlot performance of the Drakensberger in comparison with other cattle breeds: A Meta-analysis

by

Mia Niemand

Supervisor: Prof LJ Erasmus

Department: Animal and Wildlife Sciences

Faculty: Natural and Agricultural Sciences

Degree: MSc (Agric) Animal Science: Animal Nutrition

The aim of this study was to compare the growth performance and incidences of health disorders of the Drakensberger breed to the collective total of all other beef breeds in feedlots. The objective was to conduct a meta-analysis on the performance, health and centralised growth data (Phase C) of all cattle breeds from different regions in South Africa. The intention was not to compare different breeds with each other but only the Drakensberger breed to other breeds and crossbreeds generally found in feedlots.

Results from Phase C performance tests at the centres, as well as historical growth and health data were gathered from a number of feedlots. Data from feedlots were only accepted when individual animal records were kept; classification was according to breed type; and when Drakensbergers were present in the particular feedlot. The aim was to utilise historical records of up to ten years per feedlot. After initial processing and elimination of outliers, a meta-analysis was performed on the growth data. Each feedlot was analysed separately, followed by a final meta-analysis, which incorporated results from all the feedlots. It included 497 798 head of cattle from 5 feedlots, with a separate analysis on Phase C performance test data, comprising of 6139 animals from 4 Agricultural Research Council (ARC) test centres. Health data from 2 feedlots, comprising of 24 819 animals, along with Phase C performance test data from 2 ARC test centres, including 1746 head of cattle, were analysed.

The variables included in the analysis were: average daily gain (ADG), feed conversion ratio (FCR), mortality and morbidity ratios and type of disease or disorder. In addition to determining the individual effects of breed, sex, season, year, region and diseases, possible interactions amongst these factors were investigated.

The meta-analysis on the feedlot performance and Phase C performance tests revealed that other breeds had a higher ($P < 0.01$) ADG than Drakensbergers. No difference was observed between Drakensbergers and other breeds within gender and within season. The meta-analysis on Phase C performance test data showed no significant difference in FCR between Drakensbergers and other breeds.

A feedlot study, including 23 554 head of cattle, has shown that Drakensbergers have a higher rate ($P < 0.01$) of respiratory disease occurrence during the winter season than other breeds. Likewise, results from the ARC test centre in Irene, consisting of 1553 animals, reveal that the occurrence of respiratory diseases was less ($P < 0.01$) in other breeds than in Drakensbergers. However, there seem to be no significant differences in the occurrence of metabolic disturbances and other diseases between Drakensbergers and other breeds.

Although a statistical difference of only 20 grams per day ($P < 0.01$) in ADG were found between Drakensbergers and other breeds in feedlots and test centres, the biological and economical effect would most probably be insignificant. The large dataset of close to 500 000 cattle also contributed to such a small weight difference being significant. The majority of the contributing feedlots stated that their record keeping lack accuracy and do not comprise of a complete set of health data. Readers are therefore advised to interpret the health data analyses with caution as the analyses are not representative of the actual health status of cattle in the feedlot industry, simply because accurate data does not exist.

LIST OF ABBREVIATIONS

ABBA	American Brahman breeders association
ADG	average daily gain
ARC	Agricultural Research Council
BLUP	best linear unbiased prediction
BRD	bovine respiratory disease
BRSV	bovine respiratory syncytical virus
BVDV	bovine viral diarrhoea virus
DCBS	Drakensberger cattle breeders society
FCR	feed conversion ratio
g	gram
IBR	infectious bovine rhinotraceitis
Kg	kilogram
mm	millimetres
PI-3	parainfluenza-3
Phase C	Growth test for young bulls in a central testing facility as part of the National Beef Cattle Performance Testing Scheme
SAS	Statistical Analysis System
SEM	standard error of the mean
TFI	total feed intake
USA	United States of America

LIST OF FIGURES

Page

Chapter 2

LIST OF TABLES

Page

Chapter 2

Chapter 4

Chapter 5

Chapter 6

CHAPTER 1

Introduction & Motivation

The Drakensberger is a medium sized cattle breed, indigenous to South Africa. They form part of the *Bos taurus africanus* type, also known as the Sanga breed (Bosman, 2002). Afrikaner, Bonsmara, Nguni and Tuli cattle also belong to this breed type. The breed is currently widespread throughout Southern Africa, and can be found from Humansdorp in the Eastern Cape Province, throughout the eastern Free State, KwaZulu-Natal and eastern Mpumalanga to Messina in the Northern Province and Grootfontein in Namibia.

The breed was developed over a period of several centuries (www.drakensbergers.co.za, 11 May 2011). According to the Breeders' society, the existing gene pool cannot be improved or enlarged through the importation of animals or new genes when the need arises (www.drakensbergers.co.za, 11 May 2011). The breed is thus self-sufficient. The Drakensberger has the ability to cross well with both *Bos indicus* and *Bos taurus* breeds, and is therefore a motherline breed in crossbreeding systems. They became known as Drakensbergers owing to their concentration on sourveld in the Drakensberg region. The Drakensberger Cattle Breeders Society (DCBS) of South Africa received recognition in 1947 (Drakensbergbeestelersgenootskap, 1969). The DCBS made Performance Testing compulsory in 1980 and have ever since only inspected and registered cattle that have performance data available (Bosman, 1994). The South African National Cattle Performance and Progeny Testing Scheme consist of five phases. The Central Performance Tests (Phase C) are completed either at Agricultural Research Council (ARC) testing centres, private testing centres or testing centres on farms. Young bulls are fed individually and maintained under uniform conditions, during which their post weaning growth and feed conversion ratio (FCR) are recorded (Bosman, 1994). Notable progress in productive value has been made by using performance data in the endorsement of future stud stock.

Drakensbergers are mainly used for beef production within extensive grazing systems. In a study by Dreyer (1982) where the feedlot performance of Drakensbergers was compared to three other beef breeds, it was established that Drakensbergers are equally able to perform in intensive feedlot conditions, resulting in economic beef production. The breed's inherent qualities renders them with an ability to adapt to diverse conditions, good milk production, an average calf birth weight of 35 kg, high fertility and low mortality. According to results from the SA Stud Book Annual Logix Beef Report (2012), heifer and bull calves reach weaning weights of 213 kg and 228 kg respectively. Furthermore, the Drakensberger’s even temperament allows easy handling and the cows have an outstanding mothering ability. Purebred weaner calves, finished at a feedlot are able to achieve a weight of 440 kg at an age of 11 months (www.embryoplus.com, 12 May 2011). In a feedlot trial conducted at Kanhym Feedlot in Middelburg, Mpumalanga, where 1015 Drakensbergers were tested, the mean average daily gain (ADG) and FCR were 1.45 kg and 4.72 : 1 respectively, with a morbidity rate of 7.5% (www.embryoplus.com, 12 May 2011). According to these efficiency indicators, Drakensbergers are competitive in the feedlot.

Despite these aforementioned inherent qualities and growth performance, there are negative perceptions in the feedlot resulting in Drakensbergers not being favoured as feedlot animals and being discriminated against by some in the industry. The perception is that Drakensbergers are more prone to health problems, especially lung diseases and that once these animals are in hospital camps they stay there for longer periods than other breeds. This also leads to higher mortality rates and poor performance of the affected animals. Although these are only perceptions and not based on fact, it has resulted in some feedlots not buying Drakensbergers or insisting on paying lower prices for Drakensberger weaners. No large scale scientific studies, however, have been conducted to confirm or deny the abovementioned perceptions.

The aim of this study was to compare the growth performance and incidences of health disorders of Drakensbergers to the collective total of all other beef breeds in feedlots. The objective was to conduct a meta-analysis on the performance, health and Phase C growth data of all cattle breeds from different regions in South Africa. By conducting a meta-analysis, the results of independent studies regarding the same subject matter are combined. The larger size of the pooled data will yield more effective results and significant differences (Crombie & Davies, 2009). The intention was not to compare different breeds with each other but only the Drakensberger breed to other breeds.

The following hypotheses were tested in this study:

H_O = There is no significant difference in feedlot performance and disease occurrence of the Drakensberger breed compared to the average of other breeds.

H_A = There is a significant difference in feedlot performance and disease occurrence of the Drakensberger breed compared to the average of other breeds.

In the next chapter (chapter 2) a literature review of the South African feedlot industry, as well as breeds and common health problems in the feedlot are presented. In chapter 3 the basics of meta-analyses are discussed, followed by materials and methods (chapter 4), results and discussion (chapters 5 and 6) and finally chapter 7, which deals with final conclusions of the study.

CHAPTER 2

Literature review: The feedlot industry, the most common breeds in feedlots and common health problems in the feedlot

A feedlot is defined as: "An intensive animal production system that subjects an otherwise unmarketable calf to a process of intensive feeding and care, transforming it into high quality beef products" (Ford, 2011). A beef carcass consists of muscle, fat and bone. A newborn calf has a very low fat content, while bone and muscle growth takes place firstly. Fat deposition increases as the animal gets older. Once the animal has reached the desired amount of carcass fat, it is said to be finished and allowed to be slaughtered (Anonymous, 2005a). The market demand determines the acceptable live weight and fat content at which an animal can be slaughtered.

The vital role of feedlots is accentuated by the fact that beef production merely from extensive systems is no longer able to satisfy the consumers' demand. Considering that feedlots are found mainly in the grain-producing areas of South Africa (Highveld and eastern parts of South Africa), Drakensbergers should be competitive in feedlots to be acceptable in these areas (Dreyer, 1982).

2.1 Brief overview and statistics of the feedlot industry in South Africa

2.1.1 Structure of the red meat industry

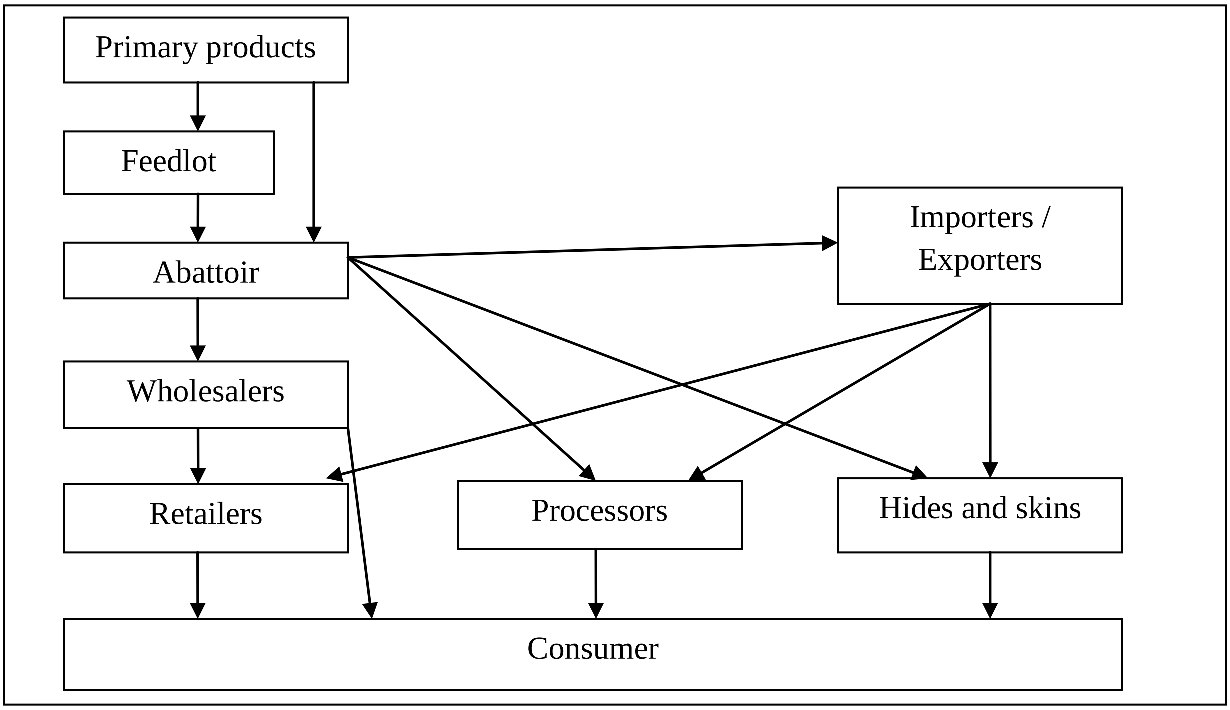

Figure 2.1 The red meat industry structure (Adopted from SAFA, 2003)

The red meat industry structure in Figure 2.1 illustrates that the beef supply chain has undergone a significant amount of vertical integration (The value chain for red meat, 2003). This integration is mainly stimulated by the feedlot industry where the majority of large feedlots have their own abattoirs. Some feedlots acquire their own retail outlets and distribute their products directly to consumers. Presently, several wholesalers obtain live slaughter animals directly from farmers or feedlots. The wholesaler determines at which abattoir the animals are slaughtered, after which the carcasses are either distributed to retailers, or directly sold to customers. The abattoir industry consists of several subdivisions and may be associated with feedlots and the wholesale sector, while some are owned by municipalities, or primarily by farmers (The value chain for red meat, 2003).

2.1.2 Feedlot industry

From the beef produced in South Africa, 75-80% originates from the feedlot industry, which slaughter about 1.533 million head of cattle per annum (The value chain for red meat, 2003). The different feedlot categories include: farmer feeders, small, medium, large, extra large and ultra large feedlots, which hold up to 3000, 3000-8000, 8000-12000, 12000-20000, 20000-30000 and over 30000 head of cattle respectively. According to Ford (2011) there are currently 60 commercial feedlots in South Africa, which collectively have a one time standing of approximately 460 000 head of cattle. The feedlot industry mainly supply to the domestic market.

Cattle normally enter the feedlot at a weight of 235 kg and remain in the feedlot for approximately 122 days. A weight of approximately 450 kg is reached at the end of the feedlot period, which results in carcass weights of around 258 kg. Mean dressing percentages of 57.5% are achieved. 95% of all carcasses are A-grades (cattle with no permanent teeth), with the remaining 5% being AB-grades (cattle with one to two permanent teeth) (Anonymous, 2005b). Commercial feedlots experience a mortality rate of 0.8%, with cattle achieving a mean ADG and FCR of 1.7 kg and 5.5 respectively (Ford, 2011).

2.1.3 Feedlot economics

In terms of economics, there are two main concepts governing the viability and strategic management of a feedlot. The first is the beef to grain ratio, which is defined as “the amount in kilograms of grain that can be purchased per kilogram of beef income" (Ford, 2011). In South Africa the ratio is approximately 13:1, compared to American and Australian feedlots which operate at a ratio of 22:1 to 24:1. This indicates that the South African feedlot industry is under more pressure than markets in other countries to produce efficiently, since it is uneconomical to feed cattle in a feedlot below a ratio of 13:1. The second concept consists of the price margin (calf purchase price vs. meat price) and the feeding margin (feeding costs to produce 1kg of meat vs. the price of 1kg meat). The price margin, feeding margin and other expenses determine the feedlot profit margin. The feedlot breakeven is the point where the total input costs per kilogram beef produced amounts to the total income per kilogram beef sold. The input cost to produce the final carcass constitutes of several expenses during the lifetime of the animal at the feedlot. The main cost is the purchase price of the weaner (64.4%), followed by the price of feed (23.3%), overheads (6.7%), transport (2.43%), interest (2.27%) and mortalities (0.9%) (Ford, 2011). The income from selling carcasses, hides and offal as well as any other earnings amount to the total income.

The purchase price of weaners are typically influenced by the supply and demand, but are also reliant on world meat trends, present and expected grain prices (Ford, 2011). Farmers that offer animals of the desired type and required quality receive a premium from the feedlot. It should be noted that the South African feedlot industry is the only feedlot industry in the world where the final price of the carcass being sold, is unknown at the time of purchasing weaner calves (SAFA, 2003). This stresses the fact that the feedlot industry is a high-risk business.

2.1.4 Feedlot market structure

The market players in the feedlot industry are vertically integrated. They are independent, since they manage their own abattoirs, processors and distributors. The majority of the beef market share is supplied by eight companies, with the largest being Karan Beef (25%), Bull Brand (12%) and Beef Master (10%) (Anonymous, 2010).

It is evident from Table 2.1 that although the number of cattle slaughtered increased up to 2008/09, South Africa is still a net importer of beef, as the current production of beef does not supply in the demand of the domestic market (Agricultural statistics, 2009).

Table 2.1 Total cattle slaughtering, production and consumption of beef (Agricultural statistics, 2009)

Year	Cattle slaughtered (Head)	Production (Kilograms)	Consumption (Kilograms)
1999/00	2,726,000	512,000,000	671,000,000
2000/01	2,302,000	625,000,000	555,000,000
2001/02	2,510,000	525,000,000	603,000,000
2002/03	2,535,000	574,000,000	644,000,000
2003/04	2,599,000	610,000,000	675,000,000
2004/05	2,671,000	632,000,000	723,000,000
2005/06	2,972,000	672,000,000	817,000,000
2006/07	3,077,000	769,500,000	861,000,000
2007/08	2,781,000	830,700,000	784,000,000
2008/09	2,910,000	750,600,000	815,000,000

South Africa achieved an export value of R185 million in 2009, exporting nearly 4.6 million kilograms of beef. During 2009, the Netherlands and Mozambique were the two main importers of South African beef, as they demanded 31% and 28% respectively. Seven other countries share 39%, with the remaining 10% being unassigned (Anonymous, 2010). Gauteng Province dominated South Africa's beef exports in 2009 with 40.5%, followed by the Western Cape with 22.11%. This is explained by Gauteng being the main exit point when exporting to neighbouring countries and the majority of beef exporters being positioned in the Gauteng Province. The remaining provinces exported frequently, whereas in the Free State, North West and Limpopo limited exports were recorded.

Almost 10 million kilograms of beef were imported into South Africa in 2009, valued at R140 million. The contributing countries were Uruguay, Argentina, Australia, Paraguay and New Zealand with shares of 41%, 27%, 18%, 13% and 1% respectively (Anonymous, 2010). According to the Meat Board of Namibia (2012), approximately 50% of Namibia's meat exports are supplied to South Africa.

2.2 Most common breeds present in the feedlot

Breeds of cattle can be classified according to their type, namely *Bos indicus* (Zebu), *B. taurus* (European, British and dual-purpose breeds) and *B. taurus africanus* (Sanga and indigenous African cattle), as well as crossbreeds of the different types. There are significant differences between types in terms of feedlot performance, as well as their adaptability. In general, the tropically adapted cattle (Zebu and Sanga types) have poorer performance in feedlots compared to temperate cattle breeds (Bosman, 2002). Of the cattle slaughtered from feedlots, an estimate of the different cattle types is as follows: Sanga types – 29%; Zebu types – 11%; British types – 26%; European types – 27%; Dairy and other – 7% (Anonymous, 2010). Another way to classify breeds is according to maturity type, which is linked to frame size. Later maturing animals have higher growth rates and are more efficient in the feedlot, although they require longer feeding periods (Anonymous, 2005). It should be noted that selection for feed conversion ratio (FCR) is the most important trait that influences profitability in feedlot cattle, and variation do exist between and within breeds, which makes selection possible (Bosman, 2002).

Differences exist between breeds for average daily gain (ADG) and FCR. Economically important decisions involving breed selection and performance characteristics can be based on ADG and FCR values (Chewning *et al*., 1990). Significant differences regarding growth test results between breed types are presented in the next table (Table 2.2).

Table 2.2 Different breed types of beef cattle in South Africa with the ADG and FCR recorded in 112 day growth tests (Bosman, 2002)

Type	Breed	n	ADG (g)	FCR
Bos indicus	Brahman	411	1345	6.79
Bos taurus africanus	Afrikaner	327	1220	7.12
	Bonsmara	2371	1680	6.58
	Drakensberger	240	1550	6.84
	Nguni	134	1120	6.70
	Tuli	10	1270	7.16
Average			1368	6.88
Bos taurus indicus	Beefmaster	37	1725	6.48
	Brangus	20	1580	6.47
	Santa Gertrudis	587	1730	6.35
	Simbra	174	1590	6.35
Average			1656	6.42
Bos taurus – British breeds	Hereford	149	1815	6.22
	Red Poll	31	1630	7.31
	SA Angus	396	1805	6.49
	Shorthorn	52	1765	6.81
	Sussex	240	1635	6.51
Average			1730	6.67
Bos taurus – Dual Purpose	Braunvieh	46	1725	7.03
	Gelbvieh	116	1880	6.68
	Simmentaler	1471	1915	6.46
	South Devon	57	1895	6.18
Average			1854	6.59
Bos taurus – Lean meat	Charolais	141	1925	6.09
	Limousin	189	1710	6.44
	Pinzgauer	295	1790	6.68
Average		625	1808	6.40

n = number of animals, ADG = average daily gain, FCR = feed conversion ratio.

2.2.1 Afrikaner

It is believed that the ancestors of the Afrikaner resided in East Asia, which were introduced into North Africa by Semite migrations approximately 1500 B.C. (Friend, 1978). These *Bos indicus* cattle migrated further southwards, with only the hardiest animals reaching the southern tip of Africa, where they were influenced by the cattle of the Hottentots (Rouse, 1969a). Large herds of Hottentot cattle were already seen by the early Portugese sailors reaching the Cape of Good Hope. Careful selection by the European colonists resulted in the Africaner (*Bos taurus africanus*), which is regarded as an indigenous breed (Rouse, 1969a).

