FARMERS' PERCEPTION AND FACTORS AFFECTING SCROTAL CIRCUMFERENCE OF BEEF BULLS IN SOUTH AFRICA

by

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DECLARATION

I declare that the full dissertation hereby submitted to the University of Limpopo for the degree of Master of Agricultural Management (Animal Production) is my own work and it has not been submitted for any other purposes or to any other University, and that all materials contained herein has been acknowledged.

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I would like to thank God for the strength and perseverance He instilled in me to finish all the work.

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DEDICATION

I dedicate this dissertation to myself, my daughter and my upcoming children in future. Should they know I worked hard, and I am proud of my achievements.

ABSTRACT

The size of scrotal circumference is highly associated with fertility of a bull, however bulls with under-developed scrotum contributes to unsatisfying performance and low reproduction potential of a bull. The objectives of the study were to: a) identify the perception of farmers on factors affecting scrotal circumference of beef bulls, b) determine the effect of breed and age on scrotal circumference of South African beef bulls during phase D (on-farm), c) determine the interaction effect between breed and age on scrotal circumference of South African beef bulls during phase D (on-farm), d) determine the minimum acceptable scrotal circumference by breed in South African beef bulls during phase D (on-farm). The current study utilized secondary data to address second, third and fourth objectives whereas a questionnaire was used to achieve first objective. Bulls participated into Phase D were aged between 325 and 425 days of age at the start of adaptation period. The test length lasted 90 days with 21 days of adaptation. During the adaptation period, bulls have fed on the same diet similar to the diet they had fed during the trial. Age (days), live weight (kg) and scrotal circumference (cm) were measured on the date of measuring scrotal circumference. During measurement, animals were moved into a crush pen and restrained. First objective was analyzed using frequencies whereas second, third and fourth objectives ware analyzed using Two-way Analysis of Variance (General Linear model) and descriptive statistics. The results indicated farmers' perception with a high percentage that farmers agree that breed (83.3%), age (83.3%), body weight (75%) and nutrition (66.7%) affect the scrotal circumference of bulls. Furthermore, results showed the high significant difference ($P< 0.01$) on effect of breed on scrotal circumference, age is also highly significant ($P < 0.01$) to SC showing the effect, and there is non-significant difference ($P> 0.01$) on the interaction effect of breed and age on scrotal circumference. Also, presented breeds that are within acceptable standards of scrotal circumference.

In conclusion, the perception of farmers is justified by the results of this study when determining the effect of breed and age on scrotal circumference. Furthermore, on conclusions, the scrotal circumference in bulls is affected by breed and age, which implies that the growth of scrotal circumference depends on breed or age of a bull. Also, there is no interaction between breed and age on scrotal circumference, which implies that breed

is independent on scrotal circumference and age is independent on scrotal circumference. Lastly, breeds with higher scrotal size are regarded as highly fertile bulls. Findings suggest that bulls with a higher scrotal circumference can be selected looking at breed and age in this study. Findings suggest a scrotal circumference as a dependent factor on breed and age.

Keywords: Age, beef bulls, breed, farmers' perception, fertility, scrotal circumference

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ANOVA	Analysis of variance
ARC	Agricultural Research Council
SC	Scrotal Circumference

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CHAPTER ONE

INTRODUCTION

1.1. Background

The National Beef Cattle Recording and Improvement Scheme is managed by the Agricultural Research Council (ARC) on behalf of the South African National Department of Agriculture and the state. Bull testing is one of the seven (7) phases that comprises the scheme, and only farmers that belongs to breeders' association participate in the scheme (ARC, 2014). The bull performance test can be conducted at a centralized station (Phase C) or on-farm (Phase D). The on-farm test is conducted at owner's (participant) farm, and it reflect on the animal performance where it will be raised. Bulls with larger testicles are found to be heritable with 41% for age at puberty in their daughters and for scrotal circumference in half-brothers (Menegassi *et al.,* 2011). The size of the scrotum is an excellent reference point in the evaluation of reproduction potential (Bosman and Scholtz, 2010). In addition, bulls' scrotal circumference is regarded as crucial because as it grows, the daily output of high-quality sperms also increases (Maime, 2015). Swanepoel and Heyns, (1987) highlighted factors that influences scrotal circumference such as breed, age, season and body mass. However, studies have been conducted on the relationship between scrotal circumferences and factors that affects it, and these had been outlined in the next chapter.

1.2. Problem statement

Smallholder and emerging beef cattle farmers do not participate in the bull testing process and their calving rate are lower (less than 40%) compared to that received (more than 70%) in commercial setup (Mapiye *et al.,* 2018). Musemwa *et al.* (2010) observed that bulls raised in rural areas under smallholder farming are of poor quality owing to poor management including lack of selection practices. Every bull raised in the herd is used for breeding purposes including yearlings. The failure of bulls to impregnate cows, largely affected by underdevelopment of testicles has been identified among the main causes of low reproductive efficiency under communal and emerging herds (Maime, 2015). There is insufficient information on the assessment of normal development of testicles conducted under farm level (Phase D) in South Africa. Lack of infrastructure, expertise and capital has prevented communal and emerging beef cattle farmers from participating in breeders' association, but these farmers can benefit from studies of factors affecting fertility in bulls since they have animals.

