



**EVALUATION OF NUTRITIONAL AND MINERAL BLOOD PARAMETERS
AS TOOLS TO PREDICT BOVINE REPRODUCTIVE CONDITIONS IN THE
NGAKA MODIRI MOLEMA DISTRICT OF THE
NORTH-WEST PROVINCE**

By

KEITIRETSE MOLEFE (20958277)

BSc. BSc (Hons) AGRIC (ANIMAL HEALTH)

**Submitted in fulfilment of the requirements for the degree of Master of
Science in Agriculture, Department of Animal Health, Faculty of
Agriculture, Science and Technology, North-West University**

MAFIKENG CAMPUS

Supervisor: Dr MULUNDA MWANZA

January 2016

ACKNOWLEDGEMENTS

Firstly, I would like to thank my family and friends for their love and support. They were always there for me when I needed their help regarding my research work.

My deepest gratitude goes to my supervisor, Dr Mulunda Mwanza. I thank him for his dedication, cooperation and the time he took to assist me in my work. I am also grateful for financial support offered by the North-West University postgraduate, Agri-Seta and National Research Foundation bursaries.

My appreciation is also extended to Ms Lungisile Tshitshi for her assistance at the laboratory and department of Animal Health at the North-West University for the provision of resources. My friends, Miss L. Magapong, Miss N. Khoza, Mr Tsepo Ramatla and Dr M.E Tshipamba encouraged me always and need to be acknowledged for their unfailing support.

I appreciate greatly the cooperation of the farmers in the rural areas of Ngaka Modiri Molema District in the North-West Province, who were interviewed, as well as the State veterinarian, Dr M.B.N Phala, and the state animal health technician who helped in the collection of samples. This study would not have been possible without their teamwork.

Lastly, the most important people in my life - my parents - for always being there for me, I would like to say to you that without you I would not have reached where I am now I am deeply grateful for everything.

DECLARATION

I, Molefe Keitiretse hereby declare that EVALUATION OF NUTRITIONAL AND MINERAL BLOOD PARAMETERS AS TOOLS TO PREDICT BOVINE REPRODUCTIVE CONDITIONS IN THE NGAKA MODIRI MOLEMA DISTRICT OF THE NORTH-WEST PROVINCE is an original research done by me and it has never been published or submitted for a degree at any other institution elsewhere.

.....

Signature

Name: Keitiretse Molefe

Student number: 20958277

ABSTRACT

The aim of this study was to evaluate the nutritional and mineral levels in blood to assist in predicting the occurrence of reproductive conditions in cows. The study was conducted in Ngaka Modiri Molema District of the North-West Province in South Africa. All calls related to the incidences of reproductive conditions were recorded and blood samples collected from cows of different farmers. A total of 108 samples were collected between 2012 and 2015 from cases of reproductive conditions such as downer cow syndrome (n=13), dystocia (n=14), retained placenta (n=13), vaginal prolapse (n=9), abortion (n=28) and those from cows in the final trimester of pregnancy (n=31) reported to the North-West University teaching hospital between June 2012 and June 2015. Structured questionnaires were also used to collect data from farmers in Ngaka Modiri Molema District of the North-West Province. Farmers were interviewed during farm visits and at community outreach programmes organized by North-West University Animal Health Department. Farmers were asked about the types of conditions that their cows experience, age of the cow, breed, the body condition score, incidences of the condition, parity, whether the cows supplemented or not, and whether or not any treatment was given to the cows prior to the condition and medical history. Blood samples were screened for brucellosis by Rose Bengal Plate Test and later analysed for serum biochemical parameters such as calcium, magnesium, total protein, creatinine kinase, lipase, triglycerides, blood urea nitrogen, uric acid, Aspartate amino-transferase, sodium, chloride, potassium, cholesterol, total bilirubin and ammonia. Blood collected from cows that showed signs of abortion, retained placenta, downer cow syndrome, vaginal prolapse and dystocia were collected at the same time with the controls from cows in the final trimester of pregnancy. Data were analysed in SAS (version 20) using the analysis of variance techniques (ANOVA). The results were expressed as means $\pm$ SEM. The different treatments were significant if the associated P-value was less than the alpha level established (i.e. $P < 0.05$). Correlation analysis was performed to see if there is association between reproductive conditions, breed types and blood chemistry between the experimental groups. The data from completed questionnaires were coded, captured and analysed using Statistical Package for Social Sciences (SPSS) version 21. Descriptive statistics (frequencies and percentages) was used to determine proportions of the different factors and how often these were experienced in rural areas.

In this study, dystocia was found to be the most frequently (26.2%) experienced condition, followed by abortion and retained placenta with equal proportions of 23.1%, then downer

cow syndrome (20%). This study also established that 46.15% of the reproductive conditions occurred in cows aged between 4-6 years, followed by cows aged between 1-2 years (38.3 %). On the other hand, body condition score (BCS) did not show any significant differences ($P>0.05$). It was also seen that cows at first calving were mostly (41.1%) affected by reproductive conditions. Cows in this study were reported to be experiencing the conditions for the first time with abortion (100%), retained placenta (50%), dystocia (94%); downer cow syndrome (93.31%) and vaginal prolapse (80%). It was also noticed that the majority of downer cows (61.1%) had Brucellosis. Other reproductive conditions experienced with brucellosis were dystocia (50.0%) and vaginal prolapse (77.8%). The incidences of abortions in this study were found to be significantly higher (60.00%) in Brahman. The cows in the final trimester of pregnancy were mostly *Brucella* negative (74.2%).

The levels of calcium and magnesium in this study were found to be significantly lower than the normal range in all breeds (Afrikander, Bonsmara, Brahman, Nguni, Charolaise, Mixed breed and Drakensberger) with values ranging between 0-3.2 mg/dL and 0.32-0.7 mg/dL respectively. Calcium concentrations were significantly lower ($P<0.01$) than the normal range in downer cow syndrome, dystocia and cows in the last trimester of gestation. Low magnesium concentrations were seen in Afrikander, Brahman and Nguni breed in aborting cows. This study revealed that levels of aspartate amino-transferase (AST) were within normal ranges in most breeds. The mean concentrations of serum urea were within normal ranges (8–20 mg/dL) in all breeds. The concentrations of total bilirubin were above the normal ranges in all breeds, with between 8.25 mg/dL and 10.16 mg/dL. Levels of ammonia were higher than normal ranges, with values ranging between 626.00 mg/dL and 960 mg/dL in this study. Serum concentrations of triglycerides and lipase were found to be lower than normal with values ranging from 0.0 mg/dL and between (45.33 U/L -101.80 U/L) respectively. Serum triglyceride illustrated significant variations ($P<0.05$) only in mixed breed which experienced dystocia, downer cow syndrome and cows in their last trimester of gestation. Results obtained also showed that the mean concentrations of lipase were statistically significant ($P<0.01$) in aborting Afrikander and Nguni breeds. The present study also revealed that the levels of total protein were mostly above the normal ranges in most breeds with values ranging from 25.31 g/dL to 38.25 g/dL. The mean concentrations of cholesterol (CHOL) were all below the normal ranges in Afrikander (2.82 mg/dL), Bonsmara (2.95 mg/dL), Brahman (3.14 mg/dL), Nguni (3.34 mg/dL), Charolaise (1.90 mg/dL) and Drakensberger (2.67 mg/dL).

There were no significant differences in number of parity and whether or not the cows were supplemented. The results in this study show that the majority of cows in communal farming are not supplemented. The levels of disease control in communal farming areas are still lagging behind and this interferes with cow reproduction and production. Competent cattle production in communal farming requires adequate and monitored dietary needs of cows. Optimum herd management strategies are important contributing aspects in ensuring maximum production feedback. Deficiencies of trace minerals such as calcium and magnesium can influence the occurrence of reproductive conditions and impair cow fertility. However, due to the high infection of *Brucella* in these communal areas, it is therefore not easy to conclude that the conditions were as a result of nutritional deficiencies or brucellosis. The study was also limited in terms of formulating a reference parameter which could be used as a tool to predict the possibility of the occurrence of reproductive conditions in this study. It is therefore important to further study the incidences of these reproductive conditions with bigger samples and removing all *Brucella* infected samples so as to rule it out as a cause of these conditions. The results of this study are important and can be used by veterinary practitioners and farmers when dealing with such cow reproductive conditions.

Contents

ACKNOWLEDGEMENTS.....	ii
DECLARATION	iii
ABSTRACT.....	iv
LIST OF ABBREVIATIONS	x
LIST OF FIGURES	xi
TABLE OF CONTENTS.....	vii-ix
LIST OF TABLES.....	xiii
CHAPTER 1:	1-2
11.1. Problem statement.....	2-3
CHAPTER 2:	4
LITERATURE REVIEW	4
2.2. Cattle farming in Southern Africa.....	4-5
2.3. Bovine and reproductive efficacy	5
2.4. Susceptibility to diseases	5-6
2.5. Reproductive conditions and animal health.....	6-7
2.5. Bovine reproductive conditions	7
2.5.1. Retained placenta	7-8
2.5.2. Prolapses and nutrition in bovines	9
2.5.3. Dystocia and bovine reproduction performance	9-12
2.5.4. Abortions and nutrition in bovines	13-14
2.5.5. Downer cow syndrome and nutrition in bovines	14
2.6. Trace minerals and reproduction	16
2.6.1. Mineral requirements and animal health.....	16
2.6.2. Calcium (ca) and reproduction.....	17-18
2.6.3. Phosphorus (P) and reproduction.....	18
2.6.4. Selenium (Se) and reproduction.....	19
2.6.5. Magnesium (Mg) and reproduction	20-21

2.6.6. Copper (cu) and reproduction	21
2.6.7. Iodine and reproduction	21
2.6.8. Iron and reproduction.....	22
2.6.9. Zinc and reproduction	23
2.7. Biochemical serum enzymes in animal health and reproduction.....	24
2.7.1. Total protein (TP) and animal health	25
2.7.2. Creatinine (C) and animal health	25
2.7.3. Aspartate amino transferase (AST) and Creatinine kinase (CK).....	26
2.7.4. Lipase and animal health	27
2.7.5. Cholesterol and animal health.....	27
2.7.6. Urea and animal health	28
2.8. Conclusion	29
CHAPTER 3:	30
MATERIAL AND METHODS	30
3.1. Sample collection and handling.....	30
3.1.1. Working group	30
3.1.2. Study area.....	30
3.1.3. Sample collection.....	31
3.1.4. Sample preparation	31
3.2. Sample analysis.....	31
3.2.1. Rose Bengal Plate Test (RBPT).....	31
3.2.2. Biochemistry (IDEXX CATALYST Dx tm)	32
3.2.3. Questionnaire	32
3.3.4. Statistical analysis.....	33
CHAPTER 4	34
RESULTS	34
CHAPTER 5	81-90

DISCUSSION	81-90
CHAPTER 6:	91
CONCLUSION.....	91
REFERENCES	94
APPENDIX.....	120-127

LIST OF ABBREVIATIONS

1. AST.....Aspartate amino-transferase
2. BCS.....Body condition score
3. BUN.....Blood urea nitrogen
4. CA.....Calcium
5. CHO.....Cholesterol
6. CK.....Creatinine kinase
7. CRE.....Creatinine
8. LIP.....Lipase
9. MG2+.....Magnesium
10. NH3.....Ammonia
11. PHO.....Phosphates
12. TBIL.....Total bilirubin
13. TP.....Total protein

LIST OF FIGURES

Figures	Pages
Figure 3.1: Brucella Rose Bengal Plate Test indicating positive and negative results.....	30
Figure 3.2: Brucella Rose Bengal Plate Test indicating positive and negative results.....	32
Figure 4.2.1: Serum Urea/BUN levels in cows of different reproductive conditions.....	46
Figure 4.2.2: Serum uric acid concentrations in cows of different reproductive conditions.....	48
Figure 4.2.3: Levels of serum calcium (Ca) in cows of different reproductive conditions.....	50
Figure 4.2.4: Serum magnesium (Mg) in cows of different reproductive conditions.....	53
Figure 4.2.5: The association of serum AST in cows of different reproductive conditions.....	55
Figure 4.2.6: The association between serum total bilirubin (TBIL) and different reproductive conditions.....	57
Figure 4.2.7: The association between serum cholesterol and different reproductive conditions.....	59
Figure 4.2.8: The association between serum ammonia and reproductive conditions.....	62
Figure 4.2.9: The association between serum triglycerides (TRIG) and different reproductive conditions.....	64
Figure 4.2.10: The association between serum Lipase (LIPA) and different reproductive conditions.....	66
Figure 4.2.11: The association between serum Creatinine kinase (CK) and cows of different reproductive conditions.....	68
Figure 4.2.12: The association of serum Sodium (Na) and cows of different reproductive conditions.....	71
Figure 4.2.13: The association between serum potassium and cows of different reproductive conditions.....	73

Figure 4.2.14: The association between serum Chloride (Cl) and cows of different reproductive conditions.....	75
Figure 4.2.15: The association between serum Total Protein (TP) and cows of different reproductive conditions.....	78

LIST OF TABLES

Tables	Pages
Table 4.1.1: Frequencies of the type of reproductive condition experienced, treatment given, supplementation status, obtained from farmers in Ngaka Modiri Molema district.....	35
Table 4.1.2: Proportions of different factors affecting cow reproductive performance.....	36
Table 4.1.3: Frequency of reproduction conditions VS selected important factors.....	38
Table 4.2.1: Summary of the serum biochemical profile (Urea, uric acid, calcium, magnesium and AST) in cows affected by reproductive conditions and those in the last trimester of pregnancy in different cattle breeds.....	40
Table 4.2.2: Serum biochemical profiles (Total bilirubin, cholesterol, ammonia, triglycerides) in cows affected by reproductive conditions in different cattle breeds.....	41
Table 4.2.3: Serum metabolites mean concentrations in cows affected by reproductive conditions.....	43
Table 4.2.4: Summary of the association between serum metabolites and reproductive conditions in cows of different breeds.....	44
Table 4.2.5: Least square means ($\pm$ SE) and p-values of serum urea concentration in cow experiencing reproductive conditions.....	45
Table 4.2.6: Least square means ($\pm$ SE) and p-values of serum Uric acid concentration in cow experiencing reproductive conditions.....	47
Table 4.2.7: Least square means ($\pm$ SE) and p-values of serum calcium (Ca) concentration in cow experiencing reproductive conditions.....	49
Table 4.2.8: Least square means ($\pm$ SE) and p-values of serum magnesium concentration in cow experiencing reproductive conditions.....	52
Table 4.2.9: Least square means ($\pm$ SE) and p-values of serum aspartate amino-transferase (AST) concentration in cow experiencing reproductive conditions.....	54

Table 4.2.10: Least square means ($\pm$ SE) and p-values of serum total bilirubin (TBIL) concentration in cow experiencing reproductive.....	56
Table 4.2.11: Least square means ($\pm$ SE) and p-values of serum cholesterol concentration in cow experiencing reproductive conditions.....	58
Table 4.2.12: Least square means ($\pm$ SE) and p-values of serum ammonia concentration in cow experiencing reproductive conditions.....	61
Table 4.2.13: Least square means ($\pm$ SE) and p-values of serum triglycerides (TRIG) concentration in cow experiencing reproductive conditions.....	63
Table 4.2.14: Least square means ($\pm$ SE) and p-values of serum lipase concentration in cow experiencing reproductive conditions.....	65
Table 4.2.15: Least square means ($\pm$ SE) and p-values of serum creatinine kinase (CK) concentration in cow experiencing reproductive conditions.....	65
Table 4.2.16: Least square means ($\pm$ SE) and p-values of serum sodium (Na) concentration in cow experiencing reproductive conditions and those in the last trimester of gestation.....	67
Table 4.2.17: Least square means ($\pm$ SE) and p-values of serum Potassium concentration in cows experiencing reproduction conditions.....	70
Table 4.2.18: Least square means ($\pm$ SE) and p-values of serum chloride (Cl) concentration in cow experiencing reproductive conditions and those in the last trimester of gestation.....	72
Table 4.2.19: Least square means ($\pm$ SE) and p-values of serum total protein (TP) concentration in cow experiencing reproductive conditions.....	74
Table 4.3.1: Association between body condition score and prevalence of reproductive condition.....	77
Table 4.3.2: Association between breed type and prevalence of reproductive condition.....	79
Table 4.3.3: Association between bovine Brucellosis infections and prevalence of reproductive condition.....	80
Table 5.1: Resume of possible breed's correlations to reproductive conditions vs. blood parameters.....	80
Table 5.2: Resume of possible breed's correlations to reproductive conditions vs. blood biochemistry.....	89

Table 6.1: Serological screening results obtained using Rose Bengal test from cows which had aborted.....	90
Table 6.2: Serological screening results obtained using Rose Bengal test from cows which had retained placenta.....	120
Table 6.3: Serological screening results obtained using Rose Bengal test from cows which had prolapsed vaginas.....	121
Table 6.4: Serological screening results obtained using Rose Bengal test from cows which had downer cow syndrome.....	122
Table 6.5: Serological screening results obtained using Rose Bengal test from cows which had dystocia.....	123
Table 6.6: Serological screening results obtained using Brucella Rose Bengal test (BRBT) pregnant cows.....	124

CHAPTER 1

INTRODUCTION

Thirty percent of the planet's ice free surface area is occupied by livestock (Steinfeld et al., 2006). The global livestock sector employs about 1.3 billion people and 600 million are small scale farmers (Thornton et al., 2006). Livestock farming is, therefore, a significant and low risk investment in rural communities (Thornton et al., 2010). Economic growth, social equity, public health and natural resources can be affected both positively and negatively by livestock (World Bank, 2009). Livestock in developing countries is currently one of the most rapidly growing agricultural subsectors, while in developed countries livestock production and consumption are gradually emerging but at high levels (Thornton et al., 2010).

The significance of minerals in livestock nutrition was first recorded in South Africa in 1912 (Theiler, 1912). Communally reared cattle largely rely on browsing and grazing for feed and most of the cattle in rural areas are not supplemented due to low or no financial capabilities among the small scale farmers and this is the case in most areas in Mafikeng. A predisposition towards nutritional deficiencies is then inevitable in such areas and reduced production is consequently experienced. The nutritional qualities of feeds and forage have a huge influence on the reproductive performance of cattle (Bell, 1973). In many rural communities there is an absence of a properly managed grazing system which leads to over grazed fields and eventually feed insufficiency (Ndlovu et al., 2007).

Studies have shown that the situation of feed scarcity is worse during the dry (winter) period when forage quality is also low (Undi, 2003). Animals require mineral nutrients, including several trace elements and vitamins for maintenance of body processes and for successful reproduction (Minson, 1990). According to Mathis and Sawyer (2007) part of the environment and management of any animal is adequate and quality nutrition. Other studies have also reported that the nutritional quality of feeds and forage can have tremendous influence on the reproductive performance of cattle (Bell, 1973).

It has been discovered that reproductive failure may occur due to several reasons, mostly due to ineffective management and poor environment as major contributing factors (Adams, 1999). In addition, even marginal mineral deficiencies can affect growth, reproduction and health of the cattle showing few, if any, clinical signs of deficiency (Kreplin and Yaremicio, 2009). Other reports indicate that mineral deficiencies and imbalance for livestock are

reported from almost all regions of the world (McDowell 1992). Moreover, diseases attributed to mineral origin have been recognised as both deficiencies and toxicities (Barber and Wood 1976). A study by Hall and ZoBell (2010) indicated that minerals such as iron and molybdenum may be naturally present in feeds in levels high enough to reduce animal productivity. On the other hand, minerals such as iodine, selenium, calcium, magnesium, phosphorus and zinc are also associated with the disease conditions of infectious agents (Boyazoglu, 2004). Many minerals have been proven in research studies to be essential for optimal growth, physiological function and productivity in ruminants; furthermore testing for minerals has been performed on diets and/or dietary components to ensure adequate concentration of specific minerals in the diet (Hall and ZoBell, 2010).

Arthington (2008) states that a number of trace minerals such as calcium, iodine, magnesium, phosphorus, selenium and zinc are required in cattle. It has also been noted that feed consumed by cattle may supply most trace minerals in adequate amounts (Minson 1990). A review study of Kreplin and Yaremcio (2009) recommended that producers must be aware of daily changes in the cow's feeds requirements if they want to wean calves from at least 90 per cent of cows exposed to the bull, for instance cows in the last third of pregnancy or those producing milk have special needs and if these needs are not met, reproduction is compromised. Better understanding of processes involved in animal nutrition could also contribute to improved management and maximise production capacity (Battler, 2000).

1.1. Problem statement and justification

Cattle production in communal areas is known and accepted to be low (Ndlovu et al., 2007). Prevalence of high numbers of reproductive disorders is a major constraint to the growth of emerging farmers in communal Ngaka Modiri Molema District. This district is found in a semi-arid area of the North-West Province and has many emerging communal farmers who are facing many production and reproduction challenges in their cattle. Knowledge about the causes of reproductive conditions is essential in initiating proper and sustainable management strategies to improve cattle reproductive performances and increase the overall productivity in communal areas. Bovine reproductive performance of cattle in most rural communities is usually not exactly known. However, there is an increased prevalence of reproductive conditions such as downer cow syndromes, abortion, dystocia, retained placenta and vaginal prolapses in communal areas. This situation affects production growth and keeps most of the communal farmers in poverty which then has a great impact on the country's economy as well as making the farmer prone to financial stagnation. There is therefore a need to conduct

this study so as to address issues such as whether or not reproductive conditions in communal small scale farms occur as a result of nutritional insufficiency. The causes for these conditions in rural areas are in most cases never discovered as many of the cases are not clinically reported. Production is therefore affected as a result of massive losses from reproductive conditions. It is consequently crucial to determine whether or not malnutrition/nutritional deficiencies are the causes of the occurrence of these conditions in communal areas. Knowledge about the causes of reproductive condition is essential in establishing proper and sustainable interventional strategies to improve reproduction efficacy in rural communities. Strategies such as evaluating nutritional and mineral status of cattle in these areas need to be implemented. Farmers should be informed on how to implement suitable methods to improve production. Farmers having acquired the knowledge should be able to devise plans that can reduce or eliminate the prevalence of reproductive conditions in order to improve the general health status of cattle in these areas.

.

Study Aim

This study aimed to evaluate the serum nutritional and mineral levels in bovine presenting with reproductive conditions in order to assist in predicting the occurrence of these conditions and assist animal practitioners to predict any of these conditions.

Specific Objective

- To develop a tool as a reference parameter for each reproductive condition this will assist animal practitioners to predict any of these condition.
- Analyse blood for nutritional content and minerals for each of the reproductive conditions observed in cows of different breeds.
- To advise the veterinary practitioners and farmers on the type of reproductive condition the animal might face if not supplemented for or reared on poor diet.

.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Livestock production in rural areas plays a critical role as a poverty reduction strategy, as it is a major source of income for most communal small scale farmers. According to Dijkman (2009), the impact of smallholder farming on food production and security is still unclear and reports have been made that in the last ten years only a few countries effectively utilised the opportunity to grow. Nevertheless, in previous decades global livestock production has significantly grown (Thornton, 2010). Research shows that income generation is one very prominent force responsible for the substantial increase of livestock product demand (Thornton and Gerber, 2010). It has been estimated that about 75 % of total livestock production growth is generated from small-scale farming systems (Bruinsma, 2003).

Studies report that interference in a cow's normal reproduction capacity can severely affect production (Pradhan and Nakagoshi, 2008). It has been noted that the prevalence of reproductive conditions or metabolic disorders (abortions, dystocia, downer cow syndrome, retained placenta and vaginal prolapses) can greatly reduce production quality and capacity (Algers et al., 2009). Small scale farming practices in developing countries are reported to be responsible for the majority of livestock production (Thornton, 2010). However, in rural farming, cattle rearing practices are mainly on uncontrolled and improperly managed grazing systems which lead to feed insufficiency due to high competition for natural resources and poor production.

2.2. Cattle farming in Southern Africa

Livestock production contributes extensively to the livelihoods of communal farmers in Southern Africa (Ainslie et al., 2002). About half of the 14.1 million cattle in South Africa belong to communal farmers (National Department of Agriculture, 2008). South African livestock production is nearly entirely reliant on indigenous grazing land for fulfilling their nutritional requirements (Ateba and Beighle, 2011). Communal grazing areas are managed under a communal land tenure system where the land resources are utilized by all members of

the community (Delali et al., 2006). It has been recognized that agriculture is an important aspect in poverty reduction (ECA and African Union 2007).

Communal economic growth has been described as a major source of the economies of most small-scale farmers in African countries (Balarane and Oladele, 2012). A study conducted by Schwalbach et al. (2001) indicated that the majority of farmers earn low income per year from their farming activities. A few studies have revealed that the majority of farmers in North-West Province of South Africa have low educational levels and that this aspect also serves as one of the many prominent constraints in cattle production (Mabe et al., 2010). Research conducted by Zhang et al. (2003) indicated that farming literacy information is an essential element in agricultural development programmes although small-scale farmers rarely adopt novel agricultural innovations either because they have no access to such vital information or because it is poorly disseminated, often in a language that they have no access to. It has been confirmed that lack of knowledge, specifically the innovative agricultural practices, is also a limiting factor in cattle production (Menbere, 2014).

2.3. Bovine and Reproductive efficacy

The status of cattle reproductive capacity in most rural communities is still unclear (Ndlovu et al., 2007). However, according to Thornton (2010), reproductive performance of cattle in communal areas is generally low. The association between nutrition and reproductive performance is a subject of increasing interest to producers, veterinarians and nutritional researchers (Pradhan and Nakagoshi, 2008). Management practices, diseases, breeds, nutrition, parity and age at puberty are factors which influence reproductive efficiency (Kanuya et al., 2006; Matiko et al., 2008). Maintaining a satisfactory fertility capacity in cows is essential to optimise pregnancy rate so as to obtain maximum profit (Alam and Sarder, 2010). Adequate and improved feeding is required in enhancing reproductive performance (Jalil et al., 1995; Blache and Martin, 2009). It has been noted that feeding fat to dairy cattle usually improved the risk for pregnancy, although responses have not been consistent (Santos et al., 2009).

2.4. Susceptibility to diseases

During the peri-partum period, the cow's immune system is severely challenged (Goff, 2006). Many studies have shown that the incidence of diseases and disorders can be high during this period and that these have a negative impact on reproductive performance

(Goshen and Shpigel, 2006; Santos et al., 2008). Other researchers have revealed that the deficiency in calcium has an increased incidence of dystocia, downer cow syndrome, retained placentas and prolapsed uterus (Lanyasunya et al., 2005). On the other hand, phosphorus deficiencies have been noted to decrease feed intake, conception rates, ovarian activity, and causes anoestrus (Lopez et al., 2004). It is also important to mention that selenium deficiency predisposes the majority of cows to retained placentas, embryonic deaths, increased metritis, poor fertility and birth of weak calves (Rae, 2002). Studies have indicated that lowered reproductive efficiencies and suppression of disease resistance in cattle are greatly influenced by the deficiencies of copper, zinc, selenium, manganese, vitamin A and E (Stanton et al., 2009). Some studies show that the nutritive value of communal rangelands varies with seasons (Ndlovu et al., 2007). One other important aspect is that during dry seasons, the nutrient content of forage is significantly low when compared to summer forage and that consequently leads to deficiencies in the majority of nutrients which exacerbates the risk of many reproductive conditions (Botsime, 2006). In addition, it has been indicated that rangeland lose nutritive value, the soils lack in mineral content and supplementary feeding becomes a necessity if one is to get good returns from the animals during the dry season in Southern Africa (Raats, 2004; Robb et al., 2008).

2.5. Reproductive conditions and animal health

Normally, there are fundamental physiological processes which take place in the neuro-hormonal system in the uterus of a cow at the end of the pregnancy and these processes are important in preparing the cow for the calving period (Kaczmarowski et al., 2006). However, physiological changes in the neuro-hormonal system can lead to metabolic and immunological disorders (Kornmatitsuk et al., 2000; Farzaneh et al., 2002). According to Azawi (2008) uterine infection implies adhesion of pathogenic organisms to the mucosa, colonization or penetration of the epithelium, and/or release of bacterial toxins that lead to establishment of uterine diseases. Furthermore, the development of reproductive disorders relies mainly on the immune response of the cow; as well as the variation in symptoms with the virulence of the causative organisms and the presence of factors that predispose the cow to disease (Azawi, 2008).

Many studies have shown that the prevalence of uterine infections is regarded to be low in indigenous cattle and may be related to the low incidences of dystocia (Narasimha Rao, 1982; Vale-Filho et al., 1986; Muchenje, 2007). According to Abd Elleh et al. (2014) animal health

is defined as the determination of a disease using clinical examination and different diagnostic tests. Reports have stated that diseases attributed to mineral origin have been recognised as both deficiencies and toxicities (Barber and Wood, 1976). Trace minerals are very important in the health of animals given that their deficiencies reduce the animal's resistance to diseases and increase the risk or susceptibility to reproductive disorders (Yatoo et al., 2013).

2.5. Bovine reproductive conditions

2.5.1. Retained placenta

Retained placenta can be defined as the retention of the foetal membrane after delivery from six to twenty-four hours (Swiefy, 2003). Adequate and regular uterine contractions are required for the physiological release of the placenta after parturition (Akar and Yildiz, 2005). The deficiency in secretions of oxytocin, prostaglandins (PGF₂ α) and serum calcium concentration, which sustain sufficient contraction of the uterus may cause retained placenta, increase the risk of dystocia and delay the involution of the uterus (Hurley and Doane, 1989; Morrow, 1980; Akar and Yildiz, 2005). Stress is also said to be a cause of retained placenta (Kornmatitsuk et al., 2000).

Factors such as selenium deficiency (Ishak et al., 1983), calf birth weight and placental weight (Echternkamp, 1993), delayed involution of the uterus (Swiefy, 2003) have been implicated in the incidence of retained placenta. It has been proven that premature induction of parturition with glucocorticoids and/or prostaglandins increases the cases of placenta retention (Echternkamp et al., 1999). Moreover, retained placenta may be caused by low plasma estrogen concentration (Chew et al., 1978). On the other hand, deficiency in vitamin E and selenium also has an impact on retention of placenta (Ishak et al., 1983).

Studies illustrated that in cattle, calf birth weight and placental weight have been reported to be positively correlated with the incidence of retained placenta (Echternkamp, 1993). A study done by Peters and Ball (1995) proved that placental retention is usually accompanied by delayed involution of the uterus and adversely affects reproductive performance (Swiefy, 2003). According to Correa et al. (1993) dystocia, twinning, stillbirth, negative energy balance (ketosis) and hypocalcaemia may also be associated with increased risk of retained placenta. Furthermore, according to Samad and Islam (1989); Laven and Peters (1996) retained placenta incidence can increase due to dystocia in cows, abortion, forced labour,

delayed gestation, early parturition, uterine atony, infections, and both seasonal and hormonal disorders.

The causes of the lower incidence in the winter season compared to hot season are due to the environmental and nutritional differences, e.g. temperature and concentrate to forage ratio in the diet (Echternkamp and Gregory, 1999). Moreover, seasonal differences in nutrition may influence placental development; placental growth (i.e. mass and net cellular proliferation) in the first half of the gestation period (Ehrhardt and Bell, 1995). Other researchers have proved that cows with reproductive disorders have longer intervals from calving to first service. In addition to reproductive disorders, conception also required more services per conception and lower pregnancy rate and conception to first service (Shiferaw et al., 2005; Han and Kim, 2005). A study conducted by Lucey et al. (1986) revealed that milk yield was suppressed for about 4 weeks after calving with retained placenta.

According to Esslemont and Kossaibati (2002) the incidence of retained placenta among dairy cattle averages around 4% and appears to be worsening in Southern Africa. Other studies reported that vitamin E has been studied in relation to prevention of retained placenta with no clear link found between circulating tocopherol levels and retained placenta (Campbell and Miller, 1998; LeBlanc et al., 2004). Many studies have shown that deficiencies of some minerals induce or predispose animals to retained placenta (Alaçam and Evcil, 2002; Laven and Peters, 1996; Hurley and Doane, 1989). Other reports showed that low serum concentrations of certain minerals such as zinc (Zn), magnesium (Mg) and potassium (K) in cows before parturition might increase the risk of retained placenta (Zang et al., 1999; Akar and Yildiz, 2005). Selenium dependant glutathione peroxidase (GSH- Px) has been found to be associated with the incidence of retained foetal membrane (Brzezinska-Slebodzinska et al., 1994) with low levels in plasma being reported with higher incidence of retained placenta.

A study by Harrison and Conrad (1984) showed that animals supplemented with selenium had no cases of retained placenta whereas the control animals had a 17.4% incidence. D'Aleo et al. (1983) obtained similar results with control cows showing 20% incidence of retained placenta with a low selenium diet against 0% in the supplemented animals. On the other hand, retained placenta is more likely to occur in cows with milk fever as compared to those without milk fever (Abuom et al., 2012). It has been observed in many studies that cows that previously experienced retained placenta have a higher risk of developing retained placentas relative to those that did not encounter it in their previous parturitions (Arthur et al., 1996; Fleischer et al., 2001).

2.5.2. Prolapses and nutrition in bovine

Genital prolapse is a major but not very common reproductive disorder in cattle (Seth, 1970; Ahmed et al., 2005). However, it is regarded as an emergency condition and should be managed before mucosal trauma, contamination fatal haemorrhage and excessive oedema, lead to a grave prognosis (Miesner and Anderson, 2008). It has been noticed that the exact aetiology of uterine prolapse still remains unclear (Noakes et al., 2001a). As stated by Kreplin and Yaremcio (2009) the cause of prolapses in all variations stands indefinite and precise causes have not been identified. It was as well revealed that foods containing oestrogenic substances, such as subterranean clover pasture in Western Australia, soyabean meal, mouldy maize and barley, may result in a high incidence of vaginal (Bennett, 1944; Davis and Bennett, 1959) or uterine prolapse (Noakes et al., 2001a). A study conducted by McDermott (1992) indicated that there is an association between uterine or vaginal prolapses and decreased pregnancy rates.

Several researchers indicated that vaginal prolapse is one of the reproductive conditions responsible for economic losses and imbalance on reproductive efficiency of dairy and beef cows (Marques et al., 1991; Bartolomeun et al., 1997). In addition, reports showed that most of the treated animals with mechanical replacement of organs and suture of vulva became sterile after prolapsed vagina, showing chronic cervicitis (Pandit et al., 1992). A study conducted by Abuom et al. (2012) revealed that the incidence of vaginal prolapse increased during the dry season, which came as a result of poor nutrition leading to loss of body condition, peri-vaginal fat that is important in supporting the uterus and vagina within the pelvic cavity.

2.5.3. Dystocia and bovine reproduction performance

Dystocia refers to abnormal difficulty in giving birth (Kahn, 2005; frame, 2006). Factors influencing dystocia in cattle can be classified into various categories which are direct factors, phenotypic factors related to calf and cow, non-genetic and genetic factors (Gaafar et al., 2011). Some of the direct causative factors include uterine torsion (Sloss and Dufty, 1980; Mee, 2012) and foetal mal-presentations (Meijering, 1984), whereas phenotypic causes include calf birth weight, multiple calvings, prenatal mortality, cow pelvic area, cow body weight, and body condition at calving, and gestation length (Gaafar et al., 2011).

On the other hand, non-genetic factors include, among others, oversized calves (Johanson and Berger, 2003) and retained placenta Mee (2004) which are highly incriminated factors in the

prevalence of dystocia. Additionally, age at calving within parity is said to be one of many factors that highly influence the prevalence of dystocia (Ettema and Santos, 2004). Reports made by Zaborski et al. (2009) revealed that nutritional insufficiency had an effect on dystocia. It was as well noted that dystocia can occur when a cow does not experience normal parturition due to weakness, stress, or hormonal abnormalities (Gaafar et al., 2011).

While risk of dystocia is greater in very young or very old heifers, between two and three years of age, age at first calving has no effect on risk of dystocia (Meijering, 1984). Studies stated that uterine inertia is whereby the cervix is fully dilated but uterine contractions are too weak to expel the foetus, it is then associated with approximately 10% of all dairy cattle dystocia, primarily in older cows (Sloss and Dufty, 1980). On the other hand, fat mobilisation in over-fat heifers can reduce magnesium availability and calcium mobilisation leading to uterine inertia and prolonged stage two of calving (Gaafar et al., 2011).

2.5.3.1. Dystocia and nutrition in bovines

Several studies have implicated dystocia as a contributing factor to reduced milk yield (Berry et al., 2007) and poorer fertility (Lopez de Maturana et al., 2007). Little is known about the effects of nutrition in early gestation on placental development or birth weight of calves (Hickson et al., 2006). However, according to Zaborski et al. (2009) nutrition has an effect on the prevalence of dystocia. It is also said that manipulating feeding levels during pregnancy offers an alternative method for manipulating the birth weight of calves (Gaafar et al., 2011).

Most published data on the adverse effects of under or over feeding on calf birth weight and dystocia originate from beef cattle studies (Freetly et al., 2000). Studies with dairy heifers and older cows have shown little effect of maternal nutrition during the last month of gestation on calf birth weight or dystocia (Sorge, 2005). It is also important to point out that severe nutritional restriction during the last trimester, to the extent that the cow loses body condition, leading to reduced placental, foetal weight and pelvic area may induce dystocia. This can result in dystocia and stillbirth due to uterine inertia and inadequate relaxation of the pelvic ligaments (Grunert, 1979; Gearhart et al., 1990).

2.5.3.2. Effect of body weight on bovine dystocia

Studies show that the probability of dystocia ascends by a 13%/kg increase in birth weight (Johanson and Berger, 2003). According to Meijering (1984) the two primary determinants of calf oversize are, in order of importance, calf birth weight and maternal pelvic size with these

two factors accounting for 5 and 10% of the phenotypic variance in dystocia, respectively. While underweight (weighing <260 kg) Holstein-Friesian heifers at service are at significantly greater risk of dystocia and the risk of calving assistance and dystocia also tends to increase in overweight (>360 kg at breeding) heifers (Drew, 1986).

Research has shown that overfeeding during the last trimester, to the point that dam body condition score is increased can result in foetal oversize and excess adipose deposition in the birth canal in heifers with consequent dystocia and stillbirth (Mee, 2012). It is important to mention that an excess of or inadequate body condition in Holstein-Friesian heifers at calving is a significant risk factor for increased incidence of calving assistance and dystocia (Drew, 1986). Studies have shown that within the pre-calving body weight range of 520-600 kg and body condition ranges 2.75-3.50, differences in dystocia rate were not reported in first calving Holstein-Friesians (Carson et al., 2000).