The number of Afrikaner cattle decreased significantly due to Rinderpest outbreaks, as well as the Anglo-Boer war during 1899 - 1902 (www.afrikanerbees.com, 28 June 2011). This was followed by the importation of several European breeds. The Breed society was established in 1912, with the Afrikaner being the largest breed in South Africa prior to 1970 (Bosman, 1994). Over the last twenty years, the breeders have shifted their focal point towards traits of economic importance, with their main goal being to improve fertility and traits influencing functional efficiency (Bergh *et al*., 2010).

Unlike most British beef breeds, the Afrikaner has a leaner body with poorer conformation. Despite its longer legs, the Afrikaner still has good depth of body and a muscular back. The sloped rump ensures minimal calving difficulties. This medium sized breed has a characteristic neck hump, dewlap, distinctive wide spreading horns, with their short hair varying from different shades of red (Friend, 1978). Afrikaners are medium to early maturing cattle (Strydom, 2002; Bergh *et al*., 2010).

A mature Afrikaner bull and cow weighs 820 – 1090 kg and 450 – 600 kg respectively. During 2008, the National Beef Cattle Recording and Improvement Scheme recorded an average birth weight of 31 kg for Afrikaner calves (Bergh *et al*., 2010). Female calves reach an average weight of 205 kg at 210 days, with bull calves reaching 225 kg.

Due to their innate resistance to the majority of South Africa’s endemic diseases, including Redwater, Heartwater and Gallsickness, they are well adapted to the country’s extensive regions. Furthermore, they perform acceptably in intensive feeding conditions (www.afrikanerbees.com, 28 June 2011). Due to their beneficial qualities like hardiness and calving ease, the Afrikaner is often used in cross-breeding practices involving exotic beef breeds (Bergh *et al*., 2010).

2.2.2 Angus

According to archaeological evidence, black polled cattle were present in north-eastern Scotland as early as the nineteenth century (Rouse, 1969a). Two polled cattle breeds were found in the two neighbouring counties of Aberdeenshire and Angusshire. These breeds had similar qualities, therefore the original double-barrelled name of Aberdeen-Angus. The Aberdeen-Angus was registered with the establishment of the Polled Herdbook in the middle of the nineteenth century.

This *Bos taurus* breed was first imported into South Africa in 1895, with the Aberdeen-Angus Cattle Breeders' Society of South Africa being established in 1917 (Bergh *et al*., 2010). According to Eric L.C. Pentecost, renowned English breeder of Red Angus cattle, red genes were introduced into the Aberdeen-Angus breed as early as the eighteenth century (www.angus.org.za, 29 June 2011). Heavier black, polled cattle were the result of crosses from the black native polled cattle and English longhorns, being primarily red. Given that black is a dominant colour and red recessive, approximately one in four calves were red, since all cattle were carriers of the red gene (www.angus.org.za, 29 June 2011). Of all registered Angus cattle, 69% are red, with the remaining 31% being black. This indicates that South African farmers traditionally prefer red cattle.

Angus cattle are widespread throughout South Africa. Since the breed originated in the Scottish Highlands, it is well adapted to colder regions with intense winters (www.angus.org.za, 29 June 2011). Black Angus cattle therefore thrive in the Western Cape and the Eastern Free State. The Angus is currently the largest beef breed in the world (Bergh *et al*., 2010).

The Angus was bred to be a heavily muscled, early maturing polled type, with colour being the only distinguishing feature between the black and red types (Strydom, 2002). Outstanding mothering ability, growth and calving ease exemplify the quality of the breed (Bergh *et al*., 2010). Angus cattle are commonly used in cross-breeding systems with native breeds to enhance their muscling abilities (Friend, 1978). Calves have an average birth weight of 35 kg (Bergh *et al*., 2010). Performance Test results (2004) from the Agricultural Research Council (ARC) indicate that the Angus has made significant progress regarding performance and fertility (Bergh *et al*., 2010).

2.2.3 Bonsmara

Several cross-breeding attempts have been performed to improve the growth potential and fertility of native cattle, in addition to improving the adaptability of exotic breeds to the hotter South African climate. It was only in 1947, that the Mara and Messina Research Stations in the northern Transvaal initiated a breeding programme involving the Afrikaner, Hereford and Shorthorn breeds (Rouse, 1969a). By following strict selection practices and utilizing objective performance data, the scientific breeding of the Bonsmara was performed under the supervision of Professor J.C. Bonsma (Bergh *et al.*, 2010). Ultimately, the Bonsmara was produced by crossing three-sixteenths Hereford, three-sixteenths Shorthorn and five-eights Afrikaner (Rouse, 1970). Since the Bonsmara's composition is five-eights Sanga type and three-eights *Bos taurus*, one of its qualities include exceptional adaptability. Some of the earliest results from this cross-breeding system at Mara research station already appeared promising, since calving percentages and weaning weights were significantly higher than the three parent breeds. Calf mortality was much lower than that of the exotic beef breeds.

The breed's name resulted from combining part of Professor J.C. Bonsma's surname and the Mara research station. The breed society was established in 1964 and its increasing popularity resulted in the Bonsmara currently being the largest beef breed in South Africa (Bergh *et al.*, 2010). Bonsmara cattle can nowadays be found in various African countries, as well as Argentina, Australia, Brazil, Paraguay, Colombia, USA and Uruguay.

This indigenous breed's large gene pool allows for sufficient variation and performs equally well on natural grazing and in feedlots (Bergh *et al.*, 2010). Bonsmaras have better muscling characteristics and a less prominent sloping rump than the Afrikaner. The humps of bulls are smaller and virtually absent in females. Bonsmaras belong to the *Bos taurus africanus* type and are medium maturing (Strydom, 2002). According to the National Beef Cattle Recording and Improvement Scheme, Bonsmara calves had a birth weight of 35 kg in 2008 (Bergh *et al.*, 2010).

2.2.4 Brahman

The Brahman was developed predominantly from Guzerat cattle, as well as a mixture of the Krishna Valley, Nellore and Brazillian Gir breeds (Rouse, 1970). These humped

Indian cattle are known as Zebu breeds and belong to the *Bos indicus* species (Friend, 1978). The Guzerat, being the largest of these four breeds, varies in colour from white to dark grey. The Krishna Valley and Nellore varieties have a grey-white appearance, with the last-mentioned having less pronounced drooping ears. The Gir strain has a contrasting roan appearance, with black individuals occurring occasionally (Friend, 1978).

The first Indian cattle were imported into the United States of America in 1849. In 1854, 2 additional Indian bulls were imported, who produced offspring with exceptional beef qualities (http://www.embryoplus.com/cattle_brahman.html, 4 July 2011). Guzerat, Gir and Nellore types continued to be imported from Brazil after 1923, with the American Brahman Breeders Association (ABBA) being established in 1924 (Friend, 1978). Brahman cattle were first imported into South Africa from the United States of America in 1954 (Bergh *et al*., 2010).

The Brahman is a medium to early maturing breed (Strydom, 2002). Its conformation allows for good muscling characteristics, due to its great length and depth. Large drooping ears, a prominent hump and dewlap in both males and females are distinct features of this breed. Brahman cattle are smart, curious animals and quick to respond. Their black pigmented skin serves as protection against the sun's rays and is covered by short, shiny hair. Coat colour can be light grey, red or almost black. The majority of Brahman cattle are light to medium grey. Their loose skin enhances their ability to thrive in hot conditions by increasing their body surface area (http://www.embryoplus.com/cattle_brahman.html, 4 July 2011). This hardy breed's exceptional adaptability can be ascribed to its heat-tolerance and disease-resistance (Friend, 1978).

Due to the hybrid vigour resulting from cross-breeding systems with Brahman cattle, offspring have improved health and growth performance. Female calves have an average birth weight of 31.6 kg, with males weighing approximately 33.2 kg at birth (Bergh *et al*., 2010). Since Brahman cattle produce lean carcasses, the breed plays a valuable role in beef production in harsher environments (Bergh *et al*., 2010).

2.2.5 Charolais

The Charolais originated from the Bresse-plateau region of Eastern France. These cattle obtained the name Charolais after being confined to the plateau region up to the Charolles area (Bergh *et al*., 2010). This breed was primarily managed for beef production until the eighteenth century, after which they were moved into the central parts of France, Nievre and Vendeé. Their principal function in these areas included milk production and draught power (Friend, 1978). The first Charolais Herd book was established in France in 1864. The Charolais is currently the most prevalent beef breed in France, representing 80% of all cattle in the area (Bergh *et al*., 2010).

Initially, minor exportations to several countries commenced after the Second World War. Since the breed easily adapted to its new surroundings, an escalating number of cattle were introduced into different parts of the world (Bergh *et al*., 2010). The first imports of Charolais cattle into South Africa occurred in 1955. According to Bosman (1994), the Charolais Breeders Association of South Africa became a member of South African Stud Book in May 1965.

The French considered size and good muscling ability as fundamental components which had to be included in the selection criteria (http://www.embryoplus.com/cattle_charolais.html, 5 July 2011). These late maturing cattle add great value to cross-breeding beef programmes and lean meat production (Strydom, 2002). The Charolais is a *Bos taurus* breed type with a white or cream coat colour (Bosman, 2002). The hair is short but become thicker and longer during winter. The skin contains light brown pigments, which provide adequate protection against the sun. These large framed animals have long bodies with great depth, well sprung ribs and heavily muscled hindquarters (Rouse, 1970).

Mature bulls weigh from 910 kg to well over 1100 kg, with cows ranging from 570 - 910 kg (http://www.embryoplus.com/cattle_charolais.html, 5 July 2011). A birth weight of 41 kg was recorded in 2008 by the National Beef Cattle Recording and Improvement Scheme (Bergh *et al*., 2010). The Charolais is a popular breed regarding veal production, since selection practices that intend to produce fast-gaining calves are highly successful. Although horns occur naturally in Charolais cattle, polled animals have lately become increasingly sought after (http://www.embryoplus.com/cattle_charolais.html, 5 July 2011).

2.2.6 Drakensberger

It is known that in 1659 the Dutch settlers observed black cattle of the Hottentot people in the Bredasdorp area (Bosman, 1994). Groningen bulls were imported from the Netherlands in the 1700’s, which are believed to have been bred to the female cattle of the Hottentot people (Friend, 1978). The Dutch named these cattle "Vaderlanders", with whom these Voortrekker families travelled northwards during the Great Trek. With some of these families remaining within the Drakensberg area, the cattle numbers increased, while they were utilised for three important functions; meat, milk and draught purposes (Friend, 1978). It was during 1840 – 1947 that the breed was known as Uys cattle, due to the contribution of Dirk Cornelius Uys and his family to the improvement of the purity of the Vaderlander breed (http://www.embryoplus.com/cattle_drakensberger.html, 12 May 2011). Although herd sizes were reduced to a great extent by the Anglo Boer War, adequate numbers of cattle were saved by their owners who took off into the Free State, Natal and Transvaal areas (Drakensbergbeestelersgenootskap, 1969).

The Uys Cattle Breeders Society was established in May 1946. These cattle were finally named Drakensbergers in 1947, when the Minister of Agriculture publicly acknowledged the breed (Friend, 1978). The society was affiliated with South African Stud Book and the Livestock Improvement Association in 1972 (Bergh *et al*., 2010). Seeing that Performance Testing have been compulsory for the entire breed since 1980, the first Best Linear Unbiased Prediction (BLUP) test in South Africa was completed by using the Drakensberger data base (Bosman, 1994).

According to Rouse (1970), this *Bos taurus africanus* type is the only indigenous breed that has been developed in the sourveld regions of Southern Africa. Consequently, it resulted in a hardy animal with natural disease resistance and exceptional adaptability to a wide range of climatic conditions (Bergh *et al*., 2010; Van Rensburg, 2010).

Drakensberger breeders aim to produce efficient beef animals with good temperaments, able to adapt to diverse environmental conditions. This early to medium maturing breed remains productive for 12 or more years (Van Rensburg, 2011). Their good pigmented skin and short glossy black hair provide resistance against the ultra violet rays of the sun. Black is a dominant colour which ensures uniformity in the progeny. Drakensbergers have great length and depth of body, with an excellent marbling ability with regards to meat quality (Friend, 1978). They have strong claws, capable of walking long distances and males have a characteristic shoulder hump.

Mature bulls reach weights of 820 – 1100 kg, with cows having average weights of 550 – 720 kg (Van Rensburg, 2011). As recorded by the National Beef Cattle Recording and Improvement Scheme, calves have an average birth weight of 35 kg (Bergh *et al*., 2010).

2.2.7 Limousin

Limousin cattle originated from the Limousin and Marche regions of the southern and western areas in central France, where they were mainly used for draught purposes (http://www.embryoplus.com/cattle_limousin.html, 8 July 2011). Since they were developed in these rocky grounds and unfavourable climatic conditions, the breed effortlessly adapts to most environments (Bergh *et al*., 2010). The Limousin Herd Book was officially established in 1886, after notable attempts were initiated to improve the breed (Friend, 1978). Since its establishment, the Herd Book has been restructured twice, once in 1923, and again in 1937. The purpose was to refine the standards and selection procedures to produce more superior animals (http://www.embryoplus.com/cattle_limousin.html, 8 July 2011). Consequently, this breed has progressed to be an efficient medium sized beef animal with exceptional muscling ability, resulting in lean carcasses and exceptional meat-to-bone ratios (Bergh *et al*., 2010).

Limousin cattle were imported into South Africa during the 1960's and have been introduced into more than 70 countries across the world (www.limousinsa.co.za, 8 July 2011). The Limousin Cattle Breeders Society of South Africa was established in 1986 (Bosman, 1994). According to Bosman (2002), Limousin cattle belong to the *Bos taurus* breed type and can be maintained on diverse terrains including the Bushveld, Highveld, Karoo, Namibia and the Cape.

Due to its broad chest, well sprung ribs and heavily muscled rump, this medium to late maturing breed has excellent beef qualities (Strydom, 2002; Chambaz *et al*., 2003). It has strong, though shorter and more delicate legs, with light coloured claws (Friend, 1978). The coat colour is solid golden-red or tan. Their legs are a lighter yellow, and light coloured rings are visible around the eyes (Rouse, 1970).

Limousin cattle are renowned for being able to yield carcasses which can be marketed at any age. Calves that have only been milk fed may be used for veal production at the age of 3 months, while some males are only finished by 3 years (Friend, 1978). The average birth weight of calves is 32 kg and cows frequently produce up to 14 calves during their productive life (www.limousinsa.co.za, 8 July 2011)

2.2.8 Nguni

It is believed that this Sanga type of cattle originated about 1600 B.C. in the current Ethiopia and Somalia regions (Bosman, 1994). It was developed by crossing the now extinct Hamitic Longhorn of north-eastern Africa with the Indian Zebu (Friend, 1978). These animals accompanied their owners from the Bantu tribes on their migrations southwards through East- and West-Africa, finally reaching Southern Africa. These cattle, currently known as Nguni's, were initially named "Zulu" or "Swazi" cattle, depending on the tribe that owned them. Nguni cattle are indigenous to South Africa and are similar to the Landim cattle in Mozambique (Rouse, 1970).

Nguni cattle serve important functions in the economic and social components of the natives. Their main purpose is milk production and cattle are only consumed when they die of natural causes. Hides are never wasted and oxen are often used as draught animals. The tribe members' wealth status is determined by the number of cattle they own (Friend, 1978). The Zulu and Swazi tribes obtain their wives by offering her family cattle in exchange, a practice commonly known as Lobola.

The native people had only one objective and this was to increase cattle numbers, therefore the quality of the animals was never improved. This resulted in overstocked pastures and thin cattle. Later on, the Bantu Administration at Bartlow Combine in Natal initiated a selection improvement scheme to develop and improve the breed's performance (Rouse, 1970). It was only in 1986 that the Nguni Cattle Breeders Society of South Africa was established and acknowledged by South African Stud Book (Bosman, 1994; Bergh *et al*., 2010).

Nguni's have dark pigmented skin, covered by short, smooth hair which together serve as protection against the ultra violet rays of the sun (Friend, 1978). The diverse colours of the Nguni include black, brown, red, tan and yellow. These unique colour patterns are either whole or mixed and seven characteristic colour patterns exist, each having a Zulu name. Cattle with mixed colour patterns always have a white face, under and top line (Rouse, 1970). The breed has lyre-shaped horns, with the male's horns being shorter and thicker than the female's. Males have well developed muscular humps, though virtually absent in females. Nguni cattle are early maturing and belong to the *Bos taurus africanus* breed type (Bosman, 2002).

Since Nguni cattle developed in the natural environmental conditions of South Africa over thousands of years, the crucial genes affecting adaptability have been transmitted to hundreds of generations. Natural selection allowed this breed to have a beneficial surface area to body weight ratio, which enables them to release excess heat rapidly (Maree & Casey, 1993). In addition to being highly fertile, Nguni cattle are renowned for their longevity, due to the slow wearing of teeth and cows often produce more than 10 calves during their productive life (Bothma, 1993; Bergh *et al*., 2010). Cows also have an inhibiting effect on the size of the fetus, therefore preventing incidences of dystocia (Scholtz *et al*., 1990).

In 2008, an average birth weight of 25 kg was recorded by the National Beef Cattle Recording and Improvement Scheme (Bergh *et al*., 2010). Nguni's are small with mature bulls reaching weights of 500 – 700 kg and cows having average weights of 320 – 440 kg (http://www.embryoplus.com/cattle_nguni.html, 12 July 2011).

2.2.9 Simmentaler

Simmentaler cattle originated from the Simme Valley in Western Switzerland. "Tal" is the German word for valley, therefore Simmentaler literally means "Simme Valley" (Bergh *et al*., 2010). Although first official records of the Simmentaler breed were documented in the first Herd Book, which were found in the Swiss Canton of Berne in 1806, evidence of large red and white cattle was discovered much earlier in Western Switzerland (http://www.embryoplus.com/cattle_simmental.html, 13 July 2011). It was only in 1890 when the Swiss "Red and White Spotted Simmentaler Cattle Association" was established, that the development of the breed received attention (Friend, 1978). These valuable animals that were originally kept for milk and beef production, as well as for draught purposes, once were Switzerland's main export product (www.simmentaler.org, 13 July 2011).

This breed spread rapidly to various neighbouring countries. Guatemala executed the first Simmentaler importations into the Western Hemisphere in 1897, shortly followed by Brazil in 1918 and Argentina in 1922 (http://www.embryoplus.com/cattle_simmental.html, 13 July 2011). Nowadays, Simmentaler cattle are distributed all over the world. The Simmentaler is also known as the "Fleckvieh" in Germany, the "Pezzata Rossa" in Italy, "Pie Rouge de l'Est", "Montbéliard" or "Abondance" of France (www.simmentaler.org, 13 July 2011).

Namibia was the first country in Southern Africa to receive Simmentaler cattle exportations from Europe in 1895, with importations into South Africa occurring in 1903 (Bosman, 1994). The main purpose for these importations was to use Simmentaler cattle in cross breeding systems to improve milk and beef production of indigenous animals. The Simmentaler Cattle Breeders Society of South Africa was established and associated with the South African Stud Book in 1964 (Bosman, 1994; Bergh *et al*., 2010).

These late maturing cattle belong to the *Bos taurus* breed type and are used for milk and beef production (Bosman, 2002). It can therefore be utilised in cross breeding practices, either to improve muscling characteristics, or to enhance milk production. Their coat colour ranges from yellow to red, combined with a white background. These cattle have distinctive white faces and tail ends, with the lower parts of their legs also being white (Rouse, 1970). White patches may occur, especially on the sides of the body and behind the shoulders. The lightly pigmented skin is of intermediate thickness and is covered by smooth hair (Friend, 1978). Records from the National Beef Cattle Recording and Improvement Scheme in 2008 reveal that calves have an average birth weight of 40 kg (Bergh *et al*., 2010).

2.2.10 Sussex

Evidence of horned Red Cattle in the southern parts of England can be traced back to the time of the Norman Conquest of Britain in 1066 (Friend, 1978). These Red Cattle were the ancestors of the well known Sussex breed, and were raised primarily as draught animals on the deprived and barren soils of Kent, Sussex, Hampshire and Surrey (www.sussex.co.za, 14 July 2011). Sussex cattle were bred pure until the eighteenth century, after which significant breed improvement and development commenced (http://www.embryoplus.com/cattle_sussex.html, 14 July 2011). Even though the breed was well known in these areas by 1840, the official Herd Book was only issued in 1879 (Rouse, 1970).

Sussex cattle adapt to hot and tropical environments and are frequently used in cross breeding systems for beef production. The breed has a tendency to be non-selective grazers and is therefore capable of converting poor quality feed into good quality beef (Bergh *et al*., 2010).