1.3. Rationale

Bull performance test (Phase D) is used to estimate the bull's performance under natural grazing conditions, and is based on traits, which are of particular importance to producers (Scheepers *et al.,* 2010). The aim of any testing programme is to identify suitable parents of the next generation, which are likely to contribute to increased herd net income (Mashiloane *et al*., 2012). The overall reproductive efficiency in the herd can be enhanced by eliminating bulls with physical problems or minimized fertility from the breeding herd (Yimer *et al.,* 2011). In the beef cattle industry, the practice of performance testing is aimed at providing the industry with objective performance information on individual animal in order to improve the biological and economic efficiency of beef production (Groenewald, 2017). Testicular and scrotal measurement are important parameters to predict fertility in post-pubertal breeders' bulls. Bull fertility traits also has an effect on calf growth including age at puberty, calving interval, number of services per conception and pregnancy rate (Savinob *et al.,* 2017). Phase D performance test is a reflection of the performance of bulls at farm level where it is expected to produce. According to Maiwashe *et al.,* (2000), bull performance test (Phase D) is conducted to evaluate young bulls for post-weaning growth and efficiency. However, the current study will evaluate farmers' perception and factors affecting scrotal circumference in beef bulls in South Africa.

1.4. Aim of the study

The aim of the study was to evaluate farmers' perception and factors affecting scrotal circumference in beef bulls in South Africa.

1.5. Objectives

The objectives of the study were to:

i. Identify factors perceived by farmers to affect scrotal circumference of bulls in beef cattle.
ii. Determine effect of breed and age on scrotal circumference in South African beef bulls during Phase D (on farm) test.
iii. Determine interaction effect between breed and age on scrotal circumference in South African beef bulls during Phase D.
iv. Determine minimum acceptable scrotal circumference by breed and age in South African beef bulls during Phase D (on-farm) test.

1.6. Research Questions

i. What are farmers perceptions on factors affecting scrotal circumference of bulls in beef cattle?

ii. How do breed and age affect the scrotal circumference of South African beef bulls during the Phase D (on-farm) test?

iii. What is the interaction effect between breed and age on the scrotal circumference of South African beef bulls during the Phase D (on-farm) test?

iv. What is the minimum acceptable scrotal circumference by breed and age in South African beef bulls during the Phase D (on-farm) test?

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The objectives of this chapter were (1) to present the comprehensive review of the published origin of South African beef bulls and (2) to highlight factors affecting beef bull performance during bull test at Phase D. To achieve the above objectives, this review was structured as follows: (a) interaction effect of breed, age and live weight on scrotal circumference of South African beef bulls (b) the factors affecting performance of beef bulls in test station (c) bull selection practices on commercial farmers and smallholder farmers and (d) conclusion.

2.2 Effect of breed, age and body weight on scrotal circumference of beef bulls

Breed, age, season, and body weight are among the factors that affect scrotal circumference (Makarechian *et al.,* 1984). It is suggested that a significant number of bulls might not have a scrotal circumference that meets the minimum standard (20 cm) by the time they are 365 days old (Grupioni *et al.,* 2015). Coulter *et al.* (1987) had made recommendations of minimum acceptable scrotal circumference for two years old beef bulls of several breeds which ranged from 30cm to 36cm. Additionally, breeds included in that recommendations were Simmental, Angus and Charolais, Herefords and Shorthorn and Limousin. Whereas Bosman (2019) found that among bulls of the Bovelder breed, those with scrotal circumferences between 24 and 40 cm at 730 days generated the best-quality semen with the lowest defects. Moreover, according to Mukuahima (2010), the size and shape of a bull's scrotum significantly affects the animal's ability to reproduce. Perumal (2018), indicated that testicular growth parameters and scrotal circumference of bulls serve as valuable indicators for assessing testicular development, which is crucial when selecting them for breeding purposes. Furthermore, it was discovered that heifers from bulls with larger-than-average scrotal circumference experienced puberty at earlier age than those from bulls with smaller circumference.

Body weight and scrotal circumference are traits that can be measured multiple times throughout an animal's life and may experience changes in their genetic control over time. (Manuela *et al.,* 2021). Scrotal circumference is influenced by body weight in a way that is a function of age, pre-weaning and feedlot growth rates, and birth weight, all of which may have an impact on scrotum development (Makarechian *et al.,* 2014). Menegassi *et*

al. (2011) indicated that the increase in body weight leads to an increase in scrotal circumference within the age at puberty. Boligon *et al.* (2010) stated that the selection of heifers with a higher body weight may result in excessively heavy animals at a mature age with consequent reproductive problems. Scrotal circumference and body weight provides an idea about the physical and physiological maturity of the bulls and their sperm output (Evans *et al.,* 1996).

2.3 Factors affecting performance of beef bulls in test station

The Department of Agriculture initiated the central performance testing of beef bulls (Phase D) in South Africa as early as 1963 (Nephawe *et al.,* 2006). In recent years, young weaner bull calves have been involved in on-farm testing stations, where their individual feed intake and body weight are recorded weekly. Body measurements, such as scrotal circumference, are also documented at the end of the test. Performance testing's purpose is to enable uniform comparisons of beef bulls from various herds to find genetically superior bulls for use in commercial breeding herds (Liu, 1993). Additionally, performance tests as currently organised, bulls starting from age of 6 to 10 months are accepted (Barham, 2003).

A key challenge in performance testing is determining a bull's breeding value based on phenotypic measurements (Schenkel *et al*., 2004). However, this study will later on present data recorded using bulls from smallholders' farmers and that they do not participate in breeding evaluation. Furthermore, the author reported that performance testing results are known to be specific to both the environment and time. An animal that excels in a testing station may not necessarily perform the same in a different environment or at a later time. Hence, the current study bulls were tested at their original place where they are expected to mate. Studies have shown that, despite adaptation periods, the herd of origin significantly affects the performance of bulls during testing (Schenkel *et al.,* 2004).