2.5.3.3. Foetal mal-position and the incidence of dystocia

According to Mee (2012) there are different forms in which a calf can be abnormally positioned during pregnancy among which includes posterior mal-presentation, foreleg mal-posture, breech mal-presentation or cranial mal-posture which tends to be the most frequent abnormal foetal positions, respectively. Another study conducted by Mee, (1991a) reveals foetal mal-position occurs at a low prevalence (<5%). However, Meijering (1984) showed that foetal mal-presentation is the most common cause of dystocia in older cows accounting for 20 to 40% of cases. Mee (1991a) reported that mal-presented calves have a twice higher risk of dystocia and a five-time higher risk of stillbirth.

It has also been noted that an abnormal foetal position has a low heritability and essentially zero repeatability (Holland et al., 1993; Mee, 2012). Abnormal foetal position is most influenced by multiple births which have a four-time higher risk (Mee, 1991b), predominantly if unilateral (Mee, 2012). The other risk factors for twin ovulations including previous twinning can have five times higher risk, (Mee, 1991b). On the other hand, reports have stated that parity might get at three-time higher risk in older cows while season, herd, and high dry matter intake and high milk production (Mee, 1991b). Furthermore, foetal mal-position is influenced also by sire, breed of sire, gender with males have a twice higher risk, parity up to two-time higher risk in older cows, and foetal mortality (Holland et al., 1993; Mee, 2012).

2.5.3.4. Effects of animal housing and the prevalence of dystocia in bovines

Studies have related dystocia to the type of housing: higher dystocia rates in dairy cows have been reported in tie stall housing (Bendixen et al., 1986) though not in all studies (Ostojic-Andric et al., 2011). Higher dystocia may possibly also be due to inadequate exercise, mobility and psychological stress (Mee, 2012). Concerning the possible variations among management systems, health and welfare, including calving performance, tend to be better in rich pasture compared to a confinement system (Olmos et al., 2009; Mee, 2012). However, it is not just the management system but the management of the system which is also critical to calving success (Vasseur et al., 2010).

Tie stalls were used as the main calving facility by 51% of producers in a recent Canadian study which revealed that this type of housing is an incriminated factor in the prevalence of dystocia (Vasseur et al., 2008). Moreover, confinement in calving pens compared to a yard or pasture has also been associated with increased dystocia in beef heifers (Dufty, 1981) and cows (McDermott et al., 1992). In addition, calving in confined facilities has been linked with increased beef calf morbidity (Sanderson and Dargatz, 2000).

2.5.3.5. Production and reproduction capacity in dystocia cows

Cows which experience dystocia are more likely to experience dystocia at a subsequent calving (Mee et al., 2011). A study conducted in Canada illustrated that among reproductive disorders cows face during the peripartum period, dystocia has the greatest effect on future cow fertility (Bonneville-Hebert, et al., 2011), through increased risk of retained placenta and metritis may also be observed (Hosseini-Zahed and Ardalani, 2011) in addition to the effects on cow culling (Sewalem et al., 2008) and on stillbirth (Mee, 2004). A study conducted by Lopez de Maturana et al. (2007) showed that dystocia resulted in impaired fertility for the reason that it decreased the incidence of success at first insemination by 12%. Additionally, reports showed that the effect of dystocia differed significantly, implying a delay in the pregnancy periods of the cow (Gaafar et al., 2011). A study conducted by Berry et al. (2007) revealed that milk yield was less in cows that experienced dystocia at calving compared with those that did not.

A vital observation was made showing that in order of descending financial importance, dystocia in confinement systems impacts production (41% of costs), fertility (34%) and cow and calf morbidity and mortality (25%), excluding costs associated with increased culling, veterinary costs and other management costs (Dematawewa and Berger, 1997). One other

critical aspect is that production losses are greatest in high yielding cows and in early lactation, possibly associated with reduced dry matter intake (Newby et al., 2010). Concerning animal health, dystocia also increases the likelihood of calf respiratory and digestive disorders (Eaglen et al., 2011; Lombard et al., 2007; Oltenacu et al., 1988). It is also fundamental to include the fact that when the costs associated with the interrelated sequelae of dystocia are included, the total cost of dystocia is four-times greater than treatment costs alone (Oltenacu et al., 1988).

2.5.4. Abortion and nutrition in bovines

According to Kreplin and Yaremicio (2009) the incidences of abortions often result from an event that occurred weeks to months before the actual event, and the cause is probably invisible at the time of abortion itself. Studies have often stated that many causes are never discovered, and most abortions occur in the winter (Forar et al., 1996; Nadia et al., 2013). It was proven that mycotic infections (caused by mycotoxins) are a common cause of abortion in individual animals, causing in some 3 to 10 percent of all abortions (Williams, 2012). In terms of transmission, the infection may pass through the placenta and into the foetus, so plaques or crusts of fungus develop on the skin of the foetus (Hurchkinson, 2009). It was found that in about 25% of abortions, fungus invades the foetus, and red or white rings and worm-like lesions are seen (Anderson et al., 2000).

A study also showed that if the foetus remains in the uterus for any length of time after death, these lesions may no longer be visible. In addition, the afterbirth may be retained, causing even more problems (Humam, 2014). A study of Akar and Yildiz (2005) reported that nutritional deficiency is considered to be one of the most important factors in non-infectious abortion in cows and heifers. Moreover it is implicated in the development of abnormalities in the foetus and embryonic death in the early period of gestation. It has been discovered that most ruminants commonly experience reproductive failure due to early embryonic mortality which is associated greatly with nutritional deficiency during the mating time (Dunne et al., 2000; Boland and Lonergan, 2013). While the ultimate symptom of a negative consequence of nutrition on fertility may be the fatality of the embryo, it is not completely clear if nutrition affects embryo quality through changing the developmental capacity of the oocyte or through changes occurring during embryo development (Boland and Lonergan, 2003).

For diagnosis purposes, culturing the organism from aborted tissues may be used (Kreplin and Yaremicio, 2009). However, a study done by Hurchkinson (2009) demonstrated that in

about 70% of abortions, the cause cannot be determined even with careful laboratory examination. Additionally, Anka et al. (2014) also showed that most causes of abortion are never discovered and most abortions occur in the winter (Forar et al., 1996; Nadia et al, 2013).

Enjalbert et al. (2006) conducted a large case-control study of 2000 dairy and beef herds and found increased probabilities of abortion and prenatal mortality in selenium (Se) deficient herds. In earlier reports, aborted fetuses from western Canada had, on average, lower Se status than non-aborted fetuses (Orr and Blakely, 1994; Waldner, and Van De Weyer, 2011). According to Wiltbank (1961), losses from abortions and stillbirths are the most important determinants of economic failure. Moreover, the inadequate supplementation of a ration with iodine, selenium, copper and zinc may also induce abortion in the advanced stage of gestation in cows (Bedwal and Bahuguna, 1994; Graham 1995; Alaçam and Evcil 2002). A study done by Waldner and Van De Weyer (2011) indicated that aborted fetuses with selenium deficiency had lesions of cardiac failure than in fetuses aborted without these lesions.

2.5.5. Downer cow syndrome and nutrition in bovines

According to Ménard and Thompson (2007), downer cow syndrome is a condition whereby the animal is unable to rise to a standing position. Moreover, this condition commonly occurs during the early postpartum period and this is a major concern in dairy farms worldwide (Kalaitzakis et al., 2010). Studies revealed that animals developing this condition mostly show in the peripartum period changes in tissue metabolism, nutrient utilization, and disruptions in the functioning of the immune system (Kimura et al., 2006). In addition, the initial stages of uterine involution, in preparation for the subsequent reproductive cycle occur at this time (Abuom et al., 2012). Several studies have confirmed that downer cow syndrome is mostly as a result of hypocalcaemia and energy imbalance (Radostits et al., 2000).

Additionally, downer cow syndrome has also been reported to be more common in cows than in heifers (Kutanaee et al., 2014). Cows that experience downer syndrome are often hypocalcaemic (Fleischer et al., 2001; Houe et al., 2001; FitzGerald, 2011). Many studies have indicated that hypocalcaemia may result in myometrial fatigue and delays cervical involution, both of which could predispose bovines to uterine prolapse (Odeggaard, 1977; Murphy and Dobson, 2002; Roberts, 2004). Moreover, hypocalcaemia may predispose the cows to other post-parturient disorders such as fatty liver, ketosis, metritis, injuries to the

birth canal, nerve paralysis and mastitis which are more prevalent in older cows (Goff et al., 1997). Studies have demonstrated that just prior to or after calving, the cow shows symptoms including loss of appetite, reduced body temperature and anxiety (Houe et al., 2001). It has been illustrated that as the condition progresses, the cow becomes unable to rise and if no treatment is given, the majority of the afflicted cows eventually die (Hibbs, 1950; Orpin and Esslemont, 2010). Other important consequences include impaired rumen function and depressed feed intake which have been implicated in the predisposition of subclinical hypocalcaemia (Hansen et al., 2003). It is important to note that the prevalence of hypocalcaemia at calving causes the cow to be susceptible to several other diseases due to effects of low calcium ion concentrations on the immune functions and muscle contractions (Reinhardt et al., 2011; Kimura et al., 2006).

According to Lean et al. (2006) feed compositions with high phosphorus content given to cows during the dry period have been reported to increase the risk of milk fever development by to 6-9 times. Hence, in order to minimize the incidence of milk fever related losses, communal farmers in Southern Africa should be educated on appropriate feed formulations based on their animal's reproduction stage (Kimura et al., 2006). Another important aspect that should be given high consideration is that the level of susceptibility varies according to the age and level of lactation of the animal (Abuom et al., 2012). It is also necessary to note that all cows require close monitoring around calving for early signs of parturient paresis (Kreplin and Yaremcio, 2009).

The onset of lactation is related to the development of milk fever, probably because calcium is one of the most abundant minerals in cow's milk and the concentration of calcium in colostrum is almost double that in milk later in lactation (Tsioulpas et al., 2007a). Moreover, milk fever, or parturient paresis, is second only to mastitis in terms of the number of veterinary treatments in Sweden (Swedish Dairy Association, 2010). It has been shown that monitoring the blood mineral status is an important part of downer cow management and other effective strategies that prevent milk fever. These strategies are significant in decreasing downer cow syndrome (Agger and Renney, 2004).

According to Menzies et al. (1992); McEvoy, (1994); Menzies (1994) if a cow with hypocalcaemia does not respond to calcium therapy, potassium, phosphorus and magnesium should be given as additional treatments pending the results of laboratory tests. Studies indicate that maintaining satisfactory fertility in cows is essential for successful farming (Ghosh et al., 2001). Many studies have made recommendations for trace element supplementation which initially focus on the prevention of reduced productivity and clinical

signs of deficiency, but the role of trace elements in immunity has been emphasised in further studies which have been reviewed recently (Gaylean et al., 1999; Spears, 2000; Enjalbert et al., 2006). Other researchers stated that supplementation of complete trace minerals is an inexpensive insurance and is well worth the cost (Iopez-Alonso, 2008). Downer cow syndrome is one of many constraints of production in communal farming in Southern Africa due to lack of proper and sustainable feeding plans.

2.6. Trace minerals and reproduction

It has been proven in research studies that minerals are important for the functioning of various anatomical and reproductive components (Andrieu, 2008). Other studies have shown that mineral deficiencies and imbalances for livestock are reported from almost all regions of the world (McDowell, 1992). On the other hand, optimal nutrition, with adequate trace mineral levels, guarantees proper functions of the organism, among which the most important are structural, physiological, catalytic, and regulatory (Suttle, 2010). Studies have stated that requirements for minerals are hard to establish and most estimates are based on the minimum levels required to overcome a deficiency symptom and not necessarily to promote productivity (Close, 2006). Assessment of trace mineral status is considered a priority in the farm guide of good practices (Roderick and Hovi, 1999).

As indicated by Terpiłowska and Siwicki (2011) deficiencies in protein, energy, vitamins, and minerals (trace minerals) are known to compromise immune functions as well as reducing disease resistance, thereby increasing the susceptibility to diseases (Spears and Weiss, 2008). Then again trace elements are known to improve growth (Gressley, 2008; Hesari et al., 2012) and production (Gressley, 2008; Siciliano-Jones et al., 2008; Spears and Weiss, 2008). Moreover, feed intake, digestibility and feed conversion which improves production may be increased by trace minerals (NRC, 2001). However, subclinical deficiencies of minerals are by definition hard to diagnose, and the definition of a subclinical deficiency is often based on normal values of minerals in, for example, plasma (Goff et al., 1996).

2.6.1. Mineral requirements and animal health

According to Underwood (1996) requirements for minerals are hard to establish and most estimates are based on the minimum level required to overcome a deficiency symptom and not necessarily to promote productivity. Moreover, the determination of mineral

recommendations must take into consideration the quantity and type of raw ingredients as well as their inherent mineral content, the processing of the diet, the storage and environmental conditions, and the inclusion and content of other minerals (Kreplin and Yaremcio, 2009). It has also been reported that adequate nutrition before calving and during post-partum period is essential if acceptable oestrus and rebreeding performance are to be achieved (Alam et al., 2001). It is important to emphasise that during the dry season, the grasses that stand in the rangeland lose nutritive value and the soils lack in mineral content to the extent that supplementary feeding becomes a necessity if one is to get good returns from the animals (Raats, 2004). It is also important to consider that in order to meet the nutritional requirements of cattle growth and development, supplementation with macro minerals including calcium (Ca), phosphorus (P) and magnesium (Mg) is recommended (Odenya et al., 1992).

In spite of the potential benefit from the use of supplementary feeds during the dry period, the majority of livestock farmers in South Africa do not make full use of this knowledge and as a result suffer major losses in production (Ndlovu et al., 2007). The study by Kreplin and Yaremcio (2009) recommended that knowledge of daily changes in cow's feed requirements is also an issue of great importance which producers should consider. Studies have shown that minerals such as iron may be naturally present in feeds at levels high enough to reduce animal productivity (Hall and ZoBell, 2010). According to Arthington (2008), a number of trace minerals such as calcium, iodine, magnesium, phosphorus, selenium and zinc are required in cattle. Furthermore, trace minerals are also associated with the disease conditions of infectious agents (Boyazoglu, 2004).

2.6.2. Calcium (Ca) and reproduction

Calcium (Ca) is the most abundant mineral in the body and 99% is found in the skeleton; however, a small proportion of the body calcium that lies outside the skeleton is important for survival (Suttle, 2010). Some researchers (Shukla et al., 1983; Zhang et al., 1992) reported that a low serum Ca concentration plays an important role in the development of retained placenta in cows, while others (Lotthammer 1983; Mutiga 1993) found that the Ca concentration was at the physiological level, indicating that Ca has virtually no role in the development of retained placenta. Carson et al. (1978) investigated the high incidence of dystocia, retained placenta and puerperal metritis in a dairy herd and the study revealed that when these animals were fed a ration enriched with supplemental bone meal for the previous

3 months the incidence of dystocia was reduced from 75% to 10%, the retained placenta rate from 35% to 8% and the puerperal metritis rate from 70% to 10%. However, bone meal is no longer accepted in bovine nutrition (Hendriks et al., 2002).

The serum Ca concentration in these cows was reported to increase from 8.98 mg/dl to 10.26 mg/dl with this type of diet. It is also important to consider that the ratio of calcium to phosphorus should be maintained between 1.5:1 and 7:1 to avoid an imbalance (Wright, 2012). It has been proven in studies that plasma or serum concentrations of calcium can be used to diagnose the subclinical form of hypocalcaemia and cut-off points at total calcium levels of 2.0 mM (Reinhardt et al., 2011) and 1.88 mM (Goff et al., 1996) have been suggested. Dairy cows are most commonly found with such levels soon after calving (Reinhardt et al., 2011). A study by Darmono and Sudibyo (1990) indicated that even if calcium levels increased in aborting cows due to *Brucella* infection, Mg levels decreased and such a difference might occur due to the effect of *Brucella*.

According to Penner et al. (2008) adaptation to the new requirements starts immediately, with increases in parathyroid hormone and calcitriol, even if that is the case, plasma concentrations of ionised calcium may decrease to a level where milk fever develops. It was reported that hypocalcaemia is a predisposing factor for several other peri-parturient diseases, such as retained placenta, ketosis and mastitis (Correa et al., 1993), and may have a negative influence on milk yield (Rajala-Schultz et al., 1999). Milk fever is usually accompanied by increased concentrations of plasma magnesium (Klimiene et al., 2005; Larsen et al., 2001). Other studies revealed that cows suffering from milk fever usually have equal or higher levels of parathyroid hormone than healthy cows (Horst et al., 1978). Moreover, cows of certain breeds, e.g. Jersey cows, and cows in high parities have an increased risk of developing milk fever (Roche and Berry, 2006), whereas heifers rarely experience milk fever.

2.6.3. Phosphorus (P) and reproduction

In South Africa, phosphorus (P) has been recognized as a nutrient which is a major production constraint in range cattle in several parts of semi-arid communal areas and osteomalacia, which may be presented as stiffness, may be clinically observed due to the insufficiency of phosphorus in the diet (Bakunzi et al., 2012). In addition, the effects of phosphorus supplementation during summer and winter remain uncertain, but due to the low nutritional value of pastures during winter, most farmers intensively supplement (De Waal and Koekemoer, 1997).

The following recommendations were made by NRC (1984): a 30 g P/day (0.27% of diet dry matter (DM)) 550 kg lactating cow requires 30 g P/day (0.27% of diet dry matter (DM)) while a 19.5 g P/day (0.2% of diet DM) in a pregnant cow is required. According to De Brouwer et al. (2000) the requirement for phosphorus is directly proportional to an increase in production. In accordance with Du Toit et al. (1940) who conducted a study on the mineral content of natural pasture, in many parts of South Africa, the phosphorus content is not sufficient for utmost cattle production. Furthermore, a craving of sick cattle for the bones of dead animals on the South African veldt led to the identification of phosphorus deficiency in cattle (Theiler, 1912). Another researcher stated that phosphorus has more known functions in the animal body than any other mineral; it is required for bone and tissue development, energy utilization and milk production (Abrams and Atkinson 2003).

According to Nix (2002) phosphorus is commonly referred to as the “fertility” mineral. Phosphorus deficiency was discovered in some classic research during the early part of the century (Theiler, 1927). Reports show that phosphorus deficiency can severely affect reproductive performance and may be expressed as delayed puberty (associated with poor appetite and growth rate) and increased number of services required per conception (Kreplin and Yaremci, 2009). According to Erickson et al. (2002) one of the greatest challenges is controlling phosphorus (P) inputs and outputs in cattle feeding, mainly in communal farming areas. Furthermore, meeting phosphorus requirements for cattle (not reducing or exceeding intake) can act as a method of reducing phosphorus mismanagement (Erickson et al., 2002). A study done by Hadžimusić and Krnić (2012) indicated that there is a greater need for phosphorus by cows than that provided by plants contained in the animal diet, and this is a direct consequence of low values of this mineral in the soil composition.

2.6.4. Selenium (Se) and reproduction

Selenium is an important component of enzyme systems and interacts with vitamin E to prevent tissue damage (Atli, 2012). In addition, selenium (Se) is the trace mineral that gets the most attention in Alberta, Canada, because selenium toxicity can also be a problem. Moreover, levels at which selenium can be added to feeds are regulated due to the narrow range between deficiency and toxicity (Kreplin and Yaremci, 2009). Nonetheless, selenium deficiency has been associated with significantly reduced fertility in affected cattle, a higher than expected number of retained placentas, occasional abortions, premature or weak calves, reduced ability to resist disease and “white muscle disease” in calves (Crandell, 2013).

Studies have revealed that selenium in foodstuffs occurs predominantly in the amino acids seleno-methionine and selenocysteine, whereas the majority of supplemental selenium is fed in the selenite forms (Whanger, 2002). Numerous studies have shown the retention of the seleno-methionine form, as found in selenium yeast, to be greater than the inorganic sources, both in tissues and in blood (Pehrson et al., 1999; Givens et al., 2004).

A review of 13 studies also showed that where selenium was administered or fed, only 10% of cows had retained placenta versus 32% of the control animals and 28% of animals that received a Vitamin E supplement (Harrison and Hancock, 1999). Other reviews that were made indicated that Vitamin E and selenium supplementation of dairy cows facilitates retained placenta risk reduction, concluding that supplementing diets with both or either alone could reduce the risk of retained placenta and the number of services per conception in the selenium fed animals tended to be lower (1.54 versus 2.05) Mee (2004).

2.6.5. Magnesium (Mg) and reproduction

According to Blaine et al. (2014) magnesium is the second most abundant intracellular divalent cation. Moreover, several enzymes rely mainly on intracellular magnesium to regulate metabolism (Mahon et al., 2003). Intracellular magnesium is also significant in nerve transmission (Wang et al., 1994). Studies have shown that there are two mechanisms in which magnesium in adult ruminants can be absorbed which include the one dependent on the potential difference over the rumen epithelium and is the major mechanism of transportation when magnesium concentrations are low (Blaine et al., 2014). The other mechanism is that in which magnesium can be transported over the epithelium independent of the potential difference (Martens and Schweigel, 2000).

Other studies have revealed that insufficient magnesium absorption retards the cow's ability to activate the magnesium stored in the bones, which is necessary in maintaining cellular magnesium levels and in the intracellular fluid (Kronqvist, 2011). On the other hand, the low potassium concentration inhibits magnesium uptake while rumen ammonia content influences the uptake of magnesium (Jittakhot et al., 2004a; Blaine et al., 2014). It is also noticed that during calving, the magnesium content increases with the decrease in plasma calcium level (Goff et al., 2002), while the amount of magnesium required for reproduction is at least 30 per cent higher than the requirement for growth (Kreplin and Yaremcio, 2009). Furthermore, a deficiency in magnesium seriously affects reproductive performance: cows with magnesium

deficiency do not show heat, have decreased conception rates, higher abortion rates and low birth weight calves (Donna, 1994).

In addition, calves are generally born weak and may be deformed with twisted legs and enlarged joints (Kreplin and Yaremicio, 2009). According to Mayland (1988) measuring magnesium plasma concentration can be used to diagnose hypomagnesaemia, where 0.74 mM has been suggested to be a cut-off point. However, some researchers suggest that total magnesium in plasma is not always decreased at magnesium deficiency, and that the ionised magnesium level in plasma provides a more accurate measure of the magnesium status (Speich et al., 1981; Arnaud, 2008). According to Kronqvist (2011) the condition of hypomagnesaemia or low blood magnesium content can also be referred to as winter tetany, grass staggers and grass tetany depending on the circumstances in which it may occur. A study also showed that severe association of hypomagnesaemia and tetany may result in death due to low magnesium levels in the cerebrospinal fluid (McCoy et al., 2001).

2.6.6. Copper (Cu) and reproduction

Copper is an essential trace element that has been recognized for many decades and has also been found to have an influence on normal growth, production and reproductive performance (Hart et al., 1928). Some reports have shown that connective tissues, red blood cells and key enzymes in the body need copper (Lee, 1999). Copper deficiency has similar effects on reproduction as other mineral deficiencies which include delayed puberty and poor fertility (Gadberry, 2004). Other indications of copper deficiency incorporate repeat breeding and a higher than expected number of retained placentas (Kreplin and Yaremicio 2009). According to Jones and Suttle (1983) a relationship between Cu and immune function has been shown by decreased natural resistance to infection in animals that were copper (Cu) deficient. Reports by Jones and Suttle (1983) also support a relationship between Cu status and disease susceptibility.

2.6.7. Iodine and reproduction

Regulating the metabolic energy rate in the body through the thyroid hormones thyroxine (T₄) and triiodothyronine (T₃) is an essential function of iodine (NRC, 2000). As stated by Miller et al., (1988) the absorption of dietary iodine occurs at proportions of about 70 and 80 percent as iodide and abomasal re-secretion takes place in the rumen, while a greater re-absorption of iodide occurs in the small and large intestine. On the other hand, the thyroid

gland takes a large amount of iodide for the synthesis of thyroid hormone and iodine can also be lost by excretion in urine (NRC, 2000). According to the ARC (1980) the required iodine in cattle is not well known but measuring the rate of secreted thyroid hormone has been used to estimate iodine requirements.

Researchers have indicated that the feeds content of iodine rely mainly on the availability of iodine in the soil (NRC, 2000). According to NRC (1980) the amount of iodine tolerable in the diet is 50 mg/kg. Other studies have revealed that cattle need iodine for the formation of two hormones that are produced by the thyroid gland which are important in the control of the body's metabolic rate (Nelson, 1985). It has also been noted that high nitrate feeds decrease the uptake of iodine in the digestive tract (Wyngaarder and Wright, 1952). It is also important to note that the deficiency symptoms include poor conception rates, abortions, longer gestation periods and the birth of dead, weak or hairless calves (Taylor, 1996).

Other studies have also shown that retained placenta, reduced reproduction in cows characterized by irregular cycling, low conception rate are some of the signs observed in iodine deficiency (McDowell, 1992). Moreover, a lack of iodine reduces growth rate, milk production and feed consumption (Donna, 1994). Other signs include delayed puberty and ruminants frequently do not show signs of heat (Zimmermaan, 2000). It is also necessary to mention that goitre can result from severe deficiency of iodine (Felig, 2001). Other important studies have shown that grazing on pastures containing many plants belonging to Brassica spp. (i.e., kale, forage rape, cabbage or turnips) can also cause goitre by interfering with iodine utilization (Kreplin and Yaremicio 2009).

2.6.8. Iron and reproduction

Iron is essential in all mammals for the maintenance of biological processes such as transport of oxygen and enzymatic transfer of electrons (Andrews, 2005). According to McDowell (1992), a number of enzymes in mammals either carry or are activated by iron. It was revealed that haemoglobin contains above fifty percent of the bodily iron content (NRC, 2000). Studies also revealed that transferrin (TF) cycle is a very important process through which cellular iron uptake happens in many tissues (Hentze et al., 2004). On the other hand, transferrin (TF) is an abundant plasma protein that binds two iron atoms with extremely high affinity and it functions to keep iron soluble, thus preventing precipitation of Fe^{3+} ions out of aqueous plasma. Conclusively, iron needs to be bound to TF in circulation (Andrews, 2005; Lieu et al., 2001).

As mentioned in studies, the most important sources of iron in cattle are water and soil ingestion and the amount of iron present in forage is said to be less than supplemental iron (NRC, 2000). One researcher reported that reproductive performance of iron deficient animals may be badly affected due to anaemia, reduced appetite and lower body condition (Kumar et al., 2011). In foetal development, iron export is mediated by cells of the extra embryonic visceral endoderm and placental syncytiotrophoblasts (Lieu et al., 2001). According to Andrews (2005), during pregnancy the intra-placental transfer of iron occurs and it plays a very important role in the development of the foetus, and for this reason iron deficiency can be implicated in foetal mortality. A deficient animal becomes a repeat breeder and requires an increased number of inseminations per conception and occasionally may abort (Kumar et al., 2011). Other clinical signs that may be seen during iron deficiency include anaemia (hypochromic microcytic), pica, pale mucus membranes, reduced feed intake and weight gain (Bremner and Dalgarno, 1973).

It was noted that calves in confined housing and those which are mainly fed milk are highly susceptible to iron deficiency, furthermore the prevalence of iron deficiencies are also most common in highly parasite infested areas due to chronic blood loss (NRC, 2000). According to McDowell (1992), in instances where there is not blood loss, the amount lost in faeces and urine is very little. The NRC (1980) indicated that toxic amounts of iron predispose to metabolic acidosis, hypothermia, diarrhoea, weight reduction and low feed intake. An estimated 1,000 mg Fe/kg has been indicated to be the acceptable concentration required for feeding (National Research Council, 2000).

2.6.9. Zinc and reproduction

Research studies show that zinc (Zn) is an important component of many essential enzymes and it functions to activate some enzymes. Moreover, several enzyme processes such as the metabolisms of nucleic acid, protein, carbohydrate, the normal functioning and development of the immune system all require zinc in order to occur (Hambidge et al., 1986). Factors such as soil zinc, plant species and maturity affect the forage zinc content (Minson, 1990). A study done by the NRC (2000) indicated that the zinc content in grass is lower than in legumes. The toxicity of zinc results from the administration of an amount greater than the normal requirement, which is 500 mg/kg (National Research Council, 1980). A study conducted by Graham et al. (1994) showed that the serum zinc concentration in aborting cows was lower than in those not aborting and insufficient zinc in feeds played an important role in the loss of

the foetus. It is also seen that Zn deficiency may result in reduced vitamin A utilization and signs of a vitamin A deficiency may be seen. In addition, high calcium and phosphorus levels decrease zinc absorption from the intestine (Kreplin and Yaremcio, 2009). Furthermore, Zn deficient animals have been shown to have lower concentrations of FSH and LH (Boland, 2003). Many studies have revealed that in cattle, the following signs are seen as a result of severe zinc deficiency: listlessness; excessive salivation; feed inefficiency; swollen feet with open parakeratotic lesions that are most severe on the legs, neck, head, and around the nostrils; failure of wounds to heal; alopecia reduced growth, reduced feed intake, reduced testicular growth and scaly lesions (NRC, 2000).

2.7. Biochemical serum enzymes in animal health and reproduction

In veterinary medicine, the analysis of biochemical blood parameter is an important metabolic profile test in cows (Oetzel, 2004). The significance of blood biochemical parameter in the assessment of animal health has been strongly emphasised by many researchers (Nozad et al., 2011). Examination by determining the levels of biochemical blood metabolites is an aspect of great importance in diagnosing metabolic disorders in cattle herds (Oetzel, 2004, Mordak and Nicpoń, 2006). According to Magnus and Lali (2009) total protein, serum albumin, serum globulin, serum calcium, Alanine amino transferase (ALT), Aspartate aminotransferase (AST), urea/BUN and creatinine are amongst the important serum biochemical parameters in assessing herd health status. A study carried out by Ndlovu et al. (2007) indicated that compared to body mass or condition, cattle nutritional status can frequently be measured more precisely by assessing levels of important serum metabolites such as glucose, cholesterol, creatinine, total proteins, albumin, globulin, non-esterified fatty acids, blood urea nitrogen and minerals.

Dampney et al. (2014) stated that total protein, albumin, globulin, creatinine and urea function to provide indication for protein status. On the other hand, physiological status of an animal, season, age, nutrition and breed are factors which may affect blood metabolite levels (Ndlovu et al., 2007). However, alterations in concentrations of nutrient-sensitive metabolites in circulation are important indicators of ovarian function and animal metabolic status (Wettemann et al., 2003; Dampney et al., 2014). It is important to note that serum enzyme activity in healthy cows is either lacking or low (Ndlovu et al., 2007). Careful considerations also need to be taken concerning the fact that the nutritional status of animals requires proper monitoring to obtain improved production and high marketability (Chimonyo et al., 2000).

2.7.1. Total protein (TP) and animal health

According to Kreplin and Yaremicio (2009) proteins are the essential building blocks of most tissues and the in most animal feed rations they serve as the second limiting nutrient. Studies have also revealed that lowered overall conception rate, reduction of the conception rate to first insemination, increases the number of days open and delayed first ovulation or oestrus may result from excessive feeding of rumen degradable proteins (Tamminga, 2006). According to Ndlovu et al. (2007) precise protein status cannot be measured by use of a single metabolite. Instead a combination of different blood levels of creatinine, albumin, total protein and blood urea nitrogen (BUN) are utilized so as to determine protein content.

Furthermore, in nutritional status assessment blood albumin and total protein have low variability. Consequently a high diagnostic value is observed in both of them in contrast to its high variability as a low diagnostic value is found in blood creatinine. As stated by Agenas et al. (2006) serum albumin has 16 days of turnover and is therefore made a very sensitive and early indicator of dietary protein status. Titgemeyer and Loest, (2001) showed that a high disease predisposition is encountered in cases of protein deficiency due to the impairment of both cell mediated and humoral immunity. Studies have indicated that during protein insufficiency, reduced levels of albumen and total protein may be observed as they are indicators of the presence of protein (Le Banh, 2006).

Research studies have revealed that total protein (TP) is known to increase due to dehydration, chronic inflammation and para-proteinaemia, also it decreases due to over hydration, severe congestive heart failure, protein losing nephropathy, protein losing enteropathy, haemorrhages, burns, dietary protein deficiency, mal-absorption and some viral conditions (Merck Veterinary Manual, 2010). Moreover, total protein (TP) and albumin reflect availability of protein and their concentration decline in the face of protein deficiency (Ndlovu et al., 2007). A study conducted by Otto et al. (2000) revealed that elevated concentrations of protein tend to be more available in non-lactating non-pregnant cows. Blood albumin content is usually lower at birth and later increases; on the other hand the availability of total protein in mature animals is higher compared to that in younger animals (Doornenbal et al., 1988; Otto et al., 2000).

2.7.2. Creatinine (C) and animal health

Creatinine is known as a muscle metabolism waste product which is mostly excreted by kidneys and its serum concentration is used in renal function as an index (Venkatapathy et al.,

2014). In addition, it is a large molecule, with high molecular mass (MW 113Da and molecular radius of 3.2 °A) maintained at invariable plasma levels by kidneys increases due to renal dysfunction, ruptured bladder, blocked urethra and it also decreases due to sample deterioration (Merck Veterinary Manual, 2010). It is revealed in studies that serum creatinine evaluation is an important test used to assess renal function (Duncan et al., 2001). On the other hand, in clinical practice the concentration of serum creatinine can also be described as a measure of the rate of glomerular filtrate (Ronald et al., 1992).

In relation to reproduction, the impact of creatinine on blood urea makes it very important due to the positive influence that it has on fertility (Butler, 2000). However, according to Butler (1998), fertility can be negatively affected by very high levels of creatinine. Normally serum creatinine ranges from 0.6– 1.5 mg/dL while salivary creatinine ranges between 0.05– 0.2 mg/dL (Jenkins, 1978; Venkatapathy et al., 2014). It has been recognised that blood creatinine increases due to the kidney's inability to excrete it during renal failure (Guyton and Hall, 2006). In addition, the kidney also displays reduced lipid solubility consequently under normal circumstances due to its physical structure or composition it is incapable of easily diffusing across the cells and the rigid intercellular link of the salivary gland (Lamb et al., 2006).

However, in the diseased state possibly there is an alteration in the permeability of the salivary gland cells (Ivanovski et al., 2012). Moreover in kidney disorders, elevated serum creatinine levels produce a concentration gradient that facilitates increased diffusion of creatinine from serum in to saliva (Venkatapathy et al., 2014). According to Ronald et al. (1992) changes in metabolic creatinine, renal handling and the measurement of methodological interferences affect creatinine serum concentrations.

2.7.3. Aspartate amino transferase (AST) and Creatinine kinase (CK)

According to Otto et al. (2000) aspartate amino-transferase (AST) enzymes are proper indicators of damage of soft tissues and they are found in various organs, predominantly liver and cardiac muscle. Reports have indicated that high blood variability cause liver enzymes (AST, CK, ALT or AST) to attain a low diagnostic value for nutritional status (Ndlovu et al., 2007). Other studies revealed that aspartate aminotransferase (AST) contain in red blood cells is able to escape to blood plasma with no indications of the destruction of red blood cells (Abutarbush and Radostits, 2003). In a study conducted by Ndlovu et al. (2007) it was

revealed that during rainy season elevated amount of AST are observed as compared to low level seen in dry season.

Creatinine kinase (CK) is the classical muscle enzyme increase significantly in rhabdomyolysis (Merck veterinary manual, 2010). Moreover, CK is an important enzyme in tissue energy metabolism which has fluctuating and high energy requirements (Kunz, 2001). In animal production creatinine kinase can generally act as a marker for muscle damage and physical stress (Radostits, et al., 2000; Brawn et al., 2008). Cellular injury, heart and liver damage can also be indicated by creatinine kinase (Zhang et al., 2010).

Abutarbush and Radostits (2003) stated that AST is directly proportional to the amount of creatinine kinase (CK) produced in large amounts in many reproductive conditions. In addition, muscle dystrophy can result from selenium and Vitamin E dietary deficiency; moreover muscle enzymes such as AST and CK are usually used as diagnosis (Ndlovu et al., 2007). As indicated by Stull et al. (2007) in terms of muscle damage creatinine kinase may also be high in cows with hypocalcaemia.

2.7.4. Lipase and animal health

According to Afonso et al. (1999) lipases are a subclass of enzymes involved in hydrolysis of an ester. Moreover, Girod (2000) indicated that lipases in living organisms play important roles in processing, transporting and digestion of dietary lipids (e.g. triglycerides), through their involvement in a number of biological processes including metabolism of triglycerides in diet and cell signalling (Spiegel et al., 1996). Studies show that high levels of triglycerides (TRIG) are predominantly seen at calving and the TRIG accumulation is greatly influenced by depressed feed intake. Furthermore, removal of feed in animals during or shortly after calving may result in fatty liver (when animal goes off feed for 24 hours) which can concurrently be seen with other disorders including hypocalcaemia, metritis, mastitis and abomasal displacement (Merck veterinary manual, 2015). Additionally, high level of lipase in blood is called hyperlipasemia which may result from pancreatitis, increased tumors of the pancreas, gallbladder infection and kidney failure (Hamilton, 2013).

2.7.5. Cholesterol and animal health

According to Guzel, and Tanriverdi (2014) cholesterol is a lipid or fat structure which circulates in the bloodstream and it is essential for life. Furthermore, Dampney et al. (2014) states that cholesterol is a type of fat or lipid found in all cells of the body; it is also a

fundamental factor in many metabolic processes such as production of hormones (e.g. sex hormones) and building important parts of cells (cell membrane). Studies have shown that there is a twice higher risk of reproductive disorders, diabetes mellitus and cardiovascular disease due to obesity which results from increased cholesterol levels (Ahmad et al., 2004). It is important to point out that there is a positive correlation between lowered cholesterol concentration and improved reproduction in repeat breeder cows (Kumar, 2014). Cholesterol has also been reported to increase due to fatty meals, hepatic or biliary diseases, Cushing disease and hypothyroidism; however it may decrease during severe cases of liver dysfunction (Merck Veterinary Manual, 2010). Studies have verified that low cholesterol levels lead to lowered concentrations of plasma insulin growth factor and inhibition of ovulation (Maciel et al., 2001). According to Hansen et al. (2014) cholesterol levels may decrease with the stage of lactation. Conversely, it has been revealed that high dietary cholesterol levels are very influential in the occurrence of cardiovascular diseases (Faye et al., 2015). In addition, cholesterol levels in silage mixed rations are high compared to the concentration of cholesterol in natural grassland (Barlowska et al., 2011).

2.7.6. Urea and animal health

Blood Urea Nitrogen (BUN) has been defined as a small molecule that equilibrates between plasma and the reproductive tract (Canfield, 1990). Moreover, blood urea nitrogen plus creatinine concentration, aid as good indicators of protein metabolism and both play a critical role in kidney function (Dampney et al., 2014). In ruminant rations urea can be used as a replacement for protein portions (Ehrenberg et al., 1891). According to Kertz (2010) urea is converted into protein by the rumen and reticulum microorganisms. Studies have proven that BUN consumption can be maintained by reduced protein levels and high levels of starch in a diet (Allen and Miller, 1976; Kertz, 2010).