South Africa imported Sussex cattle in 1903, when the Transvaal Department of Agriculture established a Sussex herd in Potchefstroom (Bosman, 1994). Subsequent importations followed shortly by various breeders and the Sussex Cattle Breeders Society of South Africa was found in May 1920. In 1951, a red Aberdeen Angus bull was used in a breeding programme to create a polled Sussex type, due to the increasing demand for cattle without horns. Cattle from this polled strain had to be at least 94 % pure Sussex before they could be admitted for registration (Rouse, 1970).

Sussex cattle have ultimately progressed into excellent beef animals with good feet and sturdy legs, and belong to the *Bos taurus* breed type (Bosman, 2002). This early maturing breed has a long body with considerable depth and width (Strydom, 2002). The Sussex has a deep red coat colour, with only the tail end being white. The short hair coat may become longer and curly in the winter months. Sussex cows have an average weight of 585 kg, with mature bulls reaching an average of 950 kg (http://www.embryoplus.com/cattle_sussex.html, 14 July 2011). The average birth weight of calves recorded in 2008 by the National Beef Cattle Recording and Improvement Scheme was 37 kg (Bergh *et al*., 2010).

2.3 Common health problems in the feedlot

The incidence of health problems in feedlots is affected by immune status, presence of pathogens and stress, physical environment (extreme temperatures, transportation, dust, confined areas etc.), nutritional status as well as management practices involving animal husbandry and feeding systems (Fulton *et al*., 2002). Feedlot cattle are mainly prone to infectious agents and metabolic disorders (Smith, 2004).

A review by Kelly & Janzen (1986) indicated that total morbidity reached a maximum in North American Feedlot Cattle at 3 weeks after arrival at the feedlot. Mortality rate then decreased and remained stable throughout the rest of the feedlot phase. The incidence of morbidity ranged from 15 to 45% and mortality rates ranged from 1 to 5%.

Results from a study by Church & Radostits (1981) on feedlot cattle in Alberta, Canada, revealed that respiratory-related diseases were accountable for approximately 67% of morbidity and mortality rates. These recurring figures have been observed in a more recent study by Edwards (1996), who confirmed that respiratory-related diseases were accountable for 67 to 82% of total morbidity in feedlot cattle in the central United States of America. Metabolic disorders represented 3 to 7%, with the remaining 14 to 28% representing cases like injury, urinary calculi and prolapses. Total morbidity during the feedlot phase was highest (65 to 80%) during the first 45 days. In addition to respiratory-related diseases being primarily observed during this period, the majority of acidosis incidences occurred during diet alterations in this phase. After 45 days, total morbidity declined to less than one-third of the initial rate (Edwards, 1996).

As indicated by Vogel & Parrot (1994) in a mortality survey on feedlots of the Great Plains, mortality rates were higher for Holstein cattle than for typical beef breeds. The average monthly mortality rate for beef cattle was 0.268%. Respiratory-related diseases were accountable for 0.128% of this mortality figure, 0.061% was due to metabolic disorders and 0.078% resulted from various other causes (Vogel & Parrot, 1994).

Even though mortality rates are critical, the economic aspect of morbidity rates should not be overlooked. In addition to the significant economic losses which result from costs related to medication, additional labour during treatment and premature culling, the subsequent performance of diseased cattle is depressed considerably (Smith, 1998).

Numerous studies have shown that activation of the immune system and stress caused by disease may have adverse effects on performance due to reduced feed intake, impaired digestion and weight loss (Lamont, 1989; Williams *et al*., 1993). Animals suffering from disease do not reach optimal growth potential (Johnson, 1997; Spurlock, 1997). Alterations in the endocrine hormones and metabolic tissues occur due to infections or inflammation, which also leads to a reduction in feed intake (Tracey *et al*., 1988).

The consequences of diseased cattle include inferior performance, weight loss, a drop in carcass value, treatment expenditures and even death, which result in major economic losses (Fulton *et al*., 2002). A report by Roeber *et al*. (2001) indicated that cattle that received medicinal treatment more than once, had a lower ADG, reduced hot carcass weights and inferior marbling when they were compared to untreated cattle.

Monitoring infectious diseases is complex, since cattle which originate from diverse environments are forced to interact, in addition to being continually moved into and out of feedlots. According to Smith (2004), the ultimate goal is to manage the environment, nutritional regime and animal health to decrease stress levels and optimise cattle immunity, which requires cooperation between feedlot managers, nutritionists and veterinarians.

2.3.1 Acidosis

Lactic acidosis is also known as ruminal acidosis, grain engorgement, grain overload and acute indigestion (Jensen & Mackey, 1979). As reported by Owens *et al*. (1998), indicators of clinical acidosis include low blood and ruminal pH, fluctuating feed intake, diarrhoea, sluggishness and the possibility of a coma. In addition to rumen stasis, the cardiovascular and respiratory systems may even collapse in due course, which may cause death (Huber, 1976; Jensen & Mackey, 1979).

A sudden change in the diet or the intake of large amounts of carbohydrates which are easily fermentable by ruminants, may lead to acute and chronic acidosis (Owens *et al*., 1998). Jensen & Mackey (1979) further explain that the rapid increase in intake of easily fermentable carbohydrates, initiates the transition of gram-positive to gram-negative bacteria in the rumen. The consequence of acute acidosis is a rise in lactate, acidity and osmolality in the rumen, which is harmful to the rumen and intestinal wall. According to Elam (1976) high lactic acid concentrations in the blood and rumen, decreased rumen, blood and urine pH, rumenitis and a diminished protozoal population in the rumen may all be physiological indicators of acidosis. A reduction in blood pH may result in dehydration and even death, as a net water flow from the blood into the rumen results (Jensen & Mackey, 1979).

As a result of the hypertonicity of digested material, ingestion and animal performance are impaired in chronic acidosis (Owens *et al*., 1998). Nutrient assimilation may still be impaired after the animals' health is restored. Acidosis is more prevalent during warm summer months, most likely due to a higher variation in feed intake (Elam, 1976; Jensen & Mackey, 1979).

A urine pH of 5 to 6 and a blood pH of less than 7.4 substantiate the diagnosis of the animal. Various other diseases may arise from lactic acidosis. Morbidity levels range from 2 to 50%, with a mortality rate of approximately 25% (Jensen & Mackey, 1979).

Proper management regarding the feeding of cattle in feedlots may prevent potential incidences of acidosis. Management strategies may include the use of particular feed additives such as buffers, increasing the roughage content of the diet and feeding a smaller amount of highly-processed grains (Owens *et al*., 1998). Dicarboxylic acids, antibiotics such as virginiamycin, ionophores and direct-fed microbials may be used to control lactate levels in the rumen. *Megasphaera elsdenii* NCIMB 41125 may be an alternative to in-feed antibiotics, because of their similar proficiency (Meissner *et al*., 2010). Appropriate feeding regimes have to be followed upon arrival at the feedlot, during diet transition and following alterations in weather patterns (Elam, 1976; Jensen & Mackey, 1979).

2.3.2 Bloat

Bloat in feedlot cattle, also known as Tympanites (Jensen & Mackey, 1979), is classified as a digestive disorder regarding feedlot diseases, which proves to be the second major reason for mortality in feedlots. Clifford (1964) stated that younger cattle seem to be more prone to bloat. Three different surveys on the occurrence of digestive disorders, which were conducted in the United States and Canada, lead to the assumption that management strategies, feeding regimes and type of cattle play a role in the occurrence of feedlot bloat (Clarke & Reid, 1974; Merrill, 1994; Vogel & Parrot, 1994).

Two forms of bloat exist, namely frothy bloat and free-gas bloat. According to Howarth *et al*. (1991), frothy bloat is accountable for 90% of the cases. Even though free-gas bloat is primarily initiated by a blockage in the oesophagus, it also occurs in cattle suffering from persistent pneumonia or hardware disease (Garry, 1990). With frothy bloat, a stable layer of foam is produced by microbial organisms in plant material (Mangan, 1988; Majak *et al*., 1995). Since symptoms only appear after a few hours upon ingestion of feed, cases often become fatal without a chance to be treated. Morbidity and mortality rates are 1% and 50% respectively (Jensen & Mackey, 1979).

Feedlot bloat may lead to a decreased ruminal pH, aberrant ruminal and respiratory function, impaired animal performance and even death (Bartley *et al*., 1975; Cheng *et al*., 1998). Feedlot cattle suffering from bloat have a lower ADG (Miller & Frederick, 1966; Frebling *et al*., 1971). As gas builds up in the rumen, pressure in the intra-abdominal and intra-thoracic regions increase (Jensen & Mackey, 1979). As a result, the diaphragm is forced forward, the lungs become compressed and strenuous breathing follows. Jensen & Mackey (1979) report that acidosis may be triggered by the movement of blood into the peripheral blood vessels, in addition to increased carbon dioxide concentration in the plasma.

Frothy bloat occurs, following the ingestion of excessive amounts of highly fermentable carbohydrates, which produces a thicker fluid in the rumen and a more prominent layer of foam (Cheng *et al*., 1998). Free-gas bloat is more prevalent in cattle when the diet consists of more than 50% grain and during warmer climatic conditions with frequent variations in feed intake (Cheng & Hironaka, 1973; Howarth *et al*., 1991; Perry, 1995). It has a slow onset but regularly becomes chronic (Jacobsen, 1956). The process by which gas is expelled through the oesophagus from the rumen is known as eructation. Clarke & Reid

(1974) state that when eructation is prevented or obstructed, free-gas bloat results. Free-gas bloat tends to be a recurring disease in the same animal (Jensen & Mackey, 1979).

Frothy bloat and free-gas bloat can be distinguished from each other by ruminal intubation, as free-gas bloat is entirely eliminated by a stomach tube. The correct diagnosis of frothy bloat requires historic records of the diet, in addition to carcass inspections for possible lesions (Jensen & Mackey, 1979).

Free-gas bloat can be alleviated by eradicating the blockage in the oesophagus or through ruminal intubation. A trocar should be inserted into the animal in critical conditions, or a surgical opening made in the left abdominal area to eliminate the pressure instantly (Jensen & Mackey, 1979). The prevalence of digestive disorders may decrease by incorporating ionophores into feedlot diets (Smith, 2004). Prevention of feedlot bloat proves to be more profitable than treatment and can be accomplished by utilising feed additives, increasing the roughage content of the diet, applying different grain processing methods, selecting different grain types and by gradually adjusting diets (Cheng *et al*., 1998).

2.3.3 Coccidiosis

Fitzgerald (1975) reported that the majority of feedlot cattle in the United States between the age of 6 to 9 months suffer from coccidiosis, also known as Hemorrhagic diarrhoea (Jensen & Mackey, 1979). The morbidity rate of cattle in this age group reaches 40%, with a 25% mortality rate (Jensen & Mackey, 1979).

Symptoms commence with diarrhoea, and the blood content increases as the disease progresses. Animals are typically identified by soiled tails and may become dehydrated, anaemic, accompanied with a possible rectal prolapse. Exhaustion sets in as animals lose weight and fevers may develop. Impaired respiration and convulsions may occur and animals may die after the fourth day of infection (Fitzgerald, 1962; Jensen & Mackey, 1979). The economic implications of coccidiosis include poor animal performance, lower ADG and FCR, death and additional costs of medication and extended feeding periods (Niilo, 1970a; Fitzgerald, 1975).

Coccidiosis is spread by the intake of sporulated oocysts, which may be present in contaminated feed, water and surrounding housing facilities. Sporulated oocysts damage the ileum, cecum and colon by means of erosion and perforation. Clinical symptoms become visible after 2 to 6 weeks upon ingestion of oocysts (Boughtond, 1944). Fitzgerald (1962) reported that “winter” coccidiosis frequently occurs in feedlots in parts of the United States, Colorado, Utah, Nevada and California. Since oocysts easily survive in feedlots during winter and fall, calves are typically infected during their first winter, with stress playing a role in the onset of the disease (Jensen & Mackey, 1979).

In spite of the fact that lengthy recovery periods are generally required, the performance of several calves may remain permanently impaired (Jensen & Mackey, 1979; Ernst & Benz, 1986). Built-up resistance to coccidiosis does not last long and is adversely affected by stress (Niilo, 1970b). Fitzgerald (1975) & Smith (2004) reported that coccidiosis can be efficiently controlled by means of ionophores (decoquinate, monensin and amprolium) in the drinking water or feed. It is advised that the whole pen should be treated when large groups of cattle are infected, however, small numbers require individual care. Infected animals should be kept in a separate pen to avoid contact with healthy animals. Prevention of coccidiosis can be accomplished by maintaining proper pen sanitation, good moisture drainage, removal of wet manure and by keeping feed bunks and water troughs free from faeces (Jensen & Mackey, 1979).

2.3.4 Foot rot

Foot rot, also known as Infectious pododermatitis, Foul claw or Foul-in-foot (Jensen & Mackey, 1979), typically occurs during wet and cold climatic conditions. Nearly 70% of all lameness incidences in feedlot cattle can be ascribed to ailments of the feet (Griffin *et al*., 1993). The rate of occurrence will fluctuate, since it is influenced by seasonal changes, origin of cattle, processing procedures and general management.

It is thought that *Fusobacterium necrophorum* and *Bacterioides melaninogenicus*, normally present in the alimentary tracts and manure of cattle, penetrate the injured epithelium of the foot (Jensen & Mackey, 1979). The now pathogenic organisms proliferate and cause swelling and damage in the soft tissue of the foot. Cattle become lame as pressure starts to build up in the hooves and a foul-smelling fluid is secreted from the foot. A 10% loss in body weight may occur (Jensen & Mackey, 1979).

This disease is correctly diagnosed by raising the foot of the animal, followed by careful examination. The soft tissue in the middle of the toes (interdigital skin) appears inflamed, in addition to a foul odour and an increased body temperature. Initially, necrosis of the involved skin is superficial, but eventually spreads to the internal tissue layers.

According to Jensen & Mackey (1979) the majority of foot rot incidences may last from 7 to 10 days, however, chronic arthritis may persist for several months.

Since the disease rarely affects only one animal in an enclosure, it is advised that the whole pen should receive treatment in the feed. Sulfa-antibiotics, tetracycline and tylosin prove to be effective remedies against foot rot and results are most favourable when treatment follows directly after diagnosis (Griffin *et al*., 1993). Proper drainage in pens is essential and the application of powdered lime in the standing areas should eliminate pathogenic bacteria (Jensen & Mackey, 1979). All objects that may cause injury should be removed from the pen.

2.3.5 Injuries

Poorly constructed feedlot facilities may complicate the handling of cattle. Since the handling of animals become more strenuous on the workforce and cattle, the risk of injuries may increase (Harland, 2011). Common feedlot injuries include fractures, sprains, bruises and injuries from cattle riding each other.

During a survey on feedlot cattle in the Pacific Northwest, Stokka *et al*. (2001) concluded that from January to March in the year 2000, injuries were accountable for 5.6% of the total mortality. Of the injuries, 70% were observed in the hind limbs, with the remaining 30% being front limb injuries. The majority of injuries to the upper leg took place during transport and processing procedures.

Injured cattle should be identified as soon as possible and thoroughly assessed. Major economic losses may arise when animals are incapable of recovering from injuries and therefore unable to be retained to the desired slaughter weight. Taking into account that animal welfare is the major concern, it should be determined whether the animal has to be maintained or slaughtered (Stokka *et al*., 2001).

2.3.6 Laminitis

Pododermatitis aseptic diffusa, commonly known as laminitis (Nocek, 1997), is a condition where the dermal strata within the feet of cattle become aseptically inflamed.

Subclinical laminitis can be identified by a yellow colour on the soles with occasional bleeding (Bergsten, 1994; Ossent & Lischer, 1994). Epidermal damage is evident in addition to the increased temperature in the sole of the foot (Nocek, 1997). Internally, the pedal bone forms a gradient, while gas and a secretory fluid build up (Maclean, 1966; 1970).

In acute laminitis the corium becomes inflamed and swelling can be observed above the coronary band of the foot. According to Nocek (1997), the acute form is accompanied by severe pain. Animals show uncomfortable movement and may become lame, while standing with curved backs (Jensen & Mackey, 1979). Acute laminitis typically persists up to 10 days, after which either recovery occurs, or the chronic form develops. The acute form has a morbidity rate of 1 to 2% and an even lower mortality rate (Jensen & Mackey, 1979).

In chronic laminitis, the shape of the digits becomes modified and ulcers develop. As stated by Ossent & Lischer (1994), clinical symptoms include double soles, wearing away of the heel and curving in of the dorsal wall with possible ridge formation. Once the pedal bone has progressed through the corium and harder sole, the foot can never fully recover (Nocek, 1997).

Factors like metabolic and digestive ailments, trauma, hormonal changes and stress after calving are interrelated and may have detrimental effects on the internal tissues of the foot. Laminitis frequently follows cases of ruminal acidosis, critical cases of enteritis (from bovine viral diarrhoea, salmonellosis or coccidiosis) and selected cases of metritis (Jensen & Mackey, 1979). A study by Greenough *et al*. (1990) confirmed that foot health of feedlot cattle is adversely affected by intensive feeding programmes prior to the age of fourteen months. Physical damage to the feet of cattle kept on undesirable surfaces contributes to the incidence of laminitis. Bergsten (1994) informed that an unexpected increase in weight and stress on the feet may cause cattle to be more prone to laminitis.

According to Kaufmann *et al*. (1980) and Nocek (1992), the energy level of feed, frequency and strategy of nutritional regimes are crucial in the relationship between rumen pH, acidosis and laminitis. The acidotic state leads to a decrease in the rumen pH, which causes histamine and endotoxin secretion (Dain *et al*., 1955; Jensen & Mackey, 1979). These substances eventually result in deterioration of the foot tissues (Dirksen, 1969; Brent, 1976; Mgassa *et al*., 1984) and may hinder the walking ability of the animal (Boosman *et al*., 1989). Endotoxin release is also triggered by infectious diseases, and consequently initiates laminitis (Maclean, 1971; Greenough, 1982).

Diagnosis is executed by careful examination of the hooves for physical signs and by chemical determination of histamine blood levels (Jensen & Mackey, 1979).

Administering an antihistamine immediately after observing the first signs of laminitis may restore the health of the cattle (Jubb & Kennedy, 1970; Jensen & Mackey, 1979).

Jensen & Mackey (1979) report that rumen contents may be removed, followed by an oral dose of mineral oils and antibiotics to inhibit the histamine uptake. A mixture of sodium bicarbonate should re-establish the acid-base balance. Since laminitis is a consequence of ruminal acidosis, it is essential to prevent the incidence of acidosis by improving nutritional management and agricultural practices (Rowland, 1966; Hale, 1985; Nocek, 1997).

2.3.7 Liver abscesses

Liver abscesses, also known as Hepatic necrobacillosis and Rumenitis-liver abscess complex (Jensen & Mackey, 1979), are found in cattle of all ages and kinds, but are most prevalent in feedlot cattle in the USA, Canada, Europe, Japan and South Africa (Nagaraja *et al*., 1996). A liver abscess frequency rate of 12 to 32% is generally experienced in feedlot cattle (Nagaraja & Chengappa, 1998), while the National Beef Quality Audit of Denver (1995) indicated that approximately 22% of slaughtered feedlot cattle suffered from liver damage.

Since clinical symptoms of liver abscesses are rarely seen in cattle, the disease is predominantly identified when the animals are slaughtered. However, cattle may experience abdominal pain and abscesses may cause the caudal vena cava to wear down. This may lead to destruction of other organs and even death (Rubarth, 1960). Cattle may experience brief periods of anorexia and occasional fevers, accompanied by yellow faeces and diarrhoea.

In addition to the damaged liver, animal performance is reduced due to adverse effects on feed intake, ADG, FCR and carcass weight (Foster & Woods, 1970; Brown *et al*., 1973; Brown *et al*., 1975; Rust *et al*., 1980; Brink *et al*., 1990). Since the liver represents nearly 2% of the carcass weight, damage to the liver may lead to a substantial monetary loss (Thomson, 1967; Montgomery, 1992).

Liver abscesses are mainly caused by *Fusobacterium necrophorum*, which is naturally part of the rumen flora (Scanlan & Hathcock, 1983; Lechtenberg *et al*., 1988; Nagaraja *et al*., 1996; Tan *et al*., 1996). *F. Necrophorum* infects the liver through the damaged rumen wall caused by acidosis. Nakajima *et al*. (1986) describe the onset of the disease as the formation of a micro abscess, followed by the degeneration of neighbouring liver cells. Ultimately, a puss-filled abscess is formed, which is surrounded by a capsule. The resulting true abscess takes 3 to 10 days to develop and can measure up to 15 centimetres in width (Jensen *et al*., 1954; Abe *et al*., 1976; Lechtenberg & Nagaraja, 1991). Single abscesses may last between 30 and 180 days (Jensen & Mackey, 1979).

Although Weiser *et al*. (1966) identified no relationship between abrasions in the rumen wall and the prevalence of liver abscesses, Smith (1944) and Jensen *et al*. (1954a, b) established this relationship and introduced the term “rumenitis - liver abscess complex”. Abrupt changes in energy-densities of diets, feeding regimes, or diets with low roughage contents ultimately lead to acidosis (Elam, 1976). Acidosis may consequently stimulate rumenitis, which contributes to liver abscesses (Jensen *et al*., 1954b; Jensen & Mackey, 1979).