In South Africa, the feed conversion ratio of Bonsmara cattle is commonly used to assess feed efficiency in selection programs, despite its drawback as a ratio trait, which can lead to increases in body weight and size (Steyn *et al.,* 2014). Moreover, the increase in bull body weight will lead to increase in scrotal circumference (Bongso *et al.,* 2014).

Therefore, feed efficiency indirectly influences the reproductive trait, thus scrotal circumference of the bull during the performance test. However, during Phase D test bulls are expected to continue to feed on the feed they were previously feeding on, and feed conversion ratio need to be regulated with caution as it might influence body weight and size of the bull consequently affecting its mating ability.

Beef cattle in South Africa are raised in a range of environmental conditions, presenting significant challenges for breeders and producers concerning performance and genetic improvement (Marle, 1974). Cattle breeders in South Africa will need to adapt their breeding methods to align with the specific nutritional and climatic conditions. Therefore, the Phase D test are conducted in respective farms where animals have grown at. According to Schenkel et al. (2004), test performance is influenced by the pre-test setting. Although the bulls won't require an environmental adaption period at this Phase D, per on-farm protocols. Furthermore, the performance testing station will not be affected by the surrounding environment.

2.4 Bull selection practices in commercial farmers' verses smallholder farmers

Participation in animal recording through national or private services differs considerably among various breeds and livestock species (ARC, 2017). Most beef stud breed societies advocate for animal recording and the utilization of estimated breeding values (Ngarava et al., 2018). In the emerging sector, the Kaonafatso ya Dikgomo (KYD), which means 'cattle betterment,' was established by the Agricultural Research Council in 2007 to assist emerging and smallholder farmers in engaging in animal recording (Government of South Africa, 2007). The goal of this program is to empower beef farmers and enhance rural communities by facilitating smallholder farmers' access to mainstream livestock industries (ARC, 2017). However, complete phenotyping remains a challenge in both the developed and developing sectors, which has significant negative implications for genetic evaluations and sustainable genetic improvement (Ngarava *et al.,* 2018).

Southern African beef cattle production relies greatly on the use of natural pastures and is generally an enormous system (Nguni Cattle Breed Society, 2011). As beef production

is based on the reproductive rate, the growth rate of young bulls, and the weight of culled bulls, it is crucial that beef cattle's fertility and growth are improved through selection (Minick *et al.,* 2001). The lack of animal selection has been noted in communal and small-scale Nguni cattle operations that engage in community-based in-situ conservation (Tada *et al*., 2012). The Nguni, an indigenous cattle breed in South Africa, primarily found in rural regions, has not experienced the rigorous selection programs typically applied to exotic and commercially focused breeds (Nguni Cattle Breed Society, 2011).

Selecting bulls based on scrotal circumference serves as an indirect method for enhancing fertility, as it is strongly genetically linked to the age at which heifers reach puberty (Van Melis *et al.,* 2010). Smallholder cattle farmers and their breeding strategies do not depend only on natural and socio-economic conditions, but according to Van Melis *et al.* (2010) they also rely on the abilities and interests of the members of a farming family. Therefore, there is a great variability among smallholder farmers with respect to animal breeding and even within a single village (Bayer, 2009). According to Bayer (2009) meat-producing animals have been bred for faster growth, based on the premise that animals that grow more quickly will convert a larger portion of their feed into production rather than using it for maintenance.

The primary breeding challenge in smallholder regions is that herds are owned by multiple individuals (Mhlanga, 2000). As a result, cattle owners often lack the ability to choose the preferred breed of bull or cow to serve as sires or dams for their herds. This leads to the retention of inferior bulls and cows, resulting in a high rate of inbreeding. In fact, 95% of households in communal and small-scale areas utilize an open breeding system. Individual herds intermingle freely with those of neighbours, especially in communal areas where fencing is absent. Furthermore, inferior bulls are seldom castrated, with 90% of households not performing this practice, leading to uncontrolled breeding and the production of lower-quality offspring (Ndebele *et al.,* 2007).

2.5 Conclusion

All the objectives on this chapters were achieved; where comprehensive review of the published origin of South African beef bulls were presented and factors affecting beef bull performance during bull test at Phase D were highlighted. The achieved objectives were (a) interaction effect of breed, age and live weight on scrotal circumference of South African beef bulls (b) the factors affecting performance of beef bulls in test station (c) bull selection practices on commercial farmers and smallholder farmers; were thoroughly presented and criticised based on different perspectives from different authors. However, farmers should take note on factors that would influence the sperm output of bulls and their performance during on-farm testing; also communal farmers should adapt to the least of commercial selection strategies at their production.

CHAPTER THREE

METHODOLOGY AND ANALYTICAL PROCEDURES

3.1 Ethical approval

Before the study began, it obtained ethical approval from the University of Limpopo Turfloop Research Ethics Committee (TREC), along with an assigned ethical approval number: REC-0310111-031.

3.2 Study site

The study was conducted at individual farms and with farmers that enlisted for Phase D test with the Agricultural Research Council (ARC). Participating farmers are members of the breeders' association and come from all over the nine provinces.