On the other hand, an excess of urea in the blood stream has been linked to the development of high blood pressure in certain patient populations (Merck veterinary manual, 2010). Also cows with low concentrations of creatinine and higher levels of plasma urea encounter delayed ovulation (Dampney et al., 2014). A study conducted by Greenwood et al. (2002) indicated that during dry periods, energy requirements in the body can be replaced by the process of protein catabolism which results in increased urea concentrations in the blood Magnus and Lali (2009) stated that low serum urea nitrogen may be seen in animals with post-partum metritis. According to Quiroz-Rocha et al. (2009) low serum urea concentration

during the postpartum period may be seen due to reduced feed intake resulting from reduced ammonia absorption, leading to disturbance in urea recycling in the rumen. Studies show that low energy diets with high protein content increase blood urea concentration which is a risk for lipomobilization (Oetzel, 2004; Park et al., 2010). Feed which is high in crude protein increase plasma urea concentrations which decrease conception rate at first service (Canfield, 1990).

High levels of urea and ammonia also have harmful effects on both embryo and oocyte development (Ocon and Hansen, 2003). During periods of malnutrition foetal urea concentrations increase (Mellado et al., 2004). Increased usages of urea supplementation have occasionally been associated with still births and abortions (Rhoads et al., 2006). A study done by Ryley and Gartner (1970) revealed that serum levels of urea increase the probability of abortion incidences. A study done by Kertz (2010) showed that retained placenta were significant ($P < 0.05$) in urea feeding trial 2, and abortion rate was greater ($P < 0.05$) for cows in the 1.8% urea treatment in trial 1.

2.8. Conclusion

Reproductive conditions are subject to several factors such as management and some postpartum diseases. Some of these factors can be predicted by analysing serum metabolites and other trace minerals from blood samples obtained from pregnant cows. This study aimed to look into these parameters to assess the health status of different herds, so as to inform animal producers on reproductive conditions which might occur and ways to prevent them in future.

CHAPTER 3

MATERIAL AND METHODS

3.1. Sample collection and handling

3.1.1. Working group

In this study the blood samples were collected with the assistance of the Mafikeng state veterinarians and the large animal station workers at the North-West University animal hospital. Convenient sampling was applied. Sampling was done in areas around Ngaka Modiri Molema District in the North-West Province. Blood samples were collected from cows with reproductive conditions such as dystocia, vaginal prolapses, downer cow syndrome, retained placenta and those that have aborted and cows in the final trimester of pregnancy.

3.1.2. Study area

The study was conducted Local Municipality of Mafikeng, found in the North-West Province. It is located on South Africa's border with Botswana.

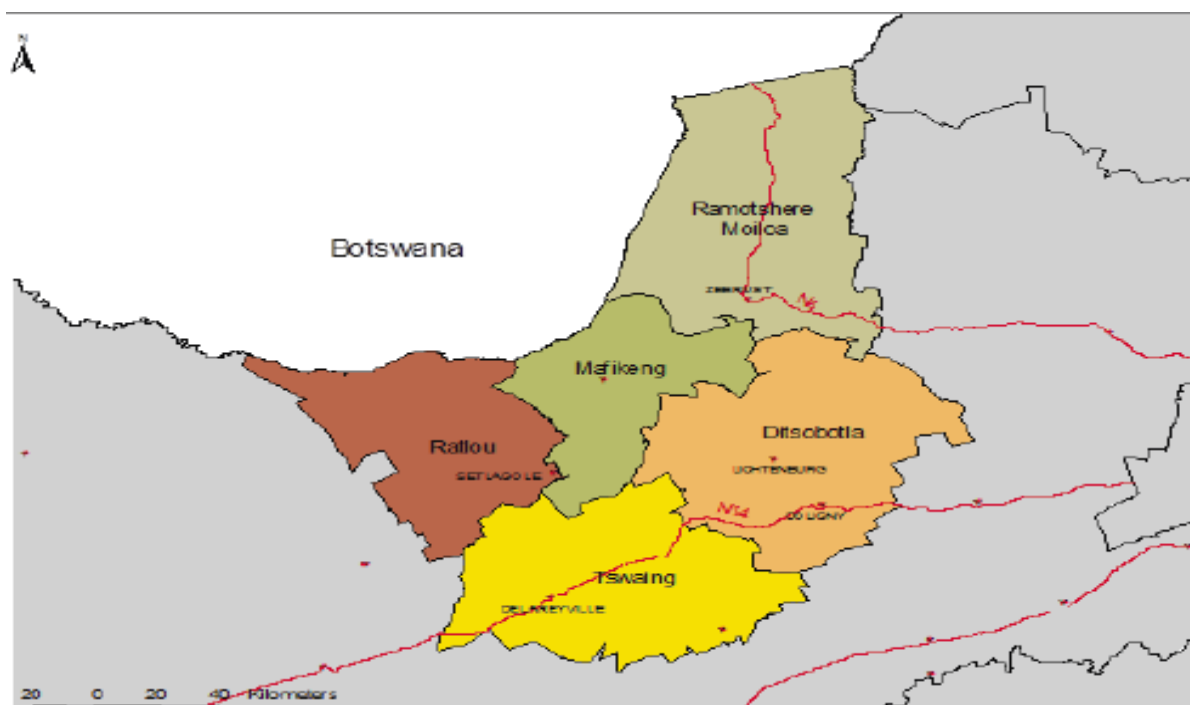


Figure 3.1: The map of Mafikeng Local Municipality, Ngaka Modiri Molema District of North-West province (Adegboye and Babalola, 2013).

The total area of the Mafikeng Local Municipality is approximately 3 703 square kilometres. A study of Matsane and Oyakale (2014) indicated that the area is divided into 28 wards consisting of 102 villages and suburbs. The coordinates are 25°51'S and 25°38'E. The main economic activity in the Ngaka Modiri Molema District of the North-West Province is agriculture, mainly producing crops and cattle. According to Materechera (2011), the climate in the study area is typical semi-arid savannah with a mean annual summer rainfall of 500mm. Temperatures in this area range from 17° to 31°C (62° to 88°F) in the summer and from 3° to 21°C (37° to 70°F) in the winter (Balarane and Oladele, 2012) .

3.1.3. Sample collection

In this study, a total of n=108 samples were collected from all cases of reproductive conditions such as downer cow syndrome, dystocia, retained placenta, vaginal prolapse and abortion reported to the North-West University teaching hospital between June 2012 and June 2015. Structured questionnaires were also issued to the farmer and animal owner. Red stoppered tubes were used to collect blood samples from cows. Approximately 10mL of each blood sample was collected from the jugular vein of each cow in a plain vacutainer tube (Neary et al., 2014). Each sample was labelled using codes describing the specific condition that the animal had. Samples were then stored in ice and transported to the animal health laboratory at the North-West University Mafikeng Campus for analysis. In addition, samples were also collected from cows in their last trimester of pregnancy.

3.1.4. Sample preparation

In this study, serum was obtained by centrifuging blood at a speed of 1000–1500 revolutions for 10 minutes under room temperature after 2 hours of collection to allow clotting and obtain clear serum (Silberová et al., 2010). Serum was then frozen at –20°C until analysis; storage temperature was maintained not exceeding –18°C as recommended by Zima et al. (2007).

3.2. Sample analysis

3.2.1. Rose Bengal Plate Test (RBPT)

To rule out brucellosis, all samples were analysed using Brucella Rose Bengal Test. 30µL of RBPT antigen and 30µL of the test serum were added together on a microtiter plate, and mixed thoroughly (Salman and El-Nasri., 2012). The plate was shaken for 4 minutes and the

plate was viewed on an x-ray light, then the degree of agglutination reactions was recorded. The samples were classified positive if any agglutination was observed and negative if there was no agglutination.

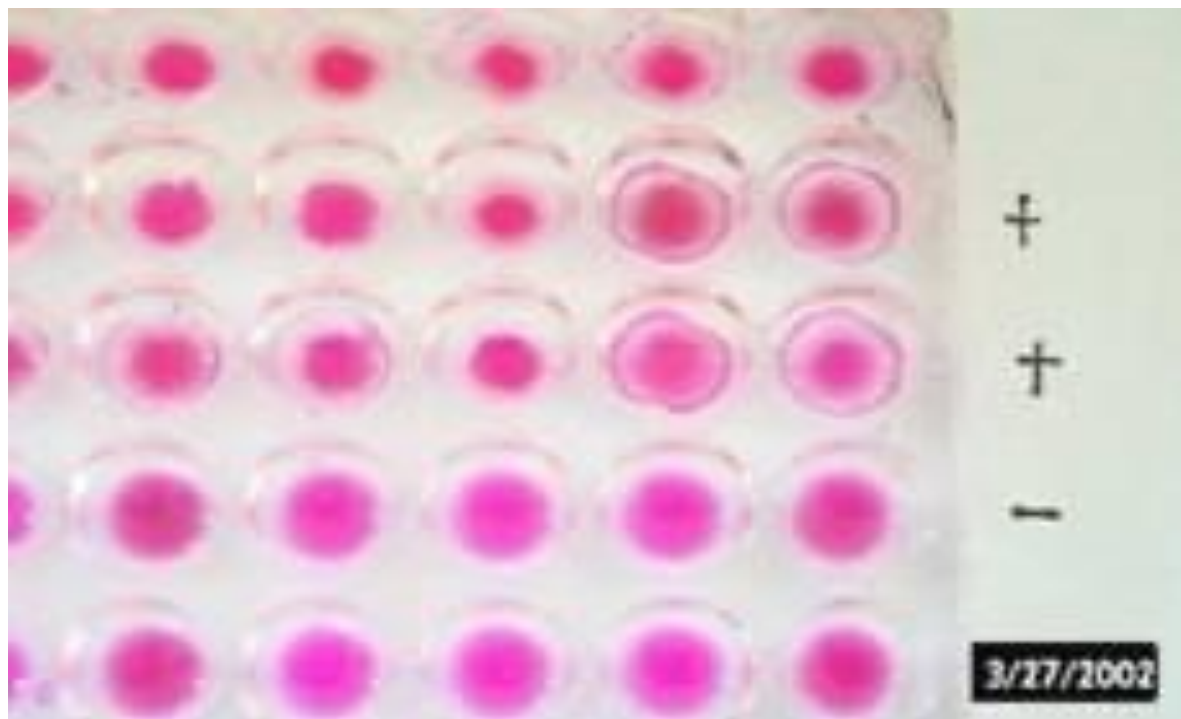


Figure 3.2: Brucella Rose Bengal Plate Test indicating positive and negative results

Source: (www.arc.agric.za/arc-ovi/Pages/Diagnosis-of-bacterial-diseases-.aspx)

3.2.2. Biochemistry (IDEXX CATALYST Dxtm)

All samples were analysed for blood chemistry test using the IDEXX CATALYST^{DX} chemistry analyser according to the manufacturer manual's instructions (IDEXX Laboratories Inc., 2010). The procedures were performed in order to determine different concentrations of minerals and to obtain a general blood chemistry profile (serum metabolites).

3.2.3. Questionnaire

In this study, structured questionnaires were used to collect data from 65 farmers in Ngaka Modiri Molema District of the North-West Province. Farmers were interviewed during farm visits and at community outreach programmes organized by North-West University Animal

Health Department. The questions they were asked included the type of conditions that their cows had experienced, age of the cow, breed, the body condition score, incidences of the condition, parity, whether or not the cows supplemented, whether or not there was any treatment given to the cows prior to the condition and medical history. The data from completed questionnaires were coded, captured and analysed using Statistical Package for Social Sciences (SPSS) version 21. Descriptive statistics (frequencies and percentages) were used to determine proportions of the different factors and how often they are experienced in rural areas. Chi-Square test was used to determine the association between dependent and independent variables.

3.3.4. Statistical analysis

Mean concentrations of blood collected from animals that showed signs of abortion, retained placenta, downer cow syndrome, vaginal prolapse and dystocia were collected at the same time with the control (healthy) at final trimester of pregnancy. Data were analysed statistically in SAS (version 20) using the analysis of variances techniques (ANOVA). The results are expressed as means $\pm$ SEM. The different treatments were significant if the associated P-value was less than the alpha level established (i.e. $P < 0.05$). Correlation analysis was performed by Pearson chi-square to see if there is an association between reproductive conditions, breed types and blood chemistry between the experimental groups (cows experiencing reproductive conditions and those in the final trimester of pregnancy).

The data was analysed using PROC GLM of Statistical Analysis System (SAS) Institute (2015) with the following model: $Y_{ijk} = \mu + C_i + e_{ijk}$

Where:

Y_{ijk} = dependant variable

μ = population mean

C_i = effect of the i^{th} treatment (condition)

e_{ijk} = error term.

CHAPTER 4

RESULTS

The aims and objectives of this study were to identify the major causes of the occurrence of bovine reproductive conditions and based on the blood and biochemical results obtained in each condition, to come up with a formula in order to predict the possibility of the occurrence of a particular condition.

Data obtained from this study were from the analysis of responses attained from farmers to whom questionnaires were administered and from the results established after analysis of serum sample analysed in the laboratory. Results obtained are represented below.

4.1 Results of the survey conducted with farmers whose cows experienced reproductive conditions

Results obtained from the analysis of data on reproductive conditions of cows in Ngaka Modiri Molema district between June 2012 and June 2015, showed that of all conditions experienced during the collection period, dystocia (26.2%) was the most common followed by retained placenta and abortion both with equal proportions (23.1%). In addition, data showed that 20% of the conditions were downer cow syndrome, while only 7.7% of the cows had vaginal prolapses. In general, 93.8% were not given any treatment prior to the condition. The survey also showed that the majority (81.5%) of cows were not given any supplement.

Table 4.1.1 Frequencies of the type of reproductive condition experienced, treatment given and supplementation status (Obtained from farmers in Ngaka Modiri Molema District).

VARIABLES	FREQUENCY	%
Condition		
Downer cow syndrome	13	20
Abortion	15	23.1
Retained placenta	15	23.1
Dystocia	17	26.2
Vaginal prolapse	5	7.7
Cows given treatment		
Yes	4	6.2
No	61	93.8
Supplementation		
Yes	12	18.5
No	53	81.5
Feeding system		
Natural grazing	65	100
Medical history		
Yes	1	1.5
No	64	98.5

N=65 (number of farmers interviewed)

Results obtained in this study also revealed that 46.15% of the reproductive conditions occurred in cows aged between 4-6 years, followed by cows aged between 1-2 years at 38.3 % (Table 4.1.2). It was also noticed that 61.3% of animals monitored had a body score condition (BSC) ranging between 2 and 3.

With regard the breeds, this study showed that Afrikander (33.8%) followed by Brahman (27.7%) and 13.8% for mixed breed were in that order affected by the reproductive conditions (Table 4.1.2). It is important to mention that 41.1% of affected animals experienced the condition at first calving.

TABLE 4.1.2 Proportions of different factors affecting cow reproductive performance.

VARIABLES	FREQUENCIES	%
Age		
1-3 years	23	38.3
4-6 years	30	46.15
7-10 years	12	18.46
Body condition score (Bcs)		
2-poor	13	20
3-good	41	63.1
4-very good	11	16.9
Breeds		
Brahman	18	27.7
Mixed breed	9	13.8
Nguni	6	9.2
Bonsmara	6	9.2
Afrikander	22	33.8
Drakensberger	2	3.1
Charolaise	2	3.1
Parity		
1 st	27	41.1
2 nd	19	29.2
3 rd	9	13.8
4 th	6	9.2
5 th	1	1.5
6 th	2	3.1
8 th	1	1.5
Number of incidences		
1 st	58	89.2
2 nd	3	4.6
3 rd	4	6.2

N=65 (number of farmers interviewed)

A closer look at the results among different conditions showed that there was correlation ($P \leq 0.05$) between the age and cows developing reproductive conditions (Table 4.1.3). It was seen that cows with abortion (1-3yrs) at 60%; retained placenta (4-6 years) at 60%; dystocia (4-6 years) at 60%; downer cow syndrome (1-3 years) at 53.85% and vaginal prolapse (4-6yrs) at 41.18% were significantly different (Table 4.1.3).

A significant correlation was also noted between selected breeds and reproductive conditions (Table 4.1.3). Abortion was noted at 60% in Brahman while 53.33% and 41.18% of

Afrikander had retained placenta and dystocia respectively. Vaginal prolapses were mostly observed in Brahman and Afrikander at 40% respectively. However, the occurrence of downer cow syndrome was evenly distributed among different breeds (7.99% - 23.08%) but this condition was not observed among Bonsmara (Table 4.1.3). The results obtained in this study showed that most reproductive conditions occurred between the 1st and 2nd parity. However, dystocia and retained placenta were mainly observed in cows at 7th and 8th parity respectively (Table 4.1.3).

Animals from which samples were collected showed the condition for the first time (Table 4.1.3) with 100% for those having abortion; 50% for retained placenta; 94% for dystocia, 93.31% for downer cow syndrome and 80 % vaginal prolapse (Table 4.1.3). However, retained placenta seems to occur more than once in the same cow with 13% of animals showing it for the 3rd time (Table 4.1.3). It was also noted from the data obtained through the questionnaire that most animals that showed the conditions were not attended to nor supplemented with mineral or other foods (Table 4.1.3). Amongst all variables tested only the breed ($P<0.001$) and age ($P=0.024$) showed significant variations in the reproductive conditions experienced.

TABLE 4.1.3 Frequency of reproduction conditions vs. selected important factors

REPRODUCTIVE CONDITIONS					
VARIABLE	Downer cow syndrome (%)	Abortion (%)	Retained placenta (%)	Dystocia (%)	Vaginal prolapse (%)
Age (P<0.0001)*					
1-3 years	53.85*	60.00*	13.33	40.00	29.41
4-6 years	38.5	33.33	60.00*	60.00*	41.18*
7-10 years	7.67	6.67	6.67	0.00	29.41
Breed (P=0.0245)*					
Brahman	23.08	60.00*	13.33	11.76	40.00*
Nguni	7.69	13.33	13.33	5.88	0.00
Bonsmara	0.00	6.67	13.33	17.65	0.00
Afrikander	23.08	13.33	53.33*	41.18*	40.00*
Drakensberger	0.00	6.67	0.00	0.00	20.00
Charolaise	15.38	0.00	0.00	0.00	0.00
Mixed breed	30.7	0.00	6.67	23.53	0.00
BCS (P=0.3718)					
2-poor	30.77	7.69	26.67	23.53	0.00
3-good	69.23	21.95	60.00	58.82	80.00
4-very good	0.00	45.45	13.33	17.65	20.00
Parity (P=0.5438)					
1 st	38.46	46.67	40.00	41.18	40.00
2 nd	46.15	26.32	6.67	29.41	40.00
3 rd	7.69	33.33	20.00	5.88	20.00
4 th	7.69	0.00	20.00	11.76	0.00
5 th	0.00	0.00	6.67	0.00	0.00
6 th	0.00	0.00	0.00	11.76	0.00
8 th	0.00	0.00	6.67	0.00	0.00
Incidence (P=0.3251)					
1 st	93.31	100.00	50.00	94.12	80.00
2 rd	7.67	0.00	6.67	5.88	20.00
3 th	0.00	0.00	13.33	13.33	0.00
Treated (P=0.6811)					
Yes	7.69	6.67	0.00	11.76	0.00
No	92.31	93.33	100.00	88.24	100.00
Supplemented (P=0.21)					
Yes	7.69	6.67	13.33	17.65	0.00
No	92.31	93.33	86.67	82.35	100.00
Medical history (P=0.58)					
Yes	0.00	0.00	0.00	25.00	7.81
No	20.31	23.44	23.44	5.88	0.00

Statistical significance ($P \leq 0.05$), *indicates ($P < 0.05$)

4.2 Evaluation of biochemical serum metabolites in relation to the prevalence of various reproductive conditions in bovines

Results from the serum biochemistry analysis obtained in this study revealed that in all breeds (Afrikander, Bonsmara, Brahman, Charolaise, Drakensberger and Nguni) the levels of urea in serum were generally within normal ranges (8–20 mg/dL) (Table 4.2.1). However, a correlation was seen in all breeds and the level of uric acid with the level being above the normal range in all breeds (Table 4.2.1). In addition, the level of calcium and magnesium were also significantly lower than the normal range in all breeds with values ranging between 0-3.2mg/dL and 0.32 and 0.7 MEq/L respectively. However, a normal range of magnesium was observed in mixed breed cows with a mean of 1.8 MEq/L (Table 4.2.1). It was also seen that the levels of aspartate amino-transferase (AST) were within normal range in most breeds (Table 4.2.1). On the other hand, AST levels in Charolaise and Drakensberger breeds were very low 0.0U/L (Table 4.2.1).

Table 4.2.1 Summary of the serum biochemical profile (Urea, uric acid, calcium, magnesium and AST) in cows affected by reproductive conditions and those in the last trimester of pregnancy in different cattle breeds.

Parameters and normal ranges (AIBM Laboratory reference , 2015)	Breed	LS Means	Standard Error
Urea (8–20 mg/dL)	Afrikander	6.16	0.817
	Bonsmara	10.9	
	Brahman	3.25	
	Charolaise	10.35	
	Drakensberger	3.067	
	Nguni	4.176	
Uric acid (3.0–7.0 mg/dL)	Afrikander	45.33	5.11
	Bonsmara	49.50	
	Brahman	39.07	
	Charolaise	30.50	
	Drakensberger	43.00	
	Nguni	35.37	
	Mixed breed	4.81	
Calcium (8.6–10.2 mg/dL)	Afrikander	1.66	3.21
	Bonsmara	1.93	
	Brahman	3.20	
	Charolaise	0.78	
	Drakensberger	0.00	
	Nguni	1.43	
Magnesium (1.7-2.2 mg/dL)	Afrikander	0.32	0.08
	Bonsmara	0.70	
	Brahman	0.44	
	Charolaise	0.46	
	Drakensberger	0.38	
	Nguni	0.46	
	Mixed breed	1.80	
	Afrikander	0.32	
Aspartate amino-transferase-AST (10–40 U/L)	Afrikander	25.31	5.56
	Bonsmara	38.25	
	Brahman	36.00	
	Charolaise	0.00	
	Drakensberger	0.00	
	Nguni	29.10	

LS Mean- Least square means

Results obtained in this study showed that the concentrations of total bilirubin were all very high above the normal ranges in all breeds having values of between 8.25 mg/dL and 10.16 mg/dL (Table 4.2.2). It was also noted that the cholesterol levels were all in the normal ranges (Table 4.2.2). However, the levels of ammonia were above normal ranges with values between 626.00 mg/dL and 960 mg/dL (Table 4.2.2). In addition, it was observed that in all breeds the serum concentrations of triglycerides and lipase were lower than normal with ranges (45.33 U/L -101.80 U/L) (Table 4.2.2).

Table 4.2.2 Serum biochemical profiles (Total bilirubin, cholesterol, ammonia, triglycerides) in cows affected by reproductive conditions in different cattle breeds.

Parameters and normal ranges (AIBM Laboratory reference , 2015)	Breed	L S Means	Standard Error
Total bilirubin (0.3–1.0 mg/dL)	Afrikander	9.212	2.29
	Bonsmara	8.25	
	Brahman	10.16	
	Charolaise	6.00	
	Drakensberger	5.33	
	Nguni	8.90	
Cholesterol (<225 mg/dL)	Afrikander	2.82	0.37
	Bonsmara	2.95	
	Brahman	3.14	
	Charolaise	1.90	
	Drakensberger	2.67	
	Nguni	3.34	
Ammonia (40–70 µg/dL)	Afrikander	794.36	46.31
	Bonsmara	626.00	
	Brahman	793.81	
	Charolaise	960.00	
	Drakensberger	718.67	
	Nguni	676.9	
Triglycerides (40- 200 mg/dL)	Afrikander	0.00	19.34
	Bonsmara	0.00	
	Brahman	0.00	
	Charolaise	0.00	
	Drakensberger	0.00	
	Nguni	0.00	
Lipase (10- 150 U/L)	Afrikander	70.73	8.23
	Bonsmara	52.50	
	Brahman	93.70	
	Charolaise	63.50	
	Drakensberger	45.33	
	Nguni	101.80	

LS Mean- Least square means

The results also showed that the creatinine kinase levels were within normal ranges (30-135 U/L) (Table 4.2.3). However, there was a significant correlation observed in sodium and potassium levels which were lower than the normal ranges except for Brahman (143.49 mEq/L) and Nguni (3.597 mEq/L) which were found to be above the normal ranges (Table 4.2.3). The levels of chloride were higher than normal ranges in Afrikander (106.17 mEq/L), Charolaise (106.17 mEq/L) and Nguni (107.50 mEq/L) breeds (Table 4.2.3). It was also observed that the chloride levels were within the normal ranges in Bonsmara, Brahman and Drakensberger (Table 4.2.3). The study also revealed that the levels of total protein were above the normal ranges in most breeds.

Table 4.2.3 Serum metabolites mean concentrations in cows affected by reproductive conditions

Parameters and normal ranges (AIBM Laboratory reference , 2015)	Breed	LS Means	Standard Error
Creatinine kinase (30-135 U/L)	Afrikander	0.375	6.33
	Bonsmara	0.00	
	Brahman	5.519	
	Charolaise	0.00	
	Drakensberger	0.00	
	Nguni	0.00	
Sodium (136–145 mEq/L)	Afrikander	147.14	2.87
	Bonsmara	286.50	
	Brahman	143.49	
	Charolaise	150.00	
	Drakensberger	147.00	
	Nguni	146.25	
Potassium (3.5–5.0 mEq/L)	Afrikander	5.15	0.51
	Bonsmara	5.03	
	Brahman	6.41	
	Charolaise	6.40	
	Drakensberger	7.13	
	Nguni	3.597	
Chloride (Cl)- (98-106 mEq/L)	Afrikander	106.17	2.34
	Bonsmara	103.00	
	Brahman	105.00	
	Charolaise	106.17	
	Drakensberger	104.67	
	Nguni	107.50	
Total protein (TP)- (5.5–9.0 g/dL)	Afrikander	25.31	5.56
	Bonsmara	38.25	
	Brahman	36.00	
	Charolaise	0.00	
	Drakensberger	0.00	
	Nguni	29.10	

LS Mean- Least square means

It was observed in this study that levels of urea, magnesium, aspartate aminotransferase (AST), total bilirubin, lipase and potassium were significantly different ($P<0.05$) in the incidences of reproductive conditions (Table 4.2.4). However, the study revealed that breed types were significantly different ($P<0.05$) in all parameters (Table 4.2.4). On the other hand, the association of breed $\times$ condition showed significant variations ($P<0.05$) of total protein, lipase, potassium and calcium (Table 4.2.4). Significant correlation was also seen ($P<0.05$) in the levels of aspartate aminotransferase, total bilirubin and urea ($P<0.05$).

Table 4.2.4 Summary of the association between serum metabolites and reproductive conditions in cows of different breeds

Parameter	Condition	Breed	Condition × breed
Urea/BUN	0.01149*	0.0024*	0.0051*
Uric acid	0.3356	0.0227*	0.8118
Calcium (Ca)	0.2808	<.0001*	0.0347*
Magnesium (Mg)	0.0001*	<.0001*	0.5977
AST	<.0001*	0.0002*	0.0002*
Total bilirubin (TBIL)	<.0001*	0.0003*	<.0001*
Cholesterol	0.2912	<.0001*	0.0931
Triglycerides	0.8005	<.0001*	0.7535
Ammonia	0.8709	<.0001*	0.6451
Lipase	0.0106*	<.0001*	0.0357*
Creatinine kinase (ck)	0.9659	<.0001*	0.6099
Sodium (Na)	0.9624	<.0001*	0.9654
Potassium	0.0184*	<.0001*	<.0001*
Chloride (Cl)	0.1918	<.0001*	0.9921
Total protein (Tp)	0.2451	<.0001*	0.0465*

*Indicates significance (P<0.05)

The mean concentrations of urea in abortions were significantly different ($P<0.05$) among Brahman and lower than normal ranges (8-20mg/dL) (Table 4.2.5). Moreover, results obtained also revealed that retained placentas had significantly low ($P<0.05$) urea concentrations in Afrikander breeds (Table 4.2.5). Additionally, it was evident that there were significant variations ($P<0.05$) in urea mean concentrations of downer cows in Afrikander and Charolaise breeds with means below and within normal ranges respectively (Table 4.2.5). However, dystocia and vaginal prolapses urea concentrations were significantly different ($P<0.05$) in Afrikander breeds and within normal ranges (Table 4.2.5). It is also important to mention that urea levels for Brahman and Nguni cows in the final trimester of pregnancy were significantly different ($P<0.05$) with both means being within the normal ranges (Table 4.2.5).

Table 4.2.5 Least square means ($\pm$ SE) and p-values of serum urea concentration in cows experiencing reproductive conditions

Condition	Breed					
	B1	B2	B3	B4	B5	B6
Abortion	3.57 $\pm$ 1.24*	18.5 $\pm$ 3.04	2.70 $\pm$ 2.15	-	3.07 $\pm$ 2.48	-
Retained placenta	-	-	-	4.32 $\pm$ 1.36*	-	-
Downer syndrome	4.40 $\pm$ 2.48	-	-	4.90 $\pm$ 2.48*	-	10.35 $\pm$ 3.04*
Dystocia	1.45 $\pm$ 3.04	-	5.85 $\pm$ 3.04	4.94 $\pm$ 1.92*	-	-
Vaginal prolapses	3.10 $\pm$ 2.84	-	-	14.7 $\pm$ 2.15*	-	-
Last trimester	3.75 $\pm$ 1.19*	3.35 $\pm$ 3.04	3.98 $\pm$ 1.92*	3.93 $\pm$ 2.15	-	-

*-Significantly different ($P<0.05$); Urea normal range (8-20mg/dL)

Key: B1-Brahman, B2- Bonsmara, B3-Nguni, B4-Afrikander, B5-Drakensberger and B6-Charolaise

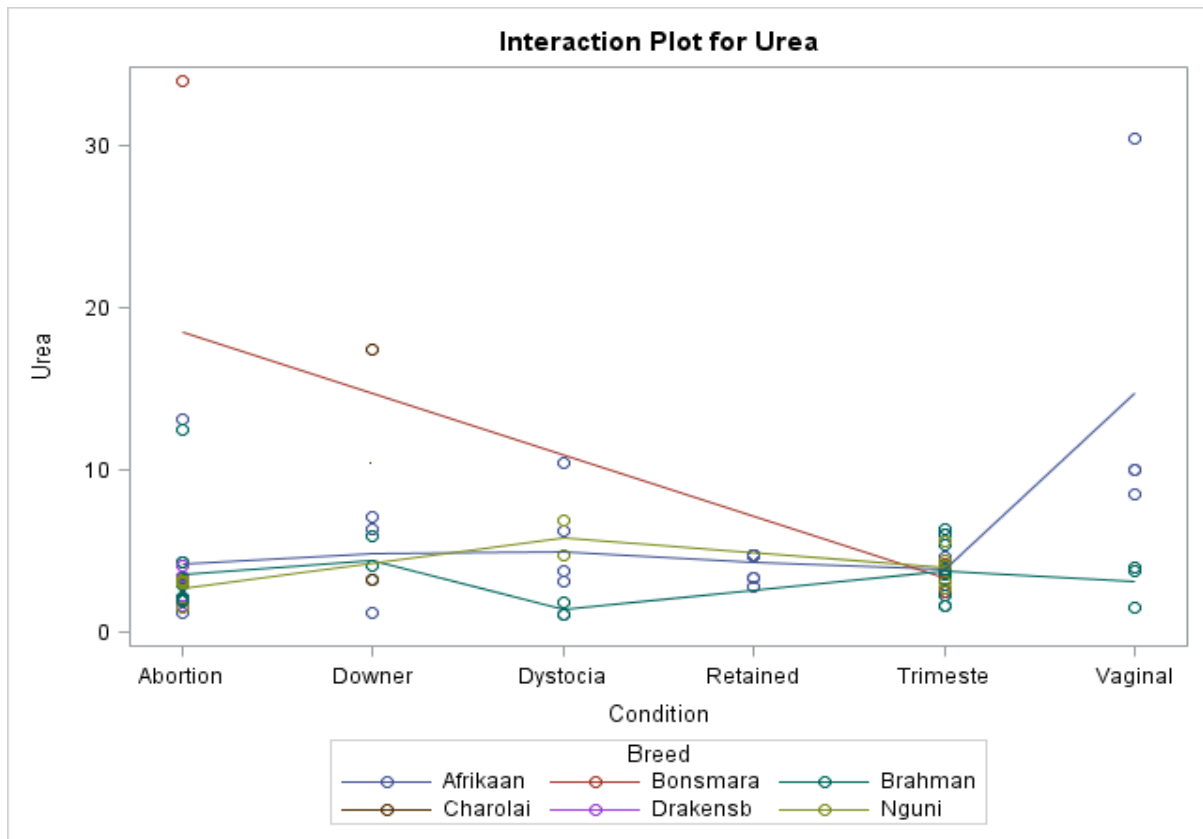


Figure 4.2.1 Serum urea/BUN levels in cows with different reproductive conditions.

Results obtained showed that the mean concentration of urea among Afrikaner breeds had significant differences ($P < 0.05$) in retained placenta, downer cow syndrome, vaginal prolapse and dystocia (Figure 4.2.1). Furthermore, significant ($P < 0.05$) urea concentrations were observed in Brahman cows experiencing abortion and in those in the last trimester of pregnancy (Figure 4.2.1). It was also noticed that the Nguni cows in final trimester of pregnancy and downer syndrome Charolaise cases revealed a statistically significant difference (Figure 4.2.1).

In this study a significant correlation ($P<0.05$) was found between levels of uric acid and Brahman, Bonsmara, Nguni, Afrikander, and Drakensberger breeds experienced abortion also higher than the normal ranges (Table 4.2.6). In addition, the incidences of retained placenta in Afrikander breeds had significantly different ($P<0.05$) uric acid concentrations which were above normal ranges (Table 4.2.6). There were also significant differences ($P<0.05$) observed among downer cows of Brahman and Afrikander breeds (Table 4.2.6). It was as well noted that dystocia and vaginal prolapses were having significantly high uric acid concentrations in Afrikander breeds (Table 4.2.6). Nevertheless, cows in the last trimester of gestation also had significantly different ($P<0.05$) uric acid levels in Brahman, Nguni, Bonsmara and Afrikander (Table 4.2.6).

Table 4.2.6 Least square means ($\pm$ SE) and p-values of serum uric acid concentrations in cows experiencing reproductive conditions

Condition	Breed					
	Brahman	Bonsmara	Nguni	Afrikander	Drakensberger	Charolaise
Abortion	50.5 $\pm$ 7.8*	53.0 $\pm$ 19.0 *	47.0 $\pm$ 13.5*	62.7 $\pm$ 10.9*	43.00 $\pm$ 15.52*	-
Retained placenta	-	-	-	34.4 $\pm$ 8.5*	-	-
Downer syndrome	36.7 $\pm$ 15.5*	-	-	36.3 $\pm$ 15.5*	-	30.50 $\pm$ 19.0
Dystocia	32.5 $\pm$ 19.0	-	20.50 $\pm$ 19.0	63.8 $\pm$ 12.0*	-	-
Vaginal prolapses	-	-	-	47.8 $\pm$ 13.5*	-	-
Last trimester	36.6 $\pm$ 7.5*	46.0 $\pm$ 19.0*	38.6 $\pm$ 12.3*	27.0 $\pm$ 13.5*	-	-

* Statistical significance ($P>0.05$), uric acid normal range (3.0-7.0 mg/dL)

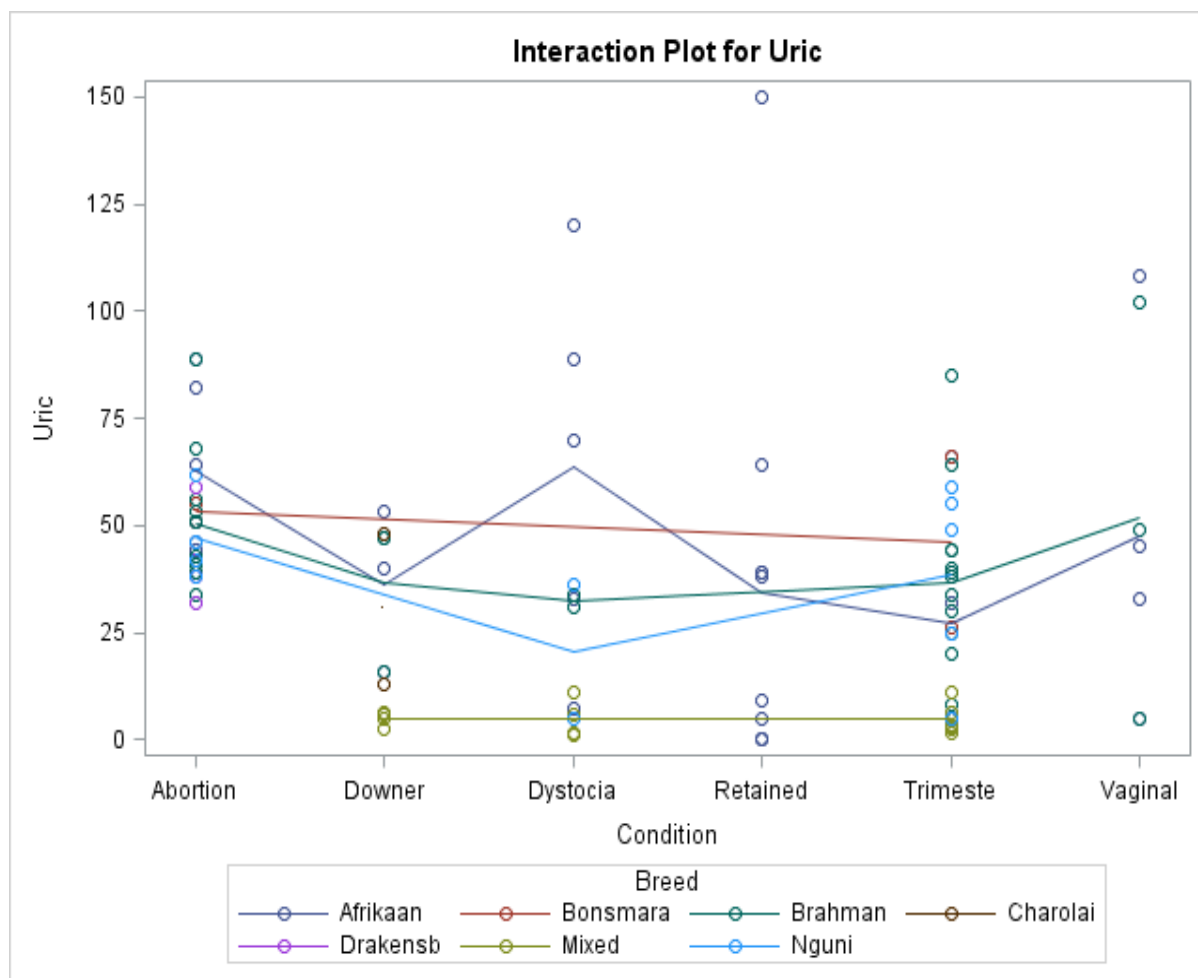


Figure 4.2.2 Serum uric acid concentrations in cows of different reproductive conditions.