Ruminal lesions, liver abscesses and peritonitis in slaughtered cattle confirm the diagnosis. Morbidity and mortality rates are 1% and 50% respectively (Jensen & Mackey, 1979).

Liver abscesses are effectively regulated by the use of antimicrobial substances like oxytetracycline, chlortetracyclin and tylosin, with tylosin decreasing the prevalence of liver abscesses by 40 to 70% (Nagaraja & Chengappa, 1998). According to Jensen & Mackey (1979) and Nagaraja & Chengappa (1998), proper feeding regimes and management may reduce the rate of abscesses.

2.3.8 Pneumonia and respiratory-related diseases

Bovine respiratory disease (BRD) is the leading cause of death in feedlots, comprising 57.1% of total deaths (Loneragan *et al*., 2001) and roughly 75% of morbidity in feedlots (Edwards, 1996). Bovine respiratory disease gives rise to major mortality, morbidity and economic losses and it is recognised as being the most costly disease of North American beef cattle (Ribble *et al*., 1988; Van Donkersgoed *et al*., 1990; Harland *et al*., 1991; Perino, 1992; Griffin, 1997; Schneider *et al*., 2009).

According to Stockdale *et al*. (1979), elements that influence cattle’s vulnerability to BRD include trauma during transportation, commingling with cattle from different backgrounds and health statuses, nutritional regimes and vaccination procedures (Martin, 1983). These stressors have an adverse effect on the immune system, which is aggravated by the low nutrient intake (Blecha *et al*., 1984; Galyean & Hubbert, 1995; Cole, 1996). Buhman *et al*. (2000) stated that the majority of BRD cases in calves are treated during the first 27 days after arriving at the feedlot. Previous studies show that approximately 75% of the incidences arise during the first 45 days in the feedlot, with BRD cases in the fall and winter being almost twice as much as in the spring and summer (Jensen & Mackey, 1979).

General symptoms of BRD include fevers, nasal secretions, coughing, lowered feed intake and body conditions, strenuous breathing and exhaustion (Buhman *et al*., 2000; Fulton *et al.*, 2000; Frank & Duff, 2000; Gibb *et al*., 2000; Berry *et al*., 2004; Chirase *et al*., 2004). Morbid cattle can be expected to lie down or stand alone with lowered heads. Although mucus is secreted from the nostrils, the muzzle is dry. Eye-infections, diarrhoea and possible convulsions may occur (Jensen & Mackey, 1979). Cattle are regarded as morbid and treated accordingly, once these symptoms are accompanied by a rectal temperature of 39.7 ˚C (Buhman *et al*., 2000). Body temperatures may reach 40 to 42 ˚C, 2 to 5 days after bacterial or viral infection (Jensen & Mackey, 1979).

BRD has deleterious effects on animal performance and carcass quality, which contribute to the economic losses resulting from additional medical and labour expenses (Gardner *et al*., 1999; Schneider *et al*., 2009). Carcasses affected by BRD show prominent lung lesions and have lower grading and marbling scores (Montgomery *et al*., 1984; Stovall *et al*., 2000; Roeber *et al*., 2001). Numerous studies have shown that calves treated for BRD had a lower ADG than non-treated calves, with a significant correlation between treated calves, reduced ADG and lung lesions (Griffin *et al*., 1995; Wittum & Perino, 1995; Gardner *et al*., 1999; Lalman & Ward, 2005; Thompson *et al*., 2006). According to McNeill *et al*. (1996), non-treated steers had a higher ADG (1.33 vs. 1.26 kg/day) than morbid steers. Stone (2004) reported that the main effect of BRD on animal performance was a 144 g/day decrease in ADG from the day of processing to day 35, and an overall decrease of 28 g/day for the entire feedlot phase. The feeding period of morbid animals increased by 4.95 days.

Mannheimia haemolytica, Pasteurella multocida, Pasteurella haemolytica, Haemophilus somnus, today known as *Histophilus somni*, and *Mycoplasma* bacterial species are often to blame for initiating BRD (Yates *et al*., 1983; Pringle *et al*., 1988; Pandher et al., 1998). Infectious bovine rhinotraceitis (IBR), parainfluenza-3 (PI-3), bovine viral diarrhoea virus (BVDV), bovine respiratory syncytical virus (BRSV) and bovine enteric coronavirus are all related to respiratory tract ailments (Jensen & Mackey, 1979; Plummer *et al*., 2004). Bacterial species, IBR and PI-3 viruses are spread among cattle by means of nasal and other bodily secretions (Jensen & Mackey, 1979).

Visual assessment of cattle is generally used to identify morbid cattle, bearing in mind that it may not always be accurate. A South African feedlot study by Thompson *et al*. (2006)

revealed that from the 42.8% slaughtered cattle with pulmonary lesions, 69.5% did not receive treatment for BRD.

Further observations which aid in diagnosing BRD are feeding and drinking behaviour. Sowell *et al*. (1998, 1999) discovered that the time that morbid calves spent at the feed bunk represented only 70% of that of the calves with good health, with the difference being greater during the first 4 days after arrival at the feedlot. Buhman *et al*. (2000) observed that morbid calves spent more time at the water troughs after 4 to 5 days in the feedlot. The diagnosis is verified by veterinarians, once fibrinous pleuritis and pneumonia are observable during autopsies. Plasma fibrinogen, *P. haemolytica* and PI-3 virus concentrations in the lungs and nasal discharges may also be indicative of BRD (Jensen & Mackey, 1979).

Various preconditioning practices, which are performed prior to the transportation of cattle to feedlots, are endorsed in attempting to reduce morbidity rates. Preconditioning may involve vaccination programmes, dehorning, castration, weaning and teaching calves to become familiar with water troughs and feed bunks (Lalman & Ward, 2005; Duff & Galyean, 2007). A feedlot trial in Texas showed major improvements in ADG, FCR, medical costs and morbidity rates of preconditioned calves (Cravey, 1996). Furthermore, calves benefit from preconditioning, since their immune system is improved and the stress of processing procedures is lowered.

Administration of parenteral antimicrobials to groups of calves, which are exposed to bacterial pathogens, decreases the morbidity rate (Van Donkersgoed, 1992; Frank & Duff, 2000; Frank *et al*., 2002; Macartney *et al*., 2003; Cusack, 2004; Step *et al*., 2007; Wellman & O’Connor, 2007). Frank *et al*. (2002) informed that the prevalence of BRD declined after treating cattle with florfenicol upon arrival at the feedlot, and that the use of antibiotics may prevent the incidence of BRD. Similar work by Lofgreen (1983) showed that the occurrence of BRD declined from 63.3 to 7.1% after treatment with a combination of antibiotics. Other recommended treatment procedures include the use of penicillin, streptomycin, chlotetracyclin, oxytetracyclin, antihistamine and cortical steroids (Jensen & Mackey, 1979).

After extensive research by Duff & Galyean (2006) it appears as though BRD can only be controlled by nutritional regimes to a certain extent.

An investigation in Australia by Cusack *et al*. (2008) revealed that by including the administration of vitamin C in common processing practices, mortality rates due to BRD decreased. It is essential to immunise against IBR and PI-3 viruses during processing procedures (Jensen & Mackey, 1979).

CHAPTER 3

Meta-analysis

Glass (1976) defines a meta-analysis as: "The statistical analysis of a large collection of analysis results for the purpose of integrating the findings". Meta-analyses are generally carried out with the use of computer and statistical programmes like SAS (DeCoster, 2004).

A meta-analysis is a statistical procedure where results from separate studies are incorporated (Crombie & Davies, 2009). The size and quality of each individual study are taken into account, since a weight factor is assigned to each study. According to Crombie & Davies (2009), a proper meta-analysis should involve all studies with similar hypotheses, in attempt to detect possible heterogeneity, while assessing the strength of the main effects.

Meta-analyses are mostly performed on results from quantitative type of experiments where a factor has been studied under several different conditions. The overall impact of the factor is then determined (DeCoster, 2004). Meta-analyses can also be used in primary studies to describe or give background on the research hypotheses, or to explain possible correlations within the primary studies (DeCoster, 2004).

Meta-analyses prove to be valuable statistical procedures, on condition that researchers reveal positive as well as negative findings (Dickersin *et al*., 1987). Since results of meta-analyses are more accurate, trustworthy and maintain a high level of confidence, it may benefit future studies (Sacks *et al*., 1987).

The intention of researchers performing meta-analyses should be to incorporate all studies, despite its value or accuracy, to reveal the actual results (Glass, 1976; Rosenthal, 1984; Wolf, 1986). Researchers can either include all the results from each and every study, with a weight factor assigned to each study, or execute individual meta-analyses on each study, after which the findings are compared (Rosenthal, 1984; Wolf, 1986; Hunter & Schmidt, 1990).

In studies with a considerable amount of variation, due to effects of animals, feed or environment, meta-analyses are essential in order to detect and verify minor statistical differences (Meissner *et al*., 2010).

3.1 Advantages of meta-analyses

Meta-analyses are quantitative statistical reviews which exclude the researcher's generalised opinion. Even though small differences may be identified, a high level of confidence is achieved, since results of numerous studies are included. Shortcomings are identified and used to enhance techniques and strategies of experiments. (Hunter & Schmidt, 1990; Mann, 1990; Pollreisz *et al*., 1991; Van Donkersgoed, 1992).

3.1.1 Reducing bias

DeCoster (2004) states that the concept of meta-analyses being biased, as it merely incorporates considerable results or outcomes, is untrue. A valuable meta-analysis aims to locate unpublished and minor findings. Bias can easily appear when studies with unfavourable results are excluded from reviews, with researchers generating their own opinions. Meta-analyses may reduce or even eliminate potential bias of experimental information, due to the accurate and methodological nature of the procedure (Crombie & Davies, 2009).

3.1.2 Increased precision

Since the findings of all relevant studies are included in the meta-analysis procedure, the effective sample size is automatically increased. Even the slightest significant effect can be identified with a higher level of precision, due to a larger number of animals involved in the meta-analysis (Crombie & Davies, 2009).

3.1.3 Transparency

The methods of meta-analyses are generally well stipulated. All decisions and steps during the procedure are recorded, which verifies the validity of the analysis to the readers (Duffield *et al*., 2008; Crombie & Davies, 2009).

3.2 Disadvantages of meta-analyses

Meta-analyses are accused of: containing one-sided information, since researchers are likely to distribute only beneficial results; the loss of minor details when figures are summarised to determine the general effect; the incorporation of studies with inaccurate or missing information; certain variables being overlooked, since findings from trials with distinct treatments are pooled (Mann, 1990; Pollreisz *et al*., 1991; Van Donkersgoed, 1992).

3.2.1 Qualitative variation

Although it is frequently stated that meta-analyses fail to account for qualitative variation between studies, DeCoster (2004) explains that the power and effect of these variables are effortlessly retrievable and statistically calculated.

3.2.2 Quality of primary studies

When the quality of information or data to be evaluated in a meta-analysis is low, it will consequently result in a poor meta-analysis. However, since it is possible to statistically determine the quality of studies, inferior studies may be eliminated from the meta-analysis (DeCoster, 2004).

3.2.3 Subjectivity

DeCoster (2004) confirms that although meta-analyses are generally perceived as subjective, the mutual subjective outcomes are openly presented and exposed to criticism.

3.3 Conducting a meta-analysis

The quality of initial reviews, on which the meta-analysis is performed, is vital in order to produce a valuable meta-analysis. It must be ensured that initial reviews are flawless, accurate and complete. A valid and efficient meta-analysis should undergo proper methodological assessment (Bailar, 1997).

3.3.1 Method

Firstly, identify the hypothesis or topic under investigation. Secondly, gather information by selecting individual studies, with related research hypotheses. Thirdly, the power and influence of each study have to be statistically calculated. Fourthly, analyse every possible effect. Lastly, interpret the results by describing the consequences and power of the effects (DeCoster, 2004).

3.3.2 Quality assessment

When determining whether original studies should be accepted or declined from the meta-analysis, the decisions should be carried out according to an established standard (Cook *et al*., 1995). After each study has been graded, a sensitivity analysis can be performed, during which the effect of the inclusion or exclusion of a study is analysed.

3.3.3 Heterogeneity

According to Huque (1988), a meta-analysis is defined as: "A statistical analysis which combines the results of several independent clinical trials considered by the analyst to be combinable". The level of heterogeneity in a meta-analysis increases when the type of study included in the analysis, differs. Therefore, it is crucial to only include studies with related hypotheses. When heterogeneity is not present in the analysis, a fixed-effect model is used in the statistical procedure. It is then assumed that the difference between studies is only due to chance. In the presence of heterogeneity, a random-effects model is used. This model complicates the ability to achieve a significant outcome, due to more variation between studies (Crombie, & Davies, 2009).

3.3.4 Data filtering

It is essential that the selected studies should coincide with the relevant aims of the meta-analysis and that it contain the factors under investigation. Secondly, an expert should assess the studies to ensure that no inaccuracies are present. Lastly, the information should be validated in the database and extreme values should be handled carefully, since these outliers of meta-analyses generally signify erroneous models (Sauvant *et al*., 2008).

3.4 Conclusion

A meta-analysis is a well-known and frequently used statistical procedure, which produces more precise and unbiased results due to its methodological and quantitative nature (Engstrom *et al*., 2010). The purpose of meta-analyses is to produce new information from existing records (Sauvant *et al*., 2008). In contrast to individual studies, meta-analyses have substantially more supporting data, allowing this statistical procedure to generate significant findings, which are exceptionally accurate and reliable (Crombie & Davies, 2009).

To ensure overall soundness of a meta-analysis, the authenticity of the primary studies to be included in the analysis has to be determined. The meta-analysis is only as good as the primary studies (DeCoster, 2004). The soundness is improved by the inclusion of a large number of primary studies, as the power and reliability of the analysis are increased.

In addition to only presenting a summary of the main effects and variables, a superior meta-analysis gives an academic interpretation of these findings. According to DeCoster (2004), it describes the consistency and suggests possible improvement or further development in future analyses, by yielding new evidence.

The primary reasons for utilising a meta-analysis in this study are the large dataset, studies have similar hypotheses, positive and negative results are included and because of considerable variation in data due to the effects of environment, feed and animals.

CHAPTER 4

Materials and Methods

4.1 Feedlots

All the commercial feedlots in South Africa that carry Drakensbergers on a regular basis were contacted for permission to obtain any possible data regarding growth performance and health of cattle. The aim was to gather up to ten years' data per feedlot. It was agreed that during the entire investigational conduct, the names of the feedlots would be kept anonymous and the information be treated with total confidentiality.

4.1.1 Inclusion criteria

The record keeping system of each feedlot had to attain a certain standard before any data could be collected and included in the analysis. The following requirements had to be met in order for the data to be of any use:

a) Record keeping had to be carried out per animal, revealing figures and results per individual animal.
b) Cattle had to be classified and identified according to breed type.
c) Drakensbergers had to be present in the feedlot.
d) The gender of the animal had to be stated.
e) Growth, as well as morbidity and mortality figures had to be represented in the data.

As a result, the qualifying feedlots, from which information was gathered and included in the subsequent analyses, were considered to maintain similar levels of standards with their data being alike in quality, however, animals, feed and environment differed.

4.1.2 Contributing feedlots

After all the data from the feedlots had been assimilated and processed, the meta-analysis could be performed. Although data collection was done from 7 feedlots, only data from 5 feedlots could be incorporated in the analysis, as the remaining 2 feedlots did not meet all of the requirements. Feedlots from which data were collected, were referred to as Feedlot A, B, C, D, E, F and G.

The final meta-analysis on the growth performance of cattle included 498 153 head of cattle from 5 feedlots. Health data from 2 feedlots, comprising of a total of 24 819 animals, were analysed.

The original number of cattle presented by the data received per feedlot is shown in Table 4.1.

Table 4.1 Summary of raw data gathered from feedlots (head of cattle per breed and feedlot)

Feedlot	Drakensbergers	Other breeds	Years represented
A	1313	21099	2009, 2010
B	25	186	2008, 2009
C	15	66	2010
D	20	123	2010
E	3497	16621	2008, 2009
F	45554	428642	2001 - 2011
G	73	1165	2011
Total	**50497**	**467902**	**2001 - 2011**

4.2 Test Centres

A separate meta-analysis was performed on Phase C performance test data, comprising of 6139 head of cattle from 3 Agricultural Research Council (ARC) test centres and 1 privately owned Sernick test centre. Health data, regarding Phase C performance tests, from only 2 ARC test centres were fit for inclusion into the analysis and included 1746 head of cattle.

The original number of cattle presented by the data received per test centre is shown in Table 4.2.

Table 4.2 Summary of raw data gathered from ARC test centres and the privately owned Sernick test centre (head of cattle per breed and centre)

Test centre	Drakensbergers	Other breeds	Years represented
Glen	113	1646	1999 - 2009
Sernick	260	3601	1999 - 2010
Vryburg	33	2239	1999 - 2010
Irene	53	810	1999 - 2010
Total	**459**	**8296**	**1999 - 2010**

4.3 Data collection

Growth results from Phase C performance tests, as well as historical growth and health data were gathered from feedlots. Raw data were managed and summarised by means of Excel spreadsheets (Microsoft Office Excel® 2007). The spreadsheets had to be sorted and processed, with the outliers being eliminated, after which the analysis could be performed.

Data from some feedlots only represented male animals and only certain seasons, nevertheless, these obtainable variables were analysed. Although, results from individual feedlots may lack figures for several seasons or female animals, the data was still able to be analysed in the meta-analysis.

Although the gathered information represented various breeds that are normally observed in feedlots, all breeds except Drakensbergers were categorised as “other breeds”. The analysis finally revealed all possible differences between Drakensbergers and other breeds.

The type of data that was collected, accompanied by an explanation of each term are presented in Table 4.3.

Table 4.3 Information obtained from feedlots, explained by definition

Data	Definition
Ear tag number	Identification number of each animal
Breed	Breed type of cattle
Gender	Male / Female
Begin date	Date on which the animal enters the feedlot
End date	The animal’s last day in the feedlot
Season	Summer (Nov, Des, Jan), Autumn (Feb, Mar, Apr), Winter (May, Jun, Jul), Spring (Aug, Sep, Oct)
Weight in	Animal weight upon day of arrival in feedlot
Weight out	Animal weight on last day in feedlot
ADG	Average daily gain
FCR	Feed conversion ratio
Reason for treatment	Disease type or diagnosis of sick animal
Treatment date	Date on which the animal receives medication

4.4 Data analysis

The variables included in the analysis were: average daily gain (ADG), feed conversion ratio (FCR), mortality and morbidity ratios and type of disease. In addition to determining the individual effects of breed, gender, season, year, region and diseases, possible interactions amongst these factors were investigated.

4.4.1 ADG

The average daily gain reflects the growth rate of the animal. Since different cattle breeds have distinct body conformations and frame sizes, ADG differ between breeds. In addition, differences in ADG occur due to variation among individual animals within a breed. According to the SA Stud Book annual report (2012), growth results from Phase C performance tests show that ADG values for beef cattle breeds in South Africa range from 1.139 to 1.955, with an average of 1.669.

In the case where ADG values from the raw data were considered as evidently incorrect, in terms of pre-determined biological values, such data was regarded as an outlier (e.g. 7.1).

4.4.2 FCR

Since the muscling ability and growth potential of cattle are influenced by the efficiency of feed utilisation, feed conversion ratios depend on the cattle breed type and variance among individual animals within a breed. FCR values will therefore depend on the breed’s size and conformation. Phase C performance test data reveal that FCR values for beef cattle breeds in South Africa range from 5.50 to 8.62, with the average being 6.25 (The SA Stud Book Annual Logix Beef Report, 2012).

Any FCR values that were classified as outliers, in terms of pre-determined biological values, were not included in the analysis (e.g. 19.0).

4.4.3 Morbidity and type of diseases

A diseased animal is regarded as an animal that has been pulled from a pen of cattle, after which it receives some form of medicinal treatment. The 3 most common disease categories to be observed in the data were: respiratory diseases; metabolic disturbances and foot rot or lameness. Counts or incidences per disease category only reflected the first time the animal had received treatment regarding that particular disease.

4.5 Statistical analysis

Each feedlot was analysed separately, followed by a final meta-analysis, which incorporated data from all the suitable feedlots. Data were analysed by means of the GenStat® statistical program (Payne, 2011).

4.5.1 Growth data from each feedlot

An analysis of variance (ANOVA) for unbalanced data (including an unequal number of replicates) was used to test for significant differences between the effects of breed, gender and season, together with the probable interactions amongst them (breed x gender; breed x season; gender x season). The data was acceptably normally distributed with non-homogenous variances. Consequently, the Fishers' protected least significant difference test (LSD) was used to separate means at a more precise 1% level of significance (Snedecor & Cochran, 1980).

4.5.2 Meta-analysis including growth data from five feedlots

In this meta-analysis a linear mixed model analysis (REML procedure) was used to combine data from all the individual feedlots, since they were considered as similar studies. A meta-analysis produces valuable estimates of treatment effects (means) in unbalanced designs with more than one source of error. Therefore, the estimates are produced from separate analyses on individual feedlots, in addition to the combined analysis on all the feedlots (Payne, 2011).