3.3 Sampling procedure

The study used secondary data where purposive sampling techniques was applied in selecting qualifying farmers to participate in the study. Thereafter, qualifying breeds with a minimum of 5000 data entry units was selected for consideration in the study. The breeds that qualified included; Angus SA, Afrikaner, Beefmaster, Bonsmara, Brahman, Charolais, Drakensberger, Hereford, Nguni, Limousing, Santa Gertrudis, Simmentaler and Sussex. Bulls was admitted into Phase D, between 325 and 425 days of age at the start of adaptation period.

3.4 Experimental design

Cross sectional study was used where questionnaires were administered to achieve objective one. Completely randomized experimental design with 13x3 factorial treatment design was used in the study.

3.5 Data collection

The study used primary data for the first objective and secondary data for second, third and fourth objectives. Primary data was collected using semi-structured questionnaires with open-ended questions to avoid leading participants. Secondary data used in the study was captured on the INTERGIS programme managed by Agricultural Research Council (ARC) on behalf of the National Department of Agriculture. The Participating farmers had complied with qualifying requirements as outline by Agricultural Research Council (ARC) such as having a functional weighing scale, accurate, complete, and up-to-date record keeping. The bulls that took part in the Phase D program had an adaptation period lasted for 21 days. During the adaptation period, bulls were fed on the same diet

similar to the diet they had fed during the trial. The test length lasted 90 days and the maximum age possible of the bulls at the end of Phase D was 530 days. Breed, age, live weight and scrotal circumference were the data collected for use in this study. The age was measured as the number of days from birth to the date of scrotal circumference measurement (days). Live weight was measured by subjecting the animal to a cattle-weighing scale (kg) on the date of scrotal circumference measurement. The scrotal circumference was measured using a testicles circumference meter tape (cm) developed in South Africa at the widest part of the testis. During measurement, animals were moved into a crush pen and restrained. According to Menegassi *et al*. (2011), bulls of more than 20 cm scrotal circumference are ideal for use in breeding, as they are considered productive. In this study, bulls with scrotal circumference of less than 20 cm were rejected because they were regarded as bulls of low quality.

3.6 Data analysis

Data in the study was analyzed using the Statistical Analysis System (SAS, 2021) version 9.4. The frequencies (PROC FREQ) were employed to achieve first objective. Procedure for two-way Analysis of Variance (PROC ANOVA) were used to achieve the second and third objectives. Procedure of means (PROC MEAN) were used to achieve the fourth objective, and the data were presented as mean ± standard error of means. The statistically significant level was determined using 5% for significant and 1% for highly significant. The following model was used:

$$Y_{ijk} = u + A_i + B_j + (AB)_{ij} + e_{ijk}$$

Where;

Y_{ijk} is the observation of the scrotal circumference in i^{th} breed, j^{th} age and k^{th} interaction, u is the overall mean, A_i is the breed effect, B_j is the age effect, $(AB)_{ij}$ is the interactions and e_{ijk} is the residual error.

CHAPTER FOUR

RESULTS

4.1 Factors perceived by farmers to affect scrotal circumference of bulls in beef cattle

4.1.1 Socio demographic characteristics of farmers

Table 1 shows the socio demographic characteristics of 12 farmers who willingly participated in the study. The results obtained indicated that majority of farmers (83.3%) were males. The majority of farmers (33.3%) in the study were between 51 and 60 years of age. Most of the farmers (50%) obtained secondary education as their highest level of education. Most farmers (66.7%) have less than 5 hectares and many of them (91.7%) owned the farms.

Table 4.01: Socio demographic characteristics of farmers

Factor	N	Percentage (%)
Gender		
Male	10	83.3 %
Female	2	16.7 %
Total	12	100%
Age		
<30	1	8.3%
31-40	2	16.7%
41-50	2	16.7%
51-60	4	33.3%
>60	3	25%
Total	12	100%
Standard qualification		
Postgraduate	1	8.3%
Degree	1	8.3%
Diploma	4	33.3%
Secondary	6	50%
Total	12	100%

Years of farming experience		
<5	4	33.3%
5-10	3	25%
10-15	1	8.3%
>20	4	33.3%
Total	12	100%
Farm size		
<5 hectares	8	66.7%
5-10 hectares	1	8.3%
>20 hectares	3	25%
Total	12	100%
Farm ownership		
Owned	11	91.7%
Leased	1	8.3%
Total	12	100%
Herd size		
<10	4	33.3%
10-20	2	16.7%
20-30	1	8.3%
30-40	2	16.7%
>40	3	25%
Total	12	100%

4.1.2 Breed kept by farmers and breeding bulls

Table 2 present breeds kept by farmers and number breeding bulls in the herd of farmers who participated in the study. The results showed that majority of the breed kept was indigenous breed (58.3%), the most preferred bulls used for breeding was indigenous breed (66.7%), and half of the interviewed farmers (50%) prefer to keep one bull in the herd for breeding.

Table 4.02: Breed kept by farmers and breeding bulls

Factor	N	Percentage (%)
Breed in herd		
Nguni	1	8.3%
Brahman	3	25%
Indigenous breed	7	58.3%
Other	1	8.3%
Total	12	100%
Breeding bull		
Nguni	1	8.3%
Brahman	2	16.7%
Indigenous breed	8	66.7%
Other	1	8.3%
Total	12	100%
No. of breeding bulls		
0	5	41.6%
1	6	50%
2	1	8.3%
Total	12	100%

4.1.3 Farmers' perception on factors affecting scrotal circumference of beef bulls

Figure 1 presents farmers' perception regarding factors affecting scrotal circumference of beef bulls. Figure 1a showed farmers' perception on breed factor affecting scrotal circumference. The results of figure 1a indicates that 83.3% of the farmers agreed that breed affect the scrotal circumference of bulls. The farmers' perception on age factor is represented on figure 1b, where 83.3% of farmers agreed that age affect scrotal circumference of bulls. Furthermore, figure 1c showed farmers' perception on body weight as a factor affecting scrotal circumference. Most farmers (75%) agreed that body weight affect scrotal circumference of beef bulls. Lastly, farmers' perception on figure 1d shows that 66.7% of farmers agreed that nutrition affect the scrotal circumference of bulls.