Results obtained from blood biochemistry indicated no significant variations of uric acid concentration in mixed breeds ($P>0.05$) (Figure 4.2.2). On the other hand, in Brahman, Bonsmara, Nguni, Afrikander, and Drakensberger significantly different ($P<0.05$) uric acid concentrations were observed (Figure 4.2.2). The study showed that significant differences were also seen in dystocia, abortion, retained placenta and vaginal prolapses in Afrikander breeds. Moreover, Bonsmara breeds were significantly ($P>0.05$) correlated to the uric acid levels (Figure 4.2.2).

It is important to mention that the means concentrations of calcium were only significant ($P<0.01$) in mixed breeds of downer cow syndrome, dystocia and cows at the last trimester of gestation with mean values higher than the normal range (8.6–10.2 mg/dL) (Table 4.2.7).

Table 4.2.7 Least square means ($\pm$ SE) and p-values of serum calcium (Ca) concentration in cow experiencing reproductive conditions

Condition	Breed	Ca LSMEAN	Pr > t
Abortion	Afrikander	0.34 $\pm$ 6.90	0.9609
	Bonsmara	0.00 $\pm$ 11.95	1.0000
	Brahman	0.10 $\pm$ 4.88	0.9832
	Drakensberger	0.00 $\pm$ 9.76	1.0000
	Nguni	0.50 $\pm$ 8.47	0.9530
Downer cow syndrome	Afrikander	2.07 $\pm$ 9.76	0.8324
	Brahman	1.98 $\pm$ 9.76	0.8393
	Charolaise	0.78 $\pm$ 11.95	0.9482
	Mixed	25.25 $\pm$ 8.47	0.0038*
Dystocia	Afrikander	2.14 $\pm$ 7.56	0.7776
	Brahman	2.42 $\pm$ 11.96	0.8402
	Mixed	85.50 $\pm$ 8.46	<.0001*
	Nguni	2.12 $\pm$ 11.95	0.8598
Retained placenta	Afrikander	2.13 $\pm$ 5.35	0.6915
Last trimester of pregnancy	Afrikander	1.59 $\pm$ 8.46	0.8509
	Bonsmara	1.93 $\pm$ 11.95	0.8722
	Brahman	1.89 $\pm$ 4.69	0.6876
	Mixed	37.50 $\pm$ 6.90	<.0001*
	Nguni	1.67 $\pm$ 7.56	0.8254
Vaginal prolapse	Afrikander	1.71 $\pm$ 8.46	0.8407

*indicate significance ($P<0.05$), normal ranges (8.6–10.2 mg/dL)

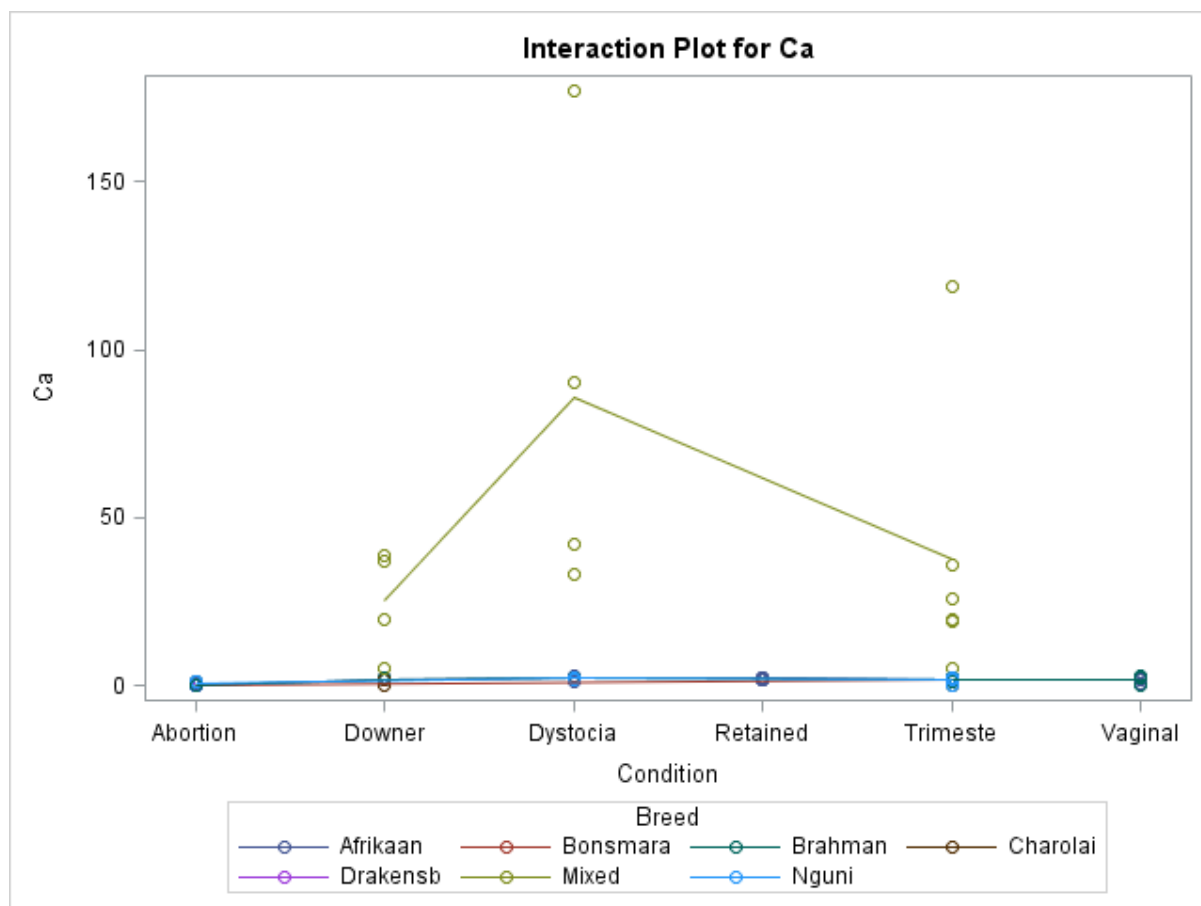


Figure 4.2.3 Levels of serum calcium (Ca) and different reproductive conditions.

Significant differences ($P < 0.05$) were observed only in mixed breed cattle (Figure 4.2.3). Greater calcium mean concentrations were seen in dystocia, cows in the last trimester of pregnancy and downer cows (Figure 4.2.3).

Significant correlation ($P<0.05$) was also noted in magnesium concentrations of Afrikander, Brahman and Nguni in aborting cows with values below and higher than normal ranges (Table 4.2.8). The study also revealed that magnesium levels were significantly ($P<0.05$) greater in mixed breed downer and dystocia (Table 4.2.8). However, there was no correlation in magnesium level of retained placenta (Table 4.2.8). In addition, significant differences were also seen in cows in the last trimester of gestation where Afrikander, Bonsmara, Brahman had mean concentrations below normal ranges while Nguni and mixed breeds were within normal ranges. A significant association ($P<0.05$) was found between magnesium mean concentrations was also observed in vaginal prolapse of Afrikander and Brahman cows with the (Table 4.2.8). The study as well revealed that magnesium levels were significantly ($P<0.05$) greater but within normal ranges in mixed breed downer cow syndrome (1.33 ± 0.23) and dystocia (2.12 ± 0.23) (Table 4.2.8). However, there was no correlation between magnesium levels among animals affected by retained placenta (Table 4.2.8). In addition, significant differences were also seen in cows in the last trimester of gestation of Afrikander, Bonsmara, Brahman, Nguni which were lower than normal ranges and mixed breeds being within the normal range. A significantly lower than normal range ($P<0.05$) association in magnesium mean concentrations was also observed in vaginal prolapse of Afrikander and Brahman cows with the (Table 4.2.8).

Table 4.2.8 Least square means ($\pm$ SE) and p-values of serum magnesium concentration in cow experiencing reproductive conditions

Condition	Breed	Mg LSMEAN	Pr > t
Abortion	Afrikander	0.57 $\pm$ 0.19	0.0033**
	Bonsmara	0.51 $\pm$ 0.32	0.1231
	Brahman	0.67 $\pm$ 0.13	<.0001**
	Drakensberger	0.67 $\pm$ 0.26	0.1518
	Nguni	0.84 $\pm$ 0.23	0.0005**
Downer cow syndrome	Afrikander	0.00 $\pm$ 0.26	1.0000
	Brahman	0.00 $\pm$ 0.26	1.0000
	Charolaise	0.46 $\pm$ 0.33	0.1637
	Mixed	1.33 $\pm$ 0.23	<.0001**
Dystocia	Afrikander	0.00 $\pm$ 0.21	1.0000
	Brahman	0.00 $\pm$ 0.32	1.0000
	Mixed	2.12 $\pm$ 0.23	<.0001**
	Nguni	0.00 $\pm$ 0.32	1.0000
Retained placenta	Afrikander	0.00 $\pm$ 0.15	1.0000
Last trimester of pregnancy	Afrikander	0.48 $\pm$ 0.23	0.0413*
	Bonsmara	0.89 $\pm$ 0.33	0.0080**
	Brahman	0.36 $\pm$ 0.13	0.0061**
	Mixed	1.96 $\pm$ 0.18	<.0001**
	Nguni	0.54 $\pm$ 0.21	0.0103*
Vaginal prolapse	Afrikander	0.88 $\pm$ 0.23	0.0003**
	Brahman	0.77 $\pm$ 0.27	0.0047**

Statistical significance *indicate $P < 0.05$, **indicate $P < 0.01$, normal ranges (1.7-2.2 mg/dL)

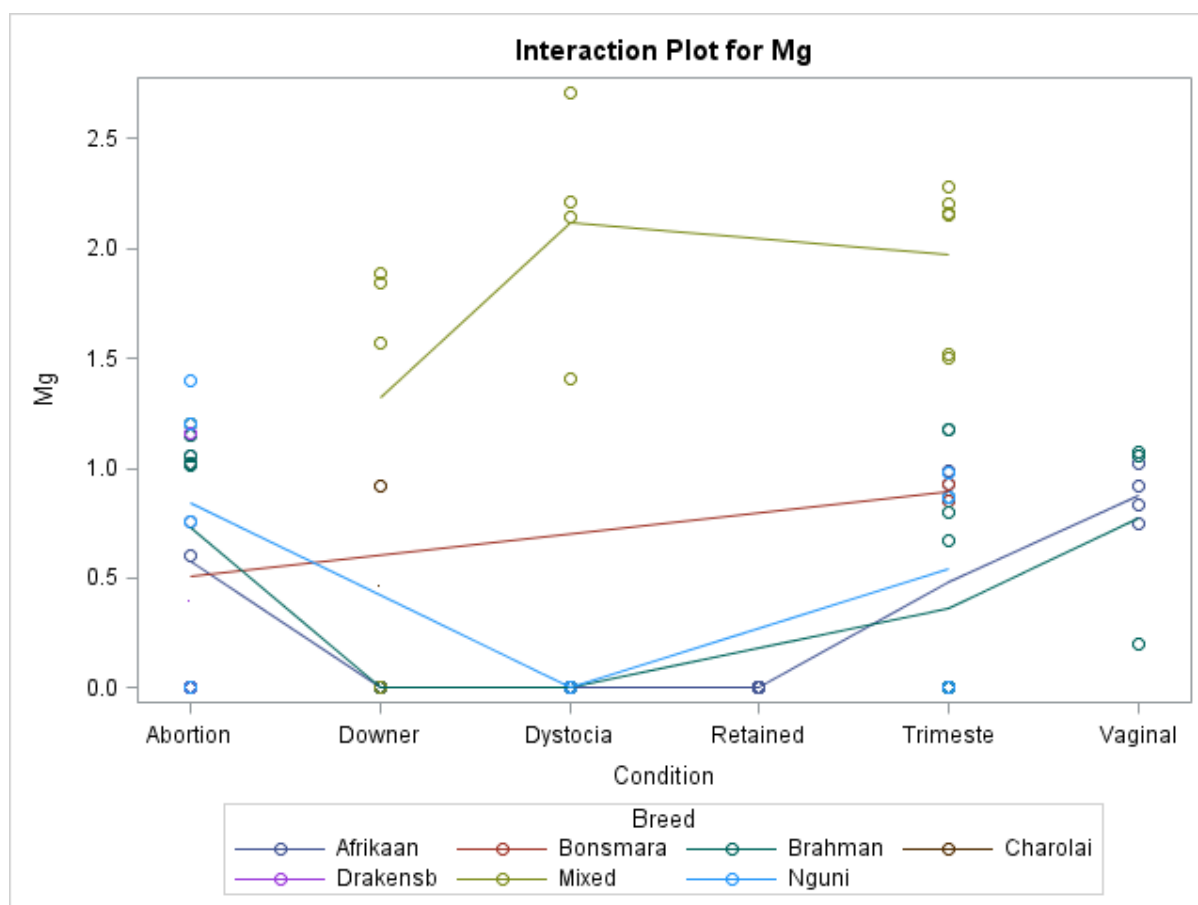


Figure 4.2.4 Serum magnesium (Mg) and different reproductive conditions

Results obtained in this study indicated that mixed breed cows were having the significantly ($P < 0.05$) high magnesium mean concentrations amongst the other breeds (Figure 4.2.4). Bonsmara cow in the last trimester of pregnancy were significantly related to the concentration of magnesium (Figure 4.2.4).

It was seen that the level of aspartate amino-transferase (AST) showed no significant difference ($P>0.05$) in abortions and vaginal prolapses (Table 4.2.9). Furthermore, mixed breed downer and dystocia cows had significantly different ($P<0.05$) aspartate amino-transferase for cows in the final trimester of pregnancy in all breeds (Table 4.2.9).

Table 4.2.9 Least square means ($\pm$ SE) and p-values of serum aspartate amino-transferase (AST) concentration in cow experiencing reproductive conditions

Condition	Breed	AST LSMEAN	Pr > t
Abortion	Afrikander	0.00 $\pm$ 11.94	1.0000
	Bonsmara	0.00 $\pm$ 20.68	1.0000
	Brahman	0.00 $\pm$ 8.44	1.0000
	Drakensberger	0.00 $\pm$ 16.88	1.0000
	Nguni	0.00 $\pm$ 14.62	1.0000
Downer cow syndrome	Afrikander	0.00 $\pm$ 16.88	1.0000
	Brahman	0.00 $\pm$ 16.88	1.0000
	Charolaise	0.00 $\pm$ 20.68	1.0000
	Mixed	72.00 $\pm$ 15.62	<.0001*
Dystocia	Afrikander	0.00 $\pm$ 13.08	1.0000
	Brahman	0.00 $\pm$ 20.68	1.0000
	Mixed	72.50 $\pm$ 14.62	<.0001*
	Nguni	0.00 $\pm$ 20.68	1.0000
Retained placenta	Afrikander	87.10 $\pm$ 9	<.0001*
Last trimester of pregnancy	Afrikander	64.750 $\pm$ 14.62	<.0001*
	Bonsmara	76.50 $\pm$ 20.62	0.0004
	Brahman	72.00 $\pm$ 8.11	<.0001*
	Mixed	81.00 $\pm$ 11.94	<.0001*
	Nguni	58.20 $\pm$ 13.08	<.0001*
Vaginal prolapses	Afrikander	0.00 $\pm$ 14.62	1.0000
	Brahman	0.00 $\pm$ 16.88	1.0000

Significance of differences *indicates $P\leq 0.05$, normal ranges (10–40 U/L)

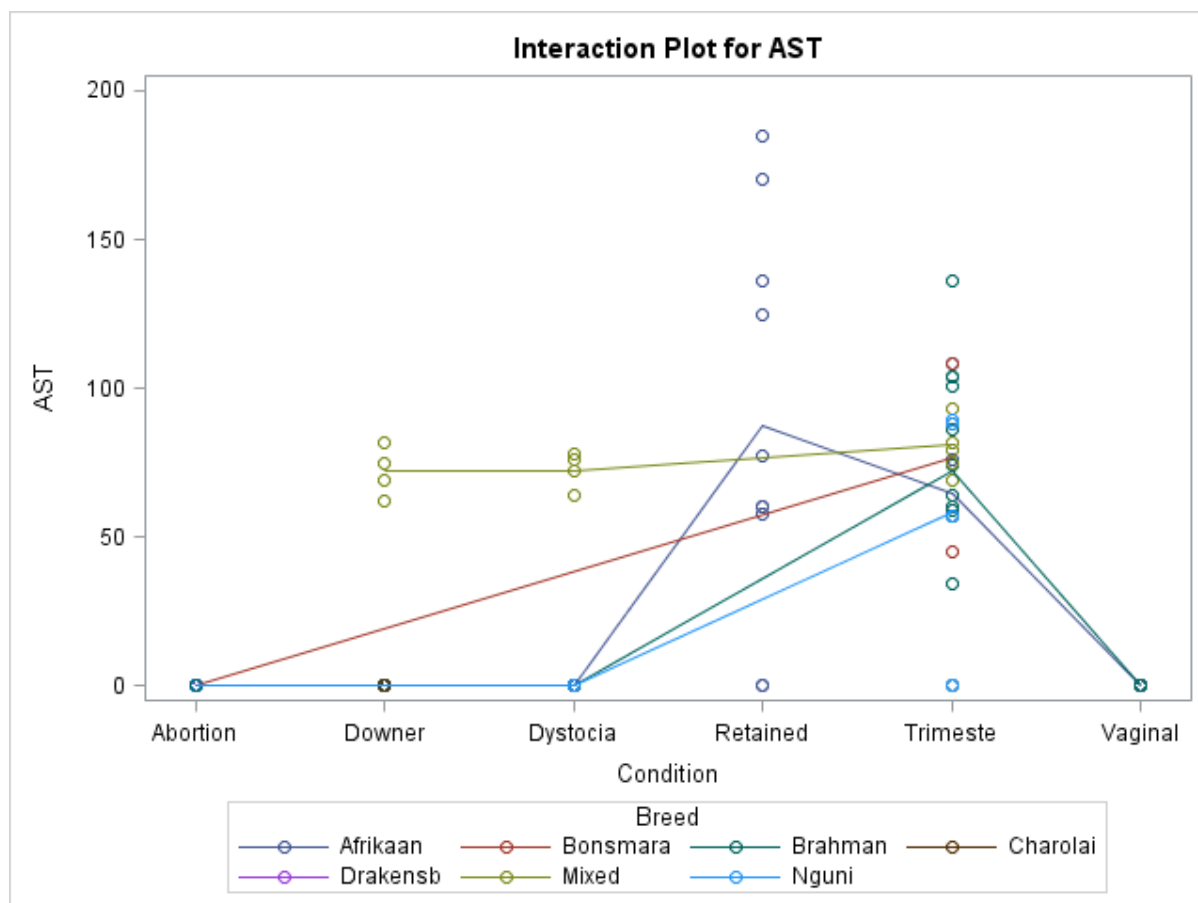


Figure 4.2.5 The association of serum AST and different reproductive conditions.

Results revealed that significant differences ($P < 0.05$) were observed for the level of aspartate amino-transferase (AST) in downer cow, dystocia and cows in the final trimester of pregnancy which were mixed breeds (Figure 4.2.5). Most of the association were seen in cows which were at the last trimester of pregnancy in Afrikander, Bonsmara, Brahman, Mixed and Nguni breeds (Figure 4.2.5).

It was noted that the mean concentration of total bilirubin in Brahman, Mixed and Nguni breeds showed significant ($P<0.05$) variations in aborting cows (Table 4.2.10). The study also showed that the mean concentration of TBIL were significantly different ($P<0.05$) in cows at the last trimester of pregnancy (Table 4.2.10). The mean concentrations of TBIL were above normal ranges in all significant associations observed in this study (Table 4.2.10).

Table 4.2.10 Least square means ($\pm$ SE) and p-values of serum total bilirubin (TBIL) concentration in cow experiencing reproductive

Condition	Breed	TBIL LSMEAN	Pr > t
Abortion	Afrikander	19.67 $\pm$ 4.92	0.000**
	Bonsmara	8.50 $\pm$ 8.52	0.3213
	Brahman	8.33 $\pm$ 3.47	0.0189*
	Drakensberger	5.333 $\pm$ 6.95	0.4454
	Nguni	7.50 $\pm$ 6.02	0.2167
Downer cow syndrome	Afrikander	7.00 $\pm$ 6.95	0.3172
	Brahman	7.33 $\pm$ 6.95	0.2949
	Charolaise	6.00 $\pm$ 8.52	0.4832
	Mixed	0.00 $\pm$ 6.02	1.0000
Dystocia	Afrikander	7.00 $\pm$ 5.38	0.1976
	Brahman	6.50 $\pm$ 8.52	0.4476
	Mixed	0.00 $\pm$ 6.02	1.0000
	Nguni	5.00 $\pm$ 8.52	0.5588
Retained prolapses	Afrikander	6.40 $\pm$ 3.81	0.0969
Last trimester of pregnancy	Afrikander	8.50 $\pm$ 6.02	0.1621
	Bonsmara	8.00 $\pm$ 8.51	0.3505
	Brahman	18.46 $\pm$ 3.24	<.0001**
	Mixed	80.33 $\pm$ 4.92	<.0001**
	Nguni	14.20 $\pm$ 5.38	0.0101*
Vaginal prolapses	Afrikander	6.750 $\pm$ 6.02	0.2658

Significance differences $P\leq 0.05$, (*indicated $P<0.05$, **indicate $P<0.01$), normal ranges (0.3–1.0 mg/dL).

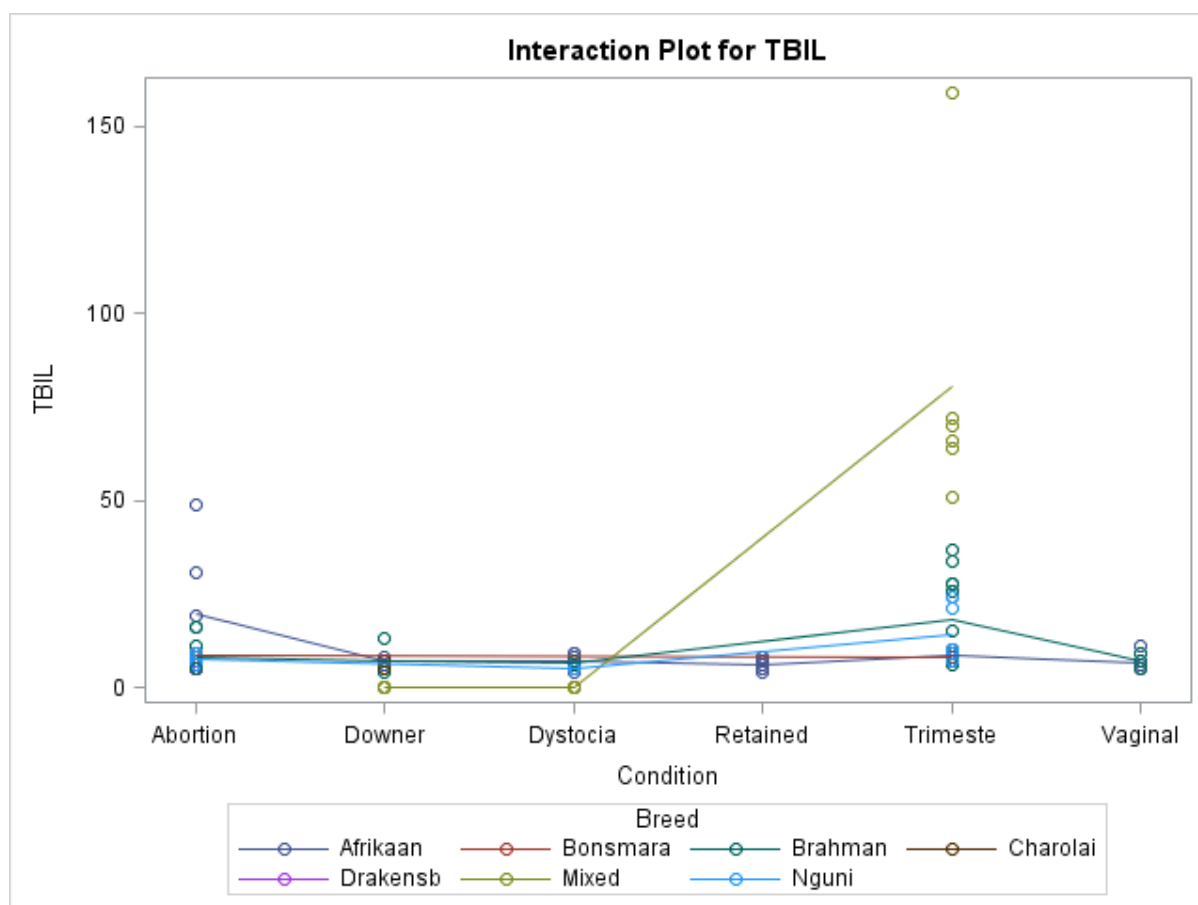


Figure 4.2.6 The association of serum total bilirubin (TBIL) and different reproductive conditions.

The mean concentration of total bilirubin indicated statistical significance in abortion cows of Brahman and Afrikaner breeds (Figure 4.2.6). Significant interactions were also seen in the Brahman, mixed and Nguni breeds (Figure 4.2.6).

Significant differences of cholesterol levels were seen in breeds affected by abortion in Afrikaner, Brahman and Nguni breeds ($P < 0.01$), while Bonsmara and Drakensberger showed significance at ($P < 0.05$) (Table 4.2.11). In addition, the mean concentration of cholesterol in Afrikaner and Brahman breeds were significantly different in downer cows ($P < 0.05$), whereas mixed breed downers showed significant differences where $P < 0.01$ (Table 4.2.11). Moreover, all breeds in dystocia indicated statistically different cholesterol concentrations ($P < 0.05$) (Table 4.2.11). It was also observed that Afrikaner breed in retained placenta were significant at ($P < 0.01$) and vaginal prolapses at ($P < 0.05$). In addition, all cholesterol values in this study were found to be within normal ranges (Table 4.2.11).

Table 4.2.11 Least square means ($\pm$ SE) and p-values of serum cholesterol concentration in cow experiencing reproductive conditions

Condition	Breed	Cholesterol LSMEAN	Pr > t
Abortion	Afrikander	2.52 $\pm$ 0.79	0.0021**
	Bonsmara	2.95 $\pm$ 1.37	0.0347*
	Brahman	3.53 $\pm$ 0.56	<.0001**
	Drakensberger	2.67 $\pm$ 1.12	0.0195*
	Nguni	3.19 $\pm$ 0.97	0.0015**
Downer cow syndrome	Afrikander	2.83 $\pm$ 1.12	0.0135*
	Brahman	2.17 $\pm$ 1.12	0.0564*
	Charolaise	1.90 $\pm$ 1.37	0.1702
	Mixed	6.50 $\pm$ 0.97	<.0001**
Dystocia	Afrikander	3.06 $\pm$ 0.87	0.0007**
	Brahman	3.68 $\pm$ 1.37	0.0089**
	Mixed	7.75 $\pm$ 0.97	<.0001**
	Nguni	4.04 $\pm$ 1.37	0.0043**
Retained placenta	Afrikander	3.18 $\pm$ 0.61	<.0001**
Last trimester of pregnancy	Afrikander	2.93 $\pm$ 0.97	0.0035**
	Bonsmara	2.96 $\pm$ 1.37	0.0341*
	Brahman	3.17 $\pm$ 0.53	<.0001**
	Mixed	11.83 $\pm$ 0.79	<.0001*
	Nguni	2.79 $\pm$ 0.87	0.0019*
Vaginal prolapses	Afrikander	2.37 $\pm$ 0.97	0.0170**

Statistical significance *indicated P<0.05, **indicate P<0.01, normal ranges (<225 mg/dL)

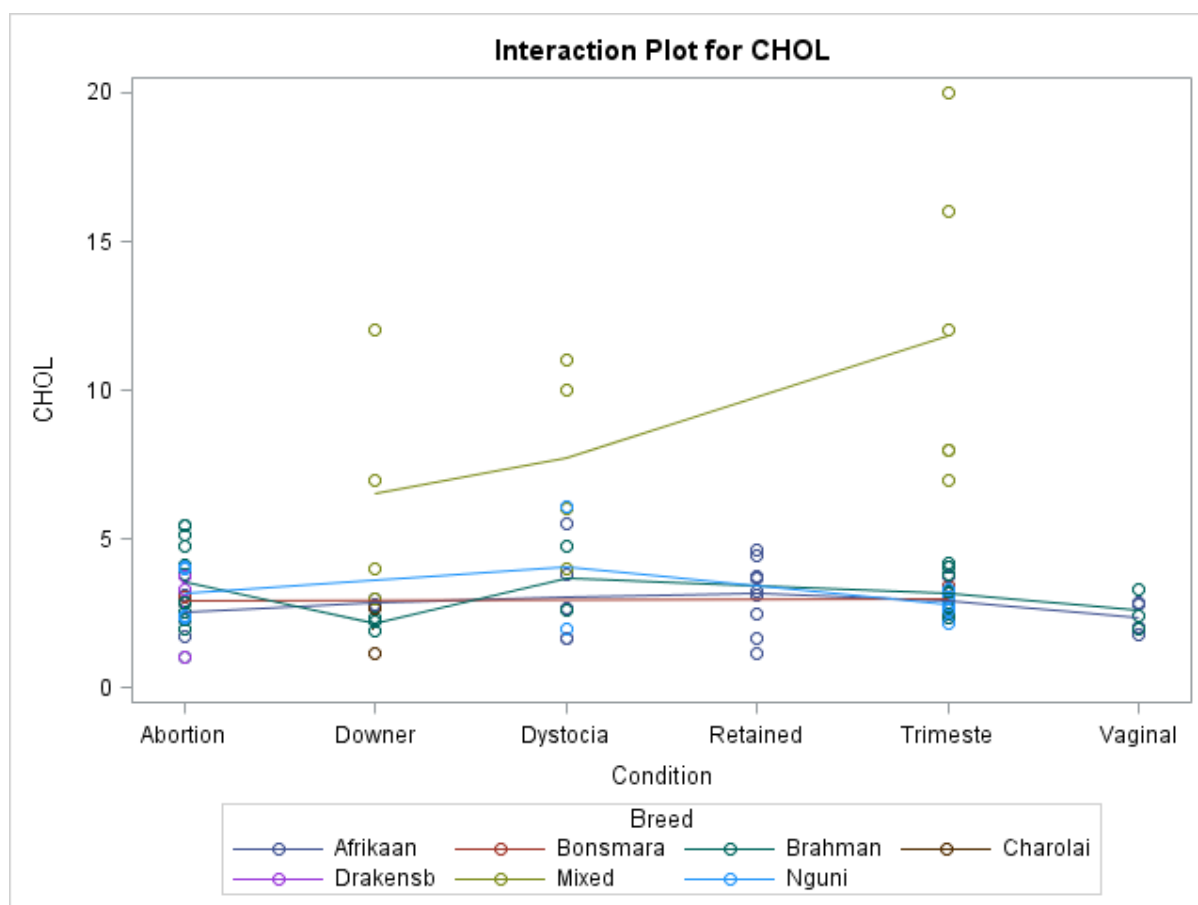


Figure 4.2.7 The association of serum cholesterol and different reproductive conditions.

The results in this study illustrated that level of cholesterol in Afrikaner breeds were significantly different ($P < 0.05$) for all conditions (Figure 4.2.7). It was seen also seen that Afrikaner, Bonsmara, Brahman, Mixed and Nguni had significantly different cholesterol levels in the final trimester cows (Figure 4.2.7). Downer cows in Afrikaner, Brahman and mixed breeds were significantly different ($P < 0.01$) (Figure 4.2.7). Dystocia in Afrikaner, Brahman, Mixed and Nguni showed significance ($P < 0.05$) (Figure 4.2.7). It was noted too that vaginal prolapses ($P < 0.01$) and retained placenta ($P < 0.05$) significantly correlated with cholesterol concentrations (Figure 4.2.7).

The level of ammonia in all the breeds of aborting cows were statistically significant ($P < 0.05$) with mean concentrations above normal ranges (40–70 $\mu\text{g/dL}$) (Table 4.2.12). On the other hand, retained placenta and vaginal prolapses in Afrikaner breeds had significant ammonia mean concentrations higher than normal ranges. No statistical significance was observed in mixed breed cows ($P > 0.05$) (Table 4.2.12). However, Afrikaner, Brahman and Charolaise and downer conditions were significantly correlated to the mean concentration of

ammonia ($P < 0.05$) with values greater than normal ranges. Significantly high differences ($P < 0.05$) were also seen in Afrikander, Brahman and Nguni dystocia cows (Table 4.2.12). Moreover, cows in the last trimester of pregnancy in Afrikander, Bonsmara, Brahman and Nguni breeds had significant ($P < 0.05$) ammonia levels (Table 4.2.12).

Table 4.2.12 Least square means ($\pm$ SE) and p-values of serum ammonia concentration in cow experiencing reproductive conditions

Condition	Breed	Ammonia LSMEAN	Pr > t
Abortion	Afrikander	760.16 $\pm$ 99.48	<.0001*
	Bonsmara	470.50 $\pm$ 172.31	0.0078*
	Brahman	713.67 $\pm$ 70.35	<.0001*
	Drakensberger	718.67 $\pm$ 140.69	<.0001*
	Nguni	719.25 $\pm$ 121.84	<.0001*
Downer cow syndrome	Afrikander	868.67 $\pm$ 140.69	<.0001*
	Brahman	750.00 $\pm$ 140.69	<.0001*
	Charolaise	960.00 $\pm$ 172.31	<.0001*
	Mixed	2.34 $\pm$ 121.84	0.9847
Dystocia	Afrikander	687.40 $\pm$ 108	<.0001*
	Brahman	815.50 $\pm$ 172	<.0001*
	Mixed	2.72 $\pm$ 121.84	0.9822
	Nguni	670.50 $\pm$ 172.31	0.0002*
Retained placenta	Afrikander	860.20 $\pm$ 77.06	<.0001*
Last trimester of pregnancy	Afrikander	629.75 $\pm$ 121.84	<.0001*
	Bonsmara	781.50 $\pm$ 172.31	<.0001*
	Brahman	698.07 $\pm$ 67.58	<.0001*
	Mixed	3.04 $\pm$ 99.48	0.9757
	Nguni	641.00 $\pm$ 108.97	<.0001*
Vaginal prolapse	Afrikander	960.00 $\pm$ 121.84	<.0001*

Statistical significance *indicates ($P \leq 0.05$), normal ranges (40–70 μ g/dL)

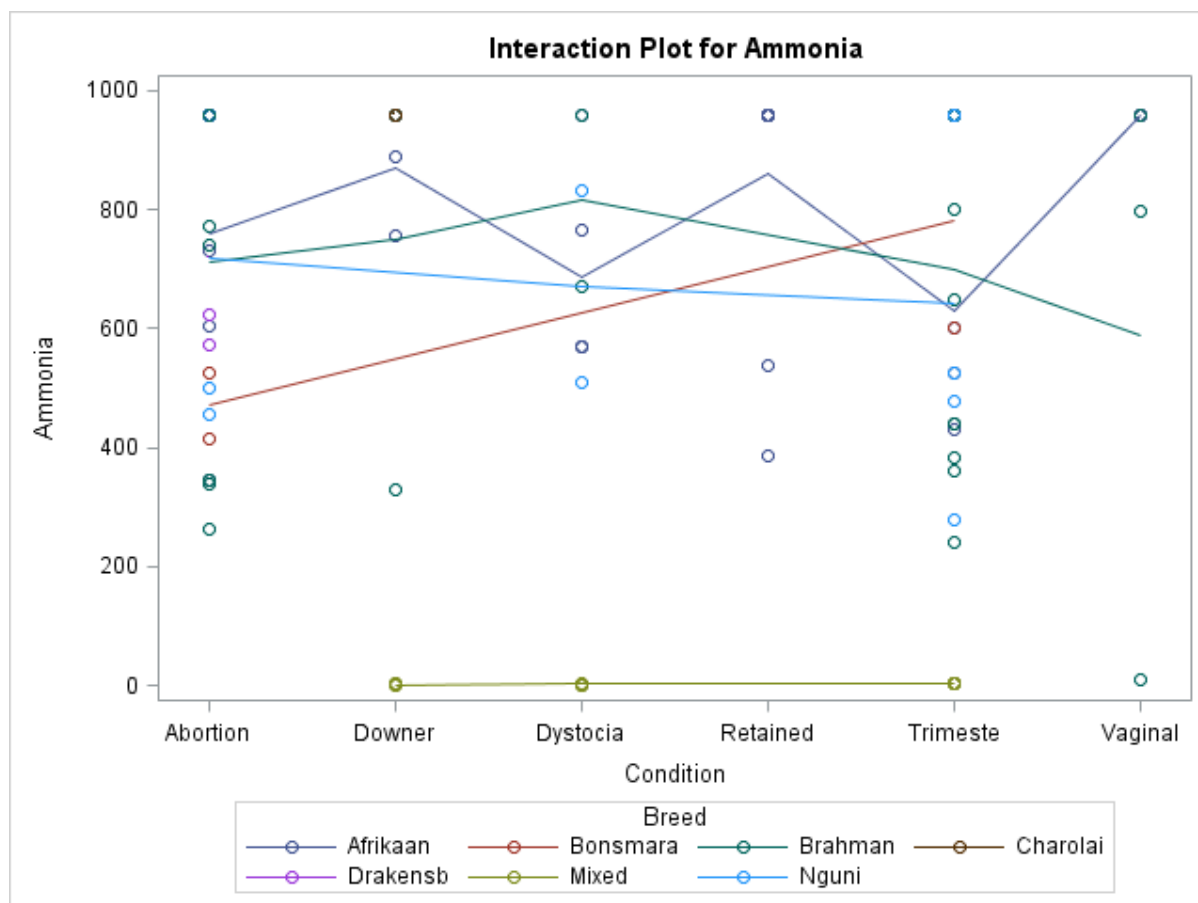


Figure 4.2.8 The association of serum ammonia and reproductive conditions.

It was observed that there was no statistical significance ($P > 0.05$) among mixed breeds in all conditions (Figure 4.2.8). However, ammonia was found to be significantly ($P < 0.01$) high among aborting Drakensberger cows (Figure 4.2.8). Additionally, ammonia concentrations in Afrikaner breed were significantly different in all conditions (Figure 4.2.8) while significances ($P < 0.01$) were also only observed Bonsmara and Nguni breeds of aborting cows and in cows at final trimester of gestation (Figure 4.2.8). Charolaise breeds of downer cows had significant serum ammonia levels in contrast to the other breeds (Figure 4.2.8).