The meta-analysis was performed over 5 different feedlots with similar data. The fixed effects were stipulated as the main effects of feedlots, breeds, gender and season, as well as all the relevant interactions amongst them. The random effect was specified as the interaction: Feedlot.Breed.Gender.Year.Season. The data was acceptably normally distributed and contained non-homogenous variances. Means were appropriately separated using Fishers' protected least significant difference test (LSD) at the more precise 1% level of significance (Glass *et al*., 1972).

4.5.3 Chi-square tests on health data

Health data were analysed by the GenStat® statistical program (Payne *et al*., 2009b). Since the observations in the study consist of frequencies (counts) of incidents categorised in distinct classes (diseased or not diseased), the appropriate analysis proves to be the Chi-square (χ^2) test. The frequencies must remain mutually exclusive and are not allowed to be part of more than one class. The classes may be in an interval ordinal or even nominal scale. According to Siegel (1956), the χ^2-test has one restriction, as it requires each category to have an expected frequency of at least 5 counts or incidences.

The health status of cattle was analysed by performing row by column χ^2-tests for categorical data to test for differences in incidences per category between breeds. It was therefore investigated whether significant differences occurred in the proportions of diseased cattle between Drakensbergers and other breeds (Snedecor & Cochran, 1980).

4.5.4 Test centre analyses

Growth data from the ARC included ADG, FCR as well as total feed intake (TFI) values. Initially, in the data validation stage of the analysis, a Linear mixed model analysis, also known as REML analysis (Payne *et al*., 2009a), was applied to the ADG of bull calves to find estimates of the residual mean squares (MS) per centre (Payne *et al*., 2009b). The fixed effects were specified as breed, season and the breed by season interaction, while the random effect was specified as test centre. Additionally, general information about sample sizes, ADG ranges, homogeneity of variances, normality of data etc. was calculated per centre.

A meta-analysis was applied to data from 4 of the bull testing centres in order to test for differences between breed and season effects, in addition to the breed by season interaction. Since ages of the bulls ranged from 245 to 451 days, it was used as a covariate to adjust for the relationship between growth and age. The data attained an acceptable normal distribution with non-homogenous variances. Consequently, means were separated using Fishers' protected least significant difference test (LSD) at the more accurate 1% level of significance (Payne *et al*., 2009b).

CHAPTER 5

Feedlots

Results and Discussion

In this chapter the results of each of the seven individual feedlot analyses will be given, followed by a final meta-analysis including all the feedlots. Feedlot F included the highest number of cattle and feedlot D the lowest total number of cattle.

5.1 Growth data

5.1.1 Feedlot A

5.1.1.1 Effects of breed, gender and season on ADG of cattle

Table 5.1 presents the mean ADG (kg/day) between Drakensbergers and other breeds. The mean ADG from the data of the 22 059 animals in Feedlot A was 1.633 kg, with a minimum ADG of 0.1118 kg and a maximum of 2.998 kg. The ADG of the 1293 head of Drakensberger cattle were comparable to the other breeds, consisting of a total of 20 766 head of cattle. No difference (P > 0.01) was observed in mean ADG between Drakensbergers (1.633 kg) and other breeds (1.634 kg). The standard errors are appropriate for interpretation of the predictions as summaries of the data, rather than as forecasts of new observations.

Table 5.1 A comparison of ADG (kg/day) between Drakensbergers and other breeds in Feedlot A

Breed	n	ADG (kg)		P-value
		Mean	SE	
Drakensberger	1293	1.633	0.009800	0.982
Other	20766	1.634	0.002438	

SE – Standard error
n – Number of animals

The interaction between breed and gender is shown in Table 5.2. Differences between Drakensbergers and other breeds were neither observed (P > 0.01) within males (1.669 kg vs. 1.667 kg), nor within females (1.552 kg vs. 1.559 kg). Male animals had, as expected, a higher ($P < 0.01$) ADG than females in both Drakensbergers (1.669 kg vs. 1.552 kg) and other breeds (1.667 kg vs. 1.559 kg). The differences between genders are typically accepted, as male animals generally gain weight at a higher rate than females and have higher birth weights and mature body weights.

Table 5.2 The effect of breed x gender interaction on ADG (kg/day) in Feedlot A when comparing Drakensbergers with other breeds

	ADG (kg)			
Gender	**Male**		**Female**	
Breed	**Mean**	**SE**	**Mean**	**SE**
Drakensberger	1.669_1	0.011784	1.552_2	0.017646
Other	1.667_1	0.002935	1.559_2	0.004376

$_{1,\,2}$ – Row means with different subscripts differ ($P < 0.01$)
SE – Standard error

Table 5.3 displays the ADG due to effects from the breed x season interaction. No differences ($P > 0.01$) between breeds were observed within any of the four analysed seasons, indicating similar performances by both Drakensbergers and other breeds within each season. Differences ($P < 0.01$) in mean ADG were detected within breeds between seasons. Although there was no difference in autumn and winter ADG values (1.639 kg vs. 1.587 kg), the total weight gained by Drakensberger cattle was higher in the summer (1.663 kg) and spring (1.652 kg) than in winter (1.587 kg). No differences ($P > 0.01$) were observed between summer (1.663 kg), autumn (1.639 kg) and spring (1.652 kg) ADG. ADG in the other breeds differed ($P < 0.01$) between all seasons, except between autumn (1.638 kg) and spring (1.637 kg). The lowest ADG was observed during the winter in both breed categories, an occurrence generally regarded as the norm.

Table 5.3 The effect of breed x season interaction on ADG (kg/day) in Feedlot A when comparing Drakensbergers with other breeds

ADG (kg)				
Breed	**Drakensberger**		**Other**	
Season	**Mean**	**SE**	**Mean**	**SE**
Summer	1.663^{a}	0.02088	1.675^{a}	0.00517
Autumn	1.639^{ab}	0.02391	1.638^{b}	0.00589
Winter	1.587^{b}	0.01747	1.597^{c}	0.00441
Spring	1.652^{a}	0.01798	1.637^{b}	0.00445

$^{a, b, c}$ – Column means with different superscripts differ ($P < 0.01$)
SE – Standard error

From the results it is evident that the growth performance of Drakensbergers is similar to that of other breeds. Furthermore, the mean ADG of both breed groups, including male and female cattle, are within the range of 1.12 – 1.93 kg that generally occur in South African feedlots (Bosman, 2002). According to Wynn *et al*. (2000), it is generally accepted that cattle grow faster in summer than during the winter season. Although seasonal ADG of other breeds proved to be consistent with this statement, some deviation occurred in the ADG of Drakensbergers, since growth in summer, autumn and spring were similar.

5.1.2 Feedlot B

5.1.2.1 Effects of breed on ADG of cattle

The mean ADG from cattle in feedlot B, accompanied by their standard errors are shown in Table 5.4. Data from this study site only represented male animals, which were present in the feedlot for one season (spring). The total of 209 head of cattle had a mean ADG of 1.555 kg per day, with a minimum and maximum ADG of 0.9014 and 2.232 kg respectively. A similar performance ($P > 0.01$) regarding ADG was observed between the 25 Drakensberger and 184 other head of cattle (1.612 kg vs. 1.547 kg). Therefore, breed type had no effect on ADG.

Table 5.4 The effect of cattle breed on ADG (kg/day) in Feedlot B when comparing the Drakensberger with other breeds

Breed	n	ADG (kg)		P-value
		Mean	SE	
Drakensberger	25	1.612	0.04758	0.202
Other	184	1.547	0.01754	

SE – Standard error
n – Number of animals

Results from feedlot B are consistent with the findings of Bosman (2002), as the ADG of Drakensbergers and other breeds occur in the range from 1.12 – 1.93 kg.

5.1.3 Feedlot C

5.1.3.1 Effects of breed on ADG of cattle

In Table 5.5 is shown the mean ADG, accompanied by the standard errors of 81 male animals subjected to a short feedlot feeding period during summer only. Performance data from 15 Drakensbergers and 66 other head of cattle from feedlot C were suitable for analysis. The effect of breed type was insignificant, since no difference ($P > 0.01$) in mean ADG was observed between breeds (1.582 kg vs. 1.664 kg). Weight gain was similar in Drakensbergers and other breeds.

Table 5.5 The effect of cattle breed on ADG (kg/day) in Feedlot C when comparing Drakensbergers with other breeds

Breed	n	ADG (kg)		P-value
		Mean	SE	
Drakensberger	15	1.582	0.07004	0.293
Other	66	1.664	0.03339	

SE – Standard error
n – Number of animals

Results from Table 5.5 reveal that growth figures from feedlot C are comparable to nationally accepted ADG (Bosman, 2002). The mean ADG of both breed groups fall within the range of 1.12 – 1.93 kg.

5.1.4 Feedlot D

5.1.4.1 Effects of breed on ADG of cattle

The growth results of cattle from this relatively minor feedlot study during the summer season are shown in Table 5.6. Mean ADG and standard errors are presented. Although data from a total of 142 head of cattle was collected, no female Drakensberger cattle were represented. Therefore, the analysis was performed merely on the male animals' data. Even though the 20 Drakensberger cattle gained an average of 138 grams more per day (2.011 kg vs. 1.873 kg) than the 15 other breeds, there was no difference (P > 0.01) between groups. The numerical difference may seem large, but due to the low number of animals in the study, the difference is insignificant. Therefore, the breed type had no effect on the ADG of the cattle in feedlot D. It is important to note that the size and quality of each individual study is taken into account in a meta-analysis, since a weight factor is assigned to each study.

Table 5.6 The effect of cattle breed on ADG (kg/day) in Feedlot D when comparing Drakensbergers with other breeds

Breed	n	ADG (kg)		P-value
		Mean	SE	
Drakensberger	20	2.011	0.0394	0.028
Other	15	1.873	0.0455	

SE – Standard error
n – Number of animals

Although the resulting mean ADG of Drakensberger cattle (2.011 kg) from feedlot D was slightly higher than the average range (1.12 – 1.93 kg) calculated by Bosman (2002), the ADG of the two breed groups did not differ. The difference in diet type between feedlots and phase C performance test centres most probably played a role, considering these high ADG values. Diet limitations exist in phase C performance tests, while feedlot rations are higher in energy.

5.1.5 Feedlot E

5.1.5.1 Effects of breed, gender and season on ADG of cattle

In Table 5.7, mean ADG, accompanied by the corresponding standard errors, from a feedlot study including 20 118 head of cattle, are shown. The length of the feedlot period was an average of 107 days. Cattle entered the feedlot at an average weight of 246.2 kg, with a total weight gain of 179.9 kg at the end of the feedlot period. It was proved that no difference (P > 0.01) in mean ADG existed between the 3497 Drakensberger and 16 621 other head of cattle (1.675 kg vs. 1.688 kg). This suggests that the breed type had no effect on the ADG of cattle in feedlot E.

Table 5.7 The effect of cattle breed on ADG (kg/day) in Feedlot E when comparing the Drakensberger with other breeds

Breed	**n**	**ADG (kg)**		**P-value**
		Mean	**SE**	
Drakensberger	3497	1.675	0.008891	0.112
Other	16621	1.688	0.003986	

SE – Standard error
n – Number of animals

Table 5.8 displays the ADG and standard errors from the analysis on the interaction between breed and gender. Although it is generally accepted that male animals have a higher ADG than females, no difference was observed (P > 0.01) between male and female cattle (1.675 kg vs. 1.674 kg) within the Drakensberger breed. There was, however, a difference (P < 0.01) in ADG between males and females within other breed types (1.696 kg vs. 1.670 kg). This implies that gender did indeed have an effect on growth performance within other breeds. ADG did not differ (P > 0.01) between breed types within the distinct gender categories (1.675 kg vs. 1.696 kg and 1.674 kg vs. 1.670 kg).

Table 5.8 The effect of breed x gender interaction on ADG (kg/day) in Feedlot E when comparing Drakensbergers with other breeds

	ADG (kg)			
Gender	**Male**		**Female**	
Breed	**Mean**	**SE**	**Mean**	**SE**
Drakensberger	1.675	0.010782	1.674	0.015673
Other	1.696_1	0.004910	1.670_2	0.006823

$_{1,\,2}$ – Row means with different subscripts differ ($P < 0.01$)
SE – Standard error

The results regarding the analysis on the interaction between breed and season concerning mean ADG are presented in Table 5.9. Differences ($P < 0.01$) in ADG values between Drakensbergers and other breeds were observed within two of the four seasons. Other breeds reached a higher ADG than Drakensbergers in the summer (1.832 kg vs. 1.739 kg), while Drakensbergers achieved a higher ADG during autumn (1.815 kg vs. 1.697 kg). No differences ($P > 0.01$) were noted between the breed types within the winter and spring seasons.

The ADG of Drakensberger cattle in summer, autumn and winter were higher ($P < 0.01$) than in spring. The ADG of the other breed types was highest ($P < 0.01$) during summer (1.832 kg) and the lowest during spring (1.500 kg). The particular season represents the season in which the cattle completed the feedlot period. Therefore, ADG for spring are the lowest ($P < 0.01$) within both breed types, since cattle may still have been in the process of increasing their ADG upon leaving the feedlot, following the low weight gain during the winter season. The breed x season interaction had noteworthy effects on the mean ADG of cattle in this feedlot study.

Table 5.9 The effect of breed x season interaction on ADG (kg/day) in Feedlot E when comparing Drakensbergers with other breeds

ADG (kg)				
Breed	**Drakensberger**		**Other**	
Season	**Mean**	**SE**	**Mean**	**SE**
Summer	1.739^{a}_{1}	0.02020	1.832^{a}_{2}	0.00767
Autumn	1.815^{a}_{1}	0.03324	1.697^{b}_{2}	0.01652
Winter	1.741^{a}	0.01276	1.723^{b}	0.00637
Spring	1.488^{b}	0.01661	1.500^{c}	0.00750

$^{a, b, c}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1, 2}$ – Row means with different subscripts differ ($P < 0.01$)
SE – Standard error

It can be concluded from the results of feedlot E that the mean ADG of both breed groups and gender categories are within the average range of 1.12 – 1.93 kg, proposed by Bosman (2002). A deviation in seasonal ADG is observed within Drakensbergers. Summer, autumn and winter ADG are similar, in stead of higher growth during summer (Wynn *et al.*, 2000).

5.1.6 Feedlot F

5.1.6.1 Effects of breed, gender, season and year on ADG of cattle

In Table 5.10 is shown the mean ADG of Drakensberger cattle, accompanied by their standard errors, compared to the other breeds in feedlot F. The total 448 028 head of cattle was represented by 43 238 Drakensbergers, while the remaining 404 790 consisted of various other breed types. Breed type had an effect on weight gain, since Drakensbergers had a lower ($P < 0.01$) ADG than other breeds (1.713 kg vs. 1.742 kg). Although this difference is regarded as statistically significant, the mean difference is a mere 29 grams per day. The difference can be assigned to the large number of animals that is included in the analysis, which leads to the increased sensitivity of the test.

Table 5.10 The effect of cattle breed on ADG (kg/day) in Feedlot F when comparing the Drakensberger with other breeds

Breed	n	ADG (kg)		P-value
		Mean	SE	
Drakensberger	43238	1.713^{a}	0.001999	< 0.001
Other	404790	1.742^{b}	0.000636	

$^{a, b}$ – Column means with different superscripts differ (P < 0.01)
SE – Standard error
n – Number of animals

It is evident from the interaction between breed and gender, shown in Table 5.11, that within both breed types, male cattle have a better growth performance than females. Male Drakensberger cattle (1.744 kg vs. 1.635 kg), together with males from other breed types (1.776 kg vs. 1.656 kg), have a higher (P < 0.01) mean ADG than females. The same trend for breed types is observed within both gender categories. Other breed types have higher (P < 0.01) ADG values within male (1.744 kg vs. 1.776 kg) and female (1.635 kg vs. 1.656 kg) cattle. The difference in mean ADG between breeds, within males, is 32 grams, while a difference of 21 grams per day exists within female animals.

Table 5.11 The effect of breed x gender interaction on ADG (kg/day) in Feedlot F when comparing Drakensbergers with other breeds

	ADG (kg)			
Gender	Male		Female	
Breed	Mean	SE	Mean	SE
Drakensberger	1.744^{a}_{1}	0.002353	1.635^{a}_{2}	0.003787
Other	1.776^{b}_{1}	0.000750	1.656^{b}_{2}	0.001196

$^{a, b}$ – Column means with different superscripts differ (P < 0.01)
$_{1, 2}$ – Row means with different subscripts differ (P < 0.01)
SE – Standard error

The effects of breed and season on weight gain are presented in Table 5.12, together with the corresponding standard errors. It can be observed that within Drakensbergers and other breed types, differences (P < 0.01) between all seasons occur. According to the results, Drakensberger cattle have the lowest ADG in the summer season (1.670 kg), with the highest being in the winter (1.764 kg). Likewise, other breed types had the highest ADG during the winter season (1.787 kg). However, their lowest ADG was noted during spring (1.717 kg). As stated before, the particular season represents the season in which the cattle completed the feedlot period.

Our results showed differences ($P < 0.01$) between breed types within every season, except within the autumn season (1.724 kg vs. 1.735 kg). In each one of these differences, Drakensberger cattle had the lower ADG value (summer: 1.670 kg vs. 1.725 kg; winter: 1.764 kg vs. 1.787 kg; spring: 1.694 kg vs. 1.717 kg). It is evident that breed type and season had significant effects on ADG values in cattle from feedlot F.

Table 5.12 The effect of breed x season interaction on ADG (kg/day) in Feedlot F when comparing Drakensbergers with other breeds

	ADG (kg)			
Breed	**Drakensberger**		**Other**	
Season	**Mean**	**SE**	**Mean**	**SE**
Summer	1.670^{a}_{1}	0.003916	1.725^{a}_{2}	0.001252
Autumn	1.724^{b}	0.004559	1.735^{b}	0.001313
Winter	1.764^{c}_{1}	0.003844	1.787^{c}_{2}	0.001242
Spring	1.694^{d}_{1}	0.003702	1.717^{d}_{2}	0.001279

$^{a, b, c, d}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1, 2}$ – Row means with different subscripts differ ($P < 0.01$)
SE – Standard error

The mean ADG and associated standard errors for each breed type within 9 consecutive years are presented in Table 5.13. Data from 2002 to 2010 for both breed types was suitable for analysis. Minor similarities were observed within breed types between the 9 years. Within Drakensberger cattle, mean ADG differed ($P < 0.01$) between each year, except between 2005 (1.689 kg), 2007 (1.675 kg) and 2009 (1.689 kg). There were no differences ($P > 0.01$) in ADG between these 3 years. Similarly, mean ADG within other breed types differed between each year, except between 2006 (1.662 kg) and 2010 (1.660 kg). There were no differences ($P > 0.01$) in ADG between these 2 years.

Differences ($P < 0.01$) in mean ADG between breed types within a particular year were present in 2002 (1.836 kg vs. 1.878 kg), 2003 (1.809 kg vs. 1.843 kg), 2005 (1.689 kg vs. 1.711 kg), 2006 (1.622 kg vs. 1.662 kg), 2007 (1.675 kg vs. 1.726 kg) and 2008 (1.597 kg vs. 1.648 kg). During 2004 (1.751 kg vs. 1.757 kg), 2009 (1.689 kg vs. 1.687 kg) and 2010

(1.646 kg vs. 1.660 kg), no difference (P > 0.01) in mean ADG occurred between breed types. Although the breed x season interaction had effects on mean ADG of cattle in feedlot F, no definite trend could be identified.

Table 5.13 The effect of breed x year interaction on ADG (kg/day) in Feedlot F when comparing Drakensbergers with other breeds

ADG (kg)				
Breed	**Drakensberger**		**Other**	
Year	**Mean**	**SE**	**Mean**	**SE**
2002	1.836^{a}_{1}	0.005148	1.878^{a}_{2}	0.001697
2003	1.809^{b}_{1}	0.005781	1.843^{b}_{2}	0.001706
2004	1.751^{c}	0.005892	1.757^{c}	0.001802
2005	1.689^{d}_{1}	0.005889	1.711^{d}_{2}	0.001884
2006	1.622^{e}_{1}	0.005469	1.662^{e}_{2}	0.001996
2007	1.675^{d}_{1}	0.005585	1.726^{f}_{2}	0.002058
2008	1.597^{f}_{1}	0.006252	1.648^{g}_{2}	0.002149
2009	1.689^{d}	0.007113	1.687^{h}	0.001963
2010	1.646^{g}	0.006808	1.660^{e}	0.002072

$^{a, b, c, d, e, f, g, h}$ – Column means with different superscripts differ (P < 0.01)
$_{1, 2}$ – Row means with different subscripts differ (P < 0.01)
SE – Standard error

Mean ADG from the analyses on breeds and breed x gender interaction occur within the range (1.12 – 1.93 kg) which is generally accepted for feedlot cattle (Bosman, 2002). It is evident from results of the breed x season interaction that both breed groups deviate from the norm (Wynn *et al*., 2000), since their highest ADG is noted during winter. Both breed groups attained their highest ADG during 2002. According to the South African Weather Service (2012), this particular region experienced a below average rainfall of 407.80 mm during 2002 (average annual rainfall during 2002 - 2010 of 616.14 mm). No considerable difference in average temperature (16.88 ˚C) was experienced during this year (average annual temperature during 2002 - 2010 of 17.17˚C). The lowest ADG of both breed groups occurred during 2008. The average rainfall and temperature for 2008 was 751.60 mm and 16.92˚C respectively. However, it remained impossible to detect a specific trend over the years of

2002 – 2010, in order to conclude whether particular climatic conditions influenced the growth performance of cattle in feedlot F.