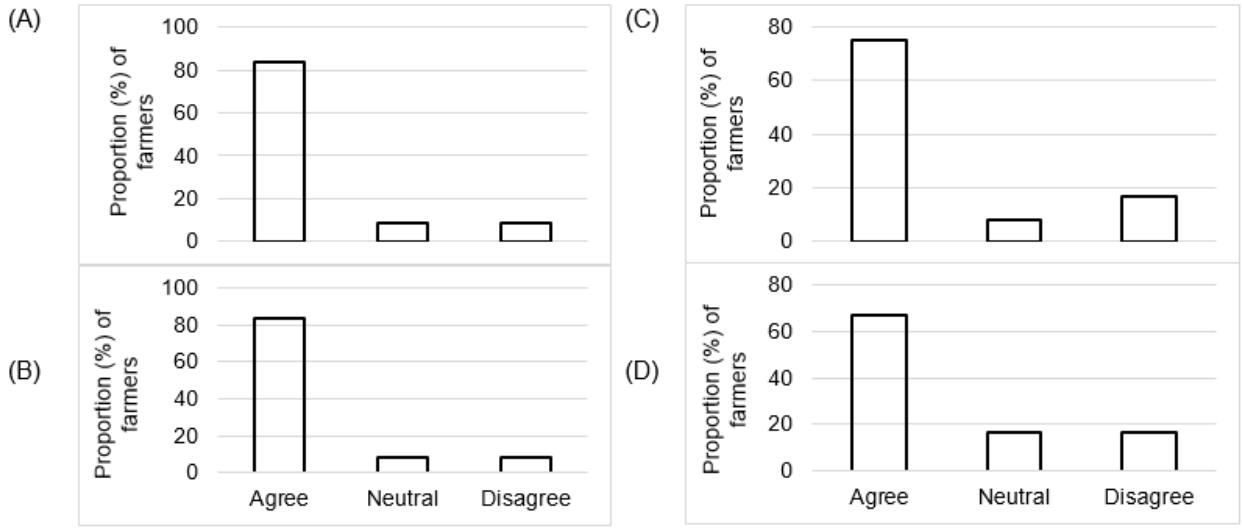

Figure 4.1: Farmers' perception on factors affecting scrotal circumference of beef bulls. (A) Breed; (B) Age; (C) Body weight and (D) Nutrition

4.2 Effect of breed and age on scrotal circumference in South African beef bulls

4.2.1 Effect of breed on scrotal circumference

Table 3 presents the mean and standard deviation of scrotal circumference per breed. Scrotal circumference ranged from the biggest mean of 34.27 cm (Drakensberger) to smallest mean of 33.49 cm (Santa Gertrudis). The breeds that participated in the study were classified into five groups. Breeds in group 1 that had the largest scrotal circumference were Drakensberger and Nguni, followed by Hereford, Sussex and Brahman breeds in group two. Afrikaner, Charolais, Angus SA, Simmentaler, Bonsmara and Beefmaster were classed in group three while the Limousine breed was in group four. Santa Gertrudis breed had the smallest scrotal circumference and was classed in group five.

Table 4.03: Effect of breed on scrotal circumference

Breed	Number of bulls	Mean ± STD
Drakensberger	9434	34.27^{a} ± 30.13
Nguni	2806	34.26^{a} ± 32.35
Hereford	2807	34.08^{b} ± 30.00
Sussex	6051	34.05^{b} ± 29.11
Brahman	4171	34.00^{b} ± 32.79
Afrikaner	7354	33.81^{c} ± 30.73
Charolais	1772	33.81^{c} ± 28.99
Angus S.A	6634	33.79^{c} ± 30.86
Simmentaler	6808	33.78^{c} ± 31.95
Bonsmara	91185	33.77^{c} ± 30.36
Beefmaster	7388	33.72^{cd} ± 32.15
Limousine	1764	33.63^{d} ± 31.15
Santa Gertrudis	6645	33.49^{e} ± 29.95

4.2.2 Effect of age on scrotal circumference

Table 4 shows the effect of age on scrotal circumference of the thirteen breeds studied. Age of the bulls was divided into two groups, namely; 10-14 months and 15-23 months. The results indicated that breeds in age group 15-23 months had the largest scrotum circumference compared to the 10-14 months' age group ($P<0.01$). within breed variation was bigger in the 10-14 months' group compared to the 15-23 months' group.