It is important to mention that levels of serum triglyceride illustrated significance variations ($P < 0.05$) only in mixed breed of downer cows and cows in last trimester of gestation with values higher than normal ranges (Table 4.2.13).

Table 4.2.13 Least square means ($\pm$ SE) and p-values of serum triglycerides (TRIG) concentration in cow experiencing reproductive conditions

Condition	Breed	TRIG LSMEAN	Pr > t
Abortion	Afrikander	0.00 $\pm$ 41.54	1.0000
	Bonsmara	0.00 $\pm$ 71.96	1.0000
	Brahman	0.00 $\pm$ 29.37	1.0000
	Drakensberger	0.00 $\pm$ 58.75	1.0000
	Nguni	0.00 $\pm$ 50.88	1.0000
Downer cow syndrome	Afrikander	0.00 $\pm$ 58.75	1.0000
	Brahman	0.00 $\pm$ 58.75	1.0000
	Charolaise	0.00 $\pm$ 71.96	1.0000
	Mixed	804.75 $\pm$ 50.88	<.0001*
Dystocia	Afrikander	0.00 $\pm$ 45.50	1.0000
	Brahman	0.00 $\pm$ 71.95	1.0000
	Mixed	656.50 $\pm$ 50.88	<.0001*
	Nguni	0.00 $\pm$ 71.96	1.0000
Retained placenta	Afrikander	0.00 $\pm$ 32.18	1.0000
Last trimester of pregnancy	Afrikander	0.00 $\pm$ 50.88	1.0000
	Bonsmara	0.00 $\pm$ 71.96	1.0000
	Brahman	0.00 $\pm$ 28.22	1.0000
	Mixed	610.0 $\pm$ 41.54	<.0001*
	Nguni	0.00 $\pm$ 45.50	1.0000
Vaginal prolapses	Afrikander	0.00 $\pm$.50.88	1.0000

Significance of differences *indicates $P \leq 0.05$, normal range (40- 200 mg/dL)

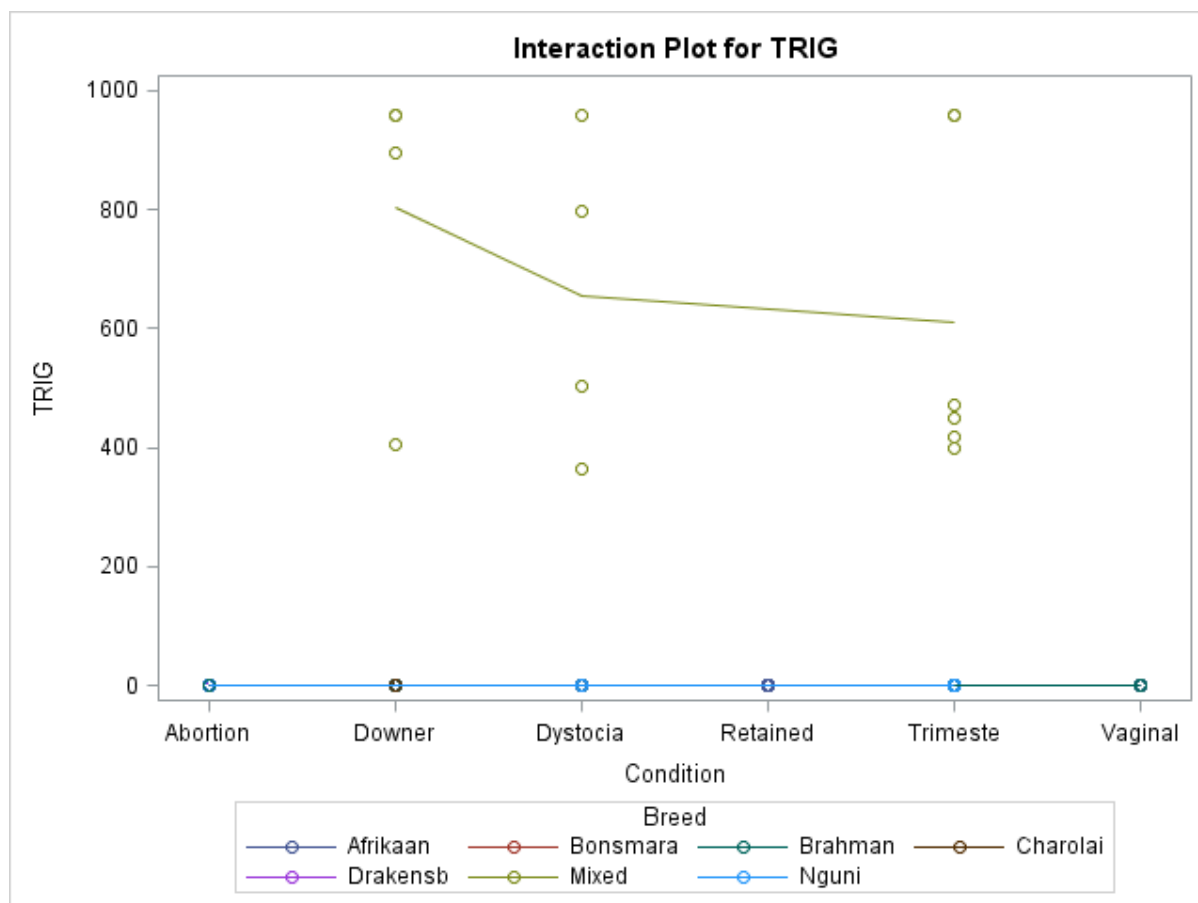


Figure 4.2.9 The association of serum triglycerides (TRIG) and different reproductive conditions.

Significant differences were seen between the mean concentrations of triglycerides and the mixed breed for dystocia, downer cow syndrome and those in the last trimester of gestation (Figure 4.2.9). Results obtained showed that the mean concentration of lipase were statistical significance ($P < 0.01$) in abortion for Afrikander and Nguni breeds (Table 4.2.14). The study also indicated that lipase mean concentrations were significantly different in Afrikander ($P < 0.05$) and Charolaise ($P < 0.01$) downer cows (Table 4.2.14). It was seen that levels of lipase in dystocia cows of Afrikander and Nguni breeds were significantly different ($P < 0.05$) (Table 4.2.14). Furthermore, mean concentrations of lipase in vagina prolapse and retained placenta were both significant for Afrikander breeds ($P < 0.05$) (Table 4.2.14). The mean concentrations of lipase in most breed were within normal ranges (10- 150 U/L) except an Nguni dystocia case which had mean value above the normal ranges.

Table 4.2.14 Least square means ($\pm$ SE) and p-values of serum lipase concentration in cow experiencing reproductive conditions

Condition	Breed	Lipase LSMEAN $\pm$ SE	Pr > t
Abortion	Afrikander	43.67 $\pm$ 17.67	0.0157**
	Bonsmara	52.507 $\pm$ 30.61	0.0903
	Brahman	50.83 $\pm$ 12.49	0.00018
	Drakensberger	45.33 $\pm$ 24.99	0.0736
	Nguni	47.00 $\pm$ 21.65	0.0330**
Downer cow syndrome	Afrikander	39.67 $\pm$ 24.99	0.1166
	Brahman	106.00 $\pm$ 24.99	<.0001*
	Charolaise	63.50 $\pm$ 30.61	0.0414**
	Mixed	0.00 $\pm$ 21.65	1.0000
Dystocia	Afrikander	113.80 $\pm$ 19.36	<.0001*
	Brahman	51.50 $\pm$ 30.61	0.0965
	Mixed	0.00 $\pm$ 21.65	1.0000
	Nguni	204.00 $\pm$ 30.61	<.0001*
Retained placenta	Afrikander	65.00 $\pm$ 13.69	<.0001*
Last trimester of pregnancy	Afrikander	75.00 $\pm$ 21.64	0.0009*
	Bonsmara	52.50 $\pm$ 30.61	0.0903
	Brahman	72.77 $\pm$ 12.01	<.0001*
	Mixed	0.00 $\pm$ 17.67	1.0000
	Nguni	54.40 $\pm$ 19.36	0.0063*
Vaginal prolapse	Afrikander	87.25 $\pm$ 21.64	0.0001*

Statistical difference ($P \leq 0.05$), *indicated $P < 0.05$, **indicate $P < 0.01$, normal ranges (10- 150 U/L)

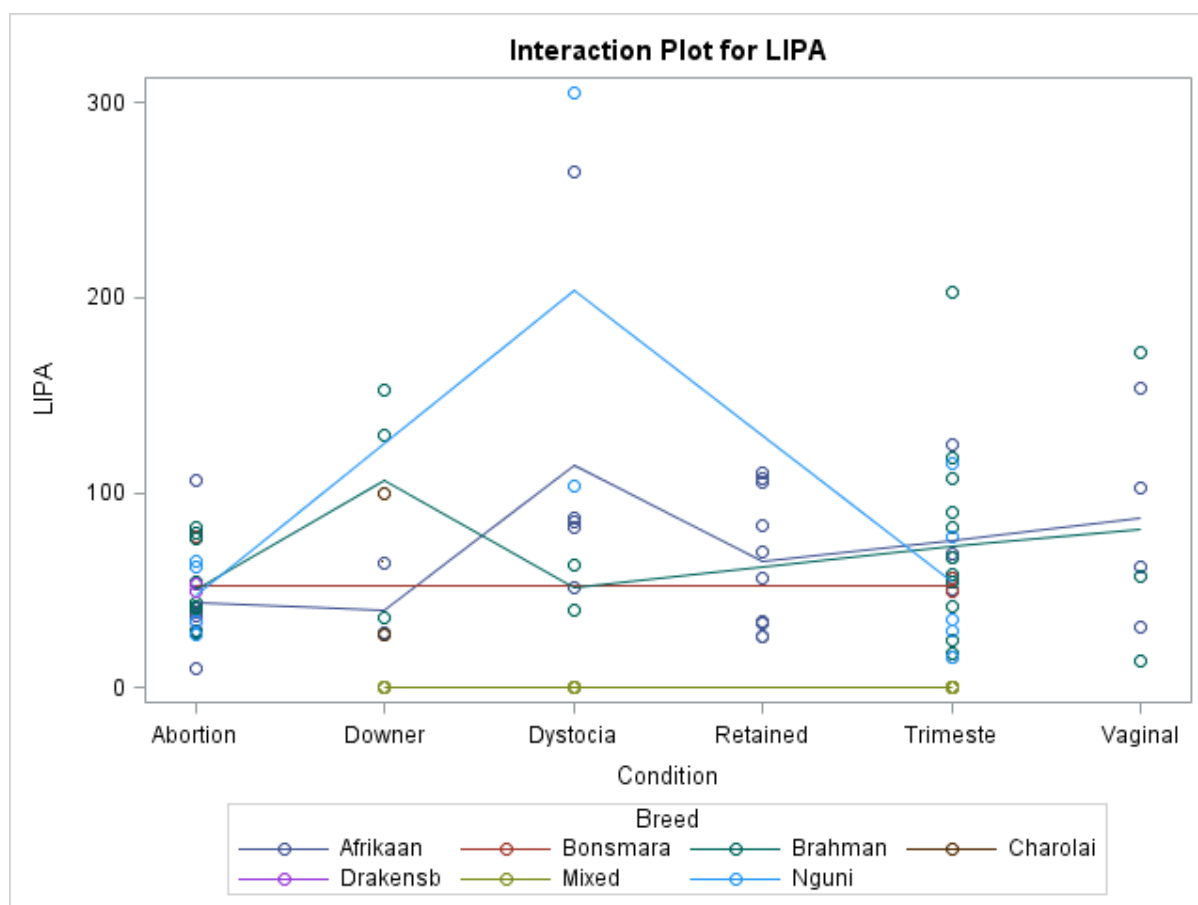


Figure 4.2.10 The association of serum Lipase (LIPA) and different reproductive conditions.

Results indicated that Nguni breeds in last trimester of pregnancy, dystocia and abortion cows had significant ($P < 0.01$) lipase levels (Figure 4.2.10). In addition, Afrikaner breeds indicated significant differences in lipase concentration in all conditions (Figure 4.2.10). Bonsmara breeds showed significant differences in abortion and cows in the last trimester of pregnancy (Figure 4.2.10). Brahman breeds indicated a significant different level of lipase in abortion, downer cow syndrome, dystocia and in the cows at the last trimester of pregnancy (Figure 4.2.10). However, no statistically significant differences were observed in mixed breed cows in all conditions (Figure 4.2.10).

It was seen that the means of creatinine kinase (CK) had significant ($P < 0.05$) concentrations for mixed breed downer cows, cows in the last trimester of gestation and dystocia cows (Table 4.2.15). Moreover, Brahman breeds showed significant differences in CK concentrations in cows in their last trimester of gestation ($P < 0.01$) and all means were within normal ranges (Table 4.2.15).

Table 4.2.15 Least square means ($\pm$ SE) and p-values of serum creatinine kinase (CK) concentration in cow experiencing reproductive conditions

Condition	Breed	CK LSMEAN $\pm$ SE	Pr > t
Abortion	Afrikander	0.00 $\pm$ 13.59	1.0000
	Bonsmara	0.00 $\pm$ 23.55	1.0000
	Brahman	0.00 $\pm$ 9.61	1.0000
	Drakensberger	0.00 $\pm$ 19.23	1.0000
	Nguni	0.00 $\pm$ 16.65	1.0000
Downer cow syndrome	Afrikander	0.00 $\pm$ 19.22	1.0000
	Brahman	0.00 $\pm$ 19.22	1.0000
	Charolaise	0.00 $\pm$ 23.56	1.0000
	Mixed	100.50 $\pm$ 16.65	<.0001*
Dystocia	Afrikander	0.00 $\pm$ 14.89	1.0000
	Brahman	0.00 $\pm$ 23.55	1.0000
	Mixed	59.75 $\pm$ 16.65	0.0006*
	Nguni	0.00 $\pm$ 23.55	1.0000
Retained placenta	Afrikander	0.00 $\pm$ 10.53	1.0000
Last trimester of pregnancy	Afrikander	2.25 $\pm$ 16.65	0.8929
	Bonsmara	0.00 $\pm$ 23.55	1.0000
	Brahman	22.08 $\pm$ 9.24	0.0192**
	Mixed	49.67 $\pm$ 13.59	0.0005*
	Nguni	0.00 $\pm$ 14.89	1.0000
Vaginal prolapse	Afrikander	0.00 $\pm$ 16.65	1.0000

Statistical significance ($P \leq 0.05$), *indicated $P < 0.05$, **indicate $P < 0.01$, normal range (30-135 U/L)

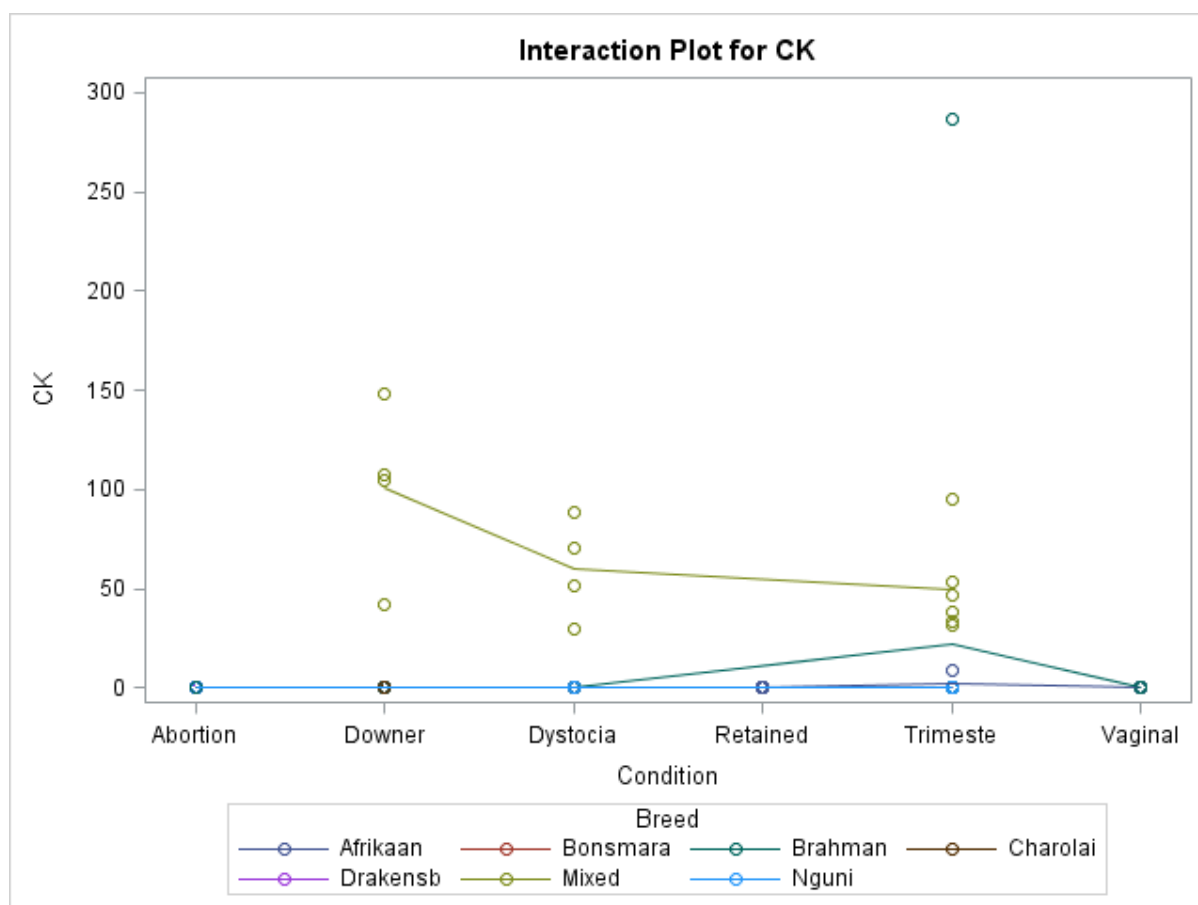


Figure 4.2.11 The association of serum creatinine kinase (CK) and cows of different reproductive conditions.

Creatinine kinase (CK) concentrations in different reproductive conditions were significantly different among mixed breed downer cows, last trimester of gestation cows and dystocia (Figure 4.2.11). The study also revealed that there was significant correlation ($P < 0.05$) between the levels of CK and Brahman during the last trimester of pregnancy (Figure 4.2.11).

Results obtained in this study indicated that there was significant difference ($P < 0.05$) between breeds such as Afrikaner, Brahman and Drakensberger which had sodium levels which were within normal ranges while Nguni and Bonsmara were found to have higher than normal levels of sodium in cows affected by abortion (Table 4.2.15). On the other hand, significant correlations were observed between the sodium mean concentration in Afrikaner, Brahman and Charolaise among downers with all values falling within normal ranges. Significant differences ($P < 0.05$) were also observed in dystocia Afrikaner, Brahman and Nguni breeds with mean concentrations being above normal ranges (Table 4.2.15). Retained

placenta showed significance ($P < 0.05$) correlation with Afrikaner breeds with sodium level in the normal ranges (Table 4.2.15). Whereas, in cows in the last trimester of gestation statistical significances were observed in Afrikaner higher than normal levels, whereas Bonsmara, Nguni and Brahman breed were within normal range. Vaginal prolapse showed significance in Afrikaner and Brahman with means above and below normal ranges (Table 4.2.15).

Table 4.2.16 Least square means ($\pm$ SE) and p-values of serum sodium (Na) concentration in cow experiencing reproductive conditions and those in the last trimester of gestation

Condition	Breed	Na LSMEAN $\pm$ SE	Pr > t
Abortion	Afrikander	146.50 $\pm$ 6.16	<.0001*
	Bonsmara	142.00 $\pm$ 10.68	<.0001*
	Brahman	147.17 $\pm$ 4.36	<.0001*
	Drakensberger	147.00 $\pm$ 8.72	<.0001*
	Nguni	143.25 $\pm$ 7.55	<.0001*
Downer cow syndrome	Afrikander	145.00 $\pm$ 8.72	<.0001*
	Brahman	144.67 $\pm$ 8.72	<.0001*
	Charolaise	150.00 $\pm$ 10.68	<.0001*
	Mixed	0.00 $\pm$ 7.55	1.0000
Dystocia	Afrikander	152.20 $\pm$ 6.75	<.0001*
	Brahman	146.00 $\pm$ 10.68	<.0001*
	Mixed	0.00 $\pm$ 7.55	1.0000
	Nguni	152.50 $\pm$ 10.68	<.0001*
Retained placenta	Afrikander	145.40 $\pm$ 4.77	<.0001*
Last trimester of pregnancy	Afrikander	148.00 $\pm$ 7.55	<.0001*
	Bonsmara	144.50 $\pm$ 10.68	<.0001*
	Brahman	136.15 $\pm$ 4.19	<.0001*
	Mixed	0.00 $\pm$ 6.17	1.0000
	Nguni	145.40 $\pm$ 6.75	<.0001*
Vaginal prolapses	Afrikander	145.75 $\pm$ 7.55	<.0001*
	Brahman	142.00 $\pm$ 8.72	<.0001*

Statistical significance ($P \leq 0.05$), *indicates $P < 0.05$, normal range (136–145 mEq/L)

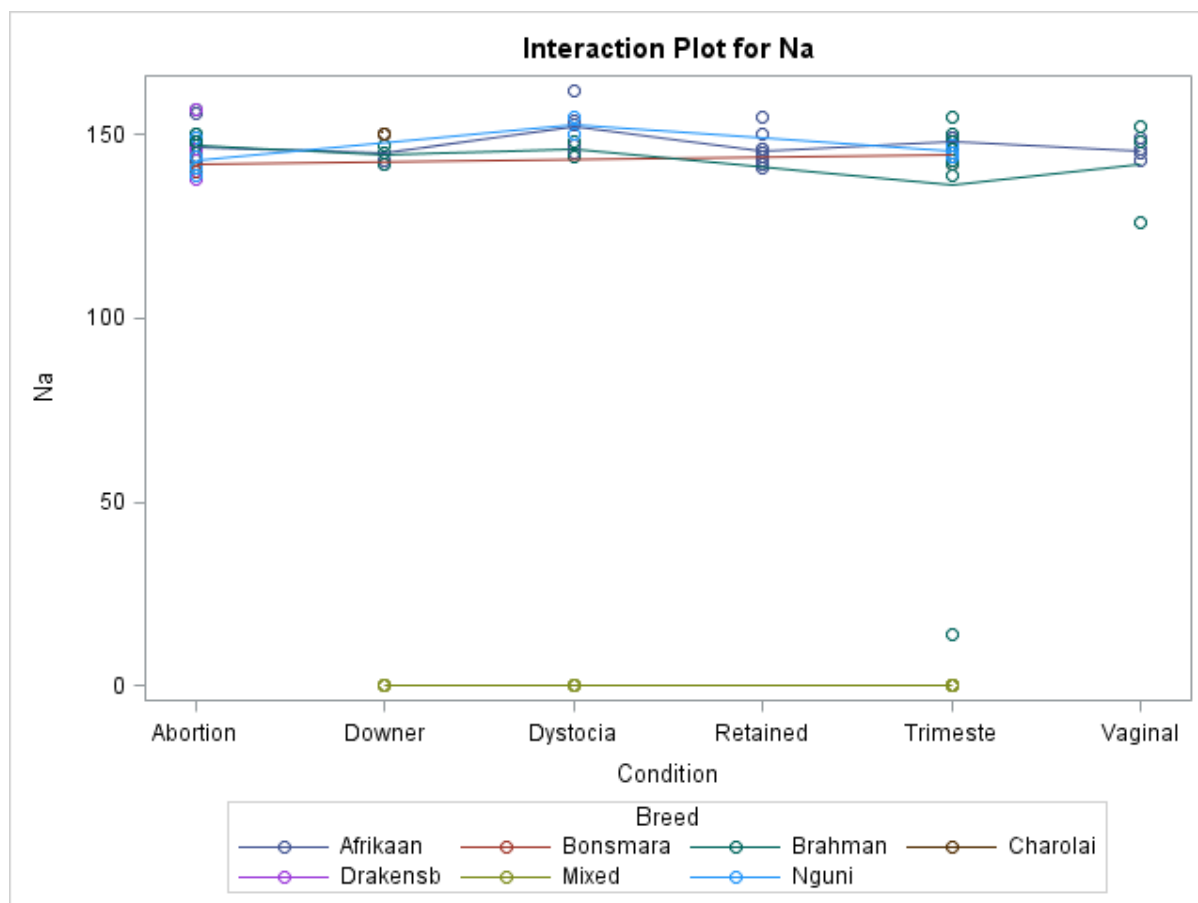


Figure 4.2.12 The association of serum Sodium (Na) and cows of different reproductive conditions.

No significance ($P > 0.05$) differences were seen in sodium concentration in mixed breeds (Figure 4.2.12). However, Abortion, downer cow syndrome, dystocia and last trimester cows showed significance ($P < 0.05$) in most breeds. Vaginal prolapses showed significance ($P < 0.05$) in Afrikaner and Brahman breeds Figure 4.2.12). Additionally, Retained placenta revealed significant differences ($P < 0.01$) with Sodium means concentration (Figure 4.2.12).

Results obtained showed that potassium mean concentrations were significant ($P < 0.05$) in abortion cases for the following cattle breeds: Afrikaner, Bonsmara, Brahman, Drakensberger and Nguni with means above normal ranges (3.5–5.0 mEq/L) (Table 4.2.17). The incidence of downer cow syndrome in Afrikaner, Brahman, Charolaise and Mixed breeds had significant correlation ($P < 0.05$) with the levels of potassium in serum with means higher than normal ranges (Table 4.2.17). It was also noted a significant link ($P < 0.05$) between selected breeds (Afrikaner, Brahman, Mixed and Nguni breeds) who developed dystocia and their serum potassium concentrations within normal ranges (3.5–5.0 mEq/L) (Table 4.2.17). However, no significant correlation was noted among Afrikaner breeds with retained placenta and potassium concentrations (Table 4.2.17).

Table 4.2.17 Least square means ($\pm$ SE) and p-values of serum Potassium concentration in cows experiencing reproduction conditions

Condition	Breed	Potassium MEAN $\pm$ SE	Pr> t
Abortion	Afrikander	6.967 $\pm$ 1.09	<.0001*
	Bonsmara	7.05 $\pm$ 1.89	0.0004*
	Brahman	7.61 $\pm$ 0.77	<.0001*
	Drakensberger	7.13 $\pm$ 1.55	<.0001*
	Nguni	7.05 $\pm$ 1.34	<.0001*
Downer cow syndrome	Afrikander	6.93 $\pm$ 1.55	<.0001*
	Brahman	6.03 $\pm$ 1.55	0.0002*
	Charolaise	6.40 $\pm$ 1.89	0.0012*
	Mixed	148.25 $\pm$ 1.34	<.0001*
Dystocia	Afrikander	4.72 $\pm$ 1.20	0.0002*
	Brahman	5.70 $\pm$ 1.89	0.0036*
	Mixed	148.75 $\pm$ 1.34	<.0001*
	Nguni	7.30 $\pm$ 1.89	0.0002*
Retained placenta	Afrikander	6.21 $\pm$ 0.84	<.0001*
Last trimester of pregnancy	Afrikander	4.18 $\pm$ 1.34	0.0026*
	Bonsmara	3.30 $\pm$ 1.89	0.0862

Statistical significance ($P \leq 0.05$), *indicated $P < 0.05$, normal ranges (3.5–5.0 mEq/L)

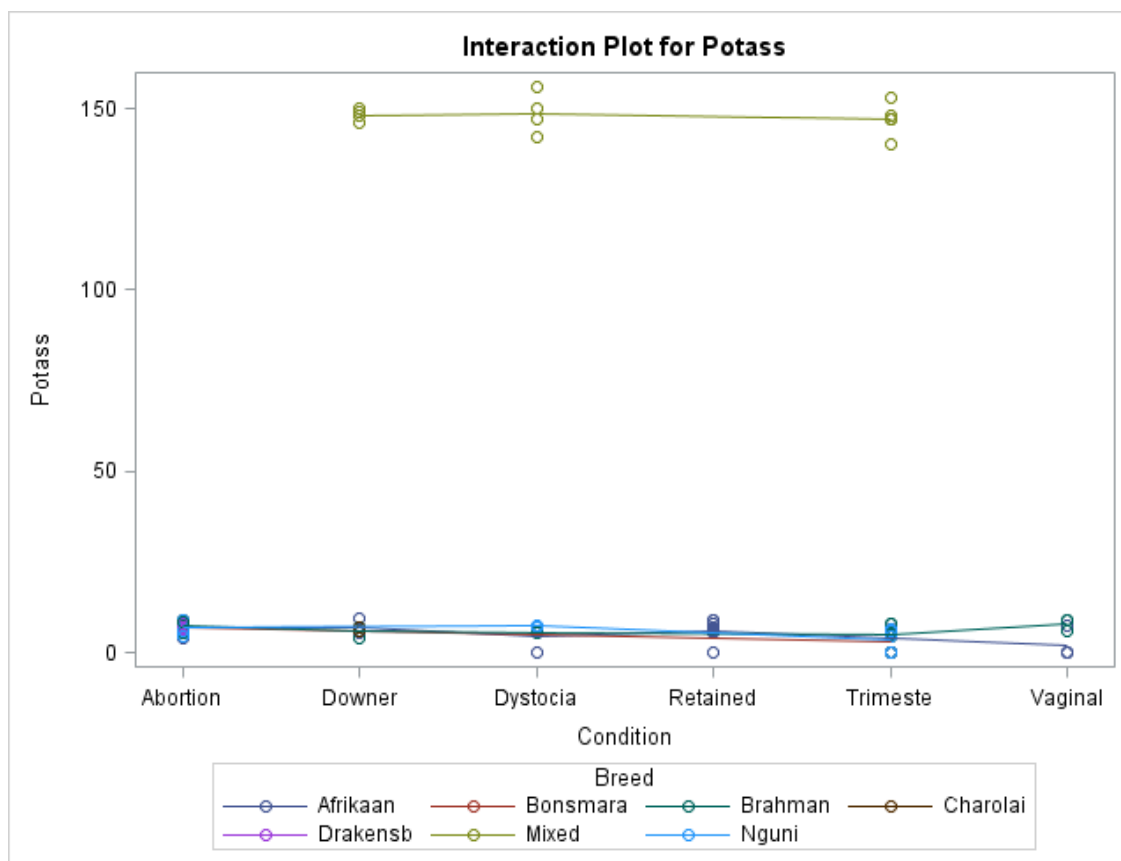


Figure 4.2.13 The association of serum potassium and cows of different reproductive conditions

Results in this study showed that there was a strong correlation ($P < 0.05$) in mixed breed downer cows, dystocia and cows in the last trimester of pregnancy (Figure 4.2.13). Moreover, in all other breeds a slight interaction was observed in the mean concentrations of potassium (Figure 4.2.13).

The study indicated that the mean concentrations of chloride had a significantly low correlation ($P < 0.05$) among cows which had abortion in Afrikander, Bonsmara, Brahman, Drakensberger and Nguni (Table 4.2.18). It was also seen that chloride mean concentrations in downer cows were significant ($P < 0.05$) in Afrikander, Brahman and Charolaise breeds. Afrikander, Brahman and Nguni breeds were significantly related ($P < 0.05$) to the chloride concentrations among animals with dystocia (Table 4.2.18). In the cases of cows in the last trimester of pregnancy, significant differences were seen in Afrikander, Brahman and Nguni breeds (Table 4.2.18). Additionally, chloride was found to be low compared to normal values and this was significantly correlated ($P < 0.05$) in animals which developed vaginal prolapses among Afrikander and Brahman (Table 4.2.18).

Table 4.2.18 Least square means ($\pm$ SE) and p-values of serum chloride (Cl) concentration in cow experiencing reproductive conditions and those in the last trimester of gestation

Condition	Breed	Chloride LSMEAN $\pm$ SE	Pr> t
Abortion	Afrikander	111.00 $\pm$ 5.03	<.0001*
	Bonsmara	102.00 $\pm$ 8.72	<.0001*
	Brahman	106.00 $\pm$ 3.56	<.0001*
	Drakensberger	104.67 $\pm$ 7.12	<.0001*
	Nguni	104.50 $\pm$ 6.17	<.0001*
Downer cow syndrome	Afrikander	104.67 $\pm$ 7.12	<.0001*
	Brahman	106.67 $\pm$ 7.12	<.0001*
	Charolaise	109.50 $\pm$ 8.19	<.0001*
	Mixed	6.950 $\pm$ 6.17	0.2631
Dystocia	Afrikander	110.00 $\pm$ 5.51	<.0001*
	Brahman	104.00 $\pm$ 8.72	<.0001*
	Mixed	5.975 $\pm$ 6.17	0.3355
	Nguni	114.00 $\pm$ 8.72	<.0001*
Retained placenta	Afrikander	95.60 $\pm$ 3.89	<.0001*
Last trimester of pregnancy	Afrikander	106.00 $\pm$ 6.17	<.0001*
	Bonsmara	104.00 $\pm$ 8.72	<.00018
	Brahman	107.69 $\pm$ 3.42	<.0001*
	Mixed	4.08 $\pm$ 5.03	0.4198
	Nguni	104.60 $\pm$ 5.51	<.0001*
Vaginal prolapses	Afrikander	109.75 $\pm$ 6.17	<.0001*
	Brahman	106.33 $\pm$ 7.12	<.0001*

Statistical significance ($P \leq 0.05$), *indicates $P < 0.05$, normal ranges (98-106 mEq/L)

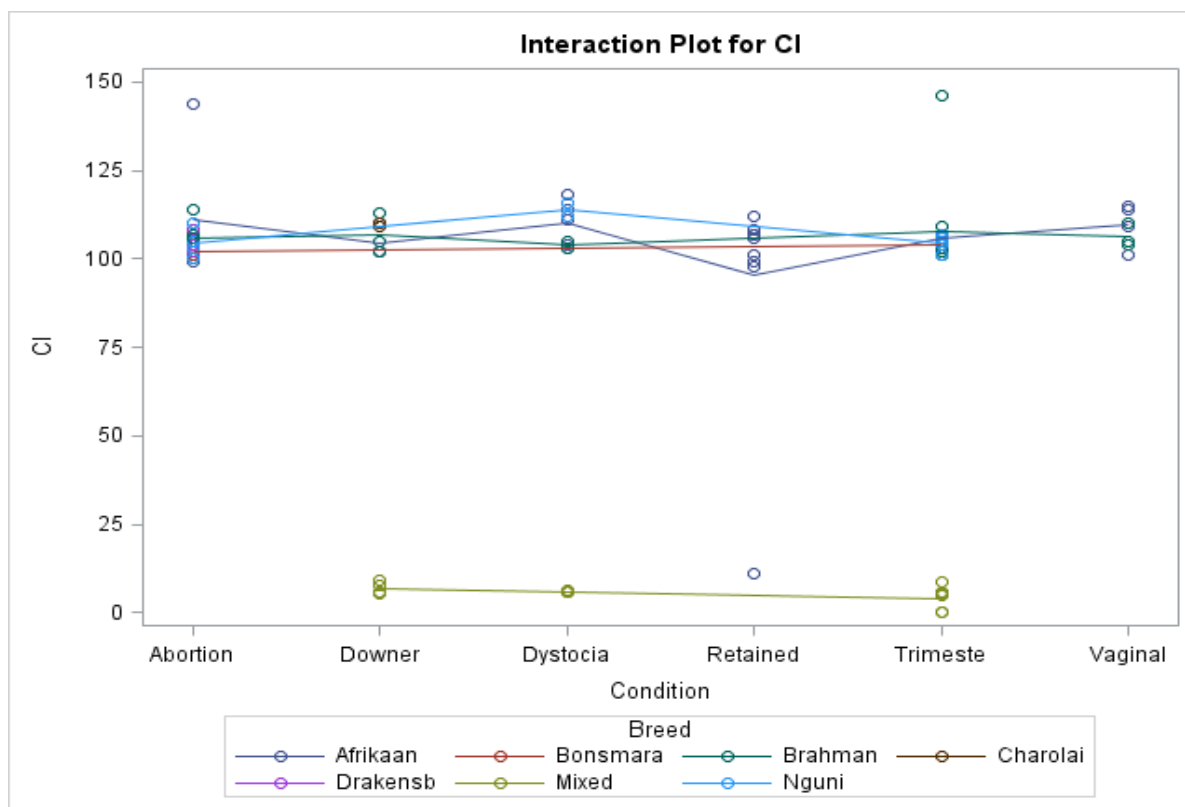


Figure 4.2.14. The association of serum chloride (Cl) and cows of different reproductive conditions

Results obtained showed that there was no significant correlation between mixed breeds and the level of chloride ($P > 0.05$) (Figure 4.2.14). However, Afrikaner breeds showed significance in all conditions. A correlation ($P < 0.01$) was found between the Charolaise affected by downer cow syndrome and the level of Chloride (Figure 4.2.14). In addition, significance correlation was found for Brahman affected by abortion, downer cow syndrome, dystocia, vaginal prolapses and among cow in last trimester of pregnancy (Figure 4.2.14). However, chloride concentrations were seen in correlation in Bonsmara affected by abortion and those in their last trimester of pregnancy (Figure 4.2.14).

The analysis of protein levels in all affected animal revealed that there a correlation ($P<0.01$) between protein concentration and cow affected by vaginal prolapses in Afrikander and Brahman (Table 4.2.19). Afrikander, Brahman, Mixed and Nguni with dystocia had significantly related to total protein concentration (Table 4.2.19). Furthermore, downer cows in Afrikander, Brahman and Charolaise breeds indicated a significant correlation with TP concentration ($P<0.01$) (Table 4.2.19). However, in all abortion cows' statistical significances were observed in Afrikander, Bonsmara, Brahman, Drakensberger, Nguni and Afrikander breeds (Table 4.2.19).