5.1.7 Feedlot G

5.1.7.1 Effects of breed and gender on ADG of cattle

Data from feedlot G was representative of 2 seasons from 2011. From a total of 1237 head of cattle, the mean ADG was calculated as 1.754 kg, ranging from 0.470 – 3.970 kg. Cattle spent an average of 115 days in the feedlot. The role of breed type on growth performance is summarised in Table 5.14. The 73 Drakensberger cattle had a mean ADG of 1.732 kg, with the 1164 cattle from other breed types having a mean ADG of 1.755 kg. ADG did not differ between breeds (P > 0.01), suggesting that the Drakensberger performed the same as other breeds in the feedlot.

Table 5.14 The effect of cattle breed on ADG (kg/day) in Feedlot G when comparing the Drakensberger with other breeds

Breed	n	ADG (kg)		P-value
		Mean	SE	
Drakensberger	73	1.732	0.03651	0.469
Other	1164	1.755	0.00900	

SE – Standard error
n – Number of animals

The mean ADG and corresponding standard errors from the analysis on the interaction between breed and gender in feedlot G are shown in Table 5.15. The analysis could merely distinguish between bulls and steers, since these were the only gender categories available from the collected data. The figures from the breed x gender interaction follow the trend observed in Table 5.14. Mean ADG between breed types did neither differ (P > 0.01) within bulls (1.657 kg vs. 1.727 kg), nor in steers (1.747 kg vs. 1.760 kg). No differences (P > 0.01) between bulls and steers were observed within Drakensbergers (1.657 kg vs. 1.747 kg), likewise in the other cattle breed types (1.727 kg vs. 1.760 kg).

Table 5.15 The effect of breed x gender interaction on ADG (kg/day) in Feedlot G when comparing Drakensbergers with other breeds

		ADG (kg)		
Gender	**Bull**		**Steer**	
Breed	**Mean**	**SE**	**Mean**	**SE**
Drakensberger	1.657	0.07236	1.747	0.04136
Other	1.727	0.02240	1.760	0.00982

SE – Standard error

The results from feedlot G show that the mean ADG of Drakensbergers and other breeds, together with both gender categories, were consistent with the proposed range (1.12 – 1.93 kg) of feedlot cattle (Bosman, 2002). Bulls from both breed groups had a similar performance than that of steers, in stead of being the superior gender category.

5.1.8 Meta-analysis

5.1.8.1 Effects of feedlot, breed, gender, season and year on ADG when comparing the Drakensberger with other breeds

The final meta-analysis was performed over 5 feedlots which ultimately included 497798 head of cattle. Data from 5 of the 7 feedlots met the requirements in order to be included in the analysis. The mean ADG was predicted as 1.738 kg, with the minimum and maximum being 0.112 kg and 2.998 kg respectively.

In Table 5.16 is shown the mean ADG obtained from each individual feedlot, accompanied by the standard errors and the number of cattle per feedlot. No differences ($P > 0.01$) in mean ADG were observed between any of the 5 feedlots (1.666 kg vs. 1.690 kg vs. 1.695 kg vs. 1.700 kg vs. 1.692 kg). Therefore it can be concluded that feedlot, as a variable, had no effect on mean ADG in cattle and no single feedlot can be regarded as superior to another with reference to growth performance.

Table 5.16 The effect of feedlot on ADG (kg/day) in the meta-analysis

Feedlot	n	ADG (kg)	
		Mean	SE
A	22059	1.666	0.023
B	209	1.690	0.061
C	81	1.695	0.089
E	20118	1.700	0.026
F	455331	1.692	0.008

SE – Standard error
n – Number of animals

The findings of the meta-analysis regarding the effect of cattle breed type on mean ADG are displayed in Table 5.17. From the results it is evident that a difference ($P < 0.01$) occurs between the mean ADG of 48 600 Drakensberger cattle (1.679 kg) and 449 198 head of cattle from other breed types (1.699 kg). Although this difference is statistically significant, it is a mere 20 grams and would most probably be biologically and economically insignificant. In a practical commercial feeding situation, such differences are meaningless and would not be noticed, suggesting similar performance under commercial feedlot conditions.

Table 5.17 The effect of cattle breed on ADG (kg/day) in the meta-analysis

Breed	n	ADG (kg)		P-value
		Mean	SE	
Drakensberger	48600	1.679^{a}	0.025	< 0.001
Other	449198	1.699^{b}	0.025	

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
SE – Standard error
n – Number of animals

Mean ADG and standard errors produced from the analysis on the interaction between breed and gender are presented in Table 5.18. Within male cattle, no differences ($P > 0.01$) are observed between breed types (1.728 kg vs. 1.757 kg). Likewise, within female animals, a similar performance regarding ADG ($P > 0.01$) is noted between Drakensbergers (1.629 kg) and other breed types (1.641 kg). Therefore, the performance of the breed types within each gender category is similar. On the other hand, differences ($P < 0.01$) between male and female cattle are observed within both breed groups. Male cattle have a higher ($P < 0.01$)

mean ADG than females, within both Drakensbergers (1.728 kg vs. 1.629 kg) and other breed types (1.757 kg vs. 1.641 kg). These differences in weight gain between genders are generally expected and are accepted as the norm.

Table 5.18 The effect of breed x gender interaction on ADG (kg/day) in the meta-analysis when comparing Drakensbergers with other breeds

	ADG (kg)			
Gender	**Male**		**Female**	
Breed	**Mean**	**SE**	**Mean**	**SE**
Drakensberger	1.728_1	0.027	1.629_2	0.028
Other	1.757_1	0.026	1.641_2	0.027

$_{1,\,2}$ – Row means with different subscripts differ ($P < 0.01$)
SE – Standard error

Table 5.19 displays the mean ADG predictions, along with the standard errors, for both breed types per season. From the results it is evident that no differences ($P > 0.01$) occur between breed types within any of the 4 analysed seasons. The effect of breed on the average growth performance is therefore negligible.

Conversely, differences ($P > 0.01$) between seasons were indeed noted within breed types. Within the Drakensberger breed, no differences ($P > 0.01$) were observed among summer (1.659 kg); autumn (1.693 kg) and winter (1.719 kg) mean ADG. Likewise, summer and autumn values did not differ ($P > 0.01$) from the mean spring ADG (1.644 kg). A difference ($P < 0.01$) was noted between winter and spring mean ADG, with Drakensberger cattle reaching a maximum ADG of 1.719 kg during winter and a minimum of 1.644 kg in spring. Likewise, no differences ($P > 0.01$) in mean ADG were noted among summer (1.712 kg); autumn (1.693 kg) and winter (1.737 kg) within other breed types. Again, the mean spring ADG (1.653 kg) was no different ($P > 0.01$) from summer and autumn values, but differed ($P > 0.01$) from the mean winter ADG. Similar to Drakensberger cattle, other breed types accomplished a maximum ADG during winter and a minimum in spring (1.737 kg vs. 1.653 kg).

The spring ADG represents cattle that leave the feedlot period during spring. Therefore, the low ADG during spring can be ascribed to the fact that the cattle exit the feedlot directly after the slow growing winter phase. Based on the same principle, the high ADG of cattle that leave the feedlot during winter are due to the preceding fast growing phases of summer and autumn.

Table 5.19 The effect of breed x season interaction on ADG (kg/day) in the meta-analysis when comparing Drakensbergers with other breeds

ADG (kg)				
Breed	**Drakensberger**		**Other**	
Season	**Mean**	**SE**	**Mean**	**SE**
Summer	1.659^{ab}	0.030	1.712^{ab}	0.030
Autumn	1.693^{ab}	0.032	1.693^{ab}	0.031
Winter	1.719^{a}	0.031	1.737^{a}	0.030
Spring	1.644^{b}	0.030	1.653^{b}	0.030

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
SE – Standard error

Results from the analyses concerning the breed by year interaction are summarised in Table 5.20. From the table it is evident that, regarding the analysis between breed types, no differences ($P > 0.01$) in mean ADG occurred within any of the years from 2002 – 2010. Therefore, it can be concluded that the effect of breed type was irrelevant, with the 2 breed categories having a similar growth performance within the various years.

Conversely, differences ($P < 0.01$) within both breed categories were noted between the years. The relevant differences are displayed in Table 5.20. As a result, the main effect of year in the breed by year interaction had an influence on the growth performance of cattle within each breed type.

Table 5.20 The effect of breed x year interaction on ADG (kg/day) in the meta-analysis when comparing Drakensbergers with other breeds

	ADG (kg)			
Breed	**Drakensberger**		**Other**	
Year	**Mean**	**SE**	**Mean**	**SE**
2002	1.798^{a}	0.041	1.840^{a}	0.041
2003	1.769^{abd}	0.041	1.801^{ab}	0.041
2004	1.715^{ac}	0.041	1.718^{bc}	0.041
2005	1.662^{bc}	0.041	1.676^{c}	0.041
2006	1.611^{c}	0.041	1.643^{c}	0.041
2007	1.656^{dc}	0.041	1.701^{bc}	0.041
2008	1.608^{c}	0.034	1.643^{c}	0.034
2009	1.653^{c}	0.031	1.622^{c}	0.029
2010	1.633^{c}	0.032	1.646^{c}	0.030

$^{a, b, c, d}$ – Column means with different superscripts differ ($P < 0.01$)
SE – Standard error

The meta-analyses reveal mean ADG figures that are within the range previously discussed (1.12 – 1.93 kg). In addition, the ADG of Drakensberger cattle (Table 5.17) is comparable to that of commercial Drakensbergers (1.679 kg vs. 1.760 kg) in a study on Southern African indigenous breeds (Strydom, 2008). It is evident that growth performance of feedlot cattle has improved over the years, since production statistics of 11 feedlots from 1982 – 1988 showed an average ADG of 1.224 kg (De Bruyn, 1991).

According to Maree & Casey (1993), the effect of cold weather on feedlot performance is unfavourable. Winter periods may decrease feed conversion efficiencies of cattle in feedlots of the eastern highveld by 10 - 15 %. Therefore, superior growth performance can be expected during summer months. Variation in feedlot performance between years is most probably due to fluctuations in: annual rainfall; temperatures; length of seasons etc. Climatic conditions influence the feed intake of cattle, which has an impact on growth performance and disease incidence. Feedlot performance will therefore differ from year to year, since it is impossible to control or predict environmental conditions.

5.2 Health data

5.2.1 Feedlot A

5.2.1.1 The association between breed type and total disease status per season

The number of animals, accompanied by the calculated proportions, categorised as diseased or not during summer are presented in Table 5.21. With regards to the total disease status of cattle, a total of 5.9 % of Drakensberger cattle (n = 51) were observed as diseased. A proportion of 7.4 % of cattle from other breed types (n = 1007) were noted as diseased. No difference (P > 0.01) between these 2 breed types was observed during the summer season. Therefore, breed type had no influence on disease occurrence in feedlot A.

Table 5.21 The effect of breed x season interaction on total disease occurrence during summer in Feedlot A when comparing Drakensbergers with other breeds

			Summer		
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	51	5.9	810	94.1	861
Other	1007	7.4	12517	92.6	13524

n – Number of animals

Total disease status between breeds, within the winter period, are displayed in Table 5.22 in terms of the number of cattle, in addition to the calculated proportions of diseased animals. A difference (P < 0.01) in disease occurrence was noted, since 55.6 % of Drakensberger cattle and 43.3 % of cattle from other breed types were regarded as diseased. Therefore, it can be concluded that cattle from other breed types had a lower disease occurrence than Drakensberger cattle. The difference between these proportions may be due to the large number of cattle (514 Drakensbergers; 8655 head of cattle from other breed types), since the sensitivity of the test is strengthened.

Table 5.22 The effect of breed x season interaction on total disease occurrence during winter in Feedlot A when comparing Drakensbergers with other breeds

Winter					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	286	55.6^a	228	44.4^a	514
Other	3749	43.3^b	4906	56.7^b	8655

$^{a, b}$ – Column means with different superscripts differ (P < 0.01)
n – Number of animals

The results from the analysis on total disease status over all seasons are showed in Table 5.23. Total disease occurrence over all seasons differed (P < 0.01) between Drakensbergers and cattle from other breed types (24.5 % vs. 21.4 %). As stated before concerning results from Table 5.22, the difference between breeds may be due to the large number of animals, with the analysis including 1375 Drakensberger cattle and 22 179 head of cattle from other breeds.

Table 5.23 The effect of breed x season interaction on total disease occurrence over all seasons in Feedlot A when comparing Drakensbergers with other breeds

All seasons					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	337	24.5^a	1038	75.5^a	1375
Other	4756	21.4^b	17423	78.6^b	22179

$^{a, b}$ – Column means with different superscripts differ (P < 0.01)
n – Number of animals

5.2.1.2 The association between breed type and respiratory disease status per season

The incidence of respiratory disease in Drakensberger cattle and other breed types during summer is summarised in Table 5.24. A total of 4.5 % of Drakensbergers (n = 39) were regarded as diseased, while 6.1 % of cattle from other breed types (n = 822) were diseased. Although respiratory disease occurrence was higher in other breed types, the analysis showed no difference (P > 0.01) between breeds during summer. Therefore, breed type had no effect on the incidence of respiratory disease in feedlot A.

Table 5.24 The effect of breed x season interaction on respiratory disease occurrence during summer in Feedlot A when comparing Drakensbergers with other breeds

Summer					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	39	4.5	822	95.5	861
Other	822	6.1	12702	93.9	13524

n – Number of animals

In Table 5.25 is shown the results from the analysis on respiratory disease occurrence between breed types during winter. Due to the large number of cattle included in the analysis, a difference (P < 0.01) in respiratory disease occurrence between Drakensbergers (n = 514) and other breed types (n = 8655) was observed within the winter season. Other cattle breed types had a lower disease incidence than Drakensbergers (50.2 % vs. 39.1 %).

Table 5.25 The effect of breed x season interaction on respiratory disease occurrence during winter in Feedlot A when comparing Drakensbergers with other breeds

Winter					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	258	50.2^{a}	256	49.8^{a}	514
Other	3380	39.1^{b}	5275	60.9^{b}	8655

$^{a, b}$ – Column means with different superscripts differ (P < 0.01)
n – Number of animals

The analysis on respiratory disease status between Drakensberger cattle and other breed types over all seasons includes 1375 Drakensbergers and 22 179 head of cattle from other breed types. The numbers and proportions of cattle per breed and disease status are displayed in Table 5.26. A proportion of 21.6 % of Drakensbergers (297) were noted as diseased, while

18.9 % of cattle from other breed types (4202) were regarded as diseased. The analysis over all seasons showed no difference (P > 0.01) in respiratory disease occurrence between breed types. Therefore, breed type had no effect on the incidence of respiratory disease in feedlot A.

Table 5.26 The effect of breed x season interaction on respiratory disease occurrence over all seasons in Feedlot A when comparing Drakensbergers with other breeds

All seasons					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	297	21.6	1078	78.4	1375
Other	4202	18.9	17977	81.1	22179

n – Number of animals

5.2.1.3 The association between breed type and metabolic disease status per season

Table 5.27 displays the findings from the analysis on metabolic disease occurrence between breed types within summer. Although the incidence of metabolic diseases in cattle from other breeds was twice as much than in Drakensberger cattle (0.3 % vs. 0.6 %), our results showed no difference (P > 0.01) between breeds during summer. Since some values are less than 5 per category (Diseased Drakensbergers = 3), the reliability of the Chi-square test may be reduced.

Table 5.27 The effect of breed x season interaction on metabolic disease occurrence during summer in Feedlot A when comparing Drakensbergers with other breeds

Summer					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	3	0.3	858	99.7	861
Other	80	0.6	13444	99.4	13524

n – Number of animals

Results from the analysis on breed types and metabolic disease status within winter are presented in Table 5.28. The proportion of diseased Drakensbergers was 0.8 %, with a total of 1.3 % of cattle from other breeds regarded as diseased. Although other breed types had a higher disease incidence, no difference (P > 0.01) was observed between breeds within the winter season. Since some values are less than 5 per category (Diseased Drakensbergers = 4), the reliability of the Chi-square test may be reduced.

Table 5.28 The effect of breed x season interaction on metabolic disease occurrence during winter in Feedlot A when comparing Drakensbergers with other breeds

Winter					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	4	0.8	510	99.2	514
Other	110	1.3	8545	98.7	8655

n – Number of animals

The analysis on metabolic diseases between breeds over all seasons are summarised in Table 5.29. Out of the 1375 Drakensbergers and 22 179 head of cattle from other breeds, an incidence rate of 0.5 % for Drakensbergers (n = 7) and 0.9 % for other breed types (n = 190) occurred. The analysis over all seasons showed no difference (P > 0.01) in metabolic disease occurrence between breeds. Therefore, breed type had no effect on disease occurrence in feedlot A.

Table 5.29 The effect of breed x season interaction on metabolic disease occurrence over all seasons in Feedlot A when comparing Drakensbergers with other breeds

All seasons					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	7	0.5	1368	99.5	1375
Other	190	0.9	21989	99.1	22179

n – Number of animals

5.2.1.4 The association between breed type and other disease status per season

In Table 5.30 is shown results from the analysis involving 861 Drakensberger cattle and 13 524 head of cattle from other breed types. The relationship between breed type and the incidence of various diseases during the summer season was investigated. The proportions of Drakensbergers compared to cattle from other breeds (0.9 % vs. 0.6 %) did not differ (P > 0.01) regarding disease status during summer. Therefore, breed type had no effect on disease occurrence in feedlot A.

Table 5.30 The effect of breed x season interaction on other disease occurrence during summer in Feedlot A when comparing Drakensbergers with other breeds

Summer					
Other diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	8	0.9	853	99.1	861
Other	77	0.6	13447	99.4	13524

n – Number of animals

The analysis on breed type and various other disease occurrences during winter included 514 Drakensberger cattle and 8655 head of cattle from other breed types. Table 5.31 displays the results as proportions and number of cattle. The disease incidence in Drakensbergers reached a total of 3.3 %, while 2.6 % of other cattle breed types were regarded as diseased. The analysis revealed no difference (P > 0.01) between breed types with regards to other disease status within the winter season. As a result, breed type had no influence on the incidence rate of other diseases during winter in feedlot A.

Table 5.31 The effect of breed x season interaction on other disease occurrence during winter in Feedlot A when comparing Drakensbergers with other breeds

Winter					
Other diseases	Diseased		Not diseased		Total
Breed	n	Proportion (%)	n	Proportion (%)	n
Drakensberger	17	3.3	497	96.7	514
Other	229	2.6	8426	97.4	8655

n – Number of animals

The analysis on the relationship between breed type and other disease status over all seasons included 1375 Drakensbergers and 22 179 head of cattle from other breeds. From the results in Table 5.32, the proportions of Drakensbergers and cattle from other breed types that had suffered from other diseases are observed as 1.8 % and 1.4 % respectively. The analysis showed no difference (P > 0.01) between breeds regarding other disease status over all seasons. It can be concluded that breed type had no effect on the occurrence of other diseases in feedlot A.

Table 5.32 The effect of breed x season interaction on other disease occurrence over all seasons in Feedlot A when comparing Drakensbergers with other breeds

All seasons					
Other diseases	Diseased		Not diseased		Total
Breed	n	Proportion (%)	n	Proportion (%)	n
Drakensberger	25	1.8	1350	98.2	1375
Other	306	1.4	21873	98.6	22179

n – Number of animals

5.2.1.5 The association between breed type and total disease status within genders

The relationship between breed type and gender regarding total disease occurrence in 935 Drakensbergers and 15 158 cattle from other breeds was analysed. The results are presented in Table 5.33 as numbers of cattle and proportions per disease status. The analysis showed that 24.1 % of Drakensbergers (n = 225) and 22.4 % of cattle from other breed types (n = 3393) were regarded as diseased. No difference ($P > 0.01$) was observed between the proportions of diseased cattle breeds, indicating that breed type had no effect on total disease occurrence in bulls from feedlot A.

Table 5.33 The effect of breed x gender interaction on total disease occurrence in bulls from Feedlot A when comparing Drakensbergers with other breeds

Bulls					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	225	24.1	710	75.9	935
Other	3393	22.4	11765	77.6	15158

n – Number of animals

Table 5.34 displays the results from the analysis on the interaction between breed type and gender category regarding total diseases in cattle from feedlot A. The number of cattle and associated proportions are summarised as 25.6 % of Drakensberger cattle (n = 112) and 19.4 % of cattle from other breed types (n = 1361) being diseased. Due to the greater sensitivity of the test that was caused by the large number of cattle in the analysis, the proportion of diseased cattle differed ($P < 0.01$) between breeds. The disease incidence of other breed types was lower than that of Drakensbergers. Breed type had an effect on total disease occurrence within heifers.