Table 4.04: The effect of age on scrotal circumference

Breed	Age Groups	
	10-14 Months (Mean ± STD)	**15-23 Months (Mean ± STD)**
Charolais	33.60[b] ± 27.39	33.97[a] ± 30.14
Bonsmara	33.32[b] ± 29.72	34.18[a] ± 30.36
Sussex	33.85[b] ± 28.77	34.24[a] ± 29.31
Angus S. A	33.49[b] ± 32.76	34.11[a] ± 28.72
Santa Gertrudis	33.28[b] ± 30.95	33.67[a] ± 28.94
Afrikaner	33.37[b] ± 32.17	34.23[a] ± 28.67
Beefmaster	33.22[b] ± 33.87	34.13[a] ± 30.00
Brahman	33.22[b] ± 32.13	34.62[a] ± 32.01
Limousine	33.10[b] ± 31.30	34.04[a] ± 30.40
Nguni	33.71[b] ± 31.60	34.83[a] ± 32.15
Simmentaler	33.69[b] ± 32.65	33.84[a] ± 31.24
Drakensberger	33.88[b] ± 29.93	34.58[a] ± 29.93
Hereford	33.89[b] ± 30.98	34.27[a] ± 28.98

4.3 Interaction effect between breed and age on scrotal circumference in South African beef bulls during Phase D.

4.3.1 The interaction effect of breed and age on scrotal circumference

Table 5 presents the summary of interaction effect of breed and age on scrotal circumference of bulls selected for performance test during Phase D. The bulls in age 15-23 months have a higher scrotal circumference mean compared to bulls in 10-14 months.

Table 4.05: The interaction effect of breed and age on scrotal circumference

Breed	Age group			
	10-14 Months		15-23 Months	
	Mean	STD	Mean	STD
Charolais	33.60	27.39	33.98	30.15
Bonsmara	33.32	29.72	34.19	30.36
Sussex	33.85	28.77	34.24	29.30
Angus SA	33.42	32.75	34.12	28.72
Santa Gertrudis	33.28	30.94	33.67	28.94
Afrikaner	33.37	32.17	34.24	28.67
Beefmaster	33.22	33.87	34.13	30.00
Brahman	33.22	32.12	34.62	32.01
Limousine	33.11	31.30	34.05	30.40
Nguni	33.71	31.60	34.83	30.40
Simmentaler	33.69	32.65	33.84	31.24
Drakensberger	33.88	29.93	34.58	29.98
Hereford	33.89	30.98	34.26	28.98

4.4 Minimum acceptable scrotal circumference by breed and age in South African beef bulls

4.4.1 The minimum acceptable scrotal circumference by breed.

Table 6 presents the acceptable scrotal circumference of the thirteen breeds. In all of the thirteen breeds the scrotal circumference was above the minimum acceptable (20 cm) per breed. Drakensberger had the largest scrotal circumference with 34.26 cm compared to rest of the breeds. The breed with smallest scrotum was the Santa Gertrudis with 33.49cm.

Table 4.06: Minimum acceptable scrotal circumference (SC) in cattle

Breed	**Number of bulls**	**Mean**	**Standard error of mean**
Drakensberger	9434	34.26	30.13
Nguni	2806	34.26	32.35
Hereford	2807	34.08	30.00
Sussex	6051	34.05	29.11
Brahman	4171	34.00	32.79
Afrikaner	7354	33.81	30.73
Charolais	1772	33.81	28.99
Angus S.A	6634	33.79	30.86
Simmentaler	6808	33.77	31.95
Bonsmara	91185	33.77	30.36
Beefmaster	7388	33.72	32.14
Limousine	1764	33.63	31.15
Santa Gertrudis	6645	33.49	29.95
SC standard; 28.8cm (Menegassi *et al*., 2011)			

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

Scrotal circumference, age, body weight and breed were good indicators of pubertal and mature status of bulls and could be used as references by producers when selecting bulls of similar genotype (Brito *et al*., 2004). The present study looked on the perception of farmers and effect of breed and age on scrotal circumference of South African beef bulls during phase D (on-farm test). The study used mean and standard deviation to determine the effect of breed and age on scrotal circumference of bulls. The results showed that breed and age influenced scrotal circumference. The size of scrotal circumference varied according to the breeds and the Drakensberger had significantly higher scrotal circumference compared to the rest of the breed. The breeds of bulls that were 15 to 23 months of age had bigger scrotal circumference when compared to those in the 10 to 14 months of age. Furthermore, all breeds used in the studied meet the minimum standards of scrotal circumference as shown in the results. The results from farmers' perception showed that farmers agreed that breed, age, body weight and nutrition affect the scrotal circumference of beef bulls. Moreover, the results on scrotal circumference studies showed that breed and age had a significant effect on SC. The results also did not show the interaction effect between breed and age on the scrotal circumference. Men are the most owners of cattle as compared to women, from this study. The results are similar to that reported by Tada *et al*. (2013) noted that men typically own large livestock, including cattle. Similar findings were observed by Katiyatiya *et al*. (2014) where men dominated the livestock industry in Eastern Cape Province as they owned more cattle than women. Byrne *et al*. (2017) had proven that there is an effect of nutrition by breed and age interaction for scrotal circumference. However, these findings were similar to that of the farmers' perception on this study that the breed, age, body weight and nutrition affect scrotal circumference of bulls.