Table 4.2.19 Least square means ($\pm$ SE) and p-values of serum total protein (TP) concentration in cow experiencing reproductive conditions

Condition	Breed	Total protein LSMEAN $\pm$ SE	Pr> t
Abortion	Afrikander	74.33 $\pm$ 4.16	<.0001*
	Bonsmara	81.00 $\pm$ 7.21	<.0001*
	Brahman	70.68 $\pm$ 2.94	<.0001*
	Drakensberger	66.00 $\pm$ 7.21	<.0001*
	Nguni	83.50 $\pm$ 5.09	<.0001*
Downer cow syndrome	Afrikander	75.33 $\pm$ 5.88	<.0001*
	Brahman	65.67 $\pm$ 5.88	<.0001*
	Charolaise	66.00 $\pm$ 7.20	<.0001*
	Mixed	0.27 $\pm$ 5.09	0.9571
Dystocia	Afrikander	72.00 $\pm$ 4.56	<.0001*
	Brahman	78.00 $\pm$ 7.20	<.0001*
	Mixed	0.00 $\pm$ 5.09	1.0000
	Nguni	59.00 $\pm$ 7.20	<.0001*
Retained placenta	Afrikander	77.30 $\pm$ 3.22	<.0001*
Last trimester of pregnancy	Afrikander	76.50 $\pm$ 5.09	<.0001*
	Bonsmara	77.00 $\pm$ 7.21	<.0001*
	Brahman	78.77 $\pm$ 2.83	<.0001*
	Mixed	0.43 $\pm$ 4.16	0.9176
	Nguni	80.00 $\pm$ 4.56	<.0001*
Vaginal prolapses	Afrikander	70.25 $\pm$ 5.09	<.0001*
	Brahman	91.00 $\pm$ 5.88	<.0001*

Statistical significance ($P \leq 0.05$), *indicated $P < 0.01$, normal range (5.5–9.0 g/dL)

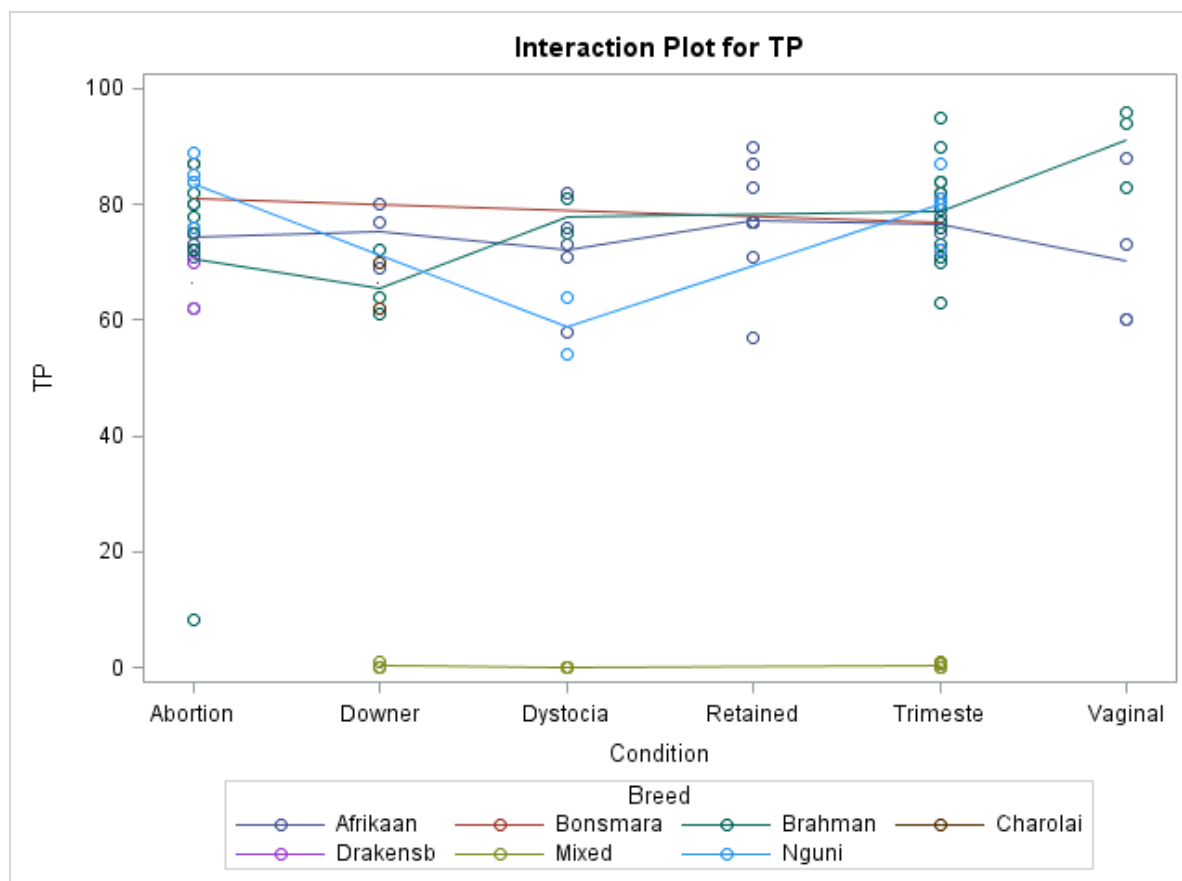


Figure 4.2.15 The association of serum Total Protein (TP) and cows of different reproductive conditions.

In this study, no statistical significances were observed in mixed breed cows for all conditions in relation to the total protein ($P > 0.05$). Afrikander, Bonsmara, Brahman, Drakensberger and Nguni in abortion cows showed significance ($P < 0.05$). Statistical significances were also observed in dystocia cows Afrikander, Brahman and Nguni breeds ($P < 0.05$). Afrikander, Brahman and Charolaise in downer cows were significant ($P < 0.05$). Afrikander and Brahman with vaginal prolapses and retained placenta Afrikander showed correlation with the total protein concentration in serum.

4.3 Factors (cow breed, body condition score and brucellosis infections status) that might influence the incidences of different reproductive conditions.

In this study results showed the majority (60%) of aborting cows were in a poor body condition score (1-2) (Table 4.3.1). High proportions of cow with retained placenta (46.2%) were observed in cow of good (2-3) body condition score (Table 4.3.1). It was also seen that BSC did not correlate with the prevalence of downer cow syndrome as the animals affected had spread body condition score which were poor (35.7%), good (35.7%) and very good (28.6%) indicated in (Table 4.3.1). On the other hand animal with vaginal prolapses were at 77.8% seen in cows of good (2-3) BCS while the rest (22.2%) were having poor body condition score (Table 4.3.1). In addition the study revealed that dystocia occurred in cows of poor, good and very good BCS with the proportions 41.9%, 45.2% and 12.9% respectively (Table 4.3.1).

Table 4.3.1 Association body condition score and prevalence of reproductive condition

Condition	Body condition score (BCS)		
	2-poor (n=17)	3-good (n=10)	4-very good (n=1)
Abortion %	60.7	35.7	3.6
Retained placenta %	38.5	46.2	15.4
Downer cow syndrome %	35.7	35.7	28.6
Vaginal prolapse %	22.2	77.8	0.0
Dystocia %	41.9	45.2	12.9

Pearson Chi-Square P=0.082, No statistical significance observed P>0.05

In terms of the breed types Brahman (46.4%) and Afrikander (21.4%) experienced high numbers of abortion (Table 4.3.2). The results also showed that retained placenta was mostly seen in Afrikander breed (76.9%) seen in (Table 4.3.2). The highest incidences of downer cow syndrome were observed in mixed breed (30.8%), Brahman (23.1%) and Afrikander (23.1%) as shown in (Table 4.3.2). The study also revealed that Afrikander (35.7%) and mixed breeds (35.7%) were the most affected by dystocia. Moreover vaginal prolapse occurred in Brahman (44.4%) and Afrikander (44.4%) with equal proportion (Table 4.3.2).

Table 4.3.2 Association breed type and prevalence of reproductive condition

Condition (%)	Cattle Breed						
	B1 n=36	B2 n=13	B3 n=6	B4 n=32	B5 n=4	B6 n=2	B7 n=15
Abortion (n=28)	46.4	14.3	15.4	21.4	10.7	0.0	0.0
Retained placenta (n=13)	7.69	7.69	7.69	76.9	0.0	0.0	0.0
Downer (n=13)	23.1	7.69	0.0	23.1	0.0	15.4	30.8
Dystocia (n=14)	7.1	14.3	7.1	35.7	0.0	0.0	35.7
Vaginal prolapse (n=9)	44.4	0.0	0.0	44.4	11.1	0.0	0.0

Key: B1-brahman, B2-Nguni, B3-Bonsmara, B4-Afrikander, B5-Drakensberger, B6-Charolaise, B7- Mixed breed; Pearson Chi-Square $P=0.000$, There was statistical significance observed $P<0.05$.

The study showed that Brucella infections were found in 53.6% of the cows which were aborting. While only 30.8% of retained placenta were positive for Brucella (Table 4.3.3). It was also seen that 61.5% of cow that had downer cows, dystocia (50%), vaginal prolapse (77.8%) and those in their final trimester of pregnancy tested positive for Brucella (Table 4.3.3).

Table 4.3.3 Association between bovine Brucellosis infections and prevalence of reproductive condition

Condition	Brucella rose Bengal test	
	Positive	Negative
Abortion	53.6	46.4
Retained placenta	30.8	69.2
Downer syndrome	61.5	38.5
Dystocia	50.0	50.0
Vaginal prolapse	77.8	22.2
Last trimester	25.8	74.2

Pearson Chi-Square $P=0.035$, There was a statistical significance observed $P<0.05$

CHAPTER 5

DISCUSSION

The aims and objectives of this study were to identify the major cause of the occurrence of bovine reproductive conditions and based on the blood and biochemical results obtained in each condition, to come up with a formula that predicts the possibility of the occurrence of a particular condition.

Results in this study were from data obtained through a questionnaire administered to farmers and analyses of blood samples from cows experiencing reproductive conditions in Ngaka Modiri Molema District. Data obtained showed that of all reproductive conditions recorded in this study, cows mostly experienced dystocia (26.2%), followed by retained placenta and abortion both with equal proportions (23.1%) shown in (Table 4.1.1). Similarly, higher incidences of dystocia (calving difficulty) were reported in twin bearing heifers (42.2%) and (20.4%) in single birth cows (Çobanoğlu, 2010). The results were further confirmed in a several studies which found high prevalence of dystocia which concurrently occurred with increased incidences of retained placenta (Bellows and Lammoglia, 2000; Grohn et al., 2003; Ettema and Santos, 2004). This could be due poor nutrition owing to the fact that 86.67% of dystocia and 82.35% retained placenta cows were not supplemented (Table 4.1.3). The results obtained in this study can be explained by the climatic conditions in the Ngaka Modiri Molema District where this study was conducted that are characterised by low rainfall and poor grazing pasture. Climate changes observed in the semi-arid area of Mafikeng seriously affect rainfall patterns, leading to drought and animal production being adversely affected.

In order to rule out the effect of bovine brucellosis among animals affected by reproductive conditions, serum samples in this study were analysed for brucellosis and almost 50 % were positive (Table 4.3.3). Brucellosis is known to be highly contagious, zoonotic and caused by bacteria of the genus *Brucella* which affects domestic and wild mammals in South Saharan Africa (Ducrotoy et al., 2015). The detection of positive samples might explain the occurrence of abortion among heifers during the first calving as seen in this study (Table 4.3.3) and not necessarily a result of food problems (Table.4.3.3). This can also be the effect of a combination of both the disease and nutrition. *Brucella* contamination has been known also to induce abortion only on the first calving and the animal remains a carrier and would mostly show the presence of other clinical signs which are retained placenta, dystocia and

retained placenta which occur at late age or parities. This corroborates the results obtained in this study in which a significant correlation was seen between the age and parity of the animal affected (Table 4.3.3).

In this study 20% of the conditions were downer cow syndrome, while only 7.7% of the cows had vaginal prolapses (Table 4.1.1). The occurrence of these conditions has been linked to hypocalcaemia (Radostits et al., 2000; Fleischer et al., 2001; Houe et al., 2001; FitzGerald, 2011). These results corroborate the findings of this study in which there were significantly low levels of calcium ($P < 0.05$) in analysed samples of animals developing downer cow syndrome and vaginal prolapses (Table 4.2.7).

In contrast to previous studies, significantly higher than normal calcium levels were seen in mixed breed (25.25%) cows (Table 4.2.7). These imply that in this study downer cow syndrome in mixed breeds could have resulted from other factors except calcium deficiency. It was also noticed that the majority of downer cows (61.1%) had Brucellosis (Table 4.3.3). These results agree with the findings of Darmono and Sudibyo (1990) which proved that calcium levels increase in cows due to *Brucella* infection.

The incidences of abortions in this study were found to be significantly high (60%) in Brahman (Table 4.1.3). Similar results were reported in Australia whereby foetal mortalities in Brahman cows were seen in half of the whole herd (Northern Territory Government, 2003). The cause for these incidences could have resulted from nutritional insufficiency which greatly compromises an animal's immunity to diseases. However, according to Murray (2006) the prevalence of abortion has a wide variation based on the herd health status and may occur at any stage during the gestation period. On the other hand, several researchers revealed that nutritional deficiency also predisposes cows to foetal mortality (Boland and Lonergan, 2013; Dunne et al., 2000).

Results obtained in this study also revealed that 46.15% of the reproductive conditions occurred in cows aged between 4-6 years, followed by cows aged between 1-2 years (38.3 %) indicated in Table 4.1.2. There is a significant difference ($P < 0.05$) in age of cows experiencing reproductive conditions observed in this study. These results agree with those of Gaafar et al. (2011) who stated that cow age greatly influences the occurrence of reproductive conditions. Moreover, these results are in line with the findings of Kanuya et al. (2006) and Matiko et al. (2008) who showed that age could influence reproductive efficiency and increase disease susceptibility. Results in this study also showed that downer cow syndrome and abortion mostly occurred with significant differences ($P < 0.05$) in ages between 1-3yrs while dystocia, retained placenta and vaginal prolapses were seen in cows aged between 4-6

years (Table 4.1.3). These results agree with those of Zaborski et al. (2009) who found that the incidence of dystocia did differ significantly in younger cows. This could be due to the fact that the reproductive capability of an older cow is low (Zaborski et al. 2009).

It was also noticed that 61.3% of animals monitored had a body condition score (BSC) 2-3 (good) in all reproductive conditions (Table 4.1.2). Body condition score did not show any significant differences ($P>0.05$) in the present study. The results in this study agree with those of Jílek et al. (2008) who observed no significant difference in BCS in cows in a Czech study. Some researchers have indicated that body condition score directly affects reproductive performance and may also induce calving difficulty (Pryce et al., 2001; Zaborski et al., 2009). Potential motives for the insignificant differences in BCS found in this study could be attributed to sample size, differences in other parameters examined and type of feeding used in these rural areas.

Results obtained also showed that there was a correlation between certain breeds (Brahman and Afrikaner) and the occurrence of reproductive conditions (abortion, downer cow syndrome, dystocia and retained placenta) (Table 4.1.3). Significant differences were seen in Afrikaner (33.8%), followed by Brahman (27.7%) and mixed breed (13.8%) in the present study (Table 4.2.1). Other results of this study showed that the occurrence dystocia (41.18%) and retained placenta (53.33%) differed significantly ($P>0.05$) in Afrikaner breed. These results agree with Schoeman (1989) who reported significant correlation in Afrikaner cows with dystocia and who further stated that this breed ranked low in a reproductive performance assessment study conducted in South and South West Africa.

It is important to mention that cows at first calving were the most (41.1%) affected by reproductive conditions (Table 4.1.3). Other results obtained in this study showed that most reproductive conditions occurred between the 1st and 2nd parity (Table 4.1.2). These results agree with those found in Norman et al. (2012) who showed that reproductive conditions are more prevalent in cows of low parity than in older cows. However, in this study parity did not significantly differ ($P>0.05$). Possible causes for this could be the lack of proper and uncontrolled breeding systems used in communal farms and environmental contextual changes which were not taken into account in the current study.

A study by Sawa et al. (2012) reported that increased prevalence of reproductive conditions was seen in cows at 4th to 8th parity. These results agree with those of the current study which found that dystocia and retained placenta were observed in cows at 7th and 8th parity (Table 4.1.3). These findings were further confirmed by Alam et al. (2014) who showed that

older cows may have retained placenta and contradicted own findings in stating that dystocia may occur in cows of low parity.

Cows in this study were reported to be experiencing the conditions for the first time with abortion (100%), retained placenta (50%), dystocia (94%); for downer cow syndrome (93.31%) and 80% vaginal prolapse (Table 4.1.3). It was also seen in the present study that retained placenta seems to occur more than once in the same cow with 13% of animals showing it for the 3rd time (Table 4.1.3). The recurring incidences of retained placenta could be due to lack of proper treatment of these conditions, attributable to lack of knowledge and financial incapacities of rural farmers.

The data obtained also showed that most animals that showed the conditions were not attended to nor supplemented with mineral or other foods (Table 4.1.3). The results of this study are in line with studies of Gupta et al. (2005) and Mee (2004) which revealed that the incidences of retained placenta and abortion may result from nutritional deficiencies. In the current study, there were no significant differences observed with regards supplementation. However, researchers have shown that significant differences in reproductive performance have been observed when cows are supplemented (Hemmingway, 2003; Black and French, 2004). The small sample size utilised in this study and lack of properly managed herds in communal farms may have influenced the results in this study. Amongst all variables tested only the breed ($P < 0.01$) and age ($P > 0.05$) showed significant variations in the reproductive conditions experienced.

According to Shirima et al. (2014) Brucellosis is a contagious, infectious and zoonotic bacterial disease which mostly affects domestic and wild animals. The disease primarily causes abortions, sterility and decreased milk production (Radostits et al. 2000). The infection of brucellosis in humans is transmitted by direct contact with infected animals and through eating of infected dairy products (Franco et al., 2007). Results in this study showed a slight significance in the Brucella infection with 53.6% of aborting cows being positive and 46.4% being negative. Other reproductive conditions experienced with brucellosis were downer cow syndrome (61.5%), dystocia (50.0%) and vaginal prolapse (77.8%) as seen in Table 4.3.3. The high concurrent incidence of brucellosis with other reproductive conditions could be seen in Ngaka Modiri Molema communities due to a lack of proper disease control and management. The incidence of brucellosis signifies that many people working with animals with unknown Brucella status may also be in danger when improperly handling such animals.

The significance of blood biochemical parameters in the assessment of animal health have been strongly emphasised by many researchers (Nozad et al., 2011). The serum metabolites analysis results obtained in this study revealed that the mean concentration of serum urea were within normal ranges (8–20 mg/dL) in all breeds (Table 4.2.1). These results agree with those of Ahmad et al. (2004) who also found that blood urea levels were within normal ranges in different cow breeds. It was also noted that urea mean concentration in abortion were significantly different ($P<0.05$) in Brahman breeds (Table 4.2.5 and Figure 4.2.1). These results agree with those of Ryley and Gartner (1970) who revealed that serum levels of urea increases the probability of abortion incidences. Moreover, results obtained revealed that retained placentas had significantly different ($P<0.05$) urea concentrations in Afrikander breeds (Table 4.2.5 and Figure 4.2.1).

A correlation was seen in all breeds and the level of uric acid with the level being above the normal range in all breeds (Table 4.2.1). Similar results were observed in a study by Mamun et al. (2013) who found significantly high uric acid levels in cows in Bangladesh. Results in this study also showed significant correlations ($P<0.05$) between levels of uric acid and Brahman, Bonsmara, Nguni, Afrikander, and Drakensberger breeds experiencing abortion (Table 4.2.6 and Figure 4.2.2).

The levels of calcium and magnesium in this study were also found to be significantly lower than the normal range in all breeds with values ranging between 0–3.2 mg/dL and 0.32–0.7 mg/dL respectively. Reports of many researchers have indicated that increased incidences of dystocia, downer cow syndrome and retained placenta may occur due to calcium deficiency (Lanyasunya et al., 2005; Akar and Yildiz, 2005). This is in line with results obtained in the current study which revealed low levels of calcium in downer cow syndrome, retained placenta and vaginal prolapses (Table 4.2.7). It is important to mention that the mean concentrations of calcium were only significant ($P<0.01$) in mixed breeds of downer cow syndrome, dystocia and cows at the last trimester of gestation (Table 4.2.7 and Figure 4.2.3).

On the other hand, normal range of magnesium was observed in mixed breed cows with a mean of 1.8 mg/dL (Table 4.2.1). These results agree with those of Kronqvist et al. (2011) who reported significant magnesium concentrations in mixed breed cows during the postpartum period. A significant correlation ($P<0.05$) was also noted in low magnesium concentrations of Afrikander, Brahman and Nguni breeds in aborting cows (Table 4.2.8 and Figure 4.2.4). These results agree with those of Donna (1994) which revealed that cows with

magnesium deficiency may result in higher abortion rates. The results obtained in this study may be due to inadequate feed supply in rural farming communities.

It was also seen that levels of aspartate amino-transferase (AST) were within normal ranges in most breeds. On the other hand, AST levels in Charolaise and Drakensberger breeds were very low 0.0U/L (Table 4.2.1). However, high levels of AST in Charolaise cows were observed in a study of Głowińska and Oler (2013). Results obtained in this study showed that the concentrations of total bilirubin were above normal ranges in all breeds having values of between 8.25 mg/dL and 10.16mg/dL (Table 4.2.2). Balakrishnan et al. (2011) reported similar results indicating a significant increase of bilirubin in cows that had aborted. However, the reason for these amounts of bilirubin could be due to haemolysis since some of the samples were collected from remote areas and were centrifuged after the recommended 2 hours.

The levels of ammonia were very high above normal ranges with values between 626.00 mg/dL and 960 mg/dL (Table 4.2.2). Similarly, a study of Sinclair et al. (2000b) indicated high ammonia concentrations. It was also noted that the level of ammonia in all the breeds of aborting cows were statistically ($P<0.05$) significant (Table 4.2.12 and Figure 4.2.8). Serum concentrations of triglycerides and lipase were found to be lower than normal with values ranging from 0.0 mg/dL and 45.33 U/L-101.80 U/L respectively (Table 4.2.2). It is important to mention that levels of serum triglyceride illustrated significant variations ($P<0.05$) only in mixed breed of dystocia, downer cows and cows in last trimester of gestation (Table 4.2.13 and Figure 4.2.9). These results are in agreement with those of Merck Veterinary Manual (2015) which indicated that hypocalcaemia may result in increased level of triglycerides resulting from fatty liver.

Results obtained showed also that the mean concentration of lipase were statistically significant ($P<0.01$) in abortion for Afrikaner and Nguni breeds (Table 4.2.14 and Figure 4.2.10). The results also indicated that there was a significant correlation observed in sodium and potassium levels which were lower than the normal ranges except for Brahman (143.49 mEq/L) and Nguni (3.597 mEq/L) (Table 4.2.3). A study of Yasothai (2014) indicated that both sodium and potassium negatively affect reproductive performance and fertility. These findings further prove the results of the present study showing significantly low levels of sodium and potassium. Results in this study indicated that Afrikaner, Bonsmara, Brahman, Drakensberger and Nguni breeds in abortion cases had significantly different ($P<0.05$) sodium levels (Table 4.2.16 and Figure 4.2.12).

The present study also revealed that the levels of total protein were mostly above normal ranges in most breeds with values ranging from 25.31g/dL and 38.25g/dL (Table 4.2.3). Hamudikuwanda (1999) reported high total protein as cause for low conception rate in cows. Furthermore, downer cows in Afrikander, Brahman and Charolaise breeds indicated a significant correlation with TP concentration ($P<0.01$) (Table 4.2.19). These findings imply that total protein has a direct effect on reproduction in cattle. On the other hand, Afrikander, Bonsmara, Brahman and Nguni breeds indicated a significantly different total protein (TP) concentration in cows in the last trimester of pregnancy ($P<0.01$). The results obtained in this study revealed that levels of protein in vaginal prolapses in Afrikander and Brahman breeds were significantly ($P<0.01$) different (Table 4.2.19).

It was noted that the mean concentration of total bilirubin in Brahman, Mixed and Nguni breeds showed significant ($P<0.05$) variations in aborting cows (Table 4.2.10 and Figure 4.2.6). A study by Balakrishnan et al. (2011) reported similar results, indicating a significant increase of bilirubin in cows that had aborted. Moreover, mean concentration of TBIL significantly related to the Brahman, Mixed and Nguni breeds ($P<0.05$). Significant differences of cholesterol levels were seen in breeds affected by abortion in Afrikander, Brahman and Nguni at ($P<0.01$), while Bonsmara and Drakensberger showed significance at ($P<0.05$) (Table 4.2.11 and Figure 4.2.7). The mean concentrations of cholesterol (CHOL) were all below the normal ranges in Afrikander (2.82 mg/dL), Bonsmara (2.95 mg/dL), Brahman (3.14mg/dL), Nguni (3.34mg/dL), Charolaise (1.90mg/dL) and Drakensberger (2.67mg/dL).

Similarly, low levels of serum cholesterol were reported by Dampthey et al. (2014) in Nguni and mixed breed cows, which were grazing on natural grassland in Eastern Cape, South Africa. Nonetheless, the current study found that cholesterol concentrations in all reproductive conditions were within normal ranges (Table 4.2.2). It was seen that creatinine kinase (CK) means had significant ($P<0.05$) concentrations in mixed breeds downer cows, cows in the last trimester of gestation and dystocia cows (Table 4.2.15 and Figure 4.2.11). These results agree with those of Stull et al. (2007) which indicated that in terms of muscle damage, creatinine kinase may be high in cows with hypocalcaemia. The study also agrees with results obtained by Magnus and Lali (2009) who indicated that calcium deficiency predisposes cows to dystocia.

The present study revealed that in cows which were experiencing reproductive conditions, body condition score, number of incidence of the condition, treatment given to the cows prior

to the condition, medical history of the cows (Table 4.3.1), parity (Table 4.3.4) and supplementation (Table 4.3.5) did not differ significantly ($P>0.05$). The study further showed that among all parameters, cow age (Table 4.1.3), breed (Table 4.3.2) and brucellosis infection (Table 4.3.3) had significant ($P<0.05$) influences on the prevalence of reproductive condition. Other results of this study show that all the blood parameters tested in this study were significantly different related to the breed, while only urea/BUN, magnesium, AST, total bilirubin, lipase and potassium were significantly related to the different reproductive condition. In terms of condition $\times$ breed interaction, the serum metabolites which showed significant variation were urea/BUN, calcium, AST, total bilirubin, lipase, potassium and total protein. The results of this study show that there are many factors that may influence the incidences of reproductive conditions. Tables 5.1 and 5.2 summarise parameters which were particular and significant for each condition and that one would look at and predict the condition. However, more still needs to be done in terms of validating these results. The number of samples needs to be increased for a more robust statistical analysis and the exclusion of all *Brucella* positive in order to confirm the hypothesis at the centre of this study.

Table 5.1 Resume of possible breed's correlations to reproductive conditions vs. blood parameters

Condition	Breed	Ca	Mg	Urea	Uric acid	AST	Cholesterol	Ammonia
Abortion	Brahman	0.10±4.88	0.67±0.13*	3.57±1.3	50.5±7.8*	0±8.44	3.53±0.56**	713.67±70.35*
	Nguni	0.50 ±8.47	0.84±0.23*	2.70±2.3	47.0±13.5*	0±14.62	3.19±0.97**	719.25±121.84*
	Bonsmara	0.00 ±11.95	0.51±0.32	-	53.0±19.0 *	0±20.68	2.95±1.37*	470.5 ±172.31*
	Afrikander	0.34 ±6.90	0.57±0.19*	-	62.7±10.9*	0±11.94	2.52±0.79**	760.16±99.48*
	Drakensberger	0.00±9.76	0.67±0.26	3.07±2.5	43.00±15.52*	0±16.88	2.67±1.12*	718.7±140.69*
Dystocia	Brahman	2.42±11.96	0.00±0.32	1.45±3.1	32.5±19.0	0±20.68	3.68±1.37**	815.5±172*
	Nguni	2.12 ±11.95	0.00±0.32	5.85±3.1	20.50±19.0	0±20.68	4.04±1.37**	670.5±172.31*
	Afrikander	2.14 ±7.56	0.00±0.21	4.9±1.9*	63.8±12.0*	0±13.08	3.06±0.87**	687.40±108*
	Mixed breed	85.50 ±8.46*	2.12±0.23*	-	-	73±14.6*	7.75±0.97**	2.72±121.84*
Downer cow syndrome	Brahman	1.98±9.76	0.00±0.26	4.40±2.48	36.7±15.5*	0±16.88	2.17±1.12*	750.±140.69*
	Nguni	-	-	-	-	0±20.68	-	-
	Afrikander	2.07±9.76	0.00±0.26	4.9±2.5*	36.3±15.5*	0±16.88	2.83±1.12*	868.7±140.69*
	Charolaise	0.78±11.95	0.46±0.33	10.4±3.4*	30.50±19.0	0±20.68	1.90±1.37	960.±172.31*
	Mixed breed	25.25 ±8.47*	1.33±0.23*	-	-	72. ±15.62*	6.50±0.97**	2.34±121.84
Retained placenta	Afrikander	2.13±5.35	0.00±0.15	-	34.4±8.5*	87.1±9*	3.18±0.61**	860.20±77.06*
Vaginal prolapse	Brahman	3.10±2.84	0.77±0.27*	-	-	0±16.88	-	-
	Afrikander	14.7±2.15*	0.88±0.23*	-	47.8±13.5*	0±14.62**	2.37±0.97**	960.00±121.84*

* Statistically significant (p <0.001), **significant (p<0.05)

Table 5.2 Resume of possible breed's correlations to reproductive conditions vs. blood biochemistry

Condition	Breed	Lipase	Creatinine kinase	Sodium	Potassium	Chloride	Total protein	Triglycerides
Abortion	Brahman	50.8±12.49	0.0±9.61	147.2±4.4*	7.61±0.77*	106.00±3.56*	70.68±2.94*	0.00±29.37
	Nguni	47.0±21.65**	0.0±16.65	143.3±7.6*	7.05±1.34*	104.50±6.17*	83.50±5.09*	0.00±50.88
	Bonsmara	52.5±30.6	0.0±23.55	142±10.68*	7.05±1.89*	102.00±8.72*	81.00±7.21*	0.00±71.96
	Afrikander	43.7±17.7**	0.0±13.59	146.5±6.2*	6.967±1.09*	111.00±5.03*	74.33±4.16*	0.00±41.54
	Drakensberger	45.3±24.9	0.0±19.23	147±8.72*	7.13±1.55*	104.67±7.12*	66.00±7.21*	0.00±58.75
Dystocia	Brahman	51.50±30.6	0.0±23.6	146±10.68	5.70±1.89*	104.00±8.72*	78.00±7.20*	0.00±71.95
	Nguni	204. ±30.6*			7.30±1.89*	114.00±8.72*		0.00±71.96
	Afrikander	114±19.4*	0.0±14.89	152.2±6.75	4.72±1.20*	110.00±5.51*	72.00±4.56*	0.00±45.50
	Mixed breed	0.0±21.65*	59.8±16.7*	0.00±7.55	148.75±1.34*	5.975±6.17	0.00±5.09*	656.50±50.88*
Downer cow syndrome	Brahman	106.±24.9*	0.0±19.22	144.7±8.72*	6.03±1.55	106.67±7.12*	59.00±7.20*	0.00±58.75
	Nguni						65.67±5.88	0.00±71.96
	Afrikander	39.7±24.9	0.0±19.22	145±8.72*	6.93±1.55	104.67±7.12*	75.33±5.88*	0.00±58.75
	Charolaise	63.5±30.6**	0.0±23.56	150±10.68*	6.40±1.89	109.50±8.19*	66.00±7.20*	
	Mixed breed	0.0±21.65	100.5±16.7*	0.00±7.55	148.25±1.34	6.950±6.17	0.27±5.09*	0.00±71.96*
Retained placenta	Afrikander	65.0±13.7	0.00±10.53	145.4±4.8*	6.21±0.84*	95.60±3.89	77.30±3.22*	0.00±32.18
Vaginal prolapse	Brahman			142.±8.72*		106.33±7.12*	91.00±5.88*	
	Afrikander	87.3±21.64	0.00±16.65	145.8±7.6*		109.75±6.17*	70.25±5.09*	0.00±50.88

* Statistically significant (p <0.001), **significant (p<0.05)

CHAPTER 6

CONCLUSION

This study aimed to evaluate the serum nutritional and mineral levels in bovine presenting with reproductive conditions with the objective of developing a tool that predicts the occurrence of a specific reproductive condition, and to determine whether or not nutrition has an influence on the occurrence of these. To accomplish these objectives a total of 108 blood samples were collected between 2012 and 2015 from cases of reproductive conditions such as downer cow syndrome, dystocia, retained placenta, vaginal prolapse, abortion and those from cows in the final trimester of pregnancy reported to the North-West University teaching hospital. Structured questionnaires were also used to collect data from farmers in Ngaka Modiri Molema District of the North-West Province. Farmers were interviewed during farm visits and at community outreach programmes organized by North-West University Animal Health Department. Farmers were asked questions including the type of conditions that their cows had experienced, age of the cow, breed, the body condition score, incidences of the condition, parity, whether the cows supplemented or not, and whether there was any treatment given to the cows prior to the condition and medical history. Blood samples were screened for brucellosis by Rose Bengal Plate Test and later analysed by IDEXX catalyst machine for serum biochemical parameters such as calcium, magnesium, total protein, creatinine kinase, lipase, triglycerides, blood urea nitrogen, uric acid, Aspartate amino-transferase, sodium chloride, potassium, cholesterol, total bilirubin and ammonia. Blood collected from cows that show signs of abortion, retained placenta, downer cow syndrome, vaginal prolapse and dystocia were collected at the same time with the controls from cows in the final trimester of pregnancy. Results obtained showed dystocia was found to be the most frequent (26.2%) experienced condition, followed by abortion and retained placenta with equal proportions of 23.1%, then downer cow syndrome (20%). This study also revealed that 46.15% of the reproductive conditions occurred in cows aged between 4-6 years, followed by cows aged between 1-2 years at (38.3 %). On the other hand, body condition score (BCS) did not show any significant differences ($P>0.05$). It was also seen that cows at first calving were mostly (41.1%) affected by reproductive conditions. Results also showed that cows in this study were reported to be experiencing the conditions for the first time with abortion at (100%), retained placenta (50%), dystocia (94%); downer cow syndrome (93.31%) and 80%

vaginal prolapse. It was as well noticed that the majority of downer cows (61.1%) had Brucellosis. Other reproductive conditions experienced with brucellosis were dystocia (50.0%) and vaginal prolapse (77.8%). The incidences of abortions in this study were found to be significantly high (60%) in Brahman. The cows in the final trimester of pregnancy were mostly Brucella negative (74.2%).

The levels of calcium and magnesium in this study were found to be significantly lower than the normal range in all breeds with values ranging between 0-3.2 mg/dL and 0.32-0.7 mg/dL respectively. Calcium concentrations were significantly low ($P < 0.01$) in downer cow syndrome, dystocia and cows in the last trimester of gestation. Low magnesium concentrations were seen in Afrikaner, Brahman and Nguni breed in aborting cows. This study moreover revealed that levels of aspartate amino-transferase (AST) were within normal range in most breeds. The mean concentrations of serum urea were within normal ranges (8–20 mg/dL) in all breeds. The concentrations of total bilirubin were above the normal ranges in all breeds having values between 8.25 mg/dL and 10.16mg/dL. Levels of ammonia were very high above normal ranges with values between 626.00 mg/dL and 960 mg/dL in this study. Serum concentrations of triglycerides and lipase were found to be lower than normal with values ranging from 0.0 mg/dL to (45.33 U/L -101.80 U/L) respectively. Serum triglyceride illustrated significant variations ($P < 0.05$) only in mixed breed of dystocia, downer cows and cows in last trimester of gestation. Results obtained showed also that the mean concentration of lipase were statistically significant ($P < 0.01$) in aborting Afrikaner and Nguni breeds. The present study also revealed that the levels of total protein were mostly above the normal ranges in most breeds with values ranging from 25.31g/dL to 38.25g/dL. The mean concentrations of cholesterol (CHOL) were all below the normal ranges in Afrikaner (2.82 mg/dL), Bonsmara (2.95 mg/dL), Brahman (3.14mg/dL), Nguni (3.34mg/dL), Charolaise (1.90mg/dL) and Drakensberger (2.67mg/dL).

There were no significant differences in number of parity and whether or not the cows were supplemented. The results in this study show that the majority of cows in communal farming areas are not supplemented. Increased incidences of conditions such as downer cow syndrome, abortion, dystocia, retained placenta and vaginal prolapses in communal areas are a serious concern. The causes for these conditions in rural areas are in most cases never discovered as many of the cases are not reported for clinical investigation. Cattle production is therefore affected as a result of massive losses from cow reproductive conditions. The non-controlled feeding systems practiced in small scale farming areas lead to poor and limited

pasture. In this form of feeding, overgrazing is usually experienced due to high competition for natural resources which limit the availability of nutrient feed. Small scale farmers in most rural areas and in Ngaka Modiri Molema District in particular, keep cattle to generate income to support their families. From that reality, the financial capacity of these farmers mainly depends on the production of cattle. The levels of disease control in communal farming are still lagging behind and this interferes with cow reproduction and production. Competent cattle production in communal farming requires adequate and well monitored dietary needs of the cows. Optimum herd management strategies are as well important contributing aspects in ensuring maximum production. Mineral deficiencies such as calcium and magnesium can influence the occurrence of reproductive conditions and impair cow fertility. However, due to the high infection of *Brucella* in these communal areas, it is therefore not easy to conclude that the conditions were as a result of nutritional deficiencies or brucellosis. The study was also limited in terms of formulating a reference tool enabling veterinary practitioners to predict the occurrence of any conditions. It is therefore important to further this study with more cases by eliminating all *Brucella* positive animals, increasing the number of different conditions, evaluating all parameters such as food, environment, breeds and blood in order to reach the main objective.

The general observation seen was that most animals showing reproductive conditions had deficiency of major minerals such as calcium, magnesium and potassium, hence the lack in energy. There is a need for proper cow management in the rural areas. The study still needs to be extended and more robust in order to find solutions for the production of bovines in emerging farms and improving the economic quality of life for the affected farmers.