Table 5.34 The effect of breed x gender interaction on total disease occurrence in heifers from Feedlot A when comparing Drakensbergers with other breeds

Heifers					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	112	25.6^{a}	326	74.4^{a}	438
Other	1361	19.4^{b}	5652	80.6^{b}	7013

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
n – Number of animals

5.2.1.6 The association between breed type and respiratory disease status within genders

The analysis on the incidence of respiratory disease in bulls from feedlot A is summarised in Table 5.35 as numbers and proportions of cattle per breed type. From the 935 Drakensberger cattle, a total of 21.1 % were regarded as diseased. A proportion of 19.7 % of the 15 158 head of cattle from other breeds had respiratory diseases. No difference (P > 0.01) between breed types was noted from the analysis. Therefore, breed type did not have an effect on respiratory disease occurrence in bulls.

Table 5.35 The effect of breed x gender interaction on respiratory disease occurrence in bulls from Feedlot A when comparing Drakensbergers with other breeds

Bulls					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	197	21.1	738	78.9	935
Other	2992	19.7	12166	80.3	15158

n – Number of animals

Table 5.36 summarises the results from the analysis on respiratory disease occurrence within heifers. A total of 100 out of the 438 Drakensberger cattle (22.8 %) were regarded as diseased, while 1209 of the 7013 cattle from other breed types (17.2 %) had suffered from respiratory diseases. A difference (P < 0.01) in respiratory disease incidence between breed types was noted from the analysis. Therefore, breed type had an influence on respiratory disease occurrence in heifers from feedlot A.

Table 5.36 The effect of breed x gender interaction on respiratory disease occurrence in heifers from Feedlot A when comparing Drakensbergers with other breeds

Heifers					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	100	22.8^a	338	77.2^a	438
Other	1209	17.2^b	5804	82.8^b	7013

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
n – Number of animals

5.2.1.7 The association between breed type and metabolic disease status within genders

Results from the analysis on the occurrence of metabolic disease within bulls are presented in Table 5.37. A mere 0.5 % of Drakensberger cattle (5 out of the total of 935) had metabolic diseases, while the incidence rate in cattle from other breed types was 0.9 % (135 out of the total of 15 158). From our results it is obvious that disease occurrence did not differ ($P > 0.01$) between breed types. Breed type had no effect on metabolic disease occurrence within bulls from feedlot A.

Table 5.37 The effect of breed x gender interaction on metabolic disease occurrence in bulls from Feedlot A when comparing Drakensbergers with other breeds

Bulls					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	5	0.5	930	99.5	935
Other	135	0.9	15023	99.1	15158

n – Number of animals

The number of cattle accompanied by the calculated proportions of heifers that had metabolic diseases are summarised in Table 5.38. The interaction between breed type and gender was analysed and revealed that the incidence rate of Drakensberger cattle was 0.5 %, while 0.8 % of cattle from other breed types had metabolic diseases. The analysis on metabolic disease occurrence in heifers from feedlot A revealed that no difference (P > 0.01) occurred between breed types. Since some values are less than 5 per category (Diseased Drakensbergers = 2), the reliability of the Chi-square test may be reduced.

Table 5.38 The effect of breed x gender interaction on metabolic disease occurrence in heifers from Feedlot A when comparing Drakensbergers with other breeds

Heifers					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	2	0.5	436	99.5	438
Other	55	0.8	6958	99.2	7013

n – Number of animals

5.2.1.8 The association between breed type and other disease status within genders

The effect of breed type on various other diseases in bulls was analysed, with the results presented in Table 5.39 as numbers and proportions of cattle. The analysis included 935 Drakensberger cattle and 15 158 cattle from other breed types. A total of 1.8 % of Drakensbergers (n = 17) had various other diseases, while an incidence rate of 1.5 % was noted in cattle from other breed types (n = 230). Disease occurrence did not differ (P > 0.01) between breeds. Therefore, breed type had no effect on the incidence rate of other diseases in feedlot A within bulls.

Table 5.39 The effect of breed x gender interaction on other disease occurrence in bulls from Feedlot A when comparing Drakensbergers with other breeds

Bulls					
Other diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	17	1.8	918	98.2	935
Other	230	1.5	14928	98.5	15158

n – Number of animals

The analysis on the incidence rate of other diseases in heifers of feedlot A included 7451 head of cattle. Results from the analysis are displayed in Table 5.40 as numbers and proportions of cattle per breed and disease category. A disease incidence rate of 1.8 % was noted in Drakensberger cattle, while 1.1 % of cattle from other breeds were regarded as diseased. However, no difference (P > 0.01) was observed between breed types. Therefore, breed type had no effect on other disease status considering heifers in feedlot A.

Table 5.40 The effect of breed x gender interaction on other disease occurrence in heifers from Feedlot A when comparing Drakensbergers with other breeds

Heifers					
Other diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	8	1.8	430	98.2	438
Other	76	1.1	6937	98.9	7013

n – Number of animals

5.2.2 Feedlot G

5.2.2.1 The association between breed type and total disease status within genders

With reference to the available data from Feedlot G, statistics from 1265 head of cattle complied with the criteria and were regarded as fit for inclusion into the analysis. The analysis investigated the effects of breed type, gender and disease category. The available data was only representative of one season (autumn), which included only bulls and steers.

In Table 5.41 is shown the results from the analysis between breed type and total disease status in bulls. The analysis involved 19 Drakensberger cattle and 193 head of cattle from other breeds. A total of 15.8 % of Drakensberger cattle were regarded as diseased, while an incidence rate of 39.4 % was found in other cattle breeds. Although the proportion of other cattle breed types was more than double the rate of Drakensbergers, the analysis revealed no difference (P > 0.01) in proportions of diseased cattle between breeds. Therefore, breed type had no influence in total disease occurrence in bulls from feedlot G. Since some values are less than 5 per category (Diseased Drakensbergers = 3), the reliability of the Chi-square test may be reduced.

Table 5.41 The effect of breed x gender interaction on total disease occurrence in bulls from Feedlot G when comparing Drakensbergers with other breeds

Bulls					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	3	15.8	16	84.2	19
Other	76	39.4	117	60.6	193

n – Number of animals

Results from the analysis on total disease status in steers are summarised in Table 5.42 as numbers and proportions of cattle. Drakensberger cattle (n = 57) had an incidence rate of 26.3 %, while 23.2 % of cattle from other breed types (n = 996) were regarded as diseased. The results revealed a similar disease incidence between breeds ($P > 0.01$), indicating that breed type did not influence the total disease occurrence in steers from feedlot G.

Table 5.42 The effect of breed x gender interaction on total disease occurrence in steers from Feedlot G when comparing Drakensbergers with other breeds

Steers					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	15	26.3	42	73.7	57
Other	231	23.2	765	76.8	996

n – Number of animals

In Table 5.43 is shown the results from the analysis on total disease status, combining both gender groups from feedlot G. From the total of 1265 head of cattle, 76 were Drakensbergers. A proportion of 23.7 % of Drakensberger cattle were regarded as diseased, while an incidence rate of 25.8 % occurred in other cattle breed types. From the analysis, no difference (P > 0.01) was observed in the incidence rate between cattle breeds. Therefore, it is evident that breed type had no influence on total disease occurrence in cattle from feedlot G.

Table 5.43 The effect of cattle breed on total disease occurrence in all animals from Feedlot G when comparing Drakensbergers with other breeds

All animals					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	18	23.7	58	76.3	76
Other	307	25.8	882	74.2	1189

n – Number of animals

5.2.2.2 The association between breed type and respiratory disease status within genders

The numbers of cattle, together with the proportions that represent the respiratory disease incidence of bulls in feedlot G, are presented in Table 5.44. Although only 2 Drakensbergers (10.5 %) had respiratory related diseases, compared to the 28 head of cattle from other breeds (14.5 %), the analysis showed no difference (P > 0.01) regarding respiratory disease status in bulls. The interaction between breeds and genders was therefore negligible. Since some values are less than 5 per category (Diseased Drakensbergers = 2), the reliability of the Chi-square test may be reduced.

Table 5.44 The effect of breed x gender interaction on respiratory disease occurrence in bulls from Feedlot G when comparing Drakensbergers with other breeds

Bulls					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	2	10.5	17	89.5	19
Other	28	14.5	165	85.5	193

n – Number of animals

Results from the analysis on the interaction between breed and gender are displayed in Table 5.45 as numbers and proportions of cattle. From the total of 57 Drakensbergers, 14.0 % had respiratory related diseases, while an incidence rate of 13.5 % occurred in the 996 head of cattle from other breeds. The results show that respiratory disease status of steers from feedlot G did not differ (P > 0.01). Therefore, the interacting effects had no influence on disease occurrence.

Table 5.45 The effect of breed x gender interaction on respiratory disease occurrence in steers from Feedlot G when comparing Drakensbergers with other breeds

Steers					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	8	14.0	49	86.0	57
Other	134	13.5	862	86.5	996

n – Number of animals

Table 5.46 shows the results from the analysis over both gender categories regarding respiratory disease occurrence in feedlot G. The respiratory disease incidence rate in Drakensbergers (n = 76) and other cattle (n = 1189) reached 13.2 % and 13.6 % respectively. It is evident from the table that no difference (P > 0.01) in disease status occurred between breeds, indicating that the effect of breed was negligible regarding respiratory disease occurrence in feedlot G.

Table 5.46 The effect of cattle breed on respiratory disease occurrence in all animals from Feedlot G when comparing Drakensbergers with other breeds

All animals					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	10	13.2	66	86.8	76
Other	162	13.6	1027	86.4	1189

n – Number of animals

5.2.2.3 The association between breed type and metabolic disease status within genders

The results in Table 5.47 show the comparison between Drakensbergers and other cattle breeds, concerning the incidence of metabolic disease in bulls from feedlot G. A total of 5.3 % of Drakensbergers, and 20.7 % of cattle from other breeds had suffered metabolic diseases. Although the proportion of diseased cattle from other breeds was more than 3 times that of Drakensbergers, the results prove that incidence rate did not differ ($P > 0.01$) between breeds. The interaction between breed and gender had no influence on metabolic disease occurrence. Since some values are less than 5 per category (Diseased Drakensbergers = 1), the reliability of the Chi-square test may be reduced.

Table 5.47 The effect of breed x gender interaction on metabolic disease occurrence in bulls from Feedlot G when comparing Drakensbergers with other breeds

Bulls					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	1	5.3	18	94.7	19
Other	40	20.7	153	79.3	193

n – Number of animals

The outcome from the investigation on the interaction between breed and gender regarding steers in feedlot G, are displayed in Table 5.48 as numbers and proportions of cattle per category. Only 6 of the 57 Drakensberger cattle (10.5 %) suffered from metabolic diseases, while 85 of the 996 head of cattle from other breeds (8.5 %) were regarded as diseased. The analysis showed a similar rate in disease occurrence between breeds ($P > 0.01$), indicating that the particular interaction had no influence on the metabolic disease status of steers in feedlot G.

Table 5.48 The effect of breed x gender interaction on metabolic disease occurrence in steers from Feedlot G when comparing Drakensbergers with other breeds

Steers					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	6	10.5	51	89.5	57
Other	85	8.5	911	91.5	996

n – Number of animals

Results from the analysis that combined both gender categories from feedlot G are presented in Table 5.49. Overall, 9.2 % of Drakensberger cattle (n = 76) were regarded as diseased, while an incidence rate of 10.5 % occurred in cattle from other breeds (n = 1189). Still, no difference (P > 0.01) in metabolic disease status was noted between breeds. Therefore, the effect of breed was negligible on the disease incidence rate in cattle from feedlot G.

Table 5.49 The effect of cattle breed on metabolic disease occurrence in all animals from Feedlot G when comparing Drakensbergers with other breeds

All animals					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	7	9.2	69	90.8	76
Other	125	10.5	1064	89.5	1189

n – Number of animals

5.2.3 Bottom line

Morbidity figures regarding total diseases over all seasons in feedlot A and G, for both breed groups (Tables 5.23 and 5.43), were only slightly higher than the morbidity rate of 19.23 %, which was shown in a feedlot study by Busby *et al*. (2006). Compared to other breeds, higher morbidity rates occurred in Drakensberger cattle, regarding total diseases and respiratory diseases in feedlot A during winter (Tables 5.22 and 5.25). In addition, it is evident that respiratory-related diseases were accountable for the majority of the diseases in both feedlots. A trend was observed in feedlot G, since a higher morbidity rate occurred in steers than in bulls. Although increased morbidity rates are undesirable, the reality thereof is confirmed in a study by Pinchak *et al*. (2004), where rates of 26 – 54 % were present in cattle from several American states.

CHAPTER 6

Centralised Growth Test centres

Results and Discussion

Analyses were performed over 3 ARC test centres and the privately owned Sernick test centre. Data from these 4 centres complied with the criteria and was suitable to be included in the analyses. All 4 seasons were not representative of Drakensberger cattle, which made it impossible to test the effect of that particular season. Therefore, the analyses distinguished between 2 season categories (winter = February – July; spring = August - January), with the aim of ensuring that results from the analyses are reliable. Results from these performance test centres only included data from bulls, therefore the effect of gender could not be analysed. Differences were tested at a 1% level.

6.1 Growth data

6.1.1 Glen

6.1.1.1 The effects of breed and season on mean ADG and FCR of cattle

In Table 6.1 is shown the results from the analysis on the effect of breed type on growth performance values. Data from a total of 1206 head of cattle were regarded as fit for inclusion into the analysis. Data were collected from the years 1999 – 2009 and included 93 Drakensbergers, together with 1113 head of cattle from other breeds.

Cattle from other breeds had a higher ($P < 0.01$) mean ADG than Drakensbergers (1.708 kg vs. 1.580 kg). Conversely, no difference ($P > 0.01$) between Drakensbergers and other breed types was observed regarding mean FCR (5.830 vs. 5.821). Therefore, all cattle breeds were equally efficient in the conversion of feed in order to gain weight.

Table 6.1 The effect of cattle breed on ADG (kg/day) and FCR within the Glen centre when comparing Drakensbergers with other breeds

Breed	**n**	**ADG (kg)**		**FCR**	
		Mean	**SEM**	**Mean**	**SEM**
Drakensberger	93	1.580^{a}	0.03392	5.830	0.09593
Other	1113	1.708^{b}		5.821	

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

Table 6.2 summarises mean ADG and FCR for the 2 respective seasons. When the mean ADG for the 41 Drakensbergers, which are present in the winter, are compared to the values of the 52 Drakensbergers in spring, it is evident from the analysis that no difference ($P > 0.01$) occurred (1.516 kg vs. 1.644 kg). Likewise, mean ADG did not differ ($P > 0.01$) within the other cattle breed types among the 2 seasons (1.728 kg vs. 1.689 kg). Within the winter season, the 248 head of cattle from other breeds had a higher ($P < 0.01$) mean ADG than Drakensbergers (1.516 kg vs. 1.728 kg). Conversely, no difference ($P > 0.01$) in mean ADG occurred between breeds during spring (1.644 kg vs. 1.689 kg). Therefore, a breed by season interaction existed at the Glen test centre regarding ADG.

The FCR within the winter season did not differ ($P > 0.01$) between breeds (5.985 vs. 5.900). Likewise, the results showed no difference ($P > 0.01$) within spring (5.675 vs. 5.742). FCR did not differ ($P > 0.01$) between the 2 seasons within Drakensberger cattle (5.985 vs. 5.675). On the contrary, a more efficient ($P < 0.01$) FCR was noted in spring, within other cattle breeds (5.900 vs. 5.742). Although the numerical difference in FCR within Drakensbergers are greater than in other cattle breeds, the analysis merely shows a difference within other breeds due to the larger amount of cattle present in the analysis.

Table 6.2 The effect of breed x season interaction on ADG (kg/day) and FCR within the Glen centre when comparing Drakensbergers with other breeds

Variable	Breed	Winter		Spring		SEM
		n	Mean	n	Mean	
ADG						
	Drakensberger	41	1.516^a	52	1.644	0.05002
	Other	248	1.728^b	865	1.689	
FCR						
	Drakensberger	41	5.985	52	5.675	0.1357
	Other	248	5.900_1	865	5.742_2	

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1, 2}$ – Row means with different subscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

6.1.2 Sernick

6.1.2.1 The effects of breed and season on mean ADG and FCR of cattle

The privately owned Sernick test centre had data available from the years 1999 – 2010, which represented 2591 head of cattle. Data from 246 Drakensbergers and 2345 head of cattle from other breed types complied with the criteria for inclusion into the analysis. Results from the analysis, which compared the mean ADG and FCR between Drakensbergers and other cattle breeds, are summarised in Table 6.3.

Other cattle breeds had a higher ($P < 0.01$) mean ADG than Drakensbergers (1.625 kg vs. 1.677 kg). The difference was a mere 52 grams per day and was most likely due to the large number of cattle in the analysis making it much more sensitive.

No difference ($P > 0.01$) in mean FCR was observed between cattle breed types (5.863 vs. 5.829). Therefore, the effect of cattle breed had no influence on the efficiency of feed conversion.

Table 6.3 The effect of cattle breed on ADG (kg/day) and FCR within the Sernick centre when comparing Drakensbergers with other breeds

Breed	n	ADG (kg)		FCR	
		Mean	SEM	Mean	SEM
Drakensberger	246	1.625^{a}	0.02807	5.863	0.07082
Other	2345	1.677^{b}		5.829	

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

Results from the analysis on the interaction between breed and season regarding cattle from the Sernick centre are presented in Table 6.4. From the analysis it was evident that within both Drakensbergers (1.621 kg vs. 1.629 kg) and other breeds (1.661 kg vs. 1.693 kg), mean ADG did not differ ($P > 0.01$) between the 2 seasons. Likewise, no difference ($P > 0.01$) was noted between the mean ADG of the 46 Drakensberger cattle (1.621 kg) and the 442 head of cattle from other breeds (1.661 kg), within the winter season. On the contrary, other cattle breeds had a higher ($P < 0.01$) mean ADG than Drakensbergers within the spring (1.629 kg vs. 1.693 kg). Although the difference was statistically significant, it was a mere 64 grams per day between breeds.

The analysis on mean FCR revealed that no difference ($P > 0.01$) occurred between Drakensbergers and other breeds, neither in winter (5.899 vs. 5.900), nor during the spring (5.828 vs. 5.759). The only difference ($P < 0.01$) from the analysis on FCR was observed within other cattle breed types, since they were more efficient in the conversion of feed during the spring (5.900 vs. 5.759). The effect of season on mean FCR was negligible within Drakensbergers.

Table 6.4 The effect of breed x season interaction on ADG (kg/day) and FCR within the Sernick centre when comparing Drakensbergers with other breeds

Variable	Breed	Winter		Spring		SEM
		n	Mean	n	Mean	
ADG						
	Drakensberger	46	1.621	200	1.629^{a}	0.04248
	Other	442	1.661	1903	1.693^{b}	
FCR						
	Drakensberger	46	5.899	200	5.828	0.1120
	Other	442	5.900_{1}	1903	5.759_{2}	

$^{a,\,b}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1,\,2}$ – Row means with different subscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

6.1.3 Vryburg

6.1.3.1 The effects of breed and season on mean ADG and FCR of cattle

The obtainable data from the ARC centre in Vryburg ranged from the years 1999 – 2010 and included a total of 1625 head of cattle. As observed from Table 6.5, only 30 Drakensbergers were present at this centre over the years, while data from 1595 head of cattle from other breed types were available. Due to this considerable difference in number of cattle between the 2 breed categories, the analysis showed a difference ($P < 0.01$) in mean ADG between Drakensbergers and other cattle breeds (1.595 kg vs. 1.769 kg). Likewise, other cattle breed types (6.175) had a more efficient ($P < 0.01$) mean FCR than Drakensbergers (6.667).

Table 6.5 The effect of cattle breed on ADG (kg/day) and FCR within the Vryburg centre when comparing Drakensbergers with other breeds

Breed	n	ADG (kg)		FCR	
		Mean	SEM	Mean	SEM
Drakensberger	30	1.595^{a}	0.05796	6.667^{a}	0.1565
Other	1595	1.769^{b}		6.175^{b}	

$^{a,\,b}$ – Column means with different superscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

The effect of the interaction between breed and season on mean ADG and FCR among cattle from the Vryburg centre was investigated, with the results displayed in Table 6.6. A similar mean ADG ($P > 0.01$) was observed between the 2 breed categories ($n = 420$) during winter (1.592 kg vs. 1.747 kg). Conversely, due to the large number of cattle present in spring ($n = 1205$), other cattle breeds had a higher ($P < 0.01$) mean ADG than Drakensbergers (1.598 kg vs. 1.791 kg). Within Drakensberger cattle, no difference ($P > 0.01$) in mean ADG was noted between the 2 seasons (1.592 kg vs. 1.598 kg). Conversely, other cattle breed types had a higher ($P < 0.01$) mean ADG during spring (1.747 kg vs. 1.791 kg).