Eriksson *et al.* (2012) established the average scrotal circumferences for performance-tested bulls, regardless of breed and age, which are similar to the average scrotal circumference of the present study. The mean for scrotal circumference values found in the present study are like those reported by Eriksson *et al*. (2012) for Hereford, Charolais, Angus and Simmentaler. Perumal (2014) has observed that the scrotal circumference increased rapidly in 18-24 months old bulls and gradually in 25-36 months old bulls. In

the current study, younger bulls aged 10-14 months had almost similar scrotal circumference whereas older bulls showed a gradual increase in size. This despite that the same breeds used in the current study were the same breed used in a study by Eriksson *et al*. (2012). Menegassi *et al*. (2011) indicated that breeds assessed in their study had lower values of scrotal circumference at the age of 24 months and a higher value at the age of 36 months old. This variation in scrotal circumference values across breeds may indicate a broader or narrower selection for this trait. Scrotal circumference measurements and the selection of young bulls enhance the potential for sperm production (Menegassi *et al.,* 2011). However, factors such as breed, body condition scores, age at puberty onset, and breeding system influence this potential. The present study evaluated the interaction effect of breed and age on scrotal circumference of bulls selected for performance test on the farm. The results of this study did not show the significant difference between two age groups, 10-14 months and 15-23 months, as per breed. Most studies were evaluating interaction effect between scrotal circumference and body weight. Hence studies by Indriastu *et al.* (2020) showed that there was no significant correlation, their low negative correlation for scrotal circumference with body weight might be affected by many factors including the breed and age of the bull.

Menegassi *et al.* (2011) recommended the use of a minimum standard of 28.8 cm for each age and breed to enhance the selection of this characteristic. However, their study showed the percentages of culled bulls that were below the minimum standards of SC, unlike in the current study that showed the minimum acceptable standards of scrotal circumference of bulls. In this study only bulls that were 10 to 23 months old of age with above the minimum acceptable scrotal circumference participated in the evaluation of on-farm performance test. In a study by Eriksson *et al*. (2012), only a small number of bulls were removed during the final evaluation because their scrotal circumference was too low, however, in the current study a lot of bulls were not selected for use in the study due to low scrotal circumference size. So, the study focused only on the bulls that were above minimum standards of scrotal circumference. Although Coulter (1997) has reported that farmers choosing herd sires should give serious thought to selecting bulls with scrotal circumferences significantly above the minimum standards, ideally closer to the average for the breed. The perception of farmers from this study indicate that farmers are aware

of factors that affect scrotal circumference of beef bulls, and these factors should be considered when selection of beef bulls. Also, the findings in this study indicate that additional emphasis on selection for scrotal circumference may be required if 10 months old bull of some breeds are expected to perform up to sufficient high quality. The results showed that the scrotal circumference of bulls dramatically changed with age of a bull. This continually shown that there is no interaction between breed, age and scrotal circumference. There's a lacking information on previous studies about farmers' perception on factors affecting scrotal circumference of beef bulls. The majority of interviewed cattle farmers selected their bulls to breed at the age of six years, by this time the scrotal circumference would have grown to its majority. Interviewed cattle farmers agreed that scrotal circumference grows depending on the breed of a bull, and that good nutrition contributes to good healthy and satisfying body weight.

Byrne *et al*. (2017) has shown that with bulls that have a larger scrotal circumference and are on higher plane of nutrition, they would attain puberty and sexual maturity at an earlier age Coulter *et al*. (1975) reported that the bigger scrotal circumference represents reproducible, high heritability, and is highly correlated with testicular weight. However, such bulls would be expected to more females when subjected to intense breeding pressure (Coulter and Keller, 1981). Research at the University of Saskatchewan shows that the likelihood of a beef bull having satisfactory semen quality improves as scrotal circumference measurements increase (Coulter, 1997).

Frequency results can only show the percentage of farmers' perception on those agree, disagree or neutral about the effect of breed, age, body weight and nutrition on the scrotal circumference, and it is based only on the number of farmers interviewed. The study used procedure for two-way analysis to determine the effect of factors affecting the scrotal circumference of beef bulls. Moreover, means and standards error of means shown the acceptable scrotal circumference of beef bulls participated on the on-farm test.

5.2 Conclusion

Based on these results, it can be concluded that nutrition and body weight should be maintained for bulls of bigger scrotal circumference. However, there was no interaction between breed and age and scrotal circumference. This implies that breed and age are

independent factors whereas scrotal circumference is a dependent factor on breed and age. Moreover, the selection of bulls for breeding should be based on breed that have larger scrotal size. When bulls reach puberty and their SC meet the minimum acceptable level, they should be selected for breeding. Farmers can select bulls with a higher scrotal circumference size as it contributes to high reproduction to herd.

5.3 Recommendations

Based on the findings of the present study, it is recommended that further studies be done with a fractional higher number of participants to validate the results of the current study. Other farmers who did not participate in the current study should be made aware of the findings of the current study. There is also a need to evaluate more bulls especially bulls under communal and emerging setups since calving rate under those farming systems is low and can be raised through bull selection. Farmers should measure scrotal circumference of bulls occasionally; in that way it will help them to know which bulls to select for breeding in their herd. To widen the scope of selection, and to increase the number of bulls to be assessed, it is important to also allow bulls with scrotal circumference that is less close to the minimum acceptable scrotal circumference to be evaluated.

CHAPTER SIX

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ANNEXURE A

Consent Form

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Department of Agricultural Economics and Animal Production

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Cell: 0794577480, Email: mopherekgaditsi@gmail.com

INFORMED CONSENT FORM FOR PARTICIPATING IN A RESEARCH STUDY

The researcher will talk to you before taking part in this research, and will give you this consent form to read, as well as to clarify you where you might need clarity. You are cordially asked to sign the form after you have decided to take part in this project.

I, ……. agree to participate in research titled ***"farmers' perception and factors affecting scrotal circumference of beef bulls"*** in the Department of Agricultural Economics and Animal, Production University of Limpopo.