REFERENCES

- Abd Ellah, M. R., Hamed, M. I., Ibrahim, D. R. & Rateb, H. Z., 2014. Serum biochemical and haematological reference intervals for water buffalo (*Bubalus bubalis*) heifers. *Journal of the South African Veterinary Association*; 85(1): 1- 7.
- American Board of Internal Medicine (ABIM) Laboratory Reference Ranges. 2015.
- Abrams, S. A. & Atkinson, S. A., 2003. Calcium, magnesium, phosphorus and Vitamin D fortification of complementary foods. *Journal of Nutrition*; 133: 2994S-2999S.
- Abuom, T. O., Njenga M. J., Wabacha, J. K., Tsuma, V. T. & Gitau G. K., 2012. Incidence and risk factors of peri-parturient conditions in smallholder dairy cattle herds in Kikuyu Division of Kiambu District, Kenya. *Ethiopian Veterinary Journal*; 16(2): 85-102.
- Abutarbush, S. & Radostits, O. M., 2003. Congenital nutritional muscular dystrophy in a beef calf. *Canadian Veterinary Journal*; 44(9): 738-739.
- Adams, M., 1999. Correlated factors in amphibian decline: Exotic species and habitat change in western Washington. *Journal of Wildlife Management*; 63: 1162-1171.
- Adegboye, M. F. & Babalola., O.O., 2013. Phylogenetic Characterization of Culturable Antibiotic Producing Streptomyces from Rhizospheric Soils; *Molecular Biology*: 1-7. (001. doi:10.4172/2168-9547.S1-001)
- Afonso, C., Tulman, E., Lu, Z., Oma, E., Kutish, G. & Rock, D., 1999. "The Genome of *Melanoplus sanguinipes* Entomologists". *Journal of Virology*; 73 (1): 533–52.
- Agenas, S., Heath, M. F., Nixon, R. M., Wilkinson, J. M. & Phillips, C. J. C., 2006. Indicators of under nutrition in cattle. *Animal Welfare*; 15(2): 149-160.
- Agger, N. & Renney, D. J., 2004. Prevention of milk fever by oral dosing with calcium around calving - "The Scandinavian way". *Cattle Practice*; 12: 271-274.
- Agricultural Research Council (ARC), 1980. The Nutrient Requirements of Ruminant Livestock. Slough, U.K: *Commonwealth Agricultural Bureaux*.
- Ahmad, I., Lodhi, L. A., Qureshi, Z. I. & Younis, M., 2004. Studies on blood glucose, total proteins, urea and cholesterol levels in cyclic, non-cyclic and endometritic crossbred cows. *Pakistan Veterinary Journal*; 24:92-94.
- Ahmed, S., Ahmad, I., Lodhi, L. A., Ahmad, N. & Samad, H. A., 2005. Clinical, haematological and serum macro mineral contents in buffaloes with genital prolapse. *Pakistan Veterinary Journal*; 25: 167-170.

- Ainslie, A., Kepe, T., Ntsebeza, L., Ntshona, Z. & Turner, S., 2002. Cattle ownership and production in the communal areas of the Eastern Cape, South Africa. Research Report number 10. University of the Western Cape, South Africa.
- Akar, Y. & Yildiz, H., 2005. Concentrations of Some Minerals in Cows with Retained Placenta and Abortion. *Turkey Journal of Veterinary Animal Science*; 29: 1157-1162.
- Alaçam, E. & Evcil, H., 2002. Doğum ve infertilite. *Medisan Yayınları*, Ankara.
- Alam, M. A., Bhuiyan, M. M. U., Parvin, M. S., Rahman, M. M. & Bari, F.Y., 2014. Prevalence of reproductive diseases and its associated risk factors in crossbred dairy cows. *Research Agricultural Livestock Journal- Fish*; 1(1): 71-79.
- Alam, M. G. S., Ghosh, A., Mondal, A. K. & Akbar, M. A., 2001. Supplementation and puberty of Zebu calves of Bangladesh. *The Bangladesh Veterinarian*; 18: 1-8.
- Alam, M. M. & Sarder, M. J. U., 2010. Effects of nutrition on production and reproduction of dairy cows in Bangladesh. *The Bangladesh Veterinarian*; 27(1): 8 – 17.
- Algers, B., Bertoni, G., Broom, D., Hartung, J., Lidfors, L., Metz, J., Munksgaard, L., Pina, T. N., Oltenacu, P., Rehage, P., Rushen, J., Smulders, F., Stassen, E., Stilwell, G., Waiblinger, S. & Webster, J., 2009. Effects of farming systems on dairy cow welfare and disease. Report of the Panel on Animal Health and Welfare Annex to the European Food Safety Authority Journal; 1143: 1-284.
- Allen, S. A. & Miller, E. L., 1976. Determination of nitrogen requirement of microbial growth from the effect of urea supplementation of a low N diet on abomasal N flow and N recycling in wethers and lambs. *British Journal of Nutrition*; 36: 353.
- Anderson, M. L., Andrianarivo, A. G. & Conrad, P.A., 2000. Neosporosis in cattle. *Animal Reproduction Science*; 60-61:417-431.
- Andrews, N. C., 2005. Molecular control of iron metabolism. *Best practice & research clinical haematology*; 18(2): 159 -169.
- Andrieu, S., 2008. Is there a role for organic trace element supplements in transition cow health? *Veterinary Journal*; 176: 77-83.
- Anka, M. S., Hassan, L., Khairani-Bejo, S., Zainal, M. A., Mohamad, R., Salleh, A. & Adzhar, A., 2014. A Case-Control Study of Risk Factors for Bovine Brucellosis Seropositivity in Peninsular Malaysia. *PLoS ONE*; 9(9): e108673. (doi:10.1371/journal.pone.0108673)
- Arnaud, M. J., 2008. Update on the assessment of magnesium status. *British Journal of Nutrition*; 99(3): S24-S36.

- Arthington, J. D., 2008. Essential trace minerals in grazing cattle in Florida. UF-IFAS, EDIS Publication. No. AN086, Coop. Ext., University of Florida, Gainesville.
- Arthur, G. H., Noakes D. E. & Pearson H., 1996. Dystocia and other disorders associated with parturition. In: *Veterinary Reproduction and Obstetrics*. (Therigenology) 6th edition. W. B. Saunders, London.
- Ateba, T. P. & Beighle, D. E., 2011. Effect of layer chicken litter and yellow maize meal on mineral status of bovine. *Science Journal*; 8(11): 1097 – 8135.
- Atlim, M., Erikoglu, M., Kaynak, A., Esen, H. & Kurban, S., 2012. Effects of selenium and vitamin E on the lungs tissue in rats with sepsis.j *Journal of Clinical Investigation*; 35(2):E48-54.
- Azawi, O.I., 2008. Postpartum uterine infection in cattle. *Animal Reproduction Science*; 105 (3-4): 187-203.
- Bakunzi, F., Motsei, L., Nyirenda, M., Ndou, R., Dzoma, B. & Mwanza, M. 2012. The Effect of Dicalcium Phosphate Supplement in Summer and Winter Seasons as Reflected on Bone and Blood Phosphorus, Calcium and Magnesium Levels in Range Breeding Beef Cattle. *Journal of Agriculture and Biodiversity Research*, ISSN 2277-0836; 1(4): 60-64.
- Balakrishnan, G., Parima, R. G., Thangapandian, M., Govindarajan, R., Ramaswamy, V. & Murali Manohar, B., 2011. Biochemical profiles in bovine leptospirosis. Tamilnadu *Journal Veterinary and Animal Sciences*; 7(5); 243-246.
- Balarane, A. & Oladele, O. I., 2012. Awareness and use of agricultural market information among small scale farmers in Ngaka Modiri Molema District of North-West Province *Life Science Journal*; 9(3): 57-62.
- Barber, J. & Wood, D. J., 1976. *Livestock management for East Africa*: Edwar Arnold (Publishers) Ltd 25 Hill Street London, W1X 8LL; ISBN: 071310063X.
- Barlowska, J., Szwajkowska, M., Litwinczuk, Z. & Matwijczuk, A., 2011. The influence of cow breed and feeding system on the dispersion state of milk fat and content of cholesterol. *Annals of Polish Association. Zootech*; 7: 57-65.
- Bartolomeun, C. C., Soares, P. C., Machado, E. H. L. & Alence. S. P., 1997. Incidence of vaginal prolapses in bovines, Campus Garanhuns. *Revista Brasileira de Reproducao Animal*: 177 – 180.
- Battler, W. R., 2000. Nutritional interactions with reproduction in dairy cattle. *Animal Reproduction Science*; 60(61): 449-457.

- Bedwal, R. S. & Bahuguna, A., 1994. Zinc, copper and selenium in reproduction. *Experientia*; 50: 626-640.
- Bell, H. M., 1973. *Rangeland Management for Livestock Production*. University of Oklahoma Press, Norman.
- Bellows, R. A. & Lammoglia, M. A., 2000. Effects of severity of dystocia on cold tolerance and serum concentrations of glucose and cortisol in neonatal beef calves. *Theriogenology*; 53: 803–813.
- Bendixen, P., Vilson, B., Ekesbo, I. & Astrand, D., 1986. Disease frequencies in Swedish dairy cows. I. Dystocia. *Preventive Veterinary Medication*; 4:307-316.
- Bennett, H. W., 1944. Two sheep problems on subterranean clover dominant pastures. *Journal of Agriculture of West Australia*; 21: 104-109.
- Berry, D. P., Lee, J. M., Macdonald, K. A. & Roche, J.R., 2007. Body condition score and body weight effects on dystocia and stillbirths and consequent effects on post-calving performance. *Journal of Dairy Science*; 90: 4201–4211.
- Black, D. H. & French, N. P., 2004. Effects of three types of trace element supplementation on the fertility of three commercial dairy herds. *Veterinary Record Journal*; 154: 652-658.
- Blaine, J., Chonchol, M. & Levi, M., 2014. Renal regulation of calcium, phosphate and magnesium homeostasis. *Clinical Journal of the American Society of Nephrology*, (doi: 10.2215/CJN.09750913).
- Blanche, D. & Martin, G. B., 2009. Focus to improve reproductive performance in male and female sheep and goats: how it works and strategies for using it. In Papachristou, T.G (ed). Parasi, Z. M. (ed). Ben Salem, H. (ed). Morand-Fehr. P. (ed). *Nutritional and foraging ecology of sheep and goats*. Zaragoza; CIHEAM/FAO/NAGREF: 351-364.
- Boland, M. P. & Lonergan, P., 2003. Effects of Nutrition on Fertility in Dairy Cows. *Advances in Dairy Technology*; 15: 19.
- Boland, M. P., 2003. Trace minerals in production and reproduction in dairy cattle. *Advances in Dairy Technology*; 15: 319-330.
- Bonneville-Hebert, A., Bouchard, E., Du Tremblay, D. & Lefebvre, R., 2011. Effect of reproductive disorders and parity on repeat breeder status and culling of dairy cows in Quebec. *Canadian Journal of Veterinary Research*; 75: 147-151.
- Botsime, B. D., 2006. Influence of agro-ecological region on selected anthropometrical measurements of Nguni cattle in South Africa. MSc Thesis, University of Pretoria, Pretoria, South Africa.

- Boyazoglu, P. A., 2004. Factors influencing weaning percentages of indigenous goats on communal grazing. *South African Journal of Animal Science* ; 34(1): 130-133.
- Brawn, J. P., Medaille, C. & Trumel, C., 2008. Clinically interpretation of enzyme activities and concentrations: A review of the main metabolic factors affecting variation. *Israel Journal of Veterinary Medicine*; 63(1): 1-12.
- Bremner, I. & Dalgarno, A. C., 1973. Iron metabolism in the veal calf. 2. Iron requirements and the effect of copper supplementation. *British Journal of Nutrition*; 30:61–76.
- Bruinsma, J., 2003. World Agriculture: Towards 2015/2030, An FAO perspective. Rome, Italy: Earth scans FAO.
- Brzezinska-Slebodzinska, E., Miller, J. K., Quigley, J. D., Moore III, J. R. & Madsen, F. C., 1994. Antioxidant status of dairy cows supplemented prepartum with vitamin E and selenium. *Journal of Dairy Science*; 77: 3087–3095.
- Butler, W. R., 1998. Effect of protein nutrition on ovarian and uterine physiology in dairy cattle. Symposium: Optimizing Protein Nutrition for Reproduction and Lactation. *Journal of Dairy Science*; 81: 2533–2539.
- Campbell, M. H. & Miller, J. K., 1998. Effect of supplemental dietary vitamin E and Zinc on reproductive performance of dairy cows and heifers fed excess iron. *Journal of Dairy Science*; 81: 2693- 2699.
- Canfield, R. W., Sniffen, C. J. & Butler W. R., 1990. Effects of excess degradable protein on postpartum reproduction and energy balance in dairy cattle. *Journal of Dairy Science*; 73: 9.
- Carroll, E. J., 1974. Induction of parturition in farm animals. *Journal of Animal Science*; 38(1): 1-9.
- Carson, A. F., Dawson, L. E. R. & Gordon, F.J., 2000. The effect of heifer rearing regime on body size and milk production during the first lactation. *British Journal of Animal Science*: 13.
- Carson, R. L., Caudle, A. B. & Riddle, H. E., 1978. The relationship between narrow calcium-phosphorus ratio and reproductive problems in a dairy herd: a case report. *Theriogenology*; 9: 505-507.
- Chew B. P., Erb, R. E., Randel, R. D. & Rouquette, F. M. - Jr., 1978. Effect of corticoid induced parturition on lactation and on peripartum profiles of serum progesterone and the estrogens among cows retaining and not retaining foetal membranes. *Theriogenology*; 10: 13-25.

- Chimonyo, M., Kusina, N. T., Hamudikuwanda, H. & Nyoni, O., 2000. Reproductive performance and body weight changes in draught cows in a smallholder semi-arid farming area of Zimbabwe. *Tropicana Animal Health Production*; 32(6): 405-415(11).
- Çobanoğlu, O., 2010. Twinning in Cattle: Desirable or Undesirable? *Journal of Biology and Environmental Science*; 4(10): 1-8.
- Correa, M. T., Curtis, C. R., Erb, H. N., Scarlett, J. M. & Smith, R. D., 1993. An ecological analysis of risk factors for postpartum disorders of Holstein-Friesian cows from thirty-two New York farms. *Journal of Dairy Science*; 73: 1515-1524.
- Crandell, K., 2013. Vol 2, Issue 4. (www.ker.com/library/equinenews/v2n4/v2n409)
- D'Aleo, J., Shelford, A. & Fisher, L. J., 1983. Selenium-sulphur interactions and their influences on fertility in dairy cattle. *Canadian Journal of Animal Science*; 63 : 999.
- Dampney, J. K., Obese, F. Y., Aboagye, G. S., Ayim-Akonor, M. & Ayizanga, R. A., 2014. Blood metabolite concentrations and postpartum resumption of ovarian cyclicity in Sanga cows. *South African Journal of Animal Science*; 44: 1.
- Darmono, A. & Sudibyo, A., 1990. Concentrations of calcium, magnesium and copper in serum samples of cattle known to be positive for brucellosis in Indonesia. *Penyakit Hewan*; 22: 59-61.
- Davis, H. L. & Bennett, D., 1959. Studies on the estrogenic pollen of subterranean clover (*Trifolium subterranean* L) in South Western Australia. *Australian Journal of Agricultural Research*; 13:1030-1040.
- De Brouwer, C. H. M., Cilliers, J. W., Vermaak, L. M., van der Merwe, H. J. & Groenewald, P.C.N., 2000. Phosphorus supplementation to natural pasture grazing for beef cows in the Western Highveld region of South Africa. *South African Journal of Animal Science*; 30:1.
- De Waal, H. O. & Koekemoer, G. J., 1997. Blood, rib bone and rumen fluids as indicators of phosphorus status of grazing beef cows supplemented with different levels of phosphorus at Armoedvslakte. *South African Journal of Dairy Science*; 27: 76-8.
- Delali, B. K., Dovie, D. B. K., Charlie, M., Shackleton, C. M. & Witkowski, E. T. F., 2006. Valuation of communal area livestock benefits, rural livelihoods and related policy issues. *Land Use Policy*; 23: 260–271.
- Dematawewa, C. M. B. & Berger, P. J., 1997. Effect of dystocia on yield, fertility, and cow losses and an economic evaluation of dystocia scores for Holsteins. *Journal of Dairy Science*; 80:754-761.

- Dijkman, J., 2009. Innovative capacity and elusive livestock revolution. LINK News Bulletin, October 2009. (<http://www.innovationstudies.org>).
- Donna M., Amaral, P. & Heersche, G. jr., 1994. Role of nutrition on reproductive performance. (<http://www.ca.uky.edu/agc/pubs/asc/asc138/asc138pdf>).
- Doornenbal, H., Tong, A. K. W. & Murray, N. L., 1988. Reference values of blood parameters in beef cattle of different ages and stages of lactation. *Canadian Journal of Veterinary Research*; 52(1): 99-105.
- Drew, B., 1986. Factors affecting calving rates and dystocia in Friesian dairy heifers-the results of a large scale field trial. Ireland. *Grassland Animal Production Journal*; 20:98-104.
- Du Toit, P. J., Louw, J. G. & Malan, A. I., 1940. A study of the mineral and feeding value of natural pastures in the Union of South Africa. Onderstepoort. *Journal of Veterinary Science*; 14:123.
- Dufty, J. H. 1981. The influence of various degrees of confinement and supervision on the incidence of dystocia and stillbirths in Hereford heifers. *New Zealand Veterinary of Journal*; 29:44-48.
- Duncan, L., Heathcote, J. & Djurdjev O et al. 2001. Screening for renal disease using serum creatinine: who are we missing? *Nephrol Dial Transplantation*; 16: 1042–46.
- Dunne, L. D., Diskin, M. G. & Sreenan, J. M., 2000. Embryo and foetal loss in beef heifers between day 14 of gestation and full term. *Animal Reproduction Science*; 58: 39-44.
- Eaglen, S., Coffey, M., Woolliams, J., Mrode, R. & Wall, E., 2011. Phenotypic effects of calving ease on the subsequent fertility and milk production of dam and calf in UK Holstein-Friesian heifers. *Journal of Dairy Science*; 94: 5413-5423.
- ECA & African Union., 2007. Eighth African Union Summit - Briefing Note African Regional Coverage Project. International Institute for Sustainable Development (IISD); 7(2): 1-10.
- Echternkamp, S. E. & Gregory, K. E. 1999. Effects of twinning on gestation length, retained placenta, and dystocia. *Journal of Animal Science*; 77(1): 39-47.
- Echternkamp, S. E., 1993. Relationships between placental development and calf birth weight in beef cattle. *Animal Reproduction Science*; 32: 1-13.
- Ehrenberg, P., Nitsche, H. & Muller, J., 1891. Report on protein substitutions in feed- ing experiments at Bettlerm (translated title). *Z. Tierernahr. Futtermittelk*; 1:33.
- Ehrhardt, R. A. & Bell, A. W., 1995. Growth and metabolism of the ovine placenta during. *American Journal of physiology*; 16: 727-741.

- Enjalbert, F., Lebreton, P. & Salat, O., 2006. Effects of copper, zinc and selenium status on performance and health in commercial dairy and beef herds: retrospective study *Journal of Animal Physiology and Animal Nutrition*; 90: 459–466.
- Erickson, G. E., Klopfestein, T. J., Milton, C. T., Brink, O., Orth, M. W. & Whittet, K. M., 2002. Phosphorus requirements of finishing feedlot calves. *Journal of Animal Science*; 80: 1690-1695.
- Esselmont, D. & Kobasati, M. A., 2002. *The cost of poor fertility and disease in UK dairy herds*. Milton Keynes, Intervet, United Kindom. Ltd: 146.
- Ettema, J. F. & Santos, J. E. P., 2004. Impact of age at calving on lactation, reproduction, health, and income in first-parity Hol-Trop Animal Health Production, *Journal of Dairy Science*; 87: 2730– 2742. <http://jds.fass.org/cgi/reprint/87/8/2730>
- Farzaneh, F., Moghaddam, J. A., Honarmand, K., Mirshokraei, P. & Mohri, M., 2002. Comparison of some biochemical, hormonal and haematological parameters in cows with and without retained placenta. Abstracts. XXII World Buiatrics Congress, Hannover; Germany: 98.
- Faye, B., Bengoumi, M., Musaud, A. & Konuspayeva, G., 2015. Comparative milk and serum cholesterol content in dairy cow and camel. *Journal of King Saud University-Science*; 27:168-175.
- FitzGerald, W., 2011. Milk fever (hypocalcaemia) and downer cow syndrome. www.bimeda.com.
- Fleischer, P., Metzner M., Beyerbach M., Hoedenmaker, M. & Klee, W., 2001. The relationship between milk yield and the incidence of some diseases in dairy cows. *Journal of Dairy Science*; 84: 2025-2035.
- Forar, A. L., Gay, J. M., Hancock, D. D. & Gay. C., 1996. Fetal loss frequency in ten Holstein dairy herds. *Theriogenology*; 45:1505.
- Frame, N., 2006. Management of dystocia in cattle. In *Practice*; 28:470-476.
- Franco, M. P., Mulder, M., Gilman, R. H. & Smits, H. L., 2007. Human brucellosis. *Lancet Infectious Diseases*; 7:775–786.
- Freetly, H. C., Ferrell, C. L. & Jenkins, T.G., 2000. Timing of realimentation of mature cows that were feed-restricted during pregnancy influences calf birth weights and growth rates. *Journal Animal Science*; 78: 2790-2796.
- GŁowińska, B. & Oler, A., 2013. Biochemical and hormonal characteristics of peripheral blood in bulls in relation to genotype. *Folia Biologica (Kraków)*; 61: 73-77.

- Gaafar, H. M. A., Shamiah-Sh, M., Abu Hamd, M. A., Shitta, A. A and Tag Din, M. A., 2011. Dystocia in Friesian cows and its effects on postpartum reproductive performance and milk production. *Tropical Animal Health Production*; 43:229–23.
- Gadberry, S., 2004. Mineral and Vitamin Supplementation of Beef Cows in Arkansas. FSA 3035. University. Arkansas Cooperative Extension. Little Rock, AR.
- Gaylean, M. L., Perino, L. J. & Duff, G. C., 1999. Interaction of cattle health/immunity and nutrition. *Journal of Animal Science*; 77: 1120–1134.
- Gearhart, M., Curtis, C., Erb, H., Smith, R., Sniffen, C., Chase, L. & Cooper, M., 1990. Relationship of changes in condition score to cow health in Holsteins. *Journal of Dairy Science*; 73: 3132-3140.
- Ghosh, D., Sawicki, M., Lala, P., Erman, M., Pangborn, W., Jaime Eyzaguirre, J., Gutie´ rrez, R., Jornvall, H. & Thiel, D. J., 2001 Multiple Conformations of Catalytic Serine and Histidine in Acetylxy lan Esterase at 0.90 Å. *The Journal of Biological Chemistry*; 276(14): 11159–11166.
- Girod, A., Wobus, C., Zádori, Z., Ried, M., Leike, K., Tijssen, P., Kleinschmidt, J. & Hallek, M., 2002. The VP1 capsid protein of adeno-associated virus type 2 is carrying a phospholipase A2 domain required for virus infectivity. *Journal of Genetic Virology*; 83(5): 973–8.
- Givens, D. I., Allison, R., Cottrill, B. & Blake, J. S., 2004. Enhancing the selenium content of bovine milk through alteration of the form and concentration of selenium in the diet of the dairy cow. *Journal of Food Science Agriculture*; 84, 811–817.
- Goff, J. P., 2006. Transition cow nutrition: effects on immune function and postpartum health. In Proc. 1st Annual Meeting and Conv., Dairy Cattle Reproduction Council, Denver, CO: 1-8.
- Goff, J. P., Horst, R. L., Jardon, P. W., Boreli, C. & Wedam, J., 1997. Field trials of an oral calcium propionate paste as an aid to prevent milk fever in periparturient dairy cows. *Journal of Dairy Science*; 79: 378-383.
- Goff, J. P., Kimura, K. & Horst, R.L., 2002. Effect of mastectomy on milk fever, energy, and vitamins A, E, and beta-carotene status at parturition. *Journal of Dairy Science*; 85: 1427- 1436.
- Goshen, T. & Shpigel, N. Y., 2006. Evaluation of intrauterine antibiotic treatment of clinical metritis and retained fetal membranes in dairy cows. *Theriogenology*; 66: 2210-2218.
- Graham, T. W., Giri, S. N., Daels, P. F., Cullor, J. S., Keen, C. L, Thurmond, M. C., Dellinger, J. D., Stabenfeldt, G. H. & Osburn, B. I., 1995. Associations among

- prostaglandin F2 alpha, plasma zinc, copper and iron concentrations and fetal loss in cows and mares. *Theriogenology*; 44: 379-390.
- Graham, T. W., Thurmond, M. C., Gershwin, M. E., Picanso, J. P., Garvey J. S. & Keen, C. L., 1994. Serum zinc and copper concentrations in relation to spontaneous abortion in cows: implications for human foetal loss. *Journal of Reproductive Fertility*; 102: 253-262.
- Greenwood, P. L., Hunt, A. S., Slepetis, R. M., Finnerty, K. D., Alston, C., Beermann, D. H. & Bell, A. W., 2002. Effects of birth weight and postnatal nutrition on neonatal sheep. III. Regulation of energy metabolism. *Journal of Animal Science*; 80: 2850-2861.
- Gressley, T. F., 2009. Zinc, copper, manganese, and selenium in dairy cattle ration. Proceedings of the 7 Annual Atlantic Nutrition Conference.
- Grohn, Y. T., Wilson, D. J., Gonza' lez, R. N., Hertl, J. A., Schulte, H., Bennett, G. & Schukken, Y. H., 2004: Effect of pathogen-specific clinical mastitis on milk yield in dairy cows. *Journal of Dairy Science*; 87: 3358–3374.
- Grunert, E., 1979. Clinical aspects of the nutritional status of the dam and parturition. In: Calv. Prob. and Early Viability of the Calf. *Current Topics in Veterinary Medicine and Animals*; 4: 468-477.
- Gupta, S., Gupta, H. K. & Soni, J., 2005. Effect of vitamin E and selenium supplementation on concentrations of plasma cortisol and erythrocyte lipid peroxides and the incidence of retained foetal membranes in crossbred dairy cattle. *Theriogenology*; 64: 1273-1286.
- Guyton, A. C. & Hall, J. E., 2006. "The body fluids and kidneys," in *Textbook of Medical Physiology*. Elsevier Saunders; 11: 291–415.
- Guzel, S. & Tanriverdi, M., 2014. Comparison of serum leptin, glucose, total cholesterol and total protein levels in fertile and repeat breeder cows. *Revista Brasileira de Zootecnia*; 43(12): 643-647.
- Hadzimusić, N. & Krnic, J., 2012. Values of Calcium, Phosphorus and Magnesium Concentrations in Blood Plasma of Cows in Dependence on the Reproductive Cycle and Season. *Journal of the Faculty of Veterinary Medicine – Istanbul University*; 38 (1): 1-8.
- Hall, J. O. & ZoBell, D. R., 2010. Common Vitamin and Mineral Deficiencies in Utah. U.S. Department of Agriculture, Animal, Dairy and Veterinary Sciences. Article; AG/Beef/02: 1-5.

- Hambidge, K. M., Casey, C. C. & Krebs, N. F., 1986. Zinc in Trace Elements in Human and Animal Nutrition, W. Mertz, editor (ed). New York. *The National Academic Press*; 2: 1–137.
- Hamilton, L. K., Joppé, S. E. M., Cochard, L. & Fernandes, K. J., 2013. Aging and neurogenesis in the adult forebrain: what we have learned and where we should go from here. *European Journal of Neuroscience*; 37:1978-1986.
- Hamudikuwana, H., 1999. The influence of nutrition on fertility in dairy cattle. Zimbabwe Society of Animal Production Journal. In: *Farming World*. Harare. Zimbabwe; 25(3): 20-27.
- Han, I. K. & Kim, I. H., 2005. Risk factors for retained placenta and the effect of retained placenta on the occurrence of postpartum diseases and subsequent reproductive performance in dairy cows. *Journal Veterinary Science*; 6 (1): 53-59.
- Hansen, S. L., Spears, J. W., Lloyd, K. E. & Whisnant, C. S., 2014. Growth, reproductive performance, and manganese status of heifers fed varying concentrations of manganese. *Journal of Animal Science*; 84: 3375-3380.
- Hansen, S. S., Nørgaard, P., Pedersen, C., Jørgensen, R. J., Mellau, L. S. & Enemark, J. D., 2003. The effect of subclinical hypocalcaemia induced by Na₂EDTA on the feed intake and chewing activity of dairy cows. *Veterinary Research Communications*; 27: 193-205.
- Harrison, J. H. & Cornad, H. R., 1984. The effects of selenium intake on selenium utilization by the non-lactating dairy cow. *Journal of Dairy Science*; 67: 219-233.
- Harrison, J. H., Hancock, D. D. & Conrad, H. R., 1984. Vitamin E and selenium for reproduction in the dairy cow. *Journal of Dairy Science*. 67:123-132.
- Hart, E. B., Steenbock, H., Waddell, J. & Elvehjem, C. A., 1928. Iron in nutrition. VII. Copper as a supplement to iron for haemoglobin building in the rat. *Journal of Biological Chemistry*; 77:797.
- Hemmingway, R. G., 2003. The influences of dietary intakes and supplementation with selenium and vitamin E on reproduction diseases and reproductive efficiency in cattle and sheep. *Veterinary Research Communications Journal*; 27: 159-174.
- Hendriks, W. H., Butts, C. A., Thomas, D. V., James, K. A. C., More, P. C. A. & Verstegen, A. M. W., 2002. Nutritional Quality and Variation of Meat and Bone Meal. Asian-Australia. *Journal of Animal Science*; 15(10): 1507-1516.
- Hentze, M. W., Muckenthaler, M. U. & Andrews, N. C., 2004. Balancing acts: Molecular control of mammalian iron metabolism. *Cell*; 117: 285-297.

- Hesari, B. A., Mohri, M. & Seifi, H. A., 2012. Effect of Copper edetate injection in dry pregnant cows on hematology, blood metabolites, weight gain and health of calves. *Tropical Animal Health Production Journal*; 44(5): 1041-1047.
- Hibbs, J. W., 1950. Milk fever (parturient paresis) in dairy cows – A review. *Journal of Dairy Science*; 33: 758-789.
- Hickson, R. E., Morris, S. T., Kenyon, P. R. & Lopez-Villalobos, N., 2006. Dystocia in beef heifers: a review of genetic and nutritional influences. *New Zealand Veterinary Journal*; 54: 256–264.
- Holland, M. D., Speer, N. C., LeFever, D. G., Taylor, R. E., Field, T. G. & Odde, K. G., 1993. Factors contributing to dystocia due to foetal mal-presentation in beef cattle. *Theriogenology*; 39: 899-908.
- Horst, R. L., Jorgensen, D. A and DeLuca, H. F., 1978. Plasma 1.25-dihydroxyvitamin D and parathyroid hormone levels in paretic dairy cows. *The American Journal of Physiology*; 235: E634-E637.
- Hosseini-Zadeh, N. & Ardalan, M., 2011. Cow-specific risk factors for retained placenta, metritis and clinical mastitis in Holstein cows. *Veterinary Research Communications*; 35:345-453.
- Houe, H., Østergaard, S., Thilising-Hansen, T., Jørgensen, R. J., Larsen, T., Sørensen, J. T., Agger, J. F. & Blom, J. Y., 2001. Milk fever and subclinical hypocalcaemia – an evaluation of parameters on incidence risk, diagnosis, risk factors and biological effects as input for a decision support system for disease control. *Acta Veterinaria Scandinavica*; 42: 1-29. <http://physrev.physiology.org/cgi/content/full/81/2/629>.
- Humam, N. A., 2014. An epidemic of abortion in a commercial dairy farm in the eastern region, kingdom of Saudi Arabia. *Global Journal of Dairy Farming and Milk Production*; 2 (3): 074-080.
- Hurley, W. L. & Doane, R. M., 1989. Recent Developments in the role of vitamins and minerals in reproduction. *Journal of Dairy Science*; 72(3): 784–804.
- Hutchinson, L. J., 2009. Trouble shooting infertility problems in dairy cattle Pennsylvania-State-University. (<http://www.wvu.edu/~exten/infores/pubs/livepoul/dirm19.pdf>. Accessed Nov. 13)
- IDEXX Laboratories Inc. 2010. Available at www.idexx.com (accessed 23.3.2010).
- Ishak, M. A., Larson, L. L., Owen, F. G., Lowry, S. R. & Erickson, E. D., 1983. Effects of selenium, vitamins, and ration fiber on placental retention and performance of dairy cattle. *Journal of Dairy Science*; 66: 99-106.

- Ivanovski, K., Naumovski, V., Kostadinova, M., Pesevska, S., Drijanska, K. & Filipce, V., 2012. "Xerostomia and salivary levels of glucose and urea in patients with diabetes," *Prilozi*; 33(2): 219–229.
- Jalil, M. A, Sarker, N., Paul, D. C. & Khan, A. A., 1995. Status of existing husbandry practices of dairy cattle at Manikganj, Bangladesh. *Bangladesh Journal of Animal Science*; 24: 71-80.
- Jenkins, N., 1978. *Physiology and Biochemistry of the Mouth*, 4th Edition, Blackwell Scientific, Oxford; 311-324.
- Jílek, F., Pytloun, P. Kubešová, M. Štípková, M. Bouška, J., Volek J., Frelich, J. & Rajmon, R., 2008. Relationships among body condition score, milk yield and reproduction in Czech Fleckvieh cows. *Czech Journal of Animal Science*; 53(9): 357–367.
- Jittakhot, S., Schonewille, J. T., Wouterse, H., Yuangklang, C. & Beynen, A. C., 2004a. Apparent magnesium absorption in dry cows fed at 3 levels of potassium and 2 levels of magnesium intake. *Journal of Dairy Science*; 87: 379-385.
- Johanson, J. M. & Berger, P. J., 2003. Birth weight as a predictor of calving ease and perinatal mortality in Holstein cattle. *Journal of Dairy Science*; 86: 3745-3755.
- Jones, D. G. & Suttle, N. F., 1983. The effects of copper deficiency on the resistance of mice to infection with *Pasteurella haemolytica*. *Journal of Comparative Pathology*; 93: 14.
- Kaczmarowski, M., Malinowski, E. & Markiewicz, H., 2006. Some hormonal and biochemical blood indices in cows with retained placenta and puerperal metritis. *Bulletin in the Veterinary Institute in Pulawy*; 50: 89-92.
- Kahn, C., 2005. *The Merck Veterinary Manual*. 9th Edition Merck and Co.
- Kalaitzakis, E., Panousis, N., Roubies, N., Giadinis, N., Kaldrymidou, E., Georgiadis, M. & Karatzias, H., 2010. Clinico-pathological evaluation of downer dairy cows with fatty liver. *Canadian Veterinary Journal*; 51: 615–622.
- Kanuya, N. L., Matiko, M. K., Kessy, B. M., Mgongo, F. O., Ropstad, E. & Reksen, O., 2006. Study on reproductive performance and related factors of zebu cows in pastoral herds in a semi-arid area of Tanzania. *Theriogenology*; 65 (9): 1859-1874.
- Kertz, P. A. S., 2010. Review: Urea Feeding to Dairy Cattle: A Historical Perspective and Review. *The Professional Animal Scientist*; 26: 257–272.
- Kimura, K., Reinhardt, T. A. & Goff, J. P., 2006. Parturition and hypocalcaemia blunts calcium signals in immune cells of dairy cattle. *Journal of Dairy Science*; 89: 2588-2595.

- Klimiene, I., Spakauskas, V. & Matusevicius, A., 2005. Correlation of different biochemical parameters in blood sera of healthy and sick cows. *Veterinary Research Communications*; 29: 95-102.
- Kornmatitsuk, B., Konigsson K., Kindahl, H. & Gustafsson H., 2000. Clinical signs, body temperature, and hormonal changes in dairy heifers after induction of parturition with PGF₂ α . 14th International Congress on Animal Reproduction, Stockholm; 1: 179.
- Kreplin, C. & Yeremcio, B., 2009. Effects of nutrition on beef cow. Agri-Facts (Agdex 420/51-1. / (www.agriculture.alberta.ca)
- Kronqvist, C., 2011. Minerals to Dairy Cows with Focus on Calcium and Magnesium Balance. Doctoral Thesis Swedish University of Agricultural Sciences Uppsala; ISSN (1652-6880) International Standard Book Number; 978(91): 576-762.
- Kronqvist, C., Emanuelson, U., Spörndly, R. & Holtenius, K., 2011. Effects of prepartum dietary calcium level on calcium and magnesium metabolism in periparturient dairy cows. *Journal of Dairy Science*; 94(3): 1365-1373.
- Kumar, S., Anil K. P., Waquar, A., Abdul, R. & Dinesh, K. D., 2011. Importance of micro minerals in reproductive performance of livestock. *Veterinary World*: 4-5.
- Kumar, S. A., 2014. Blood Biochemical Profile in Repeat Breeding Crossbred Dairy Cows. *International Journal of Veterinary Science*; 3(4): 172-173.
- Kunz, W. S., 2001. Control of oxidative phosphorylation in skeletal muscle. *Biochimica et Biophysica Acta*; 1504: 12-19.
- Kutanaee, S. J., Sakha, M., Haghdost, I. S. & Nadalian, G. M., 2014. Measurement of Cardiac Troponin I in Downer Cows in Dairy Herds around Tehran. *Advances in Environmental Biology*; 8(17): 367-372.
- Lamb, E., Newman, D. J. & Price, C. P., 2006. "Kidney function tests," in *Textbook of Clinical Chemistry and Molecular Diagnostics*, Burtis, C. A., Ashwood, E. R and Brun, D. E., Elsevier Saunders, St. Louis, Mo, United States of America; 4: 797–801.
- Lanyasunya, T. P., Musa, H. H. Yang, Z. P. Mekkiand, D. M. and Mukisira, E. A. 2005. Effects of Poor Nutrition on Reproduction of Dairy Stock on Smallholder Farms in the Tropics. *Pakistan Journal of Nutrition*; 4 (2): 117-122.
- Larsen, T., Møller, G. & Bellio, R., 2001. Evaluation of clinical and clinical chemical parameters in peri-parturient cows. *Journal of Dairy Science*; 84: 1749-1758.
- Laven, R. A. & Peters, A. R., 1996. Bovine retained placenta: aetiology, pathogenesis and economic loss. *Veterinary Record Journal*; 139: 465-471.

- Le Banh, M. S., 2006. Serum Proteins as Markers of Nutrition: What Are We Treating? *Nutrition Issues in Gastroenterology*; 43: 48-64.
- Lean, I. J., DeGaris, P. J., McNeil, D. M. & Block, E., 2006. Hypocalcemia in dairy cows: Meta-analysis and dietary cation anion difference theory revisited. *Journal of Dairy Science*; 89: 669-684.
- LeBlanc, S. J., Herdt, T., Seymour, W., Duffield, T. & Leslie, K., 2004. Factors associated with peripartum serum concentrations of vitamin E, retinol, and β -carotene in Holstein dairy cattle, and their associations with periparturient disease. *Journal of Dairy Science*; 87:609-619.
- Lee, G. R., 1999. "Chapter 48: Acquired haemolytic anaemias resulting from direct effects of infectious, chemical or physical agents". In lee, GR, forester, J., Lukens, J: et al. *Wintrobe's clinical hematology*. Vol 1 (10th ed). Williams & Wilkins; 1298: ISBN 0-683-18242-0.
- Leiu, T. P., Heiskala, M., Peterson. P. A. & Yang, Y., 2001. The roles of iron in health and disease. *Molecular aspects of medicine*; 22: 1-87.
- Lombard, J. E., Garry, F. B., Tomlinson, S. M. & Garber, L. P., 2007. Impacts of dystocia on health and survival of dairy calves. *Journal of Dairy Science*; 90:1751-1760.
- Lopez de Maturana, E., Legarra, A. & Ugarte, E., 2006. Effects of calving ease on fertility in the Basque Holstein population using recursive models. Abstract Book 8th World Congress on Genetics Applied to Livestock Production. Brazilian Abstracts; 10: 1-23.
- Lopez, H., Kanitz, F. D. & Moreira, V. R., 2004. Reproductive performance of dairy cows fed two concentrations of phosphorus. *Journal of Dairy Science*; 87: 146-157.
- López-Alonso, M., 2008. Evaluation of chronic hepatic copper accumulation in cattle, in *Micronutrients and Health Research*, T. Nova Science; Yoshida Ed: 207–226.
- Lotthammer, K. H., 1983. Comparative studies of the course of mineral, metabolite, enzyme and hormone levels in blood serum ante partum in dairy cows with and without later retained placenta. *Deutsche Tierärztliche Wochenschrift Journal*; 90: 427-433.
- Lucey, S., Rowlands, G. J. & Russell, A., 1986. Short- term associations between disease and milk yield of dairy cows. *Journal of Dairy Research*; 53: 1.
- Mabe, L. K., Antwi, M. A. & Oladele, O. I., 2010. Factors influencing farm income in livestock producing communities of North-West Province, South Africa. *Livestock Research for Rural Development*; 22: 8.

- Maciel, S. M., Chamberlain, C. S., Wettemann, R. P & Spicer, L. J., 2001. Dexamethasone influences endocrine and ovarian function in dairy cattle. *Journal of Dairy Science*; 84: 1998-2009.
- Magnus, P. K. & Lali, F. A., 2009. Serum Biochemical Profile of Post-Partum Metritic Cow *Veterinary World*; 2(1): 27-2.
- Mahon, M. J., Cole, J. A., Lederer, E. D. & Segre, G. V., 2003. Na⁺/H⁺exchanger- regulatory factor 1 mediates inhibition of phosphate transport by parathyroid hormone and second messengers by acting at multiple sites in opossum kidney cells. *Molecular Endocrinology*; 17: 2355–2364.
- Mamun, M. A., Hassan, M. M., Shaikat, A. H., Islam, S. K., Hoque, M. A., Uddin, M. & Hossain, M. B., 2013. Biochemical analysis of blood of native cattle in the hilly area of Bangladesh. *Bangladesh Journal of Veterinary Medicine*; 11(1): 51-56.
- Marques, L. C., Jr, D. C. & Marques, J. A., 1991. Prolapsocervico-vaginal embovinos; niveisericos de calcio, fosforo e magnesio. *ClinicaVeterinaria De Jaboticabal*; 1: 101.
- Martens, H. & Schweigel, M., 2000. Pathophysiology of grass tetany and other hypomagnesemias: Implications for clinical management. The Veterinary Clinics of North America; *Food Animal Practice*; 16: 339-368.
- Materechera, S. A., 2011. Soil salinity in irrigated fields used for urban agriculture under a semi-arid environment of South Africa. *African Journal of Agricultural Research*; 6(16): 3747-3754.
- Mathis, P. C. & Sawyer, J. E., 2007. Nutritional Management of Grazing Beef Cows. Veterinary Clinics. *Food Animal Practice*; 31: 1.
- Matiko, M. K., Kanuya, N. L., Waldmann, A., Ropstad, E. & Reksen, O., 2008. Environmental constraints on post-partum ovarian activity in Tanzanian Zebu cows. *Theriogenology*; 69 (7): 896-904.
- Matsane, S. H. & Oyekale A. S., 2014. Factors Affecting Marketing of Vegetables among Small-Scale Farmers in Mahikeng Local Municipality, North-West Province, South Africa. *Mediterranean Journal of Social Sciences*; 5(20): 390.
- Mayland, H. F., 1988. Grass tetany. In Church, D. C. (Ed): *The ruminant animal. Digestive physiology and nutrition*. Prentice Hall, Englewood Cliffs: 511-531.
- McCoy, M. A., Hutchinson, T., Davison, G., Fitzpatrick, D. A., Rice, D. A. & Kennedy, D. G., 2001. Postmortem biochemical markers of experimentally induced hypomagnesaemic tetany in cattle. *The Veterinary Record*; 148: 268-273.

- McDermott, J. J., Allen, O. B., Martin, S. W. & Alves, D. M., 1992. Patterns of stillbirth and dystocia in Ontario cow-calf herds. *Canadian Journal of Veterinary Research*; 56:47–55.
- McDowell, L. R., 1992. Minerals in animal and human nutrition. Academic Press; 8: ISBN 0-12-483369-1.
- McEvov, J. G. D., 1994. Management of the cow. *Law Enforcement Bulletin*; 36(2): 12-14.
- Mee, J., 2012. Prevalence and Risk Factors for Dystocia in Dairy Cattle – With Emphasis on Confinement Systems .*WCDS Advances in Dairy Technology*; 24: 113-12
- Mee, J. F., 1991a. Bovine perinatal mortality and parturient problems in Irish dairy herds. PhD dissertation, National University of Ireland: 1-365.
- Mee, J. F., 2004. Managing the dairy cow at calving time. *Veterinary Clinics Of North America Food, Animal Practice*; 20: 521-546.
- Mee, J. F., Berry, D. & Cromie, A., 2011. Risk factors for calving assistance and dystocia in pasture-based Holstein-Friesian heifers and cows in Ireland. *The Veterinary Journal*; 187:189-194.
- Meijering, A., 1984. Dystocia and stillbirth in cattle – a review of causes, relations and implications. *Livestock Production Science*; 11: 143-177.
- Mellado, M., Valdez, R., Lara, L. M., Garc'ia, J. E., 2004. Risk factors involved in conception, abortion, and kidding rates of goats under extensive conditions. *Small Ruminant Research*; 55:191–198.
- Ménard, L. & Thompson, A., 2007. Milk fever and alert downer cows: Does hypophosphatemia affect the treatment response? *Canadian Veterinary Journal*; 48: 487–491.
- Menbere, S., 2014. Livestock Production Constrains Priorities and its Determinant Factors in Mixed Farming System of Southern Ethiopia. *World Journal of Agricultural Sciences* 10 (4): 169-177.
- Menzies, F. D., 1994. Management of the Suckler Herd. *Journal of Veterinary Medicine*; 10-12.
- Menzies, F. D., Bryson, D. G. & McCallion, T., 1992. Summary of the Findings from the Bovine Mortality Survey: 7 -9.
- Merck Veterinary Manual, 2010, Tenth Ed: 1470-1473
- Merck Veterinary Manual, 2010. A handbook of diagnosis, therapy, and disease prevention and control for the veterinarian. (10th ed.) Eds: Kahn, C. M. & Line, S., Merck and Company. Incorporated., New Jersey; U.S.A: 905-908

- Merk Veterinary Manual. 2015. Fatty liver disease of cattle. (www.merckvetmanual.com/.../metabolic_disorders/.../fatty_liver_disease).
- Miesner, M. D. & Anderson, D. E., 2008. Management of uterine and vaginal prolapse in the bovine. *Veterinary Clinics Journal: Animal Food*; 24: 409-419.
- Miller, J. K., Ramsey, N. & Madsen, F. C., 1988. *The trace elements in the Ruminant Animal-Digestive Physiology and Nutrition*. D.C. Church, (ed). Englewood Cliffs, N.J. Prentice-Hall: 342–401.
- Minson, D. J., 1990. *Forage in ruminant nutrition*. Academic Press: 4-5.
- Mordak, R. & Nicpoń. J., 2006. Haematological and metabolic parameters of blood in cows in perinatal period and an increasing lactation. *Medycyna Weterynaryjna (veterinary medicine)*; 62: 1292-1294.
- Morrow, D. A., 1980. The role of nutrition in dairy cattle reproduction. In: Morrow, D.A. Ed. In: Current Therapy in *Theriogenology*. W.B. Saunders Cooperation; Philadelphia: 449-455.
- Muchenje, V. 2007. Growth performance, carcass characteristics and meat quality of Nguni, Bonsmara and Angus steers raised on natural pasture. PhD Thesis. University of Fort Hare, Alice, South Africa.
- Murphy, A. M. & Dobson, H., 2002. Predisposition, subsequent fertility and mortality of cows with uterine prolapse. *Journal of Veterinary Record*; 151: 733-735.
- Murray, R. D., 2006. Practical approach to infectious bovine abortion. Diagnosis World Buiatrics Congress 2006 – Nice; France: 1-9. (<http://www.ivis.org>)
- Mutiga, E. R., Mbai, K., Tsuma, V. T., Karitu, P. T. & Ojiayo, S. O., 1993. Incidence and causes of retained placenta in smallholder dairy herds. *Indian Veterinary Journal*; 70: 333-336.
- Nadia, A. B., Antoniassi, G. D., Juffo, A. S., Santos, C. A., Pescador, L. F. & David, D., 2013. *Geotrichum candidum* a possible cause of bovine abortion. *Journal of Veterinary Diagnostic Investigation*; 20(10): 1–3.
- Narasimha Rao, A. V., 1982. Causes and incidence of reproductive disorders among Zebu × Taurus crossbreed cows in Andhra Pradesh, *Theriogenology*; 17: 189–191.
- National Department of Agriculture (NDA), 2005. Red Meat Marketing/National Department of Agriculture (<http://www.nda.agric.za/docs/MarketExtension/7Livestock>)

- National Research Council (NRC), 2000. "5 Minerals." Nutrient Requirements in Beef Cattle: Seventh Revised Edition: Update 200. Washington, DC: The National Academic Press.
- National Research Council. 1980. Mineral Tolerance of Domestic Animals. Washington, D. C: National Academy of Science.
- National Research Council. 1984. Nutrient Requirements of Beef Cattle, Sixth Revised Ed. Washington, D.C.: National Academy Press.
- Ndlovu, T., Chimonyo, M., Okoh, A. I., Muchenje, V., Dzama, K. & Raats, J. G., 2007. Assessing the nutritional status of beef cattle: current practices and future prospects. *African Journal of Biotechnology*; 6 (24): 2727-2734.
- Neary, V. S., Previsic, M., Jepsen, R. A., Lawson, M. J., Yu, Y. H., Copping, A. E., Fontaine, A. A., Hallett, K. C. & Murray, D. K., 2014. *Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies*. Albuquerque, New Mexico: Sandia National Laboratories.
- Nelson, M and Phillips, D. I. W., 1985. Seasonal variations in dietary iodine intake and thyrotoxicosis. *Human Nutrition*; 39(3): 213-216.
- Newby, N., Pearl, D., LeBlanc, S., Leslie, K., von Keyserlingk, A. & Duffield, T., 2010. Impact of dystocic calvings and retained placenta in dairy cattle on dry matter intake, milk production and serum acute phase proteins. Proc. 26th World Buiatrics Congress, Santiago, Chile: 323.
- Nix, J., 2002. Dealing with fescue toxicity. www.sweetix.com/media/document/article.
- Noakes, E. D., Parkinson, T. J. & England, G. C. W., 2001a. Chapter (19) Post parturient prolapse of the uterus. In: *Arthur's Veterinary Reproduction and Obstetrics*. 8th ed. Harcourt (India) Pvt. Ltd; New Delhi: 333-338.
- Norman, H. D., Miller, R. H., Wright, J. R., Hutchison, J. L. & Olson, K. M., 2012. Factors associated with frequency of abortions recorded through Dairy Herd Improvement test plans. *Journal of Dairy Science*; 95: 7.
- Northern Territory Government, 2003. An observational study on calf losses on the Barkley table land. Technical Bulletin. No. 302; International Standard Book Number –ISBN: 07245-47045.
- Nozad, S., Ramin, A. G. & Moghadam, G et al., 2011. Diurnal variations in milk urea, protein and lactose concentration in Holstein dairy cows. *Acta Veterinaria Beograde*; 61: 3-12.

- NRC (National Research Council), 2001. Nutrient Requirements of Dairy Cattle: 7th Revised Edition. National Academy Press, Washington D.C.
- Ocon, O. M. & Hansen, P. J., 2003. Disruption of bovine oocytes and pre implantation embryos by urea and acidic pH. *Journal of Dairy Science*; 86: 1197-1200.
- Odegard, S. A., 1977. Uterine prolapse in dairy cows. *Acta Veterinaria Scandinavica. Supplement*; 63: 1-124.
- Odenya, W. O., Elzo, M. A., Manrique, C., McDowell, L. R. & Wakeman, D. L., 1992. Genetic and environmental factors affecting serum macro minerals and weight in an Angus-Brahman multibreed herd. 1 Additive and non-additive group, genetic effects of serum calcium, phosphorus and magnesium and weight at weaning. *Journal of Animal Science*; 70: 2065-2071.
- Oetzel, G. R., 2004. Monitoring and testing dairy herds for metabolic disease. *Veterinary Clinic of North America Food Animal Practice*; 20: 651-674.
- Olmos, G., Boyle, L., Hanlon, A., Patton, J., Murphy, J. & Mee, J. F., 2009. Hoof disorders, locomotion ability and lying times of cubicle-housed compared to pasture-based dairy cows. *Livestock Science*; 125: 199-207.
- Oltenacu, P. A., Frick, A. & Lindne, B., 1988. Use of statistical modelling and decision analysis to stimulate financial losses due to due to dystocia and other diseases in Swedish cattle. Proc 5th. Intl.Symp.Vet, epiderm and econ, Copenhagen; Denmark: 353- 355.
- Orpin, P. G. & Esslemont, R. J., 2010. Culling and wastage in dairy herds: An update on incidence and economic impact in dairy herds in the UK. *Cattle Practice*; 18: 163-172.
- Orr, J. P. & Blakely, B. R., 1994. Investigation of vitamin E and selenium status of aborted calves with myocardial degeneration. Saskatoon, Saskatchewan, Report No. 920001.
- Ostojic-Andric, D., Hristov, S., Novakovic, Z., Pantelic, V., Petrovic, M., Zlatanovic, Z. & Niksic, D., 2011. Dairy cow welfare qualities in loose vs tie housing systems. Biotechnology. *Internal Animal Husbandry*; 27:975-984
- Otto, F., Baggasse, P., Bogin, E., Harun, M. & Vilela, F., 2000. Biochemical blood profile of Angoni cattle in Mozambique. *Israel Veterinary Medicine Association*; 55 (3): 1-9.
- Park, A.F., Shirley, J. E., Titgemeyer, E. C., Cochran, R. C., DeFrain, J. M., Wickersham, E. E. & Johnson, D. E., 2010. Characterization of plasma metabolites in Holstein dairy

- cows during the periparturient period. *International Journal of Dairy Science*; 5: 253-263.
- Pehrson, B., Ortman, K., Madjid, N., Trafikowska, U., 1999. The influence of dietary selenium as selenium yeast or sodium selenite on the concentration of selenium in the milk of suckler cows and on the selenium status of their calves. *Journal of Animal Science*; 77: 3371–3376
- Penner, G. B., Tremblay, G. F., Dow, T. & Oba, M., 2008. Timothy hay with a low dietary cation-anion difference improves calcium homeostasis in periparturient Holstein cows. *Journal of Dairy Science*, 91: 1959-1968.
- Pradhan, R. & Nakagoshi, N., 2008. Reproductive disorders in cattle due to nutritional status. *Journal of international development and cooperation*; 14(1): 45-66.
- Pryce, J. E., Coffey, M. P. & Simm, G., 2001. The relationship between body condition score and reproductive performance. *Journal of Dairy Science*; 84: 1508-1515.
- Quiroz-Rocha, G. F., LeBlanc, S. J., Duffield, T. F., Wood, D., Leslie, K. E. & Jacobs, R. M., 2009. Reference limits for biochemical and hematological analytes of dairy cows one week before and one week after parturition. *Canadian Veterinary Journal*; 50: 383-388.
- Raats J. G., 2004. Strategies for feeding animals during the dry period. University of Fort-Hare. Department of livestock and Pasture Science. South Africa. (www.fao.org/Doc 2004.REP/004/Bulletin No: AC 152E).
- Radostits, O. M., Arundel, J. H., Gay, C. C., Hinchcliff, F. F. & Blood, D. C., 2000. 9th Edition *Veterinary Medicine: A textbook of the diseases of cattle, sheep, pigs and horses*. Elsevier Health Science: 1426-1430.
- Radostits, O. M., Gay C. C., Blood, D. C. & Hinchcliff, K.W., 2000. Veterinary Medicine. In: *Textbook of the diseases of cattle, sheep, pigs and horses*. 9th edition. W.B. Saunders, London.
- Rae, D.O., 2002. Managing for profit: Nutritional priorities - cow age and body condition. <http://gnv.ifas.ufl.edu/~animal/short95/rae.htm>.
- Rajala-Schultz, P. J., Gröhn, Y. T. & McCulloch, C.E., 1999. Effects of milk fever, ketosis, and lameness on milk yield in dairy cows. *Journal of Dairy Science*; 82: 288-294.
- Reinhardt, T. A., Lippolis, J. D., McCluskey, B. J., Goff, J. P. & Horst, R. L., 2011. Prevalence of subclinical hypocalcaemia in dairy herds. *Veterinary Journal*; 188: 122-124.

- Rhoads, M. L., Rhoads, R. P., Gilbert, R. O., Toole, R. & Butler, W. R., 2006. Detrimental effects of high plasma urea nitrogen levels on viability of embryos from lactating dairy cows. *Animal Reproduction Science*; 91: 1-10.
- Robb, G. N., McDonald, R. A., Chamberlain, D. E., Reynolds, S. J. & Harrison, T. J. E., 2008. Stuart Bear hop Winter feeding of birds increases productivity in the subsequent breeding season. *Biology Letters*; 4: 220-223.
- Roberts, S. J., 2004. Injuries and diseases of the puerperal period. In: *Veterinary Obstetrics and Genital Diseases (Theriogenology)*. 2nd ed. [Indian reprint]. CBS Publishers and Distributors, New Delhi; India: 300-335.
- Roche, J. R. & Berry, D. P., 2006. Periparturient climatic, animal, and management factors influencing the incidence of milk fever in grazing systems. *Journal of Dairy Science*; 89: 2775- 2783.
- Roderick, S. & Hovi, M., 1999. "Animal health and welfare in organic livestock systems: identification of constraints and priorities," MAFF report.
- Ronald, P. C., Salmeron, J. M., Carland, F.M. & Staskawicz, B. J., 1992. The cloned a virulence gene *avrPto* induces disease resistance in tomato cultivars containing the *Pto* resistance gene. *Journal of Bacteriology*; 174: 1604–1611.
- Ryley, J. W. & Gartner, R. J. W., 1970. Effects of Sub-Lethal doses of urea on pregnant Cattle. Queensland Department of Primary Industries. Animal Research Institute, Yeerongpilly.
- Salman, D. A. M. & El-Nasri, H. A., 2012. Evaluation of four serological tests to detect prevalence of bovine brucellosis in Khartoum State. *Journal of Cell and Animal Biology*; 6(9): 140-143.
- Samad, R. M. H. & Islam, T. S., 1989. Factors associated with placental retention in dairy cattle. *Indian Journal of Dairy Science*; 42: 720-723.
- Sanderson, M. & Dargatz, D., 2000. Risk factors for high level calf morbidity risk from birth to weaning in beef herds in the USA. *Preventive Veterinary Medicine*; 44: 97-106.
- Santos, J. E. P., Rutigliano, H. M and SáFilho, M. F., 2009. Risk factors for resumption of postpartum cyclicity and embryonic survival in lactating dairy cows. *Animal Reproduction Science*; 110: 207-221.
- Sawa, A., Bogucki, M. & Krezel-Czopek, S., 2012. Reproduction performance of cows with single, twin and triplet calves. *Journal of the University of Veterinary and Pharmaceutical Sciences in Brno, Czech Republic*; 8: 347-352.

- Schoeman, S. J., 1989. Recent research into the production potential of indigenous cattle with special reference to the Sanga. *South African Journal of Animal Science*; 26(1): 5-19.
- Schwalbach, L. M., Groenewald, I. B. & Marfo C. B., 2001. A survey of small-scale farming systems in the North-West Province of South Africa. *South African Journal of Animal Science*; 31: 3.
- Seth, A. R., 1970. Some observations about the incidence of prolapse of vagina in Surti buffaloes. *Indian Veterinary Journal*; 47: 1130-1134.
- Sewalem, A., Miglior, F., Kistemaker, G., Sullivan, P. & Van Doormaal, B., 2008. Relationship between reproduction traits and functional longevity in Canadian dairy cattle. *Journal of Dairy Science*; 91: 1660-1668.
- Shiferaw, Y., Tenhagen, B. A., Bekana, M. & Kassa, T., 2005. Reproductive disorders of crossbred dairy cows in the central highlands of Ethiopia and their effect on reproductive performance. *Tropical Animal Health and Production*; 37(5): 427-441.
- Shirima, G. M., Masola, S. N., Malangu, O. N. & Schumaker, B. A., 2014. 'Outbreak investigation and control case report of brucellosis: Experience from livestock research centre, Mpwapwa, Tanzania', *Onderstepoort Journal of Veterinary Research*; 81(1): 4. <http://dx.doi.org/10.4102/ojvr.v81i1.818>
- Shukla, S. P., Kharche, K. G. & Parekh, H. K. B., 1983. Calcium and phosphorus in relation to retained placenta in cross-bred cows. *Indian Veterinary Journal*; 60: 183-188.
- Siciliano-Jones, J. L., Socha, M. T., Tomlinson, D. J. & De Frain, J. M., 2008. Effect of trace mineral source on lactation performance, claw integrity, and fertility of dairy cattle. *Journal of Dairy Science*; 91: 1985-1995.
- Silberová, P., Lukešová, D. & Pinc, L., 2010. The determination of blood profile in captive wild ungulates with focus on eland (*Taurotragus oryx*) *Agricultura Tropica Et Subtropica*; 43(4): 360-365.
- Sinclair, K. D., Kuran, M., Gebbie, F. E., Webb, R. & McEvoy, T. G., 2000b. Nitrogen metabolism and fertility in cattle: II. Development of oocytes recovered from heifers offered diets differing in their rate of nitrogen release in the rumen. *Journal of Animal Science*; 78: 2670-2680.
- Sloss, V. & Dufty, J. H., 1980. *Dystocia. Handbook of Bovine Obstetrics*. Williams and Wilkins, Baltimore/London: 98-127.
- Sorge, U., 2005. The effect of varied duration of the close up period of primiparous cows on the incidence of dystocia and perinatal calf mortality. PhD Dissertation, FU Berlin; Germany: 10-110.

- Spears, J. W. & Weiss, W. P., 2008. Role of antioxidants and trace elements in health and immunity of transition dairy cows. *Veterinary Journal*; 176: 70-76.
- Spears, J. W., 2000. Micronutrients and immune function in cattle. *Proceedings of the Nutrition Society*; 59: 587–594.
- Speich, M., Bousquet, B. & Nicolas, G., 1981. Reference values for ionized, complexed, and protein-bound plasma magnesium in men and women. *Clinical Chemistry*; 27: 246-248.
- Spiegel, S., Foster, D. & Kolesnick, R., 1996. Signal transduction through lipid second messengers. *Current Opinion in Cell Biology*; 8(2): 159–67. (doi:10.1016/S0955-0674(96)80061-5. PMID 8791422)
- Stanton, T. L., Whittier, J. C., Geary, T. W., Kimberling, C. V. & Johnson, A. B., 2000. Effects of trace mineral supplementation on cow-calf performance, reproduction, and immune function. *The Professional Animal Scientist*; 16:121-127.
- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. & de Haan, C., 2006. Livestock's long shadow: environment issues and options. Rome, Italy: FAO.
- Stull, C. L., Payne, M. A., Berry, S. L. & Reynolds, P. J., 2007. A review of the causes, prevention, and welfare of non-ambulatory cattle Vet Med Today: Reference Point: *Journal of the American Veterinary Medical Association*; 231: 22.
- Suttle, N. F., 2010. Mineral Nutrition of Livestock. Cabi Publishing.
- Swedish Dairy Association. 2010. [online] (2010-04-10a) Available: http://www.svenskmjolk.se/ImageVault/Images/id_2354/ImageVaultHandler.aspx [2009-04-22]
- Swiefy, A. S., 2003. Effect of retained placenta on postpartum reproduction performance of Frisian cows. *Egyptian Journal of Animal Production*; 40: 111-121.
- Tamminga, S., 2006. The effect of the supply of rumen degradable protein and metabolizable protein on negative energy balance and fertility in dairy cows. *Animal Reproduction Science*; 96: 227-239.
- Taylor, A., 1996. Detection and monitoring of disorders of essential trace elements. *Annual Clinical Biochemistry*; 33: 486-510.
- Terpiłowska, S. & Siwicki, A.K., 2011. The role of selected microelements: selenium, zinc, chromium and iron in immune system. *Central European Journal of Immunology*; 36 (4): 303-307.
- Theiler, A., 1912. Facts and theories about stijfziekte and larnziekte. 2nd Reproductiont. Du. *Veterinary Research*. South Africa: 7.

- Theiler, A., 1927. Lamsiekte (parabotulism) in cattle in South Africa. Eleven and twelfth reports of the Director of Veterinary Education and Research; Part II: 821–1361
- Thornton, P. K. & Gerber, P., 2010. Climate change and the growth of livestock sector in developing countries. *Migration Adoption Strategy of Global Change*; 15: 169 -184.
- Thornton, P. K., 2010. Livestock production: recent trends, future prospects. *Philadelphian Transplantation Research Society- B*; 365: 2853–2867.
- Thorton, P. K. et al. 2006. *Mapping climate vulnerability and poverty in Africa*. Nairobi, Kenya: ILRI.
- Titgemeyer, E. C. & Loest, C. A., 2001. Amino acid nutrition: Demand and supply in forage-fed ruminants. *Journal of Animal Science*; 79: E180–E189.
- Tsioulpas, A., Grandinson, A. S. & Lewis, M. J., 2007a. Changes in physical properties of bovine milk from the colostrums period to early lactation. *Journal of Dairy Science*; 90: 5012-5017.
- Underwood, E. J., 1996. *The Mineral Nutrition of Livestock*, Wallingford: Commonwealth Agricultural Bureaux, Rome: Food and Agriculture Organization of the United Nations.
- Undi, M., 2003. Training communal farmers in Namibia: The role of the university in rural development. University of Namibia. Department of Animal Science: 1-6.
- Vasseur, E., Rushen, J., de Passille, A., Lefebvre, D and Pellerin, D., 2010. An advisory tool to improve management practices affecting calf and heifer welfare on dairy farms. *Journal of Dairy Science*; 93: 4414-4426.
- Vasseur, E., Rushen, J., Pellerin, D., Lefebvre, D. & de Passille, A., 2008. Development of an intervention strategy to improve welfare of replacement animals in Canadian dairy farms. Proc. WAFL, Ghent, Belgium: 122.
- Venkatapathy, R., Govindarajan, V., Oza, N., Parameswaran, S., Dhanasekaran, P. B. & Prashad, K. V., 2014. Salivary Creatinine Estimation as an Alternative to Serum Creatinine in Chronic Kidney Disease Patients. *International Journal of Nephrology*; Article ID 742724: 6.
- Waldner, C. L. & Van De Weyer, M. L., 2011. Selenium status at the end of the grazing season, reproductive performance and degenerative myopathy in beef herds. *Canadian Veterinary Journal*; 52: 1088.
- Wang, R., Hampton, E.M. & Whang, D. D., 1994. Magnesium homeostasis and clinical disorders of magnesium deficiency. *Animal Pharmacology- macother*; 28: 220–226.

- Wettemann, R. P., Lents, C. A., Ciccioli, N. H., White, F. J & Rubio, I., 2003. Nutritional- and suckling-mediated anovulation in beef cows. *Journal of Dairy Science*; 81(2): E48–E59.
- Whanger, P. D., 2002. Seleno-compounds in plants and animals and their biological significance. *Journal of American College of Nutrition*; 21: 223–232.
- Williams, P., 2012. Food Toxicity and Safety. In J. Mann and A. Truswell (Eds.), Essentials of Human Nutrition. *British Journal of Nutrition*; Oxford University Press: 449-466.
- Wiltbank, J. N., Warwick, E. J, Vernon. E. H. & Priode, B. M., 1961. Factors affecting net calf crop in beef cattle. *Journal of Animal Science*; 20: 409–15.
- World Bank, 2009. Minding the stock: bringing public policy to bear on livestock sector development. Washington. D C. Report no.4410-GLB.
- Wright, C. L., 2012. Applied Reproductive Strategies in beef cattle.
[Www.arc.agric.za/arc-ovi/Pages/Diagnosis-of-bacterial-diseases-.aspx](http://www.arc.agric.za/arc-ovi/Pages/Diagnosis-of-bacterial-diseases-.aspx).
- Wyngaarden & Wright., 1952. *Endocrinology*; 50: 537.
- Yaso thai, R., 2014. Importance of minerals on reproduction in dairy cattle. *International Journal of Science Environment*; 3(6): 2051 – 2057.
- Yatoo, M. I., Saxena, A., Deepa, P. M., Habeab, B. P., Devi, S., Jatav, R. S. & Dimri, U., 2013. Role of trace elements in animals: A review. *Veterinary World*; 6(12): 963-980
- Zaborski, D., Grzesiak, W., Szatkowski, I., Dybus, A., Muszynska, M. & Jedrzejczak, M., 2009. Factors affecting dystocia in cattle. Forsyth (Eds). *International handbook of tourism economics*. Edward Elgar, England; 44: 540–551.
- Zhang, C. K., Ye, J. P. & Chen, J. H., 1992. The changes of mineral contents of serum during the dry period and prior to and after calving in dairy cows with retained placenta. *Chinese Journal of Veterinary Medicine*; 18: 10-1.
- Zhang, D., Kong, W. K., You, J. & Wong, M., 2003. On-line palm print identification, IEEE Transactions on Pattern Analysis and Machine Intelligence; 25(9): 1041–1051.
- Zhang, M., Xin, L., Bao, E., Hartung, J. & Yue, Z., 2010. Variation in the expression of Hsp 27 α B-crystallin mRNA and protein in the heart and liver of pigs exposed to different transport times. *Research in Veterinary Science*; 90(3): 423-438.
- Zima, V. A., Bare, D. J., Mignery, A. G. & Blatter, A. L., 2007. IP3-dependent nuclear Ca²⁺ signalling in the mammalian heart. *Journal of Physiology*; 584(2): 601–611.
- Zimmermann, M. B., 2009. Iodine deficiency. *Endocrinology*; 30:376.

APPENDIX

Table 6.1 Serological screening results obtained using Rose Bengal test from cows which had aborted

Case ID	Results	Body condition score
Abortion (c1)	Negative	2
Abortion (c2)	Positive	2
Abortion (c3)	Positive	3
Abortion (c4)	Positive	2
Abortion (c5)	Negative	3
Abortion (c6)	Positive	2
Abortion (c7)	Positive	2
Abortion (c8)	Positive	2
Abortion (c9)	Negative	2
Abortion (c10)	Negative	3
Abortion(c11)	Negative	2
Abortion(c12)	Positive	2
Abortion (c13)	Positive	3
Abortion(c14)	Negative	3
Abortion (c15)	Positive	3
Abortion (c16)	Positive	3
Abortion (c17)	Positive	3
Abortion (c18)	Negative	2
Abortion (c19)	Negative	2
Abortion (c20)	Positive	2
Abortion (c21)	Positive	2
Abortion (c22)	Negative	2
Abortion (c23)	Negative	2
Abortion (c24)	Negative	2
Abortion (c25)	Negative	2
Abortion (c26)	Positive	2
Abortion (c27)	Positive	3

Body condition scores: 1- very poor, 2-poor, 3- good, 4- very good, 5- obese

Table 6.2 Serological screening results obtained using Rose Bengal test from cows which had retained placenta

Case ID	Results	Body condition score
Retained placenta (c1)	Negative	2
Retained placenta (c2)	Positive	3
Retained placenta (c3)	Negative	3
Retained placenta (c4)	Negative	3
Retained placenta (c5)	Negative	3
Retained placenta (c6)	Negative	2
Retained placenta (c7)	Positive	2
Retained placenta (c8)	Negative	2
Retained placenta (c9)	Positive	3
Retained placenta (c10)	Positive	3
Retained placenta (c11)	Negative	2
Retained placenta (c12)	Negative	4
Retained placenta (c13)	Negative	4
Retained placenta (14)	Positive	2
Retained placenta (15)	Positive	2
Retained placenta (16)	Positive	3
Retained placenta (17)	Positive	2

Body condition scores: 1- very poor, 2-poor, 3- good, 4- very good, 5- obese

Table 6.3 Serological screening results obtained using Rose Bengal test from cows which had prolapsed vaginas

Case ID	Results	Body condition score
Vaginal prolapse (c1)	Positive	3
Vaginal prolapse (c2)	Negative	3
Vaginal prolapse (c3)	Positive	3
Vaginal prolapse (c4)	Negative	3
Vaginal prolapse (c5)	Positive	3
Vaginal prolapse (c6)	Positive	2
Vaginal prolapse (c7)	Positive	2
Vaginal prolapse (c8)	Positive	3
Vaginal prolapse (c9)	Negative	3

Body condition scores: 1- very poor, 2-poor, 3- good, 4- very good, 5- obese

Table 6.4 Serological screening results obtained using Rose Bengal test from cows which had downer cow syndrome

Case ID	Results	Body condition score
Downer cow syndrome (c1)	Negative	2
Downer cow syndrome (c2)	Positive	2
Downer cow syndrome (c3)	Negative	2
Downer cow syndrome (c4)	Positive	2
Downer cow syndrome (c5)	Negative	2
Downer cow syndrome (c6)	Negative	2
Downer cow syndrome (c7)	Negative	2
Downer cow syndrome (c8)	Positive	2
Downer cow syndrome (c9)	Negative	3
Downer cow syndrome (10)	Positive	3
Downer cow syndrome (11)	Positive	3
Downer cow syndrome (12)	Positive	3
Downer cow syndrome (13)	Positive	

*Body condition scores: 1- very poor, 2-poor, 3- good, 4- very good, 5- obese

Table 6.5 Serological screening results obtained using Rose Bengal test from cows which had dystocia

Case ID	Results	Body condition score
Dystocia (c1)	Positive	4
Dystocia (c2)	Negative	3
Dystocia (c3)	Positive	3
Dystocia (c4)	Positive	2
Dystocia (c5)	Negative	4
Dystocia (c6)	Positive	3
Dystocia (c7)	Positive	2
Dystocia (c8)	Negative	2
Dystocia (c9)	Negative	2
Dystocia (c10)	Positive	4
Dystocia (c11)	Positive	4
Dystocia (c12)	Negative	2
Dystocia (c13)	Negative	3
Dystocia (c14)	Negative	3
Dystocia (c15)	Positive	3
Dystocia (c16)	Positive	4
Dystocia (c17)	Positive	2

Body condition scores: 1- very poor, 2-poor, 3- good, 4- very good, 5- obese

Table 6.6 Serological screening results obtained using Brucella Rose Bengal test (BRBT) pregnant cows

Case ID	BRBT Results	BODY CONDITION SCORE
Pregnant (c1)	Negative	3
Pregnant (c2)	Negative	3
Pregnant (c3)	Negative	2
Pregnant (c4)	Negative	4
Pregnant(c5)	Negative	3
Pregnant(c6)	Negative	4
Pregnant(c7)	Negative	4
Pregnant(c8)	Negative	3
Pregnant(c9)	Negative	3
Pregnant(c10)	Negative	3
Pregnant(c11)	Negative	3
Pregnant(c12)	Negative	2
Pregnant(c13)	Negative	2
Pregnant(c14)	Positive	2
Pregnant(c15)	Negative	2
Pregnant(c16)	Negative	3
Pregnant(c17)	Negative	3
Pregnant(c18)	Negative	3
Pregnant(c19)	Positive	4
Pregnant(c20)	Negative	2
Pregnant(c21)	Negative	2
Pregnant (c22)	Positive	2
Pregnant (c23)	Positive	2
Pregnant (c24)	Positive	3
Pregnant (c25)	Negative	2
Pregnant (c26)	Negative	2
Pregnant (c27)	Negative	2
Pregnant (c28)	Negative	3
Pregnant (c29)	positive	3
Pregnant (c30)	positive	3
Pregnant (c31)	Negative	3

Body condition scores: 1- very poor, 2-poor, 3- good, 4- very good, 5- obese

QUESTIONNAIRE

Evaluation of nutritional and mineral blood parameters as a tool to predict Bovine reproductive conditions in Ngaka Modiri Molema District of the North-West Province

Farmer's consent

I.....agree to participate in this study freely without pressure. I declare that information provided in this questionnaire is correct.

Signed.....at (area).....on (date).....

REPRODUCTIVE CONDITION

Downer Cow Syndrome	☐
Abortion	☐
Retained Placenta	☐
Dystocia	☐
Vaginal Prolapses	☐

AGE OF THE COW

1-3 years	☐
4-6years	☐
7+ years	☐

BODY CONDITION SCORE

1-very poor	☐
2-poor	☐
3-good	☐
4-very good	☐
5-obese	☐

BREED

- | | |
|------------------|----------------------|
| 1. Brahman | <input type="text"/> |
| 2. Nguni | <input type="text"/> |
| 3. Bonsmara | <input type="text"/> |
| 4. Angus | <input type="text"/> |
| 5. Friesland | <input type="text"/> |
| 6. Afrikander | <input type="text"/> |
| 7. Simmental | <input type="text"/> |
| 8. Drakensberger | <input type="text"/> |
| 9. Charolaise | <input type="text"/> |
| 10. Mixed breed | <input type="text"/> |

NUMBER OF CALVING/ PARITY

- | | |
|----|----------------------|
| 1 | <input type="text"/> |
| 2 | <input type="text"/> |
| 3 | <input type="text"/> |
| 4 | <input type="text"/> |
| 5 | <input type="text"/> |
| 6 | <input type="text"/> |
| 7 | <input type="text"/> |
| 8+ | <input type="text"/> |

NUMBER OF INCIDENCES IF THE CONDITION

- | | | | | | | | | | | | |
|---|----------------------|---|----------------------|---|----------------------|-----|----------------------|---|----------------------|---|----------------------|
| 1 | <input type="text"/> | 2 | <input type="text"/> | 3 | <input type="text"/> | 4 | <input type="text"/> | 5 | <input type="text"/> | 6 | <input type="text"/> |
| 7 | <input type="text"/> | 8 | <input type="text"/> | 9 | <input type="text"/> | 10+ | <input type="text"/> | | | | |

TREATMENT GIVEN

Yes ☐ No ☐

IF YES WHAT TYPE OF TREATMENT

.....

.....

.....

WAS THE COW SUPPLEMENTED

Yes ☐ No ☐

IF YES WITH WHAT

.....

.....

TYPE OF FEEDING SYSTEM

Free ranging ☐

Confined ☐

MEDICAL HISTORY OF THE SAME CONDITION

Yes ☐

No ☐

Thank you very much for your participation in this study.

Yours: Miss Molefe

Under supervision of Dr M. Mwanza