Again, due to the large number of cattle present in spring ($n = 1205$), the analysis revealed that other breeds had a more efficient ($P < 0.01$) mean FCR than Drakensberger cattle (6.645 vs. 6.049). No difference ($P > 0.01$) was noted between breeds within the winter (6.690 vs. 6.302). Other cattle breeds had a more efficient ($P < 0.01$) FCR during spring (6.302 vs. 6.049). In contrast, Drakensbergers performed equally well in both seasons regarding mean FCR (6.690 vs. 6.645). Therefore, a breed by season interaction was evident in the spring.

Table 6.6 The effect of breed x season interaction on ADG (kg/day) and FCR within the Vryburg centre when comparing Drakensbergers with other breeds

Variable	**Breed**	**Winter**		**Spring**		**SEM**
		n	**Mean**	**n**	**Mean**	
ADG						
	Drakensberger	9	1.592	21	1.598^{a}	0.09024
	Other	411	1.747_{1}	1184	1.791^{b}_{2}	
FCR						
	Drakensberger	9	6.690	21	6.645^{a}	0.2417
	Other	411	6.302_{1}	1184	6.049^{b}_{2}	

$^{a,\,b}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1,\,2}$ – Row means with different subscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

6.1.4 Irene

6.1.4.1 The effects of breed and season on mean ADG and FCR of cattle

Data from the 717 head of cattle from the centre in Irene, present from 1999 – 2010, is shown in Table 6.7. Actual ADG and FCR values, accompanied by the maximum standard errors are displayed. Mean ADG did not differ (P > 0.01) between the 52 Drakensbergers and the 665 head of cattle from other breeds (1.663 kg vs. 1.787 kg). Likewise, the analysis showed no difference (P > 0.01) in mean FCR between breeds (6.156 vs. 5.832). Therefore, breed type had no influence on the growth performance in cattle from the ARC centre in Irene.

Table 6.7 The effect of cattle breed on ADG (kg/day) and FCR within the Irene centre when comparing Drakensbergers with other breeds

Breed	n	ADG (kg)		FCR	
		Mean	SEM	Mean	SEM
Drakensberger	52	1.663	0.06367	6.156	0.1541
Other	665	1.787		5.832	

SEM – Standard error of the mean
n – Number of animals

From Table 6.8 it is evident that mean ADG did not differ (P > 0.01) between the 9 Drakensbergers (1.586 kg) and 244 head of cattle from other breeds (1.836 kg) during winter. Likewise, no difference (P > 0.01) was observed between breeds within spring (1.739 kg vs. 1.738 kg). The breed by season interaction merely affected the mean ADG within other cattle breeds, since a higher (P < 0.01) value was noted during winter than in spring (1.836 kg vs. 1.738 kg).

The effect of the interaction between breed and season on mean FCR was negligible. No difference (P > 0.01) in mean FCR between the 2 seasons was observed within Drakensbergers (6.346 vs. 5.965) and other breed types (5.865 vs. 5.800). Breeds performed equally well within winter (6.346 vs. 5.865) and spring (5.965 vs. 5.800).

Table 6.8 The effect of breed x season interaction on ADG (kg/day) and FCR within the Irene centre when comparing Drakensbergers with other breeds

Variable	**Breed**	**Winter**		**Spring**		**SEM**
		n	**Mean**	**n**	**Mean**	
ADG						
	Drakensberger	9	1.586	43	1.739	0.1038
	Other	244	1.836_1	421	1.738_2	
FCR						
	Drakensberger	9	6.346	43	5.965	0.2485
	Other	244	5.865	421	5.800	

$_{1,\,2}$ – Row means with different subscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

6.1.5 Meta-analysis

The final meta-analysis combined the data from the 4 ARC test centres, which represented data from 6139 head of cattle. These cattle were present in the respective centres during 1999 – 2010 and included 421 Drakensbergers, along with 5718 head of cattle from other breeds.

6.1.5.1 The effects of breed, centre and season on mean ADG and FCR of cattle

In Table 6.9 is shown the results from the analysis on cattle breed type, regarding mean ADG and FCR. A difference ($P < 0.01$) in mean ADG between breeds occurred, with other breeds having a higher value than Drakensbergers (1.613 kg vs. 1.737 kg). The difference was a mere 124 grams per day, but was considered as significant due to the large number of cattle, making the sensitivity of the analysis much stronger.

Mean FCR did not differ ($P > 0.01$) between Drakensbergers and other breed types (6.137 vs. 5.913). Therefore, the effect of cattle breed type on the FCR of cattle from the ARC centres was negligible.

Table 6.9 The effect of cattle breed on ADG (kg/day) and FCR over all ARC centres when comparing Drakensbergers with other breeds

Variable	Breed	n	Mean	SEM	P-value
ADG					
	Drakensberger	421	1.613^{a}	0.02503	< 0.01
	Other	5718	1.737^{b}		
FCR					
	Drakensberger	421	6.137	0.06710	0.726
	Other	5718	5.913		

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

The resulting mean ADG from the investigation on the interaction between breeds and centres are presented in Table 6.10. Although the differences in values between breed types appear small within particular centres (eg. Sernick: 70 grams), the analysis revealed differences ($P < 0.01$) between breed categories within each centre. According to the meta-analysis over all the test centres, the effect of cattle breed influenced the growth performance. Differences can probably be ascribed to the large number of animals included in the analysis.

Within the Drakensberger cattle breed, ADG did not differ ($P > 0.01$) between the 4 centres. Therefore, the centre effect was negligible for Drakensbergers. With regards to cattle from other breed types, growth performance values from the Glen and Sernick centres (1.715 kg & 1.687 kg) differed ($P < 0.01$) from those of the centres in Vryburg and Irene (1.765 kg & 1.782 kg). Therefore, the test centre had an influence on mean ADG within other breeds.

Differences in performance between centres are probably due to genetics, since the distinct genotypes of cattle from a specific region may play a role in their performance. Since the breeds represented at each centre differ substantially, differences in mean values between centres are expected. In addition, environmental factors like temperature and rainfall may influence animal performance. Although the bulls are subjected to a 4 week adaptation period prior to the growth tests, centres may obtain cattle from areas with different climatic conditions, which results in cattle that require more time to adapt before reaching their optimum growth potential.

Table 6.10 The effect of breed x centre interaction on ADG (kg/day) over all ARC centres when comparing Drakensbergers with other breeds

		ADG (kg)			
Breed	**Drakensberger**		**Other**		**SEM**
Centre	**n**	**Mean**	**n**	**Mean**	
Glen	93	1.578_1	1113	1.715^{a}_{2}	0.06730
Sernick	246	1.617_1	2345	1.687^{a}_{2}	
Vryburg	30	1.597_1	1595	1.765^{b}_{2}	
Irene	52	1.660_1	665	1.782^{b}_{2}	

$^{a,\,b}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1,\,2}$ – Row means with different subscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

The mean FCR between the 2 breed categories are summarised in Table 6.11 for each of the 4 ARC centres. No differences ($P > 0.01$) between breeds were found within the centres, except within the Vryburg centre. Other cattle breeds had a more efficient ($P < 0.01$) FCR than Drakensbergers (6.163 vs. 6.578). Generally, both breed types performed equally well within the respective centres.

Differences ($P < 0.01$) were indeed observed between centres, within both breed types. The most efficient mean FCR within Drakensbergers occurred in the Glen centre (5.866), with 93 Drakensberger cattle. The least efficient FCR was found in the 30 head of cattle from the Vryburg centre (6.578). The FCR of cattle from the Glen (5.866) and Sernick (5.884) centres differed ($P < 0.01$) from those of the Vryburg (6.578) centre.

The most efficient mean FCR within other cattle breeds occurred in the 665 head of cattle from the Irene centre (5.805). The least efficient FCR occurred in the 1595 head of cattle from the Vryburg centre (6.163). The centres from Glen (5.840), Sernick (5.842) and Irene (5.805) differed ($P < 0.01$) from the Vryburg centre (6.163). The high FCR obtained in the Vryburg centre is still more efficient than the average value (6.25) for beef cattle in South Africa, according to growth results from Phase C performance tests (The SA Stud Book Annual Logix Beef Report, 2012). As discussed earlier, distinct genotypes and environmental factors may contribute to these differences.

Table 6.11 The effect of breed x centre interaction on FCR over all ARC centres when comparing Drakensbergers with other breeds

FCR					
Breed	**Drakensberger**		**Other**		**SEM**
Centre	**n**	**Mean**	**n**	**Mean**	
Glen	93	5.866^{a}	1113	5.840^{a}	0.1634
Sernick	246	5.884^{a}	2345	5.842^{a}	
Vryburg	30	6.578^{b}_{1}	1595	6.163^{b}_{2}	
Irene	52	6.219^{ab}	665	5.805^{a}	

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1, 2}$ – Row means with different subscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

Table 6.12 displays results regarding ADG and FCR from the interaction between the relevant breed categories and the 2 particular seasons. During the spring season, 316 Drakensbergers and 4373 head of cattle from other breed types were present in the centres, with 105 Drakensbergers and 1345 head of cattle from other breeds being present during winter.

Differences ($P > 0.01$) in mean ADG between seasons were neither observed within Drakensbergers (1.572 kg vs. 1.654 kg), nor within cattle from other breeds (1.747 kg vs. 1.728 kg). Therefore, the performance of the cattle remained stable, regardless of the season. Conversely, differences ($P < 0.01$) between Drakensbergers and other breeds occurred within winter (1.572 kg vs. 1.747 kg) and spring (1.654 kg vs. 1.728 kg), with other breed types reaching a higher mean ADG than Drakensberger cattle. The main effect of breed influenced the growth performance, probably due to the large number of cattle present in the study that consequently increased the sensitivity of the test.

An interaction between breed and season occurred concerning mean FCR, except within Drakensberger cattle, since FCR did not differ ($P > 0.01$) between winter and spring (6.248 vs. 6.026). Conversely, other cattle breeds showed a more efficient ($P < 0.01$) mean FCR during spring (5.992 vs. 5.833). Differences ($P < 0.01$) between Drakensbergers and cattle from other breed types occurred within winter (6.248 vs. 5.992) and spring (6.026 vs. 5.833), with other breeds achieving a more efficient mean FCR than Drakensberger cattle.

Table 6.12 The effect of breed x season interaction on ADG (kg/day) and FCR over all ARC centres when comparing Drakensbergers with other breeds

Variable	Breed	Winter		Spring		SEM
		n	Mean	n	Mean	
ADG						
	Drakensberger	105	1.572^{a}	316	1.654^{a}	0.04072
	Other	1345	1.747^{b}	4373	1.728^{b}	
FCR						
	Drakensberger	105	6.248^{a}	316	6.026^{a}	0.1011
	Other	1345	5.992^{b}_{1}	4373	5.833^{b}_{2}	

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
$_{1, 2}$ – Row means with different subscripts differ ($P < 0.01$)
SEM – Standard error of the mean
n – Number of animals

According to standardised growth test data for bulls (Phase C), the average ADG for 1999 – 2008 was 1.739 kg (Bergh *et al.*, 2010). Although the mean ADG of Drakensbergers is slightly lower, the results from the meta-analysis regarding ADG of both breed groups are comparable to the Phase C data. Furthermore, the mean FCR of Drakensbergers, similar to that of other breeds, is consistent with the Phase C average FCR of 5.99. Drakensbergers and other cattle breeds have a numerically more efficient FCR during spring, which is in agreement with the findings of Maree & Casey (1993).

6.2 Health data

Health data from the Glen and Irene test centres complied with the criteria to be included in the analysis. Within both centres, the effect of breed type on the respective disease categories was investigated. Since numbers of cattle per season category were too few concerning certain seasons, the analyses did not distinguish between seasons. Consequently, the analyses were performed over all seasons.

6.2.1 Glen

6.2.1.1 The association between breed type and total disease status over all seasons

In Table 6.13 is summarised the number of animals, accompanied by the calculated proportions, which were categorised as diseased or not. A total of 8 Drakensbergers and 57 head of cattle from other breeds were regarded to have a certain disease during their feedlot period. The analysis on the proportions of cattle in the Glen centre revealed no difference (P > 0.01) in disease occurrence between breeds (61.5 % vs. 31.7 %). Therefore, the effect of cattle breed type was negligible.

Table 6.13 The effect of cattle breed on total disease occurrence over all seasons within the Glen centre when comparing Drakensbergers with other breeds

All seasons					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	8	61.5	5	38.5	13
Other	57	31.7	123	68.3	180

n – Number of animals

6.2.1.2 The association between breed type and respiratory disease status over all seasons

Table 6.14 presents the results from the analysis on respiratory diseases in the Glen centre. A proportion of 46.2 % of Drakensberger cattle were found to have had respiratory-related diseases, while the disease incidence in other cattle breeds was 23.3 %. Although Drakensbergers had a higher incidence of respiratory diseases, our results showed no difference (P > 0.01) between breeds. Therefore, the effect of cattle breed type on disease occurrence was negligible.

Table 6.14 The effect of cattle breed on respiratory disease occurrence over all seasons within the Glen centre when comparing Drakensbergers with other breeds

All seasons					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	6	46.2	7	53.8	13
Other	42	23.3	138	76.7	180

n – Number of animals

6.2.1.3 The association between breed type and metabolic disease status over all seasons

The occurrence of metabolic diseases in the Glen centre was investigated, with the results displayed as numbers of animals and proportions in Table 6.15. A proportion of 15.4 % of the 13 Drakensbergers from the Glen centre were regarded as diseased, while the metabolic disease incidence of the 180 other head of cattle reached a total of 5.0 %. The results showed that the incidence of metabolic disease between breeds did not differ ($P > 0.01$). Therefore, breed type had no influence on disease occurrence. Since some values are less than 5 per category (Diseased Drakensbergers = 2), the reliability of the Chi-square test may be reduced.

Table 6.15 The effect of cattle breed on metabolic disease occurrence over all seasons within the Glen centre when comparing Drakensbergers with other breeds

All seasons					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	2	15.4	11	84.6	13
Other	9	5.0	171	95.0	180

n – Number of animals

6.2.2 Irene

6.2.2.1 The association between breed type and total disease status over all seasons

Figures from the analysis on the health data from the Irene centre's 57 Drakensberger cattle and 1496 head of cattle from other breeds are shown in Table 6.16. Numbers of cattle, accompanied by the proportions, which were regarded to have had a particular disease, are presented in the table. A total of 47.4 % Drakensberger cattle showed signs of disease, while the disease incidence in other cattle breeds reached 47.3 %. Over all seasons, it seemed evident that a similar total disease status between breeds occurred (P > 0.01). Therefore, breed of cattle had no influence on the disease incidence of the centre in Irene.

Table 6.16 The effect of cattle breed on total disease occurrence over all seasons within the Irene centre when comparing Drakensbergers with other breeds

All seasons					
Total diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	27	47.4	30	52.6	57
Other	708	47.3	788	52.7	1496

n – Number of animals

6.2.2.2 The association between breed type and respiratory disease status over all seasons

Numbers and proportions of cattle from the centre in Irene, which showed signs of respiratory diseases, are summarised in Table 6.17. From the 57 Drakensberger cattle, 29.8 % were regarded as diseased, while a disease incidence of 15.5 % existed in the 1496 head of cattle from other breeds. Although the proportions of diseased cattle were acceptable, the analysis showed a difference (P < 0.01) in disease occurrence between breeds. The incidence of respiratory diseases in cattle from other breeds was lower than that of Drakensbergers.

Table 6.17 The effect of cattle breed on respiratory disease occurrence over all seasons within the Irene centre when comparing Drakensbergers with other breeds

All seasons					
Respiratory diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	17	29.8^{a}	40	70.2^{a}	57
Other	232	15.5^{b}	1264	84.5^{b}	1496

$^{a, b}$ – Column means with different superscripts differ ($P < 0.01$)
n – Number of animals

6.2.2.3 The association between breed type and metabolic disease status over all seasons

Results from the analysis on the incidence rate of metabolic diseases between breeds in the Irene centre are displayed in Table 6.18. The metabolic disease occurrence in Drakensbergers attained a total of 10.5 %, while the incidence rate in cattle from other breeds reached 14.7 %. Although the proportion of diseased cattle from other breeds was numerically higher than that of Drakensbergers, the analysis showed no difference ($P > 0.01$) in disease occurrence between breeds. Therefore, the effect of breed on metabolic disease status was negligible at the Irene centre.

Table 6.18 The effect of cattle breed on metabolic disease occurrence over all seasons within the Irene centre when comparing Drakensbergers with other breeds

All seasons					
Metabolic diseases	**Diseased**		**Not diseased**		**Total**
Breed	**n**	**Proportion (%)**	**n**	**Proportion (%)**	**n**
Drakensberger	6	10.5	51	89.5	57
Other	220	14.7	1276	85.3	1496

n – Number of animals

5.2.3 Bottom line

Although the proportion of total diseases at the Glen centre was higher than that of Irene, the reliability of the results (Glen) may be questioned, since the analysis included only 13 Drakenbergers. It can be concluded that respiratory-related diseases were accountable for the majority if the diseases at both centres. Morbidity rates (Glen and Irene) are comparable to the findings of an American study, investigating the effects of morbidity on cattle, where a rate of between 26 – 54 % existed (Pinchak *et al*., 2004).

CHAPTER 7

Conclusion

7.1 Feedlots

On various occasions in this study, relatively small numerical differences turned out to be statistically different, due to the large numbers of animals which increased the sensitivity of the test tremendously. For example, the meta-analysis on the growth performance of feedlot cattle reveals a mere 20 gram difference in ADG between the 48 600 Drakensbergers and 449 198 head of cattle from other breed types. Although statistically significant differences in growth performance between Drakensbergers and other cattle breeds were observed, these differences are most likely not economically or biologically significant. More intense studies may be required to investigate the correlation between the ADG and FCR. When comparing the growth performance of cattle, the economical advantage of cattle with lower ADG values but more efficient FCR may be similar to cattle with higher ADG values. Therefore, any potential conclusions based merely on ADG are likely to be inaccurate and biased.

It should be kept in mind that variation between studies is subject to the different management and record keeping systems of each feedlot. Since various feedlots process thousands of cattle daily, the reliability regarding the process of classifying cattle according to breed type may be queried in cases where the source of cattle is unknown.

Another factor that probably increases variation is the geographical location of the individual feedlots, together with different climatic conditions. Therefore, the performance of a certain animal can be expected to depend on environmental conditions. It is indefinite to state that the feedlots, included in this study, were entirely representative of the actual feedlot industry in South Africa.

Although analyses showed that respiratory disease incidence was higher in Drakensberger heifers of feedlot A, as well as during the winter season, the results of feedlot G showed no differences in respiratory disease occurrence between breeds. Since the majority of the contributing feedlots stated that their record keeping systems do not include complete health data, it remained a challenging task to gather figures concerning diseases in feedlot cattle. For the above mentioned reason, it can be assumed that results from the analyses on health data are not representative of the actual health status of cattle in the feedlot industry, as measures of comparison are lacking.

Considering the quality of the available health data from feedlots, it is recommended that comprehensive investigations should be performed within individual feedlots in order to monitor the health status, disease occurrence, pull rates and treatment of cattle.

The outcome revealed no obvious confirmation with regards to the growth performance and health of Drakensberger cattle compared to the average performance of other cattle breeds. Therefore, no reason exists to discriminate against Drakensberger cattle in the feedlot. Further studies within individual feedlots may yield more definite conclusions, by investigating the economical comparisons with regards to the performance of different cattle breeds.

7.2 Test Centres

A trend in results from the meta-analysis regarding the growth performance in cattle from test centres was observed, with cattle from other breeds having higher ADG values than Drakensbergers. The FCR of Drakensbergers was equal to those of cattle from other breeds. As stated in the above mentioned paragraphs with regards to feedlots, these differences may possibly not be economically or even biologically significant.

Since the numbers of cattle in the chi-square analysis on the health data of the Glen test centre are very low, the reliability of the results is questioned. However, results from the centre in Irene reveal that Drakensbergers are more prone to respiratory related diseases than cattle from other breed types. Again, results from the analyses on only 1 of the centre’s health data are not representative of the actual health status of cattle in these performance test centres.

The same sources of variation that occurred within the feedlot studies can be expected to be present within the studies on the test centres. Different management strategies and geographical locations influence the overall performance regarding growth potential and health status of cattle.

More comprehensive and complete data from all the participating test centres are required in order to formulate valid conclusions from the available data.

7.3 Bottom line

Based on the results from feedlot growth data of 497 798 cattle, there is no justification to discriminate against Drakensberger cattle based on the perception that Drakensbergers perform poorer than other breeds. Although ADG differed by 20 grams ($P < 0.01$), such a difference would most probably be biologically and economically insignificant. In a practical commercial feeding situation such differences are meaningless and would not be noticed, suggesting similar performance under commercial conditions. Due to poor record keeping on diseases by feedlot operators, it is not possible to make meaningful conclusions regarding any breed differences on the occurrence of disease in South African feedlots. More controlled studies are urgently needed.

Results from test centres that included 6139 cattle revealed a difference in ADG of 124 grams, while indicating similar performance regarding FCR. As is the case with commercial feedlots, test centres are urged to keep proper health records in future.

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