Furthermore, I understand that:

1. My participation in this research is voluntary, and I will not gain monetary/ financial compensation for my participation. I may withdraw my participation in a case of discomfort, and my withdrawal will not affect my relationship with the researcher.

2. I have the right to not answer certain questions if I am uncomfortable. I understand that this participation is entirely voluntarily. I can withdraw my consent at any time with no penalty.
3. My response to the questions will be recorded at my permission. However, where I am not comfortable about recording my response, the researcher will have to write down my responses by him/herself.
4. Confidentiality and anonymity of records identifying you as a participant will be maintained by me and my learning institution, if necessary.
5. If you have any questions or concerns about participating in the interview or about contributing to this study, you may contact me or my supervisor on the numbers listed above.

_____ _____ _____

Participant Signature Date

(Full name)

I, Andile Mophere Kgaditsi, have clarified the scope of the research to the participant and explained his/ her rights concerning his/ her participation in the study. She/ He agrees to participate in this study.

Kind regards,

_____ _____ _____

Researcher Signature Date

ANNEXURE B

QUESTIONNAIRE ON THE FARMERS' PERCEPTION 0N FACTORS AFFECTING SCROTAL CIRCUMFERENCE IN BEEF BULLS IN SOUTH AFRICA

NB: This questionnaire is confidential and information collected will be treated to confidentiality and feel free to interact and provide as truthful information as possible.

Names of respondent :_____

Province :_____

Municipal District :_____

Municipal Area :_____

Current position :_____

Contact details : _____

SECTION A. SOCIO-DEMOGRAPHIC CHARACTERISTICS

1. Gender (*please tick on the box*)

1.0 Male	
2.0 Female	

2. Age category of respondent (*please tick in the box*)

1.0 Below 30 years	
2.0 Between 31-40 years	
3.0 Between 41-50 years	
4.0 Between 51-60 years	
5.0 Above 60 years	

3. Marital status

Single		Married		Widow		Divorce	

4. Do you have any other source of income?

1.0 Yes	
2.0 No	

5. If yes, what is your source of income?

Salaries/ wages	Pension fund	Social grant	Business profit	Other

6. What is your monthly household income?

< R1000	R1000 – R5000	R 5000 – R10000	>R10000

7. What is your religion?

Christian	Muslim	African Tradition	Other

8. Highest standard passed (*please tick in the box*)

1.0 Postgraduate qualification	
2.0 Degree qualification	
3.0 Diploma qualification	
4.0 Secondary qualification	
5.0 Primary qualification	
1.0 Never schooled	

Please specify the highest qualification and type of training received (*e.g. honours in soil Science, etc.*)

9. Are you a member of any farming organisation (*please tick in the box*)?

1.0 Yes	
2.0 No	

If yes, please specify

10. How long have you been farming (*please tick from the box*)?

1.0 Below 5 year	
2.0 Between 5 - 10 years	
3.0 Between 10 – 15 year	
4.0 Between 15 – 20 years	
5.0 Above 20 years	

SECTION B: BREED AND OPERATION INFORMATION

11. How big is your cattle farm?

12. Please indicate whether the farm is owned, rented or leased (*for how long*).

13. How big is your herd size (also break it down into number of breeding cows, heifers, breeding bulls, young bulls, calves, etc.?

14. What is the type of cattle breed you keep at the farm (*please list them*)?

15. What is the breed of bull that you use or prefer to use for breeding (*please list them and specify*)?

16. What is the number of breeding bulls you currently have and their age?

17. Did you buy the bull?

1.0 Yes	
2.0 No	

Give reason/s for your answer.

18. At what age do you select the bull for future use in the herd?

19. Do you measure scrotal circumference at bull selection?

1.0 Yes	
2.0 No	

If yes, what is the minimum scrotal selection (cm)

20. Do you participate in bull performance testing?

1.0 Yes	
2.0 No	

If yes, specify the Phase (*either Phase C or D or both*)

21. What are other challenges that farmers foresee in the implementation of Phase D and C? (*Specify which Phase and challenges*)

22. What are your proposed solutions to each challenge raised? (*Refer to 21 above when responding to this question*).

SECTION C: FACTORS AFFECTING SCROTAL CIRCUMFERENCE

23. Do you select breeding bulls for your herd looking at the following:

Breed	
Age	
Body weight	
Size of SC	
Other	

24. How important do you consider SC in your selection criteria?

Very important	
Important	
Moderately important	
Slightly important	
Not important	

25. Within the following factors do you think influence the growth and development of SC in beef bulls?

Breed	
Age	
Body weight	
Nutrition	

26. Breed have an effect on scrotal circumference of bulls (*please tick from the box*)

Strongly Agree	
Agree	
Disagree	
Strongly disagree	

27. Age have an effect on scrotal circumference of bulls (*please tick from the box)*

Strongly Agree	
Agree	
Disagree	
Strongly disagree	

28. Body weight has an effect on scrotal circumference of bulls (*please tick from the box*)

Strongly Agree	
Agree	
Disagree	
Strongly disagree	

29. To what extent do you think SC affect reproduction performance in your herd?

Positive	
Moderate	
Negative	

30. Nutrition has an effect on scrotal circumference of bulls (*please tick from the box*)

Strongly Agree	
Agree	
Disagree	
Strongly disagree	

31. What management practices do you implement to optimise SC in your herd?

32. Do you monitor and record SC regularly? If so, how often.

33. Are there any concerns or misconception among farmers in your community regarding SC?

Yes	
No	

Support your answer

